BEFORE THE CANTERBURY REGIONAL COUNCIL

***IN THE MATTER OF*:** the Resource Management Act 1991

AND

***IN THE MATTER OF*:** a submission on the Proposed Canterbury Land and Water Regional Plan

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EVIDENCE OF ALASTAIR ANDREW CHALMERS FAIRWEATHER
FOR DIRECTOR-GENERAL OF CONSERVATION

Dated 28 March 2013

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INTRODUCTION

1 My full name is **Alastair Andrew Chalmers Fairweather**

2 I am a Technical Advisor at the Department of Conservation's (DOC) National Office based in Hamilton. I have worked for DOC for 15 years, initially providing advice on animal pests to Waikato Conservancy and for the last 13 years as a national key contact for animal pests.

3 I hold the degrees of Bachelor of Science Technology (Ecology, Waikato University), Doctor of Philosophy (Ecology, University of Aberdeen) and a Graduate Diploma in Applied Statistics (Massey University).

4 I sit on the executive committee of the New Zealand Biosecurity Institute, and am a member of the New Zealand Ecological Society.

5 My area of expertise is in the management of invasive pest animals, in particular the use and toxicology of Vertebrate Toxic Agents (VTAs – vertebrate pesticides), risk assessments of VTAs and the registration of VTAs under the Hazardous Substances and New Organisms Act 1996 (HSNO) and Agricultural Compounds and Veterinary Medicines Act 1997 (ACVM).

6 I hold a NZ Environmental Protection Agency (NZ EPA) Controlled Substance Licence for cyanide, 1080 and pindone, and have been involved in planning, undertaking and auditing both ground and aerial control operations.

7 I am familiar with the proposed Canterbury Land and Water Regional Plan (pCLWRP) so far as it pertains to management of pest species.

8 I have read the Environment Court's Code of Conduct for Expert Witnesses, and I agree to comply with it.

9 In compiling this statement I have consulted published scientific research, including work I have contributed to. I confirm that the issues addressed in this evidence are within my area of expertise. I have not omitted to consider

material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

10 My evidence will deal with issues relating to Rule 5.23 discharge of vertebrate toxic agents in the pCLWRP as it pertains to DOC operations and which arise in relation to Hearing Group 2.

11 My evidence will address the following:

- General information about pest animal control undertaken by DOC in New Zealand and the Canterbury Region;
- The ecotoxicity of 1080 and pindone, including its fate on land and in water and effects on terrestrial and aquatic species;
- Comment on Rule 5.23 of the pCLWRP.

12 By way of background, to my evidence, at present the effect of proposed Rule 5.23 in the pCLWRP relating to aerial discharge of VTA's to land where it may enter water means DOC would require consent for such activity. DOC sought that such discharge be provided for as a permitted activity within Rule 5.23, subject to some additional conditions, but that submission has not been accepted.

13 I understand DOC supports the recommendations in the pCLWRP regarding Rule 5.21.

PEST CONTROL IN NZ AND THE CANTERBURY REGION

14 Apart from three species of bats, New Zealand's ecosystems evolved in the absence of terrestrial mammals. However, since humans settled in New Zealand about 900 years ago, at least 31 species of mammals have been introduced and established in the wild (Parkes & Murphy 2003). Many of these introduced mammal species have had major impacts on New Zealand's ecosystems through browsing of plants and predation of wildlife. Over 40%

of the pre-human land bird species are now extinct, and the proportion of birds classed as threatened is one of the highest in the world (Clout 1997).

15 DOC is the leading central government agency responsible for the conservation of New Zealand's natural and historic heritage. Its legislative mandate is the Conservation Act 1987 and other key statutes such as the National Parks Act 1980, the Reserves Act 1977 and the Wild Animal Control Act 1977. DOC undertakes pest animal control throughout New Zealand as a key component of the meeting its legislative mandate.

16 DOC manages approximately 808 000 ha of land in the Canterbury region. The pest animals managed by DOC for conservation purposes on this land include possums, rodents, Bennett's wallabies, mustelids (stoats, weasels and ferrets), feral cats, hedgehogs, feral deer, feral pigs and tahr at a cost of approximately $760 000 in 2011-12. A further $120 000 was spent by DOC controlling pests to meet the Canterbury Regional Pest Management Strategy (RPMS) rules.

PEST CONTROL TOOLS

17 The tools used in controlling the above pests include: shooting, trapping, fencing, biocontrol and VTAs.

18 Shooting is the only method used to control tahr, feral deer and feral pigs. It is also an important tool for controlling Bennett's wallabies and rabbits at medium - low densities.

19 Trapping is the primary tool used to control feral cats, mustelids and hedgehogs.

20 Fencing, in conjunction with shooting and VTAs, is used to control rabbits.

21 Rabbit Hemorrhagic Disease (RHD) is the only biocontrol agent available in NZ for a vertebrate pest (rabbits). Unfortunately its effectiveness as a control agent is diminishing.

22 VTAs are a key tool for control of rabbits, possums, rodents and Bennett's wallabies, especially at medium-high densities and over extensive areas.

VERTEBRATE TOXIC AGENTS AS A CONTROL TOOL

Land-based methods

23 In smaller operational areas, VTAs are usually applied by land-based methods (hand, mechanical spreader, bait stations or bait bags).

24 There are a range of VTAs that can be applied in this way, including 1080; cyanide; cholecalciferol; zinc phosphide, brodifacoum, and pindone and other first generation anticoagulants.

25 The potential benefits of land-based methods of applying VTAs include:

- They can be highly effective;
- VTAs can be applied in a targeted way meaning that waterways and sensitive areas can be avoided; and
- Some land-based methods (bait stations), contain the bait meaning spillage of bait onto land/water is minimised.

26 There are a number of disadvantages of ground control with VTAs:

- They are limited by terrain - in rugged country it becomes potentially slow and dangerous to workers;
- In remote locations, access and the logistics of having staff living in the field for extended periods can be an issue;
- The logistics of ground control becomes increasingly complex in large areas (>3000 ha); and
- At high pest densities a rapid knockdown may not be achieved.

Aerial application methods

27 In the Canterbury Region, the aerial application of VTAs is a particularly important tool for controlling rabbits, possums, Bennett's wallabies and

rodents over large areas, in remote, rugged, difficult terrain, at high pest densities and/or where a rapid knockdown of pest numbers is required.

28 Currently only two VTAs are approved for aerial application on the mainland of NZ- 1080 and pindone.

29 1080 is applied aerially to control rabbits, possums, rodents and Bennett's wallabies. Normally prefeeding is undertaken before a single aerial application of the toxic bait. Currently the following baits and sowing rates are used during aerial operations:

- For rabbits, toxic baits (carrot or cereal pellets containing 0.2-0.4 g/kg 1080) are sown at a rate of up to 15 kg/ha.
- For possums and rodents, toxic cereal baits (containing 0.8-1.5 g 1080/kg) are sown at rates of up to 5 kg/ha.
- For Bennett's wallabies, toxic baits (carrot or cereal pellets containing 1.5 - 2g 1080/kg) are sown at rates of up to 5 kg/ha.
- At these sowing rates, a maximum 10 g of 1080 per hectare is entering the environment. (Max allowed by EPA is 30 g).

30 Pindone is aerially applied to control rabbits. Prefeeding is not required and the toxic baits are aerially sown 2-3 times over a 4-6 week period.

- Pindone baits (carrot or cereal pellets containing between 0.17-0.25 g pindone/kg) are sown at rates of up to 5 kg/ha.
- Therefore the maximum amount of pindone entering the environment during an aerial operation is 3.75 g per hectare over 4-6 weeks.

31 Where current best practice is followed during aerial application of 1080 or pindone, pest kills exceed 90%.

32 A disadvantage of aerial application of VTAs is the opposition to this tool by sections of the community. Often this opposition arises due to concerns over baits getting into waterways, accidentally being applied over operational boundaries and non-target deaths. I discuss this further below.

1080

33 1080 has been used for pest control in New Zealand since the 1950s. A large body of scientific research has been undertaken into the fate of 1080 in the environment, its impact on the environment, non-targets and human health over a 60 year period.

34 Two recent reviews (Eason et al. 2011; Fairweather et al. 2012) of the scientific literature are attached to this evidence (Appendices 1 & 2). A summary of the research is as follows:

a) The manufactured 1080 used in toxic baits is chemically identical to the toxic compound found in some poisonous plants, and highly toxic fluoroacetate-producing plants are globally distributed. In plants, fluoroacetate appears to be a secondary plant compound that is biosynthesised at high concentrations as a chemical defence mechanism against browsing invertebrates and vertebrates.

b) 1080 is absorbed through the gastrointestinal tract or via the lungs if inhaled. Fluoroacetate is not readily absorbed through intact skin. Within animals it is converted to fluorocitrate, which inhibits the Krebs cycle. The Krebs cycle is the metabolic pathway that produces the energy used in normal cell function. The combination of inhibited energy production and the accumulation of citrate in tissues and plasma will lead to death.

<u>Fate in the environment</u>

c) On land, 1080 in baits is removed through a combination of microbial breakdown and leaching. This process occurs within 1 – 2 weeks in warm moist conditions or when baits are exposed to rain. Under cool dry conditions it may take several weeks and, in extreme cold or drought 1080 can persist in baits for several months.

d) If baits enter waterways directly, the 1080 is rapidly lost from the baits over 36 hours and the baits themselves will disintegrate over 3 - 4 days.

e) Following rain, 1080 leaches from baits into the soil where it is broken down to non-toxic by-products by microorganisms. The rate at which 1080 is degraded in soil is affected by soil temperature and moisture content, with slower breakdown at lower temperatures/moisture content. Under favourable conditions this degradation takes 1-2 weeks. There is no indication 1080 affects mineralisation of nitrogen by soil microorganisms.

f) 1080 is highly water soluble, and has the potential to enter waterways via baits, or in groundwater containing 1080 that has leached out of baits during a heavy rainfall event. However, recent research indicates that little of the 1080 released into soil from baits leaches into ground water.

g) In natural water 1080 breaks down to non-toxic by-products within 1 - 2 weeks. Factors which affect rate at which 1080 degrades in aquatic environments include temperature, the presence of aquatic plants and microorganisms, and flow and volume of the waterway.

h) Dilution of 1080 also plays a significant part in determining the concentration of 1080 that will be present in waterways. While substantial 1080 breakdown will occur over the first 24 hours in water, the effect of dilution will be immediate. This dilution effect will rapidly lead to 1080 in water reaching undetectable concentrations.

i) There has been extensive monitoring of waterways for 1080 residues following aerial 1080 operations. Between 1990 and 2011, Landcare Research analysed 2537 water samples with 96.6% of the samples taken containing no residues.

j) Where residues have been detected in water samples, most have been less than 1 µg/l 1080 and associated with very small streams and/or the presence of bait. 1 µg/l 1080 is equivalent to about 3.75 kg of 1080 possum bait (containing a total of 2.5 g 1080) dissolving in an Olympic-sized pool.

k) The Ministry of Health has set a maximum of 3.5 µg/l for 1080 in drinking water (Ministry of Health 2008). 1080 residues have never been detected in drinking water supplies.

l) In experiments, 1080 was taken up by some plants (e.g. rye grass, käramuramu and puka), but not others (e.g. pikopiko) when toxic baits were placed at the base of the plant. However, the amount of 1080 taken up was very small. Based on the peak concentration observed in rye grass (0.08 g/kg), a 50 kg sheep would need to eat about 250 kg of grass to have a 50% chance of dying from 1080 poisoning. Similarly, a 70 kg person would need to eat 28 tonnes of käramuramu or 9.3 tonnes of puha in one sitting to have a 50% chance of dying from 1080 based on the highest residues recorded in the plants (5 µg/kg for käramuramu and 15 µg/kg for puha).

Non-target Impacts

m) While 1080 is a broad-spectrum toxin, there is a wide variation between species in their susceptibility to 1080 poisoning. Birds are generally less susceptible to 1080 than mammals. Lizards and fish appear relatively tolerant of 1080.

n) There has been monitoring of native animal populations during aerial 1080 operations since the 1980s.

o) Bird deaths have been reported during aerial 1080 operations. In response to these deaths, surveys and monitoring of native birds during 1080 operations has been undertaken since the mid 1980s.

Based on the results of this work, there is no indication that any species of native bird has been affected by 1080 at a population level when cereal pellet or carrot baits are used.

p) Invertebrate populations have been monitored during aerial poisoning operations. There have been no significant population effects on any species studied, nor is there evidence to suggest poisoned invertebrates are a significant factor in secondary poisoning of other animals.

q) Research into the responses of aquatic invertebrates community to 1080 contamination and monitoring of longfin eels, upland bullies, and freshwater crayfish indicates there is no cause for concern.

r) Dogs are especially vulnerable and highly likely to die if they eat 1080 baits or scavenge animals killed by 1080. Most estimates of deer kill during aerial 1080 operations are between 30 and 60%. However, where deer numbers are high or there is limited food for the deer, kills have been as high as 90%. Productivity figures for red deer populations are around 30% so a low to moderate by-kill of deer populations is probably negated within a couple of years.

NATIONAL REVIEWS OF USE OF 1080

35 In 2007 the Environmental Risk Management Authority NZ (ERMA NZ) (now NZ EPA) released its decision on the reassessment of 1080. The reassessment process included reviewing all available scientific literature. ERMA NZ concluded that the benefits of using 1080 outweighed the adverse effects and decided to approve the continued use of 1080 in New Zealand with additional controls around aerial application (ERMA NZ 2008).

36 The Parliamentary Commissioner for the Environment (PCE) published the findings of her review of the use of 1080 in NZ in 2011. The PCE concluded there was a solid body of evidence supporting the continued use of 1080,

therefore not only should its use continue, but more should be used. In making this conclusion, the Commissioner recommended that there was a strong case for making the use of 1080 a permitted activity under the Resource Management Act 1991 (RMA), with local control reserved to those activities that are not covered by existing controls under other legislation (Wright 2011).

PINDONE

37 A review of the existing scientific literature (Fairweather & Fisher 2012) is included in this submission (Appendix 3). A summary of the review is as follows:

a) Pindone belongs to the indandione class of anticoagulants. It has the same mode of action as other anticoagulants such as brodifacoum, by inhibiting the formation of vitamin K-dependent clotting factors in the blood. This leads to extensive haemorrhaging causing death.

b) Being a first generation anticoagulant (like warfarin and diphacinone), pindone is readily metabolised and it is far less persistent in the environment than second-generation anticoagulants such as brodifacoum. For example the elimination half-life (the time taken for 50% of the pesticide in the body to be eliminated/broken down) of pindone in rat livers is 2.1 days compared to 113.5 days for brodifacoum.

c) There are two forms of pindone - an acid and a salt. The acid form is insoluble and used in the manufacture of cereal pellets. The salt form is soluble and is used to make Pindone Liquid Concentrate which is applied to carrot and oat baits.

Fate in the Environment

d) As cereal baits containing the acid form of pindone decay, the pindone in the baits will bind with the underlying soil. The rate at which this occurs will depend on factors such as temperature, rainfall and microbial activity. Under dry conditions this process could take months. Pindone absorbs visible light and there are indications that it is broken down by sunlight. This is probably an important degradation route, and is supported by observations that the loss of pindone occurs from the surface of baits.

e) When exposed to rain or moisture, the soluble pindone salt will leach out of carrot baits. Following high rainfall this process could take days but in extreme cold or drought the soluble pindone salt could persist in baits for several months.

f) There are indications pindone has some insecticidal and fungicidal properties, hence the breakdown of pindone in soil is probably mostly through chemical reactions. As stated above sunlight plays an important part in the breakdown of pindone. If the acid form of pindone in cereal pellets entered the soil, its half-life is likely to be in the order of a month and any residues could be expected to degrade at a moderate rate. In contrast, because the sodium salt form of pindone in carrot baits is water soluble, residues are unlikely to persist.

g) The degradation time of pindone in water is likely to be slow. The pindone salt form is soluble in water so it could potentially leach into waterways. If the pindone did enter a waterway, temperature, the pH of water and exposure to sunlight light will affect the rate at which the pindone degrades. Dilution will also be important in determining the concentration of any residue present in the water. The acid form

of pindone has a very low solubility in water. Leaching from soil into water is therefore unlikely to occur.

h) Limited sampling of water following aerial pindone operations has been undertaken, with no residues being found in the water.

Non-target Impacts

i) The toxicity of pindone to different species is highly variable and animals are generally far more susceptible to repeat doses of pindone than single doses. While there is no LD_{50} (Lethal Dose 50%, which is the estimated dose that kills 50% of the test animals) data for insects, pindone is reported to have insecticidal properties.

j) A wide range of bird species (native and non-native) have been found dead following pindone operations, however it is unknown if this has an impact at a population level. A single study of lizards suggests they are unlikely to be at risk from the use of pindone. However, some lizards have been found dead following pindone operations.

k) There is an effective antidote for domestic animals poisoned with pindone.

EXISTING REGULATORY CONTROLS AROUND THE AERIAL APPLICATION OF VTAs

38 1080 and pindone have approval under the HSNO Act and are registered under the ACVM Act. As stated above 1080 has also been reassessed under the HSNO Act.

39 As part of the EPA and ACVM regulatory processes, controls have been placed on how 1080 (ERMA NZ 2008) and pindone (ERMA NZ 2011) can be applied. These controls are designed to minimise the environmental impacts of their aerial application. The EPA decision documents that contain the controls for 1080 and pindone are attached to this evidence (Appendices 4 & 5).

40 Pilots applying 1080 or pindone aerially are required to hold an ACVM controlled substance licence. The intention of the licence requirement is to ensure that a person is a 'fit and proper' person and has knowledge of the relevant legislation relating to the safe use of the VTA being applied. The pilot also must hold an Agricultural Chemical Rating from the Civil Aviation Authority (CAA). To get this rating a pilot must have shown knowledge of how to apply toxins from the air.

41 Prior to undertaking an aerial 1080 operation, permission is required from a Public Health Unit (Medical Officer of Health, Health Protection Officer or an employee of the Ministry of Health). This is to ensure that public health risks are assessed and managed effectively. The permission will include conditions around how 1080 may be applied near drinking water supplies (Ministry of Health 2010). The permissions guidelines document is appended to this submission (Appendix 6).

DOC CONTROLS AROUND USE OF VTAS

Assessment of the risks of VTA use on land managed by DOC

42 DOC has its own internal process for assessing the risks surrounding the use of VTAs on land managed by DOC. This process was developed in conjunction with Landcare Research. Before any VTA can be used on land managed by DOC it must pass this risk assessment.

43 The DOC risk assessment examines the impacts a VTA use will have on the environment, non-target animals and human health. It also assesses the operational efficacy of the VTA. The assessment is based on all the scientific literature available and is undertaken by a panel of experienced DOC scientists and VTA users.

44 All the 1080 and pindone uses discussed in my evidence have been put through the DOC risk assessment process and are permitted to be used on land managed by DOC.

Standard Operating Procedures (SOPs)

45 When DOC is applying VTAs, or VTAs are being applied by an external agency to land managed by the Department, there are a number of DOC national SOPs that must be followed. These SOPs include requirements around:

- consultation and notification of affected parties;
- writing Assessments of Environmental Effect (AEE) documents;
- accurately identifying boundaries around operational areas;
- safe handling of pesticides; and
- obtaining consents from landowners and DOC to lay VTA.

DOC Consent

46 DOC must provide its consent before a VTA can be applied to land it manages by its own staff or external people/organisations. Before granting its consent, the application is assessed to ensure all SOP requirements are met. The lowest delegation for signing off a consent for an aerial application is a Conservator.

47 In issuing its consent for an aerial operation DOC imposes performance standards (conditions around how the pesticide may be used, see Appendix 7 for examples) which are designed to minimise impacts the aerial application of a VTA may have on the environment.

48 10% of all consents are audited to ensure compliance with the performance standards.

NEED FOR ADDITIONAL CONTROLS UNDER THE RESOURCE MANAGEMENT ACT

49 As mentioned above, the Parliamentary Commissioner for the Environment stated in her report that there was a strong case for making the use of 1080 a permitted activity under the RMA, with local control reserved to those activities that are not covered by existing controls under other legislation (Wright 2011).

50 I have read the current Canterbury Region NRRP Chapter 4: Water Quality document and note rule WQL18 made the aerial discharge of VTAs a permitted activity as long as certain conditions were met. I also note that the majority of the conditions were similar to those applied to the aerial application of 1080 under the HSNO Act and in the permission from the Public Health Unit.

COMMENTS ON SECTION 42A REPORT VOLUME 2 – pCLWRP

<u>Proposed amendment to Rule 5.23</u>

Condition 2 (a): proposal to remove the words "that is more than 3 m wide"

51 The above change proposed in the s42A report means that aerial discharges of VTAs that may be to any wetted bed of a river, lake or artificial watercourse of any width (not only those over 3m wide) would require resource consent.

52 None of the scientific evidence presented above indicates a need to make this change as neither 1080 nor pindone have significant impacts on the aquatic environment at the sowing rates used to control pests.

53 The proposed change is of serious concern because streams smaller than 3 m are often not marked on maps and are difficult to see from the air through dense vegetation. As a result, it will be very difficult to meet the revised condition 2(a), and will force anyone undertaking the aerial application of a VTA into Rule 5.24 by default.

54 If users attempted to adhere to this condition 2(a), there could potentially be large gaps in bait coverage, particularly at sites where there are a number of small streams within 40 m of each other. This would result in operational failures due to pests surviving in the gaps, and conservation and Canterbury RPMS objectives not being met.

Aerial application should only be undertaken by an AIRCARE accredited operator

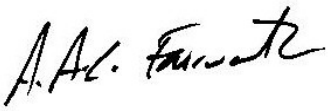
55 The NZAAA and Horticulture NZ submitted that a new clause should be added to Rule 5.23 that aerial application should only be undertaken by an AIRCARE accredited operator. In the s42A report it is proposed that this submission is accepted (Paragraph 6, page 9).

56 AIRCARE is not an industry wide standard. It has been developed by a subsection of the industry and to be AIRCARE accredited you must be a member of the NZAAA.

57 As stated above, legally all pilots who discharge a VTA from the air must hold an ACVM Controlled Substance Licence and CAA Agricultural Chemical Rating. Pilots therefore have knowledge of the rules and regulations surrounding the aerial application of 1080 and pindone.

CONCLUSION

58 I consider that the scientific evidence indicates that there will be minimal impacts from the aerial application of 1080 and pindone to control pests on the land where it may enter water in the Canterbury Region. There are also stringent requirements in place under other legislation that must be complied with before VTAs can be used aerially. On that basis I agree with the PCE's recommendation that the aerial application of VTAs is able to take place without consent being required, as a permitted activity, subject to conditions.



Alastair Andrew Chalmers Fairweather

28 March 2012

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APPENDICES

Appendix 1: Eason C, Miller A, Ogilvie SC, Fairweather A 2011. An updated review of the toxicology and acotoxicology of sodium fluoroacetate (1080) in relation to its use as a pest control tool in New Zealand. New Zealand Journal of Ecology 35: 1-20

Appendix 2: Fairweather AAC, Broome KG, Fisher P 2012. Sodium Fluoroacetate Pesticide Information Review. Version 2012/3. Unpublished report docdm-25427. Department of Conservation, Hamilton, NZ. 110 p.

Appendix 3: Fairweather AAC, Fisher P 2012. Pindone Pesticide Information Review. Version 2012/1. Unpublished report docdm-124982. Department of Conservation, Hamilton, NZ. 48 p.

Appendix 4: ERMA NZ 2008. Environmental Risk Management Authority Decision. Application for the Reassessment of a Hazardous Substance under Section 63 of the Hazardous Substances and New Organisms Act 1996: Sodium Fluoroacetate (1080) and Formulated Substances Containing 1080. ERMA, Wellington. 215 p.

Appendix 5: ERMA NZ 2011. Environmental Risk Management Authority Decision: To manufacture Pindone Liquid Concentrate as a vertebrate toxic agent for rabbits. ERMA NZ, Wellington. 25 p.

Appendix 6: Ministry of Health 2010. Issuing Permissions for the Use of Vertebrate Toxic Agents (VTAs): Guidelines for Public Health Units: Revised edition 2010. Ministry of Health, Wellington. 70 p

Appendix 7: DOC Performance Standard Sheets for 1080 1.5g/kg cereal pellets aerially applied & Pindone 0.25g/kg cereal pellet aerially applied.

Appendix 1

REVIEW

An updated review of the toxicology and ecotoxicology of sodium fluoroacetate (1080) in relation to its use as a pest control tool in New Zealand

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Abstract: Sodium fluoroacetate (1080) is a vertebrate pesticide, originally developed in the 1940s and principally used for the control of unwanted introduced animals in New Zealand and Australia. Fluoroacetate is also a toxic component of poisonous plants found in Australia, Africa, South America, and India. In relation to its use as a pesticide, recent research has focused on further elucidation of its potential sub-lethal effects, on animal welfare issues, on understanding and reducing its risk to non-target species, on its ecotoxicology, and fate in the environment following use in baits. 1080 acts by interfering with cellular energy production through inhibition of the tricarboxylic acid cycle and lethal doses can kill animal pests within 6–48 h of eating baits. Exposure to sub-lethal doses has been shown to have harmful effects on the heart and testes in animal studies, and strict safety precautions are enforced to protect contractors and workers in the pest control industry. Considerable care must be taken when using 1080 for the control of animal pests. Primary poisoning of non-target birds and secondary poisoning of dogs must be minimised to ensure that benefits in terms of conservation outcomes and pest and disease control significantly outweigh the risks associated with its use. Despite over 60 years of research and practical experience, the use of 1080 is still embroiled in controversy, while research efforts continue to improve its target specificity when it is used as a conservation tool or for Tb vector control.

Keywords: animal welfare; compound 1080; non-target effects

Introduction

The toxic nature of fluoroacetate-containing compounds was first noted in the 1930s, leading to their patenting as potential rodenticides prior to the Second World War. US-led research programmes in the early 1940s identified sodium fluoroacetate as the most promising candidate (Atzert 1971). It received the acquisition number 1080 from British scientists at the Patuxent Wildlife Research Center in Maryland, USA, and is now commonly known as compound 1080, or just 1080. The structural formula for 1080 is FCH_2COONa (empirical formula $C_2H_2FNaO_2$) and the molecular weight is 100.3. It forms an odourless, white, non-volatile powder that decomposes at about 200ºC. Sodium fluoroacetate (1080) is very water soluble but has low solubility in organic solvents such as ethanol and oils. The early studies in the 1940s marked the beginning of over 60 years of continuous research on 1080 linked to its use as a vertebrate pesticide.

1080 was first applied in bait to control gophers, ground squirrels, prairie dogs and rodents in the USA, and has been used in New Zealand for pest control since the 1950s. It is the only effective poison that is registered for aerial control of possums (*Trichosurus vulpecula*). Its use is a reflection of unique wildlife pest problems within New Zealand and its effectiveness at reducing the unwanted impacts of introduced species. Possums, introduced from Australia in the late 1800s, and other 'target' pest species in New Zealand, have no natural predators, as New Zealand's only native terrestrial mammals are both bats (*Chalinolobus tuberculatus*, *Mystacina tuberculata*). In Australia, 1080 is used for protection of native animals from introduced species such as foxes (*Vulpes vulpes*) (McIlroy 1990).

The most extensive use of 1080 occurs in New Zealand, followed by Australia (PCE 1994; JE Cavanagh & P Fisher, unpubl. report 2005). It is also used in Israel and the USA. Even in countries that have very active control programmes targeting introduced mammals, products containing vertebrate pesticides are considered 'minor use products' in terms of the total amounts of pesticides used. For example, in New Zealand, 3500 tonnes of active pesticide ingredient are used annually, most of which are herbicides (Manktelow et al. 2005). In comparison to insecticides, fungicides and herbicides, vertebrate pesticides make up only 0.1–0.2% of our annual use (i.e. 3.5–7 t), although this figure increases slightly to 0.4% (14 t) per annum if household rodenticides are included. Even though New Zealand is the largest user of 1080 in the world, the amount of active ingredient used per year is very small (1.0–3.5 t; Innes & Barker 1999), less than 0.1% of the total active pesticide ingredient used.

In the USA, 1080 use is restricted to a livestock-protection collar to protect sheep (*Ovis aries*) and goats (*Capra hircus*) from coyotes (*Canis latrans*) (Fagerstone et al. 1994). Field use of baits containing 1080 is less appropriate in countries where indigenous non-target mammals may eat bait or poisoned carcasses. In New Zealand there are six poisons currently registered for possum control: 1080 (sodium fluoroacetate), cyanide, cholecalciferol (Vitamin D_3), brodifacoum, pindone, and phosphorus. Their use for killing possums and other

animal pest species raises a variety of concerns including risks to non-target animals, persistence and humaneness, which are different for each. Zinc phosphide and a combination of coumatetralyl and cholecalciferol are currently being developed in New Zealand as additional tools for possum and rodent control (Eason et al. 2008). Currently, the most extensively used poison is 1080, applied in cereal or carrot baits for aerial sowing or use in bait stations. Despite improvements in the use and targeting of 1080 (Eason et al. 2006), its use is still embroiled in controversy (Hansford 2009). Most concerns in New Zealand relate to fears with regard to contamination of water supplies, possible sub-lethal effects on humans, welfare impacts on those species targeted by 1080, non-target species that might be inadvertently exposed to baits, and the potential to kill native birds and other non-target species (ERMA 2007).

Natural toxin

Manufactured 1080 for use in toxic baits has been shown to be chemically and toxicologically identical to the fluoroacetate found in poisonous plants (Eason 2002a). Marais (1944) identified fluoroacetate in the South African plant gifblaar (*Dichapetalum cymosum*). Interestingly, the caterpillar moth, *Sindrus albimaculatus*, which feeds on *D. cymosum*, cannot only detoxify fluoroacetate, but also accumulate it (probably in vacuoles), and uses fluoroacetate as a defence against predation (Meyer & O'Hagan 1992).

As pointed out in earlier work by Eason (2002a), fluoroacetate has been identified as the toxic agent in many other poisonous plants native to Brazil (de Moraes-Moreau et al. 1995) and Africa (Atzert 1971). Fluoroacetate also occurs naturally in some 40 plant species in Australia (Twigg 1994; Twigg et al. 1996a, b, 1999). The highest fluoroacetate concentration so far reported from a living source is 8.0 mg g^{-1} in the seeds of the African plant *Dichapetalum braunii* (O'Hagan et al. 1993). The mechanism of toxicity for naturally occurring fluoroacetate and for 1080 in bait is the same. Both forms are equally poisonous (de Moraes-Moreau et al. 1995). Fluoroacetate appears to be one of the many secondary plant compounds that have evolved at high concentrations as a defence mechanism against browsing animals (King et al. 1981). Most studies assessing fluoroacetate concentrations in plants have focused on those species that are overtly toxic to mammals. However, it would appear that the ability of plants to synthesise fluoroacetate may be more widespread than generally supposed, since fluoroacetate occurs at extremely low concentrations in some Finnish plants (Vartiainen & Kauranen 1980), in tea leaves (Vartiainen & Kauranen 1984), and guar gum (*Cyamopsis tetragonolobus*) (Vartiainen & Gynther 1984; Twigg et al. 1996b). In addition, some plants, when exposed to fluoride ions, can biosynthesise fluoroacetate, albeit at very low levels (Cheng et al. 1968). Fluorocitrate, the toxic metabolite of fluoroacetate, has also been detected in tea leaves (Peters et al. 1972). Fluoroacetate biosynthesis can occur in some bacteria, notably *Streptomyces cattleya* (O'Hagan & Harper 1999). Recent research has shown fluoroacetate to be present at extremely low concentrations in native New Zealand plants such as puha (*Sonchus asper*), both naturally, and by uptake when exposed to 1080 baits in the environment (Ogilvie et al. 2009). Puha is often consumed by humans, raising a health concern; however, puha is boiled prior to eating. As 1080 is highly water soluble (Parfitt et al. 1995), it is considered that such preparation methods render the plant non-hazardous due to the negligible 1080 concentrations present (Ogilvie et al. 2009).

Mode of action

The primary mode of action of 1080 is mediated via its toxic metabolite, fluorocitrate. Following absorption, intracellular conversion of 1080 within an animal produces fluorocitrate, which inhibits energy production in the tricarboxylic acid (Krebs) cycle (Peters 1952, 1957; Peters et al. 1953; Buffa et al. 1973). Synthesis of fluorocitrate, termed 'lethal synthesis' (Peters 1952), occurs in the mitochondria. When 1080 enters the tricarboxylic acid cycle it condenses with oxaloacetate to form fluorocitrate instead of the usual citrate. Fluorocitrate competitively inhibits tricarboxylic acid cycle enzymes, notably aconitase hydratase (Morrison & Peters 1954; Buffa et al. 1973), which prevents the conversion of citrate to aconitate (Fanshier et al. 1964). It also inhibits citrate transport into and out of mitochondria (Kirsten et al. 1978; Kun 1982). There is also evidence to suggest that fluorocitrate inhibits succinate dehydrogenase, and the high levels of citrate concentration that occur during fluoroacetate intoxication can also have an inhibitory effect on the glycolytic enzyme phosphofructokinase. Enzyme systems linked to glucose transport and lipolysis are also affected (Peters 1952; Peters et al. 1972; Buffa et al. 1973; Kirsten et al. 1978; Kun 1982; Clarke 1991).

The tricarboxylic acid cycle is a metabolic pathway that breaks down food (carbohydrates) to provide energy for normal cell functions. The inhibition of this metabolic pathway results in accumulation of citrate in the tissues and blood. At high concentrations, citrate binds serum calcium, resulting in hypocalcaemia and ultimately heart failure (Roy et al. 1980; Omara & Sisodia 1990; Parton 2001; Goh et al. 2005) when sufficiently high doses of fluoroacetate are ingested (Peters 1957; Buffa et al. 1973). Central nervous system effects also occur in many species (Buffa et al. 1973; Kirsten et al. 1978; Kun 1982). Species differences in elevation of citrate concentration in different organs and tissues may in part explain species variation in response to 1080 (Bosakowski & Levin 1986) and the difference in susceptibility to 1080 described in the next section. Death may result from: (a) gradual cardiac failure or ventricular fibrillation; or (b) progressive depression of the central nervous system with either cardiac or respiratory failure as the terminal event; or (c) respiratory arrest following severe convulsions (Atzert 1971) linked to a combination of energy depletion at a cellular level, accumulation of citrate in affected tissue, and electrolyte disturbances including hypocalcaemia and hypokalaemia (Chi et al. 1996). In early literature it is reported that death in herbivores is the result of cardiac disorders, and in carnivores the result of central nervous system disorders. Death in omnivores tends to result from both cardiac and central nervous system disorders (Chenoweth 1949).

There has been limited recent research on the mode of action of 1080 that focuses on antidotes or treatments (Wickstrom et al. 1998; Norris et al. 2000; Cook et al. 2001; Robinson et al. 2002; Goh et al. 2005; Collicchio-Zuanaze et al. 2006; Goncharov et al. 2006). 1080 is thought to induce seizures in rats (*Rattus* sp.) through alterations to neurotransmitter concentrations within the brain (Wickstrom et al. 1998). The administration of neurotransmitter-modulating agents (e.g. glutamate inhibitors, GABA and serotonergic antagonists) reduced the toxic effects of 1080 (Cook et al. 2001; Goh et al.

2005). Calcium replacement may also have a role in offsetting fluoroacetate-induced hypocalcaemia (Robinson et al. 2002; Collicchio-Zuanaze et al. 2006). Despite these endeavours, ethanol, if taken immediately with the aim of reducing fluorocitrate synthesis, has remained the accepted antidote for 1080 poisoning in the last six decades (Goncharov et al. 2006). Veterinary treatment of poisoned dogs (*Canis lupis familiaris*) relies on symptomatic and supportive care (Norris et al. 2000; Goh et al. 2005; Parton et al. 2006). For example, poisoned dogs are sedated to reduce the possibility of seizures, and fluid levels are maintained to offset electrolyte imbalances (Goh et al. 2005; Parton et al. 2006). Detailed treatment regimens, provided by Parton et al. (2006), include the use of sodium bicarbonate or acetamide and decontamination to improve chances of survival.

Acute toxicity

In pest species, the LD_{50} of sodium fluoroacetate is usually 1 mg kg^{-1} or less, whereas in humans, LD_{50} doses have been estimated to be 2–5 mg kg^{-1} (Rammell & Fleming 1978). While fluoroacetate is a broad-spectrum toxin, there are some marked differences in susceptibility (Table 1). There is an extensive database on the acute toxicity of 1080 in a diverse spectrum of species, including birds, mammals, and reptiles (Atzert 1971; Harrison 1978; Rammell & Fleming 1978; Eisler 1995). Unlike most other vertebrate pesticides, 1080 also has insecticidal properties (David & Gardiner 1950; Negherbon 1959; Notman 1989; Booth & Wickstrom 1999). As with other poisons, the relative susceptibility and LD_{50} values can be influenced by the method used to deliver the poison, and by environmental conditions (Henderson et al. 1999). Dogs are extremely susceptible, and most other carnivores are highly sensitive to poisoning. Herbivorous mammals are less sensitive, and birds and reptiles less susceptible still (Atzert 1971; Rammell & Fleming 1978; Eisler 1995).

Table 1. LD_{50} values (mg kg^{-1}) for oral toxicity of sodium fluoroacetate to vertebrates (after Rammell & Fleming 1978; Hone & Mulligan 1982; Eisler 1995). These examples represent a very small proportion of the LD_{50} data available in the literature.

Vertebrate species	LD_{50} (mg kg^{-1})
Dog (*Canis lupis familiaris*)	0.07
Cat (*Felis domesticus*)	0.3
Pig (*Sus* sp.)	0.3
Rabbit (*Oryctolagus cuniculus*)	0.4
Sheep (*Ovis aries*)	0.4
Cow (*Bos taurus*)	0.4
Deer family (Cervidae)	0.5
Goat (*Capra hircus*)	0.6
Wallaby family (Macropodidae)	< 1.0
Rat (*Rattus* sp.)	1.2
Possum (*Trichosurus vulpecula*)	1.2
Human (*Homo sapiens*)	2.5
Weka (*Gallirallus australis*)	8.0
Duck family (Anatidae)	9.0
Clawed toad (*Xenopus* sp.)	500

Several studies have revealed that animals that forage in areas where fluoroacetate-producing plants are common have evolved an increasing resistance to fluoroacetate compared with animals from areas where plants containing the toxin are not indigenous. This phenomenon is well-documented in Australia where the effect is most dramatic in herbivores and seed eaters, which are more directly exposed to the toxin than carnivores (Twigg 1994). The emu (*Dromaius novaehollandiae*) is the oldest seed-eating bird species in Australia, and has a very high level of resistance to fluoroacetate, with an LD_{50} of 100–200 mg kg^{-1}. In contrast, seed-eating birds from regions outside the range of fluoroacetate-producing plant species have an LD_{50} in the range of 0.2–20 mg kg^{-1}. Similarly, the brushtail possum of south-western Australia is 150 times less susceptible to fluoroacetate poisoning than the same species in eastern Australia where plant species containing 1080 are not present. The biochemical basis for tolerance and species variation is not clear (Twigg et al. 1988a; Twigg 1994).

Species variation in mammals in response to fluoroacetate poisoning may be due in part to differences in the biochemical response of different organs to the toxin, and may be linked to differences in glutathione level and a glutathione-requiring defluorinating enzyme (Twigg 1994). For example, 1080-induced changes in the citrate content of the heart are more pronounced than in any other organ in sheep. For this reason, citrate concentrations in sheep hearts may have diagnostic value (Annison et al. 1960; Schultz et al. 1982). Guinea pigs (*Cavia porcellus*) and rabbits (*Oryctolagus cuniculus*), like sheep, are sensitive to myocardial damage. In rats there is some short-lived elevation of citrate in the heart, but in dogs elevation of citrate concentrations in heart tissue has been reported to be minimal (Bosakowski & Levin 1986). Furthermore, dogs do not show the electrocardiogram (ECG) changes seen in sheep that are suggestive of cardiac ischaemia (Matsubara et al. 1980). In comparison with dogs, the clinical signs in cats (*Felis domesticus*) are less severe (Eason & Frampton 1991). In birds, damage to wing muscle is a unique feature that occurs at sub-lethal dose levels (Ataria et al. 2000). Most deaths in mammals generally occur 6–48 h after ingestion of a lethal dose.

A recent review paper highlighting the effects of ambient temperature on possum mortality showed that the acute toxicity of 1080 is reduced at low temperatures (Veltman & Pinder 2001). This is important given that control programmes are mostly conducted in months with the coldest average temperatures (Veltman & Pinder 2001). Research in Australia has indicated that resistance can develop after repeated use. Thus, the LD_{50} for rabbits in Western Australia appears to have increased dramatically, from 0.34 – 0.46 mg kg^{-1} over 30 years ago, to 0.74 – 1.02 mg kg^{-1} (Twigg et al. 2002).

Toxicokinetics and exposure risks

1080 is absorbed through the gastrointestinal tract, or via the lungs if inhaled. It is not readily absorbed through intact skin, but can be absorbed more easily through cuts and abrasions (Saunders et al. 1949; Pattison 1959). Studies of laboratory animals since the 1950s have shown that sub-lethal amounts of 1080 are excreted both unchanged and as a range of non-toxic metabolites. Rapid conversion to non-toxic metabolites reduces the toxicity of sub-lethal doses but does not mean there will be no toxic effects.

After oral or intravenous dosing of laboratory rodents,

1080 is rapidly absorbed and distributed through the soft tissues and organs (Hagan et al. 1950; Egekeze & Oehme 1979; Sykes et al. 1987). This contrasts with the action of commonly used anticoagulant rodenticides such as brodifacoum, which preferentially bind to liver cells (Bachman & Sullivan 1983). 1080 is excreted as unchanged fluoroacetate and a range of metabolites (Gal et al. 1961; Schaefer & Machleidt 1971). Approximately 30% of a dose of injected 1080 administered to rats was excreted unchanged in the urine over 4 days (Gal et al. 1961). At least seven unidentified metabolites other than fluoroacetate and fluorocitrate, the toxic metabolite of 1080, were also detected in rat urine (Gal et al. 1961).

Administration of ^{14}C-labelled fluoroacetate to rats showed that the toxic metabolite fluorocitrate accounted for only 3% of the radioactivity (Gal et al. 1961); this was confirmed by Schaefer and Machleidt (1971). The major unidentified metabolite, unlike fluorocitrate, did not inhibit the activity of aconitase (Gal et al. 1961). Phillips and Langdon (1955) suggested that the unidentified metabolites include non-saponifiable lipids that probably serve as intermediates for cholesterol, and some radioactivity was found in fatty acids and cholesterol in the liver. Up to 3% of the radioactivity appeared as respiratory CO_2, and cleavage of the C-F bond is a significant detoxification process (Gal et al. 1961).

Savarie (1984) noted that 1080 is readily distributed through the body and that synthesis of fluorocitrate occurs in the mitochondria. Defluorination of 1080 or its metabolites, including fluorocitrate, has been demonstrated in several animal species and other living organisms (Kirk & Goldman 1970; Smith et al. 1977; Egekeze & Oehme 1979; Soiefer & Kostyniak 1983, 1984; Twigg et al. 1986; Tecle & Casida 1989). Although fluoride is also extensively excreted, primarily in urine, some deposition occurs in bone (Sykes et al. 1987). Tissue and blood levels of fluoride are briefly elevated following exposure to 1080 and then return to normal levels (Gooneratne et al. 1994). Current understanding with regard to the metabolites of 1080 is summarised in Table 2.

The earliest reports on rats suggested that some 1080 is retained for 1–4 days (Hagan et al. 1950; Gal et al. 1961). However, in a study of mice (*Mus musculus*), 1080 concentrations in plasma, muscle, and liver decreased by half in less than 2 h (Sykes et al. 1987). Prolonged persistence of 1080 in animals after sub-lethal exposure therefore seems unlikely, and has been confirmed in more recent studies of larger animals such as rabbits, goats, possums, and sheep (Gooneratne et al. 1994; Eason et al. 1994a), in which 1080 was readily absorbed and excreted. Highest concentrations occurred in the blood, with moderate levels in the muscle and kidneys, and the lowest concentration in the liver. In sheep, the highest concentrations in blood occurred 2.5 h after dosing, with negligible amounts of 1080 seen in tissue and plasma 4 days after dosing. The elimination half-life in blood is 11 h or less in sheep (11.0 h), goat (5.5 h), rabbit (1.1 h), mouse (2.0 h) and possum (9.0 h) (Eason et al. 1994a), and contrasts with

Table 2. Summary of 1080, its metabolites and their toxicity.

Compound	Toxicity
1080	Not toxic until metabolised to fluorocitrate
Fluorocitrate	Highly toxic
Fluoride	Potentially toxic but levels in poisoned animals not high. Toxicity overshadowed by effects of fluorocitrate
Fatty acids	Not toxic[1]
Cholesterol	Not toxic[1]
CO_2	Not toxic[1]
Other unidentified metabolites	Do not inhibit aconitase; thought to be non-toxic

[1] = Natural biochemical compounds

Table 3. Elimination half-lives of 1080 in blood plasma and muscle for possum, rabbit and mouse, and for brodifacoum in blood plasma and liver of possums.

Species	Compound	Sample	Route of administration	Dose (mg kg^{-1})	Elimination half-life (h, unless specified)
Sheep	1080	Plasma	Oral	0.1	11.0 [a, b]
		Muscle			12.0
Goat	1080	Plasma	Oral	0.1	5.5 [a]
		Muscle			n.d.
Possum	1080	Plasma	Oral	0.1	9.0[a]
		Muscle			n.d.
Rabbit	1080	Plasma	Oral	0.1	1.1[c]
		Muscle		0.1	0.4[c]
Mouse	1080	Plasma	Intravenous injection	0.4	2.0[d]
		Muscle		0.4	1.7[d]
Possum	Brodifacoum	Plasma	Oral	0.1	Approx 8 days [e]
		Liver			> 252 days [e]

n.d. = not determined
[a] Eason et al. 1994b; [b] Rammell 1993; [c] Gooneratne et al. 1994, 1995; [d] Sykes et al. 1987; [e] Eason et al. 1996.

longer elimination half-lives in blood and liver for brodifacoum in possums (Eason et al. 2006), as shown in Table 3.

To further examine the persistence of 1080 and its potential to contaminate milk and meat, two groups of lactating ewes were fed 1080 baits ('high dose', 0.25 mg kg^{-1} body weight; 'low dose', 0.01 mg kg^{-1} body weight) (Milne et al. 2002). 1080 concentrations in blood and milk were examined 4–96 h after dosing. Four hours after dosing, 1080 concentration in blood (0.56 ± 0.04 µg ml^{-1}) was 30 times greater than in milk (0.017 ± 0.001 µg ml^{-1}) in the high-dose group. Lower concentrations of 1080 were detected in the blood after 72 h (0.020 ± 0.002 µg ml^{-1}), and in milk, concentrations were near the analytical level of detection (0.0006 µg ml^{-1}). The low-dose ewes had no detectable 1080 in blood or milk 72 h after dosing (Milne et al. 2002). These recent findings are consistent with earlier research by Gooneratne et al. (1994) and Eason et al. (1994a).

Limited research has been conducted on the pharmacokinetics of fluoroacetate in invertebrates. In a laboratory study, tree weta (*Hemideina* sp.) and cave weta (Rhaphidophoridae) were dosed with 1080 and the persistence of 1080 residues at specified times after dosing was determined. In this experiment most of a 1080 dose was eliminated from weta 6–10 days after exposure, and all weta survived dose levels of 15 mg kg^{-1} (Eason et al. 1993). Similar results were obtained for a native ant (*Huberia brouni*) (Booth & Wickstrom 1999). Insects have been monitored in forests for 1080 residues after aerial sowing of toxic baits for possum control. No 1080 was found in living earthworms (Oligochaeta), spiders, beetles, millipedes, or centipedes. Although 1080 was found in some cockroaches (Blattidae), bush weta, and cave weta during the period the baits were on the ground, after 3–4 weeks (when baits could have been eaten at any time) all invertebrate samples were free from 1080 residues (Eason et al. 1993). Persistence of 1080 in invertebrates appears to be short-lived, so the risk to insectivorous birds or other predators will also be confined to a short period after sowing baits. However, large invertebrates frequently eat bait (Spurr & Drew 1999) and, since species like weta can contain large amounts of bait, secondary poisoning via this route is possible. In an unusual recent study, the toxicity and persistence of 1080 was assessed in a land crab (*Gecarcinus lagostoma*) prior to the eradication of feral cats on Ascension Island to help protect breeding seabird populations. The authors reported most 1080 residues were eliminated from crab tissue within 9–11 days (Pain et al. 2008).

As illustrated above, toxicokinetics in different species has been used to help add some clarity to exposure risk. Eason et al. (2008) recently classified compounds used for animal pest control into four groups based on their persistence in sub-lethally exposed animals, to help distinguish between the risks associated with different vertebrate pesticides. The criteria for the four groups, and the allocation of different compounds to them, are described below and in Table 4.

Group 1. Sub-lethal doses of these poisons are likely to be substantially excreted within 24 h (e.g. cyanide, zinc phosphide, and 1080). In the case of 1080, complete excretion of all residues may take up to 4–7 days. Like other compounds in this group, 1080 will not readily bioaccumulate.

Group 2. Residues resulting from sub-lethal doses of these poisons are likely to be substantially cleared from the body within 2–4 weeks (e.g. pindone).

Group 3. Residues resulting from sub-lethal doses of these poisons are likely to be cleared from the body within 2–4 months (e.g. cholecalciferol and coumatetralyl).

Group 4. Residues resulting from sub-lethal doses of these poisons may never be completely cleared from the body (e.g. brodifacoum), and therefore bioaccumulate.

If recommended practices are followed in pest control operations, 1080 is unlikely to be present in meat for human consumption because of its comparatively rapid elimination as illustrated in Table 4. Where any contact of livestock (farm animals or animals intended for slaughter) with 1080 is suspected, researchers have suggested that an adequate margin of safety should be achieved by imposing a minimum withholding period of 5 days, during which animals should not be sent to an abattoir. Should a death in a flock or herd be attributed to 1080, the withholding period for the surviving stock should be doubled to 10 days and animals should be removed to a 1080-free pasture (Rammell 1993; Eason et al. 1994a) to allow for complete metabolism and excretion of any 1080 residues. The New Zealand Food Safety Authority has a caution period for hunting wild animals for procurement

Table 4. Comparative toxicokinetics and expectation for persistence of residues in sub-lethally exposed target or non-target species (adapted from Eason et al. 2008). For definition of groups, see text.

Group	Compound	Half-life values	Likely persistence of residues after sub-lethal exposure*
1	Cyanide	+	12–24 h
	Zinc phosphide	+	12–24 h
	1080	<11 h	7 days
2	Pindone	2.1 days	4 weeks
3	Cholecalciferol	10–68 days	3 months
	Coumatetralyl	50–70 days	4 months
4	Brodifacoum	130–350 days	24 months or longer

+ = No published value but likely to be <12 h.
* Values are mostly based on data from rats as surrogates for non-target species.

of meat of 2 months and 100 mm rainfall, or 4 months. While 1080 is eliminated comparatively rapidly from living animals, it can persist in carcasses for many months and will pose a risk to scavenging dogs until the carcasses are broken down (Meenken & Booth 1997). In possums that were sub-lethally poisoned, 1080 had a half-life of 9 h, suggesting no significant amount of 1080 would be expected in the tissues of live possums 4 days after exposure. In contrast, possum carcasses collected from the field were shown to pose a serious risk to dogs even up to 75 days after the poisoning operation (Meenken & Booth 1997).

Toxicodynamics and welfare

The latent period between the time fluoroacetate is ingested and the appearance of clinical signs in mammals is between 0.5 and 3 h (Chenoweth 1949; McIlroy 1981a). Peak plasma concentrations of fluoroacetate occurred in possums and rabbits 0.5 h after ingestion, in 0.75 h in goats, and in 2.5 h in sheep (Eason et al. 1994a). These values correlate with the latent period between ingestion and clinical signs, and reflect the time taken for absorption and distribution of fluoroacetate, and the conversion of fluoroacetate to fluorocitrate. Animals receiving small sub-lethal doses of 1080 show mild signs of poisoning, metabolise and excrete 1080 within 1–4 days, and then recover (Egekeze & Oehme 1979; Eason et al. 1997). Animals receiving a lethal dose usually show more severe signs of poisoning in addition to non-specific clinical signs such as nausea and vomiting. Specific signs include cyanosis, drowsiness, tremors, staggering, and death from ventricular fibrillation or respiratory failure (Dreisbach 1983). The clinical signs of 1080 poisoning in birds vary according to the species. Common signs may be lack of balance, slowness, ruffled feathers, and salivation. Vomiting occurs in some species such as raptors. In the terminal phase of poisoning, birds and mammals may exhibit convulsions and coma.

While the ecological impacts of 1080 baiting have been the subject of much research, the animal welfare implications have received comparatively less attention. In the past it has been suggested that 1080 is a humane toxin in herbivores but less so in carnivores (Batcheler 1978; Morgan 1990). Authors that reported 1080 to be a humane poison in species such as possums did so in part based on observation of subdued behaviour in herbivores and death from cardiac failure (Batcheler 1978; Morgan 1990). In carnivores, and notably in dogs, central nervous system disturbances are marked, and poisoned dogs run uncontrollably, retch and vomit, and appear distressed and agitated with prolonged involuntary muscle contractions exacerbated by convulsions and seizures prior to death from respiratory failure (Egekeze & Oehme 1979; Sherley 2007). Authors of articles that conclude that 1080 is a humane poison in carnivores base their conclusions largely on the argument that convulsive seizures seen in the final stages of 1080 toxicosis indicate that affected animals are in an unconscious state and are unable to perceive pain (Gregory 1996; Williams 1996; Twigg & Parker 2010). Other publications describe awareness during seizures or periodic lucidity that suggests central nervous system disruption cannot be assumed to produce a constant, pain-free state and conclude that 1080 should not be considered a humane poison (Sherley 2004, 2007; Cooper et al. 2007). People who have ingested 1080 by accident or in suicide attempts report abdominal pain, agitation and vomiting (Chi et al. 1996). The finding of Chenoweth and St. John (1947) (reviewed by Sherley 2007) that electroencephalogram (EEG) disturbances similar to the grand mal convulsions of epilepsy were common in poisoned dogs could be supportive of periods of unconsciousness during fitting. However, Foss (1948) indicated that a dog poisoned experimentally with fluoroacetate was conscious during a period of convulsion. Twigg and Parker (2010) disagree, and argue that 1080 will impair the functioning of pain receptors and suggest that when animals are showing disturbing behaviour, they may in fact be incapable of feeling pain.

In addition to challenging the view that animals poisoned with 1080 are unconscious during seizures, Sherley (2004, 2007) also challenged the generalisation that herbivores die of cardiac failure, that carnivores show more extensive central nervous system distress, and that omnivores exhibit a combination of signs. Potentially painful or distressing signs of fluoroacetate poisoning in herbivores have been described in the literature and include tremors, vomiting and retching, muscle weakness, partial paralysis and respiratory distress (Chenoweth & Gilman 1946; McIlroy 1981b; Schultz et al. 1982; Sherley 2004, 2007). While the argument that 1080 induces a humane death in target species has been challenged (Sherley 2004, 2007), it is clear that the symptoms observed in possums (Morgan 1990; Littin et al. 2009) indicate considerably less severe distress than those reported in species such as dogs (Chenoweth & Gilman 1946). Possum bait formulations in New Zealand contain 0.15% 1080 and are optimised to induce as swift a death as possible (Henderson et al. 1999).

A summary of behavioural and pathological observations made on caged possums fed a lethal dose of 1080 are given in Table 5 and comparisons between 1080 and three other toxins for which published data on welfare exists are made in Table 6. Information on the time to onset of the first sign of poisoning, the time of onset and duration of each effect, and the time until death is provided. Effects specific to the poison (e.g. spasms, vomiting) are also described. These provide information on the intensity and duration of each effect, and the mean overall duration of effects for each poison.

The humaneness of a poison depends on the duration and severity of distress or pain that animals experience during three stages of toxicosis, described as an initial lag phase until the onset of clinical signs; a period of sickness behaviour when animals are most likely to experience pain; and a final phase preceding death when animals may be unconscious (Eason et al. 1998a). These stages have been described in possums for cyanide (Gregory et al. 1998), phosphorus (O'Connor et al. 2007), brodifacoum (Littin et al. 2002), and 1080 (Littin et al. 2009).

Table 5. Time after dosing at which clinical signs of poisoning appeared in caged possums (n = 17) fed a lethal dose of 1080. Times are the mean ± SEM (adapted from Littin et al. 2009).

Clinical sign	Time (h: min)
Onset of change in appearance	1:50 ± 0:09
Onset of retching and vomiting	2:53 ± 0:13
Onset of uncoordination	3:37 ± 0:32
Onset of spasms, tremors and seizures	4:05 ± 0:40
Time to death	11:26 ± 1:55

Table 6. Summary of mean times to onset of clinical signs of toxicosis, duration of key symptoms during sickness behaviour, and time to death in possums following ingestion of poison baits in four studies.

Toxin	Mean time until onset of sickness	Sickness behaviour	Mean duration	Mean time until death	Study
Cyanide	3 min	Ataxia, impaired co-ordination, breathlessness, muscular spasms, unconscious after 6.5 min	15 min	18 min	Gregory et al. 1998
1080	~ 2 h	Ataxia, occasional retching, spasms, breathlessness, laboured breathing	9 h	11.5 h	Littin et al. 2009
Phosphorus paste	6 h	Retching, vomiting, hunched posture, intermittent repositioning, ataxia	19 h	25 h	O'Connor et al. 2007
Brodifacoum	14 days	Anaemia, haemorrhage, loss of appetite, hunched posture, anorexia	7 days	21 days	Littin et al. 2002

Cyanide is the fastest acting vertebrate pesticide used in New Zealand and causes the least distress. It is therefore regarded as the most humane of the toxicants evaluated. In contrast, brodifacoum is slow-acting, and possums sometimes take a long time to die, with an average of 21 days until death after eating baits. Phosphorus causes behavioural responses associated with inflammation of the stomach lining and duodenum (e.g. a crouched/hunched posture). The times to death after possums eat 1080 baits (or other poisons) are on average less than those recorded for phosphorus, and possums dosed with 1080 exhibit few overt signs of pain.

While 1080 is not as humane as cyanide, it would appear to be preferable to compounds like brodifacoum for possum control (Littin et al. 2002, 2009; Twigg & Parker 2010). In recognition of the potential to improve the humaneness of 1080, which is particularly important in control of carnivores such as foxes in Australia, recent research has focused on co-administration of analgesics with 1080, and some improved animal welfare outcomes have been reported (Marks et al. 2009).

Sub-lethal effects and exposure risk in humans and animals

Risk assessment is improved when fundamental research provides information into the fate, effects, and risk of exposure to 1080. Hence, toxicokinetics and the mechanism of toxicity are important in understanding the response of an animal or humans to a foreign compound.

1080 clearly has the potential to kill and cause sub-lethal effects in humans, but exposure of individuals or communities to amounts of 1080 that would cause such effects is most unlikely. The acute toxicity of 1080 is well understood, and the toxic manifestations of sub-lethal aconitate hydratase inhibition have been extensively studied as described above (in Mode of Action). They are explored further below.

As noted above, with the disruption of mitochondrial function and the tricarboxylic acid cycle, energy production in the form of ATP decreases, citrate and other breakdown products of fats accumulate, and cell function is impaired. This results in accumulation of intracellular citrate in the tissues and plasma, leading to energy deprivation and death when sufficiently high doses are ingested. Sub-lethal toxicological effects associated with chronic exposure are also likely to be linked to inhibition of aconitate hydratase and the mitochondrial dysfunction caused by 1080.

Known target organs in animals include the heart, lungs, liver, kidney, testes and foetus. Although 1080 itself is not cumulative (Rammell 1993; Eason et al. 1994a), animal studies demonstrate that cumulative damage to the heart or other organs from repeated exposure to large sub-lethal doses of 1080 can occur (Annison et al. 1960; Whittem & Murray 1963; Schultz et al. 1982; Gooneratne et al. 2008). That single or repeated sub-lethal exposures to fluoroacetate can have toxic effects on the heart has been known for some time (Steyn 1934; Quin & Clark 1947; Hicks et al. 1952). The target organs vary to some extent in different species, and may relate to differences in the citrate response in different species or the metabolic activity of different tissues. Accordingly, it is likely that a number of biochemical mechanisms are responsible for fluoroacetate toxicity in tissues.

Results of developmental toxicity studies in rats showed that a single sub-lethal dose had no effect (Spielmann et al. 1973). However, when female rats were exposed to relatively high doses (0.33 and 0.75 mg kg^{-1}) for about 30% of their gestation period, mild skeletal effects were detected (Eason et al. 1999). The 'no observable effects level' (NOEL) for developmental effects was 0.1 mg kg^{-1} day^{-1} based on observations of bent ribs at 0.33 mg kg^{-1} day^{-1}. The NOEL for rats administered 1080 via oral gavage for 90 days was 0.075 mg kg^{-1} day^{-1}. Microscopic changes in the testes and heart were seen in males dosed with 1080 at 0.25 mg kg^{-1} day^{-1} (Eason & Turck 2002).

The cancer-inducing potential of 1080 has been evaluated by in vitro and in vivo testing. Results of the Ames assay, the mouse lymphoma assay and the mouse micronucleus assay (bone marrow assay to detect chromosome anomalies) indicate that 1080 is not mutagenic (Eason et al. 1999). In the mouse micronucleus assay, mice were given oral 1080 doses of 0.75, 1.5, 3.0, 6.0 and 7.5 mg kg^{-1}, and no mutagenicity was observed at any dose level.

In addition to these target organs and other effects of 1080, the potential endocrine disrupting activity of 1080 has been accessed at the receptor level. Endocrine disrupting chemicals (EDCs) are defined as synthetic chemicals that, once absorbed, have oestrogenic or anti-androgenic activity, which is mediated by their ability to bind or block oestrogen or androgen receptors (Colborn et al. 1996; Tremblay et al. 2004, 2005). The reproductive studies described above (Eason et al. 1999) followed OECD (Organisation for Economic Co-operation and Development) protocols to determine teratogenicity. The potential effects of 1080 on endocrine systems have been raised as a particular concern (Weaver 2003). EDC effects cannot be determined from conventional regulatory toxicology, which focuses on different end-points, and requires specialised cell-culture test systems. The ability of fluoroacetate and its toxic metabolite, fluorocitrate, to act as EDCs has therefore been investigated in mammals and fish.

1080 and fluorocitrate were first tested to determine whether they can mimic natural oestrogen binding in vitro to mammalian oestrogen receptors. Preparations were isolated from sheep uterine tissue and used in a competitive receptor-binding assay to determine their binding affinity. In that initial study the known oestrogenic pesticides *o,p'*-DDT and tamoxifen, evaluated as positive controls, showed significant displacement of natural oestrogen, whereas neither 1080 nor its active metabolite (fluorocitrate) had any effect on oestrogen receptor binding. Therefore, they are unlikely to promote oestrogenic or anti-oestrogenic effects by binding to a mammalian oestrogen receptor (Tremblay et al. 2002, 2004) or adversely affect the breeding performance of native animals (Twigg & Parker 2010).

More recently, the potential of 1080 and fluorocitrate to interact with androgen and oestrogen receptors was assessed in animal and human test systems. Neither 1080 nor fluorocitrate showed androgenic activity in a rainbow trout (*Oncorhynchus mykiss*) androgen receptor assay. Furthermore, neither compound showed androgenic or anti-androgenic activity in a reporter gene assay using human androgenic receptors, and in a human oestrogen receptor assay no oestrogenic or anti-oestrogenic activity occurred (Tremblay et al. 2004, 2005). The researchers concluded that 1080 and fluorocitrate lack the properties of the classical EDCs. Neither compound has oestrogenic or anti-androgenic properties. Unlike well-known environmental EDCs like DDT or dioxins, 1080 and fluorocitrate are simple molecules, which are water soluble and do not persist for long in the environment.

While 1080 does not have the properties of a typical EDC, it is a male reproductive toxicant with effects on testes of mammals (Mazzanti et al. 1965; Sullivan et al. 1979; Hornshaw et al. 1986; Wolfe 1998; Shinoda et al. 2000; Eason & Turck 2002) and other species (Balcomb et al. 1983; Twigg et al. 1988b). In the most recently completed 90-day toxicology study of 1080 in rats (Eason & Turck 2002), similar effects were observed. Microscopic changes in males dosed with 1080 at 0.25 mg kg^{-1} day^{-1} included hypospermia in the epididymides, degeneration of the seminiferous tubules of the testes, and cardiomyopathy. The NOEL for rats administered 1080 via oral gavage for 90 days was 0.075 mg kg^{-1} day^{-1}. The lowest observable effects level (LOEL) dose was 0.25 mg kg^{-1} day^{-1}. Given that 1080 lacks EDC-like activity, these sub-lethal effects on testes are therefore distinct from those mediated by 'classical' endocrine disruptors and are likely to occur through a direct intracellular effect on the mitochondria.

The effects described above have mostly been observed in animal studies. There are also a number of cases of inadvertent human poisoning or exposure described in the literature (Hayes & Laws 1991). In general, these cases are not relevant to the effects of low level exposure to 1080. In several such cases symptoms included vomiting, arrhythmia, tachycardia, cardiac dysfunction, convulsions and coma, sometimes associated with temporary or more prolonged brain damage in survivors. This information from poisoning cases is therefore not particularly helpful when assessing the potential of 1080 to have sub-lethal effects within the context of its use in New Zealand for pest control, and potential exposure patterns.

To summarise, the known target organs for sub-lethal effects following 1080 exposure include the heart, lungs, liver, kidney, testes and foetus, with sub-lethal effects having been observed at doses in the range 0.055 to 0.25 mg kg^{-1} (Annison et al. 1960; McTaggart 1970; Buffa et al. 1977; Sullivan et al. 1979; Schultz et al. 1982; Trabes et al. 1983; Chung 1984; Savarie 1984; Twigg et al. 1988b; Chi et al. 1996; Gregg et al. 1998; Eason et al. 1999; Eason & Turck 2002). Concern regarding whether or not these effects are likely in humans can be explored by examining the likelihood of exposure.

Beasley (1996) pointed out that theoretical routes of human exposure to 1080 might be from drinking contaminated water, ingestion of toxic baits, consumption of food contaminated by contact with bait, or by inhalation of bait dust or contact with 1080 solution. Bait consumption is unlikely and 1080 does not persist for long in sub-lethally exposed livestock; ingestion in food is therefore unlikely (Rammell 1993; Eason et al. 1994b). Instances of contamination of meat and milk with 1080 are considered to be rare incidents. Furthermore, environmental contamination from dust following aerial possum control has been shown to be minimal and short-lived (Wright et al. 2002).

The most significant source of general public exposure to 1080 is perceived to be contamination of surface water in public water supply catchments by aerially sown baits. Consequently, 1080 water monitoring programmes have been undertaken following numerous pest control operations using aerially sown 1080 baits since 1990. There has been no evidence of significant or prolonged 1080 contamination of surface waters (see below). The risks associated with 1080 to human health are determined by the toxicity of 1080 and the potential for exposure: risk = hazard × exposure. The innate toxicity of 1080 is not in question, as there are clearly identified lethal and sub-lethal effects as illustrated above. However, exposure risk to humans is very low with the exception of the small group of workers in the pest control industry, a group that has been closely monitored to try to ensure minimal exposure (Beasley et al. 2009).

To address the potential for 1080 to exert effects on human health following its use for pest control in New Zealand, we have focused on the known sub-lethal effects outlined above, the mode of action of 1080 and the potential for exposure to 1080, and hence the likelihood of sub-lethal effects. Our conclusions in this section are based on our understanding of the effects described in animals receiving low doses coupled to different exposure scenarios.

It is apparent that 1080 exposure could have a multitude of effects resulting from aconitate hydratase inhibition and secondary biochemical perturbations. Chronic toxicology studies in animals as human substitutes, and mutagenicity tests, enable elucidation of potential toxicological effects in humans if they are exposed. Pathological changes observed in chronic animal studies are consequences of primary and

secondary effects of 1080 on the body. Animal toxicology studies by Eason and Turck (2002) have been used to define conservative no-effect levels, and more recently, tolerable daily intake (TDI) values of 0.03 µg kg^{-1} day^{-1} (Foronda et al. 2007a, b) have been proposed based on a NOEL of 0.075 mg kg^{-1} day^{-1} and a LOEL of 0.25 mg kg^{-1} day^{-1} (Eason & Turck 2002). The TDI proposed by Foronda et al. (2007a, b) is of relevance to workers at the bait manufacturing plants but not to the broader community, which should not be exposed to 1080 under normal baiting practices. Weaver (2003) suggested additional toxicology studies would be valuable. Equally, or probably more importantly in a practical sense, the use of 1080 must continue to include safeguards that focus on those individually handling 1080 or 1080 baits to ensure they do not ingest, inhale or absorb 1080.

Fate in the environment, toxicity to aquatic organisms and risk of exposure from contaminated water supplies

Persistence in soil and plants

After leaching from baits, 1080 can be metabolised (broken down) by soil microorganisms such as *Pseudomonas* and *Fusarium* species (Bong et al. 1979; Walker & Bong 1981; King et al. 1994). Under favourable conditions, such as 11–20ºC and 8–15% moisture, 1080 may be significantly defluorinated in 1–2 weeks. In less favourable conditions, breakdown might take several weeks, and in extreme cold and drought, 1080 residues might persist in baits or in the soil for several months (King et al. 1994).

Presumably, naturally occurring fluoroacetate is diluted by rainwater and breaks down in soil after leaves and seeds drop to the ground or when plants die. Not all microorganisms can readily defluorinate fluoroacetate and the rate of metabolism differs with different species of soil bacteria and fungi (King et al. 1994). Enzymes capable of defluorinating fluoroacetate have been isolated from several soil microorganisms. The fluoride–carbon bond is cleaved and, ultimately, enzyme-bound intermediates form non-toxic metabolites such as glycolate (O'Hagan & Harper 1999). The gene encoding for the bacterial enzyme capable of defluorinating fluoroacetate in soil has been cloned and expressed in the rumen bacterium *Butyrivibros fibriscolens*. This organism has then been employed, in an experimental setting, to infect the guts of sheep in an attempt to protect against dietary poisoning by fluoroacetate-containing plants. Early indications are that the genetically modified organisms become established sufficiently well to give the sheep a degree of resistance to fluoroacetate (Annison & Bryden 1998; Gregg et al. 1998). This line of research has not been pursued further and there are no plans to introduce genetically modified organisms into New Zealand livestock to protect them from 1080 baits. However, recent research has continued to clarify the enzymes involved in cleavage of the carbon-fluoride bond and their gene coding in bacteria (Kurihara et al. 2003)

1080 derived from baits will also be dispersed by water since it is highly water soluble and mobile (Parfitt et al. 1995). If heavy rainfall follows the use of 1080 baits, dilution to immeasurable concentrations (<0.0001 ppm) may precede biodegradation. In comparison with cereal bait, 1080 is retained in carrot baits and will only leach slowly from carrots into the soil (Bowen et al. 1995). However, control operations are planned to coincide with periods of dry weather, and some defluorination by microorganisms on the decaying baits and in the soil around baits is probable, particularly if baits become moist.

Recent studies have focused on determining the actual concentrations of 1080 in soil and leaf litter and whether or not these concentrations would be likely to affect soil organisms. The highest concentration of 1080 recorded in soil or leaf litter samples after aerial baiting was 0.19 mg kg^{-1} (Wright et al. 2002), but where other samples have contained 1080 with detectable residues, they were below 0.01 mg kg^{-1}. The toxicity of 1080 to earthworms has been evaluated in separate laboratory studies. A lowest observable effect concentration (LOEC) of 90 mg kg^{-1} was determined based on reduced earthworm cocoon production (O'Halloran et al. 2005), which represents a very high concentration compared with that likely to occur in practice. No mortality was observed in worms exposed to a 1080 concentration of 865 mg kg^{-1}, and concentrations of 1000 mg kg^{-1} in soil did not affect mineralisation of nitrogen by soil microorganisms (O'Halloran et al. 2005). Very recent research on the aerobic transformation of 1080 in soils has confirmed that breakdown varies significantly depending on temperature, and that the key transformation products are hydroxyacetic acid, also known as glycolate, and carbon dioxide (Fisher & Northcott 2010).

1080 that has leached into soil may be absorbed by plants (Atzert 1971; Rammell & Fleming 1978). An experiment by David and Gardiner (1950) showed that broad beans (*Vicia faba*) were able to systematically accumulate 1080 through the roots to the detriment of aphids (*Aphis fabae*) introduced to the test plants. Work on cabbage (*Brassica oleracea capitata*) also showed systematic accumulation of 1080 through the roots and subsequent toxicity to aphids, and was reviewed by Negherbon (1959). Recent research on plants has focused on determining whether 1080 residues might have an adverse effect on plant growth and whether or not uptake of 1080 by food plants could adversely affect animal or human health. Emergence of lettuce seedlings was adversely affected at 1080 concentrations in soil of 7 mg kg^{-1}, a significantly greater concentration than that found in soil after the aerial application of bait (O'Halloran et al. 2005). To investigate whether herbivores may be at risk of secondary poisoning if they consume plants that have taken up 1080 leached from bait, concentrations of 1080 were assessed in broadleaf (*Griselinia littoralis*) and perennial ryegrass (*Lolium perenne*) following simulated baiting (Ogilvie et al. 1998). The observation that both species absorbed 1080, which reached a peak and then declined to near the limits of detection, supported previous findings that plants can degrade 1080 (Preuss & Weinstein 1969; Ward & Huskisson 1969). The concentration achieved in broadleaf and ryegrass would be most unlikely to cause poisoning of herbivores (Ogilvie et al. 1998).

Recently, research has been undertaken to determine whether plants used by Māori (the indigenous people of New Zealand) for food and medicine can take up 1080. Cereal baits containing 0.15% 1080 were placed at the base of naturally growing individual plants of two species, pikopiko (*Asplenium bulbiferum*) and karamuramu (*Coprosma robusta*). Plants were sampled at various times up to 56 days and analysed for 1080 content. No 1080 was detected in any of the pikopiko samples, but it was detected in karamuramu at a maximum concentration of 5 ppb (µg L^{-1}) after 7 days, and 2.5 ppb after 14 days. Concentrations declined to zero at 28 days (Ogilvie et al. 2006). A similar study was carried out

on two commonly eaten plant species, puha (*Sonchus asper*) and watercress (*Nasturtium microphyllum/officinale*), using methods comparable to those of Ogilvie et al. (2006). Samples of plant tissue were taken at various times up to 38 days for puha, and up to 17 days for watercress. 1080 was detected at a maximum concentration of 15 ppb in a single puha sample after 3 days, and at a maximum of 63 ppb from a single watercress sample on day 8. By day 38, all 1080 concentrations were below the method's detection level for puha; 1080 was not detected in watercress after day 8 (Ogilvie et al. 2009).

Water and 1080

Beasley (1996) pointed out the theoretical routes of human exposure to 1080, as mentioned above. Of these routes, the one generally perceived to be most significant is contamination of surface water in public water-supply catchments by aerially sown 1080 baits.

In the Drinking Water Standards for New Zealand, issued in 2000 by the Ministry of Health (MoH), the provisional maximum acceptable value (PMAV) for 1080 in water is 3.5 ppb (μg L^{-1}). As a precautionary measure, MoH also recommended that water taken from catchments sown with 1080 baits should not be used for human supply until tests show that the concentration of 1080 is below 2 ppb. In this section we summarise research on the fate of 1080 after aerial application of 1080 bait, with a focus on water.

1080 is highly water-soluble (Parfitt et al. 1995). Some baits will fall into streams following aerial application, even when major watercourses are avoided. Laboratory studies have shown that 1080 is biodegraded by aquatic plants and microorganisms. Parfitt et al. (1994) showed that 1080 was degraded in biologically active water in 2–6 days, and Eason et al. (1993) showed that 1080 declined by approximately 70% in 1 day and to below detectable limits in 4 days in aquaria containing plants and invertebrates. Research has also indicated that residues of 1080 do not persist in aquatic plants. Ogilvie et al. (1996, 1998) showed that warmer temperatures significantly increased the rate of 1080 degradation, and was enhanced in the presence of aquatic plants and microorganisms. Their laboratory studies also demonstrated that concentrations of 1080 in aquatic plants decreased in parallel with the decline in concentration of 1080 in water (Ogilvie et al. 1995, 1996; Booth et al. 1999), indicating degradation of 1080 within the plants. Some of these studies of 1080 breakdown in water and aquatic plants (Ogilvie et al. 1996; Booth et al. 1999) deliberately used solutions containing much higher concentrations of 1080 (0.12 – 5 ppm) than have been detected in streams during field monitoring (0.1 – 9 ppb) to simulate worst-case scenarios.

Water monitoring of streams and waterways after aerial applications of 1080 baits was initiated by research teams studying the fate of 1080 in soil, invertebrates and water (Eason et al. 1992, 1993). It was continued in order to provide community reassurance and evolved into routine practice by the mid-1990s (MoH 1995). Results of the initial research and subsequent monitoring demonstrated that there has been no evidence of 1080 presence in reticulated water and no evidence of significant or prolonged 1080 contamination in surface waters (Parfitt et al. 1994; Eason et al. 1992, 1993; Hamilton & Eason 1994; Meenken & Eason 1995; Booth et al. 1997; Eason et al. 1999; Eason & Wright 2001; Wright et al. 2002; Eason & Temple 2008). Between 1990 and 2006, Landcare Research analysed 1973 water samples taken following 298 pest control operations. Of the samples taken, 96.3% were free of detectable 1080, including all 136 samples from reticulated town water supplies for household consumption (Booth et al. 2007).

Of the 3.7% (72) of water samples that contained detectable 1080 residues, most (65) had 1080 concentrations of less than 1 μg L^{-1} (ppb). When 1080 was found in samples in monitoring programmes, it was at very low concentrations, typically in small streams in remote locations. Often baits were seen near where samples were taken. The contamination was transient and not picked up in repeat samples.

Suren (2006) inspected small streams during aerial distribution of cereal baits containing 0.15% 1080, to quantify the number of baits falling into waterways. The number of baits found in streams was related only to bait size, with more small baits being found in streams. The leaching rates of 1080 baits were also examined under laboratory conditions. Baits leached 50% of the 1080 present in 5 h, and 90% in 24 h, consistent with results of water monitoring that have shown some contamination in streams but not in repeat samples taken later. Suren (2006) obtained no evidence of 1080 being washed into streams after heavy rainfall, perhaps not surprisingly, given the massive dilution that would occur after heavy rain. 1080 has not been detected in over 300 samples of reticulated water and there is no evidence of significant or prolonged contamination in surface waters (Eason & Temple 2008). Given the amounts of 1080 used in ground and aerial applications, exposure of individuals living near possum control areas is unlikely, and it is even more unlikely to occur if safety procedures are adhered to.

In other research by the National Institute of Water & Atmospheric Research (NIWA), scientists deliberately spiked small streams with 1080 baits. They examined the ecological consequences of 1080 baiting in waterways, found none, and at the same time monitored the fate of 1080 (Suren & Lambert 2004 unpubl., 2006; Suren 2006; Suren & Bonnett 2006). In these field experiments, quantities of baits were deliberately placed in small (< 3 m wide) streams. 1080 was only detected in water samples for a short period (< 24 h) thereafter. 1080 concentrations 10 m downstream from the site where baits were added were higher than those 100 m downstream, illustrating the influence of dilution. Observed concentrations were always below the MoH guidelines of 2 μg L^{-1} (ppb). It is noteworthy that the conclusions of research groups involved in over a decade of monitoring of actual aerial control operations, and the conclusions of the NIWA research team conducting a simulated exposure, were very similar. Suren (2006) recommended water samples be taken within 4–8 h of streams being potentially contaminated with bait, and suggested that later monitoring was likely to be of limited value. All the research groups have reported that when contamination does occur, only low concentrations are detected and only for a short period. Even in small streams and under warm conditions, dilution of 1080 will be more important than biodegradation, since dilution occurs immediately.

In practice, Medical Officers of Health in New Zealand are faced with a complex array of legislation, guidelines and challenges when exercising their responsibilities in regard to authorisation of 1080 aerial operations and applying conditions for monitoring water quality. In this regard, the conclusions of the NIWA researchers on the duration of 1080 in water after deliberate spiking of streams are helpful, in particular Suren's (2006) recommendation that water samples should preferably be taken within 4–8 h of potential contamination with 1080 from baits. It would seem to be sensible to extend

this recommendation to sampling close to reticulated water supplies. In conclusion, there is a case for rationalisation of water monitoring based on the results of the recent NIWA research, limiting samples to within or at 24 h after an operation.

In summary, research in the 1990s has demonstrated that biodegradation could play an important role in the elimination of 1080 derived from baits and residues in waterways. There are two means by which any 1080 present in water will be reduced to undetectable and toxicologically insignificant amounts: (1) dilution, and (2) biodegradation. Even though substantial biodegradation can occur over the first 24 h of 1080 entering water, the effect of dilution will be immediate. There have been recent suggestions that further research on 1080 degradation in water would be useful (Weaver 2003). However, since dilution to undetectable concentrations is likely to occur before significant biodegradation, a focus firstly on more information about the fate of baits in streams and operational improvements to avoid watercourses might be more fruitful. Water monitoring since 1990 has shown that significant water contamination is unlikely when safety procedures are adhered to. In the amounts used either in ground or aerial application, exposure of individuals living near possum control areas is most unlikely to occur. Research teams involved in water monitoring in the 1990s initially looked for 1080 in streams, sometimes for several days after rainfall and on occasion for some weeks after the application of baits. None of the monitoring work picked up 1080 washed into streams after heavy rainfall. Research on bait degradation and the effects of soil microorganisms indicate that 1080 from baits that are not eaten by pests is unlikely to migrate to streams in measurable quantities, particularly when dilution is combined with biodegradation. As indicated above, if or when small amounts of 1080 enter streams, biodegradation is likely to be overshadowed by dilution, even when conditions for biodegradation are favourable. If 1080 monitoring of small streams is to be undertaken, then water samples should be taken within 4–8 h after the streams are potentially contaminated if the purpose is to detect transient contamination. However, when testing public water supply sources, water analyses need to demonstrate absence of 1080; hence sampling within and at 24 h will be important.

