BEFORE THE WAITANGI TRIBUNAL | WAI 903

IN THE MATTER of the Treaty of Waitangi Act 1975

AND

IN THE MATTER of the Whanganui Inquiry

BRIEF OF EVIDENCE OF PENELOPE MARY FISHER
Dated 1 September 2008

Landcare Research New Zealand Limited (Pamela Pye)
Gerald Street, P O Box 40, Lincoln 7640
Telephone: (03) 321 9999, Facsimile (03) 321 9997

1 Introduction

1.1 My name is Penny Fisher. I have been employed by Manaaki Whenua Landcare Research New Zealand Limited as a research scientist since July 2001. I hold the degrees of BSc (zoology, Melbourne University), MAppSc (ecology, Monash University) and am currently awaiting confirmation of my PhD (ecotoxicology) from Lincoln University. I am first author of 15 peer-reviewed scientific papers, and co-author of another 18. My area of science expertise is the management of invasive pest animals, particularly the use and toxicology of vertebrate pesticides.

1.2 I will be presenting information about the vertebrate pesticide sodium (mono) fluoroacetate, commonly known as 1080 ("ten eighty"). In compiling this statement I have consulted published scientific research, including work that I have contributed to as a researcher, to produce summaries of information relevant to the assessment of potential environmental and human health effects of aerial application of 1080 baits for the control of possums and other introduced pest animals. Except where I state that I am relying on the specified evidence of another person or agency, the evidence in this statement is within my area of expertise.

1.3 This statement also includes summaries of the reassessment of 1080 by the Environmental Risk Management Authority (ERMA), and operational information concerning the application of 1080 for possum control in the Whanganui area. My expertise is not in the operational aspects of the application of 1080 for possum control, or the consultation processes used in the reassessment, hence for these topics I have simply summarised information and data sourced from ERMA, the Department of Conservation (DOC), the Animal Health Board (AHB) and Horizons Regional Council (Horizons).

2 1080 as a vertebrate pesticide and mode of action

2.1 1080 is manufactured in Alabama in the United States. When the technical grade (raw) 1080 product enters New Zealand it is converted to soluble concentrate and bait at factories in Wanganui, Waimate and Christchurch. The major producer of 1080 bait formulations in New Zealand is Animal Control Products, a State-owned enterprise.

2.2 Internationally, 1080 is a restricted-use pesticide. The most extensive use occurs in New Zealand, involving approximately 80% of the world's production of manufactured 1080. Australia is the next biggest user of 1080, which is also registered as a vertebrate pesticide in Israel, the United States, South Africa and, pending the outcome of reviews, in Canada. In the United States, 1080 has relatively small, limited use in livestock protection collars for predator control (Cavanagh & Fisher 2005). The United States Environmental Protection Agency is currently considering proposals to ban this use of 1080.

2.3 1080 has been used in New Zealand since the 1950s for the control of introduced pest mammals, especially possums. Various bait formulations containing 1080 are currently registered in New Zealand, but only cereal pellet or carrot baits containing 0.15% 1080 (i.e. 1.5 milligrams of 1080 per gram of bait) can be applied aerially for the control of possums and rats. Carrot baits are usually prepared at the site of the operation where carrot pieces chopped and sieved to a specified size are coated with soluble concentrate.

2.4 1080 is highly toxic to mammals (including humans) (e.g. Eisler 2000). Fluoroacetate, the toxic component of 1080, occurs naturally in some poisonous plants including species native to Australia (Twigg *et al.* 1996), Africa (Meyer 1994) and Brazil (de Oliveira 1963). The technical-grade manufactured product, sodium fluoroacetate is a highly water-soluble white powder (Pelfrene 2001). Sodium fluoroacetate is a 'salt' form of fluoroacetate, used because it is more soluble in water and thus readily formulated into bait products. Once in water, the sodium bond dissociates, leaving fluoroacetate in solution. Thus after ingestion, the mechanism of toxicity of naturally occurring fluoroacetate and of 1080 is the same (de Moraes-Moreau *et al.* 1995).

2.5 Once within the body, 1080 is converted in cells to fluorocitrate. Fluorocitrate affects the function of a number of enzymes, but especially inhibits one enzyme in the Krebs cycle, which is a metabolic pathway that converts food to the energy used for normal cell functions. Sufficient inhibition of energy production in this way results in either cardiac or respiratory failure (e.g. Savarie 1984).

2.6 1080 poisoning can be lethal or sub-lethal. In mammals, signs of poisoning usually become evident between 0.5 and 3 hours after ingesting 1080. Animals receiving a sub-lethal dose show mild symptoms, and metabolise and excrete 1080 over a number of days and recover (Eason *et al.* 1997). Animals receiving a lethal dose show more severe symptoms, and in general herbivores appear to die of cardiac failure, whereas carnivores die of respiratory failure associated with central nervous system disturbances and symptoms such as convulsions (Egeheze & Oehme 1979).

3 1080 in Water

3.1 The Drinking-Water Standards for New Zealand give the Provisional Maximum Acceptable Value (PMAV) for 1080 in water as 3.5 parts per billion (ppb) (Ministry of Health 2000). The PMAV value is one that is not considered to cause any significant risk to the health of the consumer over a lifetime of consumption of the water. However, the Ministry of Health also recommends 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.

3.2 Because of its solubility, 1080 will readily form a solution and become diluted in water. Laboratory analysis can detect 1080 in water at concentrations as low as 0.1 ppb. Monitoring of water after aerial application of 1080 baits is routinely undertaken in New Zealand. Water samples are collected from streams during the days immediately after bait application, from within or adjacent to the baited areas where there would be the greatest chance of detecting contamination were it to occur.

3.3 Between 1990 and June 2008, 2098 water samples have been tested by Landcare Research. There was no detectable 1080 in 96.4% of these samples. Concentrations of 1080 in the remaining 76 (3.6%) samples ranged from 0.1 to 9 ppb. 324 of the 2098 samples were taken from reticulated town drinking water supplies, and one of these contained detectable 1080 residues at 0.2 ppb. Water testing results from the Whanganui area in particular are summarised in paragraph 12.9 below.

3.4 In aerial applications of 1080 baits, dilution (how much 1080 enters what volume of water) and water flow volume and rate are important factors determining the concentrations of 1080 likely to be present in waterways.

3.5 Suren (2006) surveyed 48 streams during four aerial 1080 operations in New Zealand's South Island to quantify the number of 1080 baits falling into streams. The number of baits found in streams varied widely, and was related only to bait size, with more small baits found in streams than large baits. The fate of submerged 1080 baits was also examined in a laboratory flow tank. Submerged baits fragmented within 3–4 days and 1080 was rapidly leached from them: almost 50% of original 1080 had leached after 5 hours, and more than 90% after 24 hours. This finding has implications for water quality monitoring programmes used during 1080 drops, as samples should be collected within 4 to 8 hours of potential contamination to detect presence of 1080.

3.6 Laboratory studies have shown that 1080 in solution is biodegraded by aquatic plants and micro-organisms. The rate of 1080 degradation in water with natural biota is temperature-dependent, occurring more rapidly at higher temperatures, reportedly within 1–2 weeks at <7ºC (Ogilvie *et al.* 1996). I could find no publications about degradation rate in water at temperatures within the zero to 7°C range.

3.7 Monitoring to date does not suggest significant or prolonged 1080 contamination in surface or ground waters. For this reason, testing of waterways before aerial application of 1080 bait is not undertaken. However, continued water sampling and testing following aerial bait application is prudent to ensure minimal risk of exposure of the public to contaminated water.

4 Effects on non-target aquatic animals

4.1 The acute toxicity of 1080 to small freshwater crustaceans ('water fleas' /*Daphnia magna*) over 48 hours was measured. The no-observable-effect concentration (NOEC) of 1080 in water was determined as 130 ppm, so that 1080 was classified as practically non-toxic to *Daphnia* (Fagerstone *et al.* 1994).

4.2 Suren & Lambert (2006) assessed the ecological effect of 1080 leaching from baits on New Zealand freshwater invertebrate communities in four streams on the West Coast (South Island). Four sites were selected in each stream: 10 metres and 100 metres below and 10 metres and 100 metres above where 1080 cereal pellet baits were placed. All sites were monitored both four days and one day before 1080 baits were added to each stream and then one day and four days afterwards. The baits placed in streams simulated bait densities 10 times greater than those previously found after normal aerial baiting operations. Invertebrate communities were quantified by sampling ten replicate rocks at each site. Caddisflies, midges, and a mayfly species dominated the community and the addition of 1080 baits to the streams had no detectable effects on the invertebrate community.

