Review of potential soil contamination issues from pesticide use in productive land and sports fields

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CONTENTS

1. EXECUTIVE SUMMARY

- There is currently limited guidance available for regional council and territorial local authority staff for determining if a pesticide is persistent and thus whether it would trigger the Hazardous Activities and Industries List (HAIL) category A10 (Persistent pesticide bulk storage or use including sports turfs, market gardens, orchards, glasshouses and spray sheds).

- To remedy this situation, a thorough literature search was carried to, firstly determine a 'consensus' definition of 'persistent' with reference to pesticides, and then to categorise, and describe the use of, persistent pesticides in New Zealand accordingly.

- Five categories of pesticides were developed;

    1. Pesticides defined as persistent by the United Nations Environment Programme (UNEP) that have been used in New Zealand (11 pesticides),
    2. Pesticides defined as persistent by the UNEP that have been evaluated in New Zealand but not used commercially (3 pesticides),
    3. Metal-based pesticides that have been used in New Zealand but were banned between 2 - 15 years ago (4 pesticides),
    4. Pesticides currently used in New Zealand for which there is insufficient data to properly categorise them as 'persistent' or not (2 pesticides),
    5. Pesticides registered for use in New Zealand which would be classified as persistent according to their long half-lives but for which we have insufficient records of their use here (7 pesticides).

- Data on acute, dermal and environmental toxicity and environmental fate are presented for 24 of these 27 pesticides (data for three of the metal based pesticides are not presented).

2. BACKGROUND

The *National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NES)* introduced a nationwide set of consistent planning controls for land affected or potentially affected by soil contamination. Under the regulations "land is considered to be actually or potentially contaminated if an activity industry on the Hazardous Activities or Industries List (HAIL) has been, is, or is more likely than not to have been, undertaken on that land". The HAIL is a list of activities and industries considered likely to cause land contamination from the use, storage and disposal of hazardous substances.

The Hazardous Activities and Industries List (HAIL) Category A10 refers to "Persistent pesticide bulk storage or use including sports turfs, market gardens, orchards, glasshouses and spray sheds" (https://www.mfe.govt.nz/issues/managing-environmental-risks/contaminated-land/is-land-contaminated/hail.html). There is currently limited guidance available for regional council and territorial local authority staff to assist with identifying persistent pesticides. There is a need to review historic and current pesticide use in New Zealand to identify which pesticides may trigger the HAIL category A10.

Specific guidance on assessment of HAIL A10 sites is provided in the aligned Envirolink report 1472-TSDC103.

In order to identify persistent pesticides the following questions need to be addressed:

1. Defining and describing the chemical and environmental characteristics of 'persistent' pesticides (note: while this has been done to a limited extent previously most of the work occurred 10 or more years ago)
2. Compilation of data on common persistent pesticides used in New Zealand (both current and historic) and their typical applications.
3. Compilation of data on the environmental toxicity and fate of pesticides described in 2 above.
4. Review of persistent pesticides identified for productive land and sports fields internationally.
5. Review of the environmental and human health risk posed by the persistent pesticides identified above with particular reference to when land exposed to these pesticides should be classified as HAIL land.

3. METHODS

3.1 Definition of a ‘persistent’ pesticide

A thorough literature search was carried out looking at various definitions of ‘persistent’ with reference to pesticides. The search covered both a range of scientific databases to identify how these terms are used in research and an internet search for the operational definitions used by various governmental and non-governmental bodies, authorities and organisations.