In terms of effects on aquatic organisms, the concentrations described above in 'real world' operational settings are consistently below those that will impact on aquatic organisms. This conclusion is most clearly demonstrated by assessing aquatic toxicology data. Historical data indicate that fish are relatively resistant to 1080. Fingerling bream and bass (species unidentified) survived indefinitely, without any signs of toxicity, in water containing 370 mg of 1080 per litre (King & Penfound 1946). In New Zealand, fingerling trout (species unspecified) were subjected to 1080 concentrations of 500 mg L^{-1} and 1000 mg L^{-1} without any visible effect on the fish. Force-feeding pellets containing a total of about 4 mg of 1080 (two fingerling trout and five adult trout) or about 8 mg of 1080 (two adult trout) also had no visible effect (Rammell & Fleming 1978). Fluoroacetamide (a compound related to 1080) at a concentration of 3500 mg L^{-1} killed only 50% of a harlequin fish (*Rasbara heteromorpha*) population in 48 h. The LD_{50} of 1080 after intraperitoneal injection was approximately 500 mg kg^{-1} (Bauermeister et al. 1977). No explanation of the high resistance of fish to 1080 has been published, but it is presumably associated with differences in metabolic pathways or the relative importance of the Krebs cycle in fish metabolism (Rammell & Fleming 1978).

During 1993, three aquatic toxicity tests were completed in the USA. The first estimated the acute toxicity of 1080 to bluegill sunfish (*Lepomis macrochirus*). No mortality or sub-lethal effects were observed at any concentration tested, with a highest NOEC (no observed effect concentration) of 970 mg L^{-1}. Based on the results of that study and criteria established by the US Environmental Protection Agency (EPA), 1080 would be classified as practically non-toxic to bluegill sunfish. The second test, on rainbow trout, used the same test conditions as the bluegill sunfish studies. The NOEC was 13 mg L^{-1}, which the US EPA classifies as slightly toxic to rainbow trout. The third test estimated the acute toxicity (EC_{50}) of 1080 to the small freshwater invertebrate *Daphnia magna*. The 48-h EC_{50} value for daphniids exposed to 1080 was 350 mg L^{-1} and the NOEC was 130 mg L^{-1}, making 1080 practically non-toxic to *Daphnia magna* by US EPA classification standards (Fagerstone et al. 1994). An early experiment reported that mosquito larvae (*Anopheles quadrimaculatus*) were comparatively sensitive to 1080 (Deonier et al. 1946), with 1080 concentrations as low as 0.025 mg L^{-1} being fatal to 15% of a test population. Since the concentrations of 1080 described above are many times higher than residue concentrations associated with 1080 use (<0.001 mg L^{-1}), adverse effects on aquatic animals are unlikely. In practice, these data would only be of value in risk assessment relating to a large amount of 1080 bait or stock solutions being deliberately or accidentally tipped into a waterway.

In their field research on 1080 residue analyses in waterways, Suren and Lambert (2006) not only studied the responses of an invertebrate community to 1080 contamination, but also monitored caged longfin eels (*Anguilla dieffenbachii*), koaro (*Galaxias brevipinnis*) and upland bullies (*Gobiomorphus breviceps*) after deliberately spiking small streams. Despite large numbers of toxic baits being placed in the study streams (maximum 80 baits in the stream with greatest water discharge), 1080 was detected for less than 12 h, and only at very low concentrations (c. 0.2 µg L^{-1}). No effects of 1080 were detected on any of the invertebrate species, including caddisflies (*Helicopsyche* sp., *Pycnocentrodes* sp., *Pycnocentria* sp.), orthoclad midges and mayflies (*Deleatidium* sp.), or the three caged fish species. These findings are consistent with the concentrations present being below those having toxic effects on these species. Further work on eels (*Anguilla dieffenbachii*) and freshwater crayfish (*Paranephrops planifrons*), when the animals were fed 1080 baits under experimental conditions designed to mimic real-site situations, also showed no effects (Lyver et al. 2005; Suren & Bonnett 2006).

Non-target responses

Controlling pests has enhanced and restored New Zealand ecosystems and protected endangered native species. Careful monitoring of the use of 1080 has been essential to ensure that non-target effects are minimised and the benefits of pest control outweigh adverse effects (Eason 2002a). Non-target effects of 1080 used for possum control have been studied extensively during the last 20–30 years in New Zealand (Harrison 1978; Spurr 1991, 1994; Eason et al. 1998b; Innes & Barker 1999; Powlesland et al. 1999; Lloyd & McQueen 2000).

Effects on birds

Bird deaths have been reported during 1080 pest control

operations almost from when they were first conducted in New Zealand. However, the first formal monitoring of bird deaths occurred in 1976–77. During that monitoring exercise, it was discovered that a number of birds from a range of species were dying during control operations in which non-dyed, raspberry-lured carrot bait that had a high percentage of small fragments ('chaff') was being used (Harrison 1978). This led to significant changes in baits, with carrot baits being screened to remove small fragments, raspberry lure being banned, baits being dyed green, and cinnamon oil added as a deterrent. At about the same time, bait application rates started to be reduced and there was an increased use of cereal-based baits. Fewer birds and fewer species have been reported dead since these changes were made (Spurr 1994).

The significance of any loss of individuals as a result of 1080 poisoning to the long-term viability of a species depends on its resilience. Therefore, much recent monitoring has focused on the impacts 1080 has on native bird species at a population level. Those species with large populations and a high reproductive rate can compensate for small losses. North Island robins (*Petroica australis longipes*) suffered c. 50% mortality during a 1996 poison operation using 1080 carrots. However, a reduction in predators resulted in improved breeding of robins. A year later the robin population contained more birds and a greater proportion of females than just prior to the operation (Powlesland et al. 1999). Similarly, during a 1080 carrot operation in 1997, mortality of tomtits (*Petroica macrocephala*) was estimated to be 79% (Powlesland et al. 2000). However, the tomtits had enhanced nesting success following the 1080 operation, with pairs rearing two, and in some cases, three broods the following season. More recent research indicates that cereal bait operations using low sowing rates and large baits have little if any impact on tomtit populations (Westbrooke & Powlesland 2005).

In contrast, threatened species usually have a limited ability to recover from additional mortality, making the consequences of potential losses from poisoning of more concern. Therefore, a number of studies using individually marked birds have been undertaken on threatened native non-target populations to determine the effects of aerial poisoning, using carrots and cereal baits. Most intensive monitoring has been of kōkako (*Callaeas cinerea wilsoni*), with four of 366 birds monitored through 1080 operations disappearing, giving a calculated mortality rate of 1.4% deaths per operation (Flux & Innes 2001). Kiwi have been closely studied with radio-tagged adult kiwi monitored throughout 1080 operations; no deaths were recorded. In total, 269 kiwi have been monitored throughout fourteen 1080 operations (10 aerial, 3 handlaid and 1 bait station operation). Species monitored include the North Island brown kiwi (*Apteryx mantelli*), great spotted kiwi (*A. haastii*), rowi (*A. rowi*) and Haast Tokoeka (*A. australis*) (H. Robertson, pers. comm.). All 73 kākā (*Nestor meridionalis*), 19 blue ducks (*Hymenolaimus malacorhynchus*) and 15 kererū (*Hemiphaga novaeseelandiae*) monitored through aerial poisoning operations using radio transmitters have survived. During monitoring, one of 40 weka (*Gallirallus australis*) died, and four of 23 fernbirds (*Bowdleria punctata*) disappeared. None of these studies have identified population-level mortality that threatens the viability of a species (Broome et al. 2009). Recent monitoring of kea (*Nestor notabilis*) suggests that some populations may be affected by aerial 1080 operations. Research is ongoing to identify those populations at risk and whether the risks can be mitigated (Broome et al. 2009).

Seaton et al. (2009) collected productivity data from 87 New Zealand falcon nests (*Falco novaeseelandiae*) in the Kaingaroa pine plantation during three breeding seasons, 2003–2006. During this time, 1080 pellets and carrots were ground laid or aerially applied in forest compartments where falcon breed. During the study, the breeding falcon population increased from 20 to 36 pairs, leading the authors to conclude that 1080 did not have a negative impact on falcon, and in fact probably had a positive impact by reducing predation pressure on them.

Very recently, the collation and analysis of 48 surveys of individually banded or radio-tracked birds during aerial 1080 operations from 1986 to 2009 was completed by Veltman and Westbrooke (2011). Their paper is a very important contribution to the field. They confirmed that kiwi, kākā and kōkako have a small risk of mortality. However, they also noted that many of the surveys in which zero bird mortality has been observed had small sample sizes, creating a false sense of security. Furthermore, operations in which bird survival had been tracked often did not follow best baiting practices, or have adequate monitoring methodology. Eleven native species reported dead after 1080 operations have not been studied systematically by radio-collaring individuals to monitor survival (Veltman & Westbrooke 2011). The authors highlighted a further need to obtain robust information on bird mortality during 1080 operations, including long-term monitoring and the judicious use of intensive methods for data-poor species, and when baiting procedures change. Baiting practice has continued to evolve (Morgan 1994, 2004; Morgan et al. 1997) and now routinely includes prefeeding (Warburton et al. 2009), raising the possibility it could similarly affect bird behaviour and increase the poisoning risk to birds (Veltman & Westbrooke 2011).

Considerable effort has been invested in research on ways to further reduce the negative effects of 1080 on non-target species through the use of bait stations, bait matrices that are less palatable to non-target species, and by identifying and incorporating potential repellents (e.g. see Hickling 1997: Morgan et al. 1997 unpubl. report; Spurr & Porter 1998; Morgan 1999; Day et al. 2003; Ross & Henderson 2003 unpubl. report). While the first two lines of research have been successful and adopted during 1080 operations, research into repellents has been less successful. Despite improvements, Veltman and Westbrooke (2011) recommend continued diligence and vigilance to improve monitoring.

Effects on invertebrates

In surveys conducted in the 1990s, no negative impacts were detected on populations of weta in Waipoua Forest, a range of invertebrate species on Rangitoto Island, predatory insects in Mapara Reserve, or ground-dwelling invertebrates in Puketi Forest and Titirangi Reserve (Spurr 1994). Observations of the number of species and number of individual invertebrates found feeding on 1080 baits has led to the prediction that vertebrate pest control operations are unlikely to have long-term deleterious impacts on invertebrate populations (Sherley et al. 1999; Spurr & Drew 1999). This conclusion is consistent with the monitoring of Aspen et al. (1999), which showed no impacts on the number of ground-dwelling insects up to 1 year after aerial 1080 application. Similar results were obtained by Spurr and Berben (2004) using artificial refuges and mark-recapture techniques. No impacts on weta, slugs, cockroaches and spiders were identified. Powlesland et al. (2005) have since confirmed that aerial 1080 did not have a detrimental effect on forest invertebrates.

Effects on deer

The percentage of red deer (*Cervus elaphus scoticus*) killed during aerial 1080 poisoning operations has been formally monitored in several different areas, and was found to range from 5% to 93% after an aerial carrot operation in Pureora in 1997 (Fraser & Sweetapple 2000). Two-thirds to three-quarters of the fallow deer (*Dama dama*) population in the Blue Mountains were killed during an aerial pellet operation (Nugent & Yockney 2004), the kill appearing to be greatest for the youngest (smallest) deer in areas with the highest deer density and the most open understorey. There appears to be no consistent pattern in the number of deer deaths based on bait type, sowing rate or toxic loading, suggesting that other factors such as deer density are important (Nugent et al. 2001). Deer by-kill can now be avoided by including a deer repellent in bait that does not deter possums (Morriss 2007).

Risks to domestic animals

Dogs are extremely susceptible to 1080 and must be kept away from toxic baits and possum carcasses. Records of dog poisoning incidents have not been maintained during the years that 1080 has been used; however, 254 dogs were reported to have been killed by 1080 during 1960–1976 (Rammell & Fleming 1978). The results of a persistence study by Meenken and Booth (1997) coupled with knowledge of the LD_{50} for dogs, is useful for getting a better understanding of secondary poisoning risks to dogs. Based on an LD_{50} for dogs of 0.07 mg kg^{-1}, a 20-kg dog would be seriously at risk if it consumed 200 g of toxic offal containing 7 mg kg^{-1} of 1080. In Meenken and Booth's (1997) study, 5 out of 6 possums on day 25, and 4 out of 10 on day 75, were reported to exceed this threshold. One possum carcass out of 6 on day 25 contained 70 mg kg^{-1}, 10 times the amount needed to kill a 20-kg dog. These analyses confirm that dogs are a special case because of their unique sensitivity to 1080 (Meenken & Booth 1997). Concentrations of 1080 in rat and rabbit carcasses ranged from 1.9 to 14.4 mg kg^{-1} (rats) and from <0.02 to 0.78 mg kg^{-1} (rabbits) (Twigg et al. 2003), showing they also present risks to dogs. Cats, being predators, are also susceptible to secondary poisoning from 1080 (Eason 2002b). While showing a high degree of sensitivity to 1080 (LD_{50} of 0.28 mg kg^{-1}) (Eason & Frampton 1991), it is lower than that for dogs (LD_{50} of 0.07 mg kg^{-1}), and clinical signs in cats are less severe (Eason & Frampton 1991).

Livestock can also succumb to 1080 poisoning (ERMA 2008) and must be kept well away from baits. Even partially degraded baits should be regarded as hazardous to sheep and cattle (*Bos* sp.). Where livestock deaths have been reported, it has generally been due to animals being returned too early to areas where 1080 application has occurred (Eason 2002b). Sheep exposed to single sub-lethal doses of 1080 have not been reported to experience any long-term adverse affects (Eason 2002b).

Improved methods of bait application

There has been a sustained effort to increase target specificity and reduce bait application rates when using 1080. Bait application rates of 3 kg ha^{-1} or less are now used (Morgan 1994, 2004; Morgan et al. 1997a). Pest control operators guard against the careless use of 1080, poor-quality control operations, and the use of poor-quality baits. Non-target mortality can be minimised by well-planned operations using high-quality baits and by the increased use of bait stations (Eason 2002a). However, as aerial 1080 methods continue to evolve, e.g. the use of prefeeding to enhance bait uptake by possums and rodents, further monitoring is required to ensure that the new methods do not impact on native species (Veltman & Westbrooke 2011).

Conclusions

Fluoroacetate, the active ingredient of 1080, occurs naturally in toxic plants in Australia, Africa, and South America. Manufactured 1080 is used to control introduced mammals in New Zealand and Australia to protect native species from the impacts of introduced pests. Some microorganisms in the soil, such as *Pseudomonas* spp., will defluorinate 1080. Water-monitoring surveys, conducted during the 1990s, have confirmed that significant contamination of waterways is unlikely following aerial application of 1080 bait (Eason 2002a).

1080 is a broad-spectrum poison that acts by interfering with the energy-producing tricarboxylic acid cycle in the mitochondria. Possums die from heart failure, often within 6–18 h of eating baits. Dogs are extremely susceptible to poisoning. If livestock become exposed to 1080 bait, a minimum withholding period of 5–10 days should be enforced to enable excretion of 1080, so that residues will not occur in meat. High-quality baits reduce non-target impacts on birds. Current evidence suggests that populations of bird species and invertebrates are not adversely affected, and adverse

Table 7. Summary of key advantages and disadvantages of sodium fluoroacetate (compound 1080) for possum control (from Eason 2002a).

Advantages	Disadvantages
• Highly effective for achieving a rapid reduction in possum numbers	• Controversial, especially aerial operations
• Can achieve consistently high kills	
• The only poison available for aerial applications	• Secondary poisoning risk (especially dogs) from possum carcasses
• Biodegradable in the environment	• No effective antidote
• Inexpensive compared to most other poisons	• Can only be used by licensed operators in government agencies
• Kills other pest species	• Poor-quality bait causes bird deaths
• High-quality efficacy data exist to support both aerial- and ground-baiting techniques	• Generates bait shyness if target animal receives sub-lethal doses

effects of 1080 use are outweighed by ecosystem protection and the reduction of pest impacts on native species. However, further monitoring using current aerial baiting techniques that now include prefeeding is required to ensure that short-term negative effects on non-target species are minimised. Table 7 summarises the main advantages and disadvantages of 1080 use. Long-term exposure to sub-lethal doses can have harmful effects, and strict safety precautions are enforced to protect contractors and workers in the bait manufacturing industry. When its use is controversial, risk communicators must take care not to trivialise the toxicity of 1080, but to discuss the risk alongside measures taken to mitigate adverse effects (Eason 2002a).

The benefits of 1080 use in conservation, pest control, and disease control need to be weighed alongside the risks of using 1080 and alternative techniques for pest control. Considerable care must be taken when using 1080 to ensure that the risks of its use are outweighed by ecological benefits achieved.

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Appendix 2

Sodium fluoroacetate

Pesticide Information Review

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Version History:

Version	*Date Written*	*Change/Reason for Change*
2012/3	23/10/2012	New information on fernbirds (Sections 2.5.4, 3.2.1 and 3.2.3) & bees (4.2.1)
2012/2	17/10/2012	New information on 1080 resiudes in magpies (*Pica pica*) in 2.5.4, and LD_{50} for magpies in 4.1.1.
2012/1	12/04/2012	New information on 1080 in water 2.3.1, 2.3.2, and 2.3.3, and 3.2.1 (snails), corrected formatting and Table numbers.
2011/2	17/10/2011	New information (kea) 3.2.3
2011/1	13/1/2011	New information on fish and aquatic invertebrates 3.2.3
2010/2	31/08/2010	New information (kiwi) 3.2.3
2010/1	3/08/2010	New information 2.5.2, 3.2.2 & 3.2.3
2009/7	15/12/2009	3.2.3 (skinks and weka); 5.1.7, 6.2.4 (Rats)
2009/6	1/09/2009	Corrected number of operations monitored by Thomas et al. (2004) in section 2.1.1
2009/5	13/8/2009	New information in sections 2.5.4 (Quail) & 4.2.1 (0.2% carrot and 0.04% oat operations).
2009/4	20/7/2009	Rewrote sections 2.3.1, 2.4.2 and 2.4.3 based on new information.
2009/3	13/07/2009	New information in Section 3.2.2 (falcon); 6.2.4 (Mice)
2009/2	19/05/2009	New information in Section 6.2.2 (Mice)
2009/1	17/02/09	New information in Sections 2.5.1 & 2.5.4 (deer); 3.2.1 & 3.2.3 (Kakariki)
2008/1	18/09/08	New information in Sections 2.5.2; 2.5.4; 3.2.1 & 3.2.3 (kea); 4.1.4; 4.2.1; & 6.2.4
2006/2	10/08/06	New information in section 3.2.3 (paste baits)
2006/1	15/3/06	New information in sections 2.1.1; 2.5.5; 3.2.3; & 6.2.4.
2005/2	17/03/05	New information in sections 2.1.1; 2.4.2; 2.5.2; & 6.2.4.
2005/1	18/01/05	Up dated Section 1.4 pesticide uses
2004/2	8/10/2004	Residue and non-target native and feral animal information from Speedy (2003) included
2004/1	15/9/2004	Original document

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I. Overview

Introduction

Sodium monofluoroacetate (1080) is the most widely used poison for possum control in New Zealand for situations where possum numbers need to be reduced rapidly over large areas. Vertebrate pesticides containing 1080 are also registered for the control of rabbits, wallabies, deer, goats, cats and rodents. The manufactured 1080 used in toxic baits is chemically identical to the toxic compound found in some poisonous plants, and highly toxic fluoroacetate-producing plants are globally distributed. In plants, fluoroacetate appears to be a secondary plant compound that is biosynthesised at high concentrations as a chemical defence mechanism against browsing invertebrates and vertebrates.

Monofluoroacetate is converted within animals to fluorocitrate, which inhibits the tricarboxylic acid cycle. This results in accumulation of citrate in the tissues and plasma, energy deprivation, and death. Sodium monofluoroacetate (1080) is absorbed through the gastrointestinal tract or via the lungs if inhaled. Monofluoroacetate is not readily absorbed through intact skin, but it can be absorbed more readily through cuts and abrasions.

Fate in the Environment

1080 in baits may be defluorinated in 1–2 weeks under favourable conditions. However, under less favourable conditions breakdown may take several weeks and, in extreme cold and drought, 1080 residues could persist in baits for several months.

Degradation of 1080 is slow in soil and sediments, taking 1-4 weeks under favourable conditions. The rate of degradation will be influenced by the presence of soil or litter micro-organisms, and temperature, soil moisture and rainfall. Sodium monofluoroacetate is highly water soluble so leaching out of soil will occur.

While the concentration of 1080 in deionised (sterile) water remains relatively constant and independent of temperature, 1080 degradation occurs within 1-2 weeks in natural water. Temperature, and the presence of aquatic plants and microbes all affect 1080 degradation in aquatic environments. Water samples have been collected from streams following numerous pest control operations using 1080. 96.6% of these samples contained no residues of 1080. Where residues were found most of these had less than 1 $\mu g\ l^{-1}$ 1080. Where higher 1080 residues have been found in water, the samples were mostly from very small streams and/or associated with the presence of bait, during aerial operations.

While plants can take up 1080, it is unlikely to be in large amounts. If taken up, 1080 residues persist less than 38 days in plants.

1080 has a relatively short half-life in sub-lethally dosed animals and it is metabolised and eliminated from living animals within days. However, it can persist in carcasses for months. The rate of degradation of 1080 in carcasses will depend on moisture, temperature and the presence of micro-organisms.

Effects on Non-Target Native Species

Based on the few studies of native species available, and the large number of non-native species studied (Part 4) suggests 1080 is likely to be toxic to most native animals. There is wide variation in sensitivity between taxonomic groups with mammals more sensitive than birds and invertebrates (on a weight for weight basis). Sub-lethal effects have been demonstrated for native invertebrates in the laboratory. The small size of many native species (relative to the target pests) means that toxic baits used for pest control are capable of causing harm to almost any animal that eats the bait. Therefore the level of exposure to the bait becomes important in determining the effects on non-target native species in the field.

Most information on non-target exposure to 1080 bait relates to aerial poisoning as this is thought to be the "worst case scenario" for studying non-target effects. Hand laid baits are sometimes used to approximate aerial poisoning in studies. Bait station studies are scarce. It could be assumed that native species are not more at risk using bait stations than distributing the same bait type aerially.

There are records of a range of native bird species found dead after aerial poisoning operations and many of these individuals have contained residues of 1080. However when records are discounted from:

- operations which did not meet current bait quality standards (e.g. using unscreened, un-dyed carrot bait with berry fruit lures) or
- those animals which did not have detectable 1080 residues,

the Vertebrate Pesticide Residue Database (VPRD) 1994-2004 contains only 24 individuals representing 8 native species across all bait types used in aerial poisoning. No conclusions about population effects can be drawn from this information but it is useful to focus further studies. Some native species (mainly invertebrates) have contained 1080 residues when sampled, an indication of potential risk to insectivores from secondary poisoning.

Loss of individuals in a population of native species as a consequence of 1080 poisoning can have variable significance to the long term viability of the population depending on the context. Those animals with a large population and/or a high rate of increase can compensate for small loses. Poison-related mortality may be replacing deaths from predation or winter starvation. Threatened species usually have a poor ability to recover from additional mortality, making the consequences theoretically more concerning. Many studies to determine the effects of aerial poisoning on native non-target populations have been carried out over the last 20 years. Birds, particularly threatened species, and invertebrates have the most information, although the only reliably calculated mortality rate is that for kokako at 1.4% deaths per operation. There is limited information on other taxonomic groups e.g. reptiles, due to the difficulty in studying these species at sites where 1080 is used or to perceptions that they are unlikely to be exposed (e.g. aquatic organisms).

Eleven species of native bird have been intensively monitored, and several other bird species monitored using less precise techniques. None of these studies have identified population level mortality which threatens the viability of the species. All 87 kiwi, 73 kaka, 19 blue ducks and 15 kereru monitored through aerial poisoning operations using radio transmitters have survived. Four of 366 kokako

have disappeared, 1 of 40 weka died, 1 of 18 morepork died and 4 of 23 fernbirds disappeared after poisoning. 14 out of 100 radio tagged kea have died during aerial 1080 operations. About 25 of 93 colour banded robins disappeared following poisoning. Mortality of tomtits was estimated to be 10-40% in one study. However both robins and tomtits were found to increase their nesting success to compensate in sites where the 1080 operation resulted in effective control of pests.

Invertebrate populations have been monitored in nine aerial poisoning operations and none have shown significant population effects on any species studied, nor is there evidence to suggest poisoned invertebrates are a significant factor in secondary poisoning of other animals. Long term monitoring of native land snails indicates substantial benefits to threatened populations in sites treated with aerial poisoning.

Limited monitoring of native frogs, NZ falcon, kakariki, short tailed bats and Australasian harriers do not indicate detectable mortality due to aerial poisoning.

The risks 1080 operations pose to aquatic species is considered very low. Fish are very tolerant to 1080. Additionally, 1080 contamination of water is rarely found during 1080 operations and is at an extremely low level when it has occurred. No mortality of longfin eels, köaro or upland bullies was observed during experiments where high densities of cereal 1080 pellets were placed in water just upstream of them. Eels and koura have survived experimental feeding of cereal 1080 pellets, and eels have survived feeding on possum tissue containing 1080. There have also been no detectable effects on aquatic invertebrate communities in field studies when 1080 baits were placed at high densities in streams.

Effects on Domestic and Feral Animals

There is wide variation between species in their susceptibility to 1080 poisoning. Dogs are especially vulnerable and highly likely to die if they eat 1080 baits or scavenge animals killed by 1080. Larger animals such as cattle need several possum baits to receive a lethal dose but deaths have been reported where animals have access to baits, including those contained in bait stations.

Sub-lethal effects at realistic dose rates have been recorded in sheep and other species, typically affecting the heart. Exposure to prolonged high doses resulted in mild foetal abnormalities in pregnant rats and damaged sperm in male rats but no mutagenic properties were found. No antidote is currently available for 1080 poisoning although veterinary treatment can be successful.

Feral deer population mortality from aerial poisoning operations targeting possums is highly variable and does not appear to be consistently influenced by toxic loading, sowing rate, prefeeding or bait type. Most estimates of deer kill fall between 30 and 60%. Nugent et al. (2001) quote productivity figures for red deer populations of around 30% so low to moderate by-kill of deer populations is probably negated within a couple of years.

Birds are generally less susceptible to 1080 than mammals but introduced birds such as blackbirds and chaffinches are found dead after aerial poisoning operations. Lizards and fish appear quite tolerant of 1080, according to research on overseas species.

Although 1080 is toxic to bees, baits used in pest control are generally not attractive to bees. However this may not always be the case if bees are particularly hungry, so beekeepers should always be notified of operations.

Human Health

The estimated lethal dose of 1080 in humans lies in the range of 0.7 and 10.0 mg kg^{-1}. Sodium monofluoroacetate (1080) is absorbed through the gastrointestinal tract or via the lungs if inhaled. Monofluoroacetate is not readily absorbed through intact skin, but it can be absorbed more readily through cuts and abrasions. The onset clinical signs usually range from 30 minutes to about 2-3 hours. Signs of poisoning include nausea, vomiting, and abdominal pain initially, followed by respiratory distress, anxiety, agitation, muscle spasms, stupor, seizures, and coma.

1080 is not a mutagen and is unlikely to be a carcinogen. It has sub-lethal effects on reproduction and is classified as a teratogen.

There is no effective antidote for 1080 poisoning in humans and any treatment given is largely symptomatic and supportive.

Operational

1080 is considered to have medium humaneness for possums, however there has been little formal research into the humaneness of 1080 on other target species. Most deaths of pest species occur 8 – 48 hours after ingestion of a lethal dose.

All the registered target species have relatively high susceptibility to 1080. The short latent period means that bait shyness can develop in animals receiving a sub-lethal dose. Mice exhibit a marked avoidance of 1080 which is likely to result in control operation failures.

The majority of pest control operations using 1080 have target pest kills of greater than 80%.

1. Introduction

Sodium monofluoroacetate (1080) is the most widely used poison for possum control in New Zealand for situations where possum numbers need to be reduced rapidly over large areas. Vertebrate pesticides containing 1080 are also registered for the control of rabbits, wallabies, deer, goats, cats and rodents. The manufactured 1080 used in toxic baits is chemically identical to the toxic compound found in some poisonous plants, and highly toxic fluoroacetate-producing plants are globally distributed. In plants, fluoroacetate appears to be a secondary plant compound that is biosynthesised at high concentrations as a chemical defence mechanism against browsing invertebrates and vertebrates.

Monofluoroacetate is converted within animals to fluorocitrate, which inhibits the tricarboxylic acid cycle. This results in accumulation of citrate in the tissues and plasma, energy deprivation, and death. Sodium monofluoroacetate (1080) is absorbed through the gastrointestinal tract or via the lungs if inhaled. Monofluoroacetate is not readily absorbed through intact skin, but it can be absorbed more readily through cuts and abrasions.

1.1 Chemical name

Sodium monofluoroacetate

1.2 Synonyms

Sodium fluoroacetate, Monofluoroacetate, Compound-1080, 1080 ('ten-eighty')

1.3 CAS Numbers

62-74-8

1.4 Registered pesticides containing 1080 available in New Zealand

0. 2 % 1080 Pellets (2 g kg^{-1} 1080), Pesticide use numbers: 21, 22, 23

0.15% 1080 Pellets (1.5 g kg^{-1} 1080), Pesticide use numbers: 1, 2, 3, 54, 55, 56, 98

0.08 % 1080 Pellets (0.8 g kg^{-1} 1080), Pesticide use numbers: 7, 8, 9

0.08 % 1080 Rodent Pellets (0.8 g kg^{-1} 1080), Pesticide use numbers: 10, 11, 12, 99

0.06% 1080 Pellets (0.6 g kg^{-1} 1080), Pesticide use numbers: 101, 102, 103, 104, 105, 106, 107

0.04% 1080 Pellets (0.4 g kg^{-1} 1080), Pesticide use numbers: 13, 14, 100

1080 solution (200 g l^{-1} 1080), Pesticide use numbers: 5, 6, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 37

No Possums® 1080 gel (1.5 g kg^{-1} 1080), Pesticide use numbers: 91

0.1% 1080 Feral Cat Bait (1.0 g kg^{-1} 1080), Pesticide use numbers: 38, 115

10% 1080 Gel (100 g kg^{-1} 1080), Pesticide use numbers: 15, 39, 97

5% 1080 Gel (50 g kg^{-1} 1080), Pesticide use numbers: 16

Pestoff Exterminator Paste (1.5 g kg^{-1} 1080), Pesticide use numbers: 35, 36

Pestoff Professional 1080 Possum Paste 0.08% (0.8 g kg^{-1} 1080), Pesticide use numbers: 41

Pestoff Professional 1080 Possum Paste 0.15% (1.5 g kg^{-1} 1080), Pesticide use numbers: 42, 96

Pestoff Professional 1080 Possum & Rabbit Paste 0.06% (0.6 g kg^{-1} 1080), Pesticide use numbers: 44

1.5 Chemical and physical properties

1080 has an empirical formula of $C_2H_2FNaO_2$ and a molecular weight of 100.3. In its pure form 1080 is an odourless, colourless, non-volatile powder that decomposes at about 200°C. Although the compound is often said to be tasteless, dilute solutions are thought to taste like weak vinegar. Sodium monofluoroacetate is very water-soluble but has low solubility in organic solvents such as ethanol and oils. Monofluoroacetates are chemically stable, hence 1080 as a pure compound in powder form—or when prepared in an aqueous stock solution—will not readily decompose.

This section is from Eason & Wickstrom (2001).

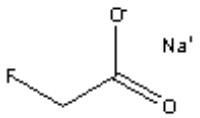

FIGURE 1. THE CHEMICAL STRUCTURE OF SODIUM FLUOROACETATE.

1.6 Historical development and use

Sodium monofluoroacetate was first patented as a rodenticide in the late 1930's, with commercial use starting in the United States in 1944 to control gophers, ground squirrels, prairie dogs, field mice, and commensal rodents. In New Zealand the first trials were carried out in 1954, and by 1957 its use had become widespread. Currently in New Zealand the principal target species is possums. It is also registered for use against rabbits, wallabies, deer, goats, cats and rodents. 1080 was also used in a fish-based paste to control wasps in the late 1990s.

Manufactured 1080 for use in toxic baits is chemically identical to the toxic compounds found in a poisonous plant, with naturally produced 1080 inducing the same signs and symptoms in animals (de Moraes-Moreau et al. 1995). In plants, monofluoroacetate appears to be a secondary plant compound that is biosynthesised at high concentrations as a chemical defence mechanism against browsing invertebrates and vertebrates.

Highly toxic fluoroacetate-producing plants are globally distributed. Research in the 1940s identified monofluoroacetate, the active toxin in 1080, as the toxicant in the South African plant gifblaar (*Dichapetalum cymosum*), which has long been recognised as a hazard to livestock. Monofluoroacetate has also been identified as the toxic agent in many other poisonous plants, such as rat weed (*Palicourea margravii*), native to Brazil (de Moraes-Moreau et al. 1995); and ratsbane (*Dichapetalum toxicarium*), native to Africa (Atzert 1971). Monofluoroacetate also occurs naturally in about 40 plant species in Australia.

Levels of monofluoroacetate can reach very high levels in these plants. For example, air-dried leaves of *Gastrolobium bilobum* (heart-leaf poison) and *G. parviflorum* (box poison), two Australian plants, can contain up to 2600 mg kg^{-1} of monofluoroacetate, and seeds of *G. bilobum* can have in excess of 6500 mg kg^{-1} of monofluoroacetate (Twigg 1994; Twigg et al. 1996a; Twigg et al. 1996b; Twigg et al. 1999). The highest monofluoroacetate concentration so far reported from a plant is 8000 mg kg^{-1} in the seeds of the East African *Dichapetalum braunii* (O'Hagan et al. 1993).

Most studies assessing monofluoroacetate concentrations in plants have focused on those species that are overtly toxic to mammals. However, it would appear that the ability of plants to synthesise monofluoroacetate is more widespread than generally supposed, since monofluoroacetate occurs at extremely low concentrations in some Finnish plants (Vartiainen & Kauranen 1980), in tea leaves (Vartiainen & Kauranen 1984) and guar gum (Vartiainen & Gynther 1984; Twigg et al. 1996b). In addition some plants, when exposed to fluoride ions, can biosynthesise fluoroacetate, albeit at very low levels. Fluorocitrate, the toxic metabolite of monofluoroacetate, has also been detected in tea leaves (Peters & Shorthouse 1972). Fluoroacetate biosynthesis can also occur in some bacteria, notably *Streptomyces cattleya* (O'Hagan & Harper 1999). Resistance in mammals, birds, and insects occurs in areas where there is continued exposure to the toxin. Interestingly, the caterpillar moth, *Sindrus albimaculatus*, which feeds on *Dichapetalum cymosum*, can not only detoxify fluoroacetate, but also accumulate it (probably in vacuoles) and uses it as a defence against predation (Meyer & O'Hagan 1992).

This section is from Eason & Wickstrom (2001).

1.7 Toxicology and pathology

1.7.1 Mode of action

Monofluoroacetate is converted within animals to fluorocitrate, which inhibits the tricarboxylic acid cycle. This results in accumulation of citrate in the tissues and plasma, energy deprivation, and death. Synthesis of fluorocitrate occurs in the mitochondria, and the fluorocitrate formed inhibits mitochondrial aconitate hydratase. There is also evidence to suggest that fluorocitrate inhibits citrate transport into and out of mitochondria, and that fluorocitrate has an inhibitory effect on succinate dehydrogenase. The high levels of citrate concentration that occur during monofluoroacetate intoxication can also have an inhibitory effect on the glycolytic enzyme, phosphofructokinase.

Death from monofluoroacetate poisoning is caused by the inhibition of energy production which, in turn, results in either cardiac or respiratory failure. Fluorocitrate is commonly described as a specific metabolic inhibitor of glial cells in the brain. Glial cells are thought to be important for extracellular fluid ion and pH regulation, and the control of breathing (Erlichman et al. 1998).

This section is from Eason & Wickstrom (2001).

1.7.2 Pathology

Known target organs in animals following 1080 exposure include the heart, lungs, liver, kidney, testes, and foetus (Annison et al. 1960; McTaggart 1970; Buffa et al. 1977; Sullivan et al. 1979; Schultz et al. 1982; Trabes et al. 1983; Chung 1984; Savarie 1984; Twigg et al. 1988; Chi et al. 1996; Gregg et al. 1998; Eason et al. 1999). The pathological changes observed at post-mortem appear to be largely the result of progressive cardiac failure with congestion of the abdominal viscera and lungs. Examination of monofluoroacetate-poisoned mammals usually reveals cyanosis of mucous membranes and other tissues. Diffuse visceral haemorrhage has been described in some animals, particularly cattle. Subepicardial haemorrhages on the epicardium and endocardium as well as on the epiglottis and trachea have been observed in sheep and possums poisoned with monofluoroacetate. The presence or absence of tissue damage is likely to be dose-related, and subepicardial haemorrhages have been observed in rabbits receiving a lethal dose of monofluoroacetate but not in those receiving a sub-lethal dose. It is apparent that the target organs vary to some extent in different species, which may relate to the citrate response in different species, or the metabolic activity in different tissue. In birds a target organ appears to be wing muscle (Ataria et al. 2000) as well as the heart, which is a more common target in other species.

This section is from Eason & Wickstrom (2001).

1.7.3 Absorption, metabolism, and excretion

Sodium monofluoroacetate (1080) is absorbed through the gastrointestinal tract or via the lungs if inhaled. Monofluoroacetate is not readily absorbed through intact skin, but it can be absorbed more readily through cuts and abrasions.

After oral or intravenous dosing of laboratory rodents, 1080 is rapidly absorbed and distributed through the soft tissues and organs (Hagan et al. 1950; Egeheze &

Oehme 1979; Sykes et al. 1987). This contrasts with the action of commonly used anticoagulant rodenticides, such as brodifacoum, which preferentially bind to liver cells (Bachmann & Sullivan 1983). Sodium monofluoroacetate is excreted as unchanged fluoroacetate and a range of non-toxic metabolites (Gal et al. 1961; Schaefer & Machleidt 1971). Approximately 30% of a dose of 1080 administered to rats was excreted unchanged in the urine over 4 days (Gal et al. 1961). At least seven unidentified metabolites other than fluoroacetate and fluorocitrate, the toxic metabolite of 1080, were also detected in rat urine (Gal et al. 1961).

Administration of ^{14}C-labelled fluoroacetate to rats showed that fluorocitrate, the toxic metabolite of 1080, accounted for only 3% of the radioactivity (Gal et al. 1961), and this was confirmed by Schafer & Machleidt (1971). The major metabolite, unlike fluorocitrate, does not inhibit the activity of aconitase (Gal et al. 1961). Phillips & Langdon (1955) suggested that the unidentified metabolites include non-saponifiable lipids that probably serve as intermediates for cholesterol, and some radioactivity was found in fatty acids and cholesterol in the liver. Up to 3% of the radioactivity appeared as respiratory CO_2, which implied cleavage of the C-F bond (Gal et al. 1961).

Defluorination of 1080 or its metabolites, including fluorocitrate, has been demonstrated in animals and other living organisms (Kirk & Goldman 1970; Smith et al. 1977; Egeheze & Oehme 1979; Soifer & Kostyniak 1983, 1984; Twigg et al. 1986; Tecle & Casida 1989). Although fluoride is extensively excreted, primarily in urine, some deposition occurs in bone (Sykes et al. 1987; Eason et al. 1993a; Eason et al. 1993b; Rammell 1993; Eason et al. 1994b).

This section is from Eason & Wickstrom (2001).

2. Fate in the Environment

1080 in baits may be defluorinated in 1–2 weeks under favourable conditions. However, under less favourable conditions breakdown may take several weeks and, in extreme cold and drought, 1080 residues could persist in baits for several months. The 1080 in certain gel block and paste baits, can still be present for up to 18.6 months, or >5000 mm of rain.

Degradation of 1080 is slow in soil and sediments, taking 1-4 weeks under favourable conditions. The rate of degradation will be influenced by the presence of soil or litter micro-organisms, and temperature, soil moisture and rainfall. Sodium monofluoroacetate is highly water soluble so leaching out of soil will occur.

While the concentration of 1080 in deionised (sterile) water remains relatively constant and independent of temperature, 1080 degradation occurs within 1-2 weeks in natural water. Temperature, and the presence of aquatic plants and microbes all affect 1080 degradation in aquatic environments. Water samples have been collected from streams following numerous pest control operations using 1080. 96.3% of these samples contained no residues of 1080. Where residues were found most of these had less than 1 $\mu g\ l^{-1}$ 1080. Where higher 1080 residues have been found in water, the samples were mostly from very small streams and/or associated with the presence of bait, during aerial operations.

While plants can take up 1080, it is unlikely to be in large amounts. If taken up, 1080 residues persist less than 38 days in plants.

1080 has a relatively short half-life in sub-lethally dosed animals and it is metabolised and eliminated from living animals within days. However, it can persist in carcasses for months. The rate of degradation of 1080 in carcasses will depend on moisture, temperature and the presence of micro-organisms.

2.1 Bait pathway

2.1.1 How long do baits remain toxic?

Under favourable conditions, e.g. 11 – 20°C and 8–15% moisture, 1080 may be significantly defluorinated in 1 – 2 weeks (King et al. 1994). Under less favourable conditions breakdown might take several weeks and, in extreme cold and drought, 1080 residues could persist in baits for several months.

Pellets

On land

Booth et al. (1999a) reported that 1080 began leaching out of Wanganui #7, 6 gram, 0.15% 1080 Pellets after 20 mm of simulated rainfall and that the 1080 declined to near the limit of detection after 250 mm simulated rainfall. Bowen et al. (1995) found that both 0.08% and 0.15% 1080 6 gm RS5 cereal pellets lost

1080 more quickly than equivalent 6 gm Wanganui #7 cereal pellets under simulated rainfall. The RS5 cereal pellets were less water resistant and started to disintegrate after approximately 5 mm of rain. 1080, at both concentrations, had been completely leached out of the RS5 cereal pellets after 150 mm rain.

When 10 - 12 g 0.15% 1080 Wanganui #7 cereal pellets were exposed to a simulated rainfall of 20 mm/hour, most of the 1080 concentration was retained after exposure to 50 mm of rain. The 1080 concentration rapidly declined in the pellets over the following 50 mm of rainfall. By comparison, the 1080 concentration in 10 - 12 g 0.15% RS5 pellets declined at a steady rate. By 100 mm the 1080 had completely leached out of both types of pellets (Thomas et al. 2004). The 10 - 12 g cereal pellets in this study retained more 1080 when exposed to <100 mm of simulated rain than the 6 g cereal pellets examined by Bowen et al. (1995).

Ogilvie et al. (2004) reported that Wanganui #7 pellets lying on the ground in the field had a 99% reduction in the 1080 concentrations after 56 days. Over this time period 110 mm of rain fell.

During trials on long-life baits, Morgan (2004) found that 0.15% 1080 Pellets with a double wax coating placed in Philproof bait stations took 9 months for the toxicant concentration to decline by 30%.

Bait breakdown was monitored during the 1990 Rangitoto Island and Waipoua Forest Sanctuary possum control operations. Aerially distributed 6 g 0.08% 1080 Pellets were used in the operations, and most baits had less than 10% of their original 1080 concentration after 28 - 29 days. However, some baits only reached 10% of their original toxic loading after 41 days (Eason et al. 1991a, 1991b).

Wright (2004) monitored the fate of 20 mm (12 g) 0.15% 1080 Wanganui #7 pellet baits at two sites during an 8600 ha aerial operation in the Hutt River upper catchment. On the day of application baits tested contained 1.43 g kg^{-1} 1080. After 29 days baits from the two sites contained 0.05 g kg^{-1} and 0.04 g kg^{-1}, and were still dyed green although damp and soft. Site one had received 30 mm of rain by this time and 70 mm for site two. After 40 days baits from both sites were pale green and had no detectable residues. Cumulative rainfall recorded by this time was 88 mm for site one and 186 mm for site two. Baits were still visible after 52 days, but by day 65 and 387 mm of rain they were not discernable at site two.

Thomas et al. (2004) analysed bait breakdown rates from data collected during 19 operations using 0.15% 1080 Wanganui #7 cereal pellets and 11 operations using 0.15% 1080 RS5 cereal pellets. Bait sizes used in the operations ranged from 3 – 12 grams. Most of the 1080 content, of both bait types, was removed following 150 – 200 mm of natural rainfall.

In water

Suren (2006) conducted laboratory experiments to examine the fate of pellet baits that fell into moving water and to quantify the rate that 1080 leached from the pellets. 0.15% 1080 Wanganui #7 pellets were placed in flow tanks that had a cobble base and water flowing through them at 20 cm s^{-1}. Eleven and 6 g baits were used in the experiment. Both bait sizes followed a similar pattern of breakdown. The baits remained relatively intact for the first 48 hours, but lost their bright green colour. After 72 hours the baits had become swollen and started to fragment. At 84 hours the baits had disintegrated. While baits

remained for up to 72 - 84 hours before they disintegrated, 1080 leached out of the baits far more rapidly. 1080 was rapidly lost from submerged baits within the first 8 - 12 hours. Fifty percent of the 1080 in the baits was lost after the baits had been submerged for 5 hours. By 24 hours, 90% of the original 1080 concentration had been lost, and no 1080 was detected in any baits after 36 hours.

Carrot

Thomas et al. (2004) subjected 12 g carrot baits containing 1.5 g kg^{-1} 1080 two different simulated rainfall treatments. The first treatment involved subjecting carrot baits to 20 mm hr^{-1} simulated rainfall starting 1 hour after the 1080 was applied. The 1080 in the carrot leached out of the carrot rapidly, with the carrot losing approximately 74% of the 1080 after 10 mm of simulated rainfall. In the second treatment, which was designed to be more representative of field operations, involved starting the simulated rainfall started 48 hours after the 1080 was applied to the carrot. The carrot in this treatment retained more than 60% of its 1080 concentration after 500 mm of simulated rainfall.

Bowen et al. (1995) reported that 6 g carrot baits containing 0.8 g kg^{-1} 1080 showed no decrease in 1080 concentration after 200 mm simulated rainfall.

Using data collected during five 0.8 g kg^{-1} 1080 carrot operations, Thomas et al. (2004) estimated that most of the 1080 content was lost from the baits following 200 mm of natural rainfall. The authors noted the results conflicted with the simulated rainfall studies. They suggested that the difference may have been a result of the carrots being present in the field for a longer period than the 2 day duration of the simulated rainfall trials. During this period the carrots would have been subjected to decay and microbial action, which may have contributed to the more rapid 1080 loss.

Blocks

Morgan (2004) reported that the concentration of 1080 in No Possums® 1080 gel blocks took 18.6 months to decline by 30% under field conditions.

Pastes

There was little loss of 1080 from Pestoff Professional 0.15% 1080 paste 49 hours after it was subjected 5 mm of simulated rain. Detoxification of Pestoff Professional 0.15% 1080 paste baits left on upturned spits took 80 days, but this was reduced to 40 days when the baits were buried (Morgan 2000). Pestoff possum paste buried in both dry and damp soil still retained significant concentrations of 1080 after 20 days (Ross & Henderson 2003).

When 10% 1080 Gel with a carbopol carrier was applied to broadleaf (*Griselinia littoralis)*, 90% of the 1080 was washed out of the baits by as little as 81 mm of rain (Batcheler & Challies 1988). Parkes (1991) found that when 10% 1080 Gel in a carbopol carrier was applied to mahoe (Melicytus ramiflorus) leaves, 95.2% of the 1080 had leached from the baits after 208 mm of rain. In contrast, 10% 1080 Gel with a petrolatum carrier is highly resistant to leaching, with 78.8% of the 1080 still remaining in the baits after 64 days and 208 mm of rain. Challies and

Thomson (1988) concluded that >5000 mm of rain was required to leach about 75% of the 1080 out of the baits.

Other

Seven months after 0.10% 1080 feral cat baits were handlaid on Raoul Island in August-September 2002, baits lying in the open were observed in good condition (S. Theobald pers. comm. 2003).

The concentration of 1080 in eggs injected with 1 mg 1080 egg^{-1} did not decline after 28 days at temperatures of 15 and 30°C (Spurr et al. 1998). Note: this product is not currently registered in New Zealand.

When 12000 kg of 1080 bait (11000 kg of 0.15% 1080 Wanganui #7 Pellets and approximately 1000 kg of 0.08% 1080 apple paste) was disposed on in a landfill site at Winton, central Southland, in August 1996 the 1080 concentration in the waste material showed a 90% decrease after 10 months (Bowman 1999).

2.1.2 How soluble is 1080 in natural water?

Sodium monofluoroacetate is highly water soluble and mobile (Parfitt et al. 1994).

Note: Solubility is the determining factor for the pesticide pathway beyond the bait.

2.2 Soil and sediment

2.2.1 What is the range of toxic residue levels observed in soil?

On the day 0.15% 1080 Pellets were handlaid in a field trial in the Tararua Forest Park, 0.01 mg kg^{-1} 1080 was detected in one of four litter samples. Following a field trial using 0.15% carrot baits in the Tararua Forest Park, litter samples had 1080 residues of between 0.0 - 0.6 mg kg^{-1} on the day the baits were laid and between 0 - 16 mg kg^{-1} seven days post poisoning (Spurr et al. 2002).

During 1997-98, 118 samples of soil were taken after three different aerial applications of Wanganui #7 0.15% 1080 Pellets. There were detectable, but low (mean 0.0092 mg kg^{-1}) 1080 residues in 6 of the soil samples taken from two of the three operations. The mean concentrations of 1080 in soil outside the two baiting areas appeared to be lower than those inside (Wright et al. 2002). During the same study, samples of leaf litter were also taken. There were low, but detectable, amounts of 1080 in the litter at Days 1, 5 and 30 post-baiting. The highest concentration found in a leaf litter sample was 0.19 mg kg^{-1} on Day 5 from inside one treatment area. All remaining leaf litter samples with detectable 1080 were below 0.01 mg kg^{-1} and were from up to 600 m outside one of the treatment areas. It was suggested that these 'outside' results were due to baits or fragments reaching the ground close to the sampling plots (Wright et al. 2002).

Soil samples (n=10) taken from two airstrips in 1997 had 1080 residues ranged from 0 – 0.0035 mg kg^{-1} (P Fisher pers. comm. 2004).

Soil from three tip/landfill sites was sampled for 1080 residues in 1996-97. The Balgownie landfill, Wanganui had 1080 residues ranged from 330 – 930 mg kg^{-1}

(n=2). Winton tip, central Southland had 1080 residues ranged from 50 - 1450 mg kg^{-1} (n=4) and at an unspecified landfill site 1080 residues ranged from 0.0008 - 3 mg kg^{-1} (n=11) (P Fisher pers. comm. 2004).

2.2.2 How long does degradation of 1080 take in soil or sediment?

Degradation of 1080 is slow in soil and sediments, taking 1-4 weeks under favourable conditions.

Laboratory studies on the biodegradation of 1080 have shown that it is defluorinated by soil micro-organisms (Walker & Bong 1981; Wong et al. 1992) and within soils themselves (David & Gardiner 1966; Parfitt et al. 1994). If 1080 is not degraded by micro-organisms present in most NZ soils, it is likely to be removed from soil by leaching (Parfitt et al. 1994).

During laboratory studies, 6.1 mg of 1080 (equivalent to one possum bait) was added to 14 g samples of Kaitoke silt loam. The time taken for the 1080 in the soil to decline by 50% was 10 days at 23°C, and 80 days at 5°C (Parfitt et al. 1994). The authors also reported that when 1080 was added to Conroy sandy loam the degradation was much slower under dry conditions than wetter conditions. In Conroy sandy loam with 20% water content, it took approximately 30 days for a 50% reduction in the 1080.

2.2.3 Are there environmental factors that affect degradation in soil?

The presence of soil or litter micro-organisms, and temperature, soil moisture and rainfall affect the rate of 1080 degradation in soil.

Some soil micro-organisms, e.g. *Pseudomonas* and *Fusarium* species, can metabolise 1080 (Walker & Bong 1981; King et al. 1994). However, not all micro-organisms can readily defluorinate monofluoroacetate and the rate of metabolism differs between species of soil bacteria and fungi (King et al. 1994). 1080 could be expected to persist in soil much longer in the absence of micro-organisms, however sterile soil is unlikely to occur naturally.

Temperature and soil moisture content affect the rate at which micro-organisms in soil degrade 1080. At lower temperatures/moisture content degradation is slower and 1080 will persist in the soil longer (Parfitt et al. 1994). Studies have shown that substantial defluorination of 1080 occurs in soil at temperatures of 15 - 30°C and with moisture levels above 8.3%.

Rainfall is also a major factor in removing 1080 from soil due to 1080's water solubility. 1080 has a low preference for adsorption on soil minerals, so that 1080 in soil not removed by microbial action is likely to be leached (Parfitt et al. 1994).

Note: Environmental factors will determine how widely the breakdown times reported for specific sites can be applied. For example, because breakdown is significantly affected by temperature, rainfall, leaf litter, presence or types of micro-organisms, it may occur faster or slower than the time quoted in Section 2.2.2.

2.3 Fate in water

2.3.1 Where available, what is the range of toxic residue levels observed in natural water?

Between 1990 and 2011, 2537 water samples were been collected from streams following aerial 1080 pest control operations throughout New Zealand. The samples were taken within 24 hours of the bait being laid and after subsequent heavy rain. 96.6% of these samples contained no residues of 1080. Residues ranging from 0.1 – 9.0 µg l^{-1} were found in 86 samples but most of these had less than 1 µg l^{-1} 1080. These samples were mostly from very small streams and/or associated with the presence of bait. Six samples contained 1080 residues higher 2.0 µg l^{-1}. Four of these six samples were likely to have been as a result of inadvertent contamination (Booth et al. 2007; Wright 2011).

A water monitoring program following aerial 1080 (0.15% and 0.08% 1080 Wanganui #7 Pellets at 5 kg ha^{-1}) possum control operations on Mt Taranaki/Egmont in 1993-94, showed no detectable 1080 in 159 (1993) and 72 (1994) water samples from surface water or treated water supplies (Fowles & Williams 1997).

Following aerial possum baiting (0.08% 1080 Wanganui #7 Pellets) in Tararua Forest Park in 1993, 66 water samples from eight sites collected over 4 months had no detectable 1080 (limit of detection 0.3 µg l^{-1}) (Meenken & Eason 1995).

Following aerial rabbit baiting (pre-feed baiting and carrot baits containing 0.023% 1080, sowing rates from 16 – 60 kg ha^{-1} depending on rabbit densities) in Otago during 1992, streams and rivers were monitored for 4 weeks after the operation. 2 out of 29 samples contained measurable amounts of 1080 (0.3 and 0.6 µg l^{-1}). These samples occurred within 48 hours of bait application, and all subsequent samples were below the limit of detection (Hamilton & Eason 1994).

No 1080 was detected in 36 water samples taken from six streams over a 4 month period at Waipoua following aerial possum control using 0.08% 1080 Pellets sown at 5 - 6 kg ha^{-1} in 1990. After the 1990 aerial possum control operation using 0.08% 1080 Pellets at 14 kg ha^{-1} on Rangitoto Island 24 water samples were collected over 6 months from 2 surface water and 2 ground water sites. No 1080 was detected in any of these samples (Eason et al. 1992).

Meekin et al. (2000) monitored water in a stream at the bottom of 14 ha catchment for the presence of 1080 after 0.15% Wanganui #7 pellets had been handlaid in a at a rate of 10.7 kg ha^{-1}. Monitoring occurred at regular intervals over the 17 hours after the bait was applied and during a rain event two days after the bait was laid. No 1080 was detected in any of the 52 water samples taken.

Srinivasan et al. (2012) investigated the fate of 1080 released from baits during a rainfall event immediately following an aerial 1080 operation. In this field study, stream and soilwater was sampled in a 148.8 ha headwater catchment of the Inangahua River, on the West Coast, following the application of 0.15% 1080 Wanganui #7 pellets. The pellets were applied at a rate of 2.5 kg ha^{-1} within 24 hours of a rainfall event (28 mm in 8 hours, with an additional 100mm falling over the next 9 days). Water sampling occurred between 5 hours and 9 days after the 1080 was applied. The only stream sample that contained 1080 (at 0.1 µg l^{-1}) was collected 105 minutes after the rain started. None of the other 15 samples

contained 1080 residues. Soilwater samples were taken approximately 200 mm downhill from baits after 34.4, 57.0 and 60.6 mm of rain had fallen. 1080 residues in these soilwater samples ranged from 0.5 – 61 µg l^{-1}.

Concentrations of 1080 in bore groundwater surrounding a landfill site at Winton, central Southland, were measured following burial of 12000 kg of 1080 bait. 1080 was detected in 5 of 28 groundwater samples analysed (highest value 24 µg l^{-1}). The amount of 1080 in groundwater sampled 5 and 13 metres from the disposal site decreased until none was detected after 10 months (Bowman 1999).

2.3.2 How long does degradation of 1080 take in natural water?

1080 degradation will occur within 1 - 2 weeks in natural water. The overall degradation rate of 1080 in stream water, when measured in the laboratory, declined by approximately 25% in the first 24 hours. After this the rate of decline was temperature dependent (Ogilvie et al. 1995; Ogilvie et al. 1996).

Eason et al. (Eason *et al.* 1993b) showed that 1080 declined by approximately 70% in 1 day and dropped to below detectable limits in 4 days in aquaria containing plants and invertebrates.

In an aquarium study by Parfitt et al. (1994) 80 litre aquaria containing biologically active streamwater at 21 °C were spiked with 0.1 mg l^{-1} of 1080 (the equivalent to adding 2-3 pellets per aquarium). Water samples were taken from the tanks at 2, 24, 48, 72, 79, 101 and 141 hours after the addition of the 1080. The 1080 was eliminated from the aquaria water within 48 - 141 hours.

When 40 0.15% 1080 Wanganui #7 pellets were placed in a stream simulator with a 5 litre s^{-1} flow rate, 1080 concentrations at the outlet of the simulator peaked at 1.1 µg l^{-1} after 2 days and no residues were detected in the water after 8 days (Suren & Bonnett 2006).

Note: Natural/stream water implies the presence of aquatic plants, invertebrates and micro-organisms, and sediment.

2.3.3 Are there environmental factors that affect degradation in aquatic environments?

A number of factors affect the degradation of 1080 in aquatic environments. These include temperature, *the presence of aquatic plants and microorganisms, and flow and volume of the waterway*.

While the concentration of 1080 in deionised (sterile) water remains relatively constant and independent of temperature, the concentration of 1080 in stream water declines over time (Booth et al. 1999b). The rate at which 1080 degrades in stream water increases significantly as water temperature rises (Ogilvie et al. 1995; Ogilvie et al. 1996). The aquatic plants *Elodea canadensis* (Wright et al. 2001) and *Myriophyllum triphyllum* (Booth et al. 1999b) were found in laboratory trials to reduce the concentration of 1080 in water. In aquaria trials Parfitt et al. (1994) reported that the rate of 1080 degradation was dependent on the species of bactaria present.

Flow and volume of the waterway affect the dilution of 1080 in natural water, but are unlikely to significantly affect degradation at the low concentrations of 1080 that have been found in the environment.

Note: Environmental factors will determine how widely the breakdown times reported for specific sites can be applied. For example, because breakdown is significantly affected by temperature, pH, volume, still/running water, or presence or types of micro-organisms, it may occur faster or slower than the time quoted in Section 2.3.2.

2.4 Fate in plants

2.4.1 Is it likely that plants could take 1080 up in solution, based on molecular structure?

Many organic acids are phloem-mobile in plants so it is likely that 1080 can be taken up by plants.

2.4.2 Is there evidence that plants either take up or don't take 1080 up?

1080 uptake has been reported in a number of plants including: käpuka (New Zealand broadleaf, *Griselinia littoralis*) (Ogilvie et al. 1998), käramuramu (*Coprosma robusta*) (Ogilvie et al. 2006), puha (*Sonchus* spp.) (Miller et al. 2009), broad beans (David & Gardiner 1951), cabbage (*Brassica oleracea*) (David & Gardiner 1953), *Elodia canadensis* (Ogilvie et al. 1996), *Helianthus annus* (Cooke 1976), lettuce (Ward & Huskisson 1972), peanut (*Archis hypogeae*) (Preuss & Weinstein 1969), perennial ryegrass (*Lolium perenne*) (Ogilvie et al. 1998) and sugar cane (*Saccharum spp.*) (Hilton et al. 1969).

However, not all plants appear to take up 1080. No uptake of 1080 was reported in pikopiko (*Asplenium bulbiferum*) when single 0.15% 1080 Wanganui #7 pellets were placed at the base of pikopiko in the field, and the plants monitored for 1080 uptake (Ogilvie et al. 2006).

Where uptake occurs, it is unlikely to be in large amounts. Ogilvie et al. (1998) reported that rye grass took up only 0.015% of the available 1080 from pellets placed beside the grass. When single 0.15% 1080 Wanganui #7 pellets were placed at the base of käramuramu in the field, the maximum concentration of 1080 detected in the plants was 5 µg kg^{-1} of plant material. This concentration occurred 7 days after the bait was place beside the plants, and declined to 2.5 µg 1080 kg^{-1} plant material after 14 days (Ogilvie *et al.* 2006). In a similar field trial, Miller et al. (2009) placed a single 0.15% 1080 Wanganui #7 pellet at the base of puha plants. The highest level of 1080 detected in puha was 15 µg kg^{-1} of leaf material 3 days after the pellets were placed at the bottom of the plants. Note: in this study 1080 residues were recorded in puha that had been used as controls (i.e. no 1080 pellets placed beside them). The authors could not rule out that 1080 occurs naturally in puha and are currently undertaking further research to confirm this.

To put these figures in perspective, based on the peak concentration observed in ryegrass (0.08 g kg^{-1}), a 50 kg sheep would need to eat (using an LD_{50} of 0.4 mg kg^{-1}) about 250 kg of grass to have a 50% chance of dying from 1080 (Ogilvie et al. 1998). Using an LD_{50} of 2 mg kg^{-1} for humans, a 70 kg person would need to eat 28 tonnes of käramuramu or 9.3 tonnes of puha in one sitting to receive an LD_{50} and therefore a 50% chance of dying from 1080 (Ogilvie *et al.* 2006; Miller *et al.* 2009). Even to reach the chronic toxicity NOEL of 0.05 - 0.1 mg kg^{-1} day^{-1} a

person would need to consume 0.7 - 1.4 tonnes of 1080-containing käramuramu daily (Ogilvie *et al.* 2006).

A laboratory study by David & Gardiner (1951) showed that broad bean plants could take up fluoroacetate through their roots and subsequently become toxic to aphids feeding on them (i.e. 1080 acted as a systemic insecticide). However, 1080 concentrations in the plants necessary to kill the aphids were approximated 1 mg kg^{-1} of plant tissue, when applied to the plant through a cut tap-root. This is a much higher concentration of 1080 than any reported in field soil samples in the context of using 1080 baits for possum control.

Where fluoroacetate is distributed in plants is likely to vary as available publications report conflicting information. For example, in *Helianthus annuus*, ammonium fluoroacetate metabolites were rapidly translocated to the shoot with little accumulation in the roots (Cooke 1976). Conversely, sugarcane was found to strongly adsorb monofluoroacetate ion onto its roots with only minor translocation to leaves and stem (Hilton et al. 1969).

Even where 1080 uptake occurs in plants, most plants are relatively insensitive to the effects of 1080 (Bong et al. 1980). However, duckweeds have been shown to have a high sensitivity, with the growth of *Spirodela polyrrhiza* being totally inhibited by 0.5 mmol of 1080, and total growth inhibition of *S. oligorrhiza* and *Lemma minor* occurring at 1 mmol 1080 (Bong et al. 1980). Oxygen consumption in pea seedling roots was almost completely blocked when exposed to 10 mmol l^{-1} monofluoroacetic acid for more than 6 hours (Polter 1967).

Plants are capable of metabolising and degrading fluoroacetate (peanuts - Preuss & Weinstein 1969; lettuce - Ward & Huskisson 1972; *Dichapetalum cymosum* - Meyer & Grobbelaar 1991)

2.4.3 Where evidence exists for plant uptake, how long do residues persist?

The maximum length of time 1080 residues persist in plants is approximately 38 days (Ogilvie et al. 1998; Miller et al. 2009).

In a laboratory experiment by Ogilvie et al. (1998), single 0.15% 1080 RS5 pellets were added to the soil of pots containing either broadleaf or ryegrass. The 1080 residues in the plants were near the Method Detection Limit (MDL) after 38 days in broadleaf and 7 days in ryegrass.

Ogilvie et al. (2004) reported that after karamu took up 1080 during field trials, the concentration of 1080 in the plants decreased to zero at 28 days. The authors recommended that a withholding period of 30 days after an aerial application of 1080 could be adopted for plants within the operational area that are used for rongoa (medicinal) purposes.

When 0.15% 1080 Wanganui #7 pellets were placed beside puha plants in the field, 1080 that had been taken up by the puha was near the MDL after 28 days and below the MDL after 38 days (Miller et al. 2009). The authors suggested a withholding period of at least 38 days could be observed on harvesting wild grown puha immediately after an aerial 1080 operation. Note: in this study 1080 residues were recorded in puha that had been used as controls (i.e. no 1080 pellets placed beside them). The authors could not rule out that 1080 occurs naturally in puha and are currently undertaking further research to confirm this.

2.5 Animal residues

2.5.1 What is the range of toxic residue levels recorded for sub-lethally exposed animals?

A number of laboratory studies have measured 1080 residue levels in sub-lethally poisoned mammals, marsupials, birds and insects.

When sheep and goats were orally dosed with an aqueous 1080 solution at 0.1 mg kg^{-1} bw (equivalent to one-quarter of the published LD_{50} for sheep and less than a quarter of the LD_{50} for goats) the maximum 1080 residues recorded in plasma were 0.16 - 0.33 mg l^{-1} and 0.22 - 0.26 mg l^{-1} respectively. In the sheep, 2.5 hours after dosing the mean 1080 concentrations of were 0.098 mg l^{-1} in plasma, 0.042 mg kg^{-1} in muscle, 0.052 mg kg^{-1} in the heart, 0.057 mg kg^{-1} in the kidney and 0.021 mg kg^{-1} in the liver. The mean 1080 concentrations declined to less than 0.003 mg kg^{-1} in all tissues sampled 96 hours after dosing (Eason et al. 1994a).

A deer 'run down and killed' following a poisoning trial using 1080 carrot baits in 1958 had 1080 concentrations of 1.50 mg kg^{-1} in its meat, 0.47 mg kg^{-1} in the heart and 0.92 kg kg^{-1} in the liver (McIntosh & Staples 1959).

Rabbits orally administered a sub-lethal dose of 1080 at 0.1 mg kg^{-1} bw (equivalent to one-quarter of the published LD_{50}) and sampled at intervals after dosing had maximum 1080 concentrations of 0.121 – 0.167 mg l^{-1} in plasma, 0.019 – 0.025 mg kg^{-1} in muscle, 0.014 - 0.08 mg kg^{-1} in kidney and 0.001 – 0.002 mg kg^{-1} in liver (Gooneratne et al. 1995).

During both these studies the highest concentrations of 1080 residues were found in the blood/plasma, with moderate levels in muscle and kidneys, and lowest concentration in the liver (Eason et al. 1994a; Gooneratne et al. 1994).

When possums were orally dosed with an aqueous 1080 solution at 0.1 mg kg^{-1} bw the maximum 1080 residues recorded in plasma were 0.11 - 0.31 mg l^{-1} (Eason et al. 1993b).

In sub-lethally poisoned mallard ducks, a maximum concentration of 1080 was 12.95 mg ml^{-1} in serum and 8.01 mg g^{-1} in heart two hours after dosing with 8 mg kg^{-1} 1080 (Ataria et al. 2000).

Lyver et al. (2004) reported that five out of 8 captive long-finned eels fed 1080 contaminated possum muscle had sub-lethal residues of 0.0174 ± 0.0104 mg kg^{-1}, while three out of nine eels fed gut tissue containing 1080 had residues of 0.0306 ± 0.0220 mg 1080 kg^{-1} bw.

Two laboratory studies have looked at 1080 residues in sub-lethally poisoned terrestrial invertebrates. Booth and Wickstrom (1999) recorded a mean 1080 concentration of 5.51 mg kg^{-1} in ants (*Huberia striata*) one day after sub-lethally dosing them with 0.3 g 1080 kg^{-1}. Tree weta (*Hemideina crassidens*) dosed with 15 g 1080 kg^{-1} had residues of between 0.033 and 5.8 mg kg^{-1} (Eason et al. 1993b).

Suren & Bonnett (2006) exposed caged koura to single 6 g 0.15% 1080 Wanganui #7 baits for up to 8 days. The maximum recorded 1080 residue level in the viscera was 3.3 µg g^{-1} in an animal collected 1 day after being exposed to bait. The maximum recorded 1080 residue in tail muscle was 5 µg g^{-1} in an individual collected after 4 days exposure. The highest recorded total 1080 residue (viscera

+ muscle tissue) was 7.7 µg g^{-1} from an individual sampled 1 day after the bait was placed in its cage.

Animals have also been sampled during pest control operations to test for sub-lethal 1080 residues. These results are presented in Table 1.

24 hours after an aerial rabbit control operation (0.4 g kg^{-1} aerial carrot at 25 kg ha^{-1}) on Motuihe Island, Auckland in July 2002, 5 live cockles and 6 live marine mussels were tested for 1080 residues. None contained 1080 residues (VPRD 4928 - 4938).

During the February 2010 Egmont National Park aerial 1080 operation (0.15% 1080 Wanganui #7 pellets, 2.3 kg ha^{-1}) freshwater and marine mussels were monitored for 1080 residues. Freshwater mussels were sampled from 11 sites within the operational area. Marine mussels were sampled at 2 sites approximately 20 km from the operational area. No 1080 was detected in any of the samples (VPRD).

Note: The information in this section is derived from direct analyses for 1080 in animal tissues, from animals known to have received a sub-lethal dose of 1080. Analyses of associated metabolites (e.g. citrate, fluorine) in tissues are difficult to compare directly with analysis of 1080 concentrations, so this information is not included.

TABLE 1. 1080 RESIDUE LEVELS RECORDED IN SUB-LETHALLY EXPOSED ANIMALS DURING PEST CONTROL OPERATIONS.

SPECIES	SAMPLE TYPE	RESIDUES (mg kg^{-1})	REFERENCE
Arthropods			
Beetles	Mixed samples	<0.1	1
Invertebrates (various)	7 mixed samples	0.0-0.75	2,3

1 Spurr et al. (2002); 2 Eason et al. (1991b); 3 VPRD.

2.5.2 How long do toxic residues of the pesticide persist in sub-lethally exposed animals?

Rabbits given sub-lethal doses of 1080 showed rapid elevation of plasma 1080 in the first hour post dose. Plasma 1080 concentration then declined rapidly at first and slowly thereafter, with very little 1080 being detected in plasma at 6 hours. The sub-lethal dose was cleared from tissues within 3 hours (Gooneratne et al. 1995). Sub-lethally dosed goats and sheep rapidly eliminated 1080, with only traces detected after 18 hours in goat plasma, and after 96 hours in sheep plasma and tissue (Eason et al. 1994a). Gooneratne et al. (2008) reported serum 1080 concentrations in ewes dosed with 0.30 mg kg^{-1} were undetectable 3 days after dosing and no 1080 was detected in the skeletal muscle, kidneys of liver of animals that survived for 14 days after dosing. In possums only traces of 1080 were detected possum plasma 24 hours after receiving a 1 mg kg^{-1} sub-lethal dose. All traces of 1080 were eliminated from the tissues of the rabbits, possums, goats and sheep within one week (Eason & Gooneratne 1993). A withholding period of 5

days has been suggested as adequate for animals suspected to have received a sub-lethal dose of 1080 (Gooneratne et al. 2008).

Mallard ducks dosed with a 8 mg 1080 kg^{-1} sub-lethal dose substantially eliminated the 1080 from heart muscle and blood within 24 hours (Ataria et al. 2000).

Tree weta orally dosed with 15 µg 1080 g^{-1} eliminated >90% of the 1080 within 4 - 6 days (Eason et al. 1993b). Ants dosed with 0.3 g 1080 kg^{-1} still had detectable levels of 1080 (0.27 mg kg^{-1}) seven days after dosing (Booth & Wickstrom 1999).

1080 residues in sub-lethally poisoned koura decrease by a factor of five after eight days, presumably as a result of the animals metabolising or excreting the compound (Suren & Bonnett 2006).

Note: This information is derived from direct analyses for 1080 in tissues from animals known to have received a sub-lethal dose of 1080. Analyses of associated metabolites e.g. citrate, fluorine in tissues are difficult to compare directly with analysis of 1080 concentrations, so this information is not included

2.5.3 What is the half life of 1080 in sub-lethally exposed animals?

Data on the half-life of 1080 in blood and tissues are presented in Table 2.

TABLE 2. HALF LIFE OF 1080 IN PLASMA AND TISSUE.

SPECIES	SAMPLE TYPE	T ½ (hours)	REFERENCE
Sheep	Plasma	10.8	1
	Muscle	12.0	2
	Liver	3.0	2
Goat	Plasma	5.5	1
Possum	Plasma	9.1	3
Rabbit	Plasma	1.1	4
	Muscle	0.4	4
	Kidney	0.8	4
Mouse	Plasma	2.0	5
	Muscle	1.7	5

1 Eason et al. (1994a); 2 Rammell (1993); 3 Eason et al. (1993b); 4 Gooneratne et al. (1994); 5 Sykes et al. (1987).

2.5.4 What is the range of residue levels recorded in carcasses of animals killed by 1080?

In sheep dosed with a lethal amount of 1080 (200 µg kg^{-1}), the concentration of 1080 in the muscle of sheep sacrificed post-dosing reached a maximum of 111 µg

kg^{-1} in 4 hours and declined exponentially thereafter. In the liver a maximum concentration of 38 µg kg^{-1} was recorded at 2 hours with exponential decline thereafter (Rammell 1993). Sheep that died 22 – 25 hours after receiving a 0.30 mg kg^{-1} dose of 1080 had 1080 concentrations of 0.06 1- 0.75 µg g^{-1} in the heart, 0.058 - 0.72 µg g^{-1} in the skeletal muscle and 0.047 - 0.051 µg g^{-1} in the liver. In sheep that died 43 - 52 hours after dosing (0.30 mg kg^{-1}) the 1080 residues in skeletal muscle was 0.023 - 0.031 µg g^{-1}, but was undetectable in the heart and liver. The concentration of 1080 in the rumin contents of sheep that died within 24 hours of dosing was 0.15 - 0.27 µg g^{-1} (Gooneratne et al. 2008).

Residues in rabbits given lethal doses of 1080 (0.8 mg kg^{-1}) were measured in the liver, kidney and muscle at the time of death and at one, two and three weeks after death. The residue concentrations were highly variable, but concentrations measured at 3 weeks were generally lower than other sample times. The maximum residue concentrations were not specified (Gooneratne et al. 1995).

Burns & Connelly (1992) reported that residues of 1080 in the breast muscle of magpies (*Pica pica*) were dose depended, with higher doses resulting in higher 1080 residues. Additionally, within dose levels, birds that survived longer had lower residues. For birds that died within 24 hours of dosing, the mean concentration of 1080 in the breast muscle was 0.73 µg g^{-1} at a 1080 dose of 1.59 mg kg^{-1} b.w., 0.70 µg g^{-1} at a dose of 2.00 mg kg^{-1} b.w., 0.84 µg g^{-1} at a dose of 2.52 mg kg^{-1} b.w. and 1.16 µg g^{-1} at a dose of 2.52 mg kg^{-1} b.w. In birds that died the day after being dosed the concentrations in the breast muscle were: 0.23 µg g^{-1} (1.59 mg kg^{-1} b.w. dose), 0.39 µg g^{-1} (2.00 mg kg^{-1} b.w. dose), 0.50 µg g^{-1} (2.52 mg kg^{-1} b.w. dose) and 0.64 µg g^{-1} (3.17 mg kg^{-1} b.w. dose).

Ants (*Huberia striata*) lethally poisoned with sugar water containing 1.5 g 1080 L^{-1} had 1080 residues of 56 mg kg^{-1}, while ants lethally poisoned with 0.15% 1080 Wanganui #7 pellets had residues of 4.78 mg kg^{-1} (Booth & Wickstrom 1999).

1080 residues have also been recorded in animal tissues sampled from field situations. A summary of these 1080 residues is given in Table 3.

TABLE 3. 1080 RESIDUE LEVELS RECORDED IN CARCASSES IN NEW ZEALAND DURING PEST CONTROL OPERATIONS.

SPECIES	SAMPLE TYPE	RESIDUES (mg kg^{-1})	REFERENCE
Birds			
Blackbird	Muscle	0.014–5.9	1; 2; 3
Chaffinch	Muscle	0.14–3.3	1
Hedge Sparrow	Muscle	0.03	1
Kea	Muscle	0.46 – 2.9	1
Keruru / Kukupa	Muscle	0.01	1
Morepork	Muscle	0.01	1
California Quail	Crop	18 - 76	4
Rifleman	Abdominal cavity	0.016–0.863	1

SPECIES	SAMPLE TYPE	RESIDUES (mg kg^{-1})	REFERENCE
NI Robin	Muscle	0.37–3.80	5
Tomtit	Abdominal cavity	0.298–0.406	1; 2
	Muscle	0.28–4.2	
Tui	Muscle	0.012	1
Waxeye	Muscle	0.68	1
Weka	Muscle	0.012–4.3	1
Fernbird	Muscle	0.14 – 0.75	6
Marsupials			
Possum	Bone	0–0.01	1; 7; 8
	Liver	1.5–8.4	
	Muscle	0.003–2.3	
	Stomach	0.05–~70	
Mammals			
Cat	Muscle	0.06–1.24	1
Cattle	Stomach	0.04–9.1	1
	Muscle	0.003–0.46	
Deer	Stomach	8.7–35.9	1; 2; 3; 9
	Muscle	0.012–7.37	
	Heart	0. 85-8.12	
	Liver	0. 75-4.05	
Dog	Stomach	0.079–0.7	1
	Intestine	0.44	
	Muscle	0.014–0.41	
	Vomit	1.07	
Ferret	Muscle	0.004–13	1; 10; 11
Mouse	Liver	7.8–17.6	1
	Muscle	9.1–10.3	
Pig	Muscle	0.21	1
	Stomach	56	
Mammals			

SPECIES	SAMPLE TYPE	RESIDUES (mg kg^{-1})	REFERENCE
Sheep	Liver	0.04	1
	Muscle	0.023–0.3	
	Plasma	0.35	
	Stomach	0.009–0.27	
Stoat	Muscle	0.002–1.07	1; 9; 12; 13
	Stomach	0–0.146	
Invertebrates			
Bee	2 whole animals	0–10.8	1
Wasp	wasps	5–38	14
	larvae	66–255	
	Nest debris	17–96	

Variation in these residue concentrations will be due to: amount of 1080 ingested over what time, time taken to death variation between species and within individuals of that species

1 VPRD; 2 Speedy (2003); 3 Nugent et al. (2004); 4 Evans & Soulsby (1993); 5 Powlesland et al. (1999b); 6 van Klink et al. (2012); 7 Eason et al. (1991a); 8 Meenken & Booth (1997); 9 McIntosh & Staples (1959); 10 Gillies & Pierce (1999); 11 Heyworth & Norbury (1999); 12 Murphy et al. (1999); 13 Dilks & Lawrence (2000); 14 Eason et al. (1991b)

2.5.5 How long do residues of 1080 persist in carcasses of animals killed by the pesticide?

While 1080 is metabolised and eliminated from living animals it can persist in carcasses for months where it will degrade more slowly than indicated by the half-life in living mammalian metabolism. The rate of degradation of 1080 in carcasses will depend on moisture, temperature and the presence of micro-organisms.

The retention of 1080 in tissue was greater in rabbits dosed with a lethal dose than in those that received a sub-lethal dose. In this study 1080 was detectable (~0.03 mg kg^{-1}) in rabbit muscle 3 weeks after death following a lethal dose of 1080 (Gooneratne et al. 1995).

Tissue from possum carcasses monitored following possum and wallaby control on Rangitoto Island in 1990 still contained high 1080 residues 13 days after the operation. By day 28 the carcasses had significantly decomposed and consisted of pelts and bone so no further samples were taken (Eason et al. 1991a).

The mean concentrations of 1080 in possum stomachs and contents collected 75 days after the estimated date of death from 0.08% 1080 paste in May - June 1994 was 4.90 mg kg^{-1}. This was significantly less than the mean of 30.06 mg kg^{-1} in possum stomachs and contents samples taken on day 25 (Meenken & Booth 1997).

Wright (2004) monitored the fate of possum carcasses at two sites after an 8600 ha aerial 1080 operation in the Hutt River upper catchment in 2003. At site one the carcasses had lost most of their fur and were described as "very putrid" 52

days after the bait was applied, 156mm of rain had fallen by this time. By day 65 bones were exposed on carcasses at site two. The stomach remains of carcasses from both sites were tested at day 73 and found to contain 6 mg kg^{-1} and 13 mg kg^{-1} at sites one and two respectively. Cumulative rainfall recorded by this time was 231 mm for site one and 458 mm at site two. Three possum carcasses found downstream at about this time were contained 1080 residues of 6 mg kg^{-1}, 7 mg kg^{-1} and <MDL. A red deer carcass also found on the river bank contained 0.5 mg kg^{-1}. The last carcass tested for residues 178 days following the bait application was found to contain green dyed bait in its stomach but residue tests were <MDL.

Note: This information is derived from direct analyses for 1080 in tissues from animals known to have died from 1080 poisoning. Analyses of associated metabolites e.g. citrate, fluorine in tissues are difficult to compare directly with analysis of 1080 concentrations, so this information is not included.

3. Effects on Non-Target Native Species

Based on the few studies of native species available, and the large number of non-native species studied (Part 4) suggests 1080 is likely to be toxic to most native animals. There is wide variation in sensitivity between taxonomic groups with mammals more sensitive than birds and invertebrates (on a weight for weight basis). Sub-lethal effects have been demonstrated for native invertebrates in the laboratory. The small size of many native species (relative to the target pests) means that toxic baits used for pest control are capable of causing harm to almost any animal that eats the bait. Therefore the level of exposure to the bait becomes important in determining the effects on non-target native species in the field.

Most information on non-target exposure to 1080 bait relates to aerial poisoning as this is thought to be the "worst case scenario" for studying non-target effects. Hand laid baits are sometimes used to approximate aerial poisoning in studies. Bait station studies are scarce. It could be assumed that native species are not more at risk using bait stations than distributing the same bait type aerially.

There are records of a range of native bird species found dead after aerial poisoning operations and many of these individuals have contained residues of 1080. However when records are discounted from:

- operations which did not meet current bait quality standards (e.g. using unscreened, un-dyed carrot bait with berry fruit lures) or
- those animals which did not have detectable 1080 residues,

the Vertebrate Pesticide Residue Database (VPRD) 1994-2004 contains only 24 individuals representing 8 native species across all bait types used in aerial poisoning. No conclusions about population effects can be drawn from this information but it is useful to focus further studies. Some native species (mainly invertebrates) have contained 1080 residues when sampled, an indication of potential risk to insectivores from secondary poisoning.