4.3 In comparison to mammals, fish are less susceptible to 1080 toxicity. Fingerling bream and bass survived without any signs of toxicity in water containing 370 ppm 1080 (King & Penfound 1946). In New Zealand, fingerling trout were subjected to

1080 concentrations of 500 and 1000 ppm without any visible effect on the fish, and in a separate study rainbow trout were maintained in 580 ppm 1080 for 24 hours with no ill effects (Batcheler 1978). Force-feeding pellets containing a total of about 4 mg of 1080 (to two fingerling trout and five adult trout) or about 8 mg of 1080 (to two adult trout) also had no visible effect (Rammell & Fleming 1978). In more formal assessments of the toxicity of 1080 to fish 1080 was classified as practically non-toxic to bluegill sunfish, and as slightly toxic to rainbow trout (Fagerstone *et al.* 1994).

4.4 In the same study described in paragraph 4.2 above, Suren & Lambert (2006) assessed the effect of 1080 leaching from baits on three species of native freshwater fish. Longfin eels, koaro and upland bullies were placed into separate cages at each site in each stream, and mortality monitored during the trial. Testing of water samples collected during the fish monitoring showed that 1080 was detected only for 12 hours after baits were placed in the streams, and at low concentrations (c. 0.2 ppb), despite baits being placed in each stream at 10 times normal density. No fish died after addition of 1080 baits, suggesting that all three species were tolerant to dissolved 1080 at concentrations observed in this study.

4.5 In response to community and particularly Maori concerns about 1080 contamination of tuna, trials with captive longfin eels were undertaken (Lyver *et al.* 2005). One group of eels was exposed to water in which 1080 cereal baits had been placed, and other groups were offered as food cereal pellet baits containing 1080, or offered tissue from 1080-poisoned possums. Compared to a group of unexposed eels (controls), no mortality or unusual behaviour occurred in any eels that were exposed to 1080. None of the eels ate cereal bait and no 1080 was detected in them. However some eels ate tissues from poisoned possums – of the eight (out of twelve) eels that consumed contaminated possum muscle, low concentrations of 1080 (average 0.0174 ppm) were detected in five. Of the nine (out of twelve) eels that consumed contaminated possum gut, low concentrations of 1080 (average 0.0306 ppm) were detected in three. At these concentrations of residual 1080, the risk of acute poisoning to humans from eating contaminated eel flesh was considered extremely low. Even so, the authors point out that any detectable 1080 residues in eel meat for human consumption would be unacceptable against current food safety standards, and suggested with-holding periods for eel harvests be implemented after aerial baiting operations.

4.6 Suren & Bonnett (2006) carried out a similar study with captive freshwater crayfish (koura) exposed to 1080 baits to determine whether they consumed baits and whether such exposure caused mortality. In an artificial stream habitat, single 0.15% 1080 cereal pellet baits were added to each of 20 underwater cages containing a crayfish, alongside control treatments not exposed to 1080. The highest concentration of 1080 (1.1 ppb) in water collected from the artificial habitat occurred after 2 days, with no residual 1080 detected in the water after 8 days. Crayfish ate bait particles but no mortality was observed. Crayfish exposed to 1080 baits were tested for 1080 in their viscera and tail muscle. The highest 1080 concentrations were 3.3 ppm in the viscera, and 5 ppm in tail muscle with concentrations in the tail muscle declining between days 4 and 8, suggesting that sub-lethal doses of 1080 were metabolised. While the authors considered that the risk of acute poisoning to humans from consuming crayfish containing 1080 was considered extremely low, they also suggested a with-holding period after application of baits would minimise the risk of any human exposure to 1080 through consuming crayfish.

5 1080 in soil

5.1 1080 can be degraded by some soil bacteria and fungi (e.g. Twigg & Socha 2001). Enzymes capable of defluorinating 1080 have been isolated from several micro-organisms, whereby the fluoride carbon bond is cleaved ultimately forming non-toxic metabolites (O'Hagan & Harper 1999). Under favourable conditions in soil, such as ambient temperatures of 11–20ºC and 8–15% soil moisture, 1080 may be significantly defluorinated in 1–2 weeks. In less favourable conditions degradation may take several weeks and, in extreme cold and drought, 1080 residues may persist in baits or in the soil for several months (King *et al.* 1994).

5.2 In a 1997-98 New Zealand field trial undertaken in central North Island sites (Rangataua, Titirangi, Whitecliffs), samples of soil and leaf litter were taken before and after three aerial applications of cereal 1080 baits (Wright *et al.* 2002). There was no detectable 1080 in the 'before' samples, or in the post-baiting samples from Rangataua but low 1080 residues were detected in some leaf litter samples after baiting in the Titirangi and Whitecliffs sites. The highest 1080 concentration measured in an individual leaf litter sample was 0.19 ppm on day 5 after baiting in Titirangi, but all other samples with detectable residues were below 0.01 ppm. From available toxicity data for invertebrates, these authors estimated that invertebrates feeding on leaf litter containing the highest concentration of residual 1080 measured in their study (0.19 ppm) would be unlikely to ingest enough for a toxic exposure.

5.3 The hazard of 1080 in soil to earthworms was evaluated in controlled laboratory tests. No mortality was measured in worm populations exposed to up to 865 milligrams of 1080 per kilogram of soil (i.e. 865 ppm). The lowest concentration of 1080 in soil at which any effect was measured was 90 mg 1080/kg soil (i.e. 90 ppm) which reduced earthworm cocoon production (O'Halloran *et al.* 2005). The same study also investigated the effects of 1080 on the ability of soil microbes to carry out nitrate mineralisation, a key metabolic function. Concentrations of 1 gram of 1080 per kilogram of soil (1000 ppm) did not affect the ability of soil microbes to mineralise nitrogen.

5.4 In 2007, the reassessment of 1080 by the Environmental Risk Management Authority (see paragraph 10 of this statement) produced a number of research recommendations. One of these was to measure the degradation pathways of 1080 in soil, and the rates of degradation in three New Zealand soil types at different temperatures, following a formal test guideline specified by the Organisation for Economic Co-operation and Development (OECD). HortResearch and Landcare Research are currently undertaking this research under contract to the Animal Health Board.

6 Effects of 1080 on plants

6.1 Plants can absorb 1080 through their roots, and in some laboratory studies toxic effects on plants have been recorded at high concentrations of fluoroacetate in the growth medium (e.g. Cooke 1976). Defluorination metabolism (i.e. detoxification) of 1080 has been demonstrated in some plants (Ward & Huskisson 1972; Vickery & Vickery 1975).

6.2 In laboratory trials where lettuce and oat plants were germinated in soil treated with different concentrations of 1080, lettuce seedlings were more sensitive than oats. Lettuce seedling emergence and seedling shoot growth were adversely affected at a soil concentration of 7 milligrams of 1080 per kilogram of soil (7 ppm) (O'Halloran *et al.* 2005).

6.3 In a laboratory trial with two New Zealand plant species, broadleaf and perennial ryegrass, a single 1080 cereal pellet bait was placed on the soil next to individually-potted plants (Ogilvie *et al.* 1998). In both species 1080 leached from baits was absorbed from the soil. In ryegrass the peak concentrations was 0.08 ppm at three days and in broadleaf 0.08 ppm at ten days. Concentrations of 1080 decreased over 38 days to below the limits of detection, and the authors concluded that these concentrations were unlikely to cause secondary poisoning of herbivorous mammals or insects.

6.4 More recently, field research has been undertaken to determine if plants used by Maori for food and medicine would take up 1080. At a site south of Lake Waikaremoana, single cereal pellet baits were placed at the base of naturally-growing, individual plants of two species, pikopiko (*Asplenium bulbiferum*) and karamuramu (*Coprosma robusta*) (Ogilvie *et al.* 2006). 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 was detected in karamuramu at a maximum concentration of 5 ppb after 7 days and 2.5 ppb after 14 days. This concentration decreased to zero at 28 days indicating that residual concentrations were not persistent. This result indicated negligible risk of humans being poisoned by consuming plants that have taken up 1080 from baits. However the authors suggested that to allay community concerns that minute concentrations of 1080 might influence the medicinal properties of plants, a withholding period of 30 days after 1080 baiting operations could be adopted.

6.5 A similar field study to determine whether other kai plant species, puha (sow thistle) and watercress, will also take up 1080 is currently being undertaken by Lincoln University in collaboration with Landcare Research.

7 Effects on invertebrates

7.1 While toxicity data for invertebrate species is more limited than that available for mammals and birds, some invertebrates appear less susceptible to 1080 than others (e.g. Twigg 1990, Eason *et al.* 1993, Booth & Wickstrom 1999). 1080 has been used experimentally as an insecticide for fleas, aphids and wasps (David 1950; Spurr 1991).