3.2 Identification of ‘persistent’ pesticides

Identification of ‘persistent’ pesticides was carried out by:

1. Creating a list of all pesticides registered in New Zealand and those de-registered within the last 5 years.
2. Adding chemicals from the International Persistent Organic Pollutants (POP) list (http://chm.pops.int/TheConvention/ThePOPs/ListingofPOPs/tabid/2509/Default.asp) if they fitted the definition of a pesticide and have ever been used in New Zealand.
3. Adding the historically used metal based pesticides including lead-arsenate and mercury based pesticides that are known to have been used in New Zealand.
4. Using the Hertfordshire Universities Pesticide Properties Database (PPDB, http://sitem.herts.ac.uk/aeru/ppdb/en/index.htm) and available New Zealand data to categorise the pesticides in the list according to soil half-life (DT_{50}) and our definition of ‘persistence’.
5. The pesticides in the list were further categorised by identifying those that had an human Acceptable Daily Intake (ADI) of less than 0.05 mg/kg Body Weight (BW)/day (Juraske et al 2007).
6. Pesticides that have been registered within the last 5 years were eliminated from the list on the grounds that recent approval guidelines would preclude registration of overly persistent pesticides or those with excessive negative environmental impacts.
7. The remaining candidate pesticides were subjected to a thorough literature search and review to determine their use patterns and indeed if they were actually ever used in New Zealand after registration.

4. RESULTS

4.1 Definition of a 'persistent' pesticide

It was concluded that for the purposes of this review the definition of 'persistent', w.r.t pesticides, accepted by the United Nations Environment Programme (UNEP), Secretariat of the Stockholm Convention on Persistent Organic Pollutants, as amended in 2009 (http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP-CONVTEXT.En.pdf), was the most appropriate:

> Annex D
> (b) Persistence:
> (i) Evidence that the half-life of the chemical in water is greater than two months, or that its half-life in soil is greater than six months, or that its half-life in sediment is greater than six months; or
> (ii) Evidence that the chemical is otherwise sufficiently persistent to justify its consideration within the scope of this convention.

This definition is consistent with the European Union definition for a very persistent pesticide of a half-life in soil of greater than 6 months (Regulation EC No 1107/2009 Concerning the placing of plant protection products on the market).

4.2 Identification of 'persistent' pesticides

After applying all the exclusion conditions listed in the methods, the list of 'persistent' pesticides comprised the eleven traditional organochlorine pesticides (Tables 1 and 2). Additionally, there are three POP's which were evaluated for use in New Zealand but for which there is no evidence of commercial use (Table 3), four metal-based pesticides (Table 4), two pesticides on a recommended watch list based on international reports of persistence and toxicity (Table 5 and 6) and seven for which we require more information (Tables 7 and 8).

Table 1 Persistent pesticides as defined by the UNEP that were used in New Zealand, but were banned between 2 - 15 years ago, soil half-lives.

Pesticide	Max half-life (days)	Typical half-life (days)	NZ data (days)
Aldrin	365	28	-
Chlordane	1387	365	-
Dieldrin	1825	-	-
DDT	10950	-	-
Endosulfan	126		
Heptachlor	730	-	-
Heptachlor epoxide	-	-	-
Hexachlorobenzene	2737	-	-
Lindane	980	-	-
Pentachlorophenol	-		
Toxaphene	-	-	-

Table 2 Persistent pesticides as defined by the UNEP that were used in New Zealand, but were banned between 2 - 15 years ago, typical uses.

Pesticide	Use
Aldrin	White fringed weevil forest nurseries, ornamental bulbs treat
Chlordane	Grass grub control in pasture
Dieldrin	Black vine weevil berryfruit, springtails and onion thrips
DDT	Chewing & sucking insects ornamentals, grass grub in lawns
Endosulfan	Aphids, thrips etc. in berryfruit, vegetables and turf
Heptachlor	White fringed weevil and grass grub in pasture
Heptachlor epoxide	White fringed weevil and grass grub in pasture
Hexachlorobenzene	Fungal control in oats
Lindane	Chewing & sucking insects in horticulture, agriculture and home gardens
Pentachlorophenol	Control of moss and slime in lawns, greens and on buildings
Toxaphene	Pest control in pasture and seed crops

Table 3 Persistent pesticides as defined by the UNEP that were evaluated in New Zealand but do not appear to have been used commercially, soil half-lives.