Loss of individuals in a population of native species as a consequence of 1080 poisoning can have variable significance to the long term viability of the population depending on the context. Those animals with a large population and/or a high rate of increase can compensate for small loses. Poison-related mortality may be replacing deaths from predation or winter starvation. Threatened species usually have a poor ability to recover from additional mortality, making the consequences theoretically more concerning. Many studies to determine the effects of aerial poisoning on native non-target populations have been carried out over the last 20 years. Birds, particularly threatened species, and invertebrates have the most information, although the only reliably calculated mortality rate is that for kokako at 1.4% deaths per operation. There is limited information on other taxonomic groups e.g. reptiles, due to the difficulty in studying these species at sites where 1080 is used or to perceptions that they are unlikely to be exposed (e.g. aquatic organisms).

Eleven species of native bird have been intensively monitored, and several other bird species monitored using less precise techniques. None of these studies have identified population level mortality which threatens the viability of the species. All 87 kiwi, 73 kaka, 19 blue ducks and 15 kereru monitored through aerial poisoning operations using radio transmitters have survived. Four of 366 kokako have disappeared, 1 of 40 weka died, 1 of 18 morepork died and 4 of 23 fernbirds disappeared after poisoning. 14 out of 101 radio tagged kea have died during aerial 1080 operations. About 25 of 93 colour banded robins disappeared following poisoning. Mortality of tomtits was estimated to be 10-40% in one study. However both robins and tomtits were found to increase their nesting success to compensate in sites where the 1080 operation resulted in effective control of pests.

Invertebrate populations have been monitored in nine aerial poisoning operations and none have shown significant population effects on any species studied, nor is there evidence to suggest poisoned invertebrates are a significant factor in secondary poisoning of other animals. Long term monitoring of native land snails indicates substantial benefits to threatened populations in sites treated with aerial poisoning.

Limited monitoring of native frogs, NZ falcon, kakariki, short tailed bats and Australasian harriers do not indicate detectable mortality due to aerial poisoning.

The risks 1080 operations pose to aquatic species is considered very low. Fish are very tolerant to 1080. Additionally, 1080 contamination of water is rarely found during 1080 operations and is at an extremely low level when it has occurred. No mortality of longfin eels, köaro or upland bullies was observed during experiments where high densities of cereal 1080 pellets were placed in water just upstream of them. Eels and koura have survived experimental feeding of cereal 1080 pellets, and eels have survived feeding on possum tissue containing 1080. There have also been no detectable effects on aquatic invertebrate communities in field studies when 1080 baits were placed at high densities in streams.

3.1 Toxicity

3.1.1 What is the lethal dose (LD_{50}) range for each taxon?

The LD_{50} values available for native mammals, birds and arthropods are presented in Table 4. While there is no information for any native reptiles, amphibians, fish or molluscs, Section 4 has information on overseas species in these taxa which is useful.

TABLE 4. ACUTE ORAL TOXICITY OF 1080 FOR NATIVE TAXA.

SPECIES	LD_{50} (mg kg^{-1})	REFERENCES
Birds	Range: 8.00 - 9.25	
Silvereye	~ 9.25	1
Weka	~ 8.1	2
Mammals		
Short tailed bat	0.15 ('Worst case' LD value)	3
Invertebrates	Range: 42.00 - 91.00	
NZ ant	72.00 (24 h LD_{50}) 42.00 (48 h LD_{50})	4
Tree weta	91.00	4

1 McIlroy (1984); 2 McIntosh et al. (1966); 3 Lloyd and McQueen (2000); 4 Booth & Wickstrom (1999)

Aquatic Invertebrates

Based on sub-lethal exposure trials, Suren & Bonnett (2006) suggest that the 1080 LC_{50} for koura is relatively high.

3.1.2 Based on the mode of action, are there any taxa that are unlikely to be affected by 1080?

1080 is considered a broad spectrum toxicant although variation in LD_{50}'s and body size of animals suggests that some native species could survive low exposure to 1080. The susceptibility of a specific animal is linked to its metabolic rate (McIlroy 1994), so cold-blooded animals may be more tolerant to 1080 as their metabolic rate is likely to be much lower. Fish have been found to be highly tolerant of 1080 in overseas studies (Fagerstone et al. 1994).

3.1.3 Have sub-lethal effects on birds, mammals, reptiles/amphibians, fish, arthropods, or molluscs been described for 1080?

Reptiles/amphibians

An Australian study of shingleback blue tongued lizards (*Tiliqua rugosa*) found a decrease in testosterone levels in the plasma in study animals and a degeneration of seminiferous tubules in some individuals when high sublethal doses of 1080 were administered intraperitoneally (Twigg et al. 1988).

Invertebrates

A laboratory study of **ground weta** (*Hemideina thoracica*) by Hutcheson (1990) found poisoned animals, including those sub-lethally poisoned, became active

during the day rather than sheltering as is their normal behaviour demonstrated by a control group and a group which fed on non-toxic baits.

Cockroaches (*Blattidae*) that had eaten 1080 baits in a laboratory study appeared drugged and their normal response to predators was suppressed (McIntyre 1987).

Smith & Grosch (1976) studied the sub-lethal effects of 1080 on Bracon hebetor, a parasitoid wasp found in North America. They found egg production decreased after a single sub-lethal dose. There was also low hatchability of eggs laid in the first few days post dosing.

In compost worms (*Eisenia fetida*), used as an surrogate for native earth worms, cocoon production and the number of live juveniles decreased progressively as 1080 concentrations increased, particularly at 1080 concentrations in the soil of ≥100 mg kg^{-1} (O'Halloran et al. 2004). These soil concentrations were well above those that normally occur following the field use of 1080.

3.1.4 How much bait needs to be ingested for poisoning, based on pen trials with native species?

Based on the information given in section 3.1.1, the amount of bait native species need to ingest to be poisoned is given in Table 5.

TABLE 5. AMOUNT OF BAIT NEEDED TO BE INGESTED TO RESULT IN DEATH BASED ON LD_{50} FOR NATIVE SPECIES.

SPECIES	LD_{50} (mg kg^{-1})	AV. WEIGHT FEMALE (g)	AMOUNT OF 0.4g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 0.8g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 1.0g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 1.5g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 2.0g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 50g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 100g kg^{-1} BAIT (g) FOR LD_{50}
Birds									
Silvereye	9.25	13	0.30	0.15	0.12	0.08	0.06	0.002	0.001
Weka	8	700	14.00	7.00	5.60	3.73	2.80	0.11	0.06
Mammals									
Short-tailed bat	0.15	14	0.005	0.006	0.002	0.001	0.001	0.00004	0.00002
Arthropods									
NZ ant	42	0.002	0.00021	0.00011	0.00008	0.00006[b]	0.00004	0.000002	0.0000008
Tree weta	91	1	0.228	0.114	0.091	0.061	0.046	0.002	0.001

[a] Weights for birds from Heather and Robertson (1996) & weights of bats from Lloyd and McQueen (2000); [b] A single 6 g 0.15% 1080 pellet has enough toxin to deliver an LD_{50} dose to >100 000 ants with a mean bodyweight of 2 mg each (Booth & Wickstrom 1999).

Note: The LD_{50} values given in section 3.1.1 have been used in the calculations. The body weights used to calculate the amount of bait required for an LD_{50} are average weights of females, which are generally more susceptible to poisoning because of smaller body weight and physiological factors therefore a 'worst case scenario' for poisoning.

3.2 Exposure

3.2.1 What species (individual animals) have been reported as non-target deaths in field operations with 1080 use?

Individual animals have been found dead after aerial, handlaying and bait station operations using 1080 carrot and cereal pellet baits (Tables 6, 7 and 8). The information presented in the tables includes animals found dead, or assumed to have been lethally poisoned from the presence of 1080 residues. The information has been restricted to those operations where the basic performance standards could be verified.

No Possums 1080 Gel Bait in bait stations

One **Kea** (*Nestor notabilis*) was found dead approximately 60 metres away from a No Possums 1080 Gel Bait bait station with beak slash marks in the bait after a possum control operation in the Fox Valley (Stephen Robson pers. comm. 2008). **Kea** or **kaka** markings were also reported on 3 out of 170 No Possums 1080 Gel Bait bait stations removed approximately 26 months after they were placed in the field in the Perry Block, Gouland Downs (Kahurangi National Park) in 2008, although no dead birds were located (Deverell 2008).

38 **Rhytida snails** (*Rhytida patula/perampla*) and one **Powelliphanta** were found dead inside 867 No Possums 1080 Gel Bait bait stations removed approximately 26 months after they were placed in the field in the Gouland Downs (Kahurangi National Park) in 2008 (Deverell 2008).

No information on deaths after the use of other methods and bait types could be located.

TABLE 6. NON-TARGET NATIVE SPECIES DEATHS REPORTED DURING AERIAL OPERATIONS USING 0.08% or 0.15% CARROT BAITS (0.08% 1080 unless stated).

SPECIES	No. FOUND DEAD	No. OF OPERATIONS	No. OF CASES WHERE RESIDUES CONFIRMED	SOWING RATE (kg ha^{-1})		REF.
				Prefeed	Toxic	
Birds					15	
Morepork	2	2[a]	2		10 - 15	1
Tomtit	8	4 [a]	8		5	1; 2
Tomtit	3	1[b]	3		15	3
NI Robin	3	1 [a]	3		15	4
Kereru	6	3	1		15	1; 5; 6
Rifleman	5	1	5		15	1
Grey warbler	1	1	0		?	7
Tui	1	1	1	?	5	8
Weka[c]	1	1	1			9

[a] 1 of these operations was at Tahae (Pureora) where there is some evidence that the carrot was not screened adequately to meet bait specifications (Powlesland et al. 1999a); [b] In this operation the carrot bait was coated with deer repellent; [c] 0.15% 1080 carrot

Records of 1 tui and 1 whitehead from Kapiti island 1984 are not included above as there is some evidence that the carrot was below specs and the birds were not residue tested (Sherley 1992).

Records of robin, grey warbler, fantail, morepork, and Tomtit from 1978/79 not included above because carrot bait not to current quality standards.

1 Spurr & Powlesland (1997); 2 VPRD: T0171 & T1195; 3 Speedy (2003); 4 Powlesland et al. (1999a); 5 Greene (1998); 6 VPRD: T1223; 7 Greene (1998); 8 VPRD: T1809; 9 VPRD: 10210

TABLE 7. NON-TARGET NATIVE SPECIES DEATHS REPORTED DURING AERIAL & HANDLAID OPERATIONS USING 0.15% or 0.08% 1080 PELLETS.

SPECIES	No. FOUND DEAD	No. OF OPERATIONS	No. OF CASES WHERE RESIDUES CONFIRMED	SOWING RATE (kg ha^{-1})		REF.
				Prefeed	toxic	
Birds						
Silvereye	1	1[a]	1		2	1
Morepork	2	1[b]	1[c]		5	2; 3
Tomtit	5+[d]	2[a]	0[e]		5 - 7	2; 4
Weka	2	2[a]	2		3 - 5	5; 6
Weka	2	2[a,f]	1[g,h]		1	7; 8
Kakariki	2	1[a]	2	3	3	9
Kakariki	1	1	0[i]	2	2	10
Kereru	4	3[a]	1[j]		2 - 3	11
Kiwi	1	1[a,f]	0[i]		1	12
Kea	6	1[a]	6	3	2.5	13
Tui	1	1	0[i]	2	2	14
Fernbird	3	1[a]	3	2	1	15
Frogs						
Hochstetter's	1	1[a]	0[i]		7	16

[a] toxic loading of baits 0.15%; [b] toxic loading of baits 0.08%; [c] the second bird was not tested; [d] number found in second operation unspecified, assumed at least 1; [e] none of these birds were tested for residues; [f] baits handlaid; [g] this bird also had cyanide residues which is thought to be the cause of death; [h] the second bird tested negative, assumed to have come from handlaid treatment block – see Pestlink report 0203SND28; [i] tested negative; [j] two other kereru tested negative.

Note: 1 kokako record (Rotoehu 1994) omitted as baits were experimental (Spurr & Powlesland 1997; Flux & Innes 2001).

1 VPRD: T1534; 2 Spurr & Powlesland (1997); 3 VPRD: T0283; 4 Calder & Deuss (1985); 5 Walker (1997); 6 VPRD: T0169 & T2061; 7 VPRD: T1370 & T1467; 8 Pestlink: 0203SND12 & 0203SND28; 9 Rhodes et al. (2008); 10 VPRD 13305; 11 VPRD: T2061; 10206 & 1427; 12 VPRD: T1283; 13 VPRD: L23934, L23949, L35852, L41021, L41026 & L23948; 14 VPRD 13306; 15 van Klink et al. (2012); 16 McNaughton & Greene (1994).

TABLE 8. NON-TARGET NATIVE SPECIES DEATHS REPORTED DURING OPERATIONS USING 0.15% 1080 PELLETS IN BAIT STATIONS.

SPECIES	No. FOUND DEAD	No. OF OPERATIONS	No. OF CASES WHERE RESIDUES CONFIRMED	SOWING RATE (kg ha^{-1})		REF.
				Prefeed	Toxic	
Birds						
Kea	1	1	1		1	1
Tui	1	1	0[a]		?	2

[a] tested negative

1 VPRD: T0597; 2 VPRD: 8692.

3.2.2 In which species have residues of 1080 been detected following operations?

1080 residues have been detected in a number of living animals following aerial and handlaying operations using 1080 cereal pellets (Table 9).

24 hours after an aerial rabbit control operation (0.4 g kg^{-1} aerial carrot at 25 kg ha^{-1}) on Motuihe Island, Auckland in July 2002, 5 live cockles and 6 live marine mussels were tested for 1080 residues. None contained 1080 residues (VPRD 4928 - 4938).

During the February 2010 Egmont National Park aerial 1080 operation (0.15% 1080 Wanganui #7 pellets, 2.3 kg ha^{-1}) freshwater and marine mussels were monitored for 1080 residues. Freshwater mussels were sampled from 11 sites within the operational area. Marine mussels were sampled at 2 sites approximately 20 km from the operational area. No 1080 was detected in any of the samples (VPRD).

The information in this section includes the results of laboratory analysis from live animals captured or killed for sampling from treatment areas. Residues from animals found dead are presented in section 3.2.1 above. The information has been restricted to those operations where the basic performance standards could be verified.

TABLE 9. RESIDUES DETECTED IN LIVE NON-TARGET NATIVE SPECIES DURING AERIAL AND HANDLAID PEST CONTROL OPERATIONS USING 0.15% AND 0.08% 1080 PELLETS.

SPECIES	RESIDUES (mg kg^{-1})	No. OF SAMPLES	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
Birds					
Kiwi	0.011	1[d]		3[a]	1
Weka	4.35	1 [d]		5 [a]	2
Invertebrates					
Tree weta	66	1 [e]		5 [a]	3
Tree weta	8.6	1		5 [a]	4
Cave weta	32–130	4 [f]		5 [a]	3
Cave weta	4	1		5 [a]	4
Weevil	10	1			4
Kauri snails	0	4		5[b,c]	5; 6
Arthropods (mixed)	0.05–0.75	4		5[b,c]	5; 6
Spiders (mixed)	14	1g		5 [a]	3
Arthropods (mixed)	14-46	3h		5 [a]	3
Arthropods (mixed)	0-0.006	3		5[b]	7

[a] toxic loading of baits 0.15%; [b] toxic loading of baits 0.08%; [c] baits were handlaid; [d] faecal dropping sample; [e] 1 sample totalling 26 individuals collected from pitfall traps in treatment area; [f] four samples totalling 9 individuals; [g] 1 samples of 4 spiders, 2 collected from baits and 2 from pitfall traps; [h] 3 samples totalling 58 individuals collected off 1080 baits.

1 VPRD: T0819; 2 VPRD: T0169; 3 Lloyd & McQueen (2000); 4 Spurr & Berben (2004); 5 Pierce & Montgomery (1992); 6 VPRD: R004; 7 VPRD: 139 & 146

3.2.3 What evidence is there to suggest that use of 1080 causes, or doesn't cause, a population decline of native species at sites where it is used?

Aerial and hand laying operations using 0.15% or 0.08% 1080 Pellets

Birds

44 radio-tagged **great spotted kiwi** (*Apteryx haastii*) have been monitored through four 0.15% 1080 Pellet aerial operations and none died from 1080 poisoning (Table 10).

TABLE 10. GREAT SPOTTED KIWI MONITORED DURING AERIAL 1080 OPERATIONS USING 0.15% 1080 PELLETS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1994 (Aug) Gouland Downs	9	0		5	1
1994 (Dec) Karamea	7	0		5	2
2009 (Sept) Gouland Downs	8	0	1	2	3
2009 (Sept) Hawdon	20	0	1	2	4

1 Walker (1997); 2 Robertson et al. (1999); 3 S. Forder pers. comm. Pestlink: 0809GDB08; 4 Veltman & Westbrooke (2011)

A total of 131 **NI brown kiwi** (*Aptreyx mantelli*) have been monitored during aerial and handlaid 1080 pellet operations during 5 operations and none have died from poisoning (Table 11). Kiwi call count monitoring during the Waipoua operation did not indicate significant 1080 related mortality (Pierce & Montgomery 1992).

TABLE 11. NI BROWN KIWI MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% OR 0.08% 1080 PELLETS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1990 (June) Waipoua	5	0		5[a]	1
1990 (Sept) Waipoua	6	0		5	1
1995 Rewarewa	22	0		3[b,c]	2
2001 (Sept) Tongariro Forest	29	0		3[b]	3
2006 (Sept) Tongariro Forest	69	0	2	4	4

[a] toxic loading of baits 0.8 g kg^{-1}; [b] toxic loading of baits 1.5 g kg^{-1}; [c] baits were handlaid.

1 Pierce & Montgomery (1992); 2 Robertson et al. (1999); 3 Pestlink: 0203RUA06; 4 Pestlink: 0808RUA01.

46 **Rowi** (*Aptreyx rowi*) were monitored during an aerial 0.15% 1080 Wanganui #7 pellet operation at Okarito in November 1998 with no deaths being reported (Veltman & Westbrooke 2011). 19 Haast **tokoeka** (*A. australis*) were monitored during an aerial 0.15% 1080 Wanganui #7 pellet operation (2 kg ha^{-1} prefeed, 3 kg ha^{-1} toxic) in the Haast Kiwi Sanctuary in May 2001, with no deaths being recorded (H Robertson pers. comm.).

A total of 302 NI **kokako** (*Callaeas cinerea wilsoni*) has been exposed to this method and bait type over 13 operations and 2 have disappeared after poisoning

(Table 12). Between 1986 and March 1998, 366 kokako (including 6 juveniles) have been monitored through 31 aerial poisoning operations (of all bait types and toxins combined), although the number exposed and known to have survived is greater. Of the monitored birds, 4 have disappeared after poisoning, leading to a maximum estimate for kokako mortality of 1.4% per operation with a 5% chance that it will exceed 4% (Flux & Innes 1999).

TABLE 12. NI KOKAKO MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% OR 0.08% 1080 PELLETS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON[a]	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1986 Pureora Nth Block	16	0		10-12[b,d]	1
1986 Okahukura Forest	11	1		10-12[b,d]	1
1986 Meyers Farm (Pureora)	5	0		8-10[c]	1
1987 Pureora Nth Block	23	0		8[c,d]	1
1988 Mapara	3	0		10[c]	1
1988 Cowan WR/ Okahukura Forest	24	0		8-10[c]	1
1990 Waipoua	6	1e		5[c]	2
1990 Mapara	52	0		8[c]	3
1989 Moki Forest	12	0		9[c]	4
1990 Kaharoa Forest	24	0		[b]	5
1991 Mapara	48	0		8[c]	3
1992 Mapara	50	0		8[c]	3
1992 Kaharoa Forest	28	0		6[b]	6

[a] monitoring method assumes birds which disappear have died from poisoning; [b] toxic loading of baits 0.15%; [c] toxic loading of baits 0.08%; [d] These operations used 'mapua' surface coated cereal pellets which are no longer used; [e] this bird least fitted the basic assumptions of the monitoring method and probably should not have been included in the assessment- according to the authors.

1 Innes & Williams (1990); 2 Pierce & Montgomery (1992); 3 Bradfield (1993); 4 Spurr (1994b); 5 Speed (1992); 6 Speed (1993).

A total of 68 **weka** (*Gallirallus australis*) has been exposed to this method and bait type over 4 operations and 1 has died from poisoning (Table 13).

TABLE 13. WEKA MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% 1080 PELLETS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1994 Gouland Downs & Tennyson inlet	24	1		5	1
1994 Rotumanu	8	0		5	2
2000 Copland	8a	0		3	3; 4
2008 Turiwhate	28	1		5	5

1 Walker (1997); 2 Spurr & Powlesland (1997); 3 Van Klink & Tansell (2003); 4 Pestlink: 02/03SWS22; 5 Veltman & Westbrooke (2011).

A total of 12 radio tagged **morepork** (*Ninox novaeseelandiae*) has been exposed to this method and bait type over 4 operations and none have died from poisoning (Table 14). Call count monitoring at Waipoua did not indicate significant 1080 related mortality (Pierce & Montgomery 1992).

TABLE 14. MOREPORK MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% OR 0.08% 1080 PELLETS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1990 Waipoua	2	0		5[a]	1
1994 Gouland Downs & Tennyson Inlet[c]	7	0		5[b]	2
1998 Pureora	3[d]	0		5[a]	3

[a] toxic loading of baits 0.08%; [b] toxic loading of baits 0.15%; [c] six of the birds monitored were at Gouland Downs; [d] This study followed 28 radio tagged birds over 3 years. Significant natural mortality (18%) was observed over hard winters.

1 Pierce & Montgomery (1992); 2 Walker (1997); 3 Powlesland et al. (1999b).

A total of 59 **fernbirds** (*Bowdleria punctata*) has been exposed to this method and bait type over 3 operations and 7 have disappeared after poisoning (Table 15).

In the 2010 study in Ianthe Forest, 36 radio-tagged South Island fernbirds were monitored during an aerially applied 1080 cereal pellet operation. 5 birds dropped their transmitters, 1 was killed by a predator and 3 died from 1080 poisoning. Based on this, the mortality of fernbirds due to 1080 poisoning was estimated at 9.4% (2.4-22.6% 95% CI). The authors concluded that the impact of

aerial 1080 operations on fernbird numbers is small, and the survival and improved breeding success that would have resulted from introducted predators being reduced during the 1080 operation would have outweighed the losses (van Klink et al. 2012).

TABLE 15. FERNBIRDS MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% OR 0.08% 1080 PELLETS.

OPERATION	No. OF BIRDS EXPOSED	No.KILLED BY POISON	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1990 Waipoua	14[d]	0		5[a]	1
1994 Gouland Downs	9	4[c]		5[b]	2
2010 Ianthe Forest	36	3	1	2 [b]	3

[a] toxic loading of baits 0.8 g kg^{-1}; [b] toxic loading of baits 1.5 g kg^{-1}; [c] due to the banded birds not being roll called immediately prior to the poisoning this study was inconclusive about cause of disappearance; [d] includes 2 banded birds.

1 Pierce & Montgomery (1992); 2 Walker (1997); van Klink et al. (2012)

A total of 40 colour banded **NI robins** (*Petroica australis longipes*) has been exposed to this method and bait type over 2 operations and 10 have disappeared after poisoning (Table 16).

19 colour banded **SI robins** (*Petroica australis australis*) monitored during a prefed aerial 1080 operation at Silver Peaks, near Dunedin, all survived the operation (Table 16). A further 5 unbanded territorial birds monitored during this operation also survived (Schadewinkel & Jamieson 2012).

TABLE 16. ROBINS MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% 1080 PELLETS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON[a]	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1994 Gouland Downs	2	0		5	1
1998 Waitotara	38	10		4	2
2011 Silver Peaks, Dunedin	19	0	1.5	2	3

[a] monitoring method assumes birds which disappear have died from poisoning.

Not included here is monitoring of robins using the 5 minute count method which can only reliably detect very large population changes (Powlesland et al. 1999).

1 Walker (1997); 2 Powlesland et al. (1999b); 3 Schadewinkel & Jamieson (2012).

A total of 29 colour banded **NI tomtit** (*Petroica macrocephala toitoi*) have been monitored during two non-prefed aerial 1080 cereal pellet operations, with 1 bird disappearing (Table 17).

A monitoring study in Tongariro Forest (2001) using distance sampling found no significant difference in the mortality of tomtits between the treatment (2 kg ha^{-1} prefeed followed by 3 kg ha^{-1} 0.15% 1080 pellets) and non-treatment sites (Westbrooke et al. 2003). Distance sampling of tomtits also occurred during an aerial 1080 operation (2 kg ha^{-1} prefeed followed by 2 kg ha^{-1} 0.08% 1080 pellets) on Mt Pureora in 2003. There was no decline in male tomtits counts in this operation (Westbrooke & Powlesland 2005). These results led the Westbrooke & Powlesland (2005) to conclude that aerial poisoning operations using cereal pellets at low sowing rates causes "...little, if any..." short term impacts on tomtit populations.

Monitoring of tomtits using distance sampling has also been undertaken during two operations using cereal pellets coated with deer repellent. Oakes (2008b) monitored tomtits at three sites during an aerial 1080 pellet operation in Rotoaira Forest in 2007. The three sites were: a block where deer repellent coated 1080 pellets were used; a block where standard, uncoated pellets were used; and a non-treatment site where no possum control occured. Tomtit numbers declined by between 20 – 36% at all sites. This led the author to conclude some factor (possibly too long a time period between the pre and post control surveys) other than the use of the deer repellent or 1080 caused the decline. In 2008, tomtits were monitored during an aerial operation using deer repellent coated pellets (2 kg ha^{-1} prefeed followed by 2 kg ha^{-1} 0.15% 1080 pellets) in the Waianakarua Scenic Reserve southwest of Oamaru and at a nearby non-treatment site when no possum control occurred. At both these sites tomtits increased by similar amounts (~13%) during the post control monitoring (Oates 2008a).

TABLE 17. TOMTITS MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% OR 0.08% 1080 PELLETS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON[c]	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1998 Pureora	14	0		5[a]	1
2001 Tongariro	15	1		3[b]	2

[a] toxic loading of baits 0.08%; [b] toxic loading of baits 0.15%. 12 g baits used; [c] monitoring method assumes birds which disappear have died from poisoning.

Not included here is monitoring of tomtit using the 5 minute count method which can only reliably detect very large population changes (Powlesland et al. 1999).

1 Powlesland et al. (2000); 2 Westbrooke et al. (2003).

Whio (*Hymenolaimus malacorhynchos*) are unlikely to eat cereal pellet baits and their aquatic invertebrate prey are unlikely to be contaminated by 1080. However, studies have been done to determine their survival following aerial 1080 operations. There was no reduction in visual counts of whio in the Otira

valley after application of 0.15% 1080 Pellets at 6 kg ha^{-1} in 1989 (Spurr & Powlesland 1997). All 19 radio-tagged whio in Waihaha survived for at least four weeks following aerial application of carrot bait (0.08%) at 15 kg ha^{-1} (Greene 1998). None of 15 whio monitored during a pre-fed aerial 0.15% 1080 Wanganui #7 pellet operation at Oparara, West Coast died (Veltman & Westbrooke 2011).

A total of 35 radio tagged **Kaka** (*Nestor meridionalis*) have been exposed to this method and bait type over 2 operations and none have died from poisoning (Table 18). Additionally, 38 radio tagged birds have been exposed to 0.08% carrot baits over 2 operations and none have died from poisoning (Greene 1998; Powlesland et al. 2003).

TABLE 18. KAKA MONITORED DURING AERIAL 1080 OPERATIONS USING 0.15% 1080 PELLETS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1998 Windbag	15	0		5	1
2001 Waipapa	20	0		5	1

1 Powlesland et al. (2003).

Kereru (NZ pigeon/kukupa) (*Hemiphaga novaeseelandiae*) have not been monitored individually when exposed to this method and bait type. However none of six birds ate non-toxic cereal pellets offered in a trial on Kapiti island (Spurr & Powlesland 1997). Monitoring of kereru during 5 aerial 1080 operations using cereal pellets did not detect population changes using the five minute count method (Spurr & Powlesland 1997). Additionally, all 15 radio tagged birds exposed to an aerial 1080 operation using carrot bait survived (Powlesland et al. 2003).

NZ falcon (*Falco novaeseelandiae*) have not been monitored individually when exposed to this method and bait type. However falcon territories have remained occupied, presumably by the resident birds, during four aerial 1080 operations using cereal pellets (Pureora 1984, Mapara 1990-92) and one using carrot bait (Waihaha 1994) (Spurr & Powlesland 1997). The total number of falcon involved in this monitoring is about 13, although the Mapara birds (3 pair) were exposed in three consecutive years (Calder & Deuss 1985; Bradfield 1993; Greene 1998). Seaton et al. (2009) collected productivity data from 87 falcon nests in Kaingaroa pine plantation during three breeding seasons, 2003 - 2006. During this time 1080 pellets and carrots were ground laid or aerially applied in forest compartments where falcon bred. The numbers of chicks successfully fledged was not related to time since 1080 application (1 month to >3 years), application method or bait type. During the study the breeding falcon population increased from 20 to 36 pairs, leading to the authors concluding that 1080 did not have a negative impact on falcon, and probably had a positive impact by reducing predation pressure on the falcon.

Kakariki (parakeet) (*Cyanoramphus spp.*) nests have been monitored during two aerial cereal 1080 operations. Fifteen nests were monitored during the October 2007 Hurunui Valley operation and a further seven nests were monitored during a 1080 operation in the Dart Valley. Dead chicks in a failed nest in the Hurunui Valley operation contained 1080 residues and the female was not seen after the nest failed. All the monitored nests in the Dart Valley operation were successful, however two unmonitored Kakariki were found dead with 1080 residues in their tissues. The combined estimate of mortality of nesting parakeets from these operations was 2.27% (0.1-12 % 0.95 CI) (Rhodes et al. 2008). The authors concluded that while some Kakariki were killed during the 1080 operations, given the rate of nest predation observed in areas where no predator control was carried out, the net benefit from the 1080 operations was positive. No detectable impact could be determined through five minute bird count monitoring before and after four aerial 1080 operations using carrot or cereal pellet baits (Spurr & Powlesland 1997). Additionally following an intensively monitored aerial 1080 operation in Waihaha in 1994 using carrot bait, Greene (1998) observed "...kakariki remained common within the study area...".

Australasian harrier (*Circus approximans*) have not been monitored individually when exposed to this method and bait type. However no detectable impact could be determined through five minute bird count monitoring before and after an aerial 1080 operation using cereal pellets on Rangitoto island and "the small resident population was still seen...throughout the year following the poisoning" (Miller & Anderson 1992). Additionally, Pierce and Maloney (1989) found no evidence of dead harriers after aerial 1080 poisoning of rabbits in the McKenzie basin.

A total of 99 radio tagged **Kea** (*Nestor notabilis*) have been exposed to this method and bait type over 6 operations and 14 have died from poisoning (Table 19). Additionally, 2 radio tagged birds have been exposed to 0.08% carrot baits during 1 operation and none died from poisoning (Kemp & van Klink 2008).

TABLE 19. KEA MONITORED DURING AERIAL 1080 OPERATIONS USING 0.15% 1080 PELLETS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
Arawata Valley	10	0	1	4	1
Franz-Fox	17	7	3	2.5	1
Mt Arthur[a]	13	0	1	2	1
Hawdon[a]	10	0	1	2	1
Okarito[a]	37	7	1	2	2
Whangapeka[a]	12	0	1	2	2

[a] These operations were undertaken using the performance standards adopted by DOC in 2009

1 Veltman & Westbrooke (2011): 2 (J. Kemp pers. comm. 2011).

Reptiles/amphibians

Lizards and frogs were not monitored in any 1080 poisoning operations prior to 1994; however, none have been reported killed by 1080. Captive **McCann's skinks** (*Oligosoma maccanni*) ate non-toxic cereal pellets (RS5 and Agtech), especially when the baits were wet, but the level of consumption (0.01 - 0.02 g over 2 days) was probably insufficient for the animals to have received a lethal dose had the baits been toxic (Freeman et al. 1997).

The attractiveness of non-toxic RS5 cereal pellets (dyed green and lured with cinnamon) to wild **grand** (*Oligosoma grande*) and **Otago** (O. otagense) **skinks** were tested by Marshall and Jewell (2007). The baits were offered in two sizes – small pieces no larger than 6 mm and large baits (whole pellets). The baits were offered dry or wet. All bait types were sampled (licked, nudged or bitten) by both species of skink, with small pieces sampled more often than large baits. No animals tried to consume large pieces of cereal bait. However, 1/10 grand skinks and 3/20 Otago skinks consumed small, wet pellet fragments.

Monitoring of a population of **Archeys frog** (*Leiopelma archeyi*) in the Coromandel Ranges before and following application of 0.15% 1080 Pellets at 5 kg ha^{-1} in 1995, showed no decline in Archeys frog (Perfect 1996). **Hochstetters frogs** (*Leiopelma hochstetteri*) were counted at 3 sites pre- and post- application at 7 kg ha^{-1}, 1994 Hunua Ranges. 1 frog found dead immediately following poison operation tested negative for 1080. Fluctuations in frog numbers counts were influenced so strongly by short term environmental effects that any effect of the poison drop could not be detected (McNaughton & Greene 1994).

Bats

Short-tailed bats (*Mystacina tuberculata*) have not been individually monitored when exposed to this method and bait type. Lloyd (1994) offered non-toxic cereal pellets to captive bats and hand broadcast baits containing a fluorescent marker throughout an area known to be inhabited by bats and concluded "...short-tailed bats are unlikely to eat carrot or grain-based baits...". However short-tailed bats are possibly vulnerable to secondary poisoning because they are known to feed on arthropods that have been recorded feeding on 1080 baits and residues in these prey can in theory be enough to kill a bat (Lloyd & McQueen 2000).

In a study in Rangataua forest where 0.15% 1080 Pellets were aerially broadcast (3 – 5 kg ha^{-1}) over "...almost the entire winter range..." of the study animals, a total of 269 short-tailed bats were caught at their roost following poisoning and held for 48 hours to determine mortality or signs of poisoning. All animals survived and showed no signs of 1080 poisoning (Lloyd & McQueen 2000).

Fish

Native fish have not been monitored during 1080 operations. However, a field experiment has been conducted to study the impact of 1080 on longfin eels (*Anguilla dieffenbachia*), koaro (*Galaxias brevipinnis*) and upland bullies (*Gobiomorphus breviceps*). Four headwater streams were selected in the Mawhera Forest in the Grey Valley, West Coast. In each stream four sites were selected – 10 m and 100 m down stream, and 10 m and 100 m upstream from

where 1080 baits were to be placed in the stream. At each site 8 fish of each species were placed in individual cages. Fish mortality was recorded after 1 and 4 days. Baits (6.5 g, 0.15% 1080 Wanganui #7 pellets) were then placed in the streams at a density equivalent to a sowing rate of 25 – 30 kg ha^{-1} (this represented an extreme scenario of 10 x normal sowing rates). Fish survival was monitored 1 and 4 days after the bait was placed in the water. No fish died after the baits were added to the water, suggesting all three species were tolerant to 1080 in water at the concentrations used in the study (Suren & Lambert 2006).

Terrestrial invertebrates

Invertebrate populations have been monitored during eight 1080 aerial poisoning operations using cereal pellets. None of these studies suggest significant population effects on any species studied nor is there evidence to suggest poisoned invertebrates are a significant factor in secondary poisoning of other animals.

An extensive study of forest invertebrates found on 1080 baits by Sherley et al. (1999) found that at any time only a small proportion of baits had invertebrates on them, and the few individuals per bait represented a small section of the fauna present in the litter. The number of invertebrates recorded on baits in treatment grids declined when 0.15% 1080 Pellets were laid at 18 kg ha^{-1}, but started to return to original levels (relative to control grids) within 6 days of removal of the toxic baits. The reduction in invertebrate numbers did not extend further than 20 cm around a bait.

Another study by Spurr & Berben (Spurr & Berben 2004) hand laid 0.15% 1080 Pellets at 5 kg ha^{-1} to simulate aerial poisoning in Tararua Forest Park in 1999 and monitored the occupancy of artificial refuges by **tree weta** (*Hemideina crassidens*) and cave weta (*Isoplectron sp.*). No significant impact of bait application was found for these species nor was there any effect observed on numbers of **slugs, spiders** and **cockroaches** which also commonly used the same refuges.

No impact was detected on populations of **weta** in Waipoua Forest and all **cockroaches, centipedes, millipedes, kauri snails** and all but one **beetle** survived in enclosures with 0.08% 1080 Pellets (Pierce & Montgomery 1992).

Spurr (1994a) found no impacts on populations **of amphipods, ants, beetles, collembolans, millipedes, mites, slugs, snails, spiders** and **cave weta** at Puketi Forest or Titirangi Scenic Reserve where 0.08% 1080 Pellets were aerially applied at 5 kg ha^{-1}.

In Mapara where 0.08% 1080 Pellets were aerially applied in three consecutive years 1990-92, a comparison of invertebrate fauna showed a greater number of predatory insects in the treatment site, characteristic of a healthy forest, and more fungal eating insects in the non-treatment site, characteristic of unhealthy forest (Bradfield 1993).

A range of invertebrate species on Rangitoto Island were sampled using a range of collection techniques, before and after aerial poisoning with 0.08% 1080 Pellets at 12 kg ha^{-1}. No population effects were observed (Anon. 1990).

Aquatic invertebrates

In the early 1990's, the Taranaki Regional Council monitored aquatic invertebrates in streams before and after two aerial 1080 operations. No effect of the aerial 1080 operations on the invertebrate communities could be demonstrated. However, the post control samples were collected between 32 and 42 days after the aerial operation, and the sampling protocol could have resulted in any short-term reductions in invertebrate numbers being missed (Suren & Lambert 2006).

Suren and Lambert (2006) therefore conducted an experiment to assess the ecological impact of 1080 leaching from baits on aquatic invertebrate communities. The experiment was conducted in four streams in the Mawhera Forest in the Grey Valley, West Coast. In each stream four sites were selected – 10 m and 100 m down stream, and 10 m and 100 m upstream from where 1080 baits were to be placed in the stream. At each site invertebrate communities on 10 replicate rocks were quantified 4 days and 1 day prior to baits being placed in the stream. The invertebrate communities were dominated by Caddisflies (*Helicopyche, Pycnocentrodes, and Pycnocentria*), orthoclad midges, and the mayfly *Deleatidum*. Baits (6.5 g 0.15% 1080 Wanganui #7 pellets) were then placed in the streams at a density equivalent to a sowing rate of 25 – 30 kg ha^{-1} (this represented an extreme scenario of 10 x normal sowing rates). The invertebrate communities were re-sampled 1 day and 4 days after the bait was placed in the stream. No biologically significant effects on the invertebrate communities as a result of the 1080 were observed.

Aerial and hand laying operations using 0.08% and 0.15% carrot baits

Two **NI brown kiwi** (*Apteryx mantelli*) followed in a 0.08% 1080 carrot operation did not die from poisoning (Table 20). Additionally, 61 radio tagged birds have been monitored during 3 cereal pellet operations and none have died from poisoning (Pierce & Montgomery 1992 & Pestlink 0203RUA06).

Following a non-toxic bait trial on Kapiti Island in May 1993, when carrot containing the biomarker pyranine was aerially sown at 10 kg ha^{-1}, none of five **little spotted kiwi** (*Apteryx owenii*) droppings examined fluoresced (Lloyd & Hackwell 1993).

Other kiwi species have not been monitored during carrot operations but all 16 radio tagged **great spotted kiwi** survived aerial poisoning using cereal pellets in two operations (Walker 1997).

TABLE 20. NI BROWN KIWI MONITORED DURING AERIAL 1080 OPERATIONS USING 0.08% CARROT BAITS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1995 Tongariro Forest	2	0		?	1

1 Robertson et al. (1999).

A total of 44 **NI kokako** (*Callaeas cinerea wilsoni*) has been exposed to 0.08% 1080 carrot baits over 2 operations and none have disappeared after poisoning (Table 21). Between 1986 and March 1998, 366 kokako (including 6 juveniles) have been monitored through 31 aerial poisoning operations (of all bait types and toxins combined), although the number exposed and known to have survived is greater. Of the monitored birds, 4 have disappeared after poisoning, leading to a maximum estimate for kokako mortality of 1.4% per operation with a 5% chance that it will exceed 4% (Flux & Innes 2001).

TABLE 21. KOKAKO MONITORED DURING AERIAL 1080 OPERATIONS USING 0.08% CARROT BAITS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON[a]	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1993 Pureora Nth Block	10	0		10	1
1996 Pureora Nth Block	34	0		15	2

[a] monitoring method assumes birds which disappear have died from poisoning.

1 Speed et al. (1993); 2 Marsh (1996)

Twenty eight **Weka** (*Gallirallus australis*) were monitored during an aerial 1080 carrot operation at Turiwhate in Central Westland in August 2008. Non-toxic pre-feed carrot (12 g) were sown at a rate of 3 kg ha^{-1}. Ten days later toxic carrot (1.5 g kg^{-1} 1080) lured with orange was sown at 5 kg ha^{-1}. One bird died for 1080 poisoning (confirmed by residue testing). All the other birds survived for at least two months after the operation. The estimated mortality rate of weka during the operation was 0.2 - 17.8% (95% confidence intervals) (van Klink 2008). 5 minute counts of weka in the Copland valley operation in 1986 (20 kg ha^{-1} 0.2% screened carrot bait) found no detectable effect (Spurr 1988). During a non-toxic carrot bait trial on Kapiti Island in May 1993, carrot containing the biomarker pyranine was aerially sown at 10 kg ha^{-1}. 10 of 87 weka droppings examined following the drop fluoresced from the pyranine. Weka were observed feeding on the baits on several occasions (Lloyd & Hackwell 1993).

A total of 6 **morepork** (*Ninox novaeseelandiae*) has been exposed to this method and bait type over 1 operation and one has died from poisoning (Table 22). Additionally, all 12 radio tagged morepork survived aerial poisoning using cereal pellets over 4 operations (Pierce & Montgomery 1992; Walker 1997; Powlesland et al. 1999b).

TABLE 22. MOREPORK MONITORED DURING AERIAL 1080 OPERATIONS USING 0.08% CARROT BAITS.

OPERATION	No. OF BIRDS	No. KILLED BY	SOWING RATE (kg ha^{-1})	REF.

	EXPOSED	POISON	Prefeed	Toxic	
1996 Tahae (Pureora)	6	1[a]		15	1

[a] there is some evidence that the carrot was not screened adequately to meet bait specifications

1 Powlesland et al. (1998).

Seaton et al. (2009) collected productivity data from 87 **NZ falcon** (*Falco novaeseelandiae)* nests in Kaingaroa pine plantation over three breeding seasons, 2003-06. During this time 1080 carrots and pellets were aerially applied or ground laid in forest compartments where falcon bred. The numbers of chicks successfully fledged was not related to time since 1080 application (1 month to >3 years), application method or bait type. During the study the breeding falcon population increased from 20 to 36 pairs, leading to the authors concluding that 1080 did not have a negative impact on falcon, and probably had a positive impact by reducing predation pressure on the falcon.

Fernbirds (*Bowdleria punctata*) have not been individually monitored through aerial carrot operations. However two studies of a total of 23 banded birds exposed to aerial operations using cereal pellets failed to find 4 birds after poisoning. There was some delay in the post poisoning assessment in this study which meant the cause of the disappearance was inconclusive (Walker 1997).

A total of 53 colour banded **robins** (*Petroica australis*) has been exposed to this method and bait type over 2 operations and 15 have disappeared after poisoning (Table 23). Additionally, 40 colour banded birds have been monitored over two aerial poisoning operations using cereal pellets and 10 have disappeared (Walker 1997; Powlesland et al. 1999b).

TABLE 23. ROBINS MONITORED DURING AERIAL 1080 OPERATIONS USING 0.08% CARROT BAITS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON[a]	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1996 Tahae (Pureora)	22	12[b]		15	1
1997 Waimanoa (Pureora)	31	3[c]		10	2

[a] monitoring method assumes birds which disappear have died from poisoning.

[b] there is some evidence that the carrot was not screened adequately to meet bait specifications (Powlesland et al. 1999b).

[c] 1 bird also disappeared form the non-treatment site during the study period

Not included is monitoring of robins using the 5 minute count method which can only reliably detect very large population changes (Powlesland et al. 1999b).

1 Powlesland et al. (1998); 2 Powlesland et al. (1999a).

A total of 19 colour banded **tomtit** (*Petroica macrocephala*) has been exposed to this method and bait type over two operations and 16 have disappeared after

poisoning (Table 24). During the 1997/98 nesting season, tomtit pairs in the 1997 treatment area had high nesting success (80% of nests fledged chicks, mean of four fledglings per nest). Even so, by the following spring it seemed that the population had not recovered to its pre-poison level. (Powlesland et al. 2000).

TABLE 24. TOMTIT MONITORED DURING AERIAL 1080 OPERATIONS USING 0.08% CARROT BAITS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON[a]	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1996 Tahae (Pureora)	5[c]	5[b]		15	1
1997 Waimanoa (Pureora)	14	11		10	1

[a] monitoring method assumes birds which disappear have died from poisoning; [b] there is some evidence that the carrot was not screened adequately to meet bait specifications (Powlesland et al. 1999b);

[c] tomtit data in this study was opportunistically collected as part of a robin study. Only 2 of the birds were banded, no non-treatment area was used.

1 Powlesland et al. (2000).

A distance sampling study of an aerial operation in 2002 using carrot bait at 2 kg ha^{-1} found the tomtit population increased by over 60% between pre-poison (winter 2002) and post poison (winter 2003) (Hamilton 2004).

Westbrooke and Powlesland (2005) reported the results of distance sampling of tomtits carried out during three 2003 aerial carrot operations (Kokmoka Forest, Mohaka Forest and Waimanoa). In these operations prefeed carrots were sown at 3-5 kg ha^{-1} followed by 0.8% 1080 carrots sown at 3-5 kg ha^{-1}. Tomtit numbers declined by between 15 -47% during each of these operations.

During August-September 2006 transect counts of male tomtits were carried out during an aerial 1080 carrot operation in Aorangi Forest Park, to examine whether carrots with deer-repellent applied to them posed a risk to tomtits. The operation was divided into two blocks: a 1200 ha block where the toxic carrot was applied without deer-repellent, and a 9,800 ha block where the toxic carrot contained deer-repellent. Following pre-operation monitoring of the tomtits, both blocks were prefed at a rate of 3 kg ha^{-1}. 13 days later the toxic bait (0.8% 1080) was applied at a rate of 5 kg ha^{-1}. Post control, there was no decline in the number of tomtits recorded in either block. It was concluded that the addition of the deer-repellent to carrot baits did not pose an increased risk to tomtits (Ross 2007).

Blue duck (whio) (*Hymenolaimus malacorhynchos*) are unlikely to eat carrot baits and their aquatic invertebrate prey is unlikely to be contaminated by 1080. However two studies have been done to determine their survival following aerial 1080 operations. All 19 radio tagged blue ducks survived for at least four weeks following aerial application of carrot bait (0.08%) at 15 kg ha^{-1} (Greene 1998).

Additionally, there was no reduction in visual counts of blue duck in the Otira valley after aerial application of 0.15% 1080 Pellets at 6 kg ha^{-1} in 1989 (Spurr & Powlesland 1997).

A total of 38 radio tagged Kaka (*Nestor meridionalis*) has been exposed to this method and bait type over 2 operations and none have died from poisoning (Table 25).

Non-toxic carrot containing the biomarker pyranine was aerially sown at 10 kg ha^{-1} on Kapiti Island in May 1993. Over the 11 days following the drop, 20 kaka were caught a total of 25 times and inspected for fluorescence due to the pyranine. Only one juvenile kaka showed traces of pyranine. A large number of kaka droppings were also inspected, but no fluorescence was observed (Lloyd & Hackwell 1993).

TABLE 25. KAKA MONITORED DURING AERIAL 1080 OPERATIONS USING 0.08% CARROT BAITS.

OPERATION	No. OF BIRDS EXPOSED	No. KILLED BY POISON[a]	SOWING RATE (kg ha^{-1})		REF.
			Prefeed	Toxic	
1994 Waihaha (Pureora)	21	0		15	1
2000 Whirinaki	17	0		10	2

Kaka monitored using 5 minute count method are not reported here because this technique cannot reliably detect population changes for kaka (Powlesland et al. 2003).

1 Greene (1998); 2 Powlesland et al. (2003).

Kereru (NZ pigeon/kukupa) (*Hemiphaga novaeseelandiae*) have been monitored using radio tagged individuals in one aerial operation using carrot bait (0.08%) at 10 kg ha^{-1} in Whirinaki. All 15 birds survived (Powlesland et al. 2003). Monitoring of kereru during 9 aerial 1080 operations using screened carrot bait did not detect population changes using the five minute count method (Spurr & Powlesland 1997).

During a non-toxic carrot bait trial on Kapiti Island in May 1993, carrot containing the biomarker pyranine was aerially sown at 10 kg ha^{-1}. Two kereru caught were examined for traces of pyranine, but none was observed. However, fluorescence due to pyranine was observed in one kereru dropping (Lloyd & Hackwell 1993).

NZ falcon (*Falco novaeseelandiae*) have not been monitored individually when exposed to this method and bait type. However falcon territories have remained occupied, presumably by the resident birds, during one aerial 1080 operation using carrot bait (Waihaha 1994) and four using cereal pellets (Pureora 1984, Mapara 1990-92) (Spurr & Powlesland 1997). The total number of falcon involved in this monitoring is about 13 although the Mapara birds (3 pair) were exposed in three consecutive years (Calder & Deuss 1985; Bradfield 1993; Greene 1998).

Kakariki (parakeet) (*Cyanoramphus* spp.) have not been monitored individually when exposed to this method and bait type. However no detectable

impact could be determined through five minute bird count monitoring before and after four aerial 1080 operations using carrot and cereal pellet baits (Spurr & Powlesland 1997). Additionally following an intensively monitored aerial 1080 operation in Waihaha in 1994 using carrot bait, Greene (1998) observed "...kakariki remained common within the study area...".

None of the three **tui** (*Prosthemedera novaeseelandiae*) and two **bellbirds** (*Anthornis melanura*) examined fluoresced, after non-toxic carrot containing the biomarker pyranine was sown at 10 kg ha^{-1} on Kapiti Island in May 1993. (Lloyd & Hackwell 1993).

Kea (*Nestor notabilis*) have been monitored using 2 radio tagged individuals in one aerial operation using carrot bait (0.08%) at 5 kg ha^{-1} in Hohonu Range. Both birds survived (Kemp & van Klink 2008).

Reptiles/amphibians

Lizards and frogs were not monitored in any 1080 poisoning operations prior to 1994; however, none have been reported killed by 1080. There has been limited population monitoring of aerial poisoning operations using cereal pellets but none using carrot baits.

The attractiveness of non-toxic carrot baits (dyed green and lured with cinnamon) to wild **grand** (*Oligosoma grande*) and **Otago** (*O. otagense*) **skinks** were tested by Marshall and Jewell (2007). The baits were offered in two sizes – small pieces no larger than 6mm and large baits (whole rounds of sliced carrot). Both bait sizes were sampled (licked, nudged or bitten) by both species of skink, with small pieces sampled more often than large baits. While the carrot baits were sampled, none were consumed.

Monitoring of a population of **Archeys frog** (*Leiopelma archeyi*) in the Coromandel Ranges before and following application of 0.15% 1080 Pellets at 5 kg ha^{-1} in 1995, showed no decline in Archeys frog (Perfect 1996). **Hochstetters frogs** (*Leiopelma hochstetteri*) were counted at 3 sites pre- and post- application at 7 kg ha^{-1}, 1994 Hunua Ranges. 1 frog found dead immediately following poison operation tested negative for 1080. Fluctuations in frog numbers counts were influenced so strongly by short term environmental effects that any effect of the poison drop could not be detected (McNaughton & Greene 1994).

Bats

Short-tailed bat (*Mystacina tuberculata*) have not been individually monitored when exposed to this method and bait type. Lloyd (1994) offered non-toxic carrot baits to captive bats and hand broadcast baits containing a fluorescent marker throughout an area known to be inhabited by bats and concluded "...short-tailed bats are unlikely to eat carrot or grain-based baits...". However short-tailed bats are possibly vulnerable to secondary poisoning because they are known to feed on arthropods that have been recorded feeding on 1080 baits and residues in these prey can, in theory, be enough to kill a bat (Lloyd & McQueen 2002).

In a study in Rangataua forest where 0.15% 1080 Pellets were aerially broadcast (3 – 5 kg ha^{-1}) over "...almost the entire winter range..." of the study animals, a total of 269 short-tailed bats were caught at their roost following poisoning and

held for 48 hours to determine mortality or signs of poisoning. All animals survived and showed no signs of 1080 poisoning (Lloyd & McQueen 2000).

Invertebrates

Invertebrate populations have been monitored in two 1080 aerial poisoning operations using carrot baits. None of these studies suggest significant population effects on any species studied nor is there evidence to suggest poisoned invertebrates are a significant factor in secondary poisoning of other animals.

No impacts on the numbers of ground-dwelling invertebrates caught in pitfall traps up to 1 year following aerial application of carrot bait at 15 kg ha^{-1} at Waihaha Forest in 1994 (Spurr 2000).

Powlesland et al. (2005) monitored invertebrate numbers every second or third month for a year before a 5 kg ha^{-1} 1080 carrot operation, and for two years afterwards. Numbers of tree weta (*Hemideina thoracica*), cave weta (*Pharmacus* sp. and *Isoplectron* sp.), cockroaches, spiders and harvestmen, and leaf-veined slugs (*Athoracophorus bitentaculatus*) did not decline substantially in refuges in the treatment area relative to those in the non-treatment area immediately after the poison operation. From the results, the authors concluded that aerial 1080 carrot operations are unlikely to have a detrimental effect on invertebrates that occupy cavities above ground.

An extensive study of forest invertebrates found on 1080 baits by Sherley et al. (1999) found that at any time only a small proportion of baits had invertebrates on them, and the few individuals per bait represented a small section of the fauna present in the litter. Each month between June to October 1995 and from April to October 1996, non-toxic carrot baits were sown at 18 kg ha^{-1} and observed for 7-10 days. Fewer invertebrates were found on non-toxic (green dyed, cinnamon lured) carrot baits than non-toxic cereal pellets. The number of invertebrates visiting the carrot baits increased as time progressed, from a low of 7% usage on day one to 17% on day three. There was no evidence that invertebrates found on baits were drawn from further than 20cm around a bait.

1080 pellets or carrot baits in bait stations

11 NI brown kiwi were monitored during a 1080 cereal bait station operation in September 2009 in Northland with no deaths being reported (P Graham pers. comm.).

No Possum® 1080 gel in bait stations

No information could be found on population effects. However some testing of non-toxic bait has been done with native species. Note that this study presented bait in open dishes rather than bait stations and the behaviour of captive animals is not always typical of those in the wild. There is also some field evidence that some native species (kea, kaka and snails) may feed on this bait.

Birds

Captive birds were offered bait on plastic dishes and wild birds were observed interacting with bait placed in bowls on tree mounted platforms and on the ground. None of three **kaka**, 4 **kereru** and 5 **kakariki** in captivity ate any bait. Two **brown kiwi** and 3 weka in captivity ate tiny amounts. A total of 87g of bait was eaten by 6 kea over the 2 days of the captive trial. **Bellbird, fantail, kereru, silvereye** and **tui** observed within 3m of the bait in the field study showed no interest while South Island **robin** investigated the bait briefly. Three **weka** were observed feeding on the bait placed on the ground during the field trial for a total of 16.9 minutes (Morgan 1999).

Reptiles

Of the 10 **Common skinks** (*Oligosoma nigriplantare*) offered non-toxic bait in captivity, 2 investigated the bait but none was eaten (Morgan 1999).

Bats

Of the 6 **short-tailed bats** (*Mystacina tuberculata*) offered non-toxic bait in captivity, none fed on it (Morgan 1999).

Invertebrates

Of the 8 **tree weta** (*Hemideina crassidens*) offered non-toxic bait in captivity, one fed on it briefly. Of the 8 **large land snails** (*Powelliphanta hochstetteri hochstetteri*) offered non-toxic bait in captivity, 3 fed on it. Of the 6 **ground beetles** (*Megadromus bullatus*) offered non-toxic bait in captivity, none fed on it (Morgan 1999).

Pestoff Professional Possum Paste (0.08% and 0.15%)

Birds

In pen trials at Orana park, Christchurch, kaka, brown kiwi, weka, kea, kereru and kakariki were offered BB13 and BB16 paste for two days. Kaka, brown kiwi, weka and kea all ate appreciable quantities (greater than 5.1 g of at least one of the paste types) (Morgan 1999).

All 14 monitored **NI brown kiwi** (*Apteryx mantelli*) survived exposure to 0.08% paste baits laid in Northland forest in 1995 (Robertson et al. 1999).

Bats

Captive short-tailed bats fed on non-toxic paste bait on all three nights that this food was presented. On average 5.73 g of paste was eaten (Morgan 1999).

Reptiles

Two out of 8 common skinks (*Leilopisma nigriplantare*) fed on non-toxic paste over two nights during laboratory trials. The total time spent feeding on the paste was 2.8 minutes (Morgan 1999).

Invertebrates

One out of 8 giant land snails (*Powelliphanta hochstetteri hochstetteri*) spent a total of 21.5 minutes feeding on non-toxic paste over two nights during laboratory trials. Two out of 10 weta (*Hemideina crassidens*) fed on non-toxic paste for a total of 5.9 minutes (Morgan 1999).

Bark beetles were observed feeding on 1080 paste in bait bags during a possum control operation at Mount Stanley, Nelson Marlborough Conservancy in April 2002. None were found dead (B. Mehrtens pers. comm.)

10% 1080 Gel

No information could be found

Cut apple bait

No information could be found on population effects. However some testing of non-toxic bait has been done with native species (Thomas et al. 2003). Note that this study presented bait in open dishes rather than bait stations and the behaviour of captive animals is not always typical of those in the wild.

Birds

Of 8 kereru offered non-toxic cut apple bait (green dyed, orange lured), none fed on it. The one kaka tested spent over 11 minutes per day on average feeding on the bait. Kakariki, silvereye and weka spent a similar time feeding on the bait. Four kea spent over an hour feeding on the bait. The authors concluded that this bait presented a risk to native birds and should only be used in bait stations (Thomas et al. 2003).

3.2.4 What evidence is there to suggest that 1080 use causes or doesn't cause a population decline of native species in aquatic ecosystems?

The effects of 1080 in aquatic ecosystems have not been well studied in New Zealand because the concentrations of 1080 observed in waterways have been negligible (see Section 2.3). Studies of 1080 toxicity to fish (non-native species see Part 4), suggest fish can tolerate concentrations many thousands of times higher than the highest ever recorded in water sampling after aerial poisoning operations.

Lyver et al. (2004) reported that there was no evidence captive longfinned eels would eat 1080 cereal pellets added to their water, nor was there any 1080 detected in eel tissue from water contaminated by baits. In the same study, eels did eat 1080 contaminated possum tissue but none died.

During trials by Suren & Bonnett (2006),1080 was not detected in any koura exposed to water containing 1080. While koura did eat Wanganui #7 baits, none died.

4. Effects on Domestic and Feral Animals

There is wide variation between species in their susceptibility to 1080 poisoning. Dogs are especially vulnerable and highly likely to die if they eat 1080 baits or scavenge animals killed by 1080. Larger animals such as cattle need several possum baits to receive a lethal dose but deaths have been reported where animals have access to baits, including those contained in bait stations.

Sub-lethal effects at realistic dose rates have been recorded in sheep and other species, typically affecting the heart. Exposure to prolonged high doses resulted in mild foetal abnormalities in pregnant rats and damaged sperm in male rats but no mutagenic properties were found. No antidote is currently available for 1080 poisoning although veterinary treatment can be successful.

Feral deer population mortality from aerial poisoning operations targeting possums is highly variable and does not appear to be consistently influenced by toxic loading, sowing rate, prefeeding or bait type. Most estimates of deer kill fall between 30 and 60%. Nugent et al. (2001) quote productivity figures for red deer populations of around 30% so low to moderate by-kill of deer populations is probably negated within a couple of years.

Birds are generally less susceptible to 1080 than mammals but introduced birds such as blackbirds and chaffinches are found dead after aerial poisoning operations. Lizards and fish appear quite tolerant of 1080, according to research on overseas species.

Although 1080 is toxic to bees, baits used in pest control are generally not attractive to bees. However this may not always be the case if bees are particularly hungry, so beekeepers should always be notified of operations.

4.1 Toxicity

4.1.1 What is the lethal dose range for each taxon?

The LD_{50} values for a range of domestic and feral animals are presented in Table 26. For completeness it includes information on species not present in New Zealand.

While no LD_{50} data is available, mortality rates of pregnant ewes exposed to 1080 are higher compared to non-pregnant ewes (O'Connor et al. 1999)

TABLE 26. ACUTE ORAL TOXICITY (LD_{50} mg kg^{-1}) OF 1080 FOR NON TARGET DOMESTIC AND FERAL ANIMALS.

SPECIES	LD_{50} (mg kg^{-1})	REF.
Birds	Range: 2.1 - 12.6	
Mallard duck (*Anas platyrhynchos*)	4.8	1
Pacific black duck (*Anas superciliosa*)	10.0	2
Maned duck (*Chenonetta jubatta*)	12.6	2
Common pigeon (*Columba livia*)	4.25	3
Leghorn hens (*Gallus gallus*)	10.0	4
White leghorn chicken[a]	7.5	5
Rhode Island red chicken	6.5	6
Plymouth rock chicken	5.5	7
Magpie (*Pica pica*)	2.12	8
Chukar partridge (*Alectoris graeca*)	3.51	3
Ring-necked pheasant (*Phasianus colchicus*)	6.46	3
California quail (*Callipepla californica*)	4.6	9
Silvereye (*Zosterops lateralis*)	9.25 approx	2
European goldfinch (*Carduelis carduelis*)	3.5 approx	2
Australian magpie (*Gymnorhina tibicen*)	9.9	2
House sparrow (*Passer domesticus*)	2.5	10
Marsupials	Range: 0.210 - 0.79	
Bennett's wallaby (*Macropus rufogriseus*)	0.21	11
Brush-tailed possum (*Trichosurus vulpecula*)	0.79	12
Dama wallaby (*Macropus eugenii*)	0.27	11
Mammals	Range: 0.06 - 8.3	
Dog (*Canis familiaris*)	0.06	7
Cat (*Felis catus*)	0.28	13
Ferret (*Mustela putorious*)	1.41	3
Rabbit (*Oryctolagus cuniculus*)	0.35	14
House mouse (*Mus musculus*)	8.3	15
Rat (wild) (*Rattus norvegicus*)	0.22-3.0	7

SPECIES	LD_{50} (mg kg^{-1})	REF.
Cattle (*Bos taurus*)	0.393	16
Deer (not specified)	0.5	17
Horse (*Equus caballus*)	0.32-1.00	18
Pig (*Sus scrofa*)	0.4	18
Sheep (*Ovis aries*)	0.25-0.64	18
Goat (*Capra capra*)	0.3-0.7	18
Reptiles/Amphibians	Range: 43.6 - >500	
Spotted grass frog (*Limnodynastes tasmaniensis*)	60	19
Bullfrog (*Rana catesbeiana*)	54.4	19
Leopard frog (*Rana pipiens*)	150	19
South African clawed frog (*Xenopus laevis*)	>500	19
Blue tongued lizard (*Tiliqua nigrolutea*)	336	19
Shingle-back lizard (*Tiliqua rugosa*)	206[b]	19
Gould's monitor (*Varanus gouldi*)	43.6	19
Fish	Range: 54 - 3500 mg l^{-1}	
Bream & bass (Not specified)	> 370[c]	20
Rainbow trout (*Oncorhynchus mykiss*)	54	21
Fingerling trout	>1000[d]	17
Harlequin fish (*Rasbara heteromorpha*)	3500[e]	22
Bluegill sunfish (*Lepomis macrochirus*)	>970[f]	21
Aquatic arthropods	Range: 0.05 - 3500 mg l^{-1}	
Daphnids (*Daphnia magna*)	350[g]	21
Mosquito larvae (*Anopheles quadrimaculatus*)	0.05-0.1 approx	23
Terrestrial arthropods	Range: 8 - 21	
Honeybee (*Apis mellifera*)	8	24
Housefly (Not specified)	21	25

[a] laying hens appeared to be more susceptible to 1080 poisoning than hens that were not laying; [b] non-tolerant populations from South Australia, Western Australian populations LD_{50} reported as 525 mg kg^{-1}; [c] survived indefinitely at this concentration; [d] survived this concentration; [e] substance tested was Fluoroacetamide (a compound related to 1080); [f] no effects observed at this level; [g] 48-hour EC_{50}

1 Hudson et al. (1972); 2 McIlroy (1984); 3 Tucker & Crabtree (1970); 4 Kalmbach (1945); 5 Cottral et al. (1947); 6 Ward & Spencer (1947); 7 Chenoweth (1949); 8 Burns & Connelly (1992); 9 Hudson et al. (1984); 10 Peacock (1964); 11 Munday (1978); 12 Bell (1972); 13 Eason & Frampton (1991); 14 McIlroy (1981); 15 McIlroy (1982); 16 Robison (1970); 17 Rammell & Fleming (1978); 18 Atzert (1971); 19 Eisler (1995); 20 King & Penfound (1946); 21 Fagerstone et al. (1994); 22 Bauermeister et al. (1977); 23 Deonier et al. (1946); 24 Booth & Wickstrom (1999); 25 Matsumura and O'Brien (1963).

4.1.2 How much bait needs to be ingested for poisoning, based on pen-trials with non-target feral and domestic species?

The amount of bait needed to be ingested by non-target domestic animals for poisoning is presented in Table 27 and for feral animals in Table 28.

Fish

No information relating to bait intake (oral LD_{50} values) could be found. Force-feeding cereal pellets containing approximately 4 mg of 1080 to two fingerling trout and five adult trout, and about 8 mg of 1080 to two adult trout had no visible effect (Rammell & Fleming 1978).

All toxicity values for fish reflect concentration of 1080 in water (LC_{50} values) which is more relevant when assessing likely risks to fish from possum baits. To achieve the 96 hour LC_{50} of 54 mg l^{-1} for rainbow trout, all the 1080 in 3.6kgs of 1.5 g 1080 kg^{-1} bait would have to leach out of the bait, and then remain in 100 litres of still water, without breaking down, for 96 hours. This is highly unlikely to occur in under pest control conditions in New Zealand.

TABLE 27. AMOUNT OF BAIT NEEDED TO BE INGESTED TO RESULT IN DEATH BASED ON LD_{50} FOR NON TARGET DOMESTIC ANIMALS.

SPECIES	LD_{50} (mg kg^{-1})	AV. WEIGHT FEMALE (g)	AMOUNT OF 0.4g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 0.8g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 1.0g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 1.5g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 2.0g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 50g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 100g kg^{-1} BAIT (g) FOR LD_{50}
Birds									
Chicken (*Gallus gallus*)	7.5	900	16.88	8.44	6.75	4.50	3.38	0.13	0.08
Mammals									
Cat (*Felis catus*)	0.28	2500	1.75	0.88	0.70	0.47	0.35	0.01	0.001
Cattle (*Bos Taurus*)	0.393	170000	167.03	83.51	66.81	44.54	33.41	1.34	0.67
Red Deer	0.5	80000	100.00	50.00	40.00	26.67	20.00	0.80	0.40
Dog (*Canis familiaris*)	0.06	8000	1.20	0.60	0.48	0.32	0.24	0.01	0.005
Goat (*Capra capra*)	0.3	35000	26.25	13.13	10.5	7.00	5.25	0.21	0.11
Horse (*Equus caballus*)	0.32	190000	152.00	76.00	60.80	40.53	30.40	1.22	0.61
Pig (*Sus scrofa*)	0.4	120000	120.00	60.00	48.00	32.00	24.00	0.92	0.48
Sheep (*Ovis aries*)	0.25	50000	31.25	15.63	12.50	8.33	6.25	0.25	0.13
Invertebrates									
Honeybee (*Apis mellifera*)	8	0.1	0.002	0.001	0.0008	0.0005	0.0004	0.00002	0.000008

The LD_{50} values given in section 4.1.1 have been used in the calculations and the average weights of females have been used, as females are generally smaller and therefore a 'worst case scenario' for poisoning. Where LD values were cited as greater (>) or less (<) than a value, this value was used to make the calculations.

TABLE 28. AMOUNT OF BAIT NEEDED TO BE INGESTED TO RESULT IN DEATH BASED ON LD_{50} FOR NON TARGET FERAL ANIMALS.

SPECIES	LD_{50} (mg kg^{-1})	AV. WEIGHT FEMALE (g)	AMOUNT OF 0.4g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 0.8g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 1.0g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 1.5g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 2.0g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 50g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 100g kg^{-1} BAIT (g) FOR LD_{50}
Birds									
Mallard duck (*Anas platyrhynchos*)	4.8	1100	13.20	6.60	5.28	3.52	2.64	0.11	0.05
Goldfinch (*Carduelis carduelis*)	3.5	15	0.13	0.07	0.05	0.04	0.03	0.001	0.0005
Australian magpie (*Gymnorhina tibicen*)	9.9	350	8.66	4.33	3.47	2.31	1.73	0.07	0.03
Chukar partridge (*Alectoris graeca*)	3.51	500	4.39	2.19	1.76	1.17	0.88	0.04	0.02
Common pigeon (*Columba livia*)	4.25	400	4.25	2.13	1.70	1.13	0.85	0.03	0.02
Pheasant (*Phasianus colchicus*)	6.46	1200	19.38	9.69	7.75	5.17	3.88	0.16	0.08
California quail (*Callipepla californica*)	4.6	180	2.07	1.04	0.83	0.55	0.41	0.02	0.01
House sparrow (*Passer domesticus*)	2.5	30	0.19	0.09	0.08	0.05	0.04	0.002	0.0008

SPECIES	LD_{50} (mg kg^{-1})	AV. WEIGHT FEMALE (g)	AMOUNT OF 0.4g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 0.8g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 1.0g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 1.5g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 2.0g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 50g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 100g kg^{-1} BAIT (g) FOR LD_{50}
Marsupials									
Brush-tailed possum (*Trichosurus vulpecula*)	0.8	3000	6.00	3.00	2.40	1.60	1.20	0.05	0.02
Bennett's wallaby (*Macropus rufogriseus*)	0.21	10000	5.25	2.63	2.10	1.40	1.05	0.04	0.02
Dama wallaby (*Macropus eugenii*)	0.27	3700	2.50	1.25	1.00	0.67	0.50	0.02	0.01
Mammals									
Red Deer	0.5	80000	100.00	50.00	40.00	26.67	20.00	0.80	0.40
Ferret (*Mustela putorious*)	1.41	650	2.29	1.15	0.92	0.61	0.46	0.02	0.01
Goat (*Capra capra*)	0.3	35,000	26.25	13.13	10.50	7.00	5.25	0.21	0.11
Mouse (*Mus musculus*)	8.3	20	0.42	0.21	0.17	0.11	0.08	0.003	0.002
Pig (*Sus scrofa*)	0.4	120,000	120.00	60.00	48.00	32.00	24.00	0.92	0.48
Rabbit (*Oryctolagus cuniculus*)	0.35	800	0.70	0.35	0.28	0.19	0.14	0.01	0.003

SPECIES	LD_{50} (mg kg^{-1})	AV. WEIGHT FEMALE (g)	AMOUNT OF 0.4g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 0.8g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 1.0g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 1.5g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 2.0g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 50g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 100g kg^{-1} BAIT (g) FOR LD_{50}
Rat (wild) (*Rattus norvegicus*)	0.22	220	0.12	0.06	0.05	0.03	0.02	0.001	0.0004

The LD_{50} values given in section 4.1.1 have been used in the calculations and the average weights of females have been used, as females are generally smaller and therefore a 'worst case scenario' for poisoning. Where LD values were cited as greater (>) or less (<) than a value, this value was used to make the calculations.

4.1.3 Based on the mode of action, are there any taxa that are unlikely to be affected by 1080?

No, all species appear to be susceptible to the mode of action of 1080. However, there is a wide variance in dose rates required to produce observable effects. This means the degree of exposure is important in assessing risk.

4.1.4 Have sub-lethal effects on birds, mammals, marsupials, reptiles/amphibians, fish, arthropods, or molluscs been described for 1080?

Domestic animals

Even small doses of monofluoroacetate result in myocardial damage in sheep, and this damage is cumulative with subsequent exposure (Annison et al. 1960). In sheep that received multiple sub-lethal doses of 1080, myocardial degeneration has been reported as well as necrosis of individual or small groups of myocardial fibres (Schultz et al. 1982). Researchers in Australia noted macroscopic lesions in the heart of sheep, described as acute multifocal injury to the myocardium, after doses as low as 0.11 mg kg^{-1} day^{-1} for 3–7 days. A dose of 0.1 mg kg^{-1} is approximately equivalent to a 30-kg sheep eating one 4 g 0.08% 1080 possum bait. Mild cardiac histopathology at doses of 0.055 mg kg^{-1} day^{-1} has been reported, but the duration of treatment was not specified (Whittem & Murray 1963).

O'Connor et al. (1999) orally administered groups of pregnant ewes with either single (0.25 mg kg^{-1}), or multiple (0.05 mg kg^{-1} over 3 consecutive days) doses of 1080 approximately two weeks prior to lambing as part of a trial on the toxicity of 1080 to pregnant ewes. The surviving ewes and their lambs were followed through to weaning. There were no differences in the ewe health, lambing percentages, lamb survival, or lamb growth rates between either of the 1080-dosed groups and a control (0 mg 1080 kg^{-1}) group.

In a study of the long-term effects of 1080 in sheep, 21 ewes that survived acute 1080 poison and a control group of 23 animals were monitored for two years (Gooneratne et al. 2008). No adverse effects on general health or condition were observed in any of the animals. There was no increase in the incidence of infectious or metabolic diseases in the 1080-exposed animals compared to the control group. The ewes were mated in both years. There was no difference in lambing percentage, lamb survival or mean lamb birth mass between the groups in either year. At the end of the study 10 ewes from each group were euthanased and post-mortemed. Tissue samples of the heart, brain, kidney, liver, lung, skeletal muscle rumen, abomasums, duodenum and ovaries were collected for histopathology. There were no grossly visible pathological lesions in the 1080-exposed ewes. Histopathological lesions were restricted to the heart and brain. There were scattered foci of fibrous tissue in the muscle of the heart. One animal had small, focal lesions in several regions of the brain, indicating chronic neuronal degeneration. The significance of the heart and brain lesions is uncertain in light of the lack of apparent adverse effects on general health and reproductive performance.

Glial cells in the brain are particularly sensitive to fluorocitrate (Erlichman et al. 1998; Hulsmann et al. 2000).

Feral animals

The results from three different, complementary tests (using laboratory rats and mice) indicate that 1080 is not mutagenic, and therefore unlikely to cause cancer. A developmental toxicity study in rats indicated that 1080 causes developmental defects in rats when pregnant females are exposed to relatively high doses (0.33 and 0.75 mg kg^{-1}) on a daily basis during the period of organogenesis (from days 6 through to 17 of gestation). The developmental abnormalities observed were mild skeletal effects: slightly curved forelimbs, and bent or 'wavy' ribs (Eason et al. 1999).

Spielman et al. (1973) reported that 1080 at a dose just below the maternal LD_{50} was not teratogenic to **rats** (*Rattus norvegicus*). The embryos in this study showed no macroscopic or skeletal abnormalities. This work involved only a single dose and the results contrast with Eason et al.'s (1999) investigation which followed current international guidelines that require dosing rats from day 6–17 of gestation at three dose levels. Eason et al.(1999) found the NOEL derived from their multi-dose study (0.1 mg kg^{-1} day^{-1}) was 10-fold less than the single dose NOEL (1 mg kg^{-1}) reported by Spielman et al. (1973).

Reduced testes weight, atrophy of seminferous tubules and damaged spermatids has been reported in **rats** (Smith et al. 1977; Sullivan et al. 1979; Shinoda et al. 2000). Wolfe (1998) reported an increased heart weight in rats of both sexes, and decreased weight of testes/epididymides and abnormal sperm formation in male rats.

In the most recent exposure study in rats (Eason & Turck 2002), the NOEL for rats administered 1080 via oral gavarge for 90 days was 0.075 mg kg^{-1} day^{-1}. This study confirmed that the epididymides, testes and heart are the target organs for 1080 sub-lethal effects, with severe hypospermia, severe degeneration of the seminiferous tubulies and cardiomyopathy seen at doses of 0.25 mg kg^{-1} day^{-1}.

Decreased body weight and food consumption in **mink** (*Mustela vison*) and **ferrets** (*Mustela putorius furo*), and impaired reproduction in mink has been reported following sub-lethal 1080 poisoning (Hornshaw et al. 1986).

In pen trials 1080 caused damage to the wing muscle in **mallard ducks** (*Anas platyrynchos*) (Ataria et al. 2000) and reduced testes weight in **starlings** (*Sturnus vulgaris*) (Balcomb et al. 1983).

An Australian study of the sub-lethal effects of 1080 on the **shingleback blue tongued lizard** (*Tiliqua rugosa*), a decrease in plasma testosterone concentration in the study animals was reported and there was a suggestion of degeneration of seminiferous tubules in some individuals (Twigg et al. 1988).

Smith & Grosch (1976) studied the effects of 1080 on Bracon hebetor, a **parasitoid wasp** found in North America. They found egg production was disrupted after a sub-lethal dose. Inhibition of reproduction in a **nematode** species (Middendorf & Dusenbery 1993) Metabolism and movement inhibited in Haemonchus **worms** (Ward & Huskisson 1978).

Note: The information in this section includes studies with species not extant in New Zealand

4.2 Exposure

4.2.1 What species (individual animals) have been reported as non-target deaths in field operations with 1080?

Aerial and hand laid operations using 0.15% or 0.08% 1080 Pellets

A number of domestic and feral non-target deaths have been reported after 1080 cereal pellets have been applied aerially (Table 29). In 2007 during aerial AHB 1080 operations horses and farmed deer were killed.

TABLE 29. FERAL AND DOMESTIC NON-TARGET ANIMAL DEATHS REPORTED DURING AERIAL & HANDLAID OPERATIONS USING 0.15% OR 0.08% 1080 PELLETS.

SPECIES	TOTAL FOUND DEAD	No. OF OPERATIONS	No. OF CASES WHERE RESIDUES CONFIRMED	SOWING RATE (kg ha^{-1})	REF.
Domestic animals					
Dog (*Canis familiaris*)	5	3	5		1
Cat (*Felis catus*)	1	1	1		2
Cattle (*Bos Taurus*)	2	2	2		3
Pig (*Sus scrofa*)	1	1	1		4
Feral animals					
Deer (*Cervus elephus*)	2	2	2		5
Introduced birds					
Blackbird (*Turdus merula*)	5	3	5	3-7	6
Chaffinch (*Fringilla coelebs*)	5	2	5	3	7

These animals were found dead or assumed to have been lethally poisoned from the presence of 1080 residues. Reports of animals killed which were not tested for residues have been omitted. The information has been restricted to those operations where the basic performance standards could be verified. Target pests have been excluded from the data.

Blackbirds and chaffinches are commonly found dead after operations but not tested. One starling found dead near a 1080 storage area and tested negative for 1080 residues has been omitted

1. VPRD: T0891; T1694; T1720 & T1657; 2 VPRD: T0971; 3 VPRD: 170 & T1693; 4 VPRD: T0517; 5 VPRD: T1407; 6 VPRD: T1809 & T0422; 7 VPRD: T1809 & T2068.

A **red deer** (*Cervus elephus*) kill of 43% was reported following application at 10 kg ha^{-1}, July 1988 at North Pureora. Simultaneous carcass searches over the poisoned area confirmed the pellet-count result (Nugent et al. 2001). A red deer kill of 54% was reported following application at 3 kg ha^{-1} June 1999 in the Orongorongo Valley (Nugent et al. 2001). A red deer kill of 5% was reported following application at 3 kg ha^{-1} overall but sown in strips of 25 kg ha^{-1}, with pre-feeding June 1999 at Wainuiomata Valley (Nugent et al. 2001).

Fallow deer (*Dama dama*) were monitored during an aerial 1080 operation in the Blue Mountains using 0.15% 1080 Pellets at 2 kg ha^{-1} 12 days after prefeeding with non-toxic bait. All three radio tagged deer were killed and estimates using a range of data available (carcass searches, deer sightings and hunter kill records) led the authors to conclude a best guess kill of 67-75% (Nugent & Yockney 2001).

During an aerial 1080 operation in Rotoehu Forest in October 2004, Fish and Game staff monitored **pheasant** crowing rates using five minute counts in treated and untreated blocks. There was a healthy population throughout the forest and there was no discernable difference in the crowing rates between the blocks following the 1080 operation (McDougall 2005).

Honey bees from hives located near the loading zone were observed during one operation to be gathering the green dust from toxic RS5 cereal baits. This loading zone had been used on previous occasions for aerial 1080 operations using the same bait type and no similar observations were made (N. Murray pers. comm.). AHB (2012) conducted trials to investigate the attractiveness of RS5 and Wanganui #7 pellets to bee. Bees were trained to visit wet and dry cereal baits coated with a sugar-syrup attractant. The attractiveness of the baits was determined by swirching the sugar-coated bait with standard non-toxic baits. Within 10 minutes, the bees lost interest in the standard baits. When EDR coated pellets were used, bees continued to visit the baits for approximately 30 minutes after the sugar-coated baits had been switched with the EDR coated pellets. When 1080 cereal pellets were placed within 80 metres of hives, no bees were observed visiting or landing on the baits. To test the risk of dust to honey bees, six hives were put out during an actual 1080 operation at Buller South. 1080 was not detected in bees, wax, nectar or pollen samples collected within 24 hours of the operation or when the monitoring was repeated after 15 – 16 days. Additionally, there was no evidence of 1080 dust on flowers on which bees were observed foraging (AHB 2012).

Aerial and hand laid operations using 0.15% or 0.08% 1080 carrot baits

A number of domestic and feral non-target deaths have been reported after 1080 carrot baits have been applied aerially (Table 30).

TABLE 30. FERAL AND DOMESTIC NON-TARGET ANIMAL DEATHS REPORTED DURING AERIAL & HANDLAID OPERATIONS USING 0.15% OR 0.08% CARROT BAITS.

SPECIES	TOTAL FOUND DEAD	No. OF OPERATIONS	No. OF CASES WHERE RESIDUES CONFIRMED	SOWING RATE (kg ha^{-1})	REF.
Domestic animals					
Sheep (*Ovis aries*)	1?	1	1		1
Feral animals					
Red deer (*Cervus elephus*)	4	1	4	5	2
Sika deer (*Cervus nippon*)	5	1[a]	5	5	3
Introduced birds					
Blackbird (*Turdus merula*)	1	1	1	5	2
Chaffinch (*Fringilla coelebs*)	1	1	1		4
Hedge sparrow	1	1	1		4

[a] In this operation the carrot baits were coated with deer repellent.