7.2 Use of apple paste ('jam') bait formulations of 1080 found to be attractive to bees (e.g. Goodwin & Ten Houten 1991) was discontinued in 1995 (D. Morgan, Landcare Research, pers. comm.) because of the potential risks of bee mortality and contamination of honey.

7.3 A range of studies have reported invertebrates feeding on 1080 baits and on carcasses of poisoned animals, indicating a risk of poisoning to susceptible species (e.g. Notman 1989; Spurr & Drew 1999; Sherley *et al.* 1999). This risk remains during the period where any uneaten baits laid for possum control have not degraded. Following sublethal exposure invertebrates may contain residual concentrations of 1080 before it is metabolised and excreted, presenting a short-term secondary hazard to insectivores (e.g. Booth & Wickstrom 1999; Lloyd & McQueen 2000).

7.4 A report by Meads (1994) describes a field study of the effects of 1080 baiting on invertebrate populations of Whitecliffs Conservation Area, Taranaki. Landcare Research was contracted by the Department of Conservation to carry out this work. From June 1991 to February 1993, invertebrates were monitored by pitfall trapping before, during and after the aerial application of 1080 baits. The study concluded that populations of some invertebrates were reduced in plots where 1080 bait was applied, but also that invertebrate populations in the control (unbaited) plots were reduced 6 weeks after bait application due to contamination with 1080 dust after heavy rainfall.

7.5 The report by Meads (1994) was not published, because scientific peer review identified concerns about the design of the experiment and the validity of the conclusions drawn. The results of the study become part of an ongoing controversy around the use of 1080, through a series of articles and letters published in August and September 1995 issues of the 'Rural News'. Assertions made by Meads (1994) about the negative impacts of aerially applied 1080 on invertebrates prompted a number of further field studies in New Zealand.

7.6 Potential exposure of invertebrates to 1080 through dust produced from aerial application of baits was further investigated in a 1997-98 New Zealand field trial undertaken in central North Island sites. Wright *et al.* (2002) (mentioned in paragraph 5.2 above) also sampled for bait dust at 1 and 5 days after three aerial applications of cereal 1080 baits. A maximum concentration of 25.2 μg 1080 per square metre was detected in dust collectors within the control zones one day after bait application. Lower concentrations of 1080 (average 0.03-0.14 μg per square metre) were found at day 5, at sites up to 1000 metres outside two of the three treatment areas. These concentrations were not considered to pose a significant risk of poisoning to invertebrates living in the leaf litter.

7.7 Other New Zealand field studies report limited impacts on invertebrate populations following 1080 applications. Spurr (1994) reported no significant impacts on invertebrate populations monitored by pitfall traps following 1080 aerial applications in a study with matched treatment and non-treatment areas. Aspin *et al.* (1999) also observed no impacts on the numbers of ground-dwelling insects up to 1 year after an aerial 1080 application. Spurr & Berben (2004) used artificial refuges and mark-recapture techniques to monitor the impacts of 1080 baiting on populations of weta and other invertebrates in Tararua Forest Park, North Island. Invertebrate numbers in refuges were monitored for 12 months before and 4 months after bait application. There was no significant impact on the numbers two species of weta, or on slugs, spiders and cockroaches, the most numerous other invertebrates occupying the refuges. These authors concluded that their results indicated that 1080 poisoning for vertebrate pest control is unlikely to have any negative impact on populations of weta or the other invertebrates monitored. In a more recent field-monitoring study, Powesland *et al.* (2005) also concluded that aerial 1080 baiting operations were unlikely to have a detrimental effect on invertebrates tree weta, cave weta, cockroaches, spiders and harvestmen, and leaf-veined slugs.

7.8 In general the literature suggests that some invertebrates will find and eat 1080 baits following aerial application, and that while mortality is likely in the insects that eat toxic baits, long-term adverse impacts at the population level have not been measured. At any one time, only a small proportion of baits are likely to have invertebrates on them, and the few individuals per bait represent a small section of the fauna present in forest litter (Sherley *et al.* 1999; Spurr & Drew 1999; Spurr *et al.* 2002).

8 Effects on birds

8.1 1080 is highly toxic to many birds (e.g. Eisler 2002), and concerns are often expressed about the non-target impacts of 1080 baiting operations on birds, especially native species. A range of bird species have been reported dead following 1080 operations (e.g. Spurr & Powesland 1997), and although the cause of death is not always confirmed, in some cases where analyses have been carried out the presence of residues in carcasses has indicated exposure to 1080. Although mortality of individual birds is undesirable, from a conservation perspective effects on small numbers of individuals are less important than effects on populations of a bird species in an area. The benefits to birds of possum, rodent and rat control achieved by 1080 operations also need to be considered in a cost-benefit appraisal.

8.2 Radio transmitters have been used to monitor impacts on less common bird species. Thirty-five radio-tagged kiwi survived at least 3 months after 1080 as 0.15% cereal pellet and 0.08% jam baits were hand-laid in ground-based operations during 1994 to 1996 (Robertson *et al.* 1999). Twenty-one kaka and 19 blue duck were radio-tagged and monitored before and after aerial application of cereal baits at 15 kg/ha in the Waihaha Ecological Area in 1994, and all birds survived at least 4 weeks (Greene 1995). One of 24 radio-tagged weka was found dead, and one was found sick but recovered, following aerial application of 0.15% cereal pellets at 5 kg/ha in 1997 at Gouland Downs (Walker cited in Spurr & Powesland 1997). Eight radio-tagged weka survived following application of cereal pellet baits at 5 kg/ha in 1994 at Rotomanu (Miller cited in Spurr & Powesland 1997). Seven radio- tagged more porks were all alive at 5 days, and six (one transmitter lost) were alive 1 month following aerial application of cereal pellet baits in 1994 at Tennyson Inlet (Walker cited in Powesland *et al.* 1998). Radio-tagged more porks (9 more porks in poisoned area, 5 in non-poisoned) survived following aerial application of carrot baits at 15 kg/ha in 1995 at Pureora Forest Park. However, one more pork was found dead and contained residues of 1080 (Powesland *et al.* 1998).

8.3 Kereru and kaka in Whirinaki Forest Park were radio-tagged from October 1998 to June 2002 and monitored in one baited and one non-baited study area to compare 1080-related mortality, nesting success and survival. 1080 carrot baits were spread in May 2000 and all radio-tagged kaka and kereru in the treatment area survived the poison operation. After this, the nesting effort and success of kaka and kereru was monitored for each of four nesting seasons, with the main cause of nesting failure for both species being identified as predation. Predation by introduced mammalian predators was the main cause of mortality of kaka eggs, chicks, fledglings and adult females, and of kereru eggs, chicks, fledglings and adults (Powesland *et al.* 2003).

8.4 Colour-banding birds to enable individual identification upon resighting has also been used to measure effects of 1080 baiting. Colour-banded North Island robins were monitored in poisoned and non-poisoned areas, in August 1996 during an aerial carrot baiting operation that included much chaff (small pieces of toxic carrot). This operation resulted in 43% mortality of territorial birds and during the same period there was no robin mortality in the non-poisoned area. By comparison, a September 1997 operation that included minimal amounts of chaff resulted in 8.6–9.7% robin mortality, which did not differ significantly from mortality in the non-poisoned area. Robin breeding was particularly successful in the poisoned areas following the two poison operations, suggesting that as long as carrot bait preparation protocols to minimise chaff production are strictly adhered to, robin populations will benefit from possum control operations (Powesland *et al.* 1999). Colour-banded North Island tomtits were monitored in poisoned and non-poisoned areas in Pureora Forest Park. In August 1997 an aerial carrot baiting operation resulted in 11 (79%) of 14 tomtits disappearing, but none of nine from the non-poisoned area. Whether the birds died from poisoning is unknown. During the 1997/98 nesting season, tomtit pairs in the area poisoned in 1997 had high nesting success, but even so, by the following spring it seemed that the population had not recovered to its pre-poison level (Powesland *et al.* 2000). No tomtits in either poisoned or non-poisoned areas disappeared following an August 1998 aerial pellet bait operation.

8.5 Counts of birds before and after baiting have also been used to measure non-target effects. There was no reduction in visual counts of blue duck following aerial application of cereal pellets at 6 kg/ha in 1989 at Otira Valley (Miller in Spurr & Powesland 1997). Five-minute counts of kaka and kakariki in poisoned and non-poisoned blocks following aerial application of cereal pellets at 7 kg/ha in 1994 at Pureora was inconclusive due to inadequacies in the indexing method (Calder & Deuss 1995). Fourteen fernbirds and five of six kokako pairs were re-sighted 5 weeks after aerial application of pellet baits at 5 kg/ha at Waipoua Forest in 1990. There was a decrease in detection of blackbirds and tomtits in treatment areas, but silvereye and tui were noted in higher numbers after the operation (Pierce & Montgomery 1992). In monitoring of forest birds at 6-weekly intervals for one year following aerial application of pellet baits at 11.8 kg/ha on Rangitoto Island in 1990, silvereyes, greenfinches and harrier hawks all showed significant increases in conspicuousness immediately after poisoning and 1 year later. Chaffinches showed an immediate increase after the operation but not after 1 year, and tui showed no increase immediately after but a significant increase 1 year later (Miller & Anderson 1992).