Pesticide	Max half-life (days)	Typical half-life (days)	NZ data (days)
Chlordecone	1387	365	-
Endrin	126		
Pentachlorobenzene	-		

Table 4 Metal based pesticides that were used in New Zealand but were banned between 2- 15 years ago.

Pesticide or base metal	Max half-life (days)
MSMA (arsenic)	As the base metal is the pollutant, their half - life (DT_{50}) is indefinite
Copper	
Lead arsenate formulations	
Mercury formulations	

Table 5 Pesticides currently used in New Zealand for which there is insufficient data to properly categorise them as 'persistent' but for which there are few reports from overseas identifying environmental problems, half-lives.

Pesticide	Type	Trade names	Max half-life (days)	Typical half-life (days)	NZ data (days)
Chlorpyrifos	Insecticide	Lorsban	141	50	-
Procymidone	Fungicide	Sumisclex	2381	7	184-850

Table 6 Pesticides currently used in New Zealand for which there is insufficient data to properly categorise them as 'persistent' but for which there are few reports from overseas identifying environmental problems, typical uses.

Pesticide	Type	Use
Chlorpyrifos	Insecticide	Insect control in tree crops, onions and pasture
Procymidone	Fungicide	Fungus disease control in vegetable and tree crops

Table 7 Pesticides registered for use in New Zealand which would be classified as persistent according to their long half-lives but for which we have insufficient records of their use here.

Pesticide	Type	Trade names	Max half-life (days)	Typical half-life (days)	NZ data (days)
Dicloran	Fungicide	Botran	617	401	-
Epoxiconazole	Fungicide	Accuro, Calibre, Opus, Spinto, Stellar	2235	354	-
Fenarimol	Fungicide	Rubigan	1360	250	-
Flupropanate	Herbicide	Taskforce		365	
Flusilazole	Fungicide	Novall, Nustar	392	300	-
Imidacloprid	Insecticide	SuperStrike, UltraStrike, Gaucho, Confidor	341	191	-
Myclobutanil	Fungicide	Systhane	1216		-

[1] Plant growth regulator

Table 8 Pesticides registered for use in New Zealand which would be classified as persistent according to their long half-lives but for which we have insufficient records of their use here, typical uses.

Pesticide	Type	Use
Dicloran	Fungicide	Stonefruit, berryfruit, grapes kumera
Epoxiconazole	Fungicide	Barley, wheat, ryegrass seed crops
Fenarimol	Fungicide	Grapes, apples, pipfruit
Flupropanate	Herbicide	Nassella tussock, Chilean needle grass
Flusilazole	Fungicide	Pipfruit, stonefruit, citrus
Imidacloprid	Insecticide	Seed dressing, vegetables, grapes
Myclobutanil	Fungicide	Grapes and squash

[1] Plant growth regulator

4.3 Toxicity of 'persistent' pesticides

Mammalian toxicity data for these pesticides are presented in Table 9 and ecotoxicity and fate in Table 10.

Table 9 Mammalian toxicity data on the pesticides listed in Tables 1 - 8 (Pesticide Properties Database).

Pesticide	ADI mg/kg bw/day[1]	Oral LD_{50} (mg/kg)[2]	Dermal LD_{50} (mg/kg)[2]	Hazardous classification
Aldrin	-	40-60	>200-	Poison S3, Pt ll
Chlordane	0.0005	460	200	
Chlordecone	-	91.3	>2000	
Chlorpyrifos	0.01	135	2000	Poison S3, Pt ll
Dieldrin	0.0001	40	100	Poison S3, Pt ll
DDT	0.01	300-500	2500	Poison S4
Dicloran	0.05	1500	>2000	
Endosulfan	0.0006	80	359	Poison S3, Pt l
Endrin	-	>7.5	5.0	
Epoxiconazole	0.008	66 >2200[3]	1250 >2000[3]	
Fenarimol	0.01	2500	>2500	None listed
Flupropanate	-	9600	>5500	
Flusilazole	0.002	674	>2000	
Heptachlor	0.0001	>147	195	
Heptachlor epoxide	-	15	-	
Hexachlorobenzene	-	>10000	-	
Imidacloprid	0.06	450	>5000	Poison
Lindane	0.003	200	500-1000	Poison S3, Pt l
MSMA	-	1200	-	Poison S3, Pt l
Myclobutanil	0.025	1600 <4420[3]	>2000 >5000[3]	
Pentachlorobenzene	-	1080	-	
Pentachlorophenol	-	80	105	
Procymidone	0.025	6,800- 7,700	>2,500	Not scheduled
Toxaphene	-	50	-	