These animals were found dead or assumed to have been lethally poisoned from the presence of 1080 residues. Reports of animals killed which were not tested for residues have been omitted. The information has been restricted to those operations where the basic performance standards could be verified. Target pests have been excluded from the data.

Blackbirds and chaffinches are commonly found dead after operations but not tested.

1 VPRD: 050; 2 Nugent et al. (2004); 3 Speedy (2003); 4 VPRD: T1195; Pestlink: 0304RAN08

A study of **red deer** mortality during 1080 carrot operations (0.15%) in Pureora in 1994 resulted in kills of 30% and 31% following application at 15 kg ha^{-1}, with non-toxic pre-feeding, and 42% where no prefeed was used (Fraser et al. 1995). Deer faecal pellet densities in this study area declined by about 40% 15 months after poisoning but returned to pre-control levels a year later, and then apparently doubled over the ensuing two years (Coleman et al. 2000).

A **red deer** kill of 57% was reported following application of 0.09% toxic loading, with pre-feeding at 15 kg ha^{-1}, May 1996 at North Pureora (Sweetapple & Fraser

1997). A red deer kill of 93% was reported following application in August 1997 of 0.08% carrot bait and at 15 kg ha^{-1}, with pre-feeding at Titiraupenga. In the same study using 0.15% bait at 15 kg ha^{-1} (prefed) the reported kill was 92% (Fraser & Sweetapple 2000).

During an aerial 1080 operation in Rotoehu Forest in October 2004, Fish and Game staff monitored **pheasant** crowing rates using five minute counts in treated and untreated blocks. There was a healthy population throughout the forest and there was no discernable difference in the crowing rates between the blocks following the 1080 operation (McDougall 2005).

Aerial and handlaying operations using 0.02% 1080 carrot baits

Evans & Soulsby (1993) recorded 27 **California Quail** dying during three 1080 carrot rabbit control operations between 1985 and 1991. In all three operations, the deaths could be attributed to 1080 either through residue testing or observing carrot in the crop. The authors also reported **Chukar** being found dead following two other rabbit control operations using carrot.

During an aerial 1080 rabbit control operation on Dovedale Station, Central Otago in August 1993, five **California quail** coveys were monitored inside (treatment coveys) and a further two outside (non-treatment coveys) the operational area. The operational area received two prefeeds of unscreened carrot bait 7 days apart. Seven days later unscreened green dyed toxic bait was applied at a rate of 25 kg ha^{-1}. California quail survived inside the operational area in significant numbers. Following the operation, of the coveys inside the operational area, quail numbers remaining the same in two and dropped in one. The other two coveys in the treatment are could not be located. One non-treatment covey's numbers remained the same and the other one appeared to break up for breeding. Insufficient information was obtained to determine whether the change in covey sizes were as a result of non-location, breeding dispersal, emigration or poisoning (Evans & Soulsby 1993).

Aerial and handlaid operations using 0.04% 1080 oat baits

Four California quail deaths were reported during two rabbit control operations using 1080 oat in the 1980-90's (Evans & Soulsby 1993).

Bait station operations using 0.15% or 0.08% 1080 Pellets

Domestic and feral non-target deaths reported after the use of 1080 cereal pellets in bait stations are reported in Table 31.

TABLE 31. FERAL AND DOMESTIC NON-TARGET ANIMAL DEATHS REPORTED DURING BAIT STATION OPERATIONS USING 0.15% 1080 PELLETS.

SPECIES	TOTAL FOUND DEAD	No. OF OPERATIONS INVOLVED	No. OF CASES WHERE RESIDUES CONFIRMED	SOWING RATE (kg ha^{-1})	REF.
Domestic animals					
Dog	2	1	1		1; 2
Cattle	16	1	2		3

1 VPRD: 6461-1; 2 Pestlink: 0405WNG12; 3 VPRD: T2109.

Pestoff Professional 1080 Possum Paste (0.08 & 0.15%)

Honey bees were known to be attracted to 1080 paste baits (sometimes referred to as jam baits) used in pest control prior to 1995. Changes in formulation of 'Pestoff Professional' possum paste since then have been found to be unattractive to bees (Morgan 2000).

No Possums® gel block bait

Honey bees offered this bait near their hive appeared to be unable to penetrate the firm gel matrix with their proboscis and were seldom observed on the bait compared with control baits offered (Morgan 1999).

Cut apple bait

Honey bees offered this bait near their hive were seldom observed on the bait compared with control baits offered (Thomas et al. 2003).

4.2.2 For which species have residues of this pesticide been detected following 1080 operations?

The information in this section includes the results of laboratory analysis from live animals captured or killed for sampling from treatment areas. Residues from animals found dead are presented in section 4.2.1 above.

Aerially applied 0.15% 1080 Pellets

Samples taken by a vet from a sick dog following application at 5 kg ha^{-1} June 1999 Nelson/Marlborough Takaka had 1.07 mg kg^{-1} 1080 in its vomit, 0.44 mg kg^{-1} 1080 in its intestine and 0.3 mg kg^{-1} 1080 in its stomach (VPRD T0891).

0.15% 1080 Pellets in bait stations

Muscle samples from 8 trout had no detectable 1080 following application in bait stations at 100g/station, approximately 1 station/ha, October 1997, Lake Rotoiti (VPRD T0543, T0642).

4.3 Treatment

4.3.1 Is there an effective treatment of 1080 poisoning that is practical to administer?

No antidotes for 1080 poisoning are currently available but research is continuing (Ataria et al. 1995; Cook et al. 2001).

5. Human Health

The estimated lethal dose of 1080 in humans lies in the range of 0.7 and 10.0 mg kg^{-1}. Sodium monofluoroacetate (1080) is absorbed through the gastrointestinal tract or via the lungs if inhaled. Monofluoroacetate is not readily absorbed through intact skin, but it can be absorbed more readily through cuts and abrasions. The onset clinical signs usually range from 30 minutes to about 2-3 hours. Signs of poisoning include nausea, vomiting, and abdominal pain initially, followed by respiratory distress, anxiety, agitation, muscle spasms, stupor, seizures, and coma.

1080 is not a mutagen and is unlikely to be a carcinogen. It has sub-lethal effects on reproduction and is classified as a teratogen.

There is no effective antidote for 1080 poisoning in humans and any treatment given is largely symptomatic and supportive.

5.1 Toxicity

5.1.1 What is the oral LD_{50} (mg kg^{-1} bw)?

The oral LD_{50} for humans has been estimated as being between 0.7 and 10.0 mg kg^{-1} (Chenoweth 1949; Kaye 1970; Eisler 1995). 2.5 mg kg^{-1} is used a working LD_{50} for all the calculations in this review.

5.1.2 How much bait would children and adults need to ingest for poisoning?

The information on bait consumption required for poisoning is presented in Table 32.

TABLE 32. AMOUNT OF 1080 BAIT NEEDED TO BE INGESTED BY A HUMAN TO RESULT IN DEATH BASED ON THE LD_{50}.

	LD_{50} (mg kg^{-1})	AV. WEIGHT (kg)	AMOUNT OF 0.8 g kg^{-1} 1080 BAIT (g) FOR LD_{50}	AMOUNT OF 1.5 g kg^{-1} 1080 BAIT (g) FOR LD_{50}
Child	2.5	15	46.9	25
Adolescent	2.5	30	93.8	50
Small adult	2.5	60	187.5	100
Large adult	2.5	90	281.3	150

These figures represent the amount of bait that would have to be consumed in one sitting for a 50% chance of death. This is a straightforward acute toxicity calculation without any “safety factors’ that are used to extrapolate the results of animal studies to humans.

5.1.3 What is the dermal LD_{50} (mg kg^{-1} bw)?

Monofluoroacetate is not readily absorbed through intact skin, but it can be absorbed more readily through cuts and abrasions. Fagerstone et al. (1994) estimated the dermal LD_{50} at 300 mg kg^{-1}. Exposure guidelines (Threshold Limit Values, TLV) for 1080 have been set in USA, with a Time-weighted average (TLV-TWA) of 0.05 mg/m3 for skin exposure (Anon. 1991). In New Zealand the Occupational Health and Safety Service (OSH) has set a Biological Exposure Index (BEI) of 15 μg l^{-1} (0.015 ppm) for 1080 in human urine (Occupational Safety and Health Service 2002).

5.1.4 Where the pesticide involves a gaseous form, what is the gaseous LC_{50} (ppm in air)?

This is not applicable for 1080.

5.1.5 Where there is dust or mist associated 1080 use, what is the dust and mist LC_{50} (ppm in air)?

There is no published information on the LC_{50} for 1080 in dust or mist. A Biological Exposure Index (BEI) of 15 μg l^{-1} (0.015 ppm) for 1080 has been set by Occupational Health and Safety Service (OSH) New Zealand (Occupational Safety and Health Service 2002).

5.1.6 Is there evidence that 1080 may have mutagenic and/or carcinogenic properties? If known, what are the LOEL or NOEL values?

Three different complementary tests indicate that 1080 is not a mutagen and is therefore unlikely to be a carcinogen (Eason et al. 1999).

5.1.7 Is there evidence that 1080 may have sub-lethal effects on reproduction or lactation, or is classified as a teratogen? If known, what are the LOEL or NOEL values for these reproductive and developmental effects?

1080 has sub-lethal effects on reproduction and is classified as a teratogen (de Meyer & de Plaen 1964; Spielmann et al. 1973).

It is a male reproductive toxicant with effects on testes of mammals (Wolfe 1998; Shinoda et al. 2000; Eason & Turck 2002). Wolfe (1998) reported a decreased weight of testes and epididymides, and abnormal sperm formation in male rats. In a 90 day toxicology study of 1080, Eason & Turck (2002) reported hypospermia in the epididymides and degeneration of the seminiferous tubules of the testes of male rats dosed with 1080 at 0.25 mg kg^{-1} day^{-1}. The NOEL for rats administered 1080 via oral gavage for 90 days was 0.075 mg kg^{-1} day^{-1}.

Neither 1080 nor its active metabolite fluorocitrate bound to human androgen or alpha oestrogen receptors during in vitro assays (Tremblay et al. 2005). 1080 and fluorocitrate did not bind to sheep oestrogen receptors either (Tremblay et al. 2004). Therefore, while 1080 is a male reproductive toxicant, it is not considered an endocrine disruptor.

Sub-lethal doses of 1080 to pregnant rats alters skeletal development of rat foetuses (Eason et al. 1997; 1999). Teratogenic effects have been reported at 0.75 mg kg^{-1} day^{-1} (Eason et al. 1999) and the developmental NOEL is 0.1 mg kg^{-1} day^{-1}.

5.1.8 Is there evidence that 1080 may have sub-lethal effects on target organs? If known, what are the LOEL or NOEL values for these effects?

Sub-lethal effects on target organs have been reported. Small testes and epididymis in male rats were observed following doses of 1080 at 0.25 mg kg^{-1} day^{-1}, and these observations were corroborated by a reduction in the weight of the testes. 1080-related increases in heart weight were noted in both males and females at 0.25 mg kg^{-1} day^{-1} when compared with controls. The NOEL for rats administered 1080 via oral gavage for 90 days was 0.075 mg kg^{-1} day^{-1} (Eason & Turck 2002).

Changes in testes in male rats and in heart weights in both sexes of rats were reported by Wolfe (1998). Based on these findings the NOEL for sodium fluoroacetate, when given orally to Sprague-Dawley rats for 13 weeks, was 0.05 mg kg^{-1} day^{-1} (Wolfe 1998).

5.1.9 How rapid is the onset of toxicity for 1080 in humans?

The onset clinical signs usually ranges from 30 minutes to about 2-3 hours (Eason & Wickstrom 2001), however, in one case of acute poisoning, onset of symptoms was described as within minutes (Williams 1948). Relatively few cases of human poisoning (accidental or deliberate) have been reported in the literature (22 cases, 16 of which were fatal) (Harrison et al. 1952; Brockmann et al. 1955; Trabes et al. 1983; Ellenhorn & Barceloux 1988; Anon. 1992).

Poisoning symptoms experienced include nausea, vomiting, and abdominal pain initially, followed by respiratory distress, anxiety, agitation, muscle spasms, stupor, seizures, and coma. Hypotension is thought to be one of the more important predictors of mortality in 1080 intoxication (Chi et al. 1996; Chi et al. 1999).

5.2 Treatment

5.2.1 Is there an effective treatment or antidote for 1080 poisoning in humans?

There is no effective antidote for 1080 poisoning in humans. Treatment is largely symptomatic and supportive, with special attention focused on stabilising cardiac and central nervous system functions (Goncharov *et al.* 2006). The success of the treatment is likely to depend on whether the dose was acute or sub-lethal.

There is ongoing research into antidotes for 1080 (e.g. Goncharov *et al.* 2006).

6. Operational

1080 is considered to have medium humaneness for possums, however there has been little formal research into the humaneness of 1080 on other target species. Most deaths of pest species occur 8 – 48 hours after ingestion of a lethal dose.

All the registered target species have relatively high susceptibility to 1080. The short latent period means that bait shyness can develop in animals receiving a sub-lethal dose. Mice exhibit a marked avoidance of 1080 which is likely to result in control operation failures.

The majority of pest control operations using 1080 have target pest kills of greater than 80%.

6.1 Animal Welfare

6.1.2 What are the animal welfare impacts of 1080 on the target pest?

1080 toxicosis generally has a characteristic 'lag time' in mammalian species, where following intake of a lethal dose, the animal will show no visible signs of poisoning for up to a number of hours, before beginning to display symptoms (Eason & Wickstrom 2001). The onset clinical signs usually ranges from 30 minutes to about 2 - 3 hours with most deaths in mammals generally occurring 8 – 48 hours after ingestion of a lethal dose (Eason & Wickstrom 2001).

Possums

Littin et al. (2009) reported that the onset of symptoms in eight unhandled lethally dosed possums occurred at 1 hour 50 minutes (±0:09 s.e.m) with animals exhibiting abnormal appearances and postures. Seven of the animals showed retching, and three vomited starting at 2 hours 53 minutes. Lack of coordination began at 3 hours 37 minutes, after which possums spent most of the time until death lying, showing spasms and tremors. Five of the possums had seizures while lying prostrate. The mean time to death was 11 hours 26 minute (±1:55 s.e.m).

In possums the animal welfare impacts of 1080 is described as intermediate when compared to other vertebrate toxic agents used to kill possums in New Zealand (Littin et al. 2009; MAFBNZ 2010).

Rodents

Cook (1998) reported laboratory rats orally dosed with 1080 exhibited hypersensitivity to light and sound, an increased incidence of grooming or scratching of the abdomen, increased cage pacing and increased curled-but-awake posture. Five of the ten rats dosed with 1080 showed convulsive behaviour between 4 to 10 hours after the 1080 was administered.

McIlroy (1982) reported that ship rats exhibited a 0.8 - 27.8 hour latent period and died 2.4 - 36.5 hours after a lethal dose of 1080 was administered. Norway rats had a 0.4 – 2.3 hour latent period and a 2.5 – 112.0 hour time to death. Mice had a 1.3 – 2.8 hour latent period and 2.2 - 68.3 hour time to death. In rats observed syptoms included animals initially appearing depressed, often sitting quietly hunched in a corner or lying on their side, back or stomach with their eyes

partially closed: hypersensitivity to touch or sounds; and uncoordinated movement with unsteady balance. Respiration was initially very rapid, but became slower, shallower and more irregular until death occurred. Convulsions were commonly observed.

In rats the animal welfare impacts of 1080 is described as intermediate when compared to other vertebrate toxic agents used to kill rats in New Zealand (MAFBNZ 2010).

Cats

The main poisoning symptoms in cats are lethargy and disorientation, which are unusual for carnivores and more closely resemble those seen in herbivores. Other symptoms include uncoordinated movements and occasional vocalisation (Eason & Frampton 1991). Neurological signs associated with 1080 exposure are generally less severe in cats than in dogs (Eason & Wickstrom 2001). McIlroy reported a latent period of 1.0 - 5.6 hours and time to death between 20.7 - 21.0 hours. In cats the animal welfare impacts of 1080 are described as intermediate when compared to other vertebrate toxic agents (MAFBNZ 2010).

Rabbits

In rabbits the animal welfare impacts of 1080 are described as intermediate (MAFBNZ 2010). The onset of symptoms has been reported as ocurring between 1.1 - 10.1 hours after exposure to a lethal dose and death occuring after 3.0 - 44.3 hours (McIlroy 1981). Gooneratne et al. (1994) reported the time to death ranging from 1 to 7.5 hours in rabbits following a lethal dose. Lying prone, lethargy, respiratory distress, sensitivity to noise or disturbance and convulsions have been reported in poisoned rabbits (McIlroy 1981; MAFBNZ 2010).

Wallabies

McIlroy (1981) reported symptoms in poisoned wallabies included animals sitting hunched up; generally appearing non-alert, with shivering or shaking forelimbs and unsteady balance; convulsions and a white froth exuded from the mouth and nostrils. The latent period in Bennett's wallabies was <16.9 to 23.2 hours (7 wallbaies observed), and the time to death was 8.9 – 38.9 hours (23 wallabies observed). For dama wallabies the time to death was 13.8 - 37.1 hours. MAFBNZ (2010) describe the overall animal welfare impacts of 1080 on wallabies as intermediate compared to other vertebrate toxic agents.

Deer

In general, herbivores experience cardiac failure, whereas carnivores experience central nervous system disturbances and convulsions then die of respiratory failure (Egeheze & Oehme 1979).

Daniel (1966) reported that deer became lethargic and lay down quietly without any of the convulsions or leg-thrashing commonly reported in Canidae. He reported that deer died between 2 and 30 hours after eating a lethal dose.

6.2 Efficacy

6.2.1 Is 1080 effective on the target pest, based on the LD_{50}?

All the registered target species have relatively high susceptibility to 1080. The LD_{50} values are presented in Table 33.

TABLE 33. ACUTE ORAL TOXICITY (LD_{50} mg kg^{-1}) OF 1080 TO THE TARGET PESTS.

TARGET PEST	LD_{50} (mg kg^{-1})	REF.
Cat *Felis catus*	0.28	1
Deer not specified	0.50	2
Mule deer	0.27 – 0.90	3
House mouse *Mus musculus*	8.30	4
Brush-tailed possum *Trichosurus vulpecula*	0.79[a]	5
Rabbit *Oryctolagus cuniculus*	0.35	6
Ship rat *Rattus rattus*	0.76	4
Laboratory rat *Rattus norvegicus*	1.71	4
Norway rat (wild) *Rattus norvegicus*	0.22-3.0	7
Bennett's wallaby *Macropus rufogriseus*	0.21	8
Dama wallaby *Macropus eugenii*	0.27	6; 8

[a] Ambient temperature may affect the acute toxicity of 1080 to possums, with increased toxicity at low temperatures (Veltman & Pinder 2001).

1 Eason & Frampton(1991); 2 Rammell & Fleming (1978); 3 Tucker & Crabtree (1970); 4 McIlroy (1982); 5 Bell (1972); 6 McIlroy (1981); 7 Chenoweth (1949); 8 Munday (1978).

6.2.2 How much bait does the target pest have to ingest in order to be poisoned, within what timeframe?

Target pests would have to eat at least the amounts given in Table 34 in one feeding session (at least three hours) to be likely to receive an acute lethal dose.

TABLE 34. AMOUNT OF BAIT A TARGET PEST NEEDS TO INGEST TO RESULT IN DEATH BASED ON LD_{50}.

SPECIES	LD_{50} (mg kg^{-1})	AV. WEIGHT FEMALE (g)	AMOUNT OF 0.2g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 0.4g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 0.6g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 0.8g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 1.0g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 1.5g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 2.0g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 50g kg^{-1} BAIT (g) FOR LD_{50}	AMOUNT OF 100g kg^{-1} BAIT (g) FOR LD_{50}
Bennetts wallaby	0.21	11000		-		-	-	1.5	1.2	0.05	0.02
Cat	0.28	2500		-		-	0.7	-	-	-	-
Dama wallaby	0.27	4300		-		-	-	0.8	0.6	0.02	0.01
House Mouse	8.30	20				0.21		0.1			
Norway rat (wild)	0.22	220		-		0.06	-	0.03	-	-	-
Possum	0.8	3000		-	4.0	3.0	-	1.6	-	-	-
Rabbit	0.35	800	1.4	0.7	0.47	-	-	-	-	-	-
Red deer	0.5	80000		-		-	-	26.67	-	-	0.4
Ship rat	0.76	140				0.13		0.07	-	-	-

Palatability

Palatability of a bait will also influence the whether the target pest will ingest a lethal dose.

Possums

For possums, Morgan (2004) reported that under field conditions No Possums® 1080 gel blocks have a 20% decline in palatability after 36.4 months. In the same study, double wax coated 1080 pellets left in Philproof bait stations had a 20% decline in palatability after 4 months.

Mice

Wild caught mice demonstrate marked avoidance of baits containing 1080 in pen studies (Morriss et al. 2008; Fisher et al. 2009). In paired choice tests (using toxic pellets and non-toxic rodent pellets), only 8% of mice died when offered 0.15% 1080 baits. Pellet type (Wanganui #7 or RS5), the presence or absence of green dye, the presence or absence of 0.3% cinnamon and bait size (2g and 12g) did not have any effect on the amount of toxic bait eaten by mice (Morriss et al. 2008). In similar paired choice tests, Fisher et al. (2009) reported that mice had a low acceptance of 0.08% and 0.15% 1080 pellets and mortality rates were similar (25%) for both concentrations of 1080. The authors also found that pre-feeding with non-toxic pellets did not improve the acceptance of 0.15% 1080 pellets by mice.

Based on the marked avoidance of 1080 by mice, O'Connor et al. (2005) recommended that 1080 should not be used for mouse control operations until new methods are developed to improve 1080 bait acceptance by mice.

Other factors

Parkes (1991) noted that the when 10% 1080 gel with a carbopol carrier was applied to mahoe leaves, the baits had a maximum life of about 60 days because phytotoxicity caused most leaves to absciss within 46 days. When mahoe leaves were smeared with 10% 1080 gel in a petrolatum carrier, the baits could remain effective as baits for at least 110 days, after which time most leaves had abscissed. However, abscissed leaves could remain toxic to animals that eat leaf-fall for at least 300 days.

6.2.3 What is the latent period between bait ingestion and onset of symptoms?

The latent period is hours. Possums receiving a sub-lethal dose of 1080 have been known to develop bait shyness (O'Connor & Matthews 1999; Ogilvie et al. 2000) and this can persist for at least three years (O'Connor & Matthews 1999). Conditioned food aversion to diets containing 1080 has been reported in rats (Nachman & Hartley 1975).

Note: A short latent period increases the likelihood of the target pest developing poison shyness.

6.2.4 What field evidence is there that this pesticide use causes a population decline of the target pest species at sites where it is used?

Possums

Aerially distributed 1080 cereal pellets

The percentage kills obtained during aerial operations using 0.08% 1080 cereal pellets are presented in Table 35. For non-prefed aerial operations using 0.08% cereal pellets the mean kill was 69.1% (n=10). The mean kill for prefed aerial operations using 0.08% cereal pellets was 91.1% (n=2).

The percentage kills obtained during aerial operations using 0.15% 1080 cereal pellets are presented in Tables 36. Based on this data, the mean possum kill for prefed operations is 93.2% (n=38), operation where cause of failure known excluded) and for non prefed operations 80.0% (N=21).

TABLE 35. THE PERCENTAGE POSSUM KILL FOR AERIAL OPERATIONS USING 0.08% 1080 CEREAL PELLETS.

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
100%	Station Creek A Trial, Jul 2006	-	5 (#7 12 g pellets)	1
82.2%	Station Creek B Trial, Jul 2006	2 (12 g pellets)	5 (12g #7 pellets, 7 days later)	1
0%	Mapara, October 1992	-	8	2
89%	Isolated Hill SR Nelson August 1992	-	4	2
96%	Titirangi Reserve Wanganui June 1992	-	5	2
50%	Puketi Forest Northland March 1992	-	5	2
32%	Mapara October 1991	-	5	2
91%	Whitecliffs Wanganui July 1991	-	6	2
61%	Waipapa EA June 1991	-	10	2
79%	Mapara September 1990	-	8	2
93%	Rangitoto Island October 1990	-	12	2

1 Josh Kemp per comm.; 2 Spurr (1993)

TABLE 36. THE PERCENTAGE POSSUM KILL FOR AERIAL OPERATIONS USING 0.15% 1080 CEREAL PELLETS.

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
100%	Blue Mountains, June-July 2008	2 (12g #7 baits)	3 (12g #7 pellets coated with deer repellent, 21 days later)	1
91.3%	Manawatu Gorge, 20-25/7/2007	2	3 (5 days later)	2
100%	Parapara 07A Trial, May 2007	3 (6g pellets)	3 (12g RS5 pellets, 25 days later)	3
100%	Parapara 07C Trial, May 2007	-	3 (12g RS5 pellets)	3
100%	Hukarere A May 2007	2 (12g pellets)	2.5 (12g #7 pellets, 25 days later)	3
100%	Hukarere B May 2007	2 (12g pellets)	2.5 (12g #7 pellets, orange lure, 25 days later)	3
100%	Hukarere C May 2007	2 (12g pellets)	2.5 (6g RS5 pellets, 25 days later)	3
87.3%	Thomas River, 12-15/01/2007	1 (6g pellets)	3.5 (12g pellets, 3 days later)	4
89.4%	Mataketake, 12-15/01/2007	1 (6g pellets)	3.5 (12g pellets, 3 days later)	5
91.1%	Otaki Bio Site, 12/09-14/12/2006	2.11 (6g pellets)	2.11 (6g pellets, 93 days later)	6
100%	Otaki Core, 12/09-14/12/2006	2.11 (6g pellets)	2.11 (6g pellets, 93 days later)	6
100%	Wangapeka, Oct 2006	0.8 (12g pellets)	5 (12g RS5 pellets, 14 days later)	3
81.1%	Hawdon Valley, 12-28/9/2006	2 (6g pellets)	5 (6g pellets, 16 days later)	7
89.4%	Poulter Valley,12-28/9/2006	2 (6g pellets)	5 (6g pellets, 14 days later)	7
100%	Whenuakite, Aug 2006	2 (6g pellets)	3 (12g #7 pellets, 13 days later)	3
100%	Station Creek C Trial, Jul 2006	2 (12g pellets)	5 (12g #7 pellets, 7 days later)	3

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
78.4%	Waiohine/Tauherenikau, 29/08/2005	-	3 (#7 pellets)	8
90.2%	Pembroke - Block 1A, 25/01/2005	-	3 (#7 pellets)	9
84.6%	Matemateaonga Stage 1, 19/11/04, 11/1/05	-	4 (#7 pellets)	10
100%	St Andrews 11/11/2004 – 21/02/2005	2	3 (#7 pellets, 102 days later)	11
85.3%	Waiotauru, 7-8/09/2004	-	3 (#7 pellets)	12
75.9%	Mt Karioi, 20/05/2004 – 09/06/2004	2	4 (12g #7 pellets, 20 days later)	13
96.6%	Copeland River, 18-19/10/2003	2	3 (12g pellets)	14
28.1%	Copeland River, 18-19/10/2003	-	3 (12 g pellets)	14
87.6%	Kahurangi Point, 10/9/2003	-	3 (12 g pellets)	15
94.7%	Gouland Downs, 29/8/2003	-	3 (12 g pellets)	16
98%	Hutt River, 28/7/03	2	2 (12g pellets, 5 days later)	17
85.7%	Featherston / Waiorongomai Block 1 retreatment, 02/03 (GWRC op)	1.5	1.5 (10g pellets)	18
93%	Mt Pirongia, 27/8/2002	2	4 (12g pellets)	19
100%	Hampden, North Otago, 28/6/2002	2	2 (12g pellets)	20
89.7%	Featherston / Waiorongomai Block 3, Dec 01-Feb 02 (GWRC op)	2	2 (10g pellets)	18
95.5%	Featherston / Waiorongomai Block 2, Dec 01-Feb 02 (GWRC op)	2	2 (10g pellets)	18
38.2%[a]	Featherston / Waiorongomai Block 1, Dec 01-Feb 02 (GWRC op)	2	2 (10g pellets)	18
94.2%	Mt Bruce / Miki Miki, 01/02 (GWRC op)	2	2 (10g pellets)	18
90.4%	Mt Bruce / Miki Miki, 01/02 (GWRC op)	2	1 (10g pellets)	18
88.1%	Akatarawa valley, 01/02 (GWRC op)	2	2 (10g pellets)	18
84.7	Owhanga, 01/02 (GWRC op)	2	2 (10g pellets)	18

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
89.2%	Castlehill/Bideford, 01/02 (GWRC op)	2	2 (10g pellets)	18
77.3%	Otaki, 2001	-	3 (12 g pellets)	18
81.1%	Upper Waingawa, 2001	-	3 (12 g pellets)	18
88.3%	Marapara EA, 5/10/2001	2	3 (12g pellets)	21
97.7%	Tongariro Forest CA, 19/9/2001	2	3 (12g pellets)	22
82.9%	Ohau/Mangahao, 8/9/2001	-	3 (12 g pellets)	23
97.2%	Leslie/Karamea, 27/8/2001	-	4 (12 g pellets)	24
81.1%	Blue Mountains, 22/8/2001	1	2 (RS5 pellets)	25
57.6 %	Hackett, 31/5/2001	-	3 (12 g pellets)	26
94.0%	Featherston, 00/01 (GWRC op)	2	2 (10g pellets)	18
92.2%	Whakatikei, 00/01 (GWRC op)	1	1 (10g pellets)	18
93.2%	Otaki Crown, Jan 01 (GWRC op)	2	2 (10g pellets)	18
97.6%	Tinui, 00/01 (GWRC op)	2	2 (10g pellets)	18
81.5%	Moeatoa, 6/8/2000	-	5 (6 g pellets)	27
81.5%	Whareorino, 6/8/2000	-	5 (6 g pellets)	28
100%	Bideford, 99/00 (GWRC op)	2	2 (10g pellets)	18
97.9%	Pukunui, 99/00 (GWRC op)	1.2	2 (10g pellets)	18
95.5%	Owhanga, 99/00 (GWRC op)	2	2 (10g pellets)	18
94.0%	Wainuiomata, 98/99 (GWRC op)	3	3 (10g pellets)	18
87.0%	Arawhata, 26/4/1999	-	3.1 (6 g pellets)	29
18.3%	Okura, 24/4/1999	-	2.6 (6 g pellets)	30
84.0%	NE Tararua, 1999	-	4 (8 g pellets)	18
92.8%	Tauherenikau, 1998	-	4 (8 g pellets)	18
94.2%	Landsborough, 30/6/1998	-	4 (6 g pellets)	31
95.8%	Landsborough, 30/6/98	-	2 (6 g pellets)	31

[a] heavy thunderstorms on the evening treatment occurred damaged the bait.

1 Morriss & Nugent (2008); 2 Pestlink:0708PNT18; 3 J Kemp per comm.; 4 Pestlink:0708SWS07; 5 Pestlink:0708SWS06; 6 Pestlink:0708KAP16; 7 Pestlink:0607WMK02; 8 Pestlink:0607WRP02; 9 Pestlink:0506TEA01; 10 Pestlink:0506WHA01; 11 Pestlink:0405BUL15; 12 Pestlink:0405KAP21; 13

Pestlink:0304WAI22; 14 Pestlink:0304SWS27; 15 Pestlink:0304GDB05; 16 Pestlink:0203GDB13; 17 Wright (2004); 18 Brown & Urlich (2005); 19 Pestlink:0203WAI05; 20 Lorigan et al. (2002); 21 Pestlink:0203MPT03; 22 Pestlink:0203RUA06; 23 Pestlink: 0304KAP12; 24 Pestlink: 0203MOT19; 25 Nugent & Yockney (2001); 26 Pestlink: 0203SWS32; 27 Pestlink: 0203MPT36; 28 Pestlink: 0203MPT04; 29 Pestlink:0203SWS17; 30 Pestlink:0203SWS18; 31 Pestlink:0304SWS05.

Aerially distributed 1080 carrots

The mean percentage possum kill for operations using 0.8 g kg^{-1} 1080 carrots (Table 37) is 91.1% (n=7).

Table 38 lists aerial operations using 1.5 g kg^{-1} 1080 carrots where the percentage kill could be calculated. The mean kill for these operations was 93.7% (n=4).

TABLE 37. THE PERCENTAGE POSSUM KILL FOR AERIAL OPERATIONS USING 0.8 g kg^{-1} 1080 CARROT.

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
93.4%	Te Kopia SR, 11-25/7/2006	2 (6g baits)	5 (6g baits, 12 days later)	1
91.8%	Whirinaki Rata Block 30/8-8/9/2005	3	5 (8 days later)	2
87.8%	Hunua Ranges, 7-8/9/2001	5	5	3
86%	Otupaka EA, 17-18/05/2000	5	10 (6g baits)	4
96.0%	Paeroa Range, 18/08/1999	5	10-15 (6g baits)	5
88.4%	Marokopa/Tawerau, 5/7/1998	5	5 (6g baits)	6
94.2%	Marokopa/Tawerau, 5/7/1998	5	10 (6g baits)	7

1 Pestlink:0607ROT01; 2 Pestlink: 0506RAN01; 3 Pestlink: 0203AKD13; 4 Pestlink: 0304RAN08; 5 Pestlink: 0304ROT05; 6 Pestlink: 0203MPT08; 7 Pestlink: 0203MPT08.

TABLE 38. THE PERCENTAGE POSSUM KILL FOR AERIAL OPERATIONS USING 1.5 g kg^{-1} 1080 CARROT.

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
98.1%	Matakuhia, Tataraakina, July 2003	5	5 (6g baits)	1
96.3%	Wakeman's Block, Tataraakina, July 2003	5	5 (6g baits with deer repellent)	1
86.6-100%	Hampden, North Otago, 28/6/2002	2	2 (6g baits)	2
92.5%	Lake Okataina SR, 27/7/1999	5	12 (6g baits)	

1 Nugent et al. (2004); 2 Lorigan et al. (2002); 3 Pestlink: 0304ROT04.

1080 cereal pellets in bait stations

Table 39 contains the percentage possum kills for bait station operations using 0.15% 1080 cereal pellets. The mean kill for these operations was 93.3% (N=8).

TABLE 39. THE PERCENTAGE POSSUM KILL FOR 0.15% 1080 CEREAL PELLETS IN BAIT STATIONS

KILL	LOCATION	METHOD	REF.
83.7%	Opuiaki, Sept-Oct 2009	100 x 100 m grid, 2 prefeeds (600g per bait station), 1 toxic fill (300 g bait per station)	1
95%	Fox Valley, April-May 2008	100 x 200 m grid, 2 prefeeds (460 g per bait station), 1 toxic fill (460 g bait per station)	2
88.9%	Fox Valley, July 2007	100 x 200 m grid, 2 prefeeds (500 g per bait station), 1 toxic fill (500 g bait per station)	2
97.1%	Rotoehu EA, Oct-Nov 2007	1 bait station/ha, 2 prefeeds (1500 g per bait station), 1 toxic fill (700 g bait per station)	3
96.2%	Mokaihaha EA, October 2001	1 bait station/ha, 3 prefeeds, 1 toxic fill (1500 g bait per station)	4
94.8%	Minganui Faces, Oct 1999	0.53 bait stations/ha, 3 prefeeds, 1 toxic fill (750 g bait per station)	5
100%	Kaharoa CA, Jan 1997	0.25 bait stations/ha, 3 prefeeds, 1 toxic fill (1000 g bait per station)	6
90.6%	Minganui Faces, Nov 1996	0.53 bait stations/ha, 3 prefeeds, 1 toxic fill	7

1 Pestlink: 0800TAU01; 2 Pestlink: 0809SWS04; 3 Pestlink 0708ROT03; 4 Pestlink: 0304ROT06; 5 Pestlink: 0304RAN12; 6 Pestlink: 0304ROT09; 7 Pestlink: 0304RAN13.

No Possums® 1080 gel (1.5 g kg^{-1} 1080) in bait stations

The mean percentage possum kill for the operations using No Possums® 1080 gel block in Table 40 is 78.4% (N=2).

TABLE 40. THE PERCENTAGE POSSUM KILL DURING BAIT STATION OPERATIONS USING NO POSSUMS® 1080 GEL BLOCK.

KILL	LOCATION	METHOD	REF.
65.6%	Whareorino, August 2003	2 bait stations/ha, 1 prefeeds, 1 toxic fill (250 g bait per station)	1
91.3%	Leslie Karamea, Jan-April 2002	0.24 bait stations/ha, 1 toxic fill (500 g bait per station), used in conjunction with feracol	2

1 Pestlink: 0304MPT03; 2 Pestlink: 0203MOT19.

Handlaid 1080 cereal pellets

The mean percentage possum kill for operations using handlaid 0.15% 1080 cereal pellets (Table 41) is 88.8% (n=6).

TABLE 41. THE PERCENTAGE POSSUM KILL FOR OPERATIONS USING HANDLAID 0.15% 1080 CEREAL PELLETS.

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
91.7%	Stewart Island, Dec 07 – Jan 2008		Not specified, but not prefed	1
100%	Colenso Basin, Ruahines, Sept-Oct 2007	2 (6 g pellets)	1.5 (12 g pellets, 31 days later)	2
66.7%	Awarua, 3/3/2000		0.4 (8 g pellets, traps and Feratox also used)	3
90.6%	Fox Valley, 23/9/1999		0.5 (8 g pellets, traps also used)	4
94.6%	Abbey Rocks B, 2/6/1999		0.5 (6 g pellets, traps also used)	5
89.3%	Abbey Rocks C, 3/6/1999		0.5 (6 g pellets, traps also used)	5

1 Pestlink: 0809SIS02; 2 Pestlink: 0708PNT17; 3 Pestlink: 0203SWS30; 4 Pestlink: 0203SWS34; 5 Pestlink: 0203SWS28.

1080 cereal pellets in bait bags

The percentage kills obtained following the use of 1080 cereal pellets in bait bags are presented in Table 42. The mean is 82.9%.

TABLE 42. THE PERCENTAGE POSSUM KILL FOR OPERATIONS USING 0.15% 1080 CEREAL PELLETS IN BAIT BAGS.

KILL	LOCATION	METHOD	REF.
96%	Stewart Island, Oct-Nov 2008	20 x 100 m grid (not prefed)	1
97.6%	Pegasus/Tin Range Oct-Nov 2004	Grid (not prefed)	2
85% (Range: 68.8%-100%)	Paterson Inlet Blocks, Oct 2003	Bags put on recent sign (not prefed)	3
~92.6%	Mt Anglem/Hananui, Oct-Nov 2003	4.3-5.3 bait bags/ha, 1 prefeed, 2 toxic bag placements (6 g baits).	4
53.1-73.2%	Warawara Forest Blocks, Mar-Jun 2003	Bags put on recent sign (not prefed)	5

1 Pestlink: 0809SIS03; 2 Pestlink: 0405SIS04; 3 Pestlink: 0304SIS19; 4 Pestlink: 0304SIS20; 5 Pestlink: 0203KAI12.

1080 paste in bait bags

See Table 43 for the percentage kill during operations using 0.15% 1080 paste in bait bags.

TABLE 43. THE PERCENTAGE POSSUM KILL FOR OPERATIONS USING 0.15% 1080 PASTE IN BAIT BAGS.

KILL	LOCATION	METHOD	REF.
56.4%	Minganui Faces, Sept-Oct 2000	Bags placed on a 75m x 10m grid, not prefed.	1

1 Pestlink: 0304RAN09.

Handlaid 1080 paste

The mean percentage possum kill for operations using handlaid 0.15% 1080 paste under good weather conditions is 83.1% (n=5) (Table 44).

TABLE 44. THE PERCENTAGE POSSUM KILL FOR OPERATIONS USING HANDLAID 0.15% 1080 PASTE.

KILL	LOCATION	METHOD	REF.
~84%	Rangitikei Snail Area, Kaimanawa FP, 2000-2002	Prefed, set on recent sign.	1
86.6%	Mortens, Canterbury	Spits 5-6 m apart around forest edge, not prefed	2
84.7%	Steventon, Canterbury	Spits 5-6 m apart around forest edge, not prefed	2
84% (Range: 50-96%)	9 sites around NZ (1996-98) – good weather conditions	Spits 5 m apart around forest edge, prefed	3
34% (Range: 0-59%)	4 sites (1997) - where rain washed out baits or hot weather dried out the baits	Spits 5 m apart around forest edge, prefed	3
76% (Range: 68-93%)	9 sites around NZ (1996-98) – good weather conditions	Spits 5 m apart around forest edge, not prefed	3
30% (Range: 11-46%)	4 sites (1997) where rain washed out baits or hot weather dried out baits.	Spits 5 m apart around forest edge, not prefed	3

1 Pestlink: 0304RAN09; 2 Ross & Henderson (2003); 3 Thomas & Morgan (1998)

Rats

Aerially distributed 1080 cereal pellets

The percentage rat kill for the aerial operations using 0.08% cereal pellets is presented in Table 45.

The percentage rat kills obtained during aerial operations using 0.15% 1080 cereal pellets are presented in Tables 46. Based on this data, the mean kill for prefed operations is 98.7% (n=30).

TABLE 45. THE PERCENTAGE RAT KILL FOR AERIAL OPERATIONS USING 0.08% 1080 CEREAL PELLETS.

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
100%	Whakapohai E, Jan 2007	5 (6g baits)	2 (12g #7 pellets, 5 days later)	1
1.2%	Station Creek A Trial, Jul 2006	-	5 (12g #7 pellets, 5 days later)	1
96.3%	Station Creek B Trial, Jul 2006	2 (12g pellets)	5 (12g #7 pellets, 7 days later)	1
<70%	Mapara, Oct 1992	-	8	2
80%	Mapara, Oct 1991	-	8	2
100%	Mapara, Sept 1990	-	8	2

1 J Kemp per comm.; 2 Bradfield. (1993).

TABLE 46. THE PERCENTAGE RAT KILL FOR AERIAL OPERATIONS USING 0.15% 1080 CEREAL PELLETS.

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
100%	Kia Wharite – Matemateaonga, Nov-Dec 2008	1 (6g pellets)	2 (12g #7 pellets, 27 days later)	1
100%	Poulter Valley, Oct 2008	1 (6g pellets)	2 (6g #7 pellets, 17 days later)	2
44.1%	Heaphy Coast A, Nov 2007	-	2 (6g #7 pellets)	3
72.7%	Heaphy Coast B, Nov 2007	-	2 (6g RS5 pellets)	3
100%	Heaphy Coast C, Nov 2007	1 (12g pellets)	2 (6g RS5 pellets, 12 days later)	3
100%	Heaphy Coast D, Nov 2007	2 (12g pellets)	2 (6g RS5 pellets, 12 days later)	3
100%	Pihanga, Nov 07	2 (12g pellets)	2 (12g #7 pellets, 8 days later)	4
100%	Catlins, Aug 2007	2 (12g pellets)	3 (12 g RS5 pellets, 29 days later)	4
100%	Parapara 07A Trial, May 2007	3 (6g pellets)	3 (12g RS5 pellets, 43 days later)	4
100%	Parapara 07B Trial, May 2007	3 (6g pellets)	3 (12g #7 pellets, 43 days later)	4
90.6%	Parapara 07C Trial, May 2007	-	3 (12g RS5 pellets)	4
0%	Parapara 07D Trial, May 2007	-	3 (12g #7 pellets)	4
100%	Hukarere A May 2007	2 (12g pellets)	2.5 (12g #7 pellets, 25 days later)	4
100%	Hukarere B May 2007	2 (12g pellets)	2.5 (12g RS5 pellets, 25 days later)	4
100%	Hukarere C May 2007	2 (12g pellets)	2.5 (12g #7 pellets, 25 days later)	4
98.1%	Whakapohai A, Jan 2007	5 (6g pellets)	2 (12g #7 pellets, 5 days later)	4
100%	Whakapohai B, Jan 2007	2 (6g pellets)	2.5 (12g #7 pellets, 5 days later)	4
100%	Whakapohai C, Jan 2007	2 (6g pellets)	2.5 (12g #7 pellets, 5 days later)	4

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
100%	Whakapohai D, Jan 2007	1 (6g pellets)	2.5 (12g #7 pellets, 5 days later)	4
98.4%	Dart/Caples, 25-30/10/2006	2	2 (6g RS5 pellets, 5 days later)	5
100%	Otaki Bio Site, 12/09-14/12/2006	2.11 (6g pellets)	2.11 (6g #7 pellets, 93 days later)	6
98.9%	Otaki Core, 12/09-14/12/2006	2.11 (6g pellets)	2.11 (6g #7 pellets, 93 days later)	6
100%	Wangapeka, Oct 2006	0.8 (12g pellets)	2.5 (12g RS% pellets, 14 days later)	4
100%	Hawdon Valley, 12-28/9/2006	2 (6g pellets)	5 (6g pellets, 16 days later)	7
100%	Poulter Valley,12-28/9/2006	2 (6g pellets)	5 (6g pellets, 14 days later)	7
100%	South Branch Hurunui Valley, 14/9-6/10/2006	2 (6g pellets)	5 (6g pellets, 22 days later)	7
98.7%	Tongariro Forest, 30/8-15/09/2006	2	4 (12g #7 pellets, 5 days later)	8
100%	Opuiaki, 18-28/8/2006	2	3 (12g #7 pellets, 5 days later)	9
94.9%	Central Coromandel, Aug 2006	2 (6g pellets)	3 (12g #7 pellets, 13 days later)	4
96.1%	Whenuakite, Aug 2006	2 (6g pellets)	3 (12g #7 pellets, 13 days later)	4
98.8%	Station Creek C Trial, Jul 2006	2 (12g pellets)	5 (12g #7 pellets, 7 days later)	4
98.0%	Waipoua Forest, 24/09 – 12/10/2005	2	3 (12g #7 pellets, 16 days later)	10
80.2%	Waipapa East, Waipapa EA, Sept 2001	2	2	11
97.8%	Waipapa North, Waipapa EA, Sept 2001	2	2	11
100%	Kaharoa, Oct 1990	2	18	12
92.1%	Makino Forest, August 1989	-	9	13

1 Pestlink:0809WHA01; 2 Pestlink:0809WMK06; 3 Pestlink:0809BUL06; 4 J Kemp per comm.; 5

Pestlink:0708WAK04; 6 Pestlink:0708KAP16; 7 Pestlink:0607WMK02; 8 Pestlink:0708RUA01; 9 Pestlink:0607TAU05; 10 Pestlink:0506KAU09; 11 Styche et al. (2004); 12 Innes et al. (1995); 13 Warburton (1989).

Handlaid 1080 cereal pellets

A 61% rat kill was achieved at Beam Head, Northland, in October 2008 when 0.08% 1080 rodent pellets were laid in clusters 50 metres apart along an existing track system. The operational area was prefed at a rate of 1 kg ha^{-1} and 30 days later the toxic bait was laid at a rate of 0.8 kg ha^{-1} (Pestlink reference: 0809WNG05).

1080 cereal pellets in bait stations

Table 47 contains the percentage rat kills for bait station operations using 0.15% 1080 cereal pellets.

TABLE 47. THE PERCENTAGE RAT KILL FOR 0.15% 1080 CEREAL PELLETS IN BAIT STATIONS

KILL	LOCATION	METHOD	REF.
97.0%	Opuiaki, Sept-Oct 2009	100 x 100 m bait station grid, 2 prefeeds (600g per bait station), 1 toxic fill (300 g bait per station)	1
91.2%	Waipapa East, Waipapa EA, Aug 2000	150 x 150 m bait station grid, 2 prefeeds, 1 toxic fill	2
87.7%	Waipapa North, Waipapa EA, Aug 2000	150 x 150 m bait station grid, 2 prefeeds, 1 toxic fill	2
85.5%	Waipapa South, Waipapa EA, Aug 2000	150 x 150 m bait station grid, 2 prefeeds, 1 toxic fill	2
100%	Trounson Kauri Park, Nov 1996	100 x 100 m bait station grid, 4 prefeeds, 1 toxic fill	3

1 Pestlink: 0800TAU01; 2 Matthew et al. (2004); 3 Gillies et al. (2003).

Mice

Aerially distributed 1080 cereal pellets

The percentage mouse kill for the aerial operations using 0.08% cereal pellets is presented in Table 48. The percentage rat kills obtained during aerial operations using 0.15% 1080 cereal pellets are presented in Tables 49. Based on this data, the mean kill for prefed operations is 90.0% (n=12).

TABLE 48. THE PERCENTAGE MOUSE KILL FOR AERIAL OPERATIONS USING 0.08% 1080 CEREAL PELLETS.

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
58%	Whakapohai E, Jan 2007	5 (6g pellets)	2 (12g #7 pellets, 5 days later)	1

1 J Kemp per comm.

TABLE 49. THE PERCENTAGE MOUSE KILL FOR AERIAL OPERATIONS USING 0.15% 1080 CEREAL PELLETS.

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
93.4%	Poulter Valley, Oct 2008	1 (6g pellets)	2 (6g #7 pellets, 17 days later)	1
100%	Pihanga, Nov 07	2 (12g pellets)	2 (12g #7 pellets, 8 days later)	1
86.2%	Parapara 07C Trial, May 2007	-	3 (12g RS5 pellets)	1
37.3%	Parapara 07D Trial, May 2007	-	3 (12g #7 pellets)	1
97.0%	Parapara 07A Trial, May 2007	3 (6g pellets)	3 (12g RS5 pellets, 43 days later)	1
92.0%	Parapara 07B Trial, May 2007	3 (6g pellets)	3 (12g #7 pellets, 43 days later)	1
100%	Whakapohai A, Jan 2007	5 (6g pellets)	2 (12g #7 pellets, 5 days later)	1
66.7%	Whakapohai B, Jan 2007	2 (6g pellets)	2.5 (12g #7 pellets, 5 days later)	1
96.4%	Whakapohai C, Jan 2007	2 (6g pellets)	2.5 (12g #7 pellets, 5 days later)	1
86.0%	Whakapohai D, Jan 2007	1 (6g pellets)	2.5 (12g #7 pellets, 5 days later)	1

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
50.0%	Dart/Caples, 25-30/10/2006	2	2 (6g RS5 pellets, 5 days later)	2
100%	Otaki Bio Site, 12/09-14/12/2006	2.11 (6g pellets)	2.11 (6g #7 pellets, 93 days later)	1
100%	Wangapeka, Oct 2006	0.8 (12g Pellets)	2.5 (12g RS5 pellets, 14 days later)	1
100%	Tongariro Forest, 30/8-15/09/2006	2	4 (12g #7 pellets, 5 days later)	1

1 J Kemp per comm.; 2 Pestlink: 0708WAK04.

1080 cereal pellets in bait stations

Table 50 contains the percentage mouse kills for bait station operations using 0.15% 1080 cereal pellets.

TABLE 50. THE PERCENTAGE MOUSE KILL FOR 0.15% 1080 CEREAL PELLETS IN BAIT STATIONS

KILL	LOCATION	METHOD	REF.
94%	Trounson Kauri Park, Nov 1996	100 x 100 m bait station grid, 4 prefeeds, 1 toxic fill	1

1 Gillies et al. (2003).

Wallabies

The percentage kill of wallabies using aerially distributed 1.5 g kg^{-1} 1080 carrot is presented in Table 51 and in Table 52 for handlaid 5% and 10% 1080 gels.

TABLE 51. THE PERCENTAGE WALLABY KILL FOR AERIALLY DISTRIBUTED 1.5 g kg^{-1} 1080 CARROTS

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
93.1%	Okataina SR, 1999 (Dama wallabies)	5	12	1

1. PESTLINK: 0304 ROT04

TABLE 52. THE PERCENTAGE WALLABY KILL FOR HANDLAID 5% AND 10% 1080 GEL

KILL	LOCATION	METHOD	REF.
86.2%	Okataina SR, 1988 (Dama wallabies)	5-10 m x 50-100 m transects, 5 baited leaves/branch (5% 1080 gel)	1
91.3%	Tasman Smith SR, Hunter hills, 1983 (Bennett's wallabies)	10 branches/ha, 25 baited leaves/branch (10% 1080 gel)	1

1. Warburton (1990)

Deer

The percentage kill of deer is presented in Table 53 for aerially distributed 1.5 g kg^{-1} 1080 carrot is and in Table 54 for handlaid 10% 1080 gel.

TABLE 53. THE PERCENTAGE DEER KILL FOR AERIALLY DISTRIBUTED 1.5 g kg^{-1} 1080 CARROTS

KILL	LOCATION	SOWING RATE (kg ha^{-1})		REF.
		Prefeed	Toxic	
92%	Titiraupunga, 1997	5	15	1
34%	Pureora, 1994	5	15	2
42%	Pureora, 1994	15	15	2

1 Fraser & Sweetapple (2000); 2 Fraser et al. (1995)

TABLE 54. THE PERCENTAGE DEER KILL FOR HANDLAID 10% 1080 GEL

KILL	LOCATION	METHOD	REF.
79%	Hauhangaroa Range, 1997	2 branches/ha, 10 baited leaves/branch	1
80%+	Stewart Island, 1981	2.5 branches/ha, 20 baited leaves/branch	2
100%	Stewart Island, 1981	5 branches/ha, 20 baited leaves/branch	2

1 Sweetapple (1997); 2 Nugent (1990).

Goats

10% 1080 gel (100 g kg^{-1} *1080), handlaid*

The percentage kill of goats using handlaid 10% 1080 gel is presented in Table 55.

TABLE 55. THE PERCENTAGE KILL OF GOATS FOLLOWING THE USE OF HANDLAID 10% 1080 GEL

KILL	LOCATION	METHOD	REF.
88%	Whitecliffs, Buller River, Jul 2007	2.2 branch/ha in preferred habitat, 10 - 20 baited leaves/branch	1
87%	Motu River, Jan 1986	1 branch/ha in preferred habitat, 20 baited leaves/branch	2
97%	Motu River, March 1982	2.5 branches/ha, 20 baited leaves/branch	3

1 Anderson (2008) Docdm-231336; 2 Veltman & Parkes (2002); 3 Parkes (1983)

7. Glossary of Terms

µg kg^{-1}**, µg** l^{-1}

See ppb.

µg g^{-1}**, µg** ml^{-1}

See ppm.

Absciss

Part of a plant breaking off naturally (e.g. leaves dying)

Aconitase

An enzyme occurring in many animal and plant tissues that accelerates the conversion of citric acid first into aconitic acid and then into isocitric acid.

Biological Exposure Index (BEI)

A reference value below which exposure to a substance will not create an unreasonable risk of disease or injury. BEIs are set by the American Conference of Governmental Industrial Hygienists (ACGIH).

Biosynthesis

The production of a chemical compound by a living organism.

bw

Body weight

Carcinogenic

The ability of a substance to cause cancer.

Citrate

A salt or ester of citric acid.

Cyanosis

Blueness of the skin and mucous membrane due to insufficient oxygen in the blood.

Defluorination

To remove fluorine

Endocardium

The lining of the interior surface of the heart chambers. The endocardium consists of a layer of endothelial cells and an underlying layer of connective tissue. a thin serous membrane lining the cavities of the heart.

Epicardium

The inner layer of the pericardium, a conical sac of fibrous tissue that surrounds the heart and the roots of the great blood vessels./ the visceral part of the pericardium that closely envelops the heart

Epiglottis

The flap that covers the trachea during swallowing so that food does not enter the lungs.

Fluorocitrate

The toxic metabolite of fluoroacetate that causes inhibition of aconitase.

Gastrointestinal tract

The stomach and intestine as a functional unit

Glial cells

A supportive cell in the central nervous system. Glial cells do not conduct electrical impulses (as opposed to neurons, which do). The glial cells surround neurons and provide support for them and insulation between them.

Half-life

During each half life (t½ or elimination half-life) 50% of the pesticide in the body at the beginning of that half-life is eliminated. The half-life is established in laboratory trials, and is used to predict the rate of elimination of a single dose of pesticide from the body and to estimate how long the disappearance of cumulative intakes of a pesticide from the body would take.

Hypotension

Abnormally low pressure of the blood -- called also low blood pressure

Intravenous

Administered into a vein.

LC_{50}

Lethal Concentration 50%. The calculated concentration of a gas/liquid that kills 50% of the test organisms

LD_{50}

Lethal Dose 50%. The estimated dose that kills 50% of the test organisms.

LOEL

Least Observable Effect Level. The lowest dose in a study in which there was an observed toxic or adverse effect

Mitochondrial aconitate hydratase

An iron-dependent enzyme that catalyzes conversion of citrate to cis-aconitate in the tricarboxylic acid cycle within the mitochondrion.

Metabolites

The breakdown of compounds resulting from the metabolism of a parent compound.

mg kg^{-1}**, mg** l^{-1}

See ppm.

mmol (, mM)

millimole: a unit of metric measurement that is equal to one thousandth (10-3) of a mole. It is the amount of a substance that corresponds to its formula mass in milligrams. [mol l^{-1}]x[mL] = mmol.

Mutagenic

The ability of a substance to cause damage to DNA and produce alterations or loss of genes or chromasomes

NOEL

No Observable Effect Level. A dosage of a toxicant that fails to produce any discernable signs of toxicosis, which may include a lack of morphological, biochemical, or physiological change

Non-saponifiable lipids

Non-polar compounds that cannot be broken down by a simple hydrolytic reaction. They include steroids and hormones.

Oral

Given or taken through or by way of the mouth, as in an oral solution.

Phosphofructokinase

An enzyme that functions in carbohydrate metabolism and especially in glycolysis by catalyzing the transfer of a second phosphate to fructose.

ppb

parts per billion. This concentration unit is equivalent to 1 µg l^{-1} in water (solution) or air and 1 µg kg^{-1} in solid samples (soil/sediments/biological tissue).

ppm

parts per million. This concentration unit is equivalent to 1 mg l^{-1} (or µg ml^{-1}) in water (i.e. solutions) or air and 1 mg kg^{-1} (or µg g^{-1}) in solid samples (i.e. soil/sediments/biological tissue).

Succinate dehydrogenase

An iron-containing flavoprotein enzyme that catalyzes, often reversibly, the dehydrogenation of succinic acid to fumaric acid in the presence of a hydrogen acceptor and that is widely distributed especially in animal tissues, bacteria, and yeast -- called also succinic dehydrogenase.

Subepicardial

Under the serious membrane which covers the heart situated or occurring beneath the epicardium or between the epicardium and myocardium.

Teratogen

A compound that causes birth defects in a developing foetus.

Toxicosis

A pathological condition caused by the action of a poison or toxin.

Toxin

A natural occurring poison, e.g. 1080, cyanide.

Toxicant

A synthetic man-made poison, e.g. brodifacoum.

Trachea

The tube-like portion of the respiratory tract that connects the "voice box" (larynx) with the bronchial parts of the lungs. called also windpipe.

Tricarboxylic acid cycle

A sequence of reactions in the living organism in which oxidation of acetic acid or acetyl equivalent provides energy for storage in phosphate bonds - called also citric acid cycle, Kreb cycle.

Threshold Limit Values (TLV)

Recommended values for the highest level of exposure to airborne chemical concentrations in the workplace that does not produce adverse health effects. They are set by the American Conference of Governmental Industrial Hygienists (ACGIH).

Viscera

Body organs.

VPRD

Vertebrate Pesticide Residue Database. (DOCDM-32812)

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Appendix 3

PINDONE

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Version	*Date Written*	*Change/Reason for Change*
2012/1	20/8/2012	Corrected information in 4.1.1.
2010/1	3/8/2010	Updated Tables 1 and 2 and non-target information in 3.2.1, 3.2.2, 4.2.1 & 4.2.2
2009/2	6/10/2009	Operation result added to 6.2.4 (Table 13)
2009/1	2/3/2009	6.2.4: rabbit kill at Ben Dhu
2008/1	4 September 2008	Original document

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I. Overview

Introduction

Pindone is a first generation anticoagulant belonging to the indandione class (like diphacinone and chlorophacinone). Pindone was developed as a pesticide in the 1940's and initially evaluated as an alternative to pyrethrins because it exhibited insecticidal properties. It is currently registered in NZ for rabbit, rat and possum control. There are two forms of pindone - an acid and a salt. The acid form is insoluble and used in the manufacture of pellets. The salt form is soluble and is used to make Pindone Liquid Concentrate.

Once absorbed through the gastrointestinal tract, pindone acts by inhibiting the formation of vitamin K-dependent clotting factors in the blood, leading to extensive, multiple, haemorrhages causing death. As with other first generation anticoagulants, pindone is readily metabolised. Tissue distribution of pindone seems to be somewhat different from other anticoagulants. Plasma concentrations remain higher than tissue concentrations, and concentrations in the liver and kidney are comparable. Pindone is far less persistent than second-generation anticoagulants such as brodifacoum, and is less persistent than diphacinone.

Fate in environment

Under favourable conditions baits containing pindone can remain toxic for months. If pindone in its acid form enters the soil, its half-life is likely to be in the order of a month and any residues could be expected to be well retained and degrade at a moderate rate. In contrast, the sodium salt form of pindone is water soluble and likely to be mobile, so residues are unlikely to persist. Pindone has some insecticidal and fungicidal properties, hence degradation of pindone is probably abiotic. There is some indication that it may undergo photodegradation.

The acid form of pindone has a very low solubility in water. Leaching from soil into water is therefore unlikely to occur. Pindone salt is soluble in water so potentially it could enter waterways. If pindone did enter a waterway, temperature and probably the pH of water and exposure to ultraviolet light will affect the rate at which the pindone degrades.

Uptake by plants is unlikely for the non-water soluble pindone acid, but more likely for water soluble sodium salt of pindone.

Pindone residues have been recorded in both sub-lethally and lethally poisoned animals. The half-life of pindone in sub-lethally poisoned animals is days.

Effects on non target native species

The toxicity of pindone to native New Zealand species has not been widely studied. A wide range of native bird species have been found dead following pindone operations to control rabbits, however it is unknown if this has an impact at a population level. A single study of lizards suggests they are unlikely to be at risk from the use of pindone. However, some lizards have been found dead following pindone operations. Pindone is reported as having insecticidal properties. However, no studies of its toxicity to native invertebrates have been undertaken.

Information from studies of non-native species (see Section 4 of this review), and in other first, and second, generation anticoagulant reviews can be used to inform risk assessments until more NZ studies are available.

Effects on domestic and feral animals

The toxicity of pindone to different species is highly variable and animals are generally far more susceptible to repeat doses of pindone than single doses. While there is no LD_{50} data for insects, pindone has significant insecticidal properties and is likely to be toxic to bees. Sub-lethal effects reported in animals include increased blood clotting times and inappetence. Sheep have died as a result of excessive bleeding from shearing cuts following poisoning with pindone. Pregnant ewes sub-lethally exposed to pindone had significantly more stillborn lambs, or lambs failing to survive more than two days compared to untreated ewes, and some deformities were reported in lambs produced by the poisoned ewes. Pindone also affected the motility of the sperm of sub-lethally poisoned rams.

Quail deaths have been recorded during broad-scale rabbit control operations.

There is an effective antidote for domestic animals poisoned with pindone. However, long term treatment is required.

Human health

There is little information specifically relating to the toxicity of pindone to humans. Based on information about other anticoagulant rodenticides, it is likely pindone has quite low acute toxicity to humans, requiring large numbers of toxic baits to be ingested to receive a median lethal dose. However, if taken repeatedly for several days, the required dose would be much less. There are conflicting reports of the mutagenicity of pindone. Pindone is likely to have a sub-lethal effect on both female and male human fertility based on the results of trials on sheep.

An antidote is readily available but should be administered by trained medical staff.

Operational

Humaneness is likely to be similar to that for other anticoagulants since the mode of action is the same. Most animals receiving a lethal dose of pindone die within two weeks.

Pindone is most effective in multiple doses where the target pest can feed freely for 5 or more days without running out of bait. While rabbits are highly susceptible to pindone, possums are relatively tolerant and need to eat large amounts of bait for them to be killed.

When pindone is used for broad scale rabbit control, kills of greater than 90% are usually achieved. Good rat kills have also been achieved at sites where possum numbers are low. Kills of only 49-65% have been achieved when pindone has been used to control possums.

1. Introduction

Pindone is a first generation anticoagulant belonging to the indandione class (like diphacinone and chlorophacinone). Pindone was developed as a pesticide in the 1940's and initially evaluated as an alternative to pyrethrins because it exhibited insecticidal properties. It is currently registered in NZ for rabbit, rat and possum control. There are two forms of pindone - an acid and a salt. The acid form is insoluble and used in the manufacture of pellets. The salt form is soluble and is used to make Pindone Liquid Concentrate.

Once absorbed through the gastrointestinal tract, pindone acts by inhibiting the formation of vitamin K-dependent clotting factors in the blood, leading to extensive, multiple, haemorrhages causing death. As with other first generation anticoagulants, pindone is readily metabolised. Tissue distribution of pindone seems to be somewhat different from other anticoagulants. Plasma concentrations remain higher than tissue concentrations, and concentrations in the liver and kidney are comparable. Pindone is far less persistent than second-generation anticoagulants such as brodifacoum, and is less persistent than diphacinone.

1.1 Chemical Names

2-(2,2-Dimethyl-1-oxopropyl)-1H–indene–1,3(2H)-dione; 2–Pivaloyl–1, 3–Indandione; 2-Pivaloylindan-1,3-dione

1.2 Synonyms

Pindone; Pival; Pivalyl; Pindone-sodium

1.3 CAS Numbers

83-26-1

1.4 Registered pesticides containing pindone available in New Zealand

Trade Name	ERMA Approval Code	ACVM Registration	Pesticide use number (Status list)	Hazard Classification[1]
Pindone Rabbit Pellets (0.25 g/kg pindone)	HRC000009	V004110	69, 71, 109	6.9B, 9.1D
Pindone RS5 Rabbit Pellets (0.25 g/kg pindone)	HRC000009	V004478	70, 72, 108	6.9B, 9.1D
Pindone Pellets (0.50 g/kg pindone)	HRC000009	V004396	68, 116	6.9B, 9.1D
Pindone Liquid Concentrate (0.17 g/kg pindone)	HRC000025	V004468	75, 76, 77, 78	6.1C, 6.4A, 6.9B, 9.1B, 9.3A

[1] Visit the ERMA NZ website for a summary of the classifications.

1.5 Chemical and physical properties

Pindone occurs in two forms – pindone acid and pindone salt.

The empirical formula for pindone acid is $C_{14}H_{14}O_3$ and the molecular weight is 230.3. It occurs in equilibrium between keto and enol tautomers, with the keto form more common (NRA 2002). Pindone is a yellow crystalline powder with a melting point of 108.5-110.5°C, low solubility in water (18 mg L^{-1}) at 25°C and very low vapour pressure (1.3 x 10^{-7} mPa) (IPCS 1995). It is soluble in most organic solvents, and due to the acidity of the enol tautomer is readily soluble in aqueous alkalis or ammonia where it forms bright yellow salts (NRA 2002). The pindone acid form is used in the manufacture of pellet baits.

The sodium salt form of pindone ('Pival' or pindone-sodium) has an empirical formula of $C_{14}H_{13}NaO_3$ and a molecular weight of 252.3 (Eason & Wickstrom 2001). The sodium salt is readily water soluble and used to manufacture Pindone Liquid Concentrate.

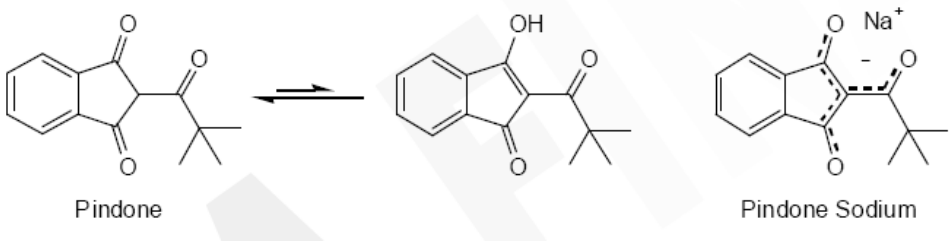

FIGURE 1. CHEMICAL STRUCTURE OF PINDONE (LEFT) AND THE SODIUM SALT FORM OF PINDONE (RIGHT)

1.6 Historical development and use

Pindone belongs to the indandione class of anticoagulants, which differ chemically from coumarin anticoagulants such as brodifacoum or warfarin.

Pindone was first synthesised in 1937 (Beauregard et al. 1955) and developed as a pesticide in the early 1940s. It was originally evaluated as an alternative to pyrethrin because of its insecticidal properties (Kilgore et al. 1942). Subsequently it was selected for extended study as it possessed the strongest insecticidal and anticoagulant characteristics of a series of 1,3 indandiones (Crabtree & Robinson 1953). In 1948 pindone was shown to be an effective alternative to DDT for the treatment of body lice (*Pediculus humanus*) (Eddy & Bushland 1948), but it has not been widely used as an insecticide.

Pindone has been used worldwide to control rodents, though its use for the control of rats and mice has decreased following the introduction of more potent anticoagulants such as brodifacoum. There are two other indandiones, diphacinone and chlorophacinone, which were synthesised in the 1950s and 1960s, and these two newer, more potent compounds have also contributed to a reduction in pindone use for rodent control.

Pindone is currently registered in New Zealand for the control of rabbits (*Oryctolagus cuniculus*), rats and brush tailed possums (*Trichosurus vulpecula*) but it is most effective for rabbit (Eason & Jolly 1993) and rat control.

This section is updated from Eason & Wickstrom (2001).

1.7 Toxicology and pathology

1.7.1 Mode of action

Pindone acts like the other anticoagulant toxicants by interfering with the normal synthesis of vitamin K-dependent clotting factors in the liver. The weaker potency of first-generation anticoagulants such as pindone is related to a generally lower binding affinity when compared to second-generation compounds (Parmar et al. 1987; Huckle et al. 1988).

This section is updated from Eason & Wickstrom (2001).

1.7.2 Pathology

The clinical signs of poisoning are usually some sign of haemorrhage. Onset of signs may occur suddenly; especially when haemorrhaging in the brain or pericardial sac occurs. Clinical signs commonly include anaemia and weakness. Haemorrhaging may be visible around the nose, mouth, eyes, and anus, and animals may pass bloody faeces. If there is haemorrhaging in the lungs, blood-tinged froth may be visible around the nose and mouth. Swollen, tender joints are common and, if haemorrhage involves the brain or central nervous system, ataxia or convulsions can occur. Poisoned animals will die usually of multiple causes associated with anaemia or hypovolemic shock. Some possums receiving high doses of pindone have died without any signs of haemorrhaging, and necropsy has revealed liver damage (Jolly et al. 1994).

This section is updated from Eason & Wickstrom (2001).

1.7.3 Absorption, metabolism, and excretion

Pindone is absorbed through the gastrointestinal tract. Tissue distribution of pindone appears to be slightly different from other anticoagulants. Plasma concentrations remain higher than tissue concentrations for 8 days and concentrations in the liver and kidney are comparable (Fitzek 1978). Pindone is far less persistent than second-generation anticoagulants, and is less persistent than diphacinone, which is consistent with the mode of action and relative potencies of these compounds.

In dogs (*Canis familiaris*) pindone is fairly well absorbed (67%) and the plasma elimination half-life is approximately 100 hours after administration of 3 mg kg^{-1} (Fitzek 1978). In sheep (*Ovis aries*), residues were detected in the liver and fat of animals dosed with 20 mg kg^{-1} for 8 days, but after 2 weeks no residues were detected (Nelson & Hickling 1994). The half-life of pindone in blood of sheep was calculated as ~4-5 days by Robinson et al. (2005).

Fisher et al. (2003) reported that the hepatic elimination half-life of pindone in laboratory rats (*Rattus norvegicus*)was 2 days after administration of an approximate LD_{15} dose.

Martin et al. (1991) estimated the half-life of pindone in blood at 3.1 days for cattle (*Bos taurus*), 2.8 days for goats (*Capra hircus*) and chickens (*Gallus gallus*), 1.9 days for horses (*Equus caballus*) and dogs and less than one day for cats (*Felis catus*).

This section is updated from Eason & Wickstrom (2001).

2. Fate in the environment

Under favourable conditions baits containing pindone can remain toxic for months. If pindone in its acid form enters the soil, its half-life is likely to be in the order of a month and any residues could be expected to be well retained and degrade at a moderate rate. In contrast, the sodium salt form of pindone is water soluble and likely to be mobile, so residues are unlikely to persist. Pindone has some insecticidal and fungicidal properties, hence degradation of pindone is probably abiotic. There is some indication that it may undergo photodegradation.

The acid form of pindone has a very low solubility in water. Leaching from soil into water is therefore unlikely to occur. Pindone salt is soluble in water so potentially it could enter waterways. If pindone did enter a waterway, temperature and probably the pH of water and exposure to ultraviolet light will affect the rate at which the pindone degrades.

Uptake by plants is unlikely for the non-water soluble pindone acid, but more likely for water soluble sodium salt of pindone.

Pindone residues have been recorded in both sub-lethally and lethally poisoned animals. The half-life of pindone in sub-lethally poisoned animals is days.

2.1 Bait pathway

2.1.1 How long do baits remain toxic?

The key difference between pindone acid and pindone salt is the water solubility of pindone salt (NRA 2002). Carrot and oat baits, which are manufactured using Pindone Liquid Concentrate (the salt form of pindone) would be expected to loose the toxicant from the baits more rapidly than pellet baits, which are manufactured from the acid form, under wet conditions.

Pindone acid

When Pindone Pellets (0.25 g/kg pindone, Agtech pellet) were exposed to simulated heavy rainfall (20 mm hr^{-1}) they crumbled quickly and lost their shape after 300 mm rainfall. The pellets nominally contained 0.25 g kg^{-1} of pindone, but assayed at 0.326 g kg^{-1}. The concentration of pindone in the pellets declined to 0.279 g kg^{-1} after 100 mm of rain and then very slowly to 0.24 g kg^{-1} following 400 mm of rainfall (Booth et al. 1999).

Following a rabbit control operation at Pukaki Flats, Twizel Area Office in 2007, pindone rabbit pellets (0.25 g/kg pindone) still contained 0.091 g kg^{-1}, sixty days after being laid (VPRD: T2913).

Under favourable conditions (i.e. dry) baits could be expected to remain toxic for months.

Pindone salt

Boswell (1995) reported that following a rabbit control operation in July 1994 on the Wither Hills, south of Blenheim, using pindone carrot baits (0.17 g/kg pindone), the fresh baits were assayed at 0.185 g kg^{-1} pindone. Pindone concentrations in the baits declined to 0.108 g kg^{-1} after one day in the field and to 0.088 g kg^{-1} after two days. After 11 days and 26 mm rain, pindone concentrations in the baits were 0.071 g kg^{-1}.

2.1.2 How soluble is pindone in natural water?

Pindone acid

The pindone in *pellet baits is the acid form and has a low solubility* (18 mg L^{-1} at 25°C) (IPCS 1995).

Pindone salt

The *sodium salt of pindone (used in Pindone Liquid Concentrate) is soluble* in water (Eason & Wickstrom 2001).

Note: Solubility is the determining factor for the pesticide pathway beyond the bait. For insoluble pesticides, fate in water (and therefore plants) is insignificant because negligible amounts of poison are dissolved.

2.2 Soil and sediment

2.2.1 What is the range of toxic residue levels observed in soil?

Pindone acid

During pen trials no pindone was recovered from soil underneath Pindone Pellets (0.25 g/kg pindone) exposed to up to 400 mm simulated rainfall (Booth et al. 1999).

Following a rabbit control operation using pindone rabbit pellets (0.25 g/kg pindone) at Pukaki Flats, Twizel Area Office, in 2007, soil samples collected from directly under baits 7 days after the bait was laid. The soil contained pindone residues of 0.65 mg kg^{-1}. Sixty days after the operation a soil sample from under bait contained a residue of 1.28 mg kg^{-1} (VPRD: T2927).

Pindone salt

Following pindone carrot operations in Otago in August 1991 soil samples were taken from four different locations where baits had been prepared. The samples were taken at varying times after the operations and all tested negative for pindone. Three soil samples taken from an airstrip where carrot bait had been prepared near Twizel in 1991 had residues of 0.7, 1.7 and 98.8 mg kg^{-1} (P Fisher pers. comm.).

Soil containing decomposing carrot that was collected by Canterbury Regional Council after a rabbit control operation near Twizel (time after operation not recorded) contained pindone residues of 1.8 g kg^{-1}, while a soil sample containing animal droppings from the same area had no detectable pindone (P Fisher pers. comm.).

2.2.2 How long does degradation of pindone take in soil or sediment?

There are no published studies on the degradation time of pindone (in either the acid or salt forms) in soils or sediments.

Pindone acid

Using data for chlorophacinone and diphacinone as a surrogate, the half-life of the acid form of pindone in soil is likely to be in the order of a month. Therefore any residues entering soils or sediments could be expected to be well retained and degrade at a *moderate rate* (NRA 2002).

Pindone salt

The sodium salt of pindone is water soluble and likely to be mobile, so residues are unlikely to persist (NRA 2002).

2.2.3 Are there environmental factors that affect degradation in soil?

Pindone has some insecticidal and fungicidal properties (Wheeler & Oliver 1978), hence *degradation of pindone is probably abiotic* (NRA 2002). Studies of closely related anticoagulants and observations of pindone loss from the surface of baits in Australian studies suggest that pindone *may undergo photodegradation* (NRA 2002).

Note: Environmental factors will determine how widely the breakdown times reported for specific sites can be applied. For example, if breakdown is significantly affected by temperature, rainfall, leaf litter, presence or types of micro-organisms, then it may occur faster or slower than the time quoted in Section 2.2.2.

2.3 Fate in water

2.3.1 Where available, what is the range of toxic residue levels observed in natural water?

A small survey of water samples (n=3) in a catchment area where pindone baits (type not specified) had been aerially sown for rabbit control was undertaken in 1994, with no pindone residues detected (Eason & Wickstrom 2001).

2.3.2 How long does degradation of pindone take in natural water?

The degradation time of pindone in water is likely to be *slow*. A stability study of pindone sodium concentrate (25 g/L) in water (pH of the solution not described, but probably neutral to alkaline) over a 24 week period showed the concentration of pindone salt declined linearly with time. The half life of pindone salt was extrapolated to 370 weeks at 8.5°C, 27 weeks at 30.5°C and 8.7 weeks at 39.5°C (Parker and Hannan-Jones in NRA 2002). However, no studies have been undertaken to confirm this half life using natural water.

2.3.3 Are there environmental factors that affect degradation in aquatic environments?

The *temperature* of the water appears to have an influence on degradation times of pindone salt (Parker and Hannan-Jones in NRA 2002). Based on studies with similar compounds (chlorophacinone and diphacinone) *pH of water and exposure to ultraviolet light* will also affect the degradation of pindone in water (NRA 2002).

Note: Environmental factors will determine how widely the breakdown times reported for specific sites can be applied. For example, if breakdown is significantly affected by temperature, pH, volume, still/running water, or presence or types of micro-organisms, then it may occur faster or slower than the time quoted in Section 2.3.2.

2.4 Fate in plants

2.4.1 Is it likely that plants could take pindone up in solution, based on molecular structure?

Uptake by plants is unlikely for the non-water soluble pindone acid, but more likely for water soluble sodium salt of pindone.

2.4.2 Is there evidence that plants either take up or don't take pindone up?

There are no published studies that provide evidence of pindone (in either the acid or salt forms) uptake by plants.

Crabtree and Robinson (1953) reported there was some evidence that pindone baits have fungicidal properties due to lack of moulds observed on cereal baits, however, Bentley and Rowe (1956) described the fungicidal properties of pindone described as 'not marked'.

2.4.3 Where evidence exists for plant uptake, how long do residues persist?

There are no published studies on residues of pindone (in either the acid or salt forms) in plants.

2.5 Animal residues

2.5.1 What is the range of toxic residue levels recorded for sub-lethally exposed animals?

Laboratory rats dosed with an approximate LD_{15} of pindone had liver residues of 1.75-4.38 µg g^{-1} two days after dosing, 0.24 – 0.61 µg g^{-1} at one week after dosing and no detectable residues from two weeks onward after dosing (Fisher et al. 2003).

In pen trials, eight rats that survived eating a mean of 90.91 mg kg^{-1} of pindone over four days had liver residues of 0.29±0.16 mg g^{-1} when euthanased 21 days after the last ingestion of pindone. Fifteen rats that ate a mean of 58.56 mg kg^{-1} of pindone in one day (equivalent to 50% of an LD_{50} dose) had residues of 5.50±0.37 mg g^{-1} in the liver the day after consuming the pindone (Fisher et al. 2004).

In a pen trial, sheep dosed with 10 mg kg^{-1} pindone had liver residues of 11.8 µg g^{1} at two days after dosing, declining to 4.9 µg g^{-1} at four days and 2.1 µg g^{-1} at eight days (Nelson & Hickling 1994). When sheep were dosed with 60 mg of pindone, residues of 19.6 µg g^{-1} were recorded in abdominal fat on day one post-dosing, declining to 0.1 µg g^{-1} eight days after dosing (Nelson & Hickling 1994).

Robinson et al. (2005) orally administered pindone in decreasing amounts (10, 3, 2 mg kg^{-1}) over three consecutive days to merino wethers. The total dose was approximately 19% of the acute LD_{50} and represented the worst case scenario with respect to the amount of pindone that an individual sheep could ingest as a result of a rabbit control program. The maximum recorded pindone residue in the blood was 12.70 mg L^{-1}. The researchers also undertook a double exposure trial where the dosing regime was repeated eight days after the initial exposure. The maximum recorded pindone residue in the blood during this trial was 13.20 mg L^{-1}.

Animals have also been sampled during pest control operations to test for sub-lethal pindone residues. These results are presented in Table 1.

TABLE 1. PINDONE RESIDUE LEVELS RECORDED IN SUB-LETHALLY EXPOSED ANIMALS.

SPECIES	RANGE OF RESIDUES (mg kg^{-1})	COMMENTS	REFERENCE
Mammals			
Sheep	0.1 to 19.6	5 fat samples, 4 with detectable residues from unspecified location Apr 1991	1
Sheep	0	2 fat samples, 2 liver samples and 1 muscle sample from Twizel area Dec 1991 and Jan 1992. All had no residues	1
Cat	0.88	Liver sample from a kitten shot feeding on a dead rabbit, Pukaki Flats, 19/3/2007	2
Hare (*Lepus europaeus*)	<MDL	Liver sample from a hare shot Pukaki Flats, 19/3/2007	2
Ferret	5.9	Liver sample from ferret caught Twizel, 8/9/2009	3
Birds			
Chaffinch (*Fringilla coelebs*)	3.5	Liver sample from chaffinch feeding on bait, Pukaki Flats, 19/3/2007	2

1 Landcare Research file; 2 VPRD: T2962; 3 VPRD: 13492.

Note: The information in this section was derived from direct analyses for pindone in animal tissues, from animals known or suspected to have received a sub-lethal dose of pindone. Where animals were found dead but with no detectable residues they have been excluded as it is likely that there was no prior exposure to pindone. Where the information is derived from the Vertebrate Pesticide Residue Database, a decision on whether animals had sub-lethal poisoning prior to sampling for has been based on the information submitted with the sample.