8.6 Recent media coverage (e.g. Dominion Post, 31 July 2008) of kea mortality following an aerial 1080 baiting operation on the West Coast of the South Island highlights an ongoing need for research of the effects of 1080 on native species. In a study conducted by DOC, keas in three areas were fitted with radio transmitters and tracked during and after bait application. Seven out of 17 kea in one population near Fox Glacier were confirmed to have died from 1080 poisoning, while no kea died in two other areas where they were also monitored. A current theory is that the kea in the Fox Glacier population were more used to sampling a range of artificial food types because of their more frequent proximity to human (tourist) activity. I would expect that this significant mortality will prompt further research of why the kea in the Fox Glacier population were particularly affected, and the development of strategies to prevent such impacts in future.

9 Effects on bats

9.1 A small number of New Zealand studies address potential effects of 1080 on short-tailed bats. Beath *et al.* (2004) found that short-tailed bats would sample some non-toxic bait and lure types in captivity, including cereal pellets lured with cinnamon. They noted that previous field trials had shown no evidence that short-tailed bats will approach baits in the wild but suggested that the least-favoured bait types and lures be used in areas where there were short-tailed bats.

9.2 The potential secondary risk to short-tailed bats has been addressed in a review of available, but limited, information (Lloyd 1994) which indicates that short-tailed bat populations were unlikely to suffer from poisoning through individual bats consuming arthropods that had fed on 1080 baits. A field trial (Lloyd & McQueen 2002) monitored short-tailed bat mortality during 11 days after 1080 baits were broadcast over their winter foraging area. It was concluded that this 1080 operation probably did not cause major mortality of the short-tailed bats, but the authors indicated that further trials are required before a generalised conclusion could be drawn about the fate of short-tailed bats following aerial 1080 operations.

9.3 I did not find any research publications relating to effects of 1080 on New Zealand long-tailed bats.

10 Effects on human health & regulatory toxicology of 1080

10.1 There is little information specifically about the effects of 1080 exposure on people, and most of the available data concerns relatively high exposures. The oral toxicity of 1080 to adult humans is estimated at 2 to 10 milligrams of 1080 per kilogram of bodyweight (Chenoweth 1949). Cases of acute human poisoning have been reported outside of New Zealand (e.g. Harrison 1952; Brockmann 1955; Trabes 1983; Chi *et al.* 1996, 1999) and have generally been either accidental ingestion of a pest control product by children, or deliberate ingestion by adults. In the first case of intentional ingestion of 1080 in the USA in over 15 years, an adult male was hospitalised under intensive care and 2 days later was discharged with no evidence of neurologic effects (Robinson *et al.* 2002).

10.2 1080 powder or solution is not volatile but could become airborne as dust, fine particles or mist. As the result of an improper application of 1080 for rat control in a South American steel mill, several workers became seriously ill, possibly due to inhalation exposure (LaGoy *et al.* 1992). A published account of a person who accidentally inhaled 1080 powder and survived describes the effects of inhalation exposure (Williams 1948).

10.3 Regulatory toxicology data are derived from standardised laboratory tests to address questions of toxicity and possible adverse effects on human and environmental health, on the basis that adverse reactions in humans and natural environments can be predicted from animal and *in vitro* tests in the laboratory. For example, results of three different laboratory tests with bacteria and cultured cell lines indicate that 1080 is not mutagenic, and is thus not anticipated to be carcinogenic (Eason *et al.* 1999).

10.4 A range of mammalian study data indicates that single or repeated sub-lethal doses of 1080 can have reproductive and/or developmental toxicity. Early reports indicated that relatively high doses of fluoroacetate could cause teratogenicity (effects on developing foetuses) in rats (de Meyer & de Plaen 1964). 1080 caused developmental defects in foetal rats when pregnant females were exposed to relatively high doses of 1080 on a daily basis during days 6 through to 17 of gestation, when a significant proportion of foetal development occurs (Eason *et al.* 1999). Teratogenic effects of 1080 occurred at 0.75-mg/kg/day dose, but not at lower doses, so that the developmental no-observable-effects level (NOEL) was 0.1 milligram of 1080 per kilogram of bodyweight per day (Eason *et al.* 1999).

10.5 Pregnant ewes were administered high sub-lethal doses of 1080 as single (0.25 mg/kg) or multiple oral doses (0.05 mg/kg over 3 consecutive days) of 1080 cereal pellet baits. There were no differences in growth rates between lambs from dosed and undosed pregnant ewes (O'Connor *et al.* 1999).

10.6 Chronic administration of high, sub-lethal oral doses of fluoroacetate in rats has been shown to temporarily inhibit growth rates (Miller & Phillips 1955; Smith *et al.* 1977; Sullivan *et al.* 1979). However, lower sub-lethal repeated doses did not affect the growth rates in groups of young laboratory rats that received daily oral doses for 90 days, as no significant changes in body weight in comparison to control animals were measured (Eason & Turck 2002).

10.7 1080 has been described as a "male reproductive toxicant" because testes are a target organ in mammals (e.g. Mazzanti 1965; Sullivan *et al.* 1979; Eason & Turck 2002), at least one species of bird (Balcomb *et al.* 1983) and one species of reptile (Twigg *et al.* 1988). In a recent study, the NOEL for testicular damages in rats administered oral sub-lethal doses of 1080 for 90 days was 0.075 milligrams of 1080 per kilogram of bodyweigh per day. The lowest-observable-effects-level (LOEL) dose was 0.25 mg/kg/day (Eason & Turck 2002).

10.8 Cardiac muscle (heart) is also recognised as a target organ following sub-lethal exposure of mammals to 1080, with cardiac histopathology reported in herbivores especially (e.g. Gooneratne *et al.* 2008). In a recent laboratory study, where rats were orally administered sublethal doses of 1080 for 90 days, there were 1080-related changes in heart weights of male and female rats so that the NOEL was 0.075 mg/kg/day, and the LOEL dose was 0.25 mg/kg/day (Eason & Turck 2002). In mallard ducks dosed with 1080, histopathological lesions indicated that skeletal (wing) muscle was a target organ for 1080-induced damage in birds (Ataria *et al.* 2000).

10.9 Current human health risk assessments for 1080 and regulatory toxicology approaches in New Zealand recognise sublethal effects of 1080 on myocardial and testicular tissue, using data from the recent studies with laboratory rats described above (e.g. Foronda *et al.* 2007). While gaps in toxicological information about the effects of 1080 remain (e.g. Weaver 2003), risk to humans can be minimised by ensuring that exposure does not occur. Thus ongoing monitoring of the occurrence of 1080 residues in potential environmental pathways of human exposure, such as drinking water and food, retain an important role in confirming whether exposure is likely to occur or to be repeated.

11 Reassessment of 1080 by ERMA New Zealand

11.1 Recent reassessment of 1080 by the Environmental Risk Management Authority (ERMA) New Zealand has relevance to the topics covered in my statement. Information in paragraphs 11.2 to 11.10 has been derived from a report produced by ERMA (2007) and is included here as summary background information, rather than being my own comment on the validity or integrity of the reassessment process.

11.2 In March 2002, an ERMA committee determined that there were grounds for reassessment of 1080, which were; the large increase in the amount of 1080 being used and planned for use, the completion of significant research on 1080 since it was first registered in 1964; and considerable public concern about the use of 1080.

11.3 In October 2006, the AHB and the Department of Conservation jointly submitted a formal application to ERMA for reassessment of 1080, seeking approval for the continued use of 1080 for the control of possums and other pests, including rabbits, wallabies, rodents and stoats. ERMA New Zealand made an analysis of the application and produced an Evaluation and Review (E&R) report with a number of recommendations, as background for the Authority's decision-making committee.

11.4 The process for reassessing a hazardous substance provides the opportunity for the public to make submissions. A total of 1406 public submissions were received on the 1080 application, and submitters were invited to respond to recommendations from the E&R report, during public hearings at seven different locations around New Zealand. In making its final decision, the Committee considered the application, all written submissions, oral presentations made at the hearings, the E&R Report and a report produced by ERMA New Zealand's Maori Advisory Committee.