2.5.2 How long do toxic residues of the pesticide persist in sub-lethally exposed animals?

Laboratory rats dosed with an approximate LD15 pindone had liver residues of 1.75-4.38 µg g^{-1} two days after dosing, 0.24 – 0.61 µg g^{-1} one week after dosing and no detectable residues from two weeks onwards after dosing (Fisher et al. 2003).

Sheep dosed with 10 mg kg^{-1} pindone had detectable liver residues at eight days after dosing. No detectable liver residues were present from 16 to 128 days after dosing (Nelson & Hickling 1994). Sheep dosed with 60 mg of pindone had residues in abdominal fat at eight days after dosing and no detectable residues in fat 16 days after dosing (Nelson & Hickling 1994).

In the trials (see 2.5.1) by Robinson et al. (2005) pindone residues in the blood had declined to relatively low levels within 7 (single exposure trial) to 14 (double exposure trial) days after the last dose being administered. No pindone was detected in the blood of the wethers 29 (single exposure trial) and 26 (double exposure trial) days after administration of the last dose.

2.5.3 What is the half life of pindone in sub-lethally exposed animals?

Fisher et al. (2003) reported that the *hepatic elimination half-life of pindone in laboratory rats was 2 days* after administration of an approximate LD_{15} dose.

Martin et al. (1991) estimated the *half-life of pindone in blood at 3.1 days for cattle, 2.8 days for goats and chickens, 1.9 days for horses and dogs and less than one day for cats. The half-life of pindone in blood of sheep was calculated as ~4-5 days* by Robinson et al. (2005).

The *plasma elimination half-life in dogs approximately 100 hours* after administration of 3 mg kg^{-1} (Fitzek 1978).

2.5.4 What is the range of residue levels recorded in carcasses of animals killed by pindone?

In pen trials, rats that died after eating a mean of 116.1 mg kg^{-1} of pindone over four days had liver residues of 1.81±0.41 mg g^{-1} (Fisher et al. 2004).

Robinson et al. (2005) recorded the distribution of pindone residues in a merino wether that died six days after receiving 10, 3 & 2 mg pindone kg^{-1} over three consecutive days, on two occasions eight days apart. The highest residues were in the liver (39 µg g^{-1}). 25 µg g^{-1} of pindone was recorded in muscle, 17 µg g^{-1} in fat, 29 µg g^{-1} in the heart and kidney, 35 µg g^{-1} in the brain and 6 mg L^{-1} in blood.

Pindone residues have also been recorded in ferrets, cats, Southern black-backed gulls (*Larus dominicanus*) and Australasian harriers (*Cirus approximans*) found dead following rabbit control operations. A summary of these pindone residues is given in Table 2.

TABLE 2. PINDONE RESIDUE LEVELS RECORDED IN CARCASSES IN NEW ZEALAND DURING PEST CONTROL OPERATIONS

SPECIES	SAMPLE TYPE	RANGE OF RESIDUES (µg g^{-1})	REFERENCE
Birds			
Southern black-backed gull	Liver	0.8 - 1.8 (n=3)	
Australasian harrier	Liver	4.3 - 11 (n=5)	1, 2, 3
Mammals			
Feral cat	Liver	2.4 (n=1)	4[1]
Ferret	Liver	5 (n=1)	5
Reptiles			
Moko skink (Oligosoma moco)	Liver	19 (n=1)	6
Green gecko (Naultinus elegans)	Whole body	0.52 (n=1)	7, 8

[1] This cat was alive when caught, but appeared to be sick and died while having a radio-collar attached to it.

1 Glentworth and Sullivan (1994); 2 VPRD 13495; 3 VPRD 44226; 4 VPRD 13494; 5 VPRD 13493; 6 VPRD 10270; 7 VPRD 10815; 8 VPRD 10816

Note: The information in this section is derived from direct analyses for pindone in animal tissues, where the animal is known to have received a lethal dose.

2.5.5 How long do residues of pindone persist in carcasses of animals killed by the pesticide?

There are no published studies on the persistence times of pindone in carcasses.

3. Effects on Non-Target Native Species

The toxicity of pindone to native New Zealand species has not been widely studied. A wide range of native bird species have been found dead following pindone operations to control rabbits, however it is unknown if this has an impact at a population level. A single study of lizards suggests they are unlikely to be at risk from the use of pindone. However, some lizards have been found dead following pindone operations. Pindone is reported as having insecticidal properties. However, no studies of its toxicity to native invertebrates have been undertaken.

Information from studies of non-native species (see Section 4 of this review), and in other first, and second, generation anticoagulant reviews can be used to inform risk assessments until more NZ studies are available.

3.1 Toxicity

3.1.1 What is the lethal dose (LD_{50}) range for each taxon?

The LD_{50} data for grey ducks (*Anas superciliosa*) is reported as 5.0 mg kg^{-1} day^{-1} over 7 days (Twigg et al. 1999).

Pindone is reported as having insecticidal properties (Kilgore et al. 1942; Eddy & Bushland 1948; Crabtree & Robinson 1953). However, no studies of its toxicity to native invertebrates have been undertaken.

Section 4 has information on overseas species which is useful when considering the toxicity of pindone to native species.

3.1.2 How much bait needs to be ingested for poisoning, based on pen trials with native species?

Birds

Based on the information given in section 3.1.1, the amount of bait grey ducks need to ingest to be poisoned is given in Table 3.

TABLE 3. AMOUNT OF BAIT NEEDED TO BE INGESTED TO RESULT IN DEATH BASED ON THE REPEAT DOSE LD_{50} FOR NATIVE SPECIES.

SPECIES	LD_{50} (mg kg^{-1} day^{-1})	AVERAGE WEIGHT FEMALE (g)	AMOUNT OF 0.17 g/kg PINDONE BAIT (g) FOR LD_{50}	AMOUNT OF 0.25 g/kg PINDONE BAIT (g) FOR LD_{50}	AMOUNT OF 0.5 g/kg PINDONE BAIT (g) FOR LD_{50}
Birds					
Grey duck	5.0 (7 days)	1000	29.4 g per day	20g per day	10g per day

Note: The LD_{50} values given in section 3.1.1 have been used in the calculations and the average weights of females have been used, as females are generally smaller and therefore a 'worst case scenario' for poisoning. Where LD values were cited as greater (>) or less (<) than a value, this value was used to make the calculations.

Reptiles

During pen trials, **McCann's skinks** (*Oligosoma maccanni*) ingested a mean of 2 mg pindone kg^{-1} bw over two days with no adverse effects. The maximum amount of pindone consumed by a skink was 15 mg kg^{-1} (Freeman et al. 1996).

3.1.3 Based on the mode of action, are there any taxa that are unlikely to be affected by pindone?

No information could be found for any native taxa.

3.1.4 Have sub-lethal effects on birds, mammals, reptiles/amphibians, fish, arthropods, or molluscs been described for pindone?

There are no published studies on the sub-lethal effects of pindone on native species. However, Section 4 has information on non-native species which is useful when considering the sub-lethal effects of pindone on native species.

3.2 Exposure

3.2.1 What species (individual animals) have been reported as non-target deaths in field operations with pindone use?

Birds

Native birds found dead following broad-scale rabbit control using pindone baits (no specifications on application available) include: **plovers**, **rail**, **wrybills** (*Anarhynchus frontalis*), **silvereyes** (*Zosterops lateralis*), **grey warblers** (*Gerygone igata*), **Southern black-backed gulls** and **Australasian harriers** (Sullivan 1994).

Dead **Australasian harrier hawks** and **black-blacked gulls** were found dead at Simmons Pass and on a neighbouring station following rabbit control using pindone pellets in June-July 1994 (Glentworth & Sullivan 1994). Six black-backed gulls were found dead following mechanical spreading of carrot baits (0.17 g/kg

pindone carrot, two applications at 6.7 kg ha^{-1} per application) on Grays Hill, Mackenzie Basin in August 1994 (Glentworth & Sullivan 1994).

In April and August 2009 DOC undertook rabbit control using mechanical spreading of pindone pellets in the Tasman Valley, Mount Cook. During the second pindone operation, four Australasian harriers were found dead within the operational area and a falcon was seen feeding on a dead rabbit. On the 7 September 2009 a hunter reported finding dead 5 **falcon** and 15 **Australasian harrier**. The birds were located approximately 2.5 km from the pindone operation. DOC staff recovered one falcon and 12 Australasian harriers but they were too decomposed for residue testing. These deaths are confounded by an aerial 1080 carrot rabbit control operation was undertaken by LINZ on land adjoining the pindone operational area on 1 July 2009. This operation was half a km from where the birds were found dead (Donoghue 2009).

An Australasian harrier was found dead following a pindone handlaying operation on the Ohau River, Twizel in September 2009 (VPRD 13495).

Reptiles

A **moko skink** was found dead following handlaying of Pindone rabbit pellets as 3.3 kg ha^{-1} at Whangapoua Conservation Area, Great Barrier Island in 2007 (VPRD).

Two **green geckos** were found dead during pindone pellet (0.5 g/kg pindone) bait station operations at Boundary Stream, Hawkes Bay in 2002 and 2003 (VPRD).

3.2.2 In which species have residues of pindone been detected following operations?

Birds

There has been limited residue testing of native species found after pest control operations using pindone. Three **Australasian harriers** and three **Southern black-backed gulls** killed during a rabbit control operation using pindone carrots in June-July 1994 were sent to MAF Wallaceville for residue testing. Residues in the liver of between 4.3-6.7 µg g^{-1} in the harriers and 0.8-1.8 µg g^{-1} in the gulls were reported (Glentworth & Sullivan 1994). An **Australasian harrier** was found dead following handlaying rabbit control on the Ohau River, Twizel in September 2009, with a liver residue of 8.9 µg g^{-1}.

Following rabbit control operations in the Tasman Valley and Ohau River in 2009 two Australasian harrier hawks found dead contained pindone residues of 8.9 and 11 µg g^{-1} in their livers (VPRD 13495, 44226).

Reptiles

A **moko skink** found dead following handlaying of Pindone rabbit pellets as 3.3 kg/ha at Whangapoua Conservation Area, Great Barrier Island in 2007 contained pindone liver residues of 19 µg g^{-1} (VPRD).

One of two **green geckos** were found dead during pindone pellet (0.5 g/kg pindone) bait station operations at Boundary Stream, Hawkes Bay in 2002 and 2003 contained a whole body residue of 0.52 µg g^{-1} (VPRD).

3.2.3 What evidence is there to suggest that pindone use causes or doesn't cause a population decline of native species at sites where it is used?

Reptiles

Freeman et al. (1996) reported that during no choice feeding trials Captive **McCann's skinks** consumed an average of 0.01 grams of non-toxic RS5 pellets and 0.02 g of AgTech Pindone Rabbit pellets (0.25 g/kg pindone – no longer registered in NZ), over two days. The lizards consumed significantly more moist bait that dry bait. However, based on the amount of bait consumed and the lack of adverse effects displayed by the skinks after eating up to 15 mg kg^{-1} of pindone (mean 2 mg kg^{-1}), the authors concluded it was unlikely the direct consumption of pindone poison baits would have a major impact of skink populations.

The attractiveness of non-toxic RS5 cereal pellets and carrot baits (dyed green and lured with cinnamon) to wild **grand** (*Oligosoma grande*) and Otago (*O. otagense*) skinks were tested by Marshall and Jewell (2007). The baits were offered in two sizes – small pieces no larger than 6mm and large baits (whole pellets and whole rounds of sliced carrot). The cereal bait was offered dry or wet. All bait types were sampled (licked, nudged or bitten) by both species of skink, with small pieces sampled more often than large baits. Both species were observed to consume small pieces of wet cereal bait. No animals tried to consume large pieces of cereal bait. While carrot baits were sampled, none were consumed.

No other information on possible declines in populations of native species as a result of the use of pindone could be found.

4. Effects on Domestic and Feral Animals

The toxicity of pindone to different species is highly variable and animals are generally far more susceptible to repeat doses of pindone than single doses. While there is no LD_{50} data for insects, pindone has significant insecticidal properties and is likely to be toxic to bees. Sub-lethal effects reported in animals include increased blood clotting times and inappetence. Sheep have died as a result of excessive bleeding from shearing cuts following poisoning with pindone. Pregnant ewes sub-lethally exposed to pindone had significantly more stillborn lambs, or lambs failing to survive more than two days compared to untreated ewes, and some deformities were reported in lambs produced by the poisoned ewes. Pindone also affected the motility of the sperm of sub-lethally poisoned rams.

Quail deaths have been recorded during broad-scale rabbit control operations.

There is an effective antidote for domestic animals poisoned with pindone. However, long term treatment is required.

4.1 Toxicity

4.1.1 What is the lethal dose range for each taxon?

The LD_{50} values for a range of domestic and feral animals are presented in Tables 4 and 5. For completeness it includes information on species not present in New Zealand.

TABLE 4. ACUTE ORAL TOXICITY OF PINDONE FOR NON TARGET DOMESTIC AND FERAL ANIMALS.

SPECIES	LD_{50} (mg kg^{-1})	REFERENCE
Mammals		
Domestic dog	4	1
Rabbit	6-18	2
Norway rat	50.0	3
Pig *Sus scrofa*	10.0	4
Sheep	>74	4
Marsupials		
Possum	>100	5
Fish		
Bluegill *Lepomis macrochirus*	1600.0 µg L^{-1} 96 hr LC_{50}	6
Rainbow trout *Oncorhynchus mykiss*	210.0 µg L^{-1} 96 hr LC_{50}	6

1 Fitzek (1978); 2 Eason and Wickstrom (2001); 3 Dubock & Kaukeinen, (1978); 4 Twigg et al. (1999); 5 Eason & Jolly (1993); 6 Office of Pesticide Programs (2000)

TABLE 5. REPEAT DOSE ORAL TOXICITY OF PINDONE FOR NON TARGET DOMESTIC AND FERAL ANIMALS.

SPECIES	LD_{50} (mg kg^{-1} day^{-1})	REFERENCE
Birds		
Chicken	2.5 (4 days)	1
Australian magpie *Gymnorhina tibicen*	4.0 (4 days)	1
Nankeen kestrel *Falco cenchroides*	8.0 (7 days)	1
Mammals		
Domestic dog	0.3 -0.5 (4 days)	1
Cat	1.0 -1.25 (4 days)	1
Sheep	>12 (7 days)	2
Cattle	2.0 (3 days)	1
Horse	1.0 (4 days)	1
Goat	2.0 (4 days)	1
Rabbit	0.52 (7 days)	2
Marsupials		
Possum	2.8 (5 days)	1

1 Twigg et al. (1999); 2 Oliver & Wheeler (1978)

While there is no LD_{50} data for insects, Kilgore et al. (1934) found that pindone had significant insecticidal properties. Eddy and Bushland (1948) conducted trials on the insecticidal properties of pindone to body lice. Adult lice were exposed to cloths impregnated with pindone solutions ranging from 0.0025 to 0.5 g L^{-1} for 24 hours. At doses of 0.005 g L^{-1} or less, lice were unaffected. At 0.01 g L^{-1} 23% of lice were affected but none died. At 0.05 g L^{-1}, 40% of lice were affected and 47% died. A dose of 0.5 g kg^{-1} caused 100% mortality. The authors also reported that pindone caused complete mortality of body louse eggs in all stages of incubation when applied as a 5 g L^{-1} solution. This suggests that pindone is likely to be toxic to honeybees (*Apis mellifera*).

4.1.2 How much bait needs to be ingested for poisoning, based on pen-trials with non-target feral and domestic species?

The amount of bait domestic and feral animals would need to eat to be poisoned is given in Tables 6 (Acute LD_{50}) and 7 (Repeat dose LD_{50}).

TABLE 6. AMOUNT OF BAIT NEEDED TO BE INGESTED TO RESULT IN DEATH BASED ON ACUTE LD_{50} FOR NON TARGET DOMESTIC AND FERAL ANIMAL TAXA.

Species	LD_{50} (mg kg^{-1})	AVERAGE WEIGHT FEMALE (kg)	AMOUNT OF 0.17 g/kg PINDONE BAIT (g) FOR LD_{50}	AMOUNT OF 0.25 g/kg PINDONE BAIT (g) FOR LD_{50}	AMOUNT OF 0.5 g/kg PINDONE BAIT (g) FOR LD_{50}
Mammals					
Domestic dog	4	8000	188.2	128.0	64.0
Rabbit	6	800	28.2	19.2	9.6
Pig	10.0	120000	7058.8	4800.0	2400.0
Sheep	74	50000	21764.7	14800.0	7400.0

Note: The LD_{50} values given in section 4.1.1 have been used in the calculations and the average weights of females have been used, as females are generally smaller and therefore a 'worst case scenario' for poisoning. Where LD values were cited as greater (>) or less (<) than a value, this value was used to make the calculations.

TABLE 7. AMOUNT OF BAIT NEEDED TO BE INGESTED TO RESULT IN DEATH BASED ON THE REPEAT DOSE LD_{50} FOR NON TARGET DOMESTIC AND FERAL ANIMAL TAXA.

Species	LD_{50} (mg kg^{-1} day^{-1})	AVERAGE WEIGHT FEMALE (kg)	AMOUNT OF 0.17 g/kg PINDONE BAIT (g) PER DAY FOR LD_{50}	AMOUNT OF 0.25 g/kg PINDONE BAIT (g) PER DAY FOR LD_{50}	AMOUNT OF 0.5 g/kg PINDONE BAIT (g) PER DAY FOR LD_{50}
Birds					
Chicken	2.5 (4 days)	900	13.2	9.0	4.5
Australian magpie	4.0 (4 days)				
Nankeen kestrel	8.0 (7 days)				
Mammals					
Domestic dog	0.3 (4 days)	8000	14.1	9.6	4.8
Cat	1.0 (4 days)	2500	14.7	10.0	5.0
Sheep	12 (7 days)	50000	3529.4	2400.0	1200.0
Cattle	2.0 (3 days)	170000	2000.0	1360.0	680.0
Horse	1.0 (4 days)	190000	1117.6	760.0	380.0
Goat	2.0 (4 days)	35000	411.8	280.0	140.0
Rabbit	0.52 (7 days)	800	2.4	1.7	0.8

Note: The LD_{50} values given in section 4.1.1 have been used in the calculations and the average weights of females have been used, as females are generally smaller and therefore a 'worst case scenario' for poisoning. Where LD values were cited as greater (>) or less (<) than a value, this value was used to make the calculations.

4.1.3 Based on the mode of action, are there any taxa that are unlikely to be affected by pindone?

No information could be located in published literature.

4.1.4 Have sub-lethal effects on birds, mammals, marsupials, reptiles/amphibians, fish, arthropods, or molluscs been described for pindone?

Birds

After oral administration of pindone to chickens, severely elevated prothrombin times were reported at 32 hours post-dosing (Charles et al. 1966). Elevations in prothrombin time was reported in chickens after sub-lethal dosing with pindone for 5 days (Martin et al. 1991).

Elevations in prothrombin time have been observed in pigeons, parrots and eagles sub-lethally dosed with pindone in pen trials. Only eagles showed sub-lethal clinical symptoms (Martin et al. 1994).

Mammals

Sheep sub-lethally dosed with pindone (8-16 mg kg^{-1} day^{-1} for 7 days) showed no changes in packed cell volumes in blood, haemorrhaging and no significant histopathological changes 3 weeks after dosing. However, significant inappetence was observed by day three of dosing and continued until the day after dosing ceased in the sheep receiving 16 mg kg^{-1} pindone (Oliver & Wheeler 1978).

Robinson et al. (2005) orally administered pindone in decreasing amounts (10, 3, 2 mg kg^{-1}) over three consecutive days to merino ewes. The dosing regime was then repeated 8 days after the initial exposure. The ewes were then shorn 2 days later. 11.2% (11/98) of the ewes died as a result of excessive bleeding from shearing cuts, and some shearing cuts in the surviving ewes bled considerably for 4-6 days after shearing.

An extensive trial to look at the effects pindone had on merino sheep reproduction was carried out by Robinson et al. (2005). Pregnant merino ewes exposed to pindone had significantly more stillborn lambs, or lambs failing to survive more than two days compared to untreated ewes. Four lambs (out of 127) produced by the pindone treated ewes had moderate to significant deformities. However, twinning rates were similar between the treated and untreated groups of ewes, as were the weights and prothrombin times of lambs surviving to weaning. The authors also looked at the effect pindone had on sperm motility in merino rams. Pindone affected the motility of the sperm of treated rams within 8 days of dosing with the effect being most pronounced 11 to 18 days after dosing. There was partial recovery in sperm motility 22 days post dosing.

In pen trials elevations in prothrombin time were reported in cattle, goats, dogs and cats after sub-lethal dosing with pindone for 5 days (Martin et al. 1991). Cats fed portions of pindone-poisoned mice for 13 days showed no gross effects and no significant changes in blood coagulation times over the period (Beauregard et al. 1955).

Note: The information in this section includes studies with species not extant in New Zealand

4.2 Exposure

4.2.1 What species (individual animals) have been reported as non-target deaths in field operations with pindone?

Quail have been found dead following broad-scale rabbit control using pindone baits (no specifications on application available) (Sullivan 1994).

A Cat and ferret were found dead following at handlaying rabbit control operation on the Ohau River, Twizel in September 2009 (VPRD 13493, 13494).

4.2.2 For which species have residues of this pesticide been detected following pindone operations?

Residues have been found in sub-lethally exposed sheep during pest control operations (no information on type of operation) (P Fisher pers. comm. Landcare Research file).

A Cat (died during handling, VPRD 13494) and two ferrets (one alive, one dead, VPRD 13492 & 13493) were found with pindone residues in their livers following a handlaying rabbit control operation on the Ohau River, Twizel in September 2009.

4.3 Treatment

4.3.1 Is there an effective treatment of pindone poisoning that is practical to administer?

An effective antidote (Vitamin K) is available, but long term treatment is needed (Eason & Wickstrom 2001).

5. Human Health

There is little information specifically relating to the toxicity of pindone to humans. Based on information about other anticoagulant rodenticides, it is likely pindone has quite low acute toxicity to humans, requiring large numbers of toxic baits to be ingested to receive a median lethal dose. However, if taken repeatedly for several days, the required dose would be much less. There are conflicting reports of the mutagenicity of pindone. Pindone is likely to have a sub-lethal effect on both female and male human fertility based on the results of trials on sheep.

An antidote is readily available but should be administered by trained medical staff.

5.1 Toxicity

5.1.1 What is the oral LD_{50} (mg kg^{-1} bw)?

The minimum oral LD_{50} for humans is estimated at 50 mg kg^{-1} in Fairchild (1977).

5.1.2 How much bait would children and adults need to ingest for poisoning?

The information on bait consumption required for poisoning is presented in Table 8.

TABLE 8. AMOUNT OF PINDONE BAIT NEEDED TO BE INGESTED BY A HUMAN TO RESULT IN DEATH BASED ON THE ORAL LD_{50}.

	LD_{50} (mg kg^{-1})	AVERAGE WEIGHT (kg)	AMOUNT OF 0.17 g/kg PINDONE BAIT (g) FOR LD_{50}	AMOUNT OF 0.25 g/kg PINDONE BAIT (g) FOR LD_{50}	AMOUNT OF 0.5 g/kg PINDONE BAIT (g) FOR LD_{50}
Child	50	15	4411.8	3000	1500
Adolescent	50	30	8823.5	6000	3000
Small adult	50	60	17647.1	12000	6000
Large adult	50	90	26470.6	18000	9000

These figures represent the amount of bait that would have to be consumed in one sitting for a 50% chance of death. This is a straightforward acute toxicity calculation without any “safety factors’ that are used to extrapolate the results of animal studies to humans.

5.1.3 What is the dermal LD_{50} (mg kg^{-1} bw)?

No information on the dermal LD_{50} could be found in the published literature.

5.1.4 Where the pesticide involves a gaseous form, what is the gaseous LC_{50} (ppm in air)?

This is not applicable for pindone.

5.1.5 Where there is dust or mist associated with pindone use, what is the dust and mist LC_{50} (ppm in air)?

No information on the dust or mist LD_{50} could be found in the published literature.

5.1.6 Is there evidence that pindone may have mutagenic and/or carcinogenic properties? If known, what are the LOEL or NOEL values?

There are conflicting reports of the mutagenicity of pindone.

A series of Ames tests, with and without metabolic activation, at different doses (0.1 to 100 µg $plate^{-1}$) and using four different strains of *Salmonella typhimurium* all had negative results (Zeiger et al. 1987). Santoro et al. (1993) reported that no significant results were obtained for pindone in a sex linked recessive lethal assay of male fruit flies (*Drosophila melanogaster*).

However, pindone significantly increased the frequency of sex chromosome loss in male fruit flies (Santoro et al. 1993).

5.1.7 Is there evidence that pindone may have sub-lethal effects on reproduction or lactation, or is classified as a teratogen? If known, what are the LOEL or NOEL values for these reproductive and developmental effects?

Pregnant sheep exposed to pindone had significantly more stillborn lambs, or lambs failing to survive more than two days compared to untreated ewes. Four lambs (out of 127) produced by the pindone treated ewes had moderate to significant deformities. Pindone also affected the motility of the sperm of treated rams (Robinson et al. 2005). See section 4.1.4 for further details of the trials. These results suggest *pindone may have a sub-lethal effect on reproduction*.

5.1.8 Is there evidence that pindone may have sub-lethal effects on target organs? If known, what are the LOEL or NOEL values for these effects?

No information could be found in the published literature.

5.1.9 How rapid is the onset of toxicity for pindone in humans?

Based on information from other first-generation anticoagulants with same mode of action, and the speed at which pindone poisoning sets in, in other mammals, the onset of toxicity in humans will be within days.

5.2 Treatment

5.2.1 Is there an effective treatment or antidote for pindone in humans?

An effective treatment is available. It involves the use of activated charcoal or induced vomiting to prevent further absorption and administering vitamin K1 (phytomenadione) regularly until clotting times return to normal. Blood transfusions may be required in severe poisonings. From a study of over 5700 reported anticoagulant rodenticide poisoning incidents receiving medical treatment in 1988 there were two deaths (IPCS 1995).

6. Operational

Humaneness is likely to be similar to that for other anticoagulants since the mode of action is the same. Most animals receiving a lethal dose of pindone die within two weeks.

Pindone is most effective in multiple doses where the target pest can feed freely for 5 or more days without running out of bait. While rabbits are highly susceptible to pindone, possums are relatively tolerant and need to eat large amounts of bait for them to be killed.

When pindone is used for broad scale rabbit control, kills of greater than 90% are usually achieved. Good rat kills have also been achieved at sites where possum numbers are low. Kills of only 49-65% have been achieved when pindone has been used to control possums.

6.1 Animal Welfare

6.1.1 What are the animal welfare impacts of pindone on the target pest?

Possums

Welfare impacts relate primarily to liver failure resulting from chronic administration of relatively high doses of pindone. Functional impairment of the liver after such chronic dosing (64 mg kg^{-1} day^{-1} over 5 days) is severe enough to eventually result in death between 1 and 2 weeks after dosing (Jolly et al. 1994). Although no data are available, progressive liver failure is likely to cause negative affective states such as sickness, lethargy/weakness, and possibly nausea (MAF BNZ 2010). For possums, MAF BNZ (2010) gave pindone a welfare impact score of 7.5 (on a scale of 1–10).

Rabbits

The most characteristic symptom of poisoning in rabbits which died following chromic administration of pindone (1-4 mg kg^{-1} daily for 7 days) was widespread haemorrhage throughout the muscles on the posterior aspect of both hind legs. Other common symptoms were massive leakage of blood into the abdominal cavity, haemorrhage in muscle around the rib cage and in the submandibular region and numerous smaller subcutaneous haemorrhages over the body. Less common symptoms included leakage of blood into the pericardium and cerebral haemorrhage and small focal haemorrhages in most internal organs. Skin and externally visible mucous membranes were almost colourless, and bleeding from external orifices was often apparent. The time to death was between 5 and 14 days (Oliver & Wheeler 1978).

Three out of six rabbits dosed with 25 mg kg^{-1} pindone (via gastric intubation) died within 6 days (Eason & Jolly 1993). Eason and Jolly (1993) reported that rabbits dosed with 25 mg kg^{-1} pindone that survived for 6 days were weak, and had colourless eyes and pale mucous membranes, indicating a extreme anaemia.

MAF BNZ (2010) considered that pindone had very high welfare impacts on rabbits, giving it a welfare impact score of 8 (on a scale of 1–10).

Rodents

While the time to death for rodents exposed to pindone has been reported, there is no published information available on duration of symptoms (i.e. time from onset of symptoms to loss of consciousness) for pindone. Reported times to death include: 7.9 days (range 3-19 d) for ship rats (*Rattus rattus*) dosed with pindone acid and 9.8 days (range 4 to 21 d) when dosed with sodium salt of pindone (Girish et al. 1972); a mean time to death of 2.0 ± 0.45 days and 8.39 ± 0.54 days in two groups of laboratory rats (*R. norvegicus*) that ingested pindone bait (Fisher et al. 2004), and 4-6 days for wild house mice (*Mus musculus*) dosed with pindone (Rowe 1961).

Fisher et al. (2003) reported that rats that died following dosing with pindone showed behaviour and post-mortem pathology indicative of anticoagulant poisoning, e.g. anaemia and un-groomed appearance, hunched posture, visible bleeding from nose, large internal haemorrhages.

In a review of the humaneness of rodent pest control, Mason and Littin (2003) reported that anticoagulant poisons generally take several days to kill rodents, during which time they cause distress, disability and/or pain.

MAF BNZ (2010) considered that there was insufficient information available to give pindone a welfare impact score for rodents.

Note: The overall assessment of humaneness is based on behavioural, pathological and physical indicators recorded during pen trials, including the time between onset of symptoms and death.

6.2 Efficacy

6.2.1 Is pindone effective on the target pest, based on the LD_{50}?

There is limited toxicity data available for pindone, with the data showing marked species variation. Generally, either a very large single dose or repeated smaller doses are needed to cause death (see Tables 9 and 10). Rabbits are recognised as being highly susceptible to pindone.

TABLE 9. ACUTE ORAL TOXICITY OF PINDONE TO THE TARGET PESTS.

SPECIES		LD_{50} VALUE (mg kg^{-1})	REFERENCE
Possums		>100	1
Rabbits		6-18	2
Rats	Species not specified	75-100	2
	Norway rats (albino)	50	3

1 Eason and Jolly (1993); 2 Eason and Wickstrom (2001); 3 Dubock and Kaukeinen (1978).

TABLE 10. REPEAT DOSE ORAL TOXICITY OF PINDONE TO THE TARGET PESTS.

SPECIES		LD_{50} VALUE (mg kg^{-1} day^{-1})	REFERENCE
Possums		51 (5 days)	1
		2.8 (5 days	2
Rabbits		0.52 (7 days)	3
Norway rats	Sprague-Dawley strain	1.34 (5 days)	4
	Wild strain	12.80 (5 days)	4

1 Jolly et al. (1994); 2 Twigg et al. (1999); 3 Oliver and Wheeler (1978); 4 IPCS (1995).

6.2.2 How much bait does the target pest have to ingest in order to be poisoned, within what timeframe?

The amount of bait a target pest would need to eat to receive a lethal dose based on the acute and repeat dose LD_{50}'s are give in Tables 11 and 12 respectively.

TABLE 11. AMOUNT OF BAIT A TARGET PEST NEEDS TO INGEST TO RESULT IN DEATH BASED ON ACUTE LD_{50}.

SPECIES	LD_{50} (mg kg^{-1})	AVERAGE WEIGHT[1] (g)	AMOUNT OF 0.17 g/kg PINDONE BAIT (g) FOR LD_{50}	AMOUNT OF 0.25 g/kg PINDONE BAIT (g) FOR LD_{50}	AMOUNT OF 0.5 g/kg PINDONE BAIT (g) FOR LD_{50}
Possum	100	3000	1764.7	1200	600
Norway rat	50	310	91.2	62	31
Rabbit	6.00	1300	45.9	31.2	15.6

[1] Maximum expected mean bodyweights are used as larger animals have to consume relatively more bait to be killed

TABLE 12. AMOUNT OF BAIT A TARGET PEST NEEDS TO INGEST TO RESULT IN DEATH BASED ON REPEAT DOSE LD_{50}.

SPECIES	LD_{50} (mg kg^{-1} day^{-1})	AVERAGE WEIGHT[1] (g)	AMOUNT OF 0.17 g/kg PINDONE BAIT (g) PER DAY FOR LD_{50}	AMOUNT OF 0.25 g/kg PINDONE BAIT (g) PER DAY FOR LD_{50}	AMOUNT OF 0.5 g/kg PINDONE BAIT (g) PER DAY FOR LD_{50}
Possum	51 (5 days)	3000	900	612	306
Norway rat	12.8 (5 days)	310	23.3	15.9	7.9
Rabbit	0.52 (7 days)	1300	4.0	2.7	1.4

[1] Maximum expected mean bodyweights are used as larger animals have to consume relatively more bait to be killed

6.2.3 What is the latent period between bait ingestion and onset of symptoms?

No information could be found on the latent period between ingestion and onset of symptoms for any target pest.

Note: A short latent period increases the likelihood of the target pest developing poison shyness.

6.2.4 What field evidence is there that this pesticide use causes a population decline of the target pest species at sites where it is used?

Possums

In 1991-1992 bait station trials of pindone pellets (0.5 g/kg pindone) were carried out in Koutunui Reserve, Hawkes Bay/East Coast Conservancy.

In the first trial PVC hockey stick bait stations were located at 1 station/7.36 ha and refilled daily with 1200g of bait for 8 days. The baiting was then paused for 6 days, and then recommenced for a further 6 days. A 49.1 ± 22.2% kill was achieved (note: monitoring not to NPCA protocol standard) (Whiting 1992).

In the second trial, using PVC hockey stick bait stations located at 1 station/3.05 ha, a 64.9 ± 22.8% kill was achieved (note: monitoring not to NPCA protocol standard). 1200g of bait was put in the bait stations on two successive days. The baiting was then paused for 11 days. Baiting then recommenced for 3 days, was paused for 14 days, then the bait stations refilled for further 4 days (Whiting 1992).

In a field trial by Eason et al (1993) pindone pellets (0.5 g/kg pindone) were put out in four pulses each separated by 10 days. The total possum bait consumption from 28 bait stations increased from 4.65 kg in the first pulse to 25 kg after the fourth pulse. A 0% kill was recorded, with the trap catch increasing from 35% pre-control to 62% six weeks after the final pulse. Eleven possums fitted with radio-collars prior to the study were all alive six weeks after the fourth application of the bait.

Rabbits

In March-April 2007 pindone rabbit pellets (0.25 g/kg pindone) were laid using a mechanical spreader in Ben Dhu Scientific Reserve (three applications at 1 kg/ha per application, 10 days apart). Pre- and post-operational spotlight counts were used to assess the kill, with rabbits declining from 34.5 rabbits/km (1/3/2007) to 1.24 rabbits/km (17/4/2007), a 96.4% kill (K Donoghue, Twizel AO, per comm. 13/11/2008).

Nelson and Hickling (1994) reported on six field trials of pindone carrot to control rabbits. The carrots had a toxic loading of 0.17 g/kg pindone and were sown on two occasions, 5 days apart, at rates of between 10 and 18 kg/ha per application. The mean kill achieved was 94% (range 89 to 98).

In 1994, Glentworth and Sullivan (1994) conducted mechanical spreading trials of pindone baits (0.17 g/kg liquid pindone) for rabbit control in the Mackenzie Basin.

At Simons Pass Station, there were two applications of toxic carrots, 3 kg/ha followed, 8 days later, by 3.5 kg/ha. Pre- and post-operational spotlight counts were used to assess the kill, with rabbits declining from 11.45 rabbits/km (Level 4 on the McLean scale) to 0.65 rabbits/km, a 94.3% kill.

At Grays Hill Station, two applications of 6.7 kg/ha toxic carrot were made nine days apart. Pre-operational spotlight counts were 23.17 rabbits/km (Level 5 on the McLean scale), declining to 1.44 rabbits/ha post control, a 93.9% reduction in rabbits.

On Quailburn Downs, 2.5 kg/ha of toxic oats were applied on two occasions 5 days apart. The pre-operational assessment of rabbit levels were 3-4+ on the McLean scale. A post-control assessment could find no fresh sign or live rabbits.

Rodents

The effectiveness of pindone pellets in bait stations for rat control is presented in Table 13. It appears that possums must be at low densities for pindone to be effective at controlling rats.

There has been one aerial trial using pindone where the percentage kill of rats was estimated. The operation occurred at Kaharoa in October 1991 using cinnamon-lured, green-dyed Mapua pellets (0.50 g/kg pindone) at a 10kg/ha sowing rate. Rat tracking rates were estimated at approximately 60% pre-control and 1% post-control. This is a 98.3% kill (Innes et al. 1995).

TABLE 13. OPERATIONAL RESULTS PINDONE PELLETS IN BAIT STATIONS FOR RAT CONTROL.

LOCATION	METHOD	BAIT FILLS	RAT TRACKING RATES	OTHER INFORMATION	REF.
Lake Tikitapu (Blue Lake) SR, 2008	100m x 100m grid and 100m x 50m grid	4/10/2008: 750g 20/10/2008: empty bait stations refilled to 750g	Pre (1-2/10/2008): 59%±10% Post (5-9/11/2008): 8%±3%	Concurrent possum control using Feratox, Pre-control RTC: 7.3%; During/post-control 1%.	1
Kaharoa, 2006	100m intervals on spurs and ridges	15/07/2006: 1.5kg 05/08/2006: 1.5kg 02/09/2006: 1.5kg	Aislabies: Pre 82%; Post: 64% Onaia East: Pre 62%; Post 21% Onaia West: Pre 64%; Post: 35%	Concurrent possum control using Feratox, Pre-control RTC: 7.8%; Post-control: 4.7%.	2
Boundary Stream, 2003 –2004	150x150m grid over 800 ha, 100m apart around the perimeter	Aug 03 – Jun 2004: 250g every 8 weeks (internal); every 4 weeks (perimeter)	Aug-03: 0% Nov-03: 0% Feb-04: 0% Mar-04: 0% May-04: 5%	Concurrent possum control using Feratox, RTC averaged 0.17% during the period of control. Rat indices variable in non-treatment site throughout the trial (3.3 – 15%).	3
Trounson Kauri Park, 2002 to 2003	50 x 100m grid	28/05/03-10/06/03: 150g 10 - 11/09/03: 150g 10 - 15/12/03: 150g	5/5/03: 10 ± 3% 12/06/03: 8 ± 3% 15/07/03: 0% 19/08/03: 0% 25/09/03: 2 ± 1% 6/11/03: 0% 7/1/04: 0%	Possum waxtag interference rates averaged <0.3% during this period.	

LOCATION	METHOD	BAIT FILLS	RAT TRACKING RATES	OTHER INFORMATION	REF.
Boundary Stream, 2002	150x150m grid over 800 ha, 100m apart around the perimeter	250g dates not specified.	May-02: 0 Aug-02: 0 Nov-02: 0 Feb-03: 0 May-03: 2.5	Concurrent possum control using Feratox, RTC averaged 0.17% during the period of control. Rat indices variable in non-treatment site throughout the trial (1.7 – 17%).	
Boundary Stream, 2001	150x150m grid over 800 ha, 100m apart around the perimeter	Every 6-8 weeks from Dec 2000: 250g	Feb-01: 1% May-01: 1% Aug-01: 0% Nov-01: 0% Feb-02: 0%	Concurrent possum control using Feratox, RTC <0.2% during the period of control. Rat indices >12.5% in non-treatment site throughout the trial.	
Ruakuri/Waitomo and Uekaha SRs, 2001 –2002	100 x 100 m grid	15/12/2001: amount not specified 10/01/2002: not specified	01/10/2001: 18.3% 26/03/2002: 13.3%	Concurrent possum control using pindone, RTC Pre-control: 1.67%; Post-control: 6.6%.	
Otamatuna Te Urewera, 1999-2000	100m x 150m grid	12 - 17/10/99: 250g internal stations, 500g perimeter stations 8 - 18/11/99: 500g 14 - 22/12/99: 250g	10/08/1999: 76 ± 7% 5/10/1999: 92 ± 4% 3/11/1999: 88 ± 5% 9/12/1999: 28 ± 6% 25/01/2000: 6 ± 2%	Concurrent possum control using a variety of techniques (including pindone), RTC post control: 1.7% RTC. Rat indices >80% at the Okopeka non-treatment site during this period.	
Mangaone Te Urewera, 1999-2000	50m along ridges and spurs and 1 sidle line	12 - 17/10/99: 500g	15/09/1999: 94 ± 3%	Concurrent possum control using a variety of techniques (including pindone), possum	

LOCATION	METHOD	BAIT FILLS	RAT TRACKING RATES	OTHER INFORMATION	REF.
	150m either side of the ridge	8 - 18/11/99: 500g 14 - 22/12/99: 500g	3/11/1999: 52 ± 12% 10/12/1999: 22 ± 9% 26/01/2000: 10 ± 5%	numbers not monitored. Rat indices >80% at the Okopeka non-treatment site during this period.	
Otamatuna, Te Urewera, 1998-1999	Bait stations 100m intervals, with 150m spacing between lines	10 - 20/10/98: 250g Last week of Dec 1998: 250g	Oct 1998: 22% Nov 1998: 0% Early Dec 1998: 14% Mid January 1999: <5%	Concurrent possum control using a variety of techniques (including pindone), RTC dropping from 5% to 2.4% during this period. Rat indices >50% at the Okopeka non treatment site during this period.	
Mangaone, Te Urewera, 1998-1999	50m along ridges and spurs and 1 sidle line 150m either side of the ridge	2/11/98: 250g 28/12/98: 250g 12/2/99: 250g	Nov 1998: <90% Dec 1998: ~20% Jan1999: ~12% Feb 1999: ~8%	Concurrent possum control using a variety of techniques (including pindone), RTC dropping from 5% to 2.4% during this period. Rat indices >50% at the Okopeka non-treatment site during this period.	

1 Pestlink: 0809ROT07; 2 Pestlink: 0708ROT07; 3 Pestlink: 0405NAP14

7. Glossary of Terms

µg kg^{-1}, µg L^{-1}

See ppb.

µg g^{-1}, µg mL^{-1}

See ppm.

Abdominal

Pertaining to the abdomen.

Abiotic

Abiotic processes are those brought about by a non-biological mechanism.

Anaemia

Too few red blood cells in the bloodstream resulting in lack of oxygen to tissues and organs. Also low iron levels.

Anticoagulant

Any agent used to prevent the formation of blood clots.

Ataxia

Loss of control of muscular movements.

bw

Body weight.

Carcinogenic

The ability of a substance to cause cancer.

Coumarin

Any of a group of synthetic anticoagulants derived from lactone $C_9H_6O_2$ (e.g. warfarin).

Dermal

Skin.

Gastrointestinal

Pertaining to the stomach and intestines

Half-life

During each half life (t½ or elimination half-life) 50% of the pesticide in the body at the beginning of that half-life is eliminated. The half-life is established in laboratory trials, and is used to predict the rate of elimination of a single dose of pesticide from the body and to estimate how long the disappearance of cumulative intakes of a pesticide from the body would take.

Hypovolemic shock

Abnormally low levels of blood plasma in the body, such that the body is unable to properly maintain blood pressure, cardiac output of blood, and normal amounts of fluid in the tissues.

Inappetence

Loss of appetite

Indandione

Any of a group of synthetic anticoagulants derived from 1,3-indanedione; they are chemically different from coumarins but similar to them in structure and activity.

LC_{50}

Lethal Concentration 50%. The calculated concentration of a gas/liquid that kills 50% of the test organisms.

LD_{50}

Lethal Dose 50%. The estimated dose that kills 50% of the test organisms.

LOEL

Least Observable Effect Level. The lowest dose in a study in which there was an observed toxic or adverse effect.

McLean scale

A method of measuring rabbit abundance

mg/kg, mg/L

See ppm.

Mutagenic

The ability of a substance to cause damage to DNA and produce alterations or loss of genes or chromosomes.

NOEL

No Observable Effect Level. A dosage that fails to produce any discernable signs of toxicosis, which may include a lack of morphological, biochemical, or physiological change.

Oral

Given or taken through or by way of the mouth, as in an oral solution.

Pericardial sac

A tough fibrous membrane that encloses and protects the heart.

Photodegradation

Breaking down in sunlight.

ppb

parts per billion. This concentration unit is equivalent to 1 µg L^{-1} in water (solution) or air and 1 µg kg^{-1} in solid samples (soil/sediments/biological tissue).

ppm

parts per million. This concentration unit is equivalent to 1 mg L^{-1} in water (i.e. solutions) or air and 1 mg kg^{-1} (µg g^{-1}) in solid samples (i.e. soil/sediments/biological tissue).

Prothrombin time

A test that measures the clotting time of plasma (the liquid portion of the blood).

Teratogen

A compound that causes birth defects in a developing foetus.

Toxicosis

A pathological condition caused by the action of a poison or toxin.

Toxicant

A synthetic man-made poison, e.g. brodifacoum, pindone c.f. a toxin, which is a naturally occurring poison, e.g. 1080, cyanide.

Toxin

A naturally occurring poison, e.g. 1080, cyanide c.f. a toxicant which is a synthetic man-made poison, e.g. brodifacoum, pindone.

Vitamin K-epoxide reductase

One of the catalytic enzymes involved in vitamin K cycling during the activation of coagulation factors. Anti-coagulants block Vitamin K-epoxide reductase preventing the cycling of vitamin K.

VPRD

Vertebrate Pesticide Residue Database (docdm-32812).

8. Common and Scientific Names of Species Mentioned in the Text

Birds

Australasian harrier	*Cirus approximans*
Australian magpie	*Gymnorhina tibicen*
Chaffinch	*Fringilla coelebs*
Chicken	*Gallus gallus*
Duck (Grey)	*Anas superciliosa*
Grey warbler	*Gerygone igata*
Gull (Southern black-back)	*Larus dominicanus*
Nankeen kestrel	*Falco cenrchroides*
Silvereye	*Zosterops lateralis*
Wrybills	*Anarhynchus frontalis*

Marsupial mammals

Brushtail possum	*Trichosurus vulpecula*

Eutherian mammals

Cat	*Felis catus*
Cattle	*Bos taurus*
Dog	*Canis familiaris*
Goat	*Capra hircus*
Hare	*Lepus europaeus*
Horse	*Equus caballus*
House mouse	*Mus musculus*
Pig	*Sus scrofa*
Rabbit	*Oryctolagus c. cuniculus*
Rat (Laboratory/Norway)	*Rattus norvegicus*
Ship rats	*Rattus rattus*
Sheep	*Ovis aries*

Reptiles

Grand skink	*Oligosoma grande*
Green gecko	*Naultinus elegans*
MacCann's skink	*Oligosoma maccanni*

Moko skink	*Oligosoma moco*
Otago skink	*O. otagense*

Fish

Bluegill sunfish	*Lepomis macrochirus*
Trout (Rainbow)	*Oncorhynchus mykiss*

Terrestrial invertebrates

Fruit fly	*Drosophila melanogaster*
Honeybees	*Apis mellifera*
Human lice	*Pediculus humanus*

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Appendix 4

Environmental Risk Management Authority Decision

Application for the Reassessment of a Hazardous Substance under Section 63 of the Hazardous Substances and New Organisms Act 1996

Name of Substance(s): Sodium Fluoroacetate (1080) and Formulated Substances Containing 1080

Application Number: HRE05002

August 2007
Amended August 2008

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Appendix A: Controls for Sodium Fluoroacetate (1080) and Formulated Substances Containing 1080 **1**

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Appendix A: Controls for Sodium Fluoroacetate (1080) and Formulated Substances Containing 1080

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Notes

1. The controls attached to sodium fluoroacetate (1080) and formulated substances containing 1080 are those prescribed by regulations made under the Act and which are assigned to these substances on the basis of their hazard classifications (the 'default controls'), with the changes set out in the following tables. The shaded text in the following tables indicate changes made to the default controls and explain the rationale for the changes. These changes are also discussed in section 11 of this decision.
2. There are two tables in this Appendix:
   - Table A1 – outlines the controls which apply to sodium fluoroacetate (1080), which is the technical grade substance used for the manufacture of formulated substances containing 1080.
   - Table A2 – outlines the controls which apply to formulated substances containing 1080.
3. The Control Code given in the left hand column in the Tables relates to the coding system used in the ERMA New Zealand Controls Matrix. This links the hazard classification categories to the regulatory controls triggered by each category. It is available from the ERMA New Zealand website www.ermanz.govt.nz/resources and is also contained in the ERMA New Zealand User Guide to the HSNO Control Regulations.
4. The regulations referred to (as varied or amended) together with the additional controls imposed under this decision, form the controls applicable to the substance(s). The accompanying explanatory text is intended for ease of reference and guidance only and has no legal status. Reference should be made to the actual text of the cited regulations (or relevant variations or amendments) for the legal wording of the controls and for relevant legal definitions and exemptions.

Interpretation

In the following tables, unless the context otherwise requires—

(a) words and phrases have the meanings given to them in the Act and regulations made under the Act; and

(b) the following words and phrases have the following meanings:

aerial application means application from an aircraft;

aircraft has the meaning given to it by section 2 of the Civil Aviation Act 1990;

application, in relation to a formulated substance containing 1080, means dropping, spreading, laying as bait, or placing the substance on ground or vegetation, and **apply** has a corresponding meaning;

contained ground-based application means application of a formulated substance containing 1080—

(a) in a bait station, or bait bag, or other container that is fixed to an object; or

(b) so that it is contained in some other way, such as in a pipe or burrow;

ground-based application, means application from the ground, and includes contained ground-based application;

public drinking water supply includes drinking water supply reservoirs, treatment plants and storage facilities; and

(c) references in the regulations or controls referred to in the tables below to the UN Model Regulations, the Land Transport Rule, the International Maritime Dangerous Goods Code, or any rules made under Part 3 of the Maritime Transport Act 1994 or Part 3 of the Civil Aviation Act 1990 shall be deemed to be references to the latest versions or editions thereof.

Table A1: Controls for sodium fluoroacetate (1080) (CAS No: 62-74-8)

Control Code	Regulation and Explanation
Hazardous Substances (Classes 6, 8 and 9 Controls) Regulations 2001	
T3 and E5	**Regulation 5-6 – Requirements for keeping records of use**
T8	**Regulation 28 – Controls on vertebrate poisons**
E2	**Regulations 46-48 – Restrictions on use within application area**
E3	**Regulation 49 – Controls relating to protection of terrestrial invertebrates**
E4	**Regulations 50-51 – Controls relating to protection of terrestrial vertebrates**
All these controls relate to the use of a hazardous substance that is discharged or laid in the environment. An additional control has been imposed under section 77A (see **Additional Control 1**) which prohibits the use of sodium fluoroacetate (1080) for any purpose other than for research or development (not involving use in the outdoor environment) or as an ingredient or component in the manufacture of another substance or product. This additional control effectively means that sodium fluoroacetate (1080) is not permitted to enter the outdoor environment. Accordingly, the Committee deletes the above 'default' controls under section 77(4)(a) on the basis that the adverse effects identified for the substance are less than the adverse effects which would usually be associated with substances with the same hazard classifications.	
T1	**Regulations 11-27 – Limiting exposure to toxic substances** This control relates to limiting public exposure to toxic substances through the setting of tolerable exposure limits (TELs). A TEL represents the maximum allowable concentration of a substance in a particular environmental medium. TEL values are established by the Authority and are enforceable controls under the HSNO Act. TELs are derived from potential daily exposure (PDE) values, which in turn are derived from acceptable daily exposure (ADE)/reference dose (RfD) values. An ADE/RfD value must be set for a toxic substance if: • it is likely to be present in an environmental medium (air, water, soil or a surface that the substance may be deposited onto) or food or other matter that might be ingested; and • it is a substance to which people are likely to be exposed to during their lifetime; and • exposure is likely to result in an appreciable toxic effect. If an ADE/RfD value is set for a substance, a PDE value for each exposure route must also be set for the substance. The PDE is a measure of the relative likelihood of a person actually being exposed to the substance through a particular exposure route given daily living patterns.
The following ADE is set for sodium fluoroacetate (1080): ADE = 0.02 µg sodium fluoroacetate (1080)/kg bw/day. The following PDE values are set for sodium fluoroacetate (1080): PDE_{FOOD} = 0.006 µg sodium fluoroacetate (1080)/kg bw/day; $PDE_{DRINKING\ WATER}$ = 0.010 µg sodium fluoroacetate (1080)/kg bw/day; $PDE_{INHALATION}$ = 0.002 µg sodium fluoroacetate (1080)/kg bw/day; and PDE_{DERMAL} = 0.002 µg sodium fluoroacetate (1080)/kg bw/day. The Committee notes the ongoing public concern about the potential for contamination of water supplies during aerial application of formulated substances containing 1080. The TEL_{water} value set below is based on the Ministry of Health Provisional Maximum Acceptable value (PMAV) in drinking water (*Drinking-water Standards for New Zealand 2005* – Ministry of Health). The PMAV represents the concentration of sodium fluoroacetate (1080) in water that, on the basis of present knowledge, is not considered to cause any significant risk to the health of the consumer over their	

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lifetime of consumption of that water. The Committee considers that setting a TEL_{water} value based on the Ministry of Health's PMAV is appropriate at this time. The PMAV is set by the Ministry of Health as a minimum standard for protection of consumers for lifetime consumption of drinking water. The Committee notes the intention of the Ministry of Health to review the PMAV for sodium fluoroacetate (1080) and recommends that the TEL_{water} values set below be reviewed when the Ministry of Health has completed its review of the PMAV. The following TEL value is set for sodium fluoroacetate (1080): **TEL_{water}= 3.5 µg sodium fluoroacetate (1080)/litre water**.	
Hazardous Substances (Classes 6, 8 and 9 Controls) Regulations 2001: Toxic Property Controls	
T2	**Regulations 29-30 – Controlling exposure in places of work** A workplace exposure standard (WES) is designed to protect persons in the workplace from the adverse effects of toxic substances. A WES is an airborne concentration of a substance (expressed as mg substance/m^3 of air or ppm in air), which must not be exceeded in a workplace and applies to every place of work where the substance is being used.
When setting a WES value, the Authority is required under regulation 30, to either adopt a WES proposed for the substance concerned by Department of Labour as part of its administration of the Health and Safety in Employment Act 1992 or arrive at the value by taking into account matters set out in regulation 30(2). In this case, as Department of Labour has set a WES value for sodium fluoroacetate (1080), the Committee therefore adopts the Department's WES value as follows: **Sodium fluoroacetate (1080) (skin, bio) [CAS No: 62-74-8] – 0.05 mg/m^3.** The '**skin**' notation indicates that there is potential for sodium fluoroacetate (1080) to be absorbed through the skin (as an additional route of exposure); and the '**bio**' notation indicates that occupational exposure to sodium fluoroacetate (1080) can be estimated by biological monitoring of urine.	
T4 and E6	**Regulation 7 – Requirements for equipment used to handle hazardous substances** Any equipment used to handle sodium fluoroacetate (1080) must retain and/or dispense the substance in the manner intended, ie without leakage, and must be accompanied by sufficient information so that this can be achieved.
T5	**Regulation 8 – Requirements for protective clothing and equipment** Protective clothing or equipment must be employed when sodium fluoroacetate (1080) is being handled. The protective clothing or equipment must be designed, constructed and operated to ensure that the person handling the substance does not come into contact with it and is not directly exposed to a concentration of the substance that is greater than the WES for that substance. The person in charge must ensure that people using the protective clothing or equipment have access to sufficient information specifying how the protective clothing or equipment may be used, and the requirements for maintaining the protective clothing or equipment.
T6 and E7	**Regulation 9 – Approved handler requirements** Where sodium fluoroacetate (1080) is held or used in any quantity, the substance must be under the personal control of an approved handler, or locked up. However, the substance may be handled by a person who is not an approved handler if: • an approved handler is present at the facility where the substance is being handled; and • the approved handler has provided guidance to the person in respect of handling; and • the approved handler is available at all times to provide assistance if necessary. **Regulation 9A – Exception to approved handler requirement for transportation of packaged class 6 substances** (1) Regulation 9 is deemed to be complied with if— (a) in the case of sodium fluoroacetate (1080) being transported on land— (i) in the case of sodium fluoroacetate (1080) being transported by rail, the person who drives the rail vehicle that is transporting the substance is fully trained in accordance with an approved safety system under section 6D of the Transport Services Licensing Act 1989 or a safety system which is referred to in an approved safety case under the Railways Act 2005; and (ii) in every other case, the person who drives, loads, and unloads the vehicle that is transporting the substance— (A) for hire or reward, or in quantities which exceed those set out in Schedule 1 of the Land Transport Rule, has a current dangerous goods endorsement on his or her driver licence; or (B) in every other case, the Land Transport Rule is complied with; or (b) in the case of sodium fluoroacetate (1080) being transported by sea, one of the following is complied with: (i) Maritime Rules: Part 24A – Carriage of Cargoes – Dangerous Goods (MR024A); or (ii) International Maritime Dangerous Goods Code; or

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	(c) in the case of sodium fluoroacetate (1080) being transported by air, Part 92 of the Civil Aviation Rules is complied with. (2) Subclause (1)(a)— (a) does not apply to a tank wagon or a transportable container to which the Hazardous Substances (Tank Wagons and Transportable Containers) Regulations 2004 applies; but (b) despite paragraph (a), does apply to an intermediate bulk container that complies with the UN Model Regulations. (3) Subclause (1)(c)— (a) applies to pilots, aircrew, and airline ground personnel loading and handling sodium fluoroacetate (1080) within an aerodrome; but (b) does not apply to the storage and handling of sodium fluoroacetate (1080) in any place that is not within an aerodrome or within an aerodrome by non-airline ground personnel.
Regulation 9 applies to sodium fluoroacetate (1080) with the addition of regulation 9A which provides for exceptions to the approved handler requirements in certain situations when transporting sodium fluoroacetate (1080). This control is varied under section 77A in order to reduce compliance costs and to avoid duplicating the requirements of other legislation. Sodium fluoroacetate (1080) is therefore required to be under the control of an approved handler unless the requirements set out in regulation 9A above are met. These requirements are considered to be a cost-effective way of ensuring the safe management of sodium fluoroacetate (1080) during the stated modes of transport.	
T7	**Regulation 10 – Restrictions on the carriage of hazardous substances on passenger service vehicles** Carriage of sodium fluoroacetate (1080) in any quantity on passenger service vehicles is prohibited.
E1	**Regulations 32-45 – Limiting exposure to ecotoxic substances** This control relates to the setting of environmental exposure limits (EELs). An EEL establishes the maximum concentration of an ecotoxic substance legally allowable in a particular environmental medium (for example, soil or sediment or water), including deposition of a substance onto surfaces. Under the regulations, an EEL can be established by one of three means: • applying the default EELs specified; • adopting an established EEL; • calculating an EEL from an assessment of available ecotoxicological data.
No environmental exposure limits (EELs) are set for sodium fluoroacetate (1080) at this time, either through applying the default EEL, adopting an established value, or calculating an EEL from an assessment of available ecotoxicological data. The Committee notes that EELs may be set at a later date when the policy for the setting of EELs under section 77B has been established. The default EELs specified under regulation 32 are accordingly deleted.	
Hazardous Substances (Identification) Regulations 2001 These Regulations prescribe requirements with regard to identification of hazardous substances in terms of: • information that must be "immediately available" with the substance (priority and secondary identifiers). This information is generally provided by way of the product label; • documentation that must be available in the workplace, generally provided by way of Safety Data Sheets; and • signage at a place where there is a large quantity of the substance.	
I1	**General identification requirements** These controls relate to the duties of suppliers and persons in charge of sodium fluoroacetate (1080) with respect to identification (essentially labelling) (Regulations 6 and 7), accessibility of the required information (Regulations 32 and 33) and presentation of the required information with respect to comprehensibility, clarity and durability (Regulations 34, 35, 36(1)–(7)). **Regulation 6 – Identification duties of suppliers** Suppliers of sodium fluoroacetate (1080) must ensure it is labelled with all relevant priority identifier information (as required by Regulations 8–17) and secondary identifier information (as required by Regulations 18–30) before supplying it to any other person. This includes ensuring that the priority identifier information is available to any person handling the substance within **two seconds** (Regulation 32), and the secondary identifier information available within **10 seconds** (Regulation 33). Suppliers must also ensure that no information is supplied with the substance (or its packaging) that suggests it belongs to a class or subclass that it does not in fact belong to. **Regulation 7 – Identification duties of persons in charge** Persons in charge of sodium fluoroacetate (1080) must ensure it is labelled with all relevant priority identifier information (as required by Regulations 8 to 17) and secondary identifier information (as required by Regulations 18 to 30) before supplying it to any other person. This includes ensuring that the priority identifier information is available to any person handling the substance within two seconds (Regulation 32), and the secondary identifier information is available within 10 seconds (Regulation

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	33). Persons in charge must also ensure that no information is supplied with the substance (or its packaging) that suggests it belongs to a class or subclass that it does not in fact belong to. **Regulations 32 and 33 – Accessibility of information** All priority identifier Information (as required by Regulations 8 to 17) must be available within two seconds, for example, on the label. All secondary identifier Information (as required by Regulations 18 to 30) must be available within 10 seconds, for example, on the label. **Regulations 34, 35, 36(1)–(7) – Comprehensibility, clarity and durability of information** All required priority and secondary identifiers must be presented in a way that meets the performance standards in these Regulations. In summary: • any information provided (either written or oral) must be readily understandable and in English; • any information provided in written or pictorial form must be able to be easily read or perceived by a person with average eyesight under normal lighting conditions; • any information provided in an audible form must be able to be easily heard by a person with average hearing; • any information provided must be in a durable format ie the information requirements with respect to clarity must be able to be met throughout the lifetime of the (packaged) substance under the normal conditions of storage, handling and use.
I3	**Regulation 9 – Priority identifiers for ecotoxic substances** This requirement specifies that sodium fluoroacetate (1080) must be prominently identified as being ecotoxic. This information must be available to any person handling the substance within two seconds (Regulation 32) and can be provided by way of signal headings or commonly understood pictograms on the label.
I8	**Regulation 14 – Priority identifiers for certain toxic substances** This requirement specifies that sodium fluoroacetate (1080) must be prominently identified as being toxic. In addition, information must be provided on the general degree and type of hazard of the substance, and the need to restrict access to the substance by children. This information must be available to any person handling the substance within two seconds (Regulation 32) and can be provided by way of signal headings or commonly understood pictograms on the label.
I9	**Regulation 18 – Secondary identifiers for all hazardous substances** This control relates to the level of detail required for sodium fluoroacetate (1080) on the product label. This information must be accessible within 10 seconds (Regulation 33) and could be provided on secondary panels on the product label. The following information is required: • an indication (which may include its common name, chemical name, or registered trade name) that unequivocally identifies it; and • enough information to enable its New Zealand importer, supplier, or manufacturer to be contacted, either in person or by telephone; and • in the case of a substance which, when in a closed container, is likely to become more hazardous over time or develop additional hazardous properties, or become a hazardous substance of a different class or subclass, a description of each likely change and the date by which it is likely to occur.
I11	**Regulation 20 – Secondary identifiers for ecotoxic substances** This control relates to the additional label detail required for sodium fluoroacetate (1080). This information must be accessible within 10 seconds (Regulation 33) and could be provided on secondary panels on the product label. The following information must be provided: • an indication of the circumstances in which it may harm living organisms; • an indication of the kind and extent of the harm it is likely to cause to living organisms; • an indication of the steps to be taken to prevent harm to living organisms; • an indication of its general type and degree of hazard (for example, very toxic to aquatic life and very ecotoxic to terrestrial invertebrates).
I16	**Regulation 25 – Secondary identifiers for toxic substances** This control relates to the additional label detail required for sodium fluoroacetate (1080). This information must be accessible within 10 seconds (Regulation 33) and could be provided on secondary panels on the product label. The following information must be provided: • an indication of its general type and degree of toxic hazard (for example, acutely toxic);

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	• an indication of the circumstances in which it may harm human beings; • an indication of the kinds of harm it may cause to human beings, and the likely extent of each kind of harm; • an indication of the steps to be taken to prevent harm to human beings; • the name and concentration of sodium fluoroacetate (1080).
I17	**Regulation 26 – Use of generic names** This control provides the option of using a generic name to identify groups of ingredients where such ingredients are required to be listed on the product label as specified by Regulations 19(f) and 25(e) and (f). The generic name must identify the key chemical entities and functional groups in the ingredients that contribute to their hazardous properties. Regulation 25(e) specifies a requirement to list on the product label, the name and concentration of sodium fluoroacetate (1080) that causes the substances to be classified as acutely toxic.
I18	**Regulation 27 – Use of concentration ranges** This control provides the option of providing concentration ranges for those ingredients whose concentrations are required to be stated on the product label as specified by Regulations 19(f) and 25(e) and (f). Regulation 25(e) specifies a requirement to list on the product label, the name and concentration of sodium fluoroacetate (1080) that causes the substances to be classified as acutely toxic.
I19	**Regulation 29-31 – Alternative information in certain cases** **Regulation 29 – Substances in fixed bulk containers or bulk transport containers** This Regulation relates to alternative ways of presenting the priority and secondary identifier information required by Regulations 8 to 25 when sodium fluoroacetate (1080) is contained in fixed bulk containers or bulk transport containers. Regulation 29(1) specifies that for fixed bulk containers, it is sufficient compliance if there is available at all times to people near the container, information that identifies the type and general degree of hazard of the substance. Regulation 29(2) specifies that for bulk transport containers, it is sufficient compliance if the substance is labelled or marked in compliance with the requirements of the Land Transport Rule, Civil Aviation Act 1990 or Maritime Transport Act 1994. **Regulation 30 – Substances in multiple packaging** This Regulation relates to situations when sodium fluoroacetate (1080) is in multiple packaging and the outer packaging obscures some or all of the required substance information. In such cases, the outer packaging must: • be clearly labelled with all relevant priority identifier information ie the hazardous properties of the substance must be identified; or • be labelled or marked in compliance with either the Land Transport Rule, Civil Aviation Act 1990 or the Maritime Safety Act 1994 as relevant; or • in the case of an ecotoxic substance, it must bear the EU pictogram "Dangerous to the Environment" ('dead fish and tree' on orange background); or • bear the relevant class or subclass label assigned by the UN Model Regulations. **Regulation 31 – Alternative information when substances are imported** This Regulation relates to alternative information requirements for sodium fluoroacetate (1080) that is imported into New Zealand in a closed package or in a freight container and will be transported to its destination without being removed from that package or container. In these situations, it is sufficient compliance with the requirements of the HSNO Act if the package or container is labelled or marked in compliance with the requirements of the Land Transport Rule.
I20	**Regulation 36(8) – Durability of information for class 6.1 substances** Any packaging in direct contact with sodium fluoroacetate (1080) must be permanently identified as having contained a toxic substance, unless the substance as packaged is restricted to a place of work.
I21	**Regulations 37-39, 47-50 – Documentation required in places of work** These controls relate to the duties of suppliers and persons in charge of places of work with respect to provision of documentation (essentially Safety Data Sheets) (Regulations 37, 38 and 50); the general content requirements of the documentation (Regulation 39 and 47); the accessibility and presentation of the required documentation with respect to comprehensibility and clarity (Regulation 48). These controls are triggered when any quantity of sodium fluoroacetate (1080) is held in a place of work. **Regulation 37 – Documentation duties of suppliers** A supplier must provide documentation containing all relevant information required by Regulations 39 to 48 when selling or supplying to another person any quantity of sodium fluoroacetate (1080), if the substance is to be used in a place of work and the supplier has not previously provided the documentation to that person. **Regulation 38 – Documentation duties of persons in charge of places of work**

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	The person in charge of any place of work where sodium fluoroacetate (1080) is present in quantities equal to or greater than those specified in Regulation 38 (and with reference to Schedule 2 of the Identification Regulations), must ensure that every person handling the substance has access to the documentation required for each hazardous substance concerned. The person in charge must also ensure that the documentation does not contain any information that suggests that the substance belongs to a class or subclass it does not in fact belong to. **Regulation 39 – General content requirements for documentation** The documentation provided with sodium fluoroacetate (1080) must include the following information: • the unequivocal identity of the substance (for example, the CAS number, chemical name, common name, UN number, registered trade name(s)); • a description of the physical state, colour and odour of the substance; • if the substance's physical state may alter over the expected range of workplace temperatures, the documentation must include a description of the temperatures at which the changes in physical state may occur and the nature of those changes; • in the case of a substance that, when in a closed container, is likely to become more hazardous over time or develop additional hazardous properties, or become a hazardous substance of a different class, the documentation must include a description of each likely change and the date by which it is likely to occur; • contact details for the New Zealand supplier/manufacturer/importer; • all emergency management and disposal information required for the substance; • the date on which the documentation was prepared. **Regulation 47 – Information not included in approval** This Regulation relates to the provision of specific documentation information (for example, as provided on an Safety Data Sheet). If information required by Regulations 39 to 46 was not included in the information used for the approval of the substance by the Authority, it is sufficient compliance with those Regulations if reference is made to that information requirement along with a comment indicating that such information is not applicable to that substance. **Regulation 48 – Location and presentation requirements for documentation** All required documentation must be available to a person handling sodium fluoroacetate (1080) in a place of work within 10 minutes. The documentation must be readily understandable by any fully-trained worker required to have access to it and must be easily read, under normal lighting conditions, at a distance of not less than 0.3m. **Regulation 49 – Documentation requirements for vehicles** This Regulation provides for the option of complying with documentation requirements as specified in the various Land, Sea and Air transport rules when sodium fluoroacetate (1080) is being transported. **Regulation 50 – Documentation to be supplied on request** Notwithstanding Regulation 37 above, a supplier must provide the required documentation to any person in charge of a place of work (where sodium fluoroacetate (1080) is present) if asked to do so by that person.
I23	**Regulation 41 – Specific documentation requirements for ecotoxic substances** The documentation provided with sodium fluoroacetate (1080) must include the following information: • its general degree and type of ecotoxic hazard (for example, highly ecotoxic to terrestrial invertebrates); • a full description of the circumstances in which it may harm living organisms and the extent of that harm; • a full description of the steps to be taken to prevent harm to living organisms; • a summary of the available acute and chronic (ecotox) data used to define the (ecotox) subclass or subclasses in which it is classified; • its bio-concentration factor or octanol-water partition coefficient; • its expected soil or water degradation rate; • any EELs set by the Authority.
I28	**Regulation 46 – Specific documentation requirements for toxic substances** The documentation provided with sodium fluoroacetate (1080) must include the following information: • its general degree and type of toxic hazard; • a full description of the circumstances in which it may harm human beings; • the kinds of harm it may cause to human beings; • a full description of the steps to be taken to prevent harm to human beings; • if it will be a liquid during its use, the percentage of volatile substance in the liquid formulation, and the temperature at which the percentages were measured; • a summary of the available acute and chronic (toxicity) data used to define the (toxic) subclass or subclasses in which it is classified; • the symptoms or signs of injury or ill health associated with each likely route of

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	exposure; • the dose, concentration, or conditions of exposure likely to cause injury or ill health; • any TELs or WESs set by the Authority.
I29	**Regulations 51-52 – Duties of persons in charge of places with respect to signage** These controls specify the requirements for signage, in terms of content, presentation and positioning at places where sodium fluoroacetate (1080) is held in quantities exceeding 50 kg. Signs are required: • at every entrance to the building and/or location (vehicular and pedestrian) where sodium fluoroacetate (1080) is present; • at each entrance to rooms or compartments where sodium fluoroacetate (1080) is present; • immediately adjacent to the area where sodium fluoroacetate (1080) is located in an outdoor area. The information provided in the signage needs to be understandable over a distance of 10 metres and be sufficient to: • advise that the location contains sodium fluoroacetate (1080); • describe the general type of hazard of the substance; • where the signage is immediately adjacent to the hazardous substance storage areas, describe the precautions needed to safely manage the substance.
I30	**Regulation 53 – Advertising corrosive and toxic substances** Any advertisement for sodium fluoroacetate (1080) must include information that identifies the substance is toxic and indicates the need to restrict access by children. In addition, it must specify the general degree and type of hazard.
Hazardous Substances (Packaging) Regulations 2001	
P1	**Regulations 5-6, 7(1), and 8** **General packaging requirements** These controls relate to the ability of the packaging to retain its contents, allowable packaging markings with respect to design approvals, factors affecting choice of suitable packaging, and compatibility of the substance with any previous contents of the packaging. **Regulation 5 – Ability to retain contents** Packaging for sodium fluoroacetate (1080) must ensure that, when the package is closed, there is no visible release of the substance, and that it maintains its ability to retain its contents in temperatures from –10°C to +50°C. The packaging must also maintain its ability to retain its remaining contents if part of the contents is removed from the package and the packaging is then re-closed. The packaging in direct contact with the substance must not be significantly affected or weakened by contact with the substance such that the foregoing requirements cannot be met. **Regulation 6 – Packaging markings** Packages containing sodium fluoroacetate (1080) must not be marked in accordance with the UN Model Regulations unless: • the markings comply with the relevant provisions of that document; and • the packaging complies with the tests set out in Schedule 1, 2 or 3 (Packaging Regulations) respectively; and • the design of the packaging has been test certified as complying with those tests. **Regulation 7(1) – Requirements when packing hazardous substance** When packing sodium fluoroacetate (1080), account must be taken of its physical state and properties, and packaging must be selected that complies with the requirements of Regulations 5 and 9 to 21. **Regulation 8 – Compatibility** Sodium fluoroacetate (1080) must not be packed in packaging that has been previously packed with substances with which it is incompatible unless all traces of the previous substance have been removed. **Regulations 9A and 9B – Large packaging** Large packaging may be used to contain sodium fluoroacetate (1080) in New Zealand if it has been constructed, marked and tested as a large package as provided in the UN Model Regulations. **"Large Packaging"** does not include: • a tank, tank wagon or transportable container (as defined in the Hazardous Substances (Tank Wagons and Transportable Containers) Regulations 2004; or • a stationary container system, a stationary tank or a tank (as defined in the Hazardous Substances (Dangerous Goods and Scheduled Toxic Substances) Transfer Notice 2004.

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P3, P13 and P15	**Regulation 19 and 21 – Packaging requirements for toxic substances** Sodium fluoroacetate (1080) must be packaged according to Schedule 1 of the Packaging Regulations. Substances that are offered for sale in a package of less than 2.5 kg (ie toxic substances liable to be in homes) must be in child resistant packaging. However, if the substance is for use in a place of work to which children do not have access, as is most likely to be the case with sodium fluoroacetate (1080), this requirement is not mandatory.
PG1	**Schedule 1 – Tests of packaging of hazardous substances required** This schedule describes the (minimum) packaging requirements that must be complied with for sodium fluoroacetate (1080) when packaged in **any quantity**. The tests in Schedule 1 correlate to the packaging requirements of UN Packing Group I (UN PGI).
Hazardous Substances (Disposal) Regulations 2001	
D4 and D5	**Regulations 8 and 9 – Disposal requirements for toxic and ecotoxic substances** Sodium fluoroacetate (1080) must be disposed of by: • treating the substance so that it is no longer a hazardous substance, including depositing the substance in a landfill, incinerator or sewage facility. However, this does not include dilution of the substance with any other substance prior to discharge to the environment; or • discharging the substance to the environment provided that after reasonable mixing, the concentration of the substance in any part of the environment outside the mixing zone does not exceed any TEL (tolerable exposure limit) or EEL (environmental exposure limit) set by the Authority for that substance; or • exporting the substance from New Zealand as a hazardous waste.
D6	**Regulation 10 – Disposal requirements for packages** This control gives the disposal requirements for packages that contained sodium fluoroacetate (1080) and are no longer to be used for that purpose. Such packages must be either decontaminated/treated or rendered incapable of containing any substance (hazardous or otherwise) and then disposed of in a manner that is consistent with the disposal requirements for the substance. In addition, the manner of disposal must take into account the material that the package is manufactured from.
D7	**Regulations 11-12 – Disposal information requirements** These controls relate to the provision of information concerning disposal (essentially on the label) that must be provided when selling or supplying any quantity of sodium fluoroacetate (1080). Information must be provided on appropriate methods of disposal and information may be supplied warning of methods of disposal that should be avoided ie that would not comply with the Disposal Regulations. Such information must be accessible to a person handling the substance within 10 seconds and must comply with the requirements for comprehensibility, clarity and durability as described in Regulations 34 to 36 of the Identification Regulations (Control Code I1).
D8	**Regulations 13-14 – Disposal documentation requirements** These controls relate to the provision of documentation concerning disposal (essentially in a Safety Data Sheet) that must be provided when selling or supplying any quantity of sodium fluoroacetate (1080). The documentation must describe one or more methods of disposal (that comply with the Disposal Regulations) and describe any precautions that must be taken. Such documentation must be accessible to a person handling the substance at a place of work within 10 minutes and must comply with the requirements for comprehensibility and clarity as described in Regulations 48(2), (3) and (4) of the Identification Regulations (Control Code I21).
Hazardous Substances (Emergency Management) Regulations 2001	
EM1	**Regulations 6-7, 9-11 – Level 1 emergency management information: General requirements** These controls relate to the provision of emergency management information (essentially on the label) that must be provided with any quantity of sodium fluoroacetate (1080). Regulation 6 describes the duties of suppliers, Regulation 7 describes the duties of persons in charge of places, Regulation 9 describes the requirement for the availability of the information (10 seconds) and Regulation 10 gives the requirements relating to the presentation of the information with respect to comprehensibility, clarity and durability. These requirements correspond with those relating to secondary identifiers required by the Identification Regulations (Control Code I1, Regulations 6, 7, 32–35, 36(1)–(7)). Regulation 11 provides for the option of complying with the information requirements specified in the various land, sea and air transport rules when the substance is being transported.
EM6	**Regulation 8(e) – Information requirements for toxic substances** The following information must be provided when sodium fluoroacetate (1080) is present in any quantity: • a description of the first aid to be given;

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	• a 24-hour emergency service telephone number.
EM7	**Regulation 8(f) – Information requirements for ecotoxic substances** The following information must be provided with sodium fluoroacetate (1080) when present in the quantities equal to or greater than 0.1 kg: • a description of the parts of the environment likely to be immediately affected by it; • a description of its typical effects on those parts of the environment; • a statement of any immediate actions that may be taken to prevent the substance from entering or affecting those parts of the environment.
EM8	**Regulations 12-16, 18-20 – Level 2 emergency management documentation requirements** These controls relate to the duties of suppliers and persons in charge of places of work with respect to the provision of emergency management documentation (essentially Safety Data Sheets). This documentation must be provided where sodium fluoroacetate (1080) is sold or supplied, or held in a workplace, in any quantity. Regulations 12 and 13 describe the duties of suppliers, regulation 14 describes the duties of persons in charge of places of work, regulation 15 provides for the option of complying with documentation requirements of the transport rules when the substance is being transported, and regulation 16 specifies requirements for general contents of the documentation. Regulation 18 prescribes location and presentation requirements for the documentation, ie it must be available within 10 minutes, be readily understandable, comprehensible and clear. These requirements correspond with those relating to documentation required by the Identification Regulations (Control Code I21).
EM11	**Regulations 25-34 – Level 3 emergency management requirements – emergency response plans** These Regulations relate to the requirement for an emergency response plan to be available at any place (excluding aircraft or ships) where sodium fluoroacetate (1080) is held (or is reasonably likely to be held on occasion) in quantities greater than 100 kg. The emergency response plan must describe all of the likely emergencies that may arise from the breach or failure of controls. The type of information that is required to be included in the plan is specified in Regulations 29 to 30. Requirements relating to the availability of equipment, materials and people are provided in Regulation 31, requirements regarding the availability of the plan are provided in Regulation 32 and requirements for testing the plan are described in Regulation 33.
EM12	**Regulations 35-41 – Level 3 emergency management requirements – secondary containment – deleted**
These regulations are deleted under section 77(4)(a). The regulations require secondary containment systems for pooling substances and do not apply to sodium fluoroacetate (1080) given that it is a solid. Having regard to the requirements of section 77(4)(a), the Committee considers that because it is a solid, the adverse effects of sodium fluoroacetate (1080) will thus be less than the adverse effects of other (liquid) substances with the same hazard classifications and therefore the control is deleted.	
EM13	**Regulation 42 – Level 3 emergency management requirements – signage** This control relates to the provision of emergency management information on signage at places where sodium fluoroacetate (1080) is held in quantities equal to or greater than 50 kg. The signage must advise of the action to be taken in an emergency and must meet the requirements for comprehensibility and clarity as defined in Regulations 34 and 35 of the Identification Regulations.
Hazardous Substances (Personnel Qualification) Regulations 2001	
AH1	**Regulations 4-6 – Approved Handler requirements** Sodium fluoroacetate (1080) is required to be under the control of an approved handler during specified parts of the lifecycle. An approved handler is a person who holds a current test certificate certifying that they have met the competency requirements specified by the Personnel Qualification Regulations in relation to handling specific hazardous substances. Regulation 4 describes the test certification requirements, Regulation 5 describes the qualification (competency and skill) requirements and regulation 6 describes situations where transitional qualifications for approved handlers apply. Also see Control Codes T6 and E7.
Hazardous Substances (Tracking) Regulations 2001	
TR1	**Regulations 4(1), 5-6 – General tracking requirements** Under regulation 4(1), sodium fluoroacetate (1080) is subject to tracking requirements, ie the location and movement of the substance must be recorded at each stage of its lifecycle until its final disposal. (The hazard classifications of the substances requiring tracking are listed in Schedule 1 of the Tracking Regulations). The person in charge of the place where the tracked substance is kept is responsible for ensuring that the necessary information is included in the record. This information to be provided is specified in Schedule 2 of the Tracking Regulations, and includes information on the identification of the approved

Control Code	Regulation and Explanation
	handler, and on the identification, quantity, location and disposal of the substance. The record must meet the location and presentation requirements specified in Part 2 of the Identification Regulations, ie it must be accessible within 10 minutes and meet the performance standards for comprehensibility and clarity (Regulation 5(1) and (2)). If a tracked substance is transferred to another place, the person in charge must ensure that the record is retained for a period of 12 months. If the substance has undergone treatment that results in it no longer being a tracked substance, or if it has been intentionally or unintentionally disposed of, the record must be kept for 3 years. However these requirements do not apply to places that are vehicles (Regulations 5(3) and (4)). Regulation 6 prescribes requirements relating to the transfer of tracked substances from one place to another. Specifically, the person in charge may only transfer the tracked substance to another place if they have received confirmation that: • an approved handler is present at the place receiving the substance; • the place receiving the substance meets any location test certification requirements; • any place where the substance is to be held during transit complies with the relevant requirements of the Hazardous Substances (Emergency Management) Regulations and Hazardous Substances (Classes 1 to 5 Controls) Regulations.
Additional Controls on sodium fluoroacetate (1080) imposed under section 77A	
Additional Control 1	**Prohibition on the use of sodium fluoroacetate (1080)** (1) No person may use sodium fluoroacetate (1080) for any purpose other than – (a) for research and development; or (b) as an ingredient or component in the manufacture of another substance or product. (2) For the purposes of this control, "research and development", means the systematic investigation or experimentation activities that involve sodium fluoroacetate (1080) but does not include investigation or experimentation in which the substance is discharged, laid, or applied in or to the outdoor environment.
This additional control is added under section 77A to prohibit the use of sodium fluoroacetate (1080) as a vertebrate poison. While it is highly unlikely that sodium fluoroacetate (1080) would be used as a vertebrate poison, it is still necessary to ensure that this use is specifically prohibited, as the risks of its use as a vertebrate poison have not been assessed. The Committee is satisfied that this additional control is more effective in terms of its effect on the management, use and risks of sodium fluoroacetate (1080) than the following 'default' controls for which this control is substituted (see above). The following controls are therefore deleted: • T3 and E5 – requirements for keeping records of use • T8 – controls on vertebrate poisons • E2 – restrictions on use within application area • E3 – controls relating to protection of terrestrial invertebrates • E4 – controls relating to protection of terrestrial vertebrates.	