11.5 The Hazardous Substances and New Organisms Act 1996 (HSNO Act) requires that decision making takes into account the relationship of Maori to the environment and the principles of the Treaty of Waitangi. ERMA New Zealand is supported by a Maori Advisory Committee, Nga Kaihautu Tikanga Taiao, which is responsible for providing advice and assistance on applications. Nga Kaihautu provided a report on the application for reassessment of 1080 and formally presented this at a public hearing.

11.6 The applicants conducted national consultation with Maori prior to formal application, to canvass opinion and obtain information on issues or concerns posed by the continued use of 1080. In addition, ERMA New Zealand hosted a hui on 1080 for its Maori National Network in November 2006. One consistent theme throughout the feedback provided by iwi/Maori was a desire to improve engagement with pest and conservation management agencies in decision-making relating to 1080 operations.

11.7 The Committee heard expressions of opposition from a number of Maori to the use of 1080, but there was also a level of reluctant acceptance among many Maori that, at this stage, 1080 is the best tool available for protecting taonga species of native birds and plants. Some submitters expressed concern that the use of 1080 undermined traditional knowledge and the kaitiakitanga role. Other Maori submitters considered the continued use of 1080 as being vital to the long-term security of taonga species and provided information about the positive results of successful operations. They noted that the more involvement they had in the development and implementation of operations, the more beneficial the outcome was overall. In general, Maori submitters were concerned that they were not sufficiently involved in the decision making processes either at the strategic or operational level.

11.8 The Committee considered these issues within the context of the Treaty of Waitangi noting that the three principles of partnership, participation and protection were relevant. At the partnership level, the Committee encouraged agencies to review the options for stronger Maori involvement in the development and decision making for pest and conservation management strategies. The Committee also believed that the early and meaningful participation of Maori in the planning, implementation and monitoring of 1080 operations was important and has put in place controls aimed at ensuring that this occurs. In terms of protection, the Committee noted the expressions of grievance outlined by submitters about the possum (and other) pest problem, but considers that the efforts of agencies like DoC and the Animal Health Board (AHB) are addressing the need to actively protect Maori interests.

11.9 The Committee decided to allow the continued use of 1080 but also placed additional mandatory controls especially around aerial application of 1080, and also a list of recommendations so that a tighter management regime is now required for aerial drops of 1080. Full details of the reassessment process and outcomes are available on the ERMA New Zealand website (**http://www.ermanz.govt.nz/news-events/1080/Decision%20_2007.08.10_%20FINAL.pdf**).

11.10 The Committee recognised the importance of engagement, attributing some of the concern surrounding aerial drops of 1080 to poor communication and consultation on the part of a few users. The Committee's recommendations and controls are aimed at improving this situation, with one specific recommendation being those using 1080 aerially must consult in good faith with local iwi/hapu. This recognises the principles of the Treaty of Waitangi and seeks to ensure the role of Maori as kaitiaki is protected and will be implemented through permissions granted for 1080 use under the Hazardous Substances and New Organisms Act.

12 1080 use and monitoring in the Whanganui area

12.1 Possum control in the area is undertaken by the Department of Conservation (DOC) for conservation purposes and by the Animal Health Board (AHB) and Regional Councils (e.g. Horizons) for vector control of bovine tuberculosis.

12.2 Areas over which DOC undertakes possum control are largely those areas of Whanganui National Park between Whakahoro and Pipiriki, Waitotara Conservation Area and Jean D'Arcy Conservation Area. Currently DOC undertakes sustained pest animal (possum) management on approximately 91,000 hectares of National Park, scenic reserves, conservation areas and other lands of which <1000 ha is treated by ground based methods using trapping and poisons including cyanide, cholecalciferol and 1080. Most of the area within the Department of Conservation's "Area under sustained control for possums" is managed with a cyclical programme of aerial 1080 bait application with approximately 7 years between cycles. DOC plan to increase the cycle frequency to 3 yearly, reduce aerial bait application rates and slightly reduce the area under sustained management. The change follows a review of options for achieving greater protection for kiwi and blue duck as well as continued protection for the forest canopy (communication from B. Fleury, DOC).

12.3 In the Whanganui Area prior to 1995/96, DOC undertook ground-based control of possums in ten small reserves or discrete parcels of Whanganui NP near Taumarunui using trapping or bait stations. Control was commenced using Task Force Green workers in 1993/94 and continued by the Department until about 1996 when control in these areas was subsumed into larger AHB operations. The area around Rotokahu (Lake Hawks) was aerially treated with 1080 cereal baits at c. 7 kg/ha over c.500 ha in 1991/92. Maintenance control around the boundary and accessible areas with brodifacoum and/or cyanide was continued by DOC until about 1996 when control in these areas was also subsumed into larger AHB operations.

12.4 A series of 'Wild Animal Control Reports' produced by DOC Wanganui Conservancy (e.g. Stronge & Dijkgraaf 2001, Stronge *et al.* 2004, Mackintosh & Hawcroft 2008) provide an overview of vertebrate pest control on conservation land managed by DOC. Appendices 2 of Mackintosh & Hawcroft (2008) and Stronge et al. (2004) provide table summaries of histories of possum control. From these tables, and possum monitoring data in Appendix 3 of Mackintosh & Hawcroft (2008), the history of application of 1080 baits by DOC within the Whanganui rohe is summarized as follows.

12.5 Wanganui Area:

- WNP River Trench, Heao/Mungapurua : 1080 cereal baits aerially applied at 5 kg/ha in 1995/96 over 20, 055 ha. This was DOCs first major possum control operation within the rohe. A further 255 ha of areas around wahi tapu and campsites was treated by iwi contractors under DOC supervision using 1080 in bait stations. In 2002/03, 1080 cereal pellet baits were again appliced over 21,000 ha.
- Matemateonga Stage 1: Knockdown aerial 1080 in 1995/96 (13,268 ha), in 1996/97 (4,112 ha), maintenance aerial 1080 in 2004/05 (16,656 ha)
- Matemateonga Stage 2: Knockdown aerial 1080 in 1996/97 (13,501 ha), AHB operation in 2001/02 (510 ha), maintenance aerial 1080 in 2003/04 (13,540 ha)
- Matemateonga Stage 3: Knockdown aerial 1080 in 1997/98 (4,745 ha), maintenance aerial 1080 in 2003/04 (6,090 ha)
- Matemateonga Stage 4: Knockdown aerial 1080 in 1999/00 (12,000 ha), maintenance aerial 1080 in 2005/06 (12,870 ha)
- Matemateonga Stage 5&6: Knockdown aerial 1080 and ground-based cyanide 2000/01 (20, 769 ha)

12.6 New Plymouth Area (where portions of operational areas below fall in the Whanganui rohe)

- Tangarakau: Knockdown aerial baiting in 1995/96 (1,875 ha), maintenance aerial application in 2003/04 (2,086 ha)
- Waitaanga: Knockdown aerial baiting in 1995/96 (18,697 ha), ground application of 1080 to part in 1996/97, maintenance aerial application in 2003/04 (19,737 ha)

12.7 In other areas administered by DOC within the rohe, possum control is undertaken by AHB or Regional Council, sometimes using private pest control contractors, with slightly different control regimes than those used by DOC. In general, aerial applications of 1080 for vector control tend to have 3 to 5 year return times, and maintenance control on boundaries and adjoining farmland with fragmented possum habitat has often been annual. Stronge & Dijkgraaf (2001), Stronge *et al.* (2004) and Mackintosh & Hawcroft (2008), provide tables in appendices 5, 3 and 4 respectively, showing DOC-managed areas treated by a regional council or private contractor and the control methods used. While an extensive list is too long to be shown here, the majority of areas are subject to ground-based control that in some cases is supplemented with aerial application of 1080. Maps in appendix 4 of Mackintosh & Hawcroft (2008) provide a visual indication of the areas of DOC-managed land treated by other agencies in 2004/05.