Table A2: Controls for formulated substances containing 1080

Note: Except as specifically provided for in the following Table, references to "formulated substances containing 1080" should be read as references to all such substances as listed in section 14.1.2 of this decision.

Control Code	Regulation and Explanation
Hazardous Substances (Classes 6, 8 and 9 Controls) Regulations 2001	
T1	**Regulations 11-27 – Limiting exposure to toxic substances** This control relates to limiting public exposure to toxic substances through the setting of tolerable exposure limits (TELs). A TEL represents the maximum allowable concentration of a substance legally allowable in a particular environmental medium. TEL values are established by the Authority and are enforceable controls under the HSNO Act. TELs are derived from potential daily exposure (PDE) values, which in turn are derived from acceptable daily exposure (ADE)/reference dose (RfD) values. An ADE/RfD value must be set for a toxic substance if: • it is likely to be present in an environmental medium (air, water, soil or a surface that the substance may be deposited onto) or food or other matter that might be ingested; and • it is a substance to which people are likely to be exposed to during their lifetime; and • exposure is likely to result in an appreciable toxic effect. If an ADE/RfD value is set for a substance, a PDE for each exposure route must also be set for the substance. The PDE is a measure of the relative likelihood of a person actually being exposed to the substance through a particular exposure route given daily living patterns.
The following ADE is set for formulated substances containing 1080: ADE = 0.02 µg sodium fluoroacetate (1080)/kg bw/day. The following PDE values are set for formulated substances containing 1080: PDE_{FOOD} = 0.006 µg sodium fluoroacetate (1080)/kg bw/day; $PDE_{DRINKING\ WATER}$ = 0.010 µg sodium fluoroacetate (1080)/kg bw/day; $PDE_{INHALATION}$ = 0.002 µg sodium fluoroacetate (1080)/kg bw/day; and PDE_{DERMAL} = 0.002 µg sodium fluoroacetate (1080)/kg bw/day. The Committee notes the ongoing public concern about the potential for contamination of water supplies during aerial application of formulated substances containing 1080. The TEL_{water} value set below is based on the Ministry of Health Provisional Maximum Acceptable value (PMAV) in drinking water (*Drinking-water Standards for New Zealand 2005*: Ministry of Health). The PMAV represents the concentration of sodium fluoroacetate (1080) in water that, on the basis of present knowledge, is not considered to cause any significant risk to the health of the consumer over their lifetime of consumption of that water. The Committee considers that setting a TEL_{water} value based on the Ministry of Health's PMAV is appropriate at this time. The PMAV is set by the Ministry of Health as a minimum standard for protection of consumers for lifetime consumption of drinking water. The Committee notes the intention of the Ministry of Health to review the PMAV for sodium fluoroacetate (1080) and recommends that the TEL_{water} values set below be reviewed when the Ministry of Health has completed its review of the PMAV. The following TEL value is set for sodium fluoroacetate (1080): **TEL_{water}= 3.5 µg sodium fluoroacetate (1080)/litre water**.	
T2	**Regulations 29-30 – Controlling exposure in places of work** A workplace exposure standard (WES) is designed to protect persons in the workplace from the adverse effects of toxic substances. A WES is an airborne concentration of a substance (expressed as mg substance/m^3 of air or ppm in air), which must not be exceeded in a workplace and applies to every place of work where the substance is being used.
When setting a WES value, the Authority is required under regulation 30, to either adopt a WES proposed for the substance concerned by Department of Labour as part of its administration of the Health and Safety in Employment Act 1992 or arrive at the value by taking into account matters set out in regulation 30(2). In this case, as Department of Labour has set a WES value for sodium fluoroacetate (1080), the Committee therefore adopts the Department's WES value as follows: **Sodium fluoroacetate (1080) (skin, bio) [CAS No: 62-74-8] – 0.05 mg/m^3.** The '**skin**' notation indicates that there is potential for 1080 to be absorbed through the skin (as an additional route of exposure); and the '**bio**' notation indicates that occupational exposure to 1080 can be estimated by biological monitoring of urine.	
T3 and E5	**Regulations 5-6 – Requirements for keeping records of use** A person using any formulated substance containing 1080 for the purposes of causing biocidal action must keep written records of each use if the application is in an area where members of the public may be present, or where the substance is likely to enter air or water and leave the place.

Control Code	Regulation and Explanation
	The information to be provided in the record is described in Regulation 6(1): • the name of the substance; • the date and time of each application or discharge of the substance; • the amount of the substance applied or discharged; • the location where the substance was applied or discharged; • if the substance is applied to or discharged in the air, a description of the wind speed and direction when the substance was applied or discharged; and • the name of the substance and the user's address. The record must be kept for a minimum of three years following the use and must be made available to an enforcement officer on request.
T4 and E6	**Regulation 7 – Requirements for equipment used to handle hazardous substances** Any equipment used to handle any formulated substance containing 1080 must retain and/or dispense the substance in the manner intended, ie without leakage, and must be accompanied by sufficient information so that this can be achieved.
T5	**Regulation 8 – Requirements for protective clothing and equipment** Protective clothing or equipment must be employed when any formulated substance containing 1080 is being handled. The protective clothing or equipment must be designed, constructed and operated to ensure that the person handling the substance does not come into contact with it and is not directly exposed to a concentration of the substance that is greater than the WES for that substance. The person in charge must ensure that people using the protective clothing or equipment have access to sufficient information specifying how the protective clothing or equipment may be used, and the requirements for maintaining the protective clothing or equipment.
T6 and E7	**Regulation 9 – Approved handler requirements** Where any formulated substance containing 1080 is held or used in any quantity, the substance must be under the personal control of an approved handler, or locked up. However, the substance may be handled by a person who is not an approved handler if: • an approved handler is present at the place where the substance is being handled; and • the approved handler has provided guidance to the person in respect of handling; and • the approved handler is available at all times to provide assistance if necessary. **Regulation 9A – Exception to approved handler requirement for transportation of packaged class 6 substances** (1) Regulation 9 is deemed to be complied with if— (a) in the case of sodium fluoroacetate (1080) being transported on land— (i) in the case of sodium fluoroacetate (1080) being transported by rail, the person who drives the rail vehicle that is transporting the substance is fully trained in accordance with an approved safety system under section 6D of the Transport Services Licensing Act 1989 or a safety system which is referred to in an approved safety case under the Railways Act 2005; and (ii) in every other case, the person who drives, loads, and unloads the vehicle that is transporting the substance— (A) for hire or reward, or in quantities which exceed those set out in Schedule 1 of the Land Transport Rule, has a current dangerous goods endorsement on his or her driver licence; or (B) in every other case, the Land Transport Rule is complied with; or (b) in the case of sodium fluoroacetate (1080) being transported by sea, one of the following is complied with: (i) Maritime Rules: Part 24A – Carriage of Cargoes – Dangerous Goods (MR024A); or (ii) International Maritime Dangerous Goods Code; or (c) in the case of sodium fluoroacetate (1080) being transported by air, Part 92 of the Civil Aviation Rules is complied with. (2) Subclause (1)(a)— (a) does not apply to a tank wagon or a transportable container to which the Hazardous Substances (Tank Wagons and Transportable Containers) Regulations 2004 applies; but (b) despite paragraph (a), does apply to an intermediate bulk container that complies with the UN Model Regulations. (3) Subclause (1)(c)— (a) applies to pilots, aircrew, and airline ground personnel loading and handling sodium fluoroacetate (1080) within an aerodrome; but (b) does not apply to the storage and handling of sodium fluoroacetate (1080) in any place that is not within an aerodrome or within an aerodrome by non-airline ground personnel.

Control Code	Regulation and Explanation
	Regulation 9B – Exception to approved handler requirement for aerial application of certain substances Regulation 9 is deemed to be complied with if, in the case of aerial application of sodium fluoroacetate (1080), the person who carried out the application has a current pilot chemical rating in accordance with Part 61 of the Civil Aviation Rules. This control only applies to the pilot of an aircraft while they are aerially applying the following substances: • Cereal-based pellets containing 0.4 – 0.8 g sodium fluoroacetate/kg • Cereal-based pellets containing 1.5 – 2.0 g sodium fluoroacetate/kg • Soluble concentrate containing 200 g sodium fluoroacetate/litre
Regulation 9 applies to formulated substances containing 1080 with the addition of regulations 9A and 9B. Regulation 9A provides for exceptions to the approved handler requirements in certain situations when transporting formulated substances containing 1080. Regulation 9B provides for exceptions to the approved handler requirements when certain formulated substances containing 1080 are aerially applied. These additional controls are added under section 77A in order to reduce compliance costs and to avoid duplicating the requirements of other legislation. Formulated substances containing 1080 are therefore required to be under the control of an approved handler unless the requirements set out in regulation 9A and 9B are met. These additional requirements are considered to be a cost effective way of ensuring the safe management of formulated substances containing 1080 during the stated modes of transport.	
T7	**Regulation 10 – Restrictions on the carriage of hazardous substances on passenger service vehicles** In order to limit the potential for public exposure to hazardous substances, the following requirements are prescribed for the carriage of formulated substances containing 1080 on passenger service vehicles: Carriage of **any quantity** of the following formulated substances containing 1080 is prohibited: • Soluble concentrate containing 200 g sodium fluoroacetate/litre; • Polymer gel containing 50 g sodium fluoroacetate/kg; • Polymer gel containing 100 g sodium fluoroacetate/kg. The maximum quantity per package of the following formulated substances containing 1080 permitted to be carried on passenger service vehicles is **0.5 kg**: • Cereal-based pellets containing 1.5–2.0 g sodium fluoroacetate/kg; • Fish paste containing 10 g sodium fluoroacetate/kg; • Apple-based paste containing 1.5 g sodium fluoroacetate/kg; • Peanut-based paste containing 1.5 g sodium fluoroacetate/kg; • Polymer gel block containing 1.5 g sodium fluoroacetate/kg. The maximum quantity per package of the following formulated substances containing 1080 permitted to be carried on passenger service vehicles is **3.0 kg**: • Fishmeal pellets containing 1.0 g sodium fluoroacetate/kg; • Cereal-based pellets containing 0.4–0.8 g sodium fluoroacetate/kg; • Apple-based paste containing 0.6–0.8 g sodium fluoroacetate/kg.
T8	**Regulation 28 – Controls on vertebrate poisons – varied (in part)** This Regulation applies to formulated substances containing 1080 that are (lawfully) laid or applied outdoors for terrestrial vertebrate pest control. Signage requirements are imposed on the person in charge of laying or applying the bait which are designed to limit the likelihood of the substances from coming into contact with members of the general public and non-target species in places of public access. The requirement for the substance to be under the control of an approved handler or secured (Control Code T6, Regulation 9) does not apply after the substance has been applied or laid. **Regulation 28 of the Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001** For formulated substances containing 1080, subclauses (2), (3)(b) and (d), (4) and (5) of regulation 28 are varied under section 77A as follows: (2) A person in charge of the substance must ensure that signs are erected at every normal point of entry to the place where the substance is to be applied or laid before the substance is applied or laid. (3) The signs must—… (b) identify the substance and state that it is toxic to human beings and ecotoxic to other vertebrates and state that it might be present in carcasses; and… (d) comply with regulations 34 and 35 of the Hazardous Substances (Identification) Regulations 2001, except that regulation 35 applies as follows: (i) in relation to the information required to be included on the signs by virtue of subclauses (3)(a) and (c) of this regulation 28, as if the distances referred to in regulation 35(3)(c) of the Hazardous Substances (Identification) Regulations 2001 were a distance of not less than 2 metres; and (ii) in relation to the information required to be included on the signs by virtue of subclause (3)(b) of this regulation 28, as if the distances referred to in regulation 35(3)(c) of the Hazardous Substances (Identification) Regulations 2001 were a distance of not less

Control Code	Regulation and Explanation
	than 10 metres. (4) The signs must remain in place for a minimum of six months after the last date of application, or until the earlier of— (a) the date when the substance (and any carcass) is no longer toxic; or (b) the date of retrieval of the substance (and any carcass) from the place concerned. (5) Signs must be removed at the later of— (a) the date when they are no longer required to remain under subclause (4); or (b) in the case of signs that include information to which a legal obligation applies that requires the signs to remain in place for a longer period of time, the expiry of that longer period of time.
Regulation 28(2) requires that signs be erected at every normal point of entry at least three days before a substance is applied or laid. At the time of transfer (and approval) of relevant formulated substances containing 1080 into the HSNO regime, the Authority's Transfer of Substances Standing Committee removed the requirement for signs to be in place "at least three days" before a substance is applied or laid. This was in response to submissions received on the three-day requirement which indicated that it was an impractical requirement which would not reduce risks to the public. The Transfer of Substances Standing Committee also noted that the Medical Officers of Health and the Department of Conservation are able to set additional conditions on the use of formulated substances containing 1080 through the requirement for permissions under section 95A of the Act. This was considered to be a more effective way to manage the signage requirement than requiring signs to be erected "at least three days" before a substance is applied or laid. The Committee in this application, is satisfied that regulation 28(2) set out above should be varied under section 77A, as the varied control will be more effective in terms of its effect on the management, use and risks of formulated substances containing 1080. **Regulation 28(3)(d)** requires that signs must comply with Part 3 of the Hazardous Substances (Identification) Regulations 2001. As the regulation is written, this means that all information displayed on a sign, including identification of the person applying the substance, their contact details and the date on which the substance is to be applied must be visible from 10 metres. In the Committee's view, the 10 metre requirement is intended to address other matters such as stating that hazardous substances are present, their general type of hazard and their general type of classification. If required to be adhered to in the case of use of formulated substances containing 1080 for information relating to date of application and contact details, signs will be considerably larger than is desirable and will lose their visibility and clarity with respect to the priority identification information and will not effectively manage risks to the public. For this reason, the visibility distance for information required in relation to formulated substances containing 1080 by regulation 28(3)(a) and (c) of the Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001, is varied under section 77A to a distance of not less than two metres. However, in respect of Regulation 28(3)(b), the Committee is of the opinion that the 10 metre requirement should apply to one other matter not currently required on signs, namely the hazards posed by poisoned carcasses to dogs. The Committee notes that ACVM and DoC currently require signs to indicate that both bait and carcasses are poisonous to dogs but considers that it is appropriate that this risk should also be managed by way of a control under the Act. The Committee is therefore satisfied that regulation 28(3)(b) and (d) should be varied under section 77A as set out above and that these variations are more effective in terms of its effect on the management, use and risks of the substances as they will help to limit the likelihood of the substances coming into contact with members of the public and non-target species in places of public access. **Regulations 28(4) and (5)** relate to the period of time during which signs must remain in place. For formulated substances containing 1080, the Committee varies these requirements under section 77A to provide that signs must remain for at least a minimum period of six months or until the earlier of retrieval of the bait or it is demonstrated that the bait has ceased to be toxic. This latter requirement will also relate to bait in carcasses. In addition, the Committee re-imposes an additional mandatory requirement under section 77A for signs to be removed after completion of an operation. This requirement was imposed by the Transfer of Substances Standing Committee on transfer of the substances into the HSNO regime based on the premise that signs should only remain in place for so long as the hazard remains present in the environment. The Committee is satisfied that these variations/additions are more effective in terms of their effect on the management, use and risks of the substances than the existing regulations.	
E1	**Regulations 32-45 – Limiting exposure to ecotoxic substances** This control relates to the setting of environmental exposure limits (EELs). An EEL establishes the maximum concentration of an ecotoxic substance legally allowable in a particular (non-target) environmental medium (for example, soil or sediment or water), including deposition of a substance onto surfaces (for example, as in spray drift deposition). Under the regulations, an EEL can be established by one of three means: • applying the default EELs specified; • adopting an established EEL; • calculating an EEL from an assessment of available ecotoxicological data.
No environmental exposure limits (EELs) are set for 1080 at this time, either through applying the default EEL, adopting an established value, or calculating an EEL from an assessment of available ecotoxicological data. The Committee notes that EELs may be set at a later date when the policy for the setting of EELs under section 77B has been established. The default EELs specified under regulation 32 are accordingly deleted.	
E2	**Regulations 46-48 – Restrictions on use within application area** These Regulations relate to controls on application areas. An application (target) area is an area that the person using the substance either has control over or is otherwise authorised to apply the substance

Control Code	Regulation and Explanation
	to. For ecotoxic substances that are intentionally released into the environment (for example, pesticides), any EEL controls will not apply within the application (target) area provided that the substance is applied at a rate that does not exceed the allowed application rate. In addition, any approved handler controls (Code T6/E7, Regulation 9) do not apply once the substance has been applied or laid. In recognition of the need to limit adverse effects within the target area, Regulations have been prescribed to restrict the use of the substance within the target area. These include a requirement to set an application rate for any substance designed for biocidal action for which an EEL has been set. The application rate must not be greater than the application rate specified in the application for approval, or not greater than a rate calculated in a similar manner to that used to calculate EELs (with the proviso that the product of the uncertainty factors must not exceed 100). Regulation 48 (as amended in the Hazardous Substances (Sodium Fluoroacetate) Transfer Notice 2005 (*New Zealand Gazette* Issue No 92, 17 June 2005) states that the Authority may set an application rate for a substance that is designed for biocidal action if an EEL has been set for the substance. This change gives the Authority discretion on whether or not to set an application rate. No application rate is set for the ground-based application of formulated substances containing 1080. The following control, however, is set for aerial application of three of the formulated substances containing 1080: **Application rates for aerial application** For **aerial application** of formulated substances containing 1080, an **application** rate not exceeding 30g sodium fluoroacetate(1080)/ha is set. This **application** rate applies to the following substances when aerially applied: • Cereal-based pellets containing 0.4–0.8 g sodium fluoroacetate/kg; • Cereal-based pellets containing 1.5–2.0 g sodium fluoroacetate/kg; • Soluble concentrate containing 200 g sodium fluoroacetate/litre.
The Committee notes that application rates per hectare have come down significantly over the past few decades and that the current practice for possum and rabbit control are for application rates of 2.4–7.5 g 1080/ha and 2–8 g 1080/ha respectively (additional information supplied by the applicants, 22 December 2006). The Committee accepts DoC's view provided at the hearings that it is appropriate to leave the rate at its current level so as to allow a sufficient degree of operational flexibility particularly when considering simultaneous multi-species pest control (for example, rats, possums and wallabies). Further, DoC advised the Committee that on occasions when pest numbers are high, double-sowing is necessary. The Committee therefore sets an application rate not exceeding 30g sodium fluoroacetate(1080)/ha for the following substances when aerially applied: • Cereal-based pellets containing 0.4–0.8 g sodium fluoroacetate/kg; • Cereal-based pellets containing 1.5–2.0 g sodium fluoroacetate/kg; • Soluble concentrate containing 200 g sodium fluoroacetate/litre.	
E3	**Regulation 49 – Controls relating to protection of terrestrial invertebrates – deleted**
This control is deleted under section 77(4)(a). The control is only triggered for the following formulated substances containing 1080: • Soluble concentrate containing 200 g sodium fluoroacetate/litre; • Fish paste containing 10 g sodium fluoroacetate/kg; • Polymer gel containing 50 g sodium fluoroacetate/kg; • Polymer gel containing 100 g sodium fluoroacetate/kg. However, while these substances all have a 9.4A classification, none of them is attractive to bees as they contain no sweeteners. Therefore, regulation 49(1)(a) does not apply as the substances are not in a form to which bees are "likely to be exposed". As a result, the Committee is satisfied, having regard to section 77(4)(a), that the adverse effects identified for these substances are less than the adverse effects which would usually be associated with substances given the same hazard classification and that the control can be deleted.	
E4	**Regulation 50 – Controls relating to protection of terrestrial vertebrates – deleted**
Regulation 50 is deleted under section 77(4)(b). The formulated substance *soluble concentrate containing 200 g sodium fluoroacetate/litre*, when mixed with oats, potentially falls within the ambit of this regulation ("coated on seed"). However, the regulation is concerned with setting an EEL for the substance so that if ingested, it would not be likely to cause adverse effects in terrestrial vertebrates. Given that the substance is to be specifically used to control possums and other vertebrates, it would not be appropriate to set an EEL under this regulation. The Committee is satisfied that the benefits of using *soluble concentrate containing 200 g sodium fluoroacetate/litre*, when mixed with oats justify deleting the regulation under section 77(4)(b) and that the deletion does not, in the Committee's opinion, significantly increase the adverse effects of using the substance, particularly given the imposition, under this approval, of other controls on its use.	
E4	**Regulation 51 – Controls relating to the use of ecotoxic substances as bait** Where substances are used outdoors as bait and are known to inhibit growth or reproduction or cause death in one or more vertebrate species, this regulation requires that the Authority must specify one or more of the following matters for the substance:

Control Code	Regulation and Explanation

- colour;
- methods of release;
- repellents or attractants to be used with the substance;
- bait size;
- degree of palatability.

In accordance with this regulation, the Committee sets the following methods of release, bait size and colours for the stated formulated substances containing 1080:

Methods of release, bait size and colour

The following Table specifies for each formulated substance containing 1080 listed in column 1—

(a) the method or methods of release and (where applicable) bait size specified in column 2 for the substance; and

(b) a colour specified in column 3 for the substance.

Column 1	**Column 2**	**Column 3**
Substance	**Method(s) of release and (where applicable) bait size**	**Colour**
Cereal-based pellets containing 0.4 – 0.8 g sodium fluoroacetate/kg Cereal-based pellets containing 1.5 – 2.0 g sodium fluoroacetate/kg	**Aerial** application or **ground-based** application	Blue or green
Soluble concentrate containing 200 g sodium fluoroacetate/litre	This substance may only be used when mixed with the following food baits and released by the following methods: <u>When mixed with prepared (cut) apple</u>: • to a maximum concentration of 2.0 g sodium fluoroacetate (1080) per kg apple **Contained ground-based** application <u>When mixed with prepared (cut) carrot (except when used for rabbit control through ground-based application):</u> • to a maximum concentration of 2.0 g sodium fluoroacetate (1080) per kg carrot; • bait must be screened so that bait has a mean weight of 6 g or larger; and • chaff (pieces <0.5 g) must be less than 1.5% of the total weight of carrot **Aerial** application or **ground-based** application <u>When mixed with oats</u> : • to a maximum concentration of 0.6 g sodium fluoroacetate (1080) per kg oats **Aerial** application or **ground-based** application	Blue or green
Peanut-based Paste containing 1.5 g sodium fluoroacetate/kg	**Contained ground-based** application	Blue or green
Apple-based Paste containing 1.5 g sodium fluoroacetate/kg	**Ground-based** application	Blue or green
Apple-based paste containing 0.6 – 0.8 g sodium fluoroacetate/kg Polymer gel containing 50 g sodium fluoroacetate/kg	**Ground-based** application	Blue or green

Control Code	Regulation and Explanation			
	Polymer gel containing 100 g sodium fluoroacetate/kg Fishmeal pellets containing 1.0 g sodium fluoroacetate/kg			
	Fish paste containing 10 g sodium fluoroacetate/kg	**Contained ground-based** application	Blue or green	
	Polymer gel block containing 1.5 g sodium fluoroacetate/kg			

The restrictions set out in the Table are imposed on formulated substances containing 1080 under Regulation 51, for the following reasons:

Colour

For all formulated substances containing 1080, baits must be coloured either blue or green. The previous requirement under the Pesticides Act (and related regulations) that baits had to be dyed green was based on the effectiveness of the colour in reducing the visual attractiveness of the baits to birds. More recent research with New Zealand native birds indicated that blue may also be an effective visual deterrent for North Island robins and weka. There have also been problems with attaining a green colour in certain bait formulations. Specification of the bait colour as either blue or green provides a visual deterrent to birds which allows some flexibility in bait colour depending on the characteristics of the bait and the specific circumstances of any particular operation.

Method(s) of release

The formulated substance *peanut-based paste containing 1.5 g sodium fluoroacetate/kg* is restricted to use in **contained ground-based application**.

The previous approval for *paste containing 1.5 g sodium fluoroacetate/kg* covered both peanut-based pastes and fruit (apple)-based paste approved for use in **ground-based application**.

Testing has shown that peanut is more attractive to native bats than some of the other types of bait and current practice is that peanut-based paste is used only in bait stations. The attractiveness of the peanut-based paste to other non-target species has not been studied. Having regard to this uncertainty over attractiveness of the peanut-based paste to non-target species, and the differing risk profiles of the peanut and apple-based pastes, the Committee has decided that they should be separately approved under this decision with a control added to restrict the peanut-based paste to use in **contained ground-based application**. This effectively restricts its use to bait stations, which accords with current practice. The Committee is of the opinion that this will be a more effective way of managing the risks posed by the peanut-based substance. It is also consistent with the approach taken by virtue of **Additional Control 10** which requires formulation changes to be notified to the Authority and could lead to changes to controls on approved substances if information provided shows changes to the risk profile.

Two other formulated substances containing 1080 are also restricted to **contained ground-based application**, consistent with current practice, to minimise the exposure of non-target species to the baits:

- Fish paste containing 10 g sodium fluoroacetate/kg;
- Polymer gel block containing 1.5 g sodium fluoroacetate/kg.

Further, the Committee has decided that when *soluble concentrate containing 200g/L sodium fluoroacetate* is mixed with cut apple to a maximum toxic loading of 2.0 g sodium fluoroacetate per kg of prepared apple, it must only be used in contained bait stations because cut apple is attractive to a range of non-target species if not contained.

Bait size

When *soluble concentrate containing 200g/L sodium fluoroacetate* is mixed with prepared (cut) carrots to a maximum toxic loading of 2.0 g sodium fluoroacetate (1080) per kg of carrot, it must be manufactured to the following specifications:

- bait must be screened so that bait has a mean weight of 6 g or larger; and
- chaff (pieces <0.5 g) must be less than 1.5% of the total weight of carrot.

This applies whichever of the two approved methods of release are used. The rationale for this is that small pieces of bait contain a higher toxic loading than larger pieces and present a higher risk to non-target species. This is due to their small size (they are more readily ingested and have a high toxic loading) and the fact that a greater number of baits per hectare increases the likelihood of exposure. The requirements do not, however, apply when the carrot bait is being used for rabbit control through **ground-based application**.

Hazardous Substances (Identification) Regulations 2001

The Identification Regulations prescribe requirements with regard to identification of hazardous substances in terms of:

- information that must be "immediately available" with the substance (priority and secondary identifiers). This information is generally provided by way of the product label;
- documentation that must be available in the workplace, generally provided by way of Safety Data Sheets; and
- signage at a place where there is a large quantity of the substance.

I1	**General identification requirements** These controls relate to the duties of suppliers and persons in charge of formulated substances containing 1080 with respect to identification (essentially labelling) (Regulations 6 and 7), accessibility of

Control Code	Regulation and Explanation
	the required information (Regulations 32 and 33) and presentation of the required information with respect to comprehensibility, clarity and durability (Regulations 34, 35, 36(1)–(7)). **Regulation 6 – Identification duties of suppliers** Suppliers of any substance containing 1080 must ensure it is labelled with all relevant priority identifier information (as required by Regulations 8–17) and secondary identifier information (as required by Regulations 18–30) before supplying it to any other person. This includes ensuring that the priority identifier information is available to any person handling the substance within **two seconds** (Regulation 32), and the secondary identifier information available within **10 seconds** (Regulation 33). Suppliers must also ensure that no information is supplied with the substance (or its packaging) that suggests it belongs to a class or subclass that it does not in fact belong to. **Regulation 7 – Identification duties of persons in charge** Persons in charge of any formulated substance containing 1080 must ensure it is labelled with all relevant priority identifier information (as required by Regulations 8 to 17) and secondary identifier information (as required by Regulations 18 to 30) before supplying it to any other person. This includes ensuring that the priority identifier information is available to any person handling the substance within **two seconds** (Regulation 32), and the secondary identifier information is available within **10 seconds** (Regulation 33). Persons in charge must also ensure that no information is supplied with the substance (or its packaging) that suggests it belongs to a class or subclass that it does not in fact belong to. **Regulations 32 and 33 – Accessibility of information** All priority identifier Information (as required by Regulations 8 to 17) must be available within **two seconds**, for example, on the label. All secondary identifier Information (as required by Regulations 18 to 30) must be available within **10 seconds**, for example, on the label. **Regulations 34, 35, 36(1)-(7) – Comprehensibility, clarity and durability of information** All required priority and secondary identifiers must be presented in a way that meets the performance standards in these Regulations. In summary: • any information provided (either written or oral) must be readily understandable and in English; • any information provided in written or pictorial form must be able to be easily read or perceived by a person with average eyesight under normal lighting conditions; • any information provided in an audible form must be able to be easily heard by a person with average hearing; • any information provided must be in a durable format ie the information requirements with respect to clarity must be able to be met throughout the lifetime of the (packaged) substance under the normal conditions of storage, handling and use.
I3	**Regulation 9 – Priority identifiers for ecotoxic substances** This requirement specifies that formulated substances containing 1080 must be prominently identified as being ecotoxic. This information must be available to any person handling the substance within **two seconds** (Regulation 32) and can be provided by way of signal headings or commonly understood pictograms on the label.
I8	**Regulation 14 – Priority identifiers for certain toxic substances** This requirement specifies that formulated substances containing 1080 must be prominently identified as being toxic. In addition, information must be provided on the general degree and type of hazard of the substance, and the need to restrict access to the substance by children. This information must be available to any person handling the substance within two seconds (Regulation 32) and can be provided by way of signal headings or commonly understood pictograms on the label.
I9	**Regulation 18 – Secondary identifiers for all hazardous substances** This control relates to the level of detail required for formulated substances containing 1080 on the product label. This information must be accessible within 10 seconds (Regulation 33) and could be provided on secondary panels on the product label. The following information is required: • an indication (which may include its common name, chemical name, or registered trade name) that unequivocally identifies it; and • enough information to enable its New Zealand importer, supplier, or manufacturer to be contacted, either in person or by telephone; and • in the case of a substance which, when in a closed container, is likely to become more hazardous over time or develop additional hazardous properties, or become a hazardous substance of a different class or subclass, a description of each likely change and the date by which it is likely to occur.

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I11	**Regulation 20 – Secondary identifiers for ecotoxic substances** This control relates to the additional label detail required for formulated substances containing 1080 substances. This information must be accessible within **10 seconds** (Regulation 33) and could be provided on secondary panels on the product label. The following information must be provided: • an indication of the circumstances in which it may harm living organisms; • an indication of the kind and extent of the harm it is likely to cause to living organisms; • an indication of the steps to be taken to prevent harm to living organisms; • an indication of its general type and degree of hazard (for example, very toxic to aquatic life for a substance triggering a 9.1A classification and ecotoxic to terrestrial invertebrates for a substance triggering a 9.3B classification).
I16	**Regulation 25 – Secondary identifiers for toxic substances** This control relates to the additional label detail required for formulated substances containing 1080. This information must be accessible within 10 seconds (Regulation 33) and could be provided on secondary panels on the product label. The following information must be provided: • an indication of its general type and degree of toxic hazard (for example, acutely toxic); • an indication of the circumstances in which it may harm human beings; • an indication of the kinds of harm it may cause to human beings, and the likely extent of each kind of harm; • an indication of the steps to be taken to prevent harm to human beings; • the name and concentration of **sodium fluoroacetate (1080)**.
I17	**Regulation 26 – Use of generic names** This control provides the option of using a generic name to identify **groups** of ingredients where such ingredients are required to be listed on the product label as specified by Regulations 19(f) and 25(e) and (f). The generic name must identify the key chemical entities and functional groups in the ingredients that contribute to their hazardous properties. Regulations 25(e) specifies a requirement to list on the product label, the name and concentration of **sodium fluoroacetate (1080)**.
I18	**Regulation 27 – Use of concentration ranges** This control provides the option of providing concentration ranges for those ingredients whose concentrations are required to be stated on the product label as specified by Regulations 19(f) and 25(e) and (f). Regulations 25(e) specifies a requirement to list on the product label, the name and concentration of **sodium fluoroacetate (1080)**.
I19	**Regulations 29-31 – Alternative information in certain cases** **Regulation 29 – Substances in fixed bulk containers or bulk transport containers** This Regulation relates to alternative ways of presenting the priority and secondary identifier information required by Regulations 8 to 25 when formulated substances containing 1080 are contained in fixed bulk containers or bulk transport containers. Regulation 29(1) specifies that for fixed bulk containers, it is sufficient compliance if there is available at all times to people near the container, information that identifies the type and general degree of hazard of the substance. Regulation 29(2) specifies that for bulk transport containers, it is sufficient compliance if the substance is labelled or marked in compliance with the requirements of the Land Transport Rule, Civil Aviation Act 1990 or Maritime Transport Act 1994. **Regulation 30 – Substances in multiple packaging** This Regulation relates to situations when formulated substances containing 1080 are in multiple packaging and the outer packaging obscures some or all of the required substance information. In such cases, the outer packaging must: • be clearly labelled with all relevant priority identifier information ie the hazardous properties of the substance must be identified; or • be labelled or marked in compliance with either the Land Transport Rule, Civil Aviation Act 1990 or the Maritime Safety Act 1994 as relevant; or • in the case of an ecotoxic substance, it must bear the EU pictogram "Dangerous to the Environment" ('dead fish and tree' on orange background); or • bear the relevant class or subclass label assigned by the UN Model Regulations. **Regulation 31 – Alternative information when substances are imported**

Control Code	Regulation and Explanation
	This Regulation relates to alternative information requirements for formulated substances containing 1080 that are imported into New Zealand in a closed package or in a freight container and will be transported to its destination without being removed from that package or container. In these situations, it is sufficient compliance with the requirements of the Act if the package or container is labelled or marked in compliance with the requirements of the Land Transport Rule.
I20	**Regulation 36(8) – Durability of information for class 6.1 substances** Any packaging in direct contact with formulated substances containing 1080 must be permanently identified as having contained a toxic substance, unless the substance as packaged is restricted to a place of work.
I21	**Regulations 37-39, 47-50 – Documentation required in places of work** These controls relate to the duties of suppliers and persons in charge of places of work with respect to provision of documentation (essentially Safety Data Sheets) (Regulations 37, 38 and 50); the general content requirements of the documentation (Regulation 39 and 47); the accessibility and presentation of the required documentation with respect to comprehensibility and clarity (Regulation 48). These controls are triggered when the following quantities of formulated substances containing 1080 are held in a place of work: **Any quantity:** • Soluble concentrate containing 200 g sodium fluoroacetate/litre; • Cereal-based pellets containing 1.5–2.0 g sodium fluoroacetate/kg; • Fish paste containing 10 g sodium fluoroacetate/kg; • Apple-based paste containing 1.5 g sodium fluoroacetate/kg; • Peanut-based paste containing 1.5 g sodium fluoroacetate/kg; • Polymer gel containing 50 g sodium fluoroacetate/kg; • Polymer gel containing 100 g sodium fluoroacetate/kg; • Polymer gel block containing 1.5 g sodium fluoroacetate/kg. **Quantities equal to or greater 0.5 kg:** • Fishmeal pellets containing 1.0 g sodium fluoroacetate/kg; • Cereal-based pellets containing 0.4–0.8 g sodium fluoroacetate/kg; • Apple-based paste containing 0.6–0.8 g sodium fluoroacetate/kg. **Regulation 37 – Documentation duties of suppliers** A supplier must provide documentation containing all relevant information required by Regulations 39 to 48 when selling or supplying to another person a quantity formulated substances containing 1080 (as indicated below), if the substance is to be used in a place of work and the supplier has not previously provided the documentation to that person. The requirements are triggered for the following quantities of formulated substances containing 1080: **Any quantity:** • Soluble concentrate containing 200 g sodium fluoroacetate/litre; • Cereal-based pellets containing 1.5–2.0 g sodium fluoroacetate/kg; • Fish paste containing 10 g sodium fluoroacetate/kg; • Apple-based paste containing 1.5 g sodium fluoroacetate/kg; • Peanut-based paste containing 1.5 g sodium fluoroacetate/kg; • Polymer gel containing 50 g sodium fluoroacetate/kg; • Polymer gel containing 100 g sodium fluoroacetate/kg; • Polymer gel block containing 1.5 g sodium fluoroacetate/kg. **Quantities equal to or greater 0.5 kg:** • Fishmeal pellets containing 1.0 g sodium fluoroacetate/kg; • Cereal-based pellets containing 0.4–0.8 g sodium fluoroacetate/kg; • Apple-based paste containing 0.6–0.8 g sodium fluoroacetate/kg. **Regulation 38 – Documentation duties of persons in charge of places of work** The person in charge of any place of work where any substance containing 1080 is present in quantities equal to or greater than those specified in Regulation 38 (and with reference to Schedule 2 of the Identification Regulations), must ensure that every person handling the substance has access to the documentation required for each hazardous substance concerned. The person in charge must also ensure that the documentation does not contain any information that suggests that the substance belongs to a class or subclass it does not in fact belong to. **Regulation 39 – General content requirements for documentation** The documentation provided with formulated substances containing 1080 must include the following information: • the unequivocal identity of the substance (for example, the CAS number, chemical name, common name, UN number, registered trade name(s));

Control Code	Regulation and Explanation
	• a description of the physical state, colour and odour of the substance; • if the substance's physical state may alter over the expected range of workplace temperatures, the documentation must include a description of the temperatures at which the changes in physical state may occur and the nature of those changes; • in the case of a substance that, when in a closed container, is likely to become more hazardous over time or develop additional hazardous properties, or become a hazardous substance of a different class, the documentation must include a description of each likely change and the date by which it is likely to occur; • contact details for the New Zealand supplier/manufacturer/importer; • all emergency management and disposal information required for the substance; • the date on which the documentation was prepared. **Regulation 47 – Information not included in approval** This Regulation relates to the provision of specific documentation information (for example, as provided on a Safety Data Sheet). If information required by Regulations 39 to 46 was not included in the information used for the approval of the substance by the Authority, it is sufficient compliance with those Regulations if reference is made to that information requirement along with a comment indicating that such information is not applicable to that substance. **Regulation 48 – Location and presentation requirements for documentation** All required documentation must be available to a person handling the substance in a place of work within **10 minutes**. The documentation must be readily understandable by any fully-trained worker required to have access to it and must be easily read, under normal lighting conditions, at a distance of not less than 0.3 m. **Regulation 49 – Documentation requirements for vehicles** This Regulation provides for the option of complying with documentation requirements as specified in the various Land, Sea and Air transport rules when the substance is being transported. **Regulation 50 – Documentation to be supplied on request** Notwithstanding Regulation 37 above, a supplier must provide the required documentation to any person in charge of a place of work (where formulated substances containing 1080 are present) if asked to do so by that person.
I23	**Regulation 41 – Specific documentation requirements for ecotoxic substances** The documentation provided with any formulated substance containing 1080 must include the following information: • its general degree and type of ecotoxic hazard (for example, highly ecotoxic to terrestrial invertebrates for substances triggering a 9.3A classification); • a full description of the circumstances in which it may harm living organisms and the extent of that harm; • a full description of the steps to be taken to prevent harm to living organisms; • a summary of the available acute and chronic (ecotox) data used to define the (ecotox) subclass or subclasses in which it is classified; • its bio-concentration factor or octanol-water partition coefficient; • its expected soil or water degradation rate; • any EELs set by the Authority.
I28	**Regulation 46 – Specific documentation requirements for toxic substances** The documentation provided with any formulated substance containing 1080 must include the following information: • its general degree and type of toxic hazard; • a full description of the circumstances in which it may harm human beings; • the kinds of harm it may cause to human beings; • a full description of the steps to be taken to prevent harm to human beings; • if it will be a liquid during its use, the percentage of volatile substance in the liquid formulation, and the temperature at which the percentages were measured; • a summary of the available acute and chronic (toxicity) data used to define the (toxic) subclass or subclasses in which it is classified; • the symptoms or signs of injury or ill health associated with each likely route of exposure; • the dose, concentration, or conditions of exposure likely to cause injury or ill health; • any TELs or WESs set by the Authority.
I29	**Regulations 51-52 – Duties of persons in charge of places with respect to signage** These controls specify the requirements for signage, in terms of content, presentation and positioning at places where formulated substances containing 1080 are held in quantities exceeding the amounts specified below.

Control Code	Regulation and Explanation
	Quantities exceeding 50 kg: • Polymer gel containing 50 g sodium fluoroacetate/kg; • Polymer gel containing 100 g sodium fluoroacetate/kg. **Quantities exceeding 50 litres:** • Soluble concentrate containing 200 g sodium fluoroacetate/litre **Quantities exceeding 250 kg:** • Cereal-based pellets containing 1.5–2.0 g sodium fluoroacetate/kg; • Fish paste containing 10 g sodium fluoroacetate/kg; • Apple-based paste containing 1.5 g sodium fluoroacetate/kg; • Peanut-based paste containing 1.5 g sodium fluoroacetate/kg; • Polymer gel block containing 1.5 g sodium fluoroacetate/kg. **Quantities exceeding 1000 kg:** • Fishmeal pellets containing 1.0 g sodium fluoroacetate/kg; • Cereal-based pellets containing 0.4–0.8 g sodium fluoroacetate/kg; • Apple-based paste containing 0.6–0.8 g sodium fluoroacetate/kg. Signs are required: • at every entrance to the building and/or location (vehicular and pedestrian) where the substances are present; • at each entrance to rooms or compartments where the substances are present; • immediately adjacent to the area where the substances are located in an outdoor area. The information provided in the signage needs to be understandable over a distance of 10 metres and be sufficient to: • advise that the location contains the relevant substances; • describe the general type of hazard of each substance; • where the signage is immediately adjacent to the hazardous substance storage areas, describe the precautions needed to safely manage the substance.
I30	**Regulation 53 – Advertising corrosive and toxic substances** Any advertisement for formulated substances containing 1080 must include information that identifies the substances as toxic and indicates the need to restrict access by children. In addition, it must specify the general degree and type of hazard.
Hazardous Substances (Packaging) Regulations 2001	
P1	**Regulations 5-6, 7(1), and 8** **General packaging requirements** These controls relate to the ability of the packaging to retain its contents, allowable packaging markings with respect to design approvals, factors affecting choice of suitable packaging, and compatibility of the substance with any previous contents of the packaging. **Regulation 5 – Ability to retain contents** Packaging for formulated substances containing 1080 must ensure that, when the package is closed, there is no visible release of the substance, and that it maintains its ability to retain its contents in temperatures from –10°C to +50°C. The packaging must also maintain its ability to retain its remaining contents if part of the contents is removed from the package and the packaging is then re-closed. The packaging in direct contact with the substance must not be significantly affected or weakened by contact with the substance such that the foregoing requirements cannot be met. **Regulation 6 – Packaging markings** Packages containing formulated substances containing 1080 must not be marked in accordance with the UN Model Regulations unless: • the markings comply with the relevant provisions of that document; and • the packaging complies with the tests set out in Schedule 1, 2 or 3 (Packaging Regulations) respectively; and • the design of the packaging has been test certified as complying with those tests. **Regulation 7(1) – Requirements when packing hazardous substance** When packing any formulated substance containing 1080, account must be taken of its physical state and properties, and packaging must be selected that complies with the requirements of Regulations 5 and 9 to 21. **Regulation 8 – Compatibility** Formulated substances containing 1080 must not be packed in packaging that has been previously packed with substances with which it is incompatible unless all traces of the previous substance have been removed. **Regulations 9A and 9B – Large packaging**

Control Code	Regulation and Explanation
	Large packaging may be used to contain formulated substances containing 1080 in New Zealand if it has been constructed, marked and tested as a large package as provided in the UN Model Regulations. **"Large Packaging"** does not include: • a tank, tank wagon or transportable container (as defined in the Hazardous Substances (Tank Wagons and Transportable Containers) Regulations 2004; or • a stationary container system, a stationary tank or a tank (as defined in the Hazardous Substances (Dangerous Goods and Scheduled Toxic Substances) Transfer Notice 2004.
P3	**Regulation 9 – Packaging requirements for substances packed in limited quantities** When any formulated substance containing 1080 is packaged in limited quantities, there is provision for it to be packaged to a lesser performance standard than normally required (as specified in Schedule 4 of the Packaging Regulations).
P3, P13 and P15	**Regulations 9, 19 and 21 – Packaging requirements for toxic substances** The packaging requirements for formulated substances containing 1080 set out in the Schedules to the Regulations are varied as set out below.
PG2	**Schedule 2 – Tests of packaging of hazardous substances required to be tested in accordance with this schedule** The minimum packaging requirements that must be complied with are varied by substituting Schedule 2 for Schedule 1 for the following formulated substances containing 1080 when packaged in quantities of more than **0.5 kg/0.1 litre**: • Soluble concentrate containing 200 g sodium fluoroacetate/litre; • Polymer gel containing 50 g sodium fluoroacetate/kg; • Polymer gel containing 100 g sodium fluoroacetate/kg. The tests in Schedule 2 correlate to the packaging requirements of UN Packing Group II (UN PGII). In quantities less than or equal to **0.5 kg/0.1 litre** the minimum packaging requirements that must be complied with are described in Schedule 4.
PG3	**Schedule 3 – Tests of packaging of hazardous substances required to be tested in accordance with this schedule** The minimum packaging requirements that must be complied with are varied by substituting Schedule 3 for Schedule 2 for the following formulated substance containing 1080 when packaged in quantities of more than **3.0 kg**: • Fish paste containing 10 g sodium fluoroacetate/kg. The tests in Schedule 3 correlate to the packaging requirements of UN Packing Group III (UN PGIII). In quantities less than or equal to **3.0 kg** the minimum packaging requirements that must be complied with are described in Schedule 4.
PS4	**Schedule 4 – Tests of packaging of hazardous substances required to be tested in accordance with this schedule** The minimum packaging requirements that must be complied with are varied by substituting Schedule 4 for Schedule 3 for the following formulated substances containing 1080 when packaged in **any quantities**: • Cereal-based pellets containing 1.5–2.0 g sodium fluoroacetate/kg; • Apple-based paste containing 1.5 g sodium fluoroacetate/kg; • Peanut-based paste containing 1.5 g sodium fluoroacetate/kg; • Polymer gel block containing 1.5 g sodium fluoroacetate/kg. • Fishmeal pellets containing 1.0 g sodium fluoroacetate/kg; • Cereal-based pellets containing 0.4–0.8 g sodium fluoroacetate/kg; • Apple-based paste containing 0.6–0.8 g sodium fluoroacetate/kg.

Regulation 19

The requirement for packaging for these substances is varied under section 77(4)(b) to substitute references to the above Schedules. The requirement for these substances to be packaged according to the Schedules in the regulations is based on the 6.1 acute oral toxicity classification of these substances. However, under the UN requirements for transport, the substances would be required to be packaged according to UNRTDG Packaging Groups based on assessment of rat toxicity data, which is less sensitive than the dog toxicity data used to classify 1080. These variations in the packaging requirements for these substances are made to align with national standards for the transport of dangerous goods.

Having regard to the requirements of section 77(4)(b), the Committee considers that the benefits of these formulated substances containing 1080 are such that the controls should be varied to retain the benefits and that the variations will not significantly increase the adverse effects of the substances. Therefore the packaging requirements can be changed as indicated above. Further, the Committee notes that the requirements of the Identification Regulations will ensure that people handling the substances or attending an incident involving the packaged substances will be made adequately aware of the risks posed by the substances.

Control Code	Regulation and Explanation
Hazardous Substances (Disposal) Regulations 2001	
D4 and D5	**Regulations 8-9 – Disposal requirements for toxic and ecotoxic substances** Formulated substances containing 1080 must be disposed of by: • treating the substance so that it is no longer a hazardous substance, including depositing the substance in a landfill, incinerator or sewage facility. However, this does not include dilution of the substance with any other substance prior to discharge to the environment; or • discharging the substance to the environment provided that after reasonable mixing, the concentration of the substance in any part of the environment outside the mixing zone does not exceed any TEL (tolerable exposure limit) or EEL (environmental exposure limit) set by the Authority for that substance; or • exporting the substance from New Zealand as a hazardous waste.
D6	**Regulation 10 – Disposal requirements for packages** This control gives the disposal requirements for packages that contained formulated substances containing 1080 and are no longer to be used for that purpose. Such packages must be either decontaminated/treated or rendered incapable of containing any substance (hazardous or otherwise) and then disposed of in a manner that is consistent with the disposal requirements for the substance. In addition, the manner of disposal must take into account the material that the package is manufactured from.
D7	**Regulation 11-12 – Disposal information requirements** These controls relate to the provision of information concerning disposal (essentially on the label) that must be provided when selling or supplying any quantity of a substance containing 1080. Information must be provided on appropriate methods of disposal and information may be supplied warning of methods of disposal that should be avoided, ie that would not comply with the Disposal Regulations. Such information must be accessible to a person handling the substance within 10 seconds and must comply with the requirements for comprehensibility, clarity and durability as described in Regulations 34 to 36 of the Identification Regulations (Control Code I1).
D8	**Regulation 13-14 – Disposal documentation requirements** These controls relate to the provision of documentation concerning disposal (essentially in an Safety Data Sheet) that must be provided when selling or supplying any quantity of the following formulated substances containing 1080: • Soluble concentrate containing 200 g sodium fluoroacetate/litre; • Cereal-based pellets containing 1.5–2.0 g sodium fluoroacetate/kg; • Fish paste containing 10 g sodium fluoroacetate/kg; • Apple-based paste containing 1.5 g sodium fluoroacetate/kg; • Peanut-based paste containing 1.5 g sodium fluoroacetate/kg; • Polymer gel containing 50 g sodium fluoroacetate/kg; • Polymer gel containing 100 g sodium fluoroacetate/kg; • Polymer gel block containing 1.5 g sodium fluoroacetate/kg. These controls relate to the provision of documentation concerning disposal (essentially in a Safety Data Sheet) that must be provided when selling or supplying the following formulated substances containing 1080 in quantities that exceed 0.5 kg: • Apple-based paste containing 0.6–0.8 g sodium fluoroacetate/kg; • Cereal-based pellets containing 0.4–0.8 g sodium fluoroacetate/kg; • Fishmeal pellets containing 1.0 g sodium fluoroacetate/kg. The documentation must describe one or more methods of disposal (that comply with the Disposal Regulations) and describe any precautions that must be taken. Such documentation must be accessible to a person handling the substance at a place of work within 10 minutes and must comply with the requirements for comprehensibility and clarity as described in Regulations 48(2), (3) and (4) of the Identification Regulations (Control Code I21).
Hazardous Substances (Emergency Management) Regulations 2001	
EM1	**Regulations 6,7, 9-11 – Level 1 emergency management information: General requirements** These controls relate to the provision of emergency management information (essentially on the label) that must be provided with **any quantity** of a formulated substance containing 1080. Regulation 6 describes the duties of suppliers, Regulation 7 describes the duties of persons in charge of places, Regulation 9 describes the requirement for the availability of the information (**10 seconds**) and Regulation 10 gives the requirements relating to the presentation of the information with respect to comprehensibility, clarity and durability. These requirements correspond with those relating to secondary identifiers required by the Identification Regulations (Control Code I1, Regulations 6, 7, 32–35, 36(1)–(7)). Regulation 11 provides for the option of complying with the information requirements specified in the various land, sea and air transport rules when the substance is being transported.

Control Code	Regulation and Explanation
EM6	**Regulation 8(e) – Information requirements for toxic substances** The following information must be provided when any formulated substance containing 1080 is present in **any quantity**: • a description of the first aid to be given; • a 24-hour emergency service telephone number.
EM7	**Regulation 8(f) – Information requirements for ecotoxic substances** The following information must be provided with the formulated substances containing 1080 when present in the quantities specified below: • a description of the parts of the environment likely to be immediately affected by it; • a description of its typical effects on those parts of the environment; • a statement of any immediate actions that may be taken to prevent the substance from entering or affecting those parts of the environment. **Quantities equal to or greater than 0.1 litre:** • Soluble concentrate containing 200 g sodium fluoroacetate/litre. **Quantities equal to or greater than 0.1 kg:** • Cereal-based pellets containing 1.5–2.0 g sodium fluoroacetate/kg; • Fish paste containing 10 g sodium fluoroacetate/kg; • Apple-based paste containing 1.5 g sodium fluoroacetate/kg; • Peanut-based paste containing 1.5 g sodium fluoroacetate/kg; • Polymer gel containing 50 g sodium fluoroacetate/kg; • Polymer gel containing 100 g sodium fluoroacetate/kg; • Polymer gel block containing 1.5 g sodium fluoroacetate/kg. **Quantities equal to or greater than 0.2 kg:** • Fishmeal pellets containing 1.0 g sodium fluoroacetate/kg; • Cereal-based pellets containing 0.4–0.8 g sodium fluoroacetate/kg; • Apple-based paste containing 0.6–0.8 g sodium fluoroacetate/kg.
EM8	**Regulations 12-16, 18-20 – Level 2 emergency management documentation requirements** These controls relate to the duties of suppliers and persons in charge of places of work with respect to the provision of emergency management documentation (essentially Safety Data Sheets). This documentation must be provided where the following formulated substances containing 1080 are sold or supplied, or held in a workplace, in **any quantity**: • Soluble concentrate containing 200 g sodium fluoroacetate/litre; • Cereal-based pellets containing 1.5–2.0 g sodium fluoroacetate/kg; • Fish paste containing 10 g sodium fluoroacetate/kg; • Apple-based paste containing 1.5 g sodium fluoroacetate/kg; • Peanut-based paste containing 1.5 g sodium fluoroacetate/kg; • Polymer gel containing 50 g sodium fluoroacetate/kg; • Polymer gel containing 100 g sodium fluoroacetate/kg; • Polymer gel block containing 1.5 g sodium fluoroacetate/kg. This documentation must be provided where the following formulated substances containing 1080 are sold or supplied, or held in a workplace, in quantities equal to or greater than **0.5 kg**: • Fishmeal pellets containing 1.0 g sodium fluoroacetate/kg; • Cereal-based pellets containing 0.4–0.8 g sodium fluoroacetate/kg; • Apple-based paste containing 0.6–0.8 g sodium fluoroacetate/kg. Regulations 12 and 13 describe the duties of suppliers, regulation 14 describes the duties of persons in charge of places of work, regulation 15 provides for the option of complying with documentation requirements of the transport rules when the substance is being transported, and regulation 16 specifies requirements for general contents of the documentation. Regulation 18 prescribes location and presentation requirements for the documentation, ie it must be available within 10 minutes, be readily understandable, comprehensible and clear. These requirements correspond with those relating to documentation required by the Identification Regulations (Control Code I21).
EM11	**Regulations 25-34 – Level 3 emergency management requirements – emergency response plans** These Regulations relate to the requirement for an emergency response plan to be available at any place (excluding aircraft or ships) where formulated substances containing 1080 are held (or are reasonably likely to be held on occasion) in quantities greater than those specified below. **Quantities greater than 100 litres:**

Control Code	Regulation and Explanation
	• Soluble concentrate containing 200 g sodium fluoroacetate/litre. **Quantities greater than 100 kg:** • Cereal-based pellets containing 1.5–2.0 g sodium fluoroacetate/kg; • Fishmeal pellets containing 1.0 g sodium fluoroacetate/kg; • Cereal-based pellets containing 0.4–0.8 g sodium fluoroacetate/kg; • Fish paste containing 10 g sodium fluoroacetate/kg; • Apple-based paste containing 1.5 g sodium fluoroacetate/kg; • Peanut-based paste containing 1.5 g sodium fluoroacetate/kg; • Apple-based paste containing 0.6–0.8 g sodium fluoroacetate/kg; • Polymer gel containing 50 g sodium fluoroacetate/kg; • Polymer gel containing 100 g sodium fluoroacetate/kg; • Polymer gel block containing 1.5 g sodium fluoroacetate/kg. The emergency response plan must describe all of the likely emergencies that may arise from the breach or failure of controls. The type of information that is required to be included in the plan is specified in Regulations 29 to 30. Requirements relating to the availability of equipment, materials and people are provided in Regulation 31, requirements regarding the availability of the plan are provided in Regulation 32 and requirements for testing the plan are described in Regulation 33.
EM12	**Regulations 35-41 – Level 3 emergency management requirements – secondary containment – deleted (in part)** These regulations relate to the requirement for a secondary containment system to be installed at any fixed location where the following formulated substance containing 1080 is held in quantities equal to or greater than **100 litres:** • Soluble concentrate containing 200 g sodium fluoroacetate/litre. Regulation 36 prescribes requirements for secondary containment systems for pooling substances. Regulation 37 prescribes requirements for places where hazardous substances are held above ground in containers each holding up to 60 litres or less. Regulation 38 prescribes requirements for places where hazardous substances are held above ground in containers each holding between 60 litres and 450 litres. Regulation 39 prescribes requirements for places where hazardous substances are held above ground in containers each holding more than 450 litres. Regulation 40 prescribes requirements for places where hazardous substances are held underground. Regulation 41 prescribes requirements for secondary containment systems that contain substances of specific hazard classifications, e.g. there is a requirement to prevent substances from coming into contact with incompatible materials, and a requirement to exclude energy sources when class 1, 2, 3, 4 or 5 substances are contained.
These regulations are deleted under section 77(4)(a) for the other formulated substances containing 1080 as they are used in solid form. Having regard to the requirements of section 77(4)(a), the Committee considers that because they are solids, the adverse effects of the other formulated substances containing 1080 will thus be less than the adverse effects of other (liquid) substances with the same hazard classifications. Therefore the control is deleted for all formulated substances containing 1080 except for *soluble concentrate containing 200 g sodium fluoroacetate/litre* where it is held in quantities equal to or greater than 100 litres.	
EM13	**Regulation 42 – Level 3 emergency management requirements – signage** This control relates to the provision of emergency management information on signage at places where formulated substances containing 1080 are held at the quantities detailed below: **Quantities equal to or greater than 50 litres:** • Soluble concentrate containing 200 g sodium fluoroacetate/litre. **Quantities equal to or greater than 50 kg:** • Polymer gel containing 50 g sodium fluoroacetate/kg; • Polymer gel containing 100 g sodium fluoroacetate/kg.
	Quantities equal to or greater than 250 kg: • Cereal-based pellets containing 1.5–2.0 g sodium fluoroacetate/kg; • Fish paste containing 10 g sodium fluoroacetate/kg; • Apple-based paste containing 1.5 g sodium fluoroacetate/kg; • Peanut-based paste containing 1.5 g sodium fluoroacetate/kg; • Polymer gel block containing 1.5 g sodium fluoroacetate/kg. **Quantities equal to or greater than 1000 kg:** • Fishmeal pellets containing 1.0 g sodium fluoroacetate/kg; • Cereal-based pellets containing 0.4–0.8 g sodium fluoroacetate/kg; • Apple-based paste containing 0.6–0.8 g sodium fluoroacetate/kg. The signage must advise of the action to be taken in an emergency and must meet the requirements for comprehensibility and clarity as defined in Regulations 34 and 35 of the Identification Regulations.
Hazardous Substances (Personnel Qualification) Regulations 2001	

Control Code	Regulation and Explanation
AH1	**Regulations 4-6 – Approved Handler requirements** Formulated substances containing 1080 are required to be under the control of an approved handler during specified parts of the lifecycle. An approved handler is a person who holds a current test certificate certifying that they have met the competency requirements specified by the Personnel Qualification Regulations in relation to handling specific hazardous substances. Regulation 4 describes the test certification requirements, Regulation 5 describes the qualification (competency and skill) requirements and regulation 6 describes situations where transitional qualifications for approved handlers apply. Also see Control Codes T6 and E7.
Hazardous Substances (Tracking) Regulations 2001	
TR1	**Regulations 4(1), 5, 6 – General tracking requirements** Under regulation 4(1), formulated substances containing 1080 are subject to tracking requirements, ie the location and movement of the substance must be recorded at each stage of its lifecycle until its final disposal. The hazard classifications of the substances requiring tracking are listed in Schedule 1 of the Tracking Regulations. The person in charge of the place where the tracked substance is kept is responsible for ensuring that the necessary information is included in the record. This information to be provided is specified in Schedule 2 of the Tracking Regulations, and includes information on the identification of the approved handler, and on the identification, quantity, location and disposal of the substance. The record must meet the location and presentation requirements specified in Part 2 of the Identification Regulations, ie it must be accessible within **10 minutes** and meet the performance standards for comprehensibility and clarity (Regulation 5(1) and (2)). If a tracked substance is transferred to another place, the person in charge must ensure that the record is retained for a period of 12 months. If the substance has undergone treatment that results in it no longer being a tracked substance, or if it has been intentionally or unintentionally disposed of, the record must be kept for 3 years. However these requirements do not apply to places that are vehicles (Regulations 5(3) and (4)). Regulation 6 prescribes requirements relating to the transfer of tracked substances from one place to another. Specifically, the person in charge may only transfer the tracked substance to another place if they have received confirmation that: • an approved handler is present at the place receiving the substance; • the place receiving the substance meets any location test certification requirements; • any place where the substance is to be held during transit complies with the relevant requirements of the Hazardous Substances (Emergency Management) Regulations and Hazardous Substances (Classes 1 to 5 Controls) Regulations.
The following provisions of Schedule 2 to the Hazardous Substances (Tracking) Regulations 2001 are varied under section 77(3) (a) so as to add to clauses 2 (substance information), 5 (details of transfer to another place), and 6 (disposal of tracked substance), the requirement to record the unique identifier for the container that contains the relevant formulated substance containing 1080: **Schedule 2, Clause 2 – Substance Information** Clause 2A is inserted after clause 2: 2A The unique identifier for the container that contains the tracked substance. **Schedule 2, Clause 5 – Details of transfer to another place** Subclause (aa) is inserted after subclause (a): (aa) the unique identifier for the container that contains the substance; and **Schedule 2, Clause 6 – Disposal of tracked substance** Subclause (e) is inserted after subclause (d): (e) the unique identifier for the container that contained the substance. The Committee is satisfied that these variations are necessary under section 77(3)(a) having regard to the adverse effects associated with the substances, in order to ensure the effectiveness of Additional Control 2 (below) (which requires packaging to be marked with a unique identifier to facilitate 'traceback' of individual packages in the event of an incident).	
Hazardous Substances (Tank Wagons and Transportable Containers) Regulations 2004	
Regulations 4 to 43 where applicable	The Hazardous Substances (Tank Wagons and Transportable Containers) Regulations 2004 prescribe a number of controls relating to tank wagons and transportable containers which must be complied with as relevant. This control applies only to the following formulated substance containing 1080: • Soluble concentrate containing 200 g sodium fluoroacetate/litre.
Schedule 8 to the Hazardous Substances (Dangerous Goods and Scheduled Toxic Substances) Transfer Notice 2004 – stationary container systems	

Control Code	Regulation and Explanation
The controls relating to stationary container systems, as set out in Schedule 8 to the Hazardous Substances (Dangerous Goods and Scheduled Toxic Substances) Transfer Notice 2004 (Supplement to the *New Zealand Gazette*, 26 March 2004, No. 35, page 767), as amended, shall apply to the following formulated substance containing 1080, notwithstanding clause 1(1) of that Schedule: • Soluble concentrate containing 200 g sodium fluoroacetate/litre.	
The above controls relating to tank wagons, transportable containers and stationary container systems are varied under section 77(3) and (4) in order to ensure that they apply, as appropriate, to the only relevant (ie liquid) formulated substance containing 1080 namely *soluble concentrate containing 200 g sodium fluoroacetate/litre.* The variations are necessary to ensure that the risks associated with transporting or storing large quantities of the substance are properly managed.	
Additional Controls on formulated substances containing 1080 imposed under section 77A	
Additional Control 2	**Packaging of substances for sale for vertebrate pest control** (1) No person may pack any formulated substance containing 1080 for sale for vertebrate pest control unless the package is marked with a unique identifier. (2) The unique identifier marked on the package must comply with regulations 35 and 36 of the Hazardous Substance (Identification) Regulations 2001. (3) For the purposes of regulation 35(3)(c) of those regulations, the unique identifier is a secondary identifier. (4) In this control, **package** means the smallest package in which the relevant substance is sold.
This control is added to all formulated substances containing 1080 to facilitate the 'trace-back' of individual packages in the event of an incident involving controlled vertebrate poisons. The control complements the requirement to keep records of the unique identifier (Control Code TR1 – Tracking requirements). This control is justifiable given the widespread use of vertebrate poisons, the large number of people potentially involved in their application and the number of occasions that have required this 'trace-back' mechanism to be used by regulatory agencies in the past. The Committee is therefore satisfied that the suite of controls imposed under this approval will be more effective in terms of their effect on the management, use and risks of the formulated substances containing 1080 as a result of adding this control.	
Additional Control 3	**Restrictions on supply and acquisition of substances** (1) This clause applies to formulated substances containing 1080. (2) No person may sell or otherwise supply formulated substances containing 1080 to any person unless the seller (or supplier) holds a licence in accordance with **Additional Control 5**. (3) No person may purchase or otherwise acquire formulated substances containing 1080 unless they hold a licence in accordance with **Additional Control 5**.
This control is added in accordance with section 77A(2)(b). A controlled substances licence is required from both the Agricultural Compounds and Veterinary Medicines (ACVM) Group of NZFSA and ERMA New Zealand for all formulated substances containing 1080 (see **Additional Control 5** below). The intention of the licence requirement is to ensure that a person is a 'fit and proper' person and has knowledge of the relevant legislation relating to the safe use of the substance (ie has an approved handler test certificate). Controlled vertebrate poisons such as formulated substances containing 1080, fall into the group of substances where it is considered appropriate that access be restricted to responsible individuals. For this reason, the Committee is satisfied that this additional control, together with Additional Control 5 is more effective in terms of its effect on the management, use and risks than other controls and thus may be added under section 77A.	
Additional Control 4	**Permissions required for application or use of substances** (1) No person may **apply** or otherwise use any formulated substance containing 1080 on land administered or managed by the Department of Conservation unless the person first obtains a permission under section 95A of the Act from the Authority. (2) No person may **apply** or otherwise use any formulated substance containing 1080 in a catchment area from which water is drawn for human consumption or in any other area where a risk to public health may be created if the substance is applied or used unless the person first obtains a permission under section 95A of the Act from the Authority.
The requirement to obtain a permission prior to the application of formulated substances containing 1080 ensures that the risks associated with any general or particular use of the substance can be appropriately addressed and any additional controls required to manage the risks are imposed (by way of conditions imposed on the permissions under section 95A). For example, an application for a permission allows the risks arising due to the intended location of the operation to be considered by those with appropriate local knowledge of the intended application site. Currently, the Authority has delegated the power to issue permissions under section 95A to DoC and the Ministry of Health. DoC is delegated the power to issue permissions when formulated substances containing 1080 are to be applied or otherwise used on land managed by DoC. The Ministry of Health is delegated the power to issue permissions when formulated substances containing 1080 are to be applied or otherwise used in a catchment area from which water is drawn for human consumption or in any other area where a risk to public health may be created if the substance is used or applied. In situations where formulated substances containing 1080 are to be applied or otherwise used on land managed by DoC that is a catchment area from which water is drawn for human consumption or is in any other area where a risk to public health may be created if the substance is used or applied, a permission is required from both DoC and the Ministry of Health. The Committee is satisfied that it is appropriate to add this control under section 77A(2)(a), as it will be more effective in terms of its effect on the management, use and risks of the substances than other controls that apply under this approval.	

Control Code	Regulation and Explanation
In particular, proper and effective use of the permissions regime is seen by the Committee as an essential tool in ensuring best practice in respect of key aspects of aerial application of formulated substances containing 1080 such as consultation and notification. One matter in particular which the Committee wishes to see addressed as part of a review of the permissions delegations is the implementation of best practice consultation with iwi/Māori whose land or other interests might be affected by the use of 1080, particularly when applied aerially. The Committee wishes to provide for better engagement with iwi/Māori and improved outcomes in terms of the management of taonga species and resources, and will be looking for this to be ensured as far as possible when permissions are granted for the aerial use of 1080. Many iwi/Māori submitters were concerned that "consultation" appeared to be given variable meanings, from notifying and informing at one end of the spectrum to acting/deciding together at the other end. The Committee notes the interpretation of "consultation" in ERMA New Zealand guidance,[1] namely that the overall aim of good consultation is to provide easily understood information about the proposal; obtain the necessary information and understanding of Māori perspectives and views as they relate to specific issues associated with the proposal and discuss, where issues are raised by Māori, ways of minimising, mitigating or remedying any potential adverse effects and enhancing any potential benefits. The Committee expects that those seeking permission from DoC or the Ministry of Health for aerial application of 1080 will be required to demonstrate consultation with Māori to at least this standard.	
Additional Control 5	**Licence required for possession of substances** (1) No person may possess any formulated substance containing 1080 unless the person has a licence under section 95B of the Act from the Authority that is obtained before the person takes possession of the substance. (2) Despite subclause (1), a person who does not have a licence may possess a formulated substance containing 1080 if— (a) the person is under the immediate supervision of a person who has a licence in accordance with this clause; or (b) the person is deemed to comply with Regulation 9 of the Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001 by regulation 9A of those regulations.
This control is added in accordance with section 77A(2)(b). In addition to holding an approved handler certificate, no person may possess formulated substances containing 1080 unless they have a licence (controlled substance licence) granted under section 95B of the Act that is obtained from the Authority before the person takes possession of the substance. Exceptions to this requirement are if the person is under the immediate supervision (meaning within eye and ear shot at all times) of a person who has a licence or if regulation 9 of the Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001 is deemed complied with in certain transport situations through the provisions of regulation 9A (Control Code T6 and E7, above). The main purpose of the licensing requirement is to add a 'fit and proper person' consideration to an approved handler qualification. This requirement is generally restricted to those substances which could be used for illegal purposes and which could present significant security concerns. Formulated substances containing 1080 fall into the group of substances for which it is considered appropriate to require a controlled substance licence and the Committee is satisfied that this additional control is more effective in terms of its effect on the management, use and risks of formulated substances containing 1080 than other controls that apply under this approval. Controlled substances licences are issued by test certifiers under delegation from the Authority through a process which covers both the HSNO Act and ACVM Group requirements. Additionally, the ACVM Group requires that, as part of the approval under the ACVM Act, certain vertebrate toxic agents may only be sold to and used by persons holding controlled substances licences (see **Additional Control 3**).	
Additional Control 6	**Restriction on aerial application of certain substances** (1) No person may **apply**, or engage another person to **apply**, a formulated substance containing 1080 by **aerial application** unless— (a) **aerial application** is a permitted method of release for that substance in accordance with regulation 51 of the Hazardous Substances (Classes 6, 8 and 9 Controls) Regulations 2001 (Control Code E4 above); and (b) if required, the person has a permission or permissions (as the case may be) granted in accordance with **Additional Control 4**; and (c) a copy of each permission is supplied to the pilot of the **aircraft**; and (d) the person has given public notice in a newspaper available in the areas in which the substance will be applied of the proposed **aerial application** in accordance with subclause (2); and (e) the substance is applied no more than 2 months after the date of the public notice referred to in paragraph (d); and (f) if the person is not the owner or occupier of the area over which the substance will be applied, the person has given notice of the proposed **aerial application** to the officer in charge of the police station that is nearest to the **application** area. (2) The public notice referred to in subclause (1)(d) must—

[1] User Guide *Working with Māori under the HSNO Act 1996: A Guide for Applicants* (ER-UG-01-4 04/05).

Control Code	Regulation and Explanation
	(a) be given with sufficient prior notification, but no more than 2 months, before the proposed **aerial application**; and (b) specify the following: (i) the approximate date on which the substance will be applied: (ii) the name and nature of the substance: (iii) a description of the area over which the substance will be applied, including— (A) the boundaries of the area; and (B) districts, roads, and other commonly known features that may identify the place: (iv) the location or locations where members of the public may view maps of the area over which the substance will be applied, and the times when such maps may be viewed: (v) the name and address of the person responsible for the **application** of the substance.
This control applies only to the following formulated substances containing 1080 that are approved for aerial application, namely: • Cereal-based pellets containing 0.4 – 0.8 g sodium fluoroacetate/kg; • Cereal-based pellets containing 1.5 – 2.0 g sodium fluoroacetate/kg; • Soluble concentrate containing 200 g sodium fluoroacetate/litre. This control is added under section 77A as it is more effective in terms of its effect on the management, use and risks of aerial application of formulated substances containing 1080 than other controls under this approval. Specifically, the control ensures that potentially affected persons are notified of the approximate time and place of a proposed aerial application in their area and enables them to obtain further information if they require. In this way, the control aids more effective communication of risks relating to aerial applications to local communities and other potentially affected groups/persons.	
Additional Control 7	**Requirements for aircraft carrying out aerial application** (1) An **aircraft** that is carrying out an **aerial application** must not, when flying to or from the area where a formulated substance containing 1080 is applied, fly over a— (a) place specified (if any) in a permission granted in relation to the substance in accordance with **Additional Control 4** as being a place over which such an **aircraft** must not fly; or (b) **public drinking water supply**; or (c) waterway that is less than 100 metres upstream of a point of extraction from a water source for a drinking water supply (not being a water supply exclusively for stock). (2) Every **aircraft** that is carrying out an **aerial application** must use a navigational guidance system to ensure that the substance is applied within the application area. (3) Every **aircraft** that has carried out an **aerial application**, and all equipment used in connection with the **aerial application**, must be decontaminated before the **aircraft** or equipment is— (a) used for another purpose; or (b) removed from a place from which the **application** operation has been carried out. (4) When an **aerial application** being carried out on a day has ceased for that day, the loading area, and any area where the substance is stored in preparation for loading the substance on to or into the **aircraft**, must be— (a) decontaminated; or (b) fenced so that— (i) people do not inadvertently enter the area; and (ii) stock cannot gain access to the area. (5) An area that is fenced in accordance with subclause (4)(b) must have signs erected at the perimeter of the fence in accordance with subclause (6). (6) The signs referred to in subclause (5) must— (a) state that people and stock should stay out of the area until the signs, and any fence around the area, have been removed; and (b) identify the person responsible for the place, and provide sufficient information to enable the person to be contacted during normal business hours; and (c) identify the substance and state that it is toxic to human beings and ecotoxic to other vertebrates; and (d) comply with regulations 34 and 35 of the Hazardous Substances (Identification) Regulations 2001, except that regulation 35 applies as follows: (i) in relation to the information required to be included on the signs by paragraphs (a) and (b), as if the distances referred to in regulation 35(3)(c) of those regulations were a distance of not less than 2 metres; and (ii) in relation to the information required to be included on the signs by paragraph (c), as if the distances referred to in regulation 35(3)(c) of those regulations were a distance of not less than 10 metres. (7) The signs and the fence required by this clause must remain in place until the place is decontaminated.
This control specifies requirements for aircraft used to apply formulated substances containing 1080 that are approved for	

Control Code	Regulation and Explanation
aerial application, namely: • Cereal-based pellets containing 0.4–0.8 g sodium fluoroacetate/kg; • Cereal-based pellets containing 1.5–2.0 g sodium fluoroacetate/kg; • Soluble concentrate containing 200 g sodium fluoroacetate/litre. Specifically, the controls: • prohibit flying over public drinking water supplies and other protected waterways or areas; • require aircraft to have suitable navigational guidance systems in order to ensure accuracy of application. Normally, this will be achieved by use of a differential global positioning system; • decontamination of aircraft and ground loading or storage areas (with fencing/signing option if decontamination of ground areas is not possible). The Committee is satisfied that all these requirements are appropriately added as controls under section 77A on the basis that they are more effective in terms of its effect on the management, use and risks of aerial application of formulated substances containing 1080 than other controls under this approval. Combined, they will ensure greater accuracy of application, and will help to limit the likelihood of traces of the substances coming into contact with aircraft/airport personnel or members of the public in places of public access.	
Additional Control 8	**Misapplied, lost or spilt substances** If a formulated substance containing 1080 is applied other than in the intended application area, or is lost or spilt, the person who is in possession of the substance at the time that it was misapplied, lost, or spilt must report the nature and quantity of the substance within 24 hours of the substance being misapplied, lost, or spilt to— (a) if a permission was granted in accordance with **Additional Control 4** to **apply** or otherwise use the substance, the person who granted the permission; and (b) the officer in charge of the nearest police station to which the person has access; and (c) the nearest Medical Officer of Health or the Medical Officer of Health in whose region the substance was misapplied, lost, or spilt; and (d) each owner or occupier of land on which the substance may have been misapplied, lost, or spilt; (e) the person on whose behalf the substance is being applied; (f) the Regional Council or councils in whose area the substance is being applied; and (g) the Authority.
This control is added under section 77A. While incidents involving hazardous substances are required under the Act to be reported to HSNO enforcement agencies, this control specifically clarifies who is responsible for reporting misapplications, losses or spillages arising from the use of formulated substances containing 1080. Notification must be to the listed agencies and owners and occupiers as well as to the Authority. The Committee is satisfied that this control is more effective in terms of its effect on the management, use and risks of formulated substances containing 1080 than other controls under this approval as it enables the appropriate agencies and the Authority to monitor and be notified of any misuse or poor practices relating to the use of these substances. This will also ensure that the appropriate action is taken to address the issue and manage any adverse effects that may arise. The obligation to report such incidents to the Authority complements Additional Control 12 (provision of information to the Authority) relating to reporting on aerial application of formulated substances containing 1080.	
Additional Control 9	**Unauthorised persons to stay clear of application area of substances** (1) A person who is not lawfully assisting in the **application** or use of formulated substances containing 1080 must not remain in the vicinity of the **application** or use of the substance (as the case may be). (2) An enforcement officer may order a person who contravenes subclause (1) to immediately leave the area in which the substance is being applied or used.
This control is added under section 77A. The intent of this control is to ensure that people whose personal safety is at risk, or who are interfering with an operation, or who are likely to be directly in the flight path of an aerial operation can be asked to leave the operational area. For the purposes of this control, **vicinity** is taken to mean an area within which someone may be directly affected by, or having a direct effect on, the operation. The Committee is satisfied that this control is more effective in terms of its effect on the management, use and risks of formulated substances containing 1080 than other controls under this approval as it helps to ensure an appropriate level of personal safety for those who may be at risk from an operation whether voluntarily or not. In the case of the former, an enforcement officer may take appropriate action to order someone to leave the area.	
Additional Control 10	**Notification of changes of composition** Any changes to the composition or proposed use of formulated substances containing 1080 must be notified to the Authority in writing before it is used such notification to include the following information, as applicable: • the name of substance; • details of the original formulation; • details of the revised formulation clearly identifying the changed ingredients, their function in the bait, and their concentration and CAS number if appropriate;

Control Code	Regulation and Explanation
	• the physical form, if different from the original; • bait colour; • changes in bait size; • the intended use(s) of the substance (to include target species, method(s) of release); • the physical properties of the substance (for example, flashpoint, pH) if different from the original; • the impurity profile and source of the 'active' ingredient, if different from the original; • any information on the effect that the formulation change may have on the risk profile of the substance, including the results of any palatability trials undertaken on both target and non-target species.
This control is added under section 77A as the Committee is satisfied it is more effective in terms of its effect on the management, use and risks of formulated substances containing 1080 than other controls under this approval. Changes in formulations and other matters such as bait size may alter the risk to non-target species, even though there are no changes to the hazard classifications. In order to ensure that there is as much information available as possible on the impact on and risks to non-target species, changes to formulations of existing substances must be notified to the Authority so that any changes to the risk profile of substances can be tracked and managed. Depending on the nature and extent of the changes, it may be necessary for this approval to be amended (or a new approval obtained) before the substance may lawfully be used.	
Additional Control 11	**Notification of aerial or ground-based operations** (1) No person may **apply**, or engage another person to **apply**, a formulated substance containing 1080 by **aerial application or ground-based application** unless the person has given notice of the proposed **application** to occupiers and, as far as practicable owners, of land, dwellings or buildings immediately abutting the application area. (2) The notice referred to in subclause (1) must— (a) be given with sufficient prior notification, but no more than 2 months, before the proposed **application** and, if requested by the person notified, shall be repeated at a mutually agreed time before the proposed **application**; and (b) specify the following: (i) the approximate date on which the substance will be applied: (ii) the name and nature of the substance: (iii) a description of the area over which the substance will be applied, including— (A) the boundaries of the area; and (B) districts, roads, and other commonly known features that may identify the place: (iv) the name and address of the person responsible for the **application** of the substance. (3) This control shall come into force on 1 January 2008.
The Committee considers that landowners and occupiers immediately abutting the site of a proposed aerial or ground-based application should be advised with sufficient prior notification (but no more than two months) before the proposed application. The notification should include similar matters to those required for public notice of aerial applications (see **Additional Control 6** above). Further, if a notified person so wishes, they may require the operator to repeat the notice at a mutually agreed time before the proposed operation. The Committee is satisfied that this control should be added under section 77A as it is more effective in terms of its effect on the management, use and risks of aerial or ground-based application of formulated substances containing 1080 than other controls under this approval. Specifically, the control ensures that potentially affected persons are notified of the approximate time and place of a proposed application in their area and enables them to obtain further information if they require. In this way, the control aids more effective communication of risks relating to the use of formulated substances containing 1080 to local communities and other potentially affected groups/persons.	
Additional Control 12	**Aerial application – provision of information to the Authority** (1) Any person who applies, or engages another person to **apply**, a formulated substance containing 1080 by **aerial application** ("the operation") must, as soon as reasonably practicable, but no later than six months, after the operation, provide a written report to the Authority, such report to include the following information— (a) the reasons for the operation, including information on pre-operation notification and the methods and outcomes of any pre-operation consultation; (b) details of the operation, including date(s), location and application rate; (c) a map of the operational area showing relevant waterbodies, any **public drinking-water supply**, nearby farmland, human habitations and recreational huts and tracks; (d) a measure of possum or other relevant pest numbers before and after the operation (if available); (e) reports on any incidents (for example, accidental releases or overflights) or complaints in relation to the operation, including details of relevant parties, locations, actions, impacts (if available); (f) details and results of pre- and post-operational monitoring of birds and invertebrates (if

Control Code	Regulation and Explanation
	available); (g) details and results of post-operational monitoring of water quality (if available); (h) details and results of pre- and post-operational monitoring of key species of relevance to Māori (food, rongoa species) (if available); and (i) an overall assessment of the outcome of the operation. (2) This control shall come into force on 1 January 2008.
This control applies to the following formulated substances containing 1080 that are approved for aerial application, namely: Cereal-based pellets containing 0.4 – 0.8 g sodium fluoroacetate/kg; Cereal-based pellets containing 1.5 – 2.0 g sodium fluoroacetate/kg; Soluble concentrate containing 200 g sodium fluoroacetate/litre. The Committee is satisfied that this control should be added under section 77A as it is more effective in terms of its effect on the management, use and risks of aerial application of formulated substances containing 1080 than other controls under this approval. In many cases, the production of post-operation reports of this type is increasingly becoming standard industry practice. Specifically, the control is in response to the concerns expressed by many submitters in relation to aerial (as opposed to ground) applications and will provide a central repository for information on aerial operations. It also supports the Committee's desire to ensure best practice and a more consistent approach nationwide, in the planning, carrying out and reporting of aerial operations. In particular, reports must contain information on key areas on 'risk communication' in relation to aerial applications, namely pre-operation notification and consultation as well as any incidents or complaints received in respect of an operation. The Committee intends that the information contained in the reports provided under this control will be made publicly available.	