12.8 Operational data provided by the Animal Health Board, covering application of 1080 in the Whanganui area between 2000 and 2008 is summarised:

- Ahu Ahu AS1 and AS2 (5,985 ha): 1080 applied in April 2006
- Hauhungaroa S1 and S2 (48,833 ha): 1080 applied to S2 in March 2000 and to both blocks in June/July 2005
- Hauhungaroa S3 (4,717 ha): 1080 applied in August 2002 and in October 2007
- Kaitieke AS1 (2,435 ha): 1080 applied in March 2006
- Kirikau AS1 (1,075 ha): 1080 applied in April 2008
- Mangaporau AS1-AS3 (8,476 ha): 1080 applied in April 2006
- Mangatepopo AS1 (6,478 ha): 1080 applied in October 2007
- Morikau AS1 (783 ha): 1080 applied in August 2001
- National Park AS1 (10,012 ha): 1080 applied in August 2005
- Niho Niho AS1 (3,376 ha): 1080 applied in November 2007
- Orautoha-DoC AS1 (5,300 ha): 1080 applied in July 2002 and in March 2008
- Papaiti AS1 (4,263 ha): 1080 applied in December 2007
- Raurimu-Tauwera AS1 (7,730 ha): 1080 applied in November 2001 and October 2006
- Retaruke AS1 (11,411 ha): 1080 applied in February 2007
- Ruatiti Stage 2 AS1 & AS2 (1,357 ha): 1080 applied in December 2006
- Ruatiti Stage 1 AS1 (2,361 ha): 1080 applied in June/July 2008
- Ruatiti Stage 3 AS1 & AS2 (7,025 ha): 1080 applied in July 2003 and in July 2008

- Tokirima AS1 (731 ha): 1080 applied in June 2006
- Tongariro Forest (5,922 ha): 1080 applied in November 2001
- Waikaka South AS1 (12,100 ha): 1080 applied in February 2006
- Waitaanga Extension (8,585 ha): 1080 applied in May 2000 and May 2005
- Whakahoro AS1 (8,975 ha): 1080 applied in May 2007

12.9 Horizons Regional Council have provided a map showing possum control operations currently (2008/09) being undertaken, and indicated proposed operations for 2009. Information on earlier pest control operations with particular regard to the use of 1080 was not available from Horizons at the time of preparing this statement.

12.10 Within the Whanganui area, between 1990 and June 2008 water monitoring has been undertaken after 34 aerial 1080 baiting operations (Residues Database, Landcare Research). 383 water samples have been tested and there was no detectable 1080 in 94% of these samples. Concentrations of 1080 in the remaining 23 (6%) samples ranged from 0.1 to 9 ppb. The latter result was from a water sample taken on the day of a carrot-baiting operation at Toko in July 1998, from a weir downstream of the baited area. The person who took the sample was wearing overalls that had also been worn during toxic bait application and took the sample in the dark so contamination of the water at sampling was a possible explanation. Of the total 383 samples tested, 76 were taken from reticulated town drinking water supplies and none contained detectable 1080 residues.

12.11 Animal samples recorded in the Residues database (Landcare Research) from the Whanganui area that were tested and found to contain detectable concentrations of 1080 are;

- Five birds (3 pied tits and 2 blackbirds) found dead in Kaimanawa Forest Park after a 1080 carrot operation 26/6/2003. All contained 1080 residues (0.07 to 4.2 ppm).
- Three honeycomb samples tested from the Taumaranui area after an operation in Tongariro National Park were found to contain 1080 residues (0.0046-0.009 ppm). No date for operation but samples received Dec 2002 and Jan 2003.
- Five sika deer were found dead after a carrot operation in Kaimanawa Forest Park (Hatepe trial) conducted 26/6/2003. All contained detectable 1080 residues (0.19-3.4 ppm).
- Five possum samples (3 muscle samples and 2 stomach contents samples) have been tested for 1080 after operations in the Hauhangaroa Ranges and all contained 1080 residues (3.4-26 ppm). No date for operation but samples received July-August 1996.
- Three stoats were fitted with mortality transmitters and killed during an aerial 1080 operation in Taranaki 60 km east of Stratford 26-28/8/1999. Stomach and muscle samples were collected after death and 1080 residues found in the muscle and stomach contents of two of the stoats (0.012-0.111 ppm) while the third stoat contained no 1080 residues. The two stoats containing residues died within the first 2 days of the operation while the 3rd one died 19 days after the 26/8 drop.

13 Specific points from claimants' statements

13.1 I have read the statements prepared by claimants where information is given about 1080 use and its effects. In general their concerns encompass issues such as contamination of waterways, contamination of kai, mortality of birds and effects on human health particularly with regard to birth defects. The above summaries of scientific information are intended to address these as topic areas. Other information provided by claimants describes specific instances or observations where an adverse effect of 1080 is suggested. Where possible I have obtained follow-up information about these to form an opinion on whether the adverse effects were likely to have been due to exposure to 1080.

13.2 While the hazard presented by 1080 (as a highly toxic substance) is clear, a critical point in these cases is the inability to confirm whether actual exposure occurred, for example through a measurement of residual 1080 in water that people were drinking. Without being able to confirm exposure to 1080 in specific instances, I do not consider it valid to attribute the reported birth defects to 1080 exposure without consideration of a wide range of other factors that may have contributed. These include genetics and heredity, lifestyle factors such as smoking, alcohol intake and medication, environmental or occupational exposure to other potentially harmful chemicals and chance. Noting that my brief concerns only the effects of 1080, further discussion of possible causes of the reported birth defects is outside my area of expertise.

13.3 From information provided by Jenny Tamakehu, I understand that a 1995 protest march against 1080 use in Whanganui started at Pakaitore, and presented a dead kereru and more pork during a hui at the Whanganui River Maori Trust Board, which was attended by representatives of DOC and the regional council. Despite enquiries, I was unable to determine whether the bird carcasses were submitted to any laboratory for analysis of 1080 concentration in tissues. Had the birds been deposited with DOC, I am unaware of any legal requirement for the carcasses to have been tested, although in the past DOC has submitted such samples to the Landcare Research toxicology laboratory for analysis that could confirm recent exposure to 1080. Paragraph 12.11 outlines the available data from the vertebrate pesticides residues database maintained by the Landcare Research toxicology laboratory, and does not indicate that kereru or more pork samples were submitted from the Whanganui area at that time. The samples may have been submitted to other laboratories in New Zealand, but I do not know which these might have been.

13.4 Some claimants have expressed concerns about the ways in which 1080 has been handled and transported. Two examples follow.

13.5 Pest control workers employed by DOC were reported to be transporting 1080 baits in their car boots, as two approximately 25 kg sacks to be used in a ground-based control operation at the Bridge To Nowhere site in 1995. Information supplied by DOC indicates that they generally employ licensed contractors to transport bait directly from storage to the flying site for aerial operations. On occasions small quantities (e.g. samples) can be carried but only within the limits imposed by the HSNO legislation (<250 kg 1080 pellets). Some staff hold appropriate endorsements to their licences allowing transport of larger quantities of bait if necessary.

13.6 Details of a road transport incident involving 1080 were provided as follows "At 5 am on 10 November 2007 Officer Walker WWI422-1050 from Ohakea attended a trucking accident where the driver lost his load. The driver just happened to observe a large container of 1080 in its raw form on the road. This was a wooden box sealed inside a steel cage containing six 60 litre drums of 1080 produced in Kentucky USA. Firstly, the truck was not a registered CHEMHAZE vehicle, and nor was the driver. Secondly, this could have been devastating had the container spilt. Thirdly, with such a dangerous chemical, the fire brigade was shocked at what they found. And lastly, it took 45 minutes to attend the crash and another 8hrs to have that area cordoned off and cleaned up, the most shocking part was, this was accompanied with food products".

13.7 ERMA New Zealand provided the following information on the investigation and outcomes: "The Police have advised us that there were several breaches of the transport regulations in that; the vehicle did not display appropriate hazardous substance placards, there was no load plan, the load was not appropriately segregated and the driver did not have a dangerous goods endorsement on their licence. The police further advised us that the person who loaded the truck admitted knowingly breaching the requirements for the loading and carriage of this substance, and that they (the Police) have taken appropriate enforcement action."

13.8 In terms of the environmental effects of this incident, a hazard was definitely present in the form of an approximately 500 kilogram quantity technical-grade (raw) 1080, however it was packaged appropriately and did not spill despite falling from the truck, so that no environmental exposure occurred.

14 References

Aspin, P.; Stringer, I.; Potter, M. (1999) Invertebrate abundance in pitfall traps before and after aerial sowing and bait station presentations of 1080. Ecological consequences of poisons used for mammalian pest control, meeting Christchurch 9–10 July 1998.

Ataria, J. M.; Wickstrom, M. L.; Arthur, D.; Eason, C. T. (2000) Biochemical and histopathological changes induced by sodium monofluoroacetate (1080) in mallard ducks. Proceedings of the New Zealand Plant Protection Conference 53, 293–298.

Balcomb, R.; Bowen, C. A.; Williamson, H. O. (1983) Acute and sub-lethal effects of 1080 on starlings. Bulletin of Environmental Contamination and Toxicology 31, 692–698.

Batcheler, C. L. (1978) Compound 1080, its properties, effectiveness, dangers, and use. (New Zealand Forest Service: Wellington)

Beath, A., Thorne, J., Robertson, A. W. (2004). Evaluating the attractiveness of pest-control baits and lures to captive short-tailed bats, *Mystacina tuberculata*. DOC Science Internal Series 189, -19 p.