Appendix 5

ENVIRONMENTAL RISK MANAGEMENT AUTHORITY DECISION

24 June 2011

Application code:	ERMA200932
Application type	Importation or manufacture of a hazardous substance for release under Section 28 of the Hazardous Substances and New Organisms Act 1996 (‘the Act’).
Application sub-type:	Section 28A(2)(c) – rapid reduced hazard
Applicant:	Pest Management Services Ltd
Purpose of the application	To manufacture Pindone Liquid Concentrate as a vertebrate toxic agent for rabbits.
Date application received:	10 June 2011
Consideration date	24 June 2011
Considered by	Rob Forlong (Chief Executive, ERMA New Zealand)

1 Summary of decision

1.1 The manufacture of Pindone Liquid Concentrate is approved with the controls as set out in Appendix 1. This approval has been given in accordance with the relevant provisions of the Act, the relevant HSNO Regulations, and the HSNO (Methodology) Order 1998 (“the Methodology”), based on the substance being formulated so that 1 or more of its hazardous properties has a lesser degree of hazard than a substance approved under the Act.

1.2 The substance has been given the following unique identifier for the ERMA New Zealand Hazardous Substances Register:

Pindone Liquid Concentrate

2 Legislative criteria for the application

2.1 Unless otherwise stated, references to section numbers in this decision refer to sections of the Act. The application was lodged pursuant to section 28. The decision was determined in accordance with section 28A(2)(c), taking into account the requirements of that section and matters specified under Part 2 of the Act.

2.2 Unless otherwise stated, references to clauses in this decision refer to clauses of the Methodology. Consideration of the application followed the relevant provisions of the Methodology.

3 Application process

3.1 The purpose of this application is to gain approval to manufacture Pindone Liquid Concentrate as a vertebrate toxic agent for rabbits.

3.2 The application was formally received on 10 June 2011.

3.3 The Agricultural Compounds & Veterinary Medicines Group (ACVMG) of the New Zealand Food Safety Authority (NZFSA), the Department of Labour Workplace Group, the Ministry of Health and the Department of Conservation were advised of the application (clause 2(2)(e)).

3.3.1 No responses were received.

3.4 Evaluation of the application was undertaken by the ERMA New Zealand project team which comprised the following staff members:

Sian Robertson	Advisor (Hazardous Substances)
Apostolos Koutsaftis	Advisor (Hazardous Substances)
Cora Drijver	Advisor (Hazardous Substances)
Patrick Gemmel	Acting General Manager (Maori Unit, Kaupapa Kura Taiao)
Haydn Murdoch	Advisor (Hazardous Substances).

3.5 The application was considered by the Chief Executive of ERMA New Zealand as provided for by a delegation from the Environmental Risk Management Authority ("the Authority") under section 19(2)(d).

4 Consideration

Sequence of the consideration

4.1 Pest Management Services Ltd seeks approval, under section 28, to manufacture Pindone Liquid Concentrate for use as a vertebrate toxic agent.

4.2 A substance can be assessed by rapid assessment procedures, under section 28A(2)(c), if it can be shown that it has been formulated so that one or more of its hazardous properties has a lesser degree of hazard than any substance already approved under the Act.

4.3 The approach adopted when considering this application was:

- to review the information provided;
- to identify the composition and hazardous properties of the proposed substance, Pindone Liquid Concentrate and of the reference substance; and
- to determine whether Pindone Liquid Concentrate has a similar use to the reference substance;
- to determine whether the reference substance is one that has been approved by the Authority and whether Pindone Liquid Concentrate has

been formulated so that one or more of its hazardous properties has a lesser degree of hazard than the reference substance.

4.4 And then:

- to consider whether the risks posed by Pindone Liquid Concentrate are the same as, less than or greater than those posed by the reference substance;
- to consider whether there are any other effects that mean Pindone Liquid Concentrate should not be approved under section 28A; and
- to consider whether the controls that apply under the Act to the reference substance, modified according to the hazardous properties of Pindone Liquid Concentrate will adequately prevent or manage the adverse effects of Pindone Liquid Concentrate.

Information review

4.5 The project team has reviewed all the information supplied by Connovation Ltd, and considers that the information constitutes an adequate and appropriate basis for assessing the application (clause 8). They also consider that there are no significant uncertainties (ie sufficient to influence decision making) in the scientific and technical information relating to the risks of Pindone Liquid Concentrate (clauses 29 and 30).

Identification of Pindone Liquid Concentrate

4.6 Pindone Liquid Concentrate is a liquid, containing pindone and other components.

Identification of the reference substance

4.7 The applicant identified a reference substance with which they consider Pindone Liquid Concentrate may be compared. This substance was transferred under the generic substance description *"Soluble concentrate containing 34g/litre pindone as the sodium salt"* and given the HSNO Approval code, HSR001597.

4.8 This reference substance is considered to be eligible for comparing with Pindone Liquid Concentrate and the project team has used it as such in this document.

Composition of Pindone Liquid Concentrate compared to that of the reference substance

4.9 Pindone Liquid Concentrate and the reference substance are both liquids containing pindone and other components.

4.10 Pindone is the major hazardous component conferring the hazard classifications on Pindone Liquid Concentrate. Pindone and other components are the major hazardous components conferring the hazard classifications on the reference substance.

4.11 The overall proportion of the major hazardous components is greater in the reference substance than in Pindone Liquid Concentrate .

Hazardous properties of Pindone Liquid Concentrate compared to those of the reference substance

4.12 The project team has determined the hazard profile of Pindone Liquid Concentrate based on the information provided by the applicant and other available information. The hazard classifications for Pindone Liquid Concentrate are set out in Table 4.1 for comparison against the reference substance.

Table 4.1: Comparison of hazard classifications

Hazard Endpoint	Proposed Substance	Reference Substance
Acute toxicity (oral)	6.1D	6.1C
Eye irritancy/corrosivity	No	6.4A
Target organ/system toxicity (oral)	6.9B	6.9B
Aquatic ecotoxicity	9.1C	9.1B
Terrestrial vertebrate ecotoxicity	9.3C	9.3A

4.13 The project team notes that Pindone Liquid Concentrate has a reduced hazard classification compared to the reference substance as it has not been classified as an eye irritant and the acute toxicity, aquatic ecotoxicity and terrestrial vertebrate ecotoxicity hazard classifications are lower than those assigned to the reference substance. The reduction in hazard is because hazardous excipients that are present in both formulations are at lower concentrations in Pindone Liquid Concentrate.

Comparison of the uses of Pindone Liquid Concentrate and the reference substance

4.14 Pindone Liquid Concentrate and the reference substance are both intended for use as vertebrate toxic agents on rabbits. Both are diluted with water and the diluted solution is mixed with cut carrot or cooked oats. Application may be by ground or aerially.

4.15 The project team considers that there are no other substantial differences in the lifecycles, uses, purposes and presentations between Pindone Liquid Concentrate and the reference substance.

Meeting the criteria for rapid assessment under section 28A(2)(c)

4.16 Based on the comparison and assessment detailed above, the project team considers that the criteria for rapid assessment under section 28A(2)(c) have been met through Pindone Liquid Concentrate being formulated so that one or more of its hazardous properties has a lesser degree of hazard than a substance that has been approved under the Act.

Comparison of the adverse effects of Pindone Liquid Concentrate and the reference substance

4.17 Given the similarities in lifecycle and use of Pindone Liquid Concentrate and the reference substance, the project team does not expect an increase in potential exposure to occur. As Pindone Liquid Concentrate is of reduced hazard, the risks it poses are less than those of the reference substance.

4.18 The project team considers that there are no other matters that would prevent this application from being approved under section 28A.

Controls

4.19 A set of controls was applied to the reference substance when it was approved under the Act. Changes that have been made in legislation subsequent to the approval of the reference substance now also apply to it (section 77(2)(a)).

4.20 The project team notes that Pindone Liquid Concentrate and the reference substance have the same use pattern, therefore most of the controls assigned to the reference substance will be applicable to the proposed substance. However, as Pindone Liquid Concentrate has a reduced hazard profile relative to the reference substance, the project team notes that the following control assigned to the reference substance is not triggered for Pindone Liquid Concentrate:

Regulation	Control
Toxicity	T3, T6
Ecotoxicity	E5
Packing	P15, PG3

4.21 The reference substance is subject to approved handler and tracking controls. While these requirements are not triggered for Pindone Liquid Concentrate, the project team considers they should be applied via section 77A to Pindone Liquid Concentrate, as the use pattern is the same, the composition is very similar and therefore the risks are similar.

4.22 The following modifications and additions applied to the reference substance, as provided for under section 77 and section 77A, and are equally applicable to Pindone Liquid Concentrate :

4.22.1 Setting of exposure limits and matters to be specified:

Control	Comment
T1	This control relates to the setting of tolerable exposure limits (TELs) to control hazardous substances entering the environment in quantities sufficient to present a risk to people. As for the reference substance, no TEL is set for this substance at this time.
T2	This control relates to the requirement to limit worker exposure to toxic substances by the setting of Workplace Exposure Standards (WESs). The Agency notes that a Department of Labour value has been set for components A and I of Pindone Liquid Concentrate.

Control	Comment
	Please refer to: http://www.osh.govt.nz/order/catalogue/pdf/wes2010.pdf
E1	This control relates to the setting of environmental exposure limits (EELs) to control hazardous substances entering the environment in quantities sufficient to present a risk to the environment. As for the reference substance, no EEL is set for this substance at this time. The default EELs, set under regulation 32 of the Hazardous Substances (Classes 6,8 and 9 Controls) Regulations, are deleted.
E2	This control relates to the requirement to set an application rate. As no EELs have been set, no application rate is required to be set under this control at this time.
E4	The following matters are specified for this substance in accordance with regulation 51: **Bait size** The bait size requirements for Pindone Liquid Concentrate mixed with carrots or cooked oats as bait in accordance with the use control on this approval are as follows: (a) if the food bait is carrot,— (i) no individual piece of carrot may have any dimension that is less than 12 mm; and (ii) all chaff and carrot pieces that have any dimension less than 12 mm must be removed from the food bait. (b) if the food bait is cooked oats, the cooked oats must be the fat white variety and be dressed to remove all seeds and foreign matter. **Method of release** For soluble concentrate containing 34 g/litre pindone mixed in accordance with the use control on this approval: - Ground-based application; or - Aerial application, if the substance is applied by the Department of Conservation, or a regional council, or a unitary authority. **Colour** This substance must be coloured: - Blue; or - Green

4.22.2 Additional controls:

Controls	Comment
Use control	As the proposed substance's assessment of risk has been based on its use as a vertebrate toxic agent, the following use restriction control is added: *Pindone Liquid Concentrate shall only be used as a vertebrate toxic agent.*
Use control	The following use control has been applied to Pindone Liquid Concentrate: (1) Pindone Liquid Concentrate may be mixed with or applied to food bait only if,— (a) the food bait is carrots or cooked oats; and (b) after the mixing or application,— (i) the amount of pindone in the food bait does not exceed 0.2 g of pindone per kilogram on average for each batch of food bait; and (ii) the food bait complies with the bait size requirements specified in accorance with Regulation 51 of the Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001 (see control E4).
Aerial Use	A restriction has been placed on aerial application of the substance: (1) An aircraft that is carrying out an aerial application must not, when flying to or from the area where the substance is applied, fly over a— (a) place specified (if any) in a permission granted in relation to the substance as being a place over which such an aircraft must not fly; or (b) public drinking water supply; or (c) waterway that is less than 100 metres upstream of a point of extraction from a water source for a drinking water supply (not being a water supply exclusively for stock). (2) Every aircraft that has carried out an aerial application, and all equipment used in connection with the aerial application, must be decontaminated before the aircraft or equipment is— (a) used for another purpose; or (b) removed from a place from which the application operation has been carried out. (3) When an aerial application being carried out on a day has ceased for that day, the loading area, and any area where the substance is stored in preparation for loading the substance on to or into the aircraft, must be— (a) decontaminated; or (b) fenced so that— (i) people do not inadvertently enter the area; and (ii) stock cannot gain access to the area. (4) An area that is fenced in accordance with subclause (3)(b) must have signs erected at the perimeter of the

Controls	Comment
	fence in accordance with subclause (5). (5) The signs referred to in subclause (4) must— (a) state that people and stock should stay out of the area until the signs, and any fence around the area, have been removed; and (b) identify the person responsible for the place, and provide sufficient information to enable the person to be contacted during normal business hours; and (c) identify the substance and state that it is toxic to human beings and ecotoxic to other vertebrates; and (d) comply with regulations 34 and 35 of the Hazardous Substances (Identification) Regulations 2001, except that regulation 35 applies as follows: (i) in relation to the information required to be included on the signs by paragraphs (a) and (b), as if the distances referred to in regulation 35(3)(c) of those regulations were a distance of not less than 2 metres; and (ii) in relation to the information required to be included on the signs by paragraph (c), as if the distances referred to in regulation 35(3)(c) of those regulations were a distance of not less than 10 metres. (6) The signs and the fence required by this clause must remain in place until the place is decontaminated.
Permissions required for application or use of certain substances	This relates to permissions required for application or use of certain substances: *(1) No person may apply or otherwise use Pindone Liquid Concentrate on land administered or managed by the Department of Conservation unless the person first obtains a permission from the Authority.*
Notification of changes of composition	This relates to notification of changes of composition: *(1) Any changes to the composition or proposed use of Pindone Liquid Concentrate must be notified to the Authority in writing before the substance is used. The notification should include the following information, as applicable:* *(a) the name of the substance and the HSNO approval number;* *(b) details of the original formulation;* *(c) details of the revised formulation clearly identifying the changed ingredients, their function in the bait, and their concentration and CAS number if appropriate;* *(d) the physical form, if different from the original;*

Controls	Comment
	(e) bait colour; *(f) changes in bait size;* *(g) the intended use(s) of the substance (to include target species, method(s) of release); change in food bait where the substance requires mixing with bait prior to use;* *(h) the physical properties of the substance (for example, flashpoint, pH) if different from the original;* *(i) the impurity profile and source of the 'active' ingredient, if different from the original;* *(j) any information on the effect that the formulation change may have on the risk profile of the substance, including the results of any palatability or field trials undertaken on both target and non-target species.*
Schedule 8	This schedule prescribes the controls for stationary container systems. The requirements of this schedule are detailed in the consolidated version of the Hazardous Substances (Dangerous Goods and Schedule Toxic Substances) Transfer Notice 2004, available from http://www.ermanz.govt.nz/Publications/Transfer-Notice-35-2004.pdf
EM12	The following subclauses are proposed for addition after subclause (3) of regulation 36[1]: *(4) For the purposes of this regulation, and regulations 37 to 40, where this substance is contained in pipework that is installed and operated so as to manage any loss of containment in the pipework it—* *(a) is not to be taken into account in determining whether a place is required to have a secondary containment system; and* *(b) is not required to be located in a secondary containment system.* *(5) In this clause, pipework—* *(a) means piping that—* *(i) is connected to a stationary container; and* *(ii) is used to transfer a hazardous substance into or out of the stationary container; and* *(b) includes a process pipeline or a transfer line.*
	The following subclauses are added at the end of regulation 37[2] (control EM12) to take into account any risk of adverse effects posed by pooling hazardous substances: *(2) If pooling substances which do not have class 1 to 5 hazard classifications are held in a place above*

1 Hazardous Substances (Emergency Management) Regulations 2001

Controls	Comment
	ground in containers each of which has a capacity of 60 litres or less— *(a) if the place's total pooling potential is less than 20,000 litres, the secondary containment system must have a capacity of at least 25% of that total pooling potential:* *(b) if the place's total pooling potential is 20,000 litres or more, the secondary containment system must have a capacity of the greater of—* *(i) 5% of the total pooling potential; or* *(ii) 5,000 litres.* *(3) Pooling substances to which subclause (2) applies must be segregated where appropriate to ensure that leakage of one substance may not adversely affect the container of another substance.*
	The following subclauses are added at the end of regulation 38[1] (control EM12) to take into account any risk of adverse effects posed by pooling hazardous substances: *(2) If pooling substances which do not have class 1 to 5 hazard classifications are held in a place above ground in containers 1 or more of which have a capacity of more than 60 litres but none of which have a capacity of more than 450 litres—* *(a) if the place's total pooling potential is less than 20,000 litres, the secondary containment system must have a capacity of either 25% of that total pooling potential or 110% of the capacity of the largest container, whichever is the greater:* *(b) if the place's total pooling potential is 20,000 litres or more, the secondary containment system must have a capacity of the greater of—* *(i) 5% of the total pooling potential; or* *(ii) 5,000 litres* *(3) Pooling substances to which subclause (2) applies must be segregated where appropriate to ensure that the leakage of one substance may not adversely affect the container of another substance.*

4.22.3 Varied controls:

Control	Comment
T8	This control is for vertebrate poisons. Regulation 28 applies to this substance as if subclauses (1) and (2) were omitted and the following substituted: (1) This regulation applies to a hazardous substance that is laid outdoors in a place to which members of the public ordinarily have access by a person lawfully allowed to do so as part of bait to inhibit reproduction, inhibit growth, or cause death, in terrestrial vertebrates. (2) A person in charge of the substance must ensure that

1 Hazardous Substances (Emergency Management) Regulations 2001

Control	Comment
	signs are erected at every normal point of entry to the place where the substance is to be applied or laid before the substance is applied or laid. This regulation applies to this substance as if subclause 3(d) was omitted and the following substituted: (d) comply with regulations 34 and 35 of the Hazardous Substances (Identification) Regulations 2001, except that regulation 35 applies as follows: (i) in relation to the information required to be included on the signs by paragraphs (a) and (c), as if the distances referred to in regulation 35(3)(c) of those regulations were a distance of not less than 2 metres; and (ii) in relation to the information required to be included on signs by paragraph (b), as if the distances referred to in regulation 35(3)(c) of those regulations were a distance of not less than 10 metres. This regulation applies to this substance as if subclauses (4) and (5) were omitted and the following substituted: (4) The signs must remain until— (i) in the case of ground-based application of the substance— (a) 2 months after the substance has been retrieved from the place; or (b) if the substance is not retrieved, 8 months after the last application of the substance; or (ii) in the case of aerial application of the substance, 8 months after the last application of the substance. (5) Signs must be removed at the later of— (a) when they are no longer required to remain under subclause (4); or (b) in the case of signs that include information to which a legal obligation applies that requires the signs to remain in place for a longer period of time, the expiry of that longer period of time.

4.23 Taking into account the control modifications and additions detailed above, the proposed controls for Pindone Liquid Concentrate are detailed in Appendix 1.

5 Environmental user charges

5.1 The project team considers that use of controls on Pindone Liquid Concentrate is an effective means of managing risks associated with this substance. At this time, no consideration has been given as to whether or not environmental user charges should be applied to this substance as an alternative or additional means of achieving effective risk management. Accordingly, no report has been made to the Minister for the Environment.

6 Decision

6.1 Pursuant to section 28A, I have considered this application to manufacture a hazardous substance for release made under section 28.

6.2 Having considered the composition, hazardous properties, and proposed use of Pindone Liquid Concentrate , I am satisfied that it meets the criteria for rapid assessment under section 28A(2)(c) in that it has been formulated so that one or more of its hazardous properties has a lesser degree of hazard than an approved reference substance.

6.3 I am satisfied with the hazard classifications identified by the project team in Table 4.1 and confer them accordingly to Pindone Liquid Concentrate.

6.4 As the risks posed by Pindone Liquid Concentrate are less than the reference substance, I consider that applying the same suite of controls to Pindone Liquid Concentrate with the variations and additions proposed, in paragraphs 4.20.1 to 4.20.3, will ensure adequate management of any adverse effects.

6.5 In this consideration, I have also applied the following criteria in the Methodology:

- clause 9 – equivalent of sections 5, 6 and 8;
- clause 12 – risk assessment;
- clause 21 – the decision accords with the requirements of the Act and regulations;
- clause 24 – the use of recognised risk identification, assessment, evaluation and management techniques;
- clause 25 – the evaluation of risks; and
- clause 35 – the costs and benefits of varying the default controls.

6.6 The application to manufacture the hazardous substance, Pindone Liquid Concentrate , for release is thus **approved** with controls as detailed in Appendix 1. I am also satisfied that, as the import of Pindone Liquid Concentrate would not impose any additional risks over the manufacture of the substance, this approval should apply to both importation and manufacture of Pindone Liquid Concentrate .

Rob Forlong Chief Executive, ERMA New Zealand	Date:

Pindone Liquid Concentrate	
ERMA New Zealand Approval Code:	**HSR100544**

Appendix 1: Controls applying to Pindone Liquid Concentrate

The controls imposed on Pindone Liquid Concentrate are as follows. The regulations cited should be referred to for definitions and exemptions. The ERMA New Zealand publication *User Guide to Control Regulations* provides useful guidance on the controls.

Table A1.1: Controls for Pindone Liquid Concentrate – codes, regulations and variations

Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001

Code	Regulation	Description	Variation
T1	Regs 11 – 27	Limiting exposure to toxic substances through the setting of TELs	No TELs are set for Pindone Liquid Concentrate at this time.
T2	Regs 29, 30	Controlling exposure in places of work through the setting of WESs.	Control T2 relates to the requirement to control exposure in places of work through the setting of WESs. The Agency typically adopts WES values listed in the Workplace Exposure Standards document: http://www.osh.govt.nz/order/catalogue/pdf/wes2010.pdf The project team notes that a Department of Labour WES value has been set for components A and I of Pindone Liquid Concentrate.
T4	Reg 7	Requirements for equipment used to handle substances	
T5	Reg 8	Requirements for protective clothing and equipment	
T7	Reg 10	Restrictions on the carriage of toxic or corrosive substances on passenger service vehicles	
T8	Reg 28	Controls for vertebrate poisons	This regulation applies to this substance as if subclauses (1) and (2) were omitted and the following substituted: (1) This regulation applies to a hazardous substance that is laid outdoors in a place to which members of the public ordinarily have access by a person lawfully allowed to do so as part of bait to inhibit reproduction, inhibit growth, or cause death, in terrestrial vertebrates. (2) A person in charge of the substance must ensure that signs are erected at every normal point of entry to the place where the substance is to be applied or laid before the substance is applied or laid. This regulation applies to this substance as if subclause 3(d) was omitted and the following substituted: (d) comply with regulations 34 and 35 of the Hazardous Substances (Identification) Regulations 2001, except that regulation 35 applies as follows:

(i) in relation to the information required to be included on the signs by paragraphs (a) and (c), as if the distances referred to in regulation 35(3)(c) of those regulations were a distance of not less than 2 metres; and

(ii) in relation to the information required to be included on signs by paragraph (b), as if the distances referred to in regulation 35(3)(c) of those regulations were a distance of not less than 10 metres.

This regulation applies to this substance as if subclauses (4) and (5) were omitted and the following substituted:

(4) The signs must remain until—

(i) in the case of ground-based application of the substance—

(a) 2 months after the substance has been retrieved from the place; or

(b) if the substance is not retrieved, 8 months after the last application of the substance; or

(ii) in the case of aerial application of the substance, 8 months after the last application of the substance.

(5) Signs must be removed at the later of—

(a) when they are no longer required to remain under subclause (4); or

(b) in the case of signs that include information to which a legal obligation applies that requires the signs to remain in place for a longer period of time, the expiry o that longer period of time.

Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001

Code	Regulation	Description	Variation
E1	Regs 32 – 45	Limiting exposure to ecotoxic substances through the setting of EELs	No environmental exposure limit (EEL) is set for this substance at this time. The default EELs given under regulation 32 are deleted.
E2	Regs 46 – 48	Restrictions on use of substances in application areas	No application rate is set for this substance at this time.
E4	Regs 50, 51	Controls relating to protection of terrestrial vertebrates	The Authority specifies the following matters for this substance in accordance with regulation 51:

Bait size

The bait size requirements for Pindone Liquid Concentrate mixed with carrots or cooked oats as bait in accordance with the use control on this approval are as follows:

(a) if the food bait is carrot,—

(i) no individual piece of carrot may have any dimension that is less than 12 mm; and

(ii) all chaff and carrot pieces that have any dimension less than 12 mm must be removed from the food bait.

(b) if the food bait is cooked oats, the cooked oats must be the fat white variety and be dressed to remove all seeds and foreign matter.

Method of release and colour

For Pindone Liquid Concentrate mixed in accordance with the use control on this approval:
- Ground-based application; or
- Aerial application, if the substance is applied by the Department of Conservation, or a regional council, or a unitary authority.

This substance must be coloured:
- Blue; or
- Green.

This sets the requirements for method of release and colour of the food bait after it has been mixed with the substance.

Interpretation

aerial application means application from an aircraft.

aircraft has the meaning given to it by section 2 of the Civil Aviation Act 1990.

application means dropping, spreading, spraying, laying as bait, dusting, sprinkling, wiping, placing, or pouring the substance on ground or vegetation, and apply has a corresponding meaning.

contained ground-based application means application of a hazardous substance—
(a) in a bait station, or bait bag, or other container that is fixed to an object; or
(b) so that it is contained in some other way, such as in a pipe or burrow.

ground-based application means application from the ground, and includes contained ground-based application.

E6	Reg 7	Requirements for equipment used to handle substances

		substances	

Hazardous Substances (Identification) Regulations 2001

Code	Regulation	Description	Variation
I1	Regs 6, 7, 32 – 35, 36(1) – (7)	Identification requirements, duties of persons in charge, accessibility, comprehensibility, clarity and durability	
I3	Reg 9	Priority identifiers for ecotoxic substances	
I8	Reg 14	Priority identifiers for toxic substances	
I9	Reg 18	Secondary identifiers for all hazardous substances	
I11	Reg 20	Secondary identifiers for ecotoxic substances	
I16	Reg 25	Secondary identifiers for toxic substances	
I17	Reg 26	Use of generic names	
I18	Reg 27	Requirements for using concentration ranges	
I19	Regs 29 – 31	Additional information requirements, including situations where substances are in multiple packaging	
I20	Reg 36(8)	Durability of information for class 6.1 substances	
I21	Regs 37 – 39, 47 – 50	General documentation requirements	
I23	Reg 41	Specific documentation requirements for ecotoxic substances	
I28	Reg 46	Specific documentation requirements for toxic substances	
I29	Regs 51, 52	Signage requirements	
I30	Reg 53	Advertising corrosive and toxic substances	

Hazardous Substances (Packaging) Regulations 2001

Code	Regulation	Description	Variation
P1	Regs 5, 6, 7(1), 8	General packaging requirements	
P3	Reg 9	Criteria that allow substances to be packaged to a standard not meeting Packing Group I, II or III criteria	
P13	Reg 19	Packaging requirements for toxic substances	
PS4	Schedule 4	Packaging requirements as specified in Schedule 4	

Hazardous Substances (Disposal) Regulations 2001

Code	Regulation	Description	Variation
D4	Reg 8	Disposal requirements for toxic	

		and corrosive substances	
D5	Reg 9	Disposal requirements for ecotoxic substances	
D6	Reg 10	Disposal requirements for packages	
D7	Regs 11, 12	Information requirements for manufacturers, importers and suppliers, and persons in charge	
D8	Regs 13, 14	Documentation requirements for manufacturers, importers and suppliers, and persons in charge	

Hazardous Substances (Emergency Management) Regulations 2001

Code	Regulation	Description	Variation
EM1	Regs 6, 7, 9 – 11	Level 1 information requirements for suppliers and persons in charge	
EM6	Reg 8(e)	Information requirements for toxic substances	
EM7	Reg 8(f)	Information requirements for ecotoxic substances	
EM8	Regs 12 – 16, 18 – 20	Level 2 information requirements for suppliers and persons in charge	
EM11	Regs 25 – 34	Level 3 emergency management requirements: duties of person in charge, emergency response plans	
EM12	Regs 35 – 41	Level 3 emergency management requirements: secondary containment	The following subclauses shall be added after subclause (3) of regulation 36: (4) For the purposes of this regulation, and regulations 37 to 40, where this substance is contained in pipework that is installed and operated so as to manage any loss of containment in the pipework it— (a) is not to be taken into account in determining whether a place is required to have a secondary containment system; and (b) is not required to be located in a secondary containment system. (5) In this clause, pipework— (a) means piping that— (i) is connected to a stationary container; and (ii) is used to transfer a hazardous substance into or out of the stationary container; and (b) includes a process pipeline or a transfer line. The following subclauses are added at the end of regulation 37: (2) If pooling substances which do not have class 1 to 5 hazard classifications are held in a place above ground in containers each of which has a capacity

			of 60 litres or less— (a) if the place's total pooling potential is less than 20,000 litres, the secondary containment system must have a capacity of at least 25% of that total pooling potential: (b) if the place's total pooling potential is 20,000 litres or more, the secondary containment system must have a capacity of the greater of— (i) 5% of the total pooling potential; or (ii) 5,000 litres. (3) Pooling substances to which subclause (2) applies must be segregated where appropriate to ensure that leakage of one substance may not adversely affect the container of another substance. The following subclauses are added at the end of regulation 38: (2) If pooling substances which do not have class 1 to 5 hazard classifications are held in a place above ground in containers 1 or more of which have a capacity of more than 60 litres but none of which have a capacity of more than 450 litres— (a) if the place's total pooling potential is less than 20,000 litres, the secondary containment system must have a capacity of either 25% of that total pooling potential or 110% of the capacity of the largest container, whichever is the greater: (b) if the place's total pooling potential is 20,000 litres or more, the secondary containment system must have a capacity of the greater of— (i) 5% of the total pooling potential; or (ii) 5,000 litres (3) Pooling substances to which subclause (2) applies must be segregated where appropriate to ensure that the leakage of one substance may not adversely affect the container of another substance.
EM13	Reg 42	Level 3 emergency management requirements: signage	

Hazardous Substances (Tank Wagon and Transportable Containers) Regulations 2004

Code	Regulation	Description	Variation
Tank Wagon	Regs 4 to 43 as applicable	Controls relating to tank wagons and transportable containers.	
Sch 8	Schedule 8	This schedule prescribes the controls for stationary container systems. The requirements of this schedule are detailed in the consolidated version of the Hazardous Substances (Dangerous Goods and Schedule Toxic Substances) Transfer Notice 2004, available from http://www.ermanz.govt.nz/Publications/Transfer-Notice-35-2004.pdf	

Additional controls set under s77A

Code	Regulation	Description	Variation
Tracking	77A	General tracking requirements	(1) The location and movement of this substance must be recorded at each stage of its lifecycle in accordance with the following requirements. (2) The person in charge of the place where this substance is present must ensure that a record is kept of the information specified in Schedule 2 of the Hazardous Substances (Tracking) Regulations 2001. (3) The record must meet the location and presentation requirements specified in Part 2 of the Hazardous Substances (Identification) Regulations 2001. (4) The person in charge of the place where this substance has been but is no longer present must ensure that the record is retained for a period of,— (a) if the substance has been transferred to another place, 12 months from the date of transfer; and (b) if the substance has undergone treatment that results in it no longer being a tracked substance, or has been intentionally or unintentionally disposed of, 3 years from the date of treatment or disposal. (5) Subclause (4) does not apply to a person in charge of a place that is a vehicle. (6) Subclauses (1) to (5) do not aply to Pindone Liquid Concentrate when mixed with food bait in accordance with the use control on this approval.
AH	77A	Approved handler/security requirements.	(1) Pindone Liquid Concentrate must be (a) under the control of an approved handler; or (b) secured so that a person cannot gain access to the substance unless the person has a key or other device used for operating locks. (2) However, Pindone Liquid Concentrate may be handled by a person who is not an approved handler if– (a) an approved handler is present at the place where the substance is being handled; and (b) the approved handler has provided guidance to the person in respect of the handling; and (c) the approved handler is available at all times to provide assistance, if necessary, to the person while the substance is being handled

by the person.

(3) Subclause (1) is deemed to be complied with if—

(a) in the case of a Pindone Liquid Concentrate being transported on land—

(i) in the case of a Pindone Liquid Concentrate being transported by rail, the person who drives the rail vehicle that is transporting the substance is fully trained in accordance with an approved safety system under section 6D of the Transport Services Licensing Act 1989 or a safety system which is referred to in an approved safety case under the Railways Act 2005; and

(ii) in every other case, the person who drives, loads and unloads the vehicle that is transporting the substance—

(a) for hire or reward, or in quantities which exceed those set out in Schedule 1 of the Land Transport Rule 45001/1: Dangerous Goods 2005, has a current dangerous goods endorsement on his or her drivers licence; or

(b) in every other case, the Land Transport Rule 45001/1: Dangerous Goods 2005 is complied with; or

(b) in the case of Pindone Liquid Concentrate being transported by sea, one of the following is complied with:

(i) Maritime Rules: Part 24A – Carriage of Cargoes – Dangerous Goods (MR024A):

(ii) International Maritime Dangerous Goods Code; or

(c) in the case of Pindone Liquid Concentrate being transported by air, Part 92 of the Civil Aviation Rules is complied with.

(4) Subclause (3)(a)—

(a) does not apply to a tank wagon or a transportable container to which the Hazardous Substances (Tank Wagons and Transportable Containers) Regulations 2004 applies; but

			(b) despite paragraph (a), does apply to an intermediate bulk container that complies with chapter 6.5 of the UN Model Regulations. (5) Subclause (3)(c): (a) applies to pilots, aircrew, and airline ground personnel loading and handling Pindone Liquid Concentrate within an aerodrome; but (b) does not apply to the storage and handling of a Pindone Liquid Concentrate in any place that is not within an aerodrome, or within an aerodrome by non-airline ground personnel. (6) Subclause (1) is deemed to be complied with if, in the case of the aerial application of Pindone Liquid Concentrate, the person who carries out the application has a current pilot chemical rating in accordance with Part 61 of the Civil Aviation Rules. (7) Subclauses (1) to (6) do not apply to this substance when mixed with or applied to food bait in accordance with the use restriction on this substance.
Aerial	77A	A restriction has been placed on aerial application of the substance.	(1) An aircraft that is carrying out an aerial application must not, when flying to or from the area where the substance is applied, fly over a— (a) place specified (if any) in a permission granted in relation to the substance as being a place over which such an aircraft must not fly; or (b) public drinking water supply; or (c) waterway that is less than 100 metres upstream of a point of extraction from a water source for a drinking water supply (not being a water supply exclusively for stock). (2) Every aircraft that has carried out an aerial application, and all equipment used in connection with the aerial application, must be decontaminated before the aircraft or equipment is— (a) used for another purpose; or (b) removed from a place from which the application operation has been carried out.

(3) When an aerial application being carried out on a day has ceased for that day, the loading area, and any area where the substance is stored in preparation for loading the substance on to or into the aircraft, must be—

(a) decontaminated; or

(b) fenced so that—

(i) people do not inadvertently enter the area; and

(ii) stock cannot gain access to the area.

(4) An area that is fenced in accordance with subclause (3)(b) must have signs erected at the perimeter of the fence in accordance with subclause (5).

(5) The signs referred to in subclause (4) must—

(a) state that people and stock should stay out of the area until the signs, and any fence around the area, have been removed; and

(b) identify the person responsible for the place, and provide sufficient information to enable the person to be contacted during normal business hours; and

(c) identify the substance and state that it is toxic to human beings and ecotoxic to other vertebrates; and

(d) comply with regulations 34 and 35 of the Hazardous Substances (Identification) Regulations 2001, except that regulation 35 applies as follows:

(i) in relation to the information required to be included on the signs by paragraphs (a) and (b), as if the distances referred to in regulation 35(3)(c) of those regulations were a distance of not less than 2 metres; and

(ii) in relation to the information required to be included on the signs by paragraph (c), as if the distances referred to in regulation 35(3)(c) of those regulations were a distance of not less than 10 metres.

			(6) The signs and the fence required by this clause must remain in place until the place is decontaminated.
Use	77A	A restriction has been placed on the use of the substance.	Pindone Liquid Concentrate shall only be used as a vertebrate toxic agent.
Permission	77A	No person may apply this substance unless that person first obtains a permission from the Authority under section 95A of the Hazardous Substances and New Organisms Act 1996.	(1) No person may apply or otherwise use this substance on land administered or managed by the Department of Conservation unless the person first obtains a Permission under section 95A of the Act from the Authority.
VTA Notify	77A	Any changes to the composition or proposed use of the proposed substance must be notified to the Authority in writing before the substance is used.	(1) Any changes to the composition or proposed use of this substance must be notified to the Authority in writing before the substance is used. The notification should include the following information, as applicable: (a) the name of substance and HSNO approval number; (b) details of the original formulation; (c) details of the revised formulation clearly identifying the changed ingredients, their function in the bait, and their concentration and CAS number if appropriate; (d) the physical form, if different from the original; (e) bait colour; (f) changes in bait size; (g) the intended use(s) of the substance (to include target species, method(s) of release); (h) change in food bait where the substance requires mixing with bait prior to use; (i) the physical properties of the substance (for example, flashpoint, pH) if different from the original; (j) the impurity profile and source of the 'active' ingredient, if different from the original; (k) any information on the effect that the formulation change may have on the risk profile of the substance, including the results of any palatability or field trials

			undertaken on both target and non-target species.
Sch 8	Schedule 8	This schedule prescribes the controls for stationary container systems. The requirements of this schedule are detailed in the consolidated version of the Hazardous Substances (Dangerous Goods and Schedule Toxic Substances) Transfer Notice 2004, available from http://www.ermanz.govt.nz/Publications/Transfer-Notice-35-2004.pdf	
Use	77A	A use restriction is applied to this substance.	(1) Pindone Liquid Concentrate may be mixed with or applied to food bait only if,— (a) the food bait is carrots or cooked oats; and (b) after the mixing or application,— (i) the amount of pindone in the food bait does not exceed 0.2 g of pindone per kilogram on average for each batch of food bait; and (ii) the food bait complies with the bait size requirements specified in accorance with Regulation 51 of the Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001 (see control E4).

Addition of subclauses after subclause (3) of Regulation 36 of the Hazardous Substances (Emergency Management Controls) Regulations 2001 (control EM12).

Addition of clauses after Regulation 37 of the Hazardous Substances (Emergency Management Controls) Regulations 2001 (control EM12).

Addition of clauses after Regulation 38 of the Hazardous Substances (Emergency Management Controls) Regulations 2001 (control EM12).

Appendix 2: Confidential Information

Appendix 6

Issuing Permissions for the Use of Vertebrate Toxic Agents (VTAs)

Guidelines for Public Health Units

Revised Edition 2010

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Preface

Vertebrate pest control is an important part of efforts to protect New Zealand's native flora and fauna, to prevent the spread of diseases and to reduce the impact of pest damage to crops and pasture. Compared with other countries, New Zealand uses large amounts of vertebrate toxic agents (VTAs) to control animal pests, in particular, 1080. The magnitude of the animal pest problem in New Zealand, and the nature and size of the terrain involved, means that targeted pest management such as hunting or non-toxic trapping methods cannot adequately control pest numbers in defined areas nor prevent the spread of those pests. Landcare Research estimates that there are approximately 60 million brush-tail possums in this country, spread over 95 percent of the land. In the absence of other suitable control methods, VTAs are the first line of management of pest populations.

The use of VTAs will continue in the foreseeable future, requiring an ongoing and consistent commitment to proper use of regulatory controls on VTAs in order to minimise risks to population health.

By definition, VTAs are toxic agents intended to kill target species, but they are also toxic to humans both through acute poisoning and chronic exposure. Methods for VTA use have improved over the last few decades, for example, global positioning systems (GPS) are now used to enable more targeted aerial applications, and the types and application of bait have improved. Despite these improvements, the use of VTAs, in particular 1080, causes significant concern in some communities.

Public health units have a key role to play in protecting public health from health risks associated with VTA use. In order to use certain VTAs, operators must apply for permission from the local public health unit, and they have a legal obligation to comply with any conditions that the public health unit should apply to that permission. These guidelines provide practical advice to public health units setting conditions on permissions to use VTAs, using Model Permit Conditions.

The specific characteristics and risk profile of each VTA operation differ, depending on the VTA being used, the terrain and factors such as public use patterns and/or proximity to dwellings and water supplies. The Model Permit Conditions may need to be modified in order to adequately manage the level of the risk to public health.

The Ministry of Health would like your comments on the implementation of these guidelines. If you would like to make specific suggestions for amendments to the guidelines, please copy and fill in the suggestions sheet provided below and send your comments to the address included at the bottom of the sheet. Suggestions and comments will be considered in the next reprinting of these guidelines.

Suggested Amendments to Issuing Permissions for Vertebrate Toxic Agents (VTAs): Guidelines for Public Health Units

Name

Organisation

Address

Section	Page	Amendment requested (include rationale)

Signature: Date:

Post to:

Environmental and Border Health Group
Ministry of Health
PO Box 5013
WELLINGTON 6145

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Introduction

Background

These guidelines provide practical information on how to identify and manage the public health hazards and risks associated with the use of the following vertebrate toxic agents (VTAs):

- all substances containing sodium fluoroacetate (1080)
- potassium cyanide
- sodium cyanide
- yellow phosphorous
- 3-chloro-p-toluidine hydrochloride (DRC 1339).

The use of VTAs, including 1080, is covered by the Hazardous Substances and New Organisms Act 1996 (the HSNO Act). Under the HSNO Act, operators intending to apply certain VTAs must obtain permission from a warranted HSNO enforcement officer (an officer) from a public health unit in the area of the proposed VTA operation. Under this regime, officers have the discretion to apply conditions to permissions to ensure that public health risks are assessed and managed effectively.

In order to help officers in using their discretion to impose conditions on permissions to use VTAs, the Ministry of Health (the Ministry) developed the original Model Permit Conditions in 1994/95. The Model Permit Conditions aim to help officers manage the risk to public health resulting from the use of VTAs in pest control operations.

Purpose of the guidelines

Properly applied, these guidelines will assist officers in:

- assessing the hazard and risks posed by a proposed VTA operation
- applying the appropriate Model Permit Conditions
- modifying the Model Permit Conditions in response to the specific risk profile of each VTA operation.

The guidelines will also help officers to appropriately communicate the risks of these operations to affected parties.

Using the Model Permit Conditions

The Model Permit Conditions are intended as a starting point. They should not be applied as a generalised standard ‘set’ of conditions. They provide a framework that officers can adjust in order to meet local needs. However, officers need to ensure that they fully consider the various risks and characteristics of each specific proposed VTA operation in order to determine the appropriate Model Permit Conditions to be used and how such conditions might need to be modified to adequately manage the public health risks posed by that particular operation.

Recording decisions on VTA applications

Officers' decisions regarding the Model Permit Conditions to be used with VTA permissions are based on statutory authority and may be subject to judicial review. This further highlights the importance of making sound decisions in regard to the appropriate use and modification of Model Permit Conditions. Officers should ensure that they keep a full record of their decision-making process to support the rationale of their decisions.

Application and exclusions

These guidelines apply only to VTAs that require public health permission for application, that is:

- all substances containing sodium fluoroacetate (1080)
- potassium cyanide
- sodium cyanide
- yellow phosphorous
- 3-chloro-p-toluidine hydrochloride (DRC 1339).

Other commonly used VTAs such as pindone and brodifacoum do *not* require public health permission and are *not* covered by these guidelines.

VTA operators must be aware of and comply with all relevant legal obligations. The conditions of a VTA permission are legally binding, however, compliance with conditions does not necessarily mean that operators have met all legal requirements for VTA use.

Physical hazard: flying bait

Operators have recounted numerous instances of people being hit by 1080 bait pellets during aerial operations. Injuries would be possible from such occurrences due to the size and speed of the pellets, but there have been no confirmed reports of such incidents to date.

These guidelines do not cover the physical hazards posed by flying bait because the warning signage placed around an area to be baited should inform people that an aerial operation will be occurring in the immediate area. Any reports of people being struck by bait should be referred to the operator.

Note: The hazard posed by flying bait is significantly less than that posed by the toxicity of the baits themselves.

Occupational hazards

Occupational hazards are not covered in these guidelines because they are covered by the Department of Labour (DoL) under the Health and Safety in Employment Act 1992 (the HSE Act). Such hazards include (but are not limited to) workers being exposed to VTAs as part of their work and workers being exposed to dust during loading operations.

VTAs in food

Ingestion of VTAs through food (eg, eating feral animals that have consumed a VTA before being shot or trapped) is covered by the New Zealand Food Safety Authority (NZFSA). For specific information, go to the ACVM register at: https://eatsafe.nzfsa.govt.nz/web/public/acvm-register, search for the appropriate VTA and click on 'Conditions' to find the specific NZFSA requirements for the use of that VTA.

Non-target species

VTAs present a hazard for non-target species, including deer, pigs, birds and feral stock. These guidelines do not identify hazards for such species nor offer suggestions for managing the attendant risks; however, officers should be aware that there are often significant public concerns about VTA impacts on non-target species.

When considering the use and/or modification of Model Permit Conditions, it is important to clearly differentiate between hazards to human health and hazards to animal health. In terms of recognising potential breaches of those conditions, officers should use information on impacts on non-target species (particularly domestic animals) as pointers to inappropriate or unlawful VTA use.

1080 reassessment

The use of VTAs, particularly aerial application of 1080, is often controversial among groups who believe that the risks of VTA use outweigh the benefits. In response to these concerns, in 2007, the Environmental Risk Management Authority (ERMA) conducted a reassessment of the use of 1080 that approved the continued use of 1080 while imposing more stringent controls.

The ERMA reassessment decision is available at: http://www.ermanz.govt.nz/news-events/1080/Decision%20_2007.08.10_%20FINAL.pdf

Risk analysis

A public health risk-analysis model is outlined in *A Guide to Health Impact Assessment* (Public Health Commission 1995) and forms the basis for these guidelines.

There are three sequential steps in the decision-making process regarding risk:

1. Risk assessment
2. Risk communication
3. Risk management.

These guidelines consider assessment and management of the potential impacts of VTA operations, using a Health Impact Assessment (HIA) approach. For more information on HIA, officers should consult the Public Health Advisory Committee health impact assessment guidelines (Public Health Advisory Committee 2005) and use the risk assessment tools provided in the course for HSNO warranted officers.

Risk assessment asks the following questions:

- What are the risks?
- Who will be affected, how and to what extent?

Risk assessment includes:

- Hazard identification
- Dose-response assessments
- Exposure assessment
- Risk characterisation.

If the assessment of the hazard suggests that there is a small likelihood of significant risk or control is straightforward and safe, it may not be necessary to proceed to quantifying the risk.

The next two steps in risk assessment are considering dose response and assessing exposure to the various VTAs. Dose-response models are developed from epidemiological data, although it should be noted that these data are limited in most hazardous substances. (See Chapter 2: Risk Communication for more information.)

The information from the three risk assessment steps described above is used in the final step of risk assessment – risk characterisation.

The acceptability of risk is a decision for either individuals involved in the risk or society as a whole. Various scientific and regulatory bodies set levels of what they consider to be acceptable risks, but there is no certainty that these levels will be understood or accepted by people.

During any communication of risk, there must be adequate consultation on the risks, and public concerns must be acknowledged. Risk management seeks to address the following questions:

- How can risks be avoided or reduced?
- What are the options in avoiding or reducing risks?
- Are contingency and emergency plans adequate?
- How can differing perceptions of risk be mediated?
- Can future health risks be predicted?
- What can we learn from past experiences?

Chapter 1: Hazard Identification, Dose Response, Exposure Assessment and Risk Characterisation

Main points

- All VTAs are, by definition, hazardous and pose a risk to human health.
- Children are most at risk from exposure to VTAs due to their relatively small body mass and tendency to pick up and eat unidentified items from anywhere.
- The VTAs covered by these guidelines vary in their toxicity to humans and require different controls to ensure the hazards are properly identified and the risks adequately managed.
- VTA risks can be exacerbated by incorrect or unsafe use, including use that does not conform to permit conditions or operations for which the conditions are not sufficiently robust.
- Research into the impact of VTAs on humans and the environment is ongoing.

Introduction

VTAs have been used in New Zealand for many decades to kill introduced vertebrate pests, including possums, rabbits, rodents, wallabies and rooks; to control the impact these animals have on pasture, native flora and fauna; and to control the spread of tuberculosis from possums to cattle and farmed deer. Some VTAs, particularly sodium cyanide, are also used for commercial skin and fur recovery operations.

In order to be effective, all VTAs are, by definition, toxic to the target species and, in most cases, to humans. Depending on the specific VTA, exposure to small amounts of some VTAs (eg, cyanide paste) can present a significant hazard to humans.

Hazard identification and dose response

The ERMA reassessment decision is available at: http://www.ermanz.govt.nz/news-events/1080/Decision%20_2007.08.10_%20FINAL.pdf and the Hazardous Substances (Vertebrate Toxic Substances) Transfer Notice 2004 (as Amended) list the HSNO hazard classifications for preparations containing VTAs: http://www.ermanz.govt.nz/hs/transfer/docs.html.

Sodium fluoroacetate (1080)

Hazard identification and dose response

Sodium fluoroacetate (1080) is highly acutely toxic. It kills by disrupting the metabolic system, leading to heart and central nervous system failure. Symptoms of acute 1080 poisoning include nausea, vomiting and abdominal pain followed by respiratory distress, anxiety and agitation; central nervous system disorders such as muscle spasms; stupor; seizures; and coma. Hypertension is thought to be one of the more important predictors of mortality in 1080 poisoning. Symptoms typically appear between 30 minutes and 2–3 hours after oral ingestion.

1080 is also a skin and eye irritant.

There are limited data on the effects of 1080 on humans, therefore, most information relates to studies on other mammals.

Based on fatal or near fatal cases of human poisoning, the range of dangerous doses of 1080 for humans in terms of acute toxicity is estimated at between 0.5 and 2.0 milligrams per kilogram of body weight (mg/kg bw). The estimated minimum lethal dose in humans is 0.7 mg/kg bw.

The acceptable daily exposure (ADE) for formulated substances containing 1080 is 0.02 µg/kg bw/day. The ADE is similar in intent and definition to tolerable daily intake (TDI).

The heart is a major target organ for 1080, with rat studies demonstrating cardiomyopathy after prolonged exposure. The no observed adverse effect level (NOAEL) for cardiomyopathy is estimated at 0.075 mg/kg bw/day; the lowest observed adverse effect level (LOAEL) is estimated at 0.25 mg/kg bw/day.

1080 is a reproductive toxin and is teratogenic. However, as there are no known studies of these effects in humans, data are extrapolated from animal studies. In male rodents, reproductive effects were noted (NOEAL = 0.1 mg/kg bw/day; LOAEL = 0.33 mg/kg bw/day). Rat studies showed no signs of maternal toxicity.

Evidence from rat studies indicates that 1080 is not genotoxic.

Further information on 1080

- *Evaluation and Review Report: Reassessment of 1080 (HRE05002)*, Appendices B (Toxicity of 1080) and M (Exposure and risk assessment: human health) available on ERMA New Zealand's website: http://www.ermanz.govt.nz/BertDocs/HRE05002-044.pdf
- *Controls for Formulated Substances Containing Sodium Fluoroacetate (1080)* available on ERMA New Zealand's website: http://www.ermanz.govt.nz/news-events/1080/controls%20document.pdf
- *1080 Vertebrate Toxic Agent Used for Possum Control in Forests and Bush Areas* available on the NZFSA's website: http://www.nzfsa.govt.nz/consumers/chemicals-nutrients-additives-and-toxins/1080/index.htm
- *Vertebrate Pesticide Toxicology Manual* available on the Department of Conservation (DoC's) website: http://www.doc.govt.nz/upload/documents/science-and-technical/docts23.pdf
- *Veterinary and Clinical Treatment of Vertebrate Pesticide Poisoning – a Technical Review* available on the Animal Health Board's website: http://tbfree.ahb.org.nz/LinkClick.aspx?fileticket=S8p0c4%2BDm8w%3D&tabid=206

Cyanide

Hazard identification and dose response

Cyanide is highly acutely toxic. It kills by preventing the use of oxygen in the body, leading to respiratory and cardiac failure. A lethal dose of cyanide can kill in minutes.

Symptoms of acute cyanide poisoning include seizures, hypoxia and cardiac arrest and coma, all within minutes of ingestion or exposure to gaseous hydrogen cyanide. At a sub-lethal dose, a person may feel weak, dizzy, confused, complain of headache and nausea and vomit. Difficulty breathing and progression to unconsciousness follow, depending on the dose. The affected person may have a bright red face and blue extremities, due to poor oxygen uptake.

Cyanide is not known to have teratogenic effects, or be a carcinogen. It does not accumulate in the body; therefore, chronic exposure comes from constant low-level ingestion or exposure through diet or continuously contaminated drinking-water. The scientific literature suggests that repeated exposure to substantial sub-lethal amounts of cyanide could potentially cause lasting neurological effects, goitre and hypothyroidism. Survivors of acute cyanide poisoning may develop cardiac and brain damage.

Based on case report studies, the following acute median-lethal exposure levels for humans were estimated: a LC_{50} of 524 parts per million (ppm) for a 10-minute inhalation exposure to hydrogen cyanide, a LD_{50} of 1.52 mg/kg for the oral route and a LD_{50} of 100 mg/kg for the dermal route, assuming that cyanide anion is readily released from the compound. Animal studies also report dyspnoea, convulsions and asphyxiation as effects of high-acute exposure to cyanide by any route of exposure. Cyanide is metabolised extensively in the liver, indicating that the only relevant route of administration for quantitative risk assessment in the derivation of a TDI is the oral route.

Human data do not provide adequate information from which to derive a TDI because effective dose levels of chronically ingested cyanide are not documented. The highest reported NOAEL for cyanide, 10.8 mg/kg/day, was chosen for the derivation of a ADE for cyanide of 0.02 mg/kg/day.

Further information on cyanide

- *Evaluation and Review Report: Reassessment of 1080 (HRE05002)*, Appendix M (Exposure and risk assessment: human health) available on ERMA New Zealand's website: http://www.ermanz.govt.nz/BertDocs/HRE05002-044.pdf
- Agency for Toxic Substances and Disease Registry (ATSDR). 2006. *Toxicological Profile for Cyanide*. Atlanta: US Department of Health and Human Services. Public Health Service.
- *Advisory Notes on Cyanide Poisoning* available on the Ministry of Health's website: http://www.moh.govt.nz/moh.nsf/indexmh/environmentalhealth-cyanide
- HSNO Chemical Classification Information Database: Sodium cyanide available on ERMA New Zealand's website: http://www.ermanz.govt.nz/Chemicals/ChemicalDisplay.aspx?SubstanceID=1940

- *Vertebrate Pesticide Toxicology Manual* (Feratox® only) available on DoC's website: http://www.doc.govt.nz/upload/documents/science-and-technical/docts23.pdf
- *Veterinary and Clinical Treatment of Vertebrate Pesticide Poisoning – a Technical Review* available on the Animal Health Board's website: http://tbfree.ahb.org.nz/LinkClick.aspx?fileticket=S8p0c4%2BDm8w%3D&tabid=206

Yellow phosphorous

Hazard identification and dose response

The hazards from human exposure to phosphorous are acute toxicity and skin and eye burns/irritation. Yellow phosphorous kills through severe acute liver damage and/or heart failure. The initial signs of phosphorus poisoning are severe abdominal pain, nausea, vomiting, dizziness, headache and a garlic odour on the breath. A large sub-lethal dose may cause liver damage.

Chronic poisoning in humans leads to toothache followed by swelling of the jaw and then necrosis of the mandible (colloquially known as 'phossy jaw'). This condition may be the only clinical sign from mild exposures to phosphorus. It can often take years to develop, and its pathogenesis currently is unknown, although higher repeat doses also cause liver and kidney damage. Signs of chronic high exposures to phosphorus are weakness, weight loss, anaemia, loss of appetite and spontaneous fractures.

The LD_{50} for yellow phosphorous in human is 2 mg/kg. In rats, the NOAEL for yellow phosphorous is 0.015 mg/kg bw/day and a LOAEL of 0.075 mg/kg bw/day, with critical effects being forelimb hair loss and parturition mortality. The oral TDI is 0.02 µg/kg bw/day.

Rat studies indicate that yellow phosphorous is not genotoxic or carcinogenic.

Further information on yellow phosphorous

- Agency for Toxic Substances and Disease Registry (ATSDR). 1997. *Toxicological Profile for White Phosphorous*. Atlanta: US Department of Health and Human Services, Public Health Service.
- *Vertebrate Pesticide Toxicology Manual* available on DoC's website: http://www.doc.govt.nz/upload/documents/science-and-technical/docts23.pdf
- *Veterinary and Clinical Treatment of Vertebrate Pesticide Poisoning – a Technical Review* available on the Animal Health Board's website: http://tbfree.ahb.org.nz/LinkClick.aspx?fileticket=S8p0c4%2BDm8w%3D&tabid=206

DRC 1339 (3-chloro-p-toluidine hydrochloride)

Hazard identification and dose response

DRC1339 is acutely toxic and harmful if swallowed, inhaled or absorbed through the skin. It is also corrosive to both skin and eyes. Repeated oral exposure may cause reproductive or developmental damage; however, there is limited detailed knowledge about the effects of DRC 1339 on humans.

From an acute oral toxicity study with rats, the LD_{50} has been estimated to be 350 mg/kg for males and 302 mg/kg for females. It is highly toxic to many bird species, in particular to starlings, with an acute LD_{50} of 3.8 mg/kg reported, but is less toxic to most other birds.

The ADE was reported to be 0.086 mg/kg/bw/day. A NOAEL of 43 mg/kg bw/day was reported, but no details on toxicity data were provided (ERMA New Zealand 2002).

Further information on DRC 1339

- Animal Control Products Ltd. 2006. *Safety Data Sheet: DRC 1339* available at: http://www.pestoff.co.nz/msd/drc.pdf
- *Controlled Pesticides: DRC 1339 for bird control* available on the NZFSA's website at: http://www.nzfsa.govt.nz/acvm/publications/notes/drc1339-bird-study-notes.pdf
- The United States Environmental Protection Agency, National Service Center for Environmental Publications (NSCEP) and National Environmental Publications Internet Site (NEPIS) – EPA's Gateway to Free Digital and Paper Publications available at: http://www.epa.gov/nscep/

Exposure assessment and risk characterisation

Knowledge of exposure is essential for environmental epidemiology and hazard control. The potential exposure pathways can be assessed on the basis of the details of applications to carry out VTA operations and form a vital part of the process of identifying, applying and where necessary modifying Model Permit Conditions.

Risk characterisation necessarily includes assumptions and uncertainties that need to be identified and managed appropriately, using the available information, although the application requirements provide extensive information on the planned operation. In some cases, officers may need additional information to build up a picture of the operation that is detailed enough to ensure protection of public health.

The hazards of VTAs have been set out earlier in this chapter. Generally, 1080 and cyanide present more of a risk to public health than DRC 1339 and yellow phosphorous due to their acute toxicity and frequent, widespread use.

Exposure varies between VTAs and depends on the method of application and presentation of the baits. The risk of exposure is also influenced by the terrain in the operational area and its proximity to residential and/or recreational areas.

Oral exposure

For each of the VTAs covered by these guidelines, the most significant acute exposure risk to members of the public is oral ingestion following direct contact with VTA baits, for example, an unsupervised young child picking up and eating poisoned bait. Most of these baits contain doses of the VTA sufficient to kill a member of the target species. While this may mean that bait would have less effect on a human adult than on the target animal, a young child would be seriously affected by ingesting bait.

The risk posed to children through oral ingestion depends on the bait formulation being used. A 14 kg child would need to consume 9.8 mg of 1080 (approximately just over a 6-g bait containing a 0.15 percent concentration of 1080) to reach the lowest end of MLD of 0.7 mg/kg bw. Due to its toxicity and rapid action, ingestion of cyanide bait presents a greater risk than 1080, yellow phosphorus or DRC 1339. A 14 kg child would receive a fatal dose of cyanide from one-quarter of a pea-sized Feratox® cyanide pellet.

The greatest risk to drinking-water supplies may occur during VTA distribution operations, particularly aerial 1080 operations, either due to major accidental spillage of bait into a water supply or the incomplete or inaccurate identification of water supplies before an operation. These scenarios could see bait entering waterways that should have been covered by exclusion zones.

There is also the potential for all VTAs to pollute drinking-water supplies through rain leaching the poison into the waterway from bait that is lying on the ground or from poisoned carcasses lying on the ground and/or through poisoned carcasses falling into waterways.

The concentration of 1080 in a waterway will depend on a number of factors, including the flow rate of the waterway, rainfall, the sowing rate, the amount of bait entering the waterway and the distance between the point at which the bait entered the water and the drinking-water intake point. It can be difficult to give precise calculations for all these factors, and such calculations can vary between seasons and between different parts of the same catchment. As a result, exclusion zones, testing regimes and mitigations (eg, provision of alternative supplies) should be used to limit any risk posed by the VTA.

Cyanide is readily water soluble and degrades rapidly in the environment. It is favoured by hunters as it kills rapidly and close to the bait station or placement point, making it unlikely that poisoned animals would enter waterways, with the exception of carcasses being washed in by rain. Note: Deaths of dogs or other domestic animals may indicate improper use of cyanide and the presence of a hazard to human health, particularly if signage is inadequate or is being disregarded.

Although an uncommon exposure route, mouth-to-mouth resuscitation of humans who have ingested cyanide is extremely hazardous.

While yellow phosphorous bait is ground laid and thus could easily be ingested (again most probably by children), it degrades rapidly once in contact with air, and thus exposure is likely to be less and it is unlikely to contaminate drinking-water supplies by being washed or rolling into drinking-water sources. However, operators must give careful consideration to bait accessibility and placement before any placement operation.

DRC 1339 could be ingested if bait fell from nests or was applied on the ground and then picked up and eaten. Mitigation measures can include keeping strict observations of the placed bait and removing any untaken bait, where possible, once birds have stopped feeding, and removing any dropped bait.

DRC 1339 is soluble in water; however, if DRC did enter waterways, it would dissolve into the water and could potentially enter drinking-water *if* the waterway was a drinking-water source. However since DRC is dropped by hand or helicopter directly into birds' nests, it's highly unlikely to come into contact with waterways. It's also used very infrequently, further reducing the risk of exposure through water. Pellet forms of DRC 1339 (eg, Starlicide) are not water soluble. Therefore, even if they did enter water, they would not dissolve. The risk of human exposure through contaminated water is very low with the use of these types of formulations.

Deliberate ingestion of bait does occur, though this is not a hazard that can be managed through the Model Permit Conditions. Breaches of HSNO controls on VTAs (eg, sales to a person who does not hold a controlled substances licence) would be investigated and dealt with by the appropriate HSNO enforcement agency.

Inhalation exposure

Non-occupational exposure to VTAs may occur through inhalation of fumes from bait, particularly cyanide.

1080 is readily absorbed through inhalation. Dust containing 1080 from laced bait may be present around loading sites; however, these sites should be restricted and non-occupational inhalation exposure should not occur. A person (particularly a child) may pick up and sniff a poisoned bait; however, the amount of 1080 on a bait is small, and the hazard is limited compared to oral exposures.

Cyanide has a bitter almond odour, though not everyone will notice and/or recognise the odour. Gaseous cyanide presents the greatest potential risk due to its toxicity; however non-occupational exposure to gas from cyanide bait is unlikely.

Yellow phosphorous is toxic if inhaled. However, as it degrades rapidly, the risk is low where a member of the public could be exposed with bait which has been in contact with the air for a sufficiently short period of time to still emit harmful vapour. The main risk for non-occupational inhalation exposure to yellow phosphorous would be to a person (most likely a child) picking up and sniffing a freshly laid bait.

There is very limited information on the inhalation effects of DRC 1339. In its concentrate form it is corrosive and is toxic when inhaled; however non-occupational inhalation exposure to DRC 1339 should not occur if the poison is properly stored and used. When presented in pellet form, the risk is further reduced.

Dermal exposure

1080 is a skin irritant, but it is not well absorbed by intact skin. Absorption may be greater in the presence of dermatitis or another skin injury, particularly cuts or abrasions on exposed areas when handling the bait. Unsupervised children are most at risk from dermal exposure to 1080 because they are more likely than adults to have cuts or abrasions, and are more likely to pick up and handle bait.

Cyanide is extremely toxic and readily absorbed through the skin, particularly broken skin. Members of the public may be at risk if they brush against a gel or paste bait or handle bait. Again, this is particularly relevant to unsupervised children.

Yellow phosphorous is corrosive to the skin, causing burns. However, the risk of dermal exposure is low due to the limited use of yellow phosphorous and its rapid deterioration once exposed to air.

There is very limited information on the risks associated with dermal exposure to DRC 1339 other than that it is corrosive, particularly in its concentrated form (eg, before it is applied to bait). Potential exposure pathways may include ground-laid bait or fallen bait being picked up; however, given that DRC 1339 sees very limited use, normally on private land, there is low potential for exposure through handling.

Chapter 2: Risk Communication

Main points

- Risk communication is an important part of all VTA operations but is especially important for 1080 aerial operations.
- Officers will primarily communicate risks in response to public enquiries or complaints about VTA operations.
- In communicating risks to the general public, officers need to be empathetic, sensitive to the ways in which people perceive risk and well informed.
- Officers may also need to provide guidance to operators on risk communication.

Risk communication

It is important that officers accurately and effectively communicate the risks of VTAs and VTA operations. More than any other type of VTA operation, officers will be required to communicate with the public on 1080 applications, particularly aerial 1080 applications.

There are two main ways of communicating the risk of VTA operations that require permissions:

- officers responding to public inquiries or complaints about operations
- operators notifying the public about operations and risks (as required by regulations, consents and permit conditions).

General guidance

The general public perceives risk in social and psychological terms rather than in technical terms. Risk communication must understand and be sensitive to this perception and aim to inform, show responsiveness and be a two-way process. When communicating risks, it is important for officers to show commitment, be open, demonstrate knowledge and be empathic.

The general public does not base their perception of risk on technical risk assessment alone. Public recognition of risk, in contrast to risk assessment based on probabilities prepared by experts, includes intuitive risk perception related to concepts of fairness, familiarity and future and present ‘catastrophic’ potential. Intuitive perceptions include a component of outrage at involuntary exposure to hazards, in contrast to, for example, a person choosing to apply bait on their own property for possum control.

Risk communication is more likely to be effective if:

- concerns are seen to be genuinely listened to and acknowledged
- a careful and sensitive explanation is given to assist and improve the level of understanding of the risk, tailored to local concerns and acknowledging any past issues or incidents in ways that are genuine and avoid patronising people or assuming that their concerns are simply the result of insufficient or incorrect information

- the levels of concern about VTA operations (particularly aerial 1080) are recognised and efforts are made to agree on an acceptable course of action for an operation before any final decisions are made
- the response to hazards that may affect a large number of people (especially children) is made with urgency and by the relevant regulatory authority.

Risk communication needs to be a two-way process. Concerned members of the public must be well informed and guided in the actions they can take, and they must feel confident that the experts are taking account of, and acting on, their concerns.

To be effective communicators of the risks associated with VTAs in the non-occupational environment, officers need to build credibility and trust with the affected individual or communities. They need to:

- show that they are professionals committed to helping the affected people
- be open and receptive to the concerns expressed by the affected people
- establish their credentials for advising on the effects of VTAs
- be sympathetic.

In many cases, difficulties in managing environmental issues or communicating risks arise because the officer's expectations differ from those of the affected people. Thus, it is important to establish early in the process what the issues are, who is affected and what can be done about the issues and by whom, that is, the scope of the issues needs to be defined tightly.

For more, information, see *A Guide to Health Impact Assessment* (Public Health Commission 1995).

Operator communications

Officers may also need to advise operators on their communication obligations required under the approved VTA application form. The operators need to follow the consultation process as prescribed in the ERMA New Zealand's Communication Guidelines for Aerial 1080 Operations and evidence of that is sent through with the application form to the Officer. Useful guidance for operators may be found in the following resources:

- ERMA New Zealand's best practice guidelines for consultation, available at: http://www.ermanz.govt.nz/hs/1080resources/ERMA%201080%20Guidelines.pdf
- ERMA New Zealand's recommendations about public consultation in its 1080 reassessment decision, available at: http://www.ermanz.govt.nz/news-events/1080/Decision_2007.08.10_FINAL.pdf
- The National Possum Control Agencies (NPCA) publications to aid operators in performing their notification obligations, available at: http://www.npca.org.nz/index.php?option=com_content&view=article&id=73&Itemid=59

Management of enquiries concerning VTAs

VTA operations are often the subject of enquiries to public health units. Such enquiries can include complaints or reports of incidents or queries relating to the scope, type and attendant risks of operations.

There are a number of local, regional and national agencies that are involved in VTA operations and management, including public health units, local and regional authorities and national government agencies. When members of the public make enquiries or report concerns or complaints about VTA use, it is important that any relevant inter-agency liaison is initiated and managed as smoothly as possible.

Below are some general guidelines on how to deal with enquiries, complaints and incidents related to VTA use, focusing on the following questions:

- Is it a public health issue?
- What process should be followed in notifying the complaint/incident?
- What other agencies need to be involved?

Is it a public health issue?

The Ministry of Health (the Ministry) is responsible for ensuring that the provisions of the HSNO Act are complied with where it is necessary to protect public health. Public health is defined in section 6.1 of the New Zealand Public Health and Disability (NZPHD) Act 2000 as the health of:

a. the people of New Zealand; or

b. a community or section of such people.

Under the NZPHD Act, the emphasis for public health units is on public health outcomes, such as preventing human poisonings as a result of exposure to VTAs.

What process should be followed in notifying the complaint/incidents?

The Investigation and Surveillance of Poisonings and Hazardous Substances Injuries: Guidelines for Public Health Units (Ministry of Health 2009) provides a comprehensive overview of investigation processes, including details on the use of the Graded Response Protocol.

Complaints relate to reports from the public (or other agencies) of concerns about the use of VTAs, such as missing signs or bait laid close to a track. These are distinct from incidents, which relate to specific adverse effect/s resulting from VTA use, for example a poisoning resulting from exposure to a VTA. Note: A complaint can lead to identification of an incident.

Model Permit Condition 4: Complaints and Incidents, requires that operators report any complaint or incident to the contact position at the relevant public health unit within 24 hours of the incident or receipt of the complaint.

When a public health unit receives a complaint or notice of an incident involving VTAs, it must record the details of the complaint, regardless of whether any further action is taken.

If the complaint relates to a public health issue and is valid, officers should investigate the complaint to determine if any further action is warranted, for example if the operator has breached Permit Conditions. If so, the public health unit must inform ERMA New Zealand and the Ministry of the complaint.

What other agencies need to be involved?

If any other agencies are involved or have associated responsibilities, the public health unit must inform these agencies of the complaint or refer it to them as appropriate.

Once the public health unit has determined that an investigation is warranted, it must forward an incident report to ERMA New Zealand at: hsincidents@ermanz.govt.nz, and copied to the Ministry if it is of public health significance.

The Ministry and ERMA New Zealand will provide advice and information on investigation and corrective action (potentially including prosecution) as appropriate to the situation. The Ministry will include details of the incident in its annual report to ERMA New Zealand on VTA permissions.

Chapter 3: Roles and Responsibilities

Main points

- There are several enforcement agencies under the HSNO Act. A number may be involved in VTA operations.
- The public health unit has a central role in enforcement; however, the regulatory framework and guidelines require that officers report to ERMA New Zealand on routine and event-based issues concerning VTAs.
- The DoL is responsible for occupational exposure to VTAs.
- The NZFSA is responsible for VTAs in foodstuffs, including 'wild foods'.
- Applicants have key roles in providing information to officers to enable good risk assessment and the application of the right Model Permit Conditions, modified when necessary.

The role of the public health unit

In regard to health permissions for using VTAs, officers and operators carry primary responsibility for managing the potential risks of VTA operations. As long as they are adequately informed, communities, families and individuals also bear a secondary responsibility for avoiding contact with poisoned bait and ensuring that children are kept away from such bait.

The warranted HSNO enforcement officer's role includes:

- assessing applications to apply VTAs
- deciding on and setting Model Permit Conditions
- revoking a permission and/or amending any Model Permit Conditions
- monitoring operations (through notifications, etc)
- responding to complaints/incidents
- exercising enforcement powers, as delegated in the warrant of appointment as an enforcement officer under the HSNO Act
- auditing operations for compliance with Model Permit Conditions.

These roles arise largely from ERMA's delegation of the function of granting permissions for the use of VTAs to medical officers of health and health protection officers who are also warranted HSNO enforcement officers and have completed a Ministry risk management course.

Officer's power to grant permissions derives from section 95A of the HSNO Act, Control 3 of schedule 3 to the Hazardous Substances (Vertebrate Toxic Substances) Transfer Notice 2004 (As Amended), and Additional Control 4 of Appendix A of the 1080 Reassessment Decision.

Role of operators

Pest control operators who use VTAs bear direct responsibility for managing the risks of VTAs. Their role includes:

- assessing risks through planning and applications processes
- designing and carrying out operations in accordance with permit conditions and other legal requirements
- following industry best practice
- reporting any incidents involving VTAs.

Operators are subject to a number of regulatory regimes when planning and carrying out VTA operations. The most important of these include:

- Hazardous Substances and New Organisms Act 1996
- Agricultural Compounds and Veterinary Medicines Act 1997
- Resource Management Act 1991
- Health and Safety in Employment Act 1992
- Civil Aviation Act 1990.

Note: This is not a complete list of all legal obligations to which operators may be subject.

Roles of other agencies

A range of other agencies may also carry responsibility for managing the risks associated with different aspects of VTA operations. Such agencies include but are not necessarily limited to:

- the NZFSA, enforcing the Agricultural Compounds and Veterinary Medicines Act 1997
- ERMA New Zealand, overseeing enforcement of the HSNO Act by the relevant enforcement agencies
- the DoL, enforcing the Health and Safety in Employment Act 1993 (HSE Act)
- the DoC, issuing permissions to use VTAs on DoC-administered land as required under the HSNO Act
- regional councils, imposing/enforcing resource consents under the Resource Management Act 1991
- Animal Health Board, managing and implementing the National Pest Management Strategy for bovine tuberculosis in New Zealand as provided in the Biosecurity Act 1993.

Chapter 4: Risk Management

Main points

- Risk management for VTAs centres on the risk assessment, and then the appropriate and considered use of the Model Permit Conditions, with modifications where necessary to meet local conditions. The Model Permit Conditions should only be modified with consideration to these guidelines.
- Both officers and operators play a role in managing risks.
- The primary risk management role of officers is to set conditions on permissions to use VTAs. However, officers also perform other roles.
- These guidelines only cover setting conditions on permissions to use VTAs.
- The Model Permit Conditions are divided into three areas: notifications, accidental direct exposure to VTAs and contamination of water supplies.
- These guidelines provide a brief commentary on and set out the scope, rationale, commentary, modification options and an example of modifications for each Model Permit Condition.

Risk management overview

Permit conditions are *in addition to* HSNO controls. They do not replace those controls. Compliance with the Permit Conditions does not necessarily ensure compliance with HSNO requirements. Operators must ensure that they are aware of and make provision for compliance with legal requirements under HSNO and any other relevant legislation.

These guidelines are intended as practical guidance for officers in assessing which of the Model Permit Conditions to use for each VTA application and whether any need to be modified to adequately manage public health risks associated with that application.

The Model Permit Conditions, modified as required, are a tool to assist with managing the public health risk posed by VTA operations.

Priorities for managing risk should be based on the risk assessment but should also take into account public perceptions of risk. Officers should evaluate the full range of risk management tools, including their social, economic and cultural implications.

Both officers and operators play important roles in managing the risks around VTA operations.

Officers should apply risk management strategies to VTA operations in:

- procedures for deciding on permit conditions (ie, utilising effective risk assessment procedures as set out in these guidelines)
- procedures for revoking VTA permissions or amending permit conditions on a VTA permission

- reacting to emergencies or incidents that occur during operations (whether reported by operators or not)
- quality control, including (but not limited to):
  - proper and appropriate use of the VTA permission documentation
  - peer review of application decisions
  - auditing of operations with regard to both the performance of the conditions applied by the public health unit and operator compliance.

Operators should apply risk management strategies to VTA operations in:

- application procedures
- good practice procedures in applying VTAs (which, as a minimum, ensure consistency with all legal requirements, including public health permissions)
- ensuring that they meet all their legal obligations (including additional obligations beyond the conditions on the permission).

Communication between applicants and public health units

An application for permission to use a VTA may require discussion between the applicant and the local public health unit in order to clarify aspects of the application and the conditions that may be imposed, and to ensure that the conditions imposed protect properly assessed risks to public health.

Communication should be open and ongoing. It is important that both officers and applicant have full information about the risk assessment and operational processes. This is particularly important when Model Permit Conditions are modified to meet local conditions and/or vary from those used for previous operations in the same or similar areas. Open lines of communication also help to ensure that, in the event of a complaint, incident or accident, all parties are informed rapidly and that the appropriate responses can be launched as soon as possible.

Reviewing permit conditions with an applicant

Public health units should use their best efforts to ensure that applicants understand why, and on what basis, particular conditions have been modified or imposed in particular ways. This can be done through discussion or in writing between the public health unit and the applicant.

If after verbal communication with the Officer the applicant is still not happy with a permit condition, the public health unit should inform them that they can:

- request, in writing, the reasons why the HSNO officer has imposed the condition(s)
- request that the medical officer of health review the Permit Condition(s) in question
- request for an appeal under the HSNO Act
- seek a judicial review of the process by which the condition(s) were imposed.

Appeals

Part 8 of the HSNO Act provides for appeals to decisions made by ERMA, and by extension those who hold delegations from ERMA.

Section 125(1A) provides for an applicant to appeal to the District Court against a decision of ERMA under section 95A:

i) about the terms and conditions of a permission held by the person; or

ii) declining to grant the person a permission or revoking a permission held by the person.

Judicial review

It is important to ensure that the rationale for decisions on permit conditions are justifiable and based on robust risk assessment as they are subject to judicial review.

The reviews cover the *process* followed in making a decision using statutory powers; they do not cover the *outcome* of the process. There are three main grounds for judicial review:

- Legality: for example, was the decision signed off by an officer with the appropriate delegation? Is the decision within the scope of the officer's statutory powers?
- Reasonableness: for example, is the decision reasonable in the circumstances? Would other sensible and reasonable officers have come to the same conclusion?
- Fairness and natural justice: for example, did the applicant have a fair opportunity to have their say? Was the decision influenced by outside factors? Is the decision consistent with comparable situations?

Officers should note that as a judicial review deals with process, it is critical to document the decision-making process and to clearly demonstrate that it included a robust risk assessment that was tailored to the specific operation in question. A standard or 'rubber stamp' approach will not demonstrate a robust process.

If the officer signing approval on the permission is not the same officer who conducted the risk analysis and communication with the applicant, then the signing officer should be sufficiently aware of the process to be satisfied that the conditions imposed are reasonable, fair, meet the expectations agreed between the applicant and the communicating officer, and are demonstrably based on a robust risk assessment.

Use of Model Permit Conditions by VTA type and operation

The table below sets out the Model Permit Conditions that apply to each kind of VTA and application type. A ticked grey box indicates that the Model Permit Condition applies to the use of that substance.

Table 1: Applicable conditions by application method

Condition	Aerial 1080	Ground 1080	Cyanide	Phosphorous	DRC 1339
Notifications					
1 Start date	✓	✓	✓	✓	✓
2 Changes to permission	✓	✓	✓	✓	✓
3 Warning sign removal	✓	✓	✓	✓	✓
4 Complaints and incidents	✓	✓	✓	✓	✓
5 Duration of permission	✓	✓	✓	✓	✓
6 Landowner notification	✓	✓	✓	✓	✓
7 School notification	✓	✓	✓	✓	✓
8 Health services notification	✓	✓	✓	✓	✓
9 Public notification	[1]	✓	✓	✓	✓
Accidental direct exposure to VTAs					
10 Exclusion from public areas	✓	✓	✓	✓	✓
11 Exclusion from walking and vehicle tracks	✓	✓	✓	✓	✓
12 Exclusion from roads	✓	✓	✓	✓	✓
13 Exclusion from dwellings	✓	✓	✓	✓	✓
14 Exclusion from schools and early childhood centres	✓	✓	✓	✓	✓
15 Aerial exclusions	✓				
16 Aerial applications to tracks and first clearances	✓				
17 Second clearances	✓				
18 GPS track logs	✓				
19 Sign contents	✓	✓	✓	✓	✓
20 Sign maintenance	✓	✓	✓	✓	✓
21 Sign vandalism	✓	✓	✓	✓	✓
Contamination of water supplies					
22 Domestic water supply: notification	✓	✓	✓	✓	✓
23 Domestic water supply: location	✓	✓	✓	✓	✓
24 Domestic water supply: exclusions		✓	✓	✓	✓
25 Domestic water supply: mitigation	✓				
26 Water supply testing	✓				
27 Public water supplies: notification	✓	✓	✓	✓	✓
28 Public water supplies: location	✓	✓	✓	✓	✓
29 Public water supplies: exclusions		✓	✓	✓	✓
30 Public water supplies: mitigation	✓				
31 Water supply mitigation: reporting	✓				
32 Water supply testing: reporting	✓				

[1] This is a legal requirement (see Additional Control 11 (under section 77A of the HSNO Act) of the reassessment decision on 1080) and is therefore not repeated in the Model Permit Conditions.

Use and modification of the Model Permit Conditions

These guidelines are primarily aimed at one area of risk management: giving officers a basic procedure for deciding on conditions to impose when issuing permissions. Each Model Permit Condition has guidelines attached to it to ensure that conditions are imposed (and/or modified) where they are necessary to manage a particular area of risk. Please note that commentaries are only included where clarification about conditions is needed.