Booth, L. H.; Wickstrom, M. L. (1999) The toxicity of sodium monofluoroacetate (1080) to Huberia striata, a New Zealand native ant. New Zealand Journal of Ecology 23, 161–165.

Brockmann, J. L.; McDowell, A. V.; Leeds, W. G. (1955) Fatal poisoning with sodium fluoroacetate : report of a case. Journal of the American Medical Association 159, 1529–1532.

Calder, B.; Deuss, F. (1985) The effect of 1080 poisoning on bird populations in Motere, Pureora Forest Park, winter 1984. Unpublished New Zealand Forest Service Internal Report.

Cavanagh, J. E.; Fisher, P. (2005) 1080 - international considerations. Landcare Research Contract report LC0405/034, 14 p., unpublished report.

Chenoweth, M. B. (1949) Monofluoroacetic acid and related compounds. Pharmacological Reviews 1, 383–424.

Chi, C.-H.; Chen, K.-W.; Chan, S.-H.; Wu, M.-H.; Huang, J.-J. (1996) Clinical presentation and prognostic factors in sodium monofluoroacetate intoxication. Journal of Toxicology: Clinical Toxicology 34, 707–712.

Chi, C.-H.; Lin, T.-K.; Chen, K.-W. (1999) Hemodynamic abnormalities in sodium monofluoroacetate intoxication. Human and Experimental Toxicology 18, 351–353.

Cooke, J. A. (1976) The uptake of sodium monofluoroacetate by plants and its physiological effects. Fluoride 9, 204–212.

David, W. A. L. (1950) Sodium fluoroacetate as a systemic and contact insecticide. Nature 165, 493–494.

de Oliveira, M. M. (1963) Chromatographic isolation of monofluoroacetic acid from Palicourea marcgravii St.Hill. Experientia 29, 586–587.

de Meyer, R. ; De Plaen, J. (1964) An approach to the biochemical study of teratogenic substances on isolated rat embryo. Life Sciences 3, 709–713.

de Moraes-Moreau, R. L.; Harguich, M.; Harasuchi, M.; Morita, H.; Palermo-Yeto, J. (1995) Chemical and biological demonstration of the presence of monofluoroacetate in the leaves of Palicourea marcgravii. Brazilian Journal of Medical and Biological Research 28, 685–692.

Eason, C. T.; Turck, P. (2002) A 90-day toxicological evaluation of compound 1080 (sodium monofluoroacetate) in Sprague-Dawley rats. Toxicological Sciences 69, 439–447.

Eason, C. T.; Gooneratne, R.; Wright, G. R.; Pierce, R.; Frampton, C. M. (1993) The fate of sodium monofluoroacetate (1080) in water, mammals, and invertebrates. Proceedings of the New Zealand Plant Protection Conference 46, 297–301.

Eason, C. T.; Wickstrom, M.; Gregory, N. (1997) Product stewardship, animal welfare, and regulatory toxicology constraints on vertebrate pesticides. Proceedings of the Fiftieth New Zealand Plant Protection Conference: 206–213.

Eason, C. T.; Wickstrom, M.; Turck, P.; Wright, G. R. G. (1999) A review of recent regulatory and environmental toxicology studies on 1080: results and implications. New Zealand Journal of Ecology 23, 129–137.

Egeheze, J. O.; Oehme, F. W. (1979) Sodium monofluoroacetate (SMFA, Compound 1080): A literature review. Veterinary and Human Toxicology 21, 411–416.

Eisler, R. (2000). Sodium monofluoroacetate (Compound 1080). In 'Handbook of Chemical Risk Assessment'. pp. 1413-1458. Lewis Publishers.

Environmental Risk Management Authority (2007). The Reassessment of 1080 – an informal guide to the August 2007 decision of the Environmental Risk Management Authority, 13 August 2007. ERMA, Wellington, New Zealand.

Fagerstone, K. A.; Savarie, P. J.; Elias, D. J.; Schaffer Jr., E. W. (1994) Recent regulatory requirements for pesticide registration and the status of Compound 1080 studies conducted to meet EPA requirements. Pp. 33–38 in Seawright A. A.; Eason C. T. (Eds): Proceedings of the Science Workshop on 1080. The Royal Society of New Zealand Miscellaneous Series 28.

Foronda, N. M., Fowles, J., Smith, N., Taylor, M., Temple, W., and Darlington, C. (2007). The use of myocardial and testicular end points as a basis for estimating a proposed tolerable daily intake for sodium monofluoroacetate (1080). Regulatory Toxicology and Pharmacology 47, 29-36.

Greene, T. G. (1995) The effect of compound 1080 on populations of specific non-target species, Waihaha Ecological Area, Pureora Forest Park, winter 1994. (Unpublished report, Department of Conservation)

Goodwin, R. M. and Ten Houten, A. (1991). Poisoning of honey bees (Apis mellifera) by sodium fluoroacetate (1080) in baits. New Zealand journal of zoology 18, 45-51.

Gooneratne, S. R., Eason, C. T., Milne, L., Arthur, D. G., Cook, C., and Wickstrom, M. (2008). Acute and long-term effects of exposure to sodium monofluoroacetate (1080) in sheep. Onderstepoort J.Vet.Res. 75, 127-139.

Harrison, J. W. E.; Ambrus, J. L.; Ambrus, C. M.; Rees, E. W.; Peters, R. H.; Reese, L. C. (1952) Acute poisoning with sodium fluoroacetate (compound 1080). Journal of the American Medical Association Aug 23, 1520–1522.

King, D. R.; Kirkpatrick, W. E.; Wong, D. H.; Kinnear, J. E. (1994) Degradation of 1080 in Australian soils. Pp. 45–49 in Seawright, A.A.; Eason, C.T. (Eds): Proceedings of the science workshop on 1080. The Royal Society of New Zealand Miscellaneous Series 28.

King, J. E.; Penfound, W. T. (1946) Effects of new herbicides on fish. Science 103, 487.

LaGoy, P. K.; Bohrer, R. L.; Halvorsen, F. H. (1992) The development of cleanup criteria for an acutely toxic pesticide at a contaminated industrial facility. American Industrial Hygiene Association Journal 53, 298–302.

Lloyd, B. D. (1994). Evaluating the potential hazard of aerial 1080 poison operations to short-tailed bat populations. Conservation Advisory Notes No. 108, -12 p. Wellington, New Zealand, Department of Conservation.

Lloyd, B. D. and McQueen, S. M. (2000). An assessment of the probability of secondary poisoning of forest insectivores following an aerial 1080 possum control operation. New Zealand Journal of Ecology 24, 47-56.

Lloyd, B. D. and McQueen, S. M. (2002). Measuring mortality in short-tailed bats (*Mystacina tuberculata*) as they return from foraging after an aerial 1080 possum control operation. *New Zealand journal of ecology* **26**, 53-59.

Mackintosh, A., Hawcroft, A. (2008) Wild Animal Control Report 2004/05 and 2005/2006, Wanganui Conservancy, Department of Conservation, Wanganui.

Mazzanti, L. (1965) Atrophy of the testis produced by sodium monofluoroacetate in albino rats. Experientia 21, 446–447.

Meads, M. Effect of sodium monofluoroacetate (1080) in non-target invertebrates of Whitecliffs Conservation Area, Taranaki. Landcare Research Contract report LC9394/126, -25. 1994.

Meyer, J. J. M. (1994) Fluoroacetate metabolism of Pseudomonas cepacia. Pp. 54–58

in Seawright, A.A.; Eason, C.T. (Eds): Proceedings of the science workshop on 1080. The Royal Society of New Zealand Miscellaneous Series 28.
Miller, C. J.; Anderson, S. (1992) Impacts of aerial 1080 poisoning on the birds of Rangitoto Island, Hauraki Gulf, New Zealand. New Zealand Journal of Ecology 16, 103–107.
Miller, R. F.; Phillips, P. H. (1955) Effect of feeding fluoroacetate to the rat. Proceedings of the Society for Experimental Biology and Medicine 89, 411–413.
Ministry of Health (2000). Drinking water standards for New Zealand 2000. http://www.moh.govt.nz/moh.nsf/238fd5fb4fd051844c256669006aed57/70727db605b9f56a4c25696400802887/$FILE/drinking%20water.pdf accessed 4th August 2008.
Notman, P. (1989) A review of invertebrate poisoning by compound 1080. New Zealand Entomologist 12, 67–71.
O'Connor, C. E.; Milne, L. M.; Arthur, D. G.; Ruscoe, W. A.; Wickstrom, M. (1999) Toxicity effects of 1080 on pregnant ewes. Proceedings of the New Zealand Society of Animal Production 59, 250–253.
O'Hagan, D.; Harper, D. B. (1999) Fluorine containing natural products. Journal of Fluorine Chemistry 100, 127–133.
O'Halloran, K., Jones, D., Booth, L., and Fisher, P. (2005). Ecotoxicity of 1080 to soil organisms. Environmental toxicology and chemistry 24, 1211-1218.
Ogilvie, S. C.; Hetzel, F.; Eason, C. T. (1996) Effect of temperature on the biodegradation of sodium monofluoroacetate (1080) in water and in Elodea canadensis. Bulletin of Environmental Contamination and Toxicology 56, 942–947.
Ogilvie, S. C.; Booth, L. H.; Eason, C. T. (1998) Uptake and persistence of sodium monofluoroacetate (1080) in plants. Bulletin of Environmental Contamination and Toxicology 60, 745–749.
Ogilvie, S. C., Ataria, J. M., Waiwai, J., Doherty, J. E., Lambert, M., Lambert, N., and King, D. (2006). Uptake and persistence of the vertebrate pesticide, sodium monofluoroacetate (compound 1080), in plants of cultural importance. Ecotoxicology. 15, 1-7.
Pelfrene, A.F. (2001). Rodenticides. Chapter 83 in "Handbook of Pesticide Toxicology, Volume 2 Agents". Ed. R.I. Kreiger, Academic Press, San Diego. Pp.1793-1830.
Pierce, R. J.; Montgomery, P. J. (1992) The fate of birds and selected invertebrates during a 1080 operation. Science and Research Internal Report 121. (Department of Conservation: Wellington)
Powlesland, R. G.; Knegtmans, J. W.; Marshall, I. S. J. (1998) Evaluating the impacts of 1080 possum control operations on North Island robins, North Island tomtits and more porks at Pureora- preliminary results. Science for Conservation 74. (Department of Conservation: Wellington)
Powlesland, R. G.; Knegtmans, J. W.; Marshall, I. S. J. (1999) Costs and benefits of aerial 1080 possum control operations using carrot baits to North Island robins (Petroica australis longipes), Pureora Forest Park. New Zealand Journal of Ecology 23, 149–159.
Powlesland, R. G.; Knegtmans, J. W.; Styche, A. (2000) Mortality of North Island tomtits (Petroica macrocephala toitoi) caused by aerial 1080 possum control

operations, 1997–98, Pureora Forest Park. New Zealand Journal of Ecology 24, 161–168.
Powlesland, R. G., Wills, D. E., August, A. C. L., and August, C. K. (2003). Effects of a 1080 operation on kaka and kereru survival and nesting success, Whirinaki Forest Park. New Zealand journal of ecology 27, 125-137.
Powlesland, R. G., Stringer, I. A. N., and Hedderley, D. I. (2005). Effects of an aerial 1080 possum poison operation using carrot baits on invertebrates in artificial refuges at Whirinaki Forest Park, 1999–2002. New Zealand journal of ecology 29, 193-205.
Rammell, C. G.; Fleming, P. A. (1978) Compound 1080 : properties and uses of sodium monofluoroacetate in New Zealand. (Animal Health Division, Ministry of Agriculture and Fisheries: Wellington)
Robertson, H. A.; Colbourne, R. M.; Graham, P.; Miller, P. J.; Pierce, R. J. (1999) Survival of brown kiwi exposed to 1080 poison used for control of brushtail possums in Northland, New Zealand. Wildlife Research 26, 209–214.
Robinson, R. F.; Griffith, J. R.; Wolowich, W. R.; Nahata, M. C. (2002) Intoxication with sodium monofluoroacetate (compound 1080). Veterinary and Human Toxicology 44, 93–95.
Savarie, P. J. (1984). Toxic characteristics of fluorocitrate, the toxic metabolite of compound 1080. Proceedings of the Vertebrate Pest Conference 11, 132-137.
Sherley, G., Wakelin, M., and McCartney, J. (1999). Forest invertebrates found on baits used in pest mammal control and the impact of sodium monofluoroacetate (1080) on their numbers at Ohakune, North Island, New Zealand. New Zealand journal of zoology 26, 279-302.
Smith, F. A.; Gardner, D. E.; Yuile, C. L.; de Lopez, O. H.; Hall, L. L. (1977) Defluorination of fluoroacetate in the rat. Life Sciences 20: 1131–1138.
Spurr, E. B. (1991) Reduction of wasp (Hymenoptera: Vespidae) populations by poison-baiting : experimental use of sodium monofluoroacetate (1080) in canned sardine. New Zealand Journal of Zoology 18, 215–222.
Spurr, E. B. (1994) Impacts on non-target invertebrate populations of aerial application of sodium monofluoroacetate (1080) for brushtail possum control. Pp.116–123 in Seawright, A.A.; Eason, C.T. (Eds): Proceedings of the science workshop on 1080. The Royal Society of New Zealand Miscellaneous Series 28.
Spurr, E. B.; Powlesland, R. G. (1997) Impacts of aerial application of 1080 on non-target native fauna: review and priorities for conservation. Science for Conservation 62. (Department of Conservation: Wellington)
Spurr, E. B.; Drew, K. W. (1999) Invertebrates feeding on baits used for vertebrate pest control in New Zealand. New Zealand Journal of Ecology 23, 167–173.
Spurr, E., Berben, P. H., McGregor, P. G., and Arnold, G. Impacts of simulated aerial application of 1080-poisoned baits on ground-dwelling invertebrate populations. Landcare Research Contract Report 0102/094 , -40. 2002. Landcare Research Contract Report.
Spurr, E. B. and Berben, P. H. (2004). Assessment of non-target impact of 1080-poisoning for vertebrate pest control on weta (Orthoptera: Anostostomatidae and Rhaphidophoridae) and other invertebrates in artificial refuges. New Zealand journal of ecology 28, 63-72.

Sullivan, J. L.; Smith, F. A.; Garman, R. H. (1979) Effects of fluoroacetate on the testis of the rat. Journal of Reproduction and Fertility 56, 201–207.

Stronge, D., Dijkgraaf, A. (2001) Wild Animal Control Report 1998/99 and 1999/00, Wanganui Conservancy. Department of Conservation, Wanganui.

Stronge, D., Mackintosh, A., Dijkgraaf, A., Hawcroft, A. (2004) Wild Animal Control Report 2000/2001 and 2001/2002, Wanganui Conservancy, Department of Conservation, Wanganui.

Suren, A. and Bonnett, M. (2006). Consumption of baits containing sodium fluoroacetate (1080) by the NZ freshwater crayfish. New Zealand journal of marine and freshwater research 40, 169-178.

Suren, A. and Lambert, P. (2006). Do toxic baits containing sodium fluroacetate (1080) affect fish and invertebrate communities when they fall into streams? New Zealand journal of marine and freshwater research 40, 531-546.

Suren, A. (2006). Quantifying contamination of streams by 1080 baits, and their fate in water. New Zealand journal of marine and freshwater research 40, 159-167.

Trabes, J.; Rason, N.; Avrahami, E. (1983) Computed tomography demonstration of brain damage due to acute sodium monofluoroacetate poisoning. Journal of Toxicology: Clinical Toxicology 20, 85–92.

Twigg 1990 The sensitivity of some Western Australian caterpillars to fluoroacetate Mulga Research centre Journal 10:14-18

Twigg, L. E.; King, D. R.; Bowen, L. H.; Wright, G. R.; Eason, C. T. (1996) Fluoroacetate content of some species of the toxic Australian plant genus, Gastrolobium and its environmental persistence. Natural Toxins 4, 122–127.

Twigg, L. E.; King, D. R.; Bradley, A. J. (1988) The effect of sodium monofluoroacetate on plasma testosterone concentration in Tiliqua rugosa (Gray). Comparative Biochemistry and Physiology 91C, 343–347.

Twigg, L. E. and Socha, L. V. (2001). Defluorination of sodium monofluoroacetate by soil microorganisms from central Australia. Soil biology and biochemistry 33, 227-234.

Vickery, B.; Vickery, M. L. (1975) The synthesis and defluorination of monofluoroacetate in some Dichapetalum species. Phytochemistry 14, 423–427.

Ward, P. F. V. and Huskisson, N. S. (1972). Defluorination of fluoroacetate by lettuce. The Biochemical Journal 127, 89P-90P.

Weaver, S. A. (2003). Policy implications of 1080 toxicology in New Zealand. Journal of Rural and Remote Environmental Health 2, 46-58.

Williams, A. T. (1948) Sodium fluoroacetate poisoning. Hospital Corps Quarterly 21, 16–18.

Wright, G. R.; Booth, L. H.; Morriss, G. A.; Potts, M. D.; Brown, L.; Eason, C. T. (2002) Assessing potential environmental contamination from compound 1080 (sodium monofluoroacetate) in bait dust during possum control operations. New Zealand Journal of Agricultural Research 45, 57–65.