Each of the Model Permit Conditions and guidelines for modification is presented in the following format:

CONDITION [Model Permit Condition number and title] [Text describing Model Permit Condition]	
Scope	The type of operation(s) that the condition should apply to in order to manage risks (eg, 'aerial operations only'). Table 1 also provides a summary of the types of VTA operations each Model Permit Condition should be applied to.
Rationale for the condition	The risk or risks that the condition is intended to manage.
Commentary	Additional information on how the condition should be interpreted or applied.
Modification options	Suggestions for officers on how to modify the condition in order to manage risks that the officers' risk assessments suggest are not adequately managed by the Model Permit Condition.
Example	Examples of the Model Permit Condition and modifications in practical situations.

Notifications

CONDITION 1: Start Date The applicant shall advise (*insert the name of the public health unit from page 1 of the application form*) of the commencement of the application of the VTA(s), at least 12 hours before commencing application.	
Scope	All VTA uses.
Rationale for the condition	Ensures that the officer is made aware that a potential risk to public health exists.
Commentary	The condition applies to the first application of VTAs in an operation. It names the public health unit rather than a specific individual in case that person is away at the time of notification.
Modification options	If necessary, the officer may stipulate what forms of notification are acceptable, such as 'in writing' or 'by telephone'. The officer may also choose to require notification for the commencement of pre-feeding. This ensures that the public are kept informed about the toxicity of bait. It manages the risk of a member of the public consuming a non-toxic bait and falsely believing that subsequently applied toxic bait is safe.

CONDITION 2: Changes to Permission The applicant shall advise (*insert the name of the public health unit from page 1 of the application form*) in writing of any material changes to the applicant's proposed operation (such as changes in operational boundaries and application types/rates).	
Scope	All VTA uses.
Rationale for the condition	Ensures that the officer is aware of changes to the operation that may affect public health impacts.
Commentary	For the purposes of this permission, 'material changes' is intended to cover any change to the operation that affects public health or the functioning of the permit conditions, such as changes in operational dates, operational areas and application types/rates. It does not include minor changes that do not affect public health or the functioning of the permit conditions, eg, correcting or adding a name of a location when the actual feature is clearly identifiable.
Modification options	The officer may wish to add examples of material changes to the condition or require that less significant changes be notified.
Example	In an area where there is considerable public opposition to an operation or heightened risks to public health, an officer may require notification of less significant changes.

CONDITION 3: Warning Sign Removal The applicant shall advise (*insert the name of the public health unit from page 1 of the application form*) in writing of their intention to remove warning signs from the operational area.	
Scope	All VTA uses.
Rationale for the condition	This ensures that the officer is aware when bait has ceased to be a risk to public health. It also helps the officer to monitor applicants' compliance with the sign removal requirements under Regulation 28 of the Hazardous Substances (Classes 6, 8 and 9) Regulations 2001 as varied by the Hazardous Substances (Vertebrate Toxic Agents) Transfer Notice 2004 and 1080 reassessment decision and provides the officer with the opportunity to require the signs to remain in place in case the sign removal requirements would not otherwise be complied with.
Modification options	The officer may stipulate that the notice be given in a different form in addition to or instead of in writing.
Example	In some circumstances, quick notification may be required (eg, by telephone) so that an officer can advise other users in the operational area of the VTA application.

CONDITION 4: Complaints and Incidents Any incidents or complaints relating to the operation that are likely to impact on public health shall be reported to (*insert the name of the public health unit from page 1 of the application form)* within 24 hours of the incident or complaint.	
Scope	All VTA uses.
Rationale for the condition	Mandatory reporting of any loss, misapplication or spillage of a VTA is required by Additional Control 7 of the Hazardous Substances (Vertebrate Toxic Agents) Transfer Notice 2004 and Additional Control 8 of the 1080 reassessment. This condition broadens the existing reporting requirements to include anything of a public health nature, such as the widespread and persistent removal of signs and the accidental presentation of VTAs in food containers.
Commentary	It should be noted that this does not include minor incidents, such as one-off sign vandalism or persistent vexatious complaints.
Modification options	The officer may alter the period of time in which notification must be made, or choose to require that the operator report *all* incidents and complaints to the officer so that the officer can decide whether the incidents and activities complained about are likely to impact on public health.
Example	In situations where there is uncertainty over whether to report incidents and complaints, the officer may require an operator to report *all* incidents and complaints so that the officer can assess the likely impact on public health and initiate appropriate measures.

CONDITION 5: Duration of Permission This approval is granted for the period commencing (*insert start date*) to (*insert end date*). (*Insert the name of the public health unit from page 1 of the application form*) shall be notified if there is any alteration to the intended date of the application. If the applicant wishes to continue the operation after this date, they should contact (*insert the name of the public health unit from page 1 of the application form*) at least two weeks before the expiry date of the original approval period. No permission may be extended beyond 12 months from the original start date.	
Scope	All VTA uses.
Rationale for the condition	This makes it easier for the permission dates to be changed in the event of poor weather or other variable circumstances. Instead of issuing a whole new permission, the officer could issue an amendment under their delegated powers under s95A (7) of the HSNO Act.
Modification options	This condition is necessary for every operation. An officer may modify the condition if circumstances change during the operation. The officer must exercise their discretion carefully when modifying the operational dates on an existing permission. Dates should not be varied to extend an operation indefinitely or to allow for a multi-year operation.
Example	Operational dates should only be varied where bad weather or other circumstances prevent an operation occurring when it was originally intended.

CONDITION 6: Landowner Notification	
Before commencing the operation, the applicant shall notify occupiers and, as far as practicable, owners of land, dwellings or buildings immediately abutting the operational area. The notice must be given sufficiently prior to, but within two months of, the proposed application of the VTA(s). If requested by the person notified, notification shall be repeated at a mutually agreed time before the proposed application. The notice shall specify: i. the approximate date on which the VTA will be applied ii. the name and nature of the VTA iii. a description of the area over which the VTA will be applied iv. the name and address of the person responsible for applying the VTA v. information on safety and precautions with respect to the VTA(s) being used.	
Scope	All VTA uses.
Rationale for the condition	Under Additional Control 11 of the 1080 Reassessment Decision, requirements i) to iv) exist for 1080 only. This condition ensures that landowners are notified when any VTA is used, some of which pose a higher risk to public health than 1080. The condition restates Additional Control 11 and adds the further requirement that information on safety and precautions with respect to the VTA(s) being used be provided. This ensures that land occupiers and owners are fully informed about the risks associated with the VTA.
Commentary	See the glossary for definitions of 'sufficiently prior' and 'land occupier'.
Modification options	The officer may modify this condition where it is useful from a public health perspective to notify a listed wider group of owners/occupiers than those 'immediately abutting'. This could include nearby schools if these are not already required to be notified under Condition 7. The officer may choose to also require a telephone contact number.
Example	In some cases, where nearby owners/occupiers commonly use the operational area, the condition could be widened to include owners/occupiers 'within 1 km of the operational area'.

CONDITION 7: School Notification	
Before commencing the operation, the applicant shall notify schools, kōhanga reo, kindergartens and early childhood centres *(list or attach the relevant attachment of the application form)* that are known to use the operational area. The notice must be given sufficiently prior to, but within two months of, the proposed application of the VTA(s). If requested by the institution notified, notification shall be repeated at a mutually agreed time before the proposed application. The notice shall specify: i. the approximate date on which the VTA will be applied ii. the name and nature of the VTA iii. a description of the area over which the VTA will be applied iv. the name and address of the person responsible for applying the VTA v. information on safety and precautions with respect to the VTA(s) being used.	
Scope	Discretionary for all VTA uses.
Rationale for the condition	This ensures that all schools, kōhanga reo, kindergartens and early childhood centres that utilise the operational area are informed about the operation and receive information on safety and precautions about the relevant VTA. This enables these institutions to make informed decisions about whether to visit the area during the operational period.
Commentary	This condition is aimed at schools and other educational institutions that, although they are not located within or adjacent to the operational area, still regularly utilise the operational area in some way. This could include having regular school camps at, day trips to or stays at huts located within the area and any other similar activities. Operators should use their best efforts to identify these institutions, beginning with those listed in the application form.
Modification options	The officer may choose to require a telephone contact number or a list of particular schools known to utilise the area.
Example	Where it would be difficult for an operator to identify all institutions that utilise the area, the operator should list all known ones for the officer.

CONDITION 8: Health Services Notification	
The applicant shall notify the nearest/local health services of the proposed application of the VTA(s). Nearest/local health services include GPs and other primary health services, ambulance services and hospitals. The notice must be given sufficiently prior to, but within two months of, the proposed application of the VTA(s). The notice shall specify: i. the approximate date on which the VTA will be applied ii. the name and nature of the VTA iii. a description of the area over which the VTA will be applied iv. the name and address of the person responsible for applying the VTA v. information on safety and precautions with respect to the VTA(s) being used.	
Scope	For aerial application of 1080; discretionary for all other VTA uses.
Rationale for the condition	This ensures that relevant local health service providers are aware of potential risks to public health and are prepared for dealing with any injuries or illness caused by exposure to VTAs.
Modification options	It is recommended that the condition be stated in full for all aerial applications of 1080 as no health services notification requirements currently exist for this VTA. The question of whether the condition is stated for all other VTA uses should be at the discretion of the officer, based on an objective risk assessment. The officer may choose to list the actual health services and/or to include other related service providers, such as vets and the police, if they believe that this will decrease the potential risk to public health from a particular operation. The police should be included where there is a risk of theft of bait or deliberate contamination incidents where public health may be put at risk.
Example	The police may also be notified if there is a possibility of protest incidents and other activities occurring as a result of the VTA use, which may have an impact on public health (eg, widespread sign vandalism or a risk of unlawful removal of bait).

CONDITION 9: Public Notification The applicant shall give public notice in the following media (eg, newspapers, community newsletters) of the proposed application of the VTA(s): (*List*). The notice must be given sufficiently prior to, but within two months of, the proposed application of the VTA(s). The notice shall specify: i. the approximate date the VTA(s) will be applied ii. the name and nature of the VTA(s) iii. a description of the area over which the VTA(s) will be applied iv. the location(s) where the public may view maps of the area over which the VTA(s) will be applied and the times when such maps can be viewed v. the name and address of the person responsible for applying the VTA(s). The applicant must provide a copy of the public notice, and the date(s) and media in which it was published to (*insert the name of the public health unit from page 1 of the application form*) before commencing the operation.	
Scope	Not required for aerial application of 1080 (see rationale below); discretionary for all other VTA uses.
Rationale for the condition	The requirement to publicly notify according to this condition already exists for the aerial application of 1080 products, under Additional Control 6 of the 1080 Reassessment Decision. This condition gives officers the option of extending the requirement for other VTA uses.
Modification options	The question of whether the condition is stated for all other VTA uses should be at the discretion of the officer, based on an objective risk assessment.
Example	This condition would generally be required for a sodium cyanide operation in which paste is ground laid in an open area near a popular tourist spot but is unlikely to be required for a phosphorous operation on private land.

Accidental direct exposure to VTAs

CONDITION 10: Exclusion from Public Areas No Vertebrate Toxic Agent (VTA) shall be (*specify 'aerially' or 'ground'*) applied within the distances listed below, and not where it is within sight of, the following huts, access points, camping and public areas: (*List) (specify exclusion distance for each listed public area)*. Warning signs shall be placed at each of the listed hut(s), access points, camping and public amenity area(s) prior to the laying of before the Vertebrate Toxic Agent VTA(s) is/are laid in adjoining areas.	
Scope	All VTA uses.
Rationale for the condition	This ensures that VTAs are applied a minimum distance away from public areas such as tramping huts, bivvies/shelters, tent camping sites, picnic areas, anglers' access points, and watercraft landing points in order to reduce the risk of direct human contact with baits. Any baits applied beyond this minimum distance are not permitted to be within sight of the public to minimise the risk of human contact. Each of these places is considered to be an entry point to the operational area for signage purposes, to ensure that members of the public are informed of the presence of VTA baits. The exclusion distance will generally be lower for ground applications as the VTAs can be placed with more accuracy, particularly controlling for visibility of baits. Some operators will do aerial applications of the general area and ground-based applications closer to listed sites/amenities.
Modification options	The officer needs to specify: • whether the condition applies to aerial or ground applications • the locations that should be excluded • the exclusion distance for each location. The base exclusion distance for ground operations should be 20 m. The base exclusion distance for aerial operations should be 80 m. The base exclusion distances may be varied to adequately manage public health risks, depending on the terrain and vegetation, accessibility and visibility of bait, method of application, and public use patterns. Sites with generally high usage or high usage during the planned operation time (eg, a long weekend) may require an increased exclusion distance. Conversely, an 80 m aerial exclusion may be excessive in rough terrain with low usage and heavy vegetation. As different locations may require different exclusion distances, the officer should specify the appropriate exclusion distance for each location listed on the condition. The officer should refer to the current approved application form when creating the list of locations. The officer should use generic wording rather than listing locations where it is not feasible or possible to obtain a complete list. The officer may list the known locations then add 'and any other tramping huts, bivvies/shelters, tent camping sites, picnic areas, angler access points and watercraft landing points in the area'. Where both aerial and ground-based applications are proposed, the officer will need to repeat the condition for each type of application.

Example	An application proposes ground-based application of cyanide paste in the vicinity of a popular tramping hut frequently used by families and school groups (Hut 1). Hut 1 stands in a large grassy clearing, including a small number of trees within 20 m of the hut. Thick bush cover begins 30 m from the hut. The officer adjusts the exclusion distance to 80 m to ensure that all bait is placed away from the hut and in vegetation cover that will help limit the accessibility and visibility of the bait. Hut 2 is within the same operational area but is extremely isolated, located in steep country and thick bush and is seldom used. The officer therefore adjusts the exclusion distance to 20 m for Hut 2. In the condition, the locations and distances are listed as follows: • Hut 1: 80 m • Hut 2: 20 m.

CONDITION 11: Exclusion from Walking and Vehicle Tracks No VTA shall be (*specify 'aerially' or 'ground'*) applied within the distances listed below and not where it is within sight of the following walking and vehicle tracks: (*List) (specify distance from each listed track).*	
Scope	All VTA uses.
Rationale for the condition	This ensures that VTAs are applied a minimum distance away from walking and vehicle tracks in order to reduce the risk of direct human contact with bait. Any bait applied beyond this minimum distance is not permitted to be within sight of the public to minimise the risk of human contact. Each of these places is considered to be an entry point to the operational area for signage purposes, to ensure that members of the public are informed of the presence of VTA baits. The exclusion distance will generally be lower for ground applications as the VTAs can be placed with more accuracy, particularly controlling for visibility of bait.
Modification options	The officer needs to specify: • whether the condition applies to aerial or ground applications • the locations that should be excluded • the exclusion distance for each location. The base exclusion distance for ground operations should be 20 m. The base exclusion distance for aerial operations should be 80 m. The base exclusion distances may be varied to adequately manage public health risks, depending on the terrain and vegetation, accessibility and visibility of bait, method of application, and public use patterns. Sites with generally high usage or high usage during the planned operation time (eg, a long weekend) may require an increased exclusion distance. Conversely an 80 m aerial exclusion may be excessive in rough terrain with low usage and heavy vegetation. As different locations may require different exclusion distances, the officer should specify the appropriate exclusion distance for each location listed on the condition. Refer to the current approved application form when creating the list of locations. The officer should use generic wording rather than attempting to list locations where it is difficult or impossible to obtain a complete list. The officer may list the known locations then add 'and any other walking and vehicle tracks in the area'. Where both aerial and ground-based applications are proposed, the officer will need to repeat the condition for each type of application.
Example	An application for aerial VTA use on forestry land includes a mapped vehicle track that is now closed. The entry to the block is by locked gate, and the mapped track has deteriorated at several points as a result of storms, including near the gate, so it is now impassable by vehicle. There is heavy brush/blackberry coverage in the area. The area is not known to be used for recreational purposes. The officer may choose to decrease or remove the aerial exclusion distance for the vehicle track as the risk to public health is limited.

CONDITION 12: Exclusion from Roads No VTA shall be (*specify 'aerially' or 'ground'*) applied within the distances listed below and not where it is within sight of the following roads and lay-bys: (*List) (specify distance from each listed road/lay-by).*	
Scope	All VTA uses.
Rationale for the condition	This ensures that VTAs are applied a minimum distance away from roads and lay-bys in order to reduce the risk of direct human contact with bait. Any bait applied beyond this minimum distance must not be visible from the listed roads and lay-bys, to minimise the risk of human contact. Each of these places is considered to be an entry point to the operational area for signage purposes, to ensure that members of the public are informed of the presence of VTA bait. The exclusion distance will generally be lower for ground applications as the VTAs can be placed with more accuracy, particularly controlling for visibility of bait.
Modification options	The officer needs to specify: • whether the condition applies to aerial or ground applications • the locations that should be excluded • the exclusion distance for each location. The base exclusion distance for ground operations should be 20 m. The base exclusion distance for aerial operations should be 80 m. The base exclusion distances may be varied to adequately manage public health risks, depending on the terrain and vegetation, accessibility and visibility of baits, method of application, and public use patterns. Sites with generally high usage or high usage during the planned operation time (eg, a long weekend) may require an increased exclusion distance. An 80 m aerial exclusion may be excessive in rough terrain with low usage and heavy vegetation. As different locations may require different exclusion distances, the officer should specify the appropriate exclusion distance for each location listed on the condition. Refer to the current approved application form when creating the list of locations. The officer should use generic wording rather than attempting to list locations where it is difficult or impossible to obtain a complete list. The officer may list the known locations then add 'and any other walking and vehicle tracks in the area'. Where both aerial and ground-based applications are proposed, the officer will need to repeat the condition for each type of application.
Example	An operational area abuts a section of a state highway that includes a lay-by lookout. A combined aerial/ground operation is planned for the area downhill from the lay-by, which sits above a 2 m bluff. The ground below the lay-by is covered with thick bush. The remainder of the area abutting the road is covered with thick bush to the road verge and rises steeply from the road. The officer chooses to allow a minimum distance for ground applications of less than 20 m, given the terrain and vegetation cover. Therefore the officer creates a condition that excludes ground-applied VTAs from within 10 m of the lay-by. As the proposed operation also includes an aerial 1080 application, the officer creates an additional condition that requires that 1080 not be aerially applied within 80 m of the listed lay-by.

CONDITION 13: Exclusion from Dwellings No VTA shall be applied within 150 m of (or within a different distance if mutually agreed in writing with the occupiers), and not be visible from, dwellings or 'built-up areas' (*list or attach relevant attachment of the application form*).	
Scope	All VTA uses.
Rationale for the condition	This ensures that VTAs are not accessible near where people live and congregate.
Commentary	The term 'built-up areas' includes areas where people may be present on the fringes of urban areas and towns, such as industrial areas.
Modification options	In some cases, it may be possible for the officer to list the dwellings and built-up areas specifically. This would provide greater clarity to operators as to locations that must be excluded. Officers should note that an explicit list should only be used where there is little or no danger of risks associated with inadvertently leaving a location off the list.
Example	An application covers a remote back-country area with four dwellings. All dwellings are in isolated locations surrounded by bush. The officer modifies the condition to list each dwelling by road address or GPS reference to ensure that the 150 m exclusion distance is maintained specifically for each dwelling.

CONDITION 14: Exclusion from Schools and Early Childhood Centres No VTA shall be applied within 150 m of (or a greater distance if mutually agreed in writing with the occupiers), and not where it is visible from, the following schools, kindergartens, kōhanga reo and early childhood centres: (*List*)	
Scope	All VTA uses.
Rationale for the condition	There is a greater risk to public health when VTAs are applied in areas accessible to children who may be more likely to pick up and eat or play with poisoned bait than adults. A fixed exclusion zone around schools, kindergartens, kōhanga reo and early childhood centres adjoining the operational area therefore minimises this risk.
Modification options	Refer to the current approved application form in creating the list of schools, kindergartens, kōhanga reo and early childhood centres close to the operational area. The officer may also choose to increase the fixed exclusion distance, regardless of any written agreements, if the officer believes that the risks warrant a larger exclusion area.
Example	Exclusion zones may need to be larger around schools where children are known to access operational areas adjoining the school property.

CONDITION 15: Aerial Exclusions An aircraft that is carrying out an aerial application must not, when flying to or from the area where the VTA is applied, fly over the following 'no fly' areas: (*List*)	
Scope	Discretionary for aerial application of 1080.
Rationale for the condition	This ensures that aircraft do not fly over any areas where accidental dropping or spillage of bait may present a substantial public health risk. This condition expands on Additional Control 7 of the 1080 Reassessment Decision, which prohibits aircraft flying over public drinking water supplies or within 100 m upstream of a drinking water intake.
Commentary	This condition does not cover aircraft flying to a loading site at the start of the operation where aircraft will not be carrying bait. It covers aircraft flying back to base following the operation as the aircraft's hopper will not yet have been decontaminated.
Modification options	The officer should list areas over which aircraft must not fly if it is believed that accidental dropping or spillage of bait in transit may present a public health risk. It is accepted that, since aircraft will always have to fly over some areas used by the public in order to reach operational areas, it is impractical for the list to include *all* areas where dropped bait may present a public health risk (eg, seldom-used and isolated areas, which include bush tracks). The list should therefore only include the areas most at risk, for example residential areas. The most important protection against this risk is responsible flying and immediate notification and mitigation of any accidental spillage.
Example	If an operation occurs near an urban area, that area should be included on the list if it is reasonable for aircraft to fly around it rather than over it.

CONDITION 16: Aerial Applications to Tracks and First Clearances The applicant may aerially apply 1080 to the following walking and vehicle tracks but not during or within 24 hours of the start of school holidays, public holidays or public holiday weekends: (*List*) If the applicant aerially applies 1080 to any of the above listed tracks, they shall inspect those tracks as soon as possible and not more than 24 hours after the VTA application and make reasonable efforts to find and remove all bait and, if encountered, animal carcasses.	
Scope	For aerial application of 1080.
Rationale for the condition	This ensures that, where aerial application to tracks is permitted, it should take place in sufficient time to allow the clearance of these tracks and roads before school or public holidays commence so as to minimise the risk of direct human (particularly children) contact with baits.
Commentary	Note that this list of tracks is different to the list in Condition 11 and should be developed in consultation with DoC and/or the relevant track manager.
Modification options	The officer has the discretion to permit the aerial application of 1080 to some tracks and roads, instead of excluding them under Condition 11, provided that bait is cleared from these tracks and roads as soon as possible. This would generally apply to low- or medium-use tracks.
Example	In back-country operations, where tracks are seldom used in winter but may still be used on weekends or by hunters, such tracks should be listed for clearance.

CONDITION 17: Second Clearances	
The applicant shall undertake a second inspection of the following walking and vehicle tracks and make reasonable efforts to find and remove all bait and, if encountered, animal carcasses: (*List*) The second inspection shall be made at least 24 hours after the VTA application. It should be timed to take place either: i. immediately after the occurrence of strong winds; or ii. immediately before the weekend or commencement of school holidays or public holidays; whichever occurs first.	
Scope	Discretionary for aerial application of 1080.
Rationale for the condition	This ensures that where 1080 is aerially applied to tracks, those tracks that receive a moderate to high level of use, or are regularly used by children, are re-cleared at least once following the initial clearance. For example, some bait can be caught in trees and may fall to the ground after high winds, creating a degree of public health risk.
Commentary	When a second clearance is undertaken, it should be timed so that it takes place after the occurrence of strong winds that may dislodge bait caught up in the forest canopy or, failing that, immediately before the weekend or public holidays.
Modification options	The officer may use their own discretion in applying this condition. The condition should be considered where the applicant is permitted to aerially apply to medium-use tracks. The condition may not be required for low-use tracks, but the officer should consider such tracks on a case-by-case basis, including consultation with DoC and/or the relevant track manager(s) if required.
Example	Tracks that have a moderate degree of use, especially in weekends, should be listed for a second clearance to ensure that any bait and/or carcasses are cleared.

CONDITION 18: GPS Track Logs	
A GPS track log shall be recorded and maintained for each track clearance and made available to (*insert the name of the public health unit from page 1 of the application form*) within 2 weeks.	
Scope	For aerial application of 1080.
Rationale for the condition	This provides a record of tracks have been cleared and when.
Modification options	The officer may apply this condition in all instances where the applicant is permitted to aerially apply 1080 to tracks and roads.
Example	An officer may require this condition on an operation that includes track and roads that receive moderate use, to ensure that the operator keeps a formal record of the work that has been undertaken. It may be useful in the event of a complaint from the public relating to bait found on roads or tracks.

CONDITION 19: Sign Contents All warning signs must include an international symbol for toxic substances (eg, skull and crossbones) and a statement advising that children and pets should not be allowed to wander (eg, 'WATCH CHILDREN at all times').	
Scope	All VTA uses.
Rationale for the condition	This ensures that all signs erected carry the skull and crossbones – an internationally recognised symbol of danger – so that older children and non-English speakers can understand that toxic substances are present. The symbol must be large enough to be readily visible and not be obscured by other wording or features of the warning sign.
Commentary	This condition would be applied in addition to any other regulatory requirements for warning signs.
Modification options	The officer may require specific wording to be included on the sign to respond to particular risks in certain circumstances.

CONDITION 20: Sign Maintenance During the period in which the bait remains toxic, warning signs at the locations listed below shall be inspected immediately before the commencement of school holidays, public holidays or public holiday weekends: (*List*) Any signs that are damaged, vandalised or otherwise become illegible shall be replaced within 24 hours of discovery of the damage.	
Scope	Discretionary for all VTA uses.
Rationale for the condition	Officers can specify a maintenance regime that ensures signs are maintained during key public health risk periods, ensuring that the public are informed about the presence of and risks posed by VTA bait. Signs also provide information on methods people can use to minimise risks, eg, to stay on tracks, ensure children do not touch bait, etc. The condition is designed to provide clarity on the Hazardous Substances (Identification) Regulations 2001, which require that signs meet visibility requirements throughout their lifetime but don't stipulate how this might be assured.
Modification options	The decision to require the condition to be stated should be at the discretion of the officer, based on an objective risk assessment. This condition should be used where the officer is not assured that the applicant has an adequate sign management plan. For certain operations, eg, DRC on open farmland in an isolated area, this condition is unlikely to be relevant and may be omitted.
Example	This condition can be used in conjunction with Condition 21, where the operation covers areas that are variously affected by sign vandalism. In some circumstances, Condition 21 may replace this condition where the degree and frequency of sign vandalism warrants a specified frequency (ie, weekly) inspection and replacement.

CONDITION 21: Sign Vandalism During the period in which the bait remains toxic, warning signs shall be inspected weekly in the following locations: (*List*) Any signs that are damaged, vandalised or otherwise become illegible shall be replaced within 24 hours of discovery.	
Scope	Discretionary for all VTA uses.
Rationale for the condition	This ensures that signs in areas where vandalism is known to be common are maintained properly, ensuring that the public are well informed about the presence of VTA bait.
Modification options	The decision to require this condition to be used as a supplement to Condition 20 should be at the discretion of the officer, generally based on any localised sign vandalism that is anticipated or that has been identified by the applicant and/or where the officer is not assured that the applicant has an adequate sign management plan. Vandalism of previous signs or vandalism and/or graffiti in the area are clear indicators of likely need for this condition.
Example	The officer requires weekly signs inspection in an area that attracts young families in the weekends but that is also known to be subject to frequent vandalism.

Contamination of water supplies

CONDITION 22: Domestic Water Supply: Notification The applicant shall notify the intended operation to all people who source their domestic water supply from the water extraction point: • from within the operational area; or • within (*specify distance*) of the operational area where the water source is a surface waterway that flows through or rises within the operational area. The notice must be given sufficiently prior to, but within two months of, the proposed application of the VTA(s). If requested by the person notified, notification shall be repeated at a mutually-agreed time before the proposed application.	
Scope	All VTA uses.
Rationale for the condition	This ensures that all people who draw water from within or near operational areas have full knowledge of the operation. The stipulated timing is consistent with the requirements of Additional Control 11 in ERMA New Zealand's 1080 Reassessment Decision.
Commentary	The condition makes it clear that the only people living outside the operational area who need to be notified are those who source their domestic water supply within 3 km of the boundary of the operational area <u>and</u> where the water source is one that may contain bait (ie, only water sources that actually pass through or rise within the operational area). People whose domestic water supplies are sourced within 3 km of the operational area but who source water from waterways that are completely separate from the operational area (eg, from a different catchment), do not need to be notified.
Modification options	In setting the distance, 200 m is considered sufficient for all ground applications of VTAs as the application methods and nature of the bait means the bait is unlikely to enter waterways. The distance is set at 3 km for aerial applications of 1080. If the officer believes the recommended distances do not appropriately address the potential risks in a particular situation, the officer may need to consult a third party (eg, local hydrologist, council officer, research provider) to determine the appropriate distance. However, the set distance of 3 km for aerial applications of 1080 should not be reduced. The officer may choose to require notification of pre-feeds. Although pre-feeds are not toxic and are not covered by the HSNO regime, officers may choose to apply the exclusion distance to pre-feeds to reduce the potential for confusion over the toxicity of baits.
Example	The officer, in consultation with a local hydrologist, extends the exclusion distance to 500 m for a ground 1080 operation in a karst landscape, which has complex local hydrology.

CONDITION 23: Domestic Water Supply: Location	
The applicant shall verify the location of water supply intakes with all people who source their domestic water supply from the water extraction point: • from within the operational area; or • within (*specify distance*) of the operational area, where the water source is a surface waterway that flows through or rises within the operational area. A GPS waypoint file of water supply intakes shall be recorded and made available to (*insert the name of the public health unit from page 1 of the application form*) on request.	
Scope	For aerial application of 1080; discretionary for all other VTA uses.
Rationale for the condition	This ensures that operators locate all water intakes within and near the operational area, in turn ensuring (in the case of aerial operations) that they can apply proper mitigation measures to all at-risk intakes. This condition strengthens the expectation of accurate identification of domestic water supply intakes, as the 1080 Reassessment Decision noted that 'prevention of exposure relies more on the accurate identification' of domestic water supplies.
Commentary	The condition makes it clear that the only water intakes from outside the operational area that need to be verified are those that source their domestic water supply within 3 km of the boundary of the operational area <u>and</u> where the water source is one that may contain bait (ie, only water sources that actually pass through or rise within the operational area). The locations of domestic water supply intakes that are sourced within 3 km of the operational area but that source water from waterways that are completely separate from the operational area (eg, from a different catchment), do not need to be verified.
Modification options	In setting the distance, 200 m is considered sufficient for all ground applications of VTAs as the application methods and nature of the bait means that bait is unlikely to enter waterways. The distance is set at 3 km for aerial applications of 1080. For non-aerial 1080 VTA uses, the condition should be discretionary, based on the probable risk from accidental treatment close to water supply intakes. For such operations, the officer may decide not to require a list of water supply intakes to be maintained where water contamination is unlikely. For uses of DRC or cyanide, where water contamination is unlikely, this condition may be omitted.
Example	The officer, in consultation with a local hydrologist, requires verification and extends the verification distance to 500 m, for a ground 1080 operation in a karst landscape, which has complex local hydrology.

CONDITION 24: Domestic Water Supply: Exclusions No VTA shall be ground-laid within 20 m of domestic water supply intakes that are within the operational area. For flowing surface watercourses, the 20 m exclusion shall extend for a length of 50 m upstream from the point of intake.	
Scope	For all ground applications of VTAs.
Rationale for the condition	This ensures that ground-laid VTAs cannot enter water supplies used for human consumption. It also reduces the risk of contamination from poisoned carcasses.
Commentary	Flowing surface watercourses include rivers, streams and creeks. To avoid doubt, where an entire, large still-water body, such as a lake or reservoir, is considered to be the water intake, the 20 m exclusion would apply around the entire water body; the 20 m exclusion extending 50 m up each feeder stream into the water body would not be required. If the still-water body is of small volume, the 20 m exclusion extending 50 m up each feeder stream may be required.
Modification options	Where there is an increased risk of the VTA or poisoned carcasses entering into waterways (eg, sloping ground toward the waterway; heavy vegetation overhanging the waterway), the exclusion distances may be increased. This will depend on local conditions, including rainfall, the gradient of the terrain, vegetation and soil type. The officer may consult a third party (eg, local hydrologist, council officer, research provider) to ascertain the relative risk of bait entering local waterways in order to appropriately modify the exclusion distance.
Example	In steeper areas, the exclusion distance could be increased to minimise the risk from VTAs or poisoned carcasses. In flat areas with low possum numbers, the exclusion distance could be decreased if this does not increase potential public health risks.

CONDITION 25: Domestic Water Supply: Mitigation	
For an aerial application of 1080, applicants must provide mitigation to all households and huts/ camping areas that source their domestic water supply from the water extraction point: • from inside the operational area; or • within 3 km of the operational area where the water source is a surface waterway that flows through or rises within the operational area if mitigation is requested by household occupiers or managers of huts/camping grounds. Mitigation shall involve either or both of the following: i. No 1080 shall be applied within 50 m of the water supply intakes. For flowing surface waterways, the 50 m exclusion shall extend for a length of 200 m upstream from the point of intake. ii. The domestic water supply shall be temporarily disconnected until such time as water testing finds no VTA contamination above 50 percent of the Ministry's PMAV.* If no temporary water source is available, an adequate alternative potable water supply (to be used for drinking and cooking) will be provided to the affected household; the amount per day to be agreed with the household, until testing is completed.	
Scope	For aerial application of 1080.
Rationale for the condition	This ensures that operators take steps to mitigate the risk of 1080 bait entering domestic water supplies through consultation with the household occupiers and managers of huts/camping areas.
Commentary	In setting the distance for which water supplies the mitigation must apply to, 200 m is considered sufficient for all ground applications of VTAs as the application methods and nature of the bait means that the bait is unlikely to enter waterways. The distance is set at 3 km for aerial applications of 1080. Flowing surface watercourses include rivers, streams and creeks. Where an entire, large still-water body, such as a lake, pond or reservoir, is considered to be the water intake, the 50 m exclusion would apply around the entire water body. The 50 m exclusion extending for 200 m up each feeder stream into the water body would not be required. If the water body is of small volume, the 50 m exclusion extending for 200 m up each feeder stream may be required.
Modification options	The exclusion zone around the intake may need to be changed to account for different contour types or particular operations.
Example	In steep areas, the exclusion area may need to be increased to protect against bait falling into the waterway. For other operations (eg, along farm streams), the officer may allow bait closer to the water edge as long as the bait can be applied in such a way as to ensure that none falls into the water (eg, using trickle feeding).

* The Provisional Maximum Accepted Value (PMAV) represents the concentration of sodium fluoroacetate (1080) in water that, on the basis of present knowledge, is not considered to cause any significant risk to the health of the consumer over their lifetime of consumption of that water. Fifty percent of the PMAV is a 1080 concentration of two parts per billion.

CONDITION 26: Water Supply Testing The water testing shall conform to the requirements attached to this permission. Where water testing reveals VTA contamination over 50 percent of the PMAV,* the alternative potable water supply shall be maintained until such time as a repeat test confirms VTA contamination below 50 percent of the PMAV, in accordance with the requirements of the Drinking-water Standards of New Zealand.	
Scope	For aerial application of 1080.
Rationale for the condition	This ensures that, where testing is requested, it conforms to robust procedures (see the box below for modification option). A robust testing regime ensures that potentially contaminated water supplies are only re-opened when there is proof that there is no possibility of contamination. The conditions must conform to the current Landcare Research Protocol for Environmental Water Sampling and Testing Associated with 1080 Pest Control Operations.
Modification options	There are no modification options for this condition.

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CONDITION 27: Public Water Supplies: Notification	
The applicant shall notify the details of the intended operation to all managers of public water supplies who source their public water supply from a water extraction point: • from within the operational area; or • within (*specify distance)* of the operational area where the water source is a surface waterway that flows through or rises within the operational area. The notice must be given sufficiently prior to, but within two months of, the proposed application of the VTA(s). If requested by the person notified, notification shall be repeated at a mutually-agreed time before the proposed application.	
Scope	All VTA uses.
Rationale for the condition	This ensures that managers of public water supplies have sufficient notice of planned operations so that they have full knowledge of the operation and should be well prepared to address the potential risks. The stipulated timing is consistent with the requirements of Additional Control 11 in ERMA's 1080 Reassessment Decision.
Commentary	The condition makes it clear that the only managers of water supplies located outside the operational area who need to be notified are those who source their public water supply within 3 km of the boundary of the operational area <u>and</u> where the water source is one that may contain bait (ie, only water sources that actually pass through or rise within the operational area). Managers whose public water supplies are sourced within 3 km of the operational area but who source water from waterways that are completely separate from the operational area (eg, from a different catchment) do not need to be notified.
Modification options	In setting the distance, 200 m is considered sufficient for all ground applications of VTAs as the application methods and nature of the bait means that bait is unlikely to enter waterways. The distance is set at 3 km for aerial applications of 1080. If the officer believes the recommended distances do not appropriately address the potential risks in a particular situation, the officer may need to consult a third party (eg, local hydrologist, council officer, research provider) to determine the appropriate distance. The officer may also choose to require notification of pre-feeds. Although pre-feeds are not toxic and are not covered by the HSNO regime, officers may choose to apply the exclusion distance to pre-feeds to reduce the potential for confusion over the toxicity of bait.
Example	Where a major public water supply sources its water 3 km from the operational area, the notification distance may need to be extended to include that water supply.

CONDITION 28: Public Water Supplies: Location	
The applicant shall mutually verify the location of public water supply intakes with all water supply managers who source their public water supply from a water extraction point: • from within the operational area; or • within (*specify distance)* of the operational area where the water source is a surface waterway that flows through or rises within the operational area. A GPS waypoint file of water supply intakes shall be recorded and made available to (*insert the name of the public health unit from page 1 of the application form*) on request.	
Scope	For aerial application of 1080; discretionary for all other VTA uses.
Rationale for the condition	This ensures that operators locate all water intakes within and near the operational area, in turn ensuring (in the case of aerial operations) that they can apply proper mitigation measures under Condition 30 to all at-risk intakes. This condition strengthens the expectation of accurate identification of domestic water supply intakes as the 1080 Reassessment Decision noted that 'prevention of exposure relies more on the accurate identification' of domestic water supplies.
Commentary	The condition makes it clear that the only public water intakes from outside the operational area that need to be verified are those that source their water supply within 3 km of the boundary of the operational area <u>and</u> where the water source is one that may contain bait (ie, only water sources that actually pass through or rise within the operational area). The locations of public water supply intakes that are sourced within 3 km of the operational area but that source water from waterways that are completely separate from the operational area (eg, from a different catchment) do not need to be verified.
Modification options	In setting the distance, 200 m is considered sufficient for all ground applications of VTAs as the application methods and nature of the bait means that the bait is unlikely to enter waterways. The distance is set at 3 km for aerial applications of 1080. For non-aerial 1080 VTA uses, the condition should be discretionary, based on the probable risk from accidental treatment close to water supply intakes. For such operations, the officer may decide not to require a list of water supply intakes to be maintained where water contamination is unlikely. For uses of DRC or cyanide, where water contamination is unlikely, this condition may be omitted. The officer may decide to require a list of public water supplies as a precondition for commencing the application of the VTA.
Example	For operations close to urban areas with multiple public water supplies, the officer may require a list of public water supplies to ensure that operators properly identify all such supplies.

CONDITION 29: Public Water Supplies: Exclusions No VTA shall be ground laid within 50 m of public water supply intakes that source water within the operational area. For flowing surface watercourses, the 50 m exclusion shall be extended to 100 m upstream of the point of intake (*list or attach relevant attachment of the application form*).	
Scope	For all ground applications of VTAs.
Rationale for the condition	This ensures that ground-laid VTAs cannot enter water supplies used for human consumption, and the risk of contamination from poisoned carcasses is also reduced.
Commentary	Flowing surface watercourses include rivers, streams and creeks. To avoid doubt, where a water intake is a large still-water body, such as a lake or reservoir, the 50 m exclusion would apply around the entire water body; the 100 m exclusion up each feeder stream into the water body would not be required. Where an entire still-water body, such as a lake or reservoir, is considered to be the water intake, and it is of a small volume, the 100 m exclusion up each feeder stream into the water body may be required.
Modification options	Where there is an increased risk of the VTA or poisoned carcasses entering into waterways, the exclusion distances may be increased. This will depend on local conditions including rainfall, the gradient of the terrain, vegetation and soil type. The officer may consult a third party (eg, local hydrologist, council officer, research provider) to ascertain the relative risk of bait entering local waterways in order to modify the exclusion distance.
Example	In steeper areas, the exclusion distance could be increased to minimise the risk from VTAs or poisoned carcasses. On flat terrain with proven low possum numbers, the exclusion distance could be decreased.

CONDITION 30: Public Water Supplies: Mitigation	
For an aerial application of 1080, applicants must provide mitigation to all public water supplies that source their public water supply from a water extraction point: • from within the operational area; or • within *(specify distance)* of the operational area where the water source is a surface waterway that flows through or rises within the operational area. Mitigation shall be mutually agreed in writing between the applicant and water supply managers and involve either or both of the following: i. No 1080 shall be applied within 200 m of the water supply intakes. For flowing surface watercourses, the 200 m exclusion shall be extended to 400 m upstream of the point of intake. ii. If an interim water supply is available, the affected water supply shall be temporarily disconnected until such time as water testing finds no VTA contamination above 50 percent of the Ministry's PMAV*, in accordance with the requirements of the Drinking-water Standards of New Zealand.	
Scope	For aerial application of 1080.
Rationale for the condition	This ensures that operators take steps to mitigate the risk of 1080 bait entering public water supplies following consultation with the water supply manager.
Commentary	In setting the distance for which water supplies the mitigation must apply to, 200 m is considered sufficient for all ground applications of VTAs as the application methods and nature of the bait means bait is unlikely to enter waterways. The distance is set at 3 km for aerial applications of 1080. Flowing surface watercourses include rivers, streams and creeks. To avoid doubt, where a water intake is a large still-water body, such as a lake or reservoir, the 200 m exclusion would apply around the entire water body; the 400 m exclusion up each feeder stream into the water body would not be required. Where an entire still-water body, such as a lake or reservoir, is considered to be the water intake, and it is of a small volume, the 400 m exclusion up each feeder stream into the water body may be required.
Modification options	The exclusion zone around the intake may need to be changed to account for different contour types or particular operations.
Example	In steep areas, the exclusion area may need to be increased to avoid bait falling in to the waterway. For other operations (eg, along farm streams), the officer may allow bait closer to the water edge as long as the bait can be laid in such a way as to ensure that none falls in the water (eg, using trickle feeding).

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CONDITION 31: Water Supply Mitigation: Reporting The applicant shall maintain a list of water mitigation measures provided under Conditions 25 and 30, which shall be available, on request, to (*insert the name of the public health unit from page 1 of the application form*).	
Scope	Discretionary for aerial application of 1080.
Rationale for the condition	This helps the officer to monitor how operators are complying with Conditions 24 and 29 – and encourages operators to comply. The condition also gives the officer the opportunity to amend, stop or suspend the operation if any mitigation measures are inadequate.
Commentary	The officer should recognise the need to request this information sufficiently in advance of the commencement of an operation, with at least 48 hours notice, to allow the applicant to address any concerns raised by the officer without causing operational delays.
Modification options	Where the numbering of conditions in the permission differs from the Model Permit Conditions, the references to Conditions 25 and 30 will need to be changed to reference whichever conditions provide for mitigation measures.
Example	In an aerial operation with no ground component, Conditions 24 and 29 could be deleted as unnecessary. Note his would affect the numbering of the mitigation conditions.

CONDITION 32: Water Supply Testing: Reporting The applicant shall provide, or arrange for the provision of, the outcome of all water testing to (*insert the name of the public health unit from page 1 of the application form*) within 24 hours of receipt of the testing results. In the event that water testing reveals VTA contamination over the PMAV,* the applicant shall discuss any further proposed mitigation measures with (*insert the name of the public health unit from page 1 of the application form*) and continue testing in accordance with the requirement for monitoring to establish compliance with the Drinking-Water Standards of New Zealand.	
Scope	For aerial application of 1080.
Rationale for the condition	This helps the officer to monitor how operations are complying with the conditions and ensures that there is a process in place to deal with the situation where high levels of VTA contamination are discovered.
Modification options	The time period in which the water-testing outcome must be reported could be decreased if the risk to public health from contaminated water is exacerbated by allowing 24 hours between discovery and notification of the results to the officer.
Example	Where there is a real risk of a substantial drop of 1080 bait into a public water supply or waterway from which many households draw water, the officer may reduce the time limit on notification.

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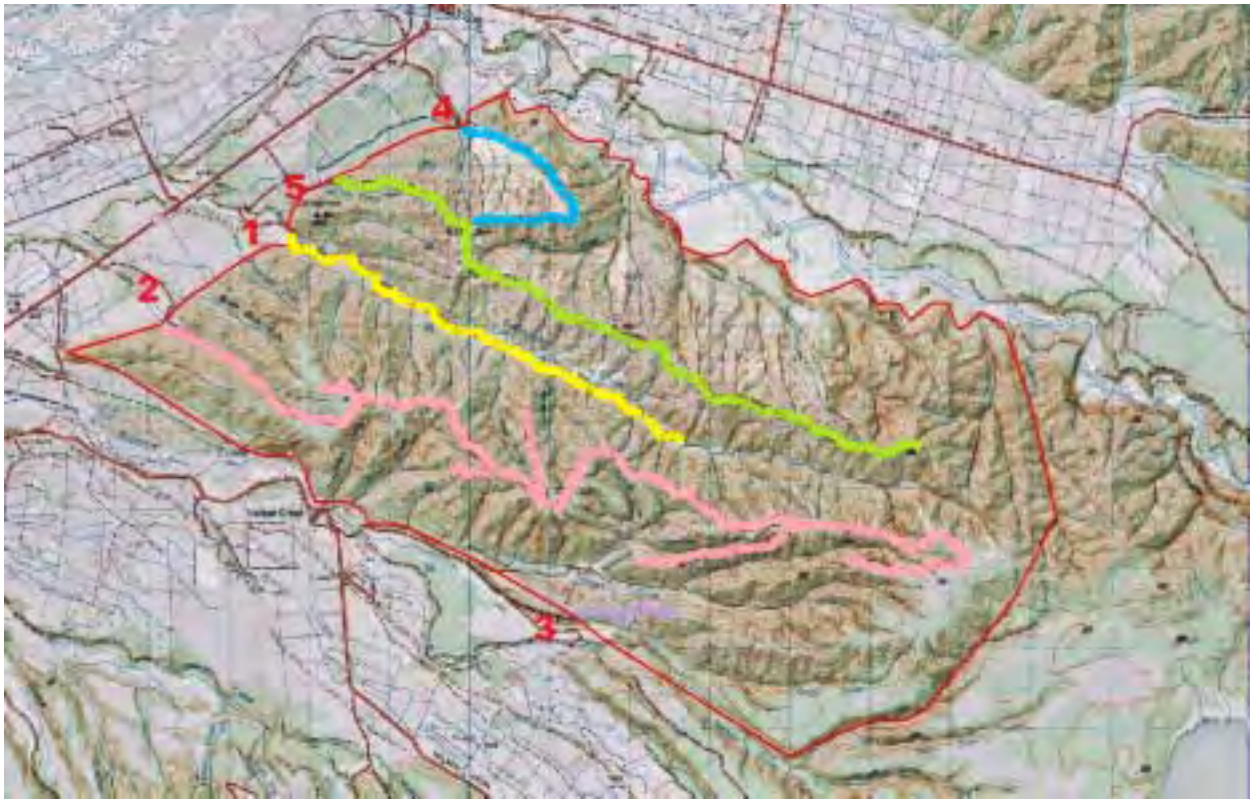
Case examples

Case example 1: Managing risk around roads and vehicle tracks



Legend

Road 1 ***

Road 2 ***

Road 3 ***

Road 4 ***

Road 5 ***

Scenario

An applicant wishes to aerially apply 1080 over 4,800 ha of the Ahaura Forest, an area comprising open beech forest and commercial forestry. The forest contains about 45 km of formed roads and vehicle tracks (Roads 1–5 as marked on the map), to which there are five main access points.

The applicant says that a large exclusion on the entire road network (as potentially envisaged by the Model Permit Conditions) would exclude a significant proportion of the operational area from aerial control and would therefore undermine the efficacy of control and increase the cost of the operation. Therefore, the applicant proposes that all the roads be sown and cleared instead, as permitted under Condition 16.

The officer consults with the relevant land manager and determines the following:

- Road 1 is a well-formed gravel road, providing river access – popular with families. It has the highest level of public use (more than 20 people per day on average).
- Road 2 is a rough, seldom-used 4WD track, mostly through steep, native bush. It is unusable in winter due to mud.
- Road 3 is a well-formed track and popular route for hunters accessing the native bush.
- Roads 4 and 5 are seldom-used commercial forestry tracks with lockable gates at their access points. Most use of these roads takes place at weekends when local families undertake firewood collection.

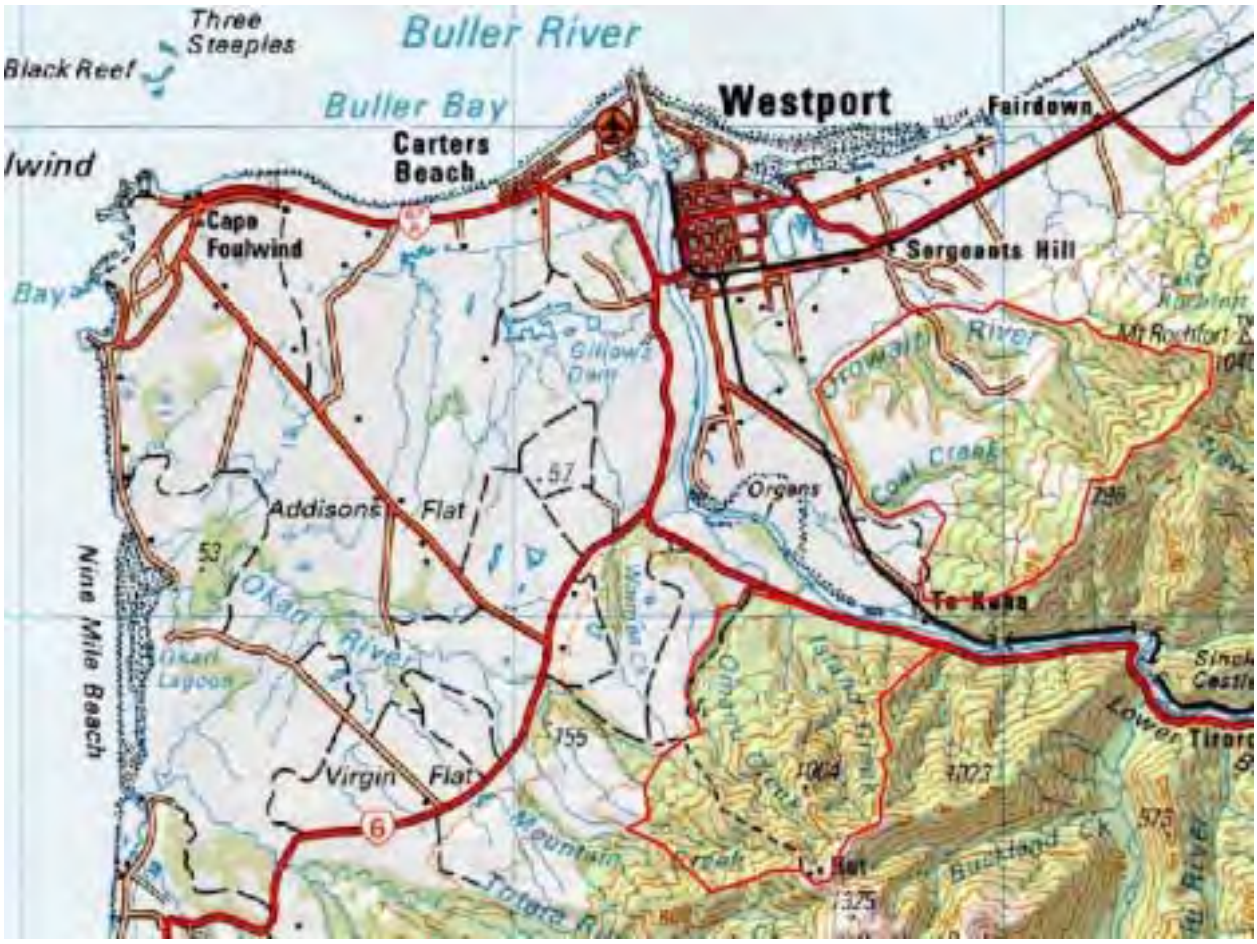
The officer seeks clarification from the applicant and determines that it is not practical to clear the 45 km of roads within 24 hours, that the maximum amount of roads that could be cleared within 24 hours is approximately 20 km and that there will be a significant loss of efficacy if large exclusions are required on all roads.

Model Permit Condition	Applicable?	Modification
Conditions 1–5	✓	[Not covered in this example]
Notifications Conditions 6–8 Condition 9	 ✓ x	[Not covered in this example]
Accidental direct exposure to VTAs		
Condition 10	✓	[Not covered in this example]
Condition 11. No VTA shall be ground applied within the distance listed below, and not where it is within sight of the following walking and vehicle tracks: **Road 3 (on the attached map): 40 m**		Road 2 is a little-used track only accessible by four-wheel drives, and so the officer decides to allow bait to be applied along it. It will be listed under Conditions 16 and 17, *not* Condition 11. Road 3 is an easily accessible track that appears to be used quite often by hunters. This means it is inappropriate to allow application of bait along this road (as requested by the applicant) and the road should be listed under Condition 12. Calculating the exclusion distance: The base 80 m distance can be significantly reduced because: • the terrain is steep • the track has low public usage • most users are experienced hunters (rather than children). The officer sets the distance at 40 m. Since roads 4 and 5 are seldom used and have lockable gates, the officer decides to allow bait to be applied along these tracks; they will be listed under Conditions 16 and 17, *not* Condition 11.
Condition 12. No VTA shall be aerially applied within the distance listed below, and not where it is within sight of the following roads and lay-bys: **Road 1 (on the attached map): 80 m**	✓	Road 1 has relatively high public usage and is popular with families. This means it is inappropriate to allow application of bait along this road (as requested by the applicant) and the road should be listed under Condition 12. The officer maintains the base 80 m distance because: • the road is in a relatively open area • it is commonly used by families.
Conditions 13–15	✓	[Not covered in this example]

Model Permit Condition	Applicable?	Modification
Condition 16. The applicant may aerially apply 1080 to the following walking and vehicle tracks, but not during, or within 24 hours of the start of, school holidays, public holidays or public holiday weekends. **Road 2 (on the attached map)** **Road 4 (on the attached map)** **Road 5 (on the attached map)** If the applicant aerially applies 1080 to any of the above listed roads, they shall inspect those roads as soon as possible, and not more than 24 hours, after the VTA application and make reasonable efforts to find and remove all bait and, if encountered, animal carcasses; provided the gates remain locked from the time of application until after the inspection and following verification that no vehicles are within the application area at the time of locking the gates.	✓	Roads 2, 4 and 5 will have bait applied along them but need to be cleared of bait as soon as possible. These roads need to be listed under Condition 16. Since Roads 4 and 5 have lockable gates, which would severely limit access, the officer also makes it clear that the gates on these roads must be locked until after the inspection. The officer modifies the Model Permit Condition accordingly.
Condition 17. The applicant shall undertake a second inspection of the following walking and vehicle tracks and make reasonable efforts to find and remove all bait and, if encountered, animal carcasses. **Road 4 (on the attached map)** **Road 5 (on the attached map)** The second inspection shall be made at least 24 hours after the VTA application. It should be timed to take place either: i. immediately after the occurrence of strong winds; or ii. immediately before the weekend or commencement of school holidays or public holidays; whichever occurs first.	✓	Road 2 is virtually unusable in winter, and so the officer decides not to require a second clearance under Condition 16. However, a second clearance is required for Roads 4 and 5, which are still used in winter.
Conditions 18–21	✓	[Not covered in this example]

Model Permit Condition	Applicable?	Modification
Contamination of water supplies		
Conditions 22–23	✓	[Not covered in this example]
Condition 24	x	
Conditions 25–28	✓	[Not covered in this example]
Condition 29	x	
Conditions 30–32	✓	[Not covered in this example]

Case Study 2: Managing risk around water supplies



Southern block

Northern block

Scenario

An aerial 1080 operation is planned in winter over two blocks immediately north and south of the Buller River (see maps).

The southern part of the operation includes three water supplies:

1. The domestic water supply for a house, drawn from a small unmarked stream east of Omanu Creek.
2. The rural water supply for Cape Foulwind, drawn from the south branch of Omanu Creek, and managed by the local council.
3. The water supply for Buckland Peak Hut, managed by DoC.

The applicant advises that they have notified each of the water supply managers and proposes excluding 50 m each side of water supply intakes 1 and 2, continuing 200 m upstream of the intake point, as permitted under Model Permit Condition 24. The applicant does not propose a water supply exclusion for water supply 3 as the hut has a rooftop rainwater supply.

In making a decision, the officer:

- consults with the local council and finds that the Cape Foulwind rural water supply is not a potable water supply but is piped 16 km to provide stock water at the cape
- confirms with DoC that the water supply for the Buckland Peak Hut is a rooftop rainwater supply and that it is a six-bunk hut with low use during winter.

The northern part of the operation includes one water supply, being the public water supply for Westport and adjoining residential areas.

The water supply is from a creek catchment in the hills behind Westport and is transferred to three large reservoirs by a series of underground tunnels and open water races. There is also a treatment plant and covered storage for about half a day's supply of treated water, which is then piped to town.

However, the officer also identifies a risk to the water supply from the open water races and reservoirs, as these are exposed to the aerial application of bait.

Model Permit Condition	Applicable?	Modification
Conditions 1–5	✓	[Not covered in this example]
Risk area: notifications Conditions 6–8 Condition 9	 ✓ x	 [Not covered in this example]
Risk area: accidental exposure to VTAs		
Condition 10. No VTA shall be aerially applied within the distance listed below, and not where it is within sight of, the following huts, access points, camping and public areas: **Buckland Peak Hut: 40 m** Warning signs shall be placed at each of the listed hut(s), camping and public amenity area(s) before the VTA(s) are laid in adjoining areas.	✓	Buckland Peak Hut is a six-bunk hut with low use during winter and lies within the operational boundary. Therefore it must be listed under Condition 10. Calculating the exclusion distance: The operator requested an exclusion distance of 40 m around the hut. The officer agrees because: • the hut has low use in winter • although on the open tops, the terrain around the hut is relatively steep. An 80 m exclusion distance would be excessive given the risk. The officer sets the exclusion distance at 40 m. Since it would have an exclusion zone under Condition 10, there is no need for Conditions 22–26 to apply to Buckland Peak Hut.
Conditions 11–14	✓	[Not covered in this example]
Condition 15. An aircraft that is carrying out an aerial application must not, when flying to or from the area where the VTA is applied, fly over the following 'no fly' areas: **Buckland Peak Hut** **Westport public water supply reservoirs and canal**	✓	Since Buckland Peak Hut has a rooftop rainwater supply, the officer wants to be assured that no bait will be accidentally dropped on the hut roof during sowing of adjoining areas. Therefore, Buckland Peak Hut should be listed under Condition 15. Given the magnitude of potential risk from an unintentional spillage of bait into the Westport public water supply, it too should be listed under Condition 15.
Conditions 16–21	✓	[Not covered in this example]
Risk area: contamination of water supplies Condition 22 Condition 23 Condition 24	 ✓ ✓ x	 [Not covered in this example] [Not covered in this example]

Model Permit Condition	Applicable?	Modification
Condition 25. For an aerial application of 1080, applicants must provide mitigation to all households and huts/camping areas that: • source water from inside the operational area; or • source their domestic water supply within 3 km of the operational area, where the water source is a surface waterway that flows through or rises within the operational area. This applies where mitigation is requested by household occupiers or managers of huts/ camping grounds. Mitigation shall involve either or both of the following: i. No 1080 shall be applied within 50 m of the water supply intakes. For flowing surface waterways, the 50 m exclusion shall extend for a distance of 200 m upstream from the point of intake. ii. The domestic water supply shall be temporarily disconnected until such time as water testing finds no VTA contamination above 50 percent of the Ministry's PMAV,* in accordance with the requirements of the Drinking-water Standards of New Zealand. If no temporary water source is available, an adequate alternative potable water supply (to be used for drinking and cooking) shall be provided to the affected household, the amount per day agreed with the household, until testing is completed.	✓	As this is a 1080 operation, the distance from the operational area within which operators must provide mitigation for residents should be 3 km. Water Supply 1 is the water supply for a house, drawn from a small, unmarked stream east of Omanu Creek. As it lies within the operational boundary, and supplies a household, the water supply counts as a domestic water supply for the purposes of Condition 25. Therefore, Condition 25 would apply to Water Supply 1. Since it would have an exclusion zone applied under Condition 10, there is no need for Conditions 22–26 to apply to Buckland Peak Hut (Water Supply 3). Any other water supplies within 3 km of the boundary of the operational zone and that draw water from a waterway that passes through the operational area may also require mitigation. It is the operator's duty to ensure that all such water supplies are correctly identified. This could include any water supplies within 3 km of the operational area that draw water from the Buller River below its confluence with Island Creek (since Island Creek flows through the operational area).

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Model Permit Condition	Applicable?	Modification
Condition 26 Condition 27 Condition 28 Condition 29	✓ ✓ ✓ x	[Not covered in this example] [Not covered in this example] [Not covered in this example]
Condition 30. For an aerial application of 1080, applicants must provide mitigation to all public water supplies that: • source their public water supply from within the operational area; or • source their public water supply within (*specify distance)* of the operational area where the water source is a surface waterway that flows through or rises within the operational area. Mitigation shall be mutually agreed in writing between the applicant and water supply managers and involve either or both of the following: i. No 1080 shall be applied within 200 m of the water supply intakes. For flowing surface watercourses, the 200 m exclusion shall extend for a length of 400 m upstream of the point of intake. ii. If an interim water supply is available, the affected water supply shall be temporarily disconnected until such time as water testing finds no VTA contamination above 50 percent of the Ministry's PMAV,* in accordance with the requirements of the Drinking-water Standards of New Zealand.		Since it is not a drinking water source for humans, the Cape Foulwind rural water supply (Water Supply 2) would not be covered by Condition 30. By contrast, the public water supply for Westport in the northern block is covered by Condition 30. Since the water supply consists of an intake, reservoirs and a canal, the suitable exclusion distance in this case would be 200 m from the water supply intake and 400 m upstream; 200 m around the edge of the reservoirs and 200 m on both sides of the water race where it is in the open.
Condition 31 Condition 32	✓ ✓	[Not covered in this example] [Not covered in this example]

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Case Study 3: Managing high-risk exclusions

Scenario

An applicant proposes a hand-laid possum control operation, using sodium cyanide paste in the Cape Foulwind area.

The operational area is mostly rolling farmland but is traversed by the 4 km Cape Foulwind Walkway, which runs from the lighthouse at Cape Foulwind to the seal rookery near Tauranga Bay. Car parks are located at each end of the walkway and Limestone and Lighthouse roads are both used to access these car parks.

The seal colony attracts an estimated 80,000 to 100,000 visitors every year, with many of these visitors walking all or part of the walkway. Many of the visitors are tourists or families with young children. The walkway passes through undulating farmland, with coastal cliffs on the seaward side.

The officer discusses the likely exclusion distance with the applicant. The applicant states that a large exclusion either side of the walkway would take in the entire coast cliff area, which is where the highest possum abundance is anticipated, and would therefore undermine the efficacy of the operation and that an alternative trapping regime in the cliff area would see budget overruns.

The officer also discusses the application with the track manager, who confirms that the walkway passes as close as 2–5 m to the edge of the coastal cliffs but that the cliffs are steep and inaccessible.

Past operations have shown that signs located in the car parks attract considerable vandalism.

Model Permit Condition	Applicable?	Modification
Conditions 1–5	✓	[Not covered in this example]
Risk area: notifications		
Conditions 6–8	✓	[Not covered in this example]
Condition 9: The officer amends the Model Permit Condition to read: "The applicant shall give public notice in the following media (eg, newspapers, community newsletters) of the proposed application of the VTA(s). **Westport News** The notice must be given sufficiently prior to, but within two months of, the proposed application of the VTA(s). The notice shall specify the following: i. The approximate date that the VTA(s) will be applied. ii. The name and nature of the VTA(s). iii. A description of the area over which the VTA(s) will be applied. iv. The location(s) where the public may view maps of the area over which the VTA(s) will be applied and the times when such maps can be viewed. v. The name and address of the person responsible for applying the VTA(s). The applicant must provide a copy of the public notice and the date(s) and media in which it was published to (*insert the name of the public health unit from page 1 of the application form*) before commencing the operation."		
Risk area: accidental exposure to VTAs		
Condition 10	✓	[Not covered in this example]
Condition 11. No VTA shall be ground applied within the distance listed below and not where it is within sight of the following walking and vehicle tracks: **Cape Foulwind Walkway: 100 m** **As an exception to this condition, VTAs shall be permitted within 100 m of the Cape Foulwind Walkway but only where they are on steep and inaccessible coastal cliffs and contained in bait stations that are clearly marked with a 'Warning: Poison' sign.**	✓	Cape Foulwind Walkway is used by up to 100,000 people each year (an annual daily average of 274 people) and lies within the operational boundary, so it must be listed under Condition 11. Calculating the exclusion distance: Although the recommended exclusion area for ground control is 20 m, the officer decides to increase this significantly to 100 m because: • there is very high public use • users are largely tourists and families who may be more at risk than other groups • the terrain is open farmland • the VTA type and method of application (easily accessible) is relatively dangerous. In light of the cliff-face issue, the officer also talks with the track manager, who confirms that the walkway passes as close as 2–5 m to the edge of the coastal cliffs, but that the cliffs are steep and inaccessible.

Model Permit Condition	Applicable?	Modification
		On that basis, the officer advises the applicant that cyanide use on the coastal cliffs themselves will be acceptable, so long as the cyanide is presented in bait stations that are clearly marked with a 'Warning: Poison' sign. On the inland side of the track, the bait must not be applied within 100 m of the track.
Condition 12. No VTA shall be ground applied within the distance listed below and not where it is within sight of the following public roads and road lay-bys: **Car parks at Tauranga Bay and Lighthouse Road: 100 m** **Lighthouse Road: 100 m** **Limestone Road: 100 m**		The car parks and roads at each end of the Cape Foulwind Walkway are likely to receive similar usage to the walkway itself, and they lie within the operational boundary and need to be listed under Condition 12. Calculating the exclusion distance: Since these areas have a similar risk profile to the walkway, the same 100 m exclusion distance would apply.
Conditions 13–18 Conditions 19–20	✓ ✓	[Not covered in this example] [Not covered in this example]
Condition 21. During the period in which bait remains toxic, warning signs shall be inspected weekly in the following locations: • Car parks at Tauranga Bay and Lighthouse Road • Lighthouse Road • Limestone Road Any signs that are damaged, vandalised or otherwise become illegible shall be replaced within 24 hours of discovery.	✓	Tourists and families with young children frequent this area, so signs need to be well maintained to ensure that at-risk people are informed of the risks. Since there has been a degree of vandalism in the past, this condition should be imposed to ensure that operators regularly check and replace vandalised signs.
Risk area: contamination of water supplies Conditions 22–24 Conditions 25–26 Conditions 27–29 Conditions 30–32	 ✓ x ✓ x	 [Not covered in this example] [Not covered in this example]

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Appendix 1: Checklist for assessing VTA applications

To be used in conjunction with the application form

Applicant: Date received:

Operation: Start date: Finish date:

- ☐ Information on application complete
- ☐ Operation area clearly defined by provided map and description (Appendix 3)
- ☐ Operational description satisfactory
- ☐ Operator identified
- ☐ Resource consent number included
- ☐ Environmental and health impact assessment information adequate
- ☐ Exclusion areas and boundaries adequately described
- ☐ Water supplies identified
  - ☐ Exclusion zones adequate
- ☐ Tracks identified in application and marked on map
- ☐ Houses, huts, public roads in operational area identified
  - ☐ Adequate exclusion zones
- ☐ All landowner's name, addresses and phone numbers provided
  - ☐ Indication that written permission has been given
- ☐ Schools identified and specified as to whether to be visited
- ☐ Notification required for and provided to: GPs, vets, hospitals, police
- ☐ Recreational user groups identified
- ☐ Public information and consultation campaign adequate
  - ☐ Newspapers, media ☐ Visits/phone neighbours
  - ☐ Public meetings

  Meets the requirements of the Communication Guidelines for Aerial 1080 Operations Yes / No

  Other.....
- ☐ Location of notices specified

Permission gained by applicant from:

☐ Local authority ☐ DoC

Appendix 2: Notes on methods of application, bait presentation, terrain and vegetation variables and identifying the potentially exposed population

Methods of application

There are a number of methods of applying VTAs, each with different associated hazards. The method used must be appropriate to the terrain in question and allow the operator certainty around the accuracy of bait placement. The concentration of bait can vary significantly depending on the application method, the VTA being used, the target species and the environment.

In certain circumstances, an operator may use a combination of ground and aerial applications. For example, an operation might involve aerial 1080 application for a wide area with ground application along the periphery to allow for control of possums in areas that abut a residential area and that require greater accuracy of bait placement.

Table A.1: Overview of VTA application methods

Application method	Substance	Bait placement and coverage
Aerial broadcast	1080	Potential for bait to be placed inaccurately. Bait is generally well spread, particularly if a low-sow bucket is used.
Aerial trickle	1080	More accurate placement than aerial broadcast; bait is generally well spaced.
Aerial cluster	1080	Relatively accurate placement; however a large cluster of bait, so exposure is to many pellets rather than spaced single pellets.
Open ground application: turf spits, hand broadcast, ground-laid paste	1080, cyanide, yellow phosphorus, DRC 1339	Accurate placement. Coverage rates vary depending on terrain, target species and VTA.
Hand-based application from an aircraft	DRC 1339	Accurate placement. Coverage rates vary depending on terrain, target species and VTA.
Bait stations	1080, cyanide	Placement divided into less or more than 1 m above the ground. Coverage rates vary depending on terrain, target species and VTA.

Aerial application

As noted in Table A.1, 1080 is the only VTA that can be aerially applied as it is used for possum control in remote areas where ground application would be difficult or impossible. There are various application methods:

- Pellets or carrot bait broadcast from a hopper underneath the aircraft with approximately 120 m swathe, 2–6 kg/ha sowing rate for possums (greater amount may be used for rabbits)

- Pellets or carrot bait trickle fed from a hopper underneath the aircraft ('clustering' of bait is also sometimes used)
- Pellets hand dropped from the aircraft (rarely used).

The ERMA reassessment decision notes that only the following formulated substances are approved for aerial application:

- cereal based pellets containing 0.4–0.8 g 1080/kg
- cereal based pellets containing 1.5–2.0 g 1080/kg
- soluble concentrate containing 200 g 1080/L (only when applied to food baits as per controls).

Aerial drops may release 1080 into areas outside the planned operational area through overflying (release outside the area due to error or mechanical problems); bait drift or accidental release. Operators are required to use GPS logs to confine aerial applications of 1080 to operational areas and to ensure that the application preserves exclusion zones around dwellings, roads and tracks, schools and drinking-water supplies.

Ground application

Ground application of VTAs allows for greater accuracy of bait placement; however, it is limited in terms of the area that can be covered. 1080, cyanide, yellow phosphorus and DRC 1339 can all be ground laid using:

- bait stations
- bait bags
- ground distribution (hand broadcast) of bait
- gels or pastes in earth 'spits'
- small dollops of paste or gel on trees and fence posts, often marked with white flour.

Note that the PHU should check the formulation to see which application methods are allowed because some are only allowed to be used in contained ground based application.

Bait presentation

There are various ways of presenting bait that aim to make the bait as attractive and as accessible as possible to the target species while reducing the risk to other species, including humans.

1080 is incorporated into a number of different baits at varying concentrations, depending on the target species, the method of application and the type of bait least likely to attract non-target species. ERMA, in its reassessment of the use of 1080, noted that public hazards from various forms of exposure to 1080 are relatively low. It stated that the greatest hazard relates to unsupervised children finding and eating bait (ERMA New Zealand 2007a).

1080 solution may be coated on carrot or apple pieces, mixed with cereal to form hard pellets or made into paste or gel formulations. Carrot bait for aerial distribution is chopped and screened to remove small pieces to reduce the risk of poisoning non-target birds. Cereal pellet bait is used for both aerial and bait station control. Paste bait, and more recently gel bait, is used for ground-based follow-up maintenance control. A range of masking agents, such as cinnamon or orange oil, is added to bait to mask the taste of 1080. Cinnamon is thought to be a partial deterrent to birds and insects; green dye is added to deter birds.

Cyanide is presented as pea-sized pieces of paste placed with a little flour and icing sugar or other lures such as cinnamon or eucalyptus oil on a rock, leaf or stick. Feratox® (a pea-sized encapsulated cyanide pellet) was developed to increase the effectiveness of cyanide and reduce the risk of operators being exposed to hydrogen cyanide vapours. The pellets are placed in a bait station either with similar sized cereal feed pellets or in a peanut-butter paste.

Yellow phosphorus comes in a paste form and is generally applied to turf spits on the ground for rabbit control or in similar ways to cyanide paste for possum control. These two forms of application may be more hazardous in easily accessible areas.

DRC 1339 is most commonly presented as laced bread bait for ground-feeding flocks or as gel bait dropped into tall trees nests by operators being lowered to the nests by helicopter.

Pre-feeding

Pre-feeds are often used to prime target species and to reduce bait shyness. While the pre-feeds themselves are not hazardous, it may be difficult for the public to differentiate between pre-feeds and VTA bait. The presence of pre-feeds without warning signs can cause concern among the public or alternatively can make people complacent about toxic baits if consultation, notification and signage are not adequate or appropriate.

Terrain and vegetation variables

The terrain and vegetation in an operational area can affect public health risks posed by a VTA operation and should be considered when assessing the suitability of the Model Permit Conditions and how they may need to be modified.

Table A.2: Overview of terrain and vegetation variables

Terrain type	Comments related to risk characteristics
Open terrain, flat to gentle contour	Relatively easy for the public to access, particularly if close to residential areas. Bait visible from long distances, regardless of method of application. Unless access is physically limited (eg, fences, ditches, walls), use may present a relatively greater public health risk.
Medium terrain (gentle rolling to hilly contour)	More difficult to access, and terrain and vegetation cover of this type may present a barrier to younger children (depending on proximity to residential areas).
Rough, steep contour	This type of terrain may act as a physical barrier, preventing ready access to bait in an operational area. Some areas of rough terrain will include vehicle or walking tracks that may provide access to otherwise inhospitable landscapes – see Model Permit Conditions 10–12.
Vegetation type	Comments related to risk characteristics.
Light to no vegetation, eg, pastureland, open grassland, sparse tree cover	Bait visible from relatively longer distances. Vegetation does not provide a barrier to accessing the bait.
Medium vegetation coverage (eg, fodder crops, open bush, tussock)	Vegetation cover may limit visibility of bait on the ground or in bait stations and may present a moderate physical barrier to access, particularly for young children.
Heavy vegetation (thick bush, extensive undergrowth)	Vegetation cover significantly limits visibility and presents a physical barrier to accessing the operational area. Note: In some areas, tracks may provide access to otherwise heavily forested or covered areas. Model Permit Conditions 10–12 provide for controls in these circumstances.

Potentially exposed population

Potential exposure to operational areas requires consideration of:

- the degree of public usage
- the types of people who use or have access to the area.

The potentially exposed population will differ for each operation. However, examples of populations that may often be exposed include (but are not limited to):

- local residents or visitors (noting that children may wander or explore more extensively than adults in areas adjoining residential areas or dwellings)
- trampers/day walkers using bush tracks and huts
- hunters
- farming families on the edges of operational areas
- school groups utilising operational areas
- watercraft users using landing sites within operational areas
- any other individuals or groups that recreate within operational areas.

Public usage patterns must be taken into account, in particular when considering the application and/or modification of, for example, Model Permit Condition 10. Areas that receive heavy public use, particularly by young children and if the terrain also allows for relatively ready access to and/or visibility of bait, may warrant a revision of the base distances provided in the Model Permit Condition.

Table A.3 sets out some examples of public use patterns that may influence the use of Model Permit Conditions. Please note: these are examples only and will be influenced by other factors such as seasonal use patterns, events that bring large groups into an area for a short time, and the characteristics of the local and likely visiting populations.

Table A.3: Examples of public use patterns

Intensity of public use	Comments related to risk characteristics
High public use (eg, more than 50 people per day)	Higher public usage may increase the risk of contact with baits due to the large number of people in the area. Some areas may experience intermittent periods of high usage around holidays, long weekends or hunting seasons. In some areas, usage will be concentrated or confined to specific parts of a proposed operational area.
Medium public usage (eg, 20–50 people per day)	There may be some risk of contact with bait due to the number of people, particularly if users include children or, for example, non-English speakers who may not fully understand warning signs.
Low public usage (eg, less than 20 people per day)	A lower concentration of users may lower the risk of contact with bait. However, the types of users must still be considered; small groups or individuals may still be at risk, particularly children.

Consideration of each of these variables is necessary for developing a robust risk assessment process for a VTA operation and for developing an appropriate application and modification of Model Permit Conditions.

Glossary of Terms and Abbreviations

For the purposes of issuing permissions for VTAs under the HSNO Act and its regulations, including the Hazardous Substances (Vertebrate Toxic Agents) Transfer Notice 2004 (as amended) and the 1080 Reassessment decision, the following definitions apply:

Abutting	A property or area physically connected to the operational area
Applicant	**For the purposes of these Guidelines, may also include the operator.**
DoC	The Department of Conservation
DoL	The Department of Labour
Domestic water supply	A water supply that is privately owned (not used for profit).
ERMA	Environmental Risk Management Authority
HIA	Health Impact Assessment
HSE Act	Health and Safety in Employment Act 1992
HSNO Act	Hazardous Substances and New Organisms Act 1996
Land occupier	Anyone who resides on a property, irrespective of ownership of the property, for example, a tenant, sharemilker and any other employee of a landowner who resides on the landowner's property
NZFSA	New Zealand Food Safety Authority
NZPHD Act	New Zealand Public Health and Disability Act 2000
Officer	Any health protection officer or medical officer of health who holds a current warrant as an enforcement officer under the HSNO Act
Public water supply	Any water supply that is not to a self-supplied building
VTA	Vertebrate Toxic Agent
Sufficiently prior to ...	A period of time that allows an affected party to adopt remedial or preventive action before a VTA is applied (as a general guideline, no less than five days before the planned VTA application)

Appendix 7

♦ INCLUDE ONE SHEET PER PESTICIDE USE ♦ COMPLETE SHADED AREAS ♦

Pesticide Use #69	Pindone 0.25g/kg Cereal pellet Aerial (Pindone Rabbit Pellets)	Target Pests: Rabbits

DOC/non-DOC* Operation
[Insert name of treatment block(s)/area here]

* Delete the one that is not applicable

CSL REQUIRED

Caution Period
The estimated caution period for this operation is *[insert number of months]* months after last date of bait application and is subject to compulsory bait and carcass monitoring. This estimated caution period cannot be reduced to less than 8 months.

DOC	non-DOC	DOC SOPs & Policies Shall Be Followed
✓	✓	Consultation and Notification of Pest Operations SOP, including Warning Signs (docdm-22832)
✓		Safe Handling of Pesticides SOP (docdm-22730)
✓		Pestlink Reporting SOP (docdm-52340)
✓	✓	Identifying Boundaries for Pesticide Operations SOP (docdm-30357)

Performance Standards

*Compulsory for **all** operations*

✓ The baits must be dyed green or blue.

✓ This pesticide must not be used, stored or prepared, with any prefeed, bait or attractant which is likely to lead any person to believe that the substance is intended for human consumption.

✓ Unless in approved container supplied by the manufacturer, this pesticide must not be used in any culinary utensil or other container which is likely to lead any person to believe the contents are intended for human consumption, regardless of any modification or other warning labels attached.

✓ Consent providers must be given at least 24 hours notice before the pesticide is applied and a close liaison will be maintained throughout the operation.

✓ Consent providers will be notified as soon as possible in case of any accidental discharge into a surface water body.

✓ Flight paths to and from the bait loading zones by aircraft equipped with loaded or uncleaned bait sowing equipment must avoid: stocked paddocks, residential dwellings, and any other 'no fly zones' specified by consent providers.

✓ An aircraft must not, when flying to or from the treatment area, fly over a public drinking water supply or waterway that is less than 100 metres upstream of a point of extraction from a water source for a drinking water supply (not being a water supply exclusively for stock).

✓ Contaminated safety equipment, machinery and any other equipment that has been in contact with the pesticide are washed at a location where runoff is unlikely to enter any natural waterbody.

✓ All pesticide not legally applied and all pesticide packaging is removed from DOC administered land and disposed of in a way which meets all legal requirements.

✓ The boundaries of the bait preparation and loading site are marked and loading site signs (docdm-353812) erected. At the end of every day of the operation (including the final day), the loading site and any storage area must be fenced so that people do not inadvertently enter the site and stock cannot gain access to the area. The fence and signs remain in place until you judge that there is no longer a risk to stock.

✓ The product must only be used as specified on the manufacturer's product label.

✓ *= Compulsory for this operation*

☐ Use bait sowing buckets with retractable legs.

☐ Designate a "Safety Officer" on loading site who audits and ensures adherence to safety standards.

☑ *[Add further standards as required, using extra pages if needed. Attach conditions from other*

To include these performance standards as part of your operational plan, attach: conditions from other consents, product label and MSDS.

consents as separate pages.]

Information Needs

*Compulsory for **all** operations*

✓ Caution Period Monitoring: Monitoring physical breakdown of bait and carcasses is required. See Chapter 6 of the Obtaining Consents SOP.

✓ = *Compulsory for this operation*

☐ Monitoring: Monitor pindone residues in carcasses of animals killed. Cage several carcasses and periodically send samples with time since poisoning for residue testing (VPRD) and report results in operational report.

☐ Monitoring: Monitor for native and introduced non-target animals in operational area, send samples for residue testing (VPRD) and report search effort and results in operational report.

☐ Monitoring: During operations monitor populations of species identified in AEE as perceived to be at risk.

☐ Monitoring: Monitor game bird populations in operational areas.

☐ Monitoring: Residue test shot samples of feral animals in operational areas, especially pigs and game birds and report results in operational report.

☐ Monitoring: Follow best practice for pre and post control result monitoring to estimate percentage kill and report results in operational report.

☑ *[Add as required.]*

Operational Planning & Design Considerations

- Have AEE independently peer reviewed.

My approval dated *[date]* is subject to these performance standards being met. Compliance monitoring may occur.

_____.

[Name] Conservator

To include these performance standards as part of your operational plan, attach: conditions from other consents, product label and MSDS.

Appendix 8