[1] ADI = Acceptable Daily Intake expressed in mg (of chemical) per kg of body weight per day.
[2] Acute and dermal toxicity usually for rats or mice.
[3] NZ registered data, probably referring to the toxicity of the formulated product.

Table 10 Ecotoxicity data on the pesticides listed in Tables 1 - 8 (Pesticide Properties Database).

Pesticide	GUS[1]	Aquatic fish[2]	Aquatic invertebrates[3]	Water solubility
Aldrin	-0.35	0.0046	0.028	0.027 mg/L
Chlordane	-0.77	0.09	0.59	0.1 mg/L
Chlordecone	1.60	0.02	0.03	3.0 mg/L
Chlorpyrifos	0.15	0.0013	0.0001	1.05 mg/L
Dieldrin	-0.25	0.0012	0.25	0.14 mg/L
DDT	-4.47	7	0.005	0.006 mg/L
Dicloran	2.84	0.48	2.07	6.4 mg/L
Endosulfan	4.64	0.002	0.44	0.32 mg/L
Endrin	0.00	0.00073	0.0042	0.24 mg/L
Epoxiconazole	2.47	3.14	8.69	7.1 mg/L
Fenarimol	2.72	4.1	6.8	13.7 mg/L
Flupropanate	7.84	>1000	-	3900000 mg/L
Flusilazole	1.93	1.2	3.4	41.9 mg/L
Heptachlor	-0.93	0.007	0.042	0.056 mg/L
Heptachlor epoxide	-	0.02	0.24-	0.02 mg/L
Hexachlorobenzene	-2.31	0.03	0.5	0.047 mg/L
Imidacloprid	3.76	211	85	610 mg/L
Lindane	3.95	0.0029	1.6	8.52 mg/L
MSMA	-	100	58	58000 mg/L
Myclobutanil	3.54	2.0	17	132 mg/L
Pentachlorobenzene	0.30	0.19	5.3	0.83 mg/L
Pentachlorophenol	4.54	0.17	0.45	1000 mg/L
Procymidone	1.20	7.22	0.99	2.46 mg/L
Toxaphene	3.92	0.0044	0.0141	3.0 mg/L

[1] GUS Leaching Potential Index, <0.1 = extremely low, >4.0 = very high.
[2] Ecotoxicity aquatic fish - Acute 96 hour LC_{50} (mg/L)
[3] Ecotoxicity aquatic invertebrates - Acute 48 hour LC_{50} (mg/L)

5. NOTES ON INDIVIDUAL PESTICIDES

5.1 Persistent pesticides as defined by the UNEP (Table 1)

All of the following persistent organochlorine pesticides were progressively restricted for use in New Zealand from the 1960s and were de-registered for use in New Zealand in 1989.

<u>ALDRIN</u>

1. Insecticide, Organochlorine
2. Soil degradation half-life: Maximum – 365 days; Typical 28 days; No NZ data available.
3. Registered in NZ as Aldrex 2, emulsifiable concentrate (EC) formulation; Full registration.
4. Registered for control white fringed weevil in Forestry nurseries and as a bulb treatment for Narcissus bulb fly.
5. Restricted Poison S3, Pt ll; A very highly hazardous material; Permit mandatory for its use and application.
6. Withholding Period: Any crops on which permitted – edible parts exposed – 6 weeks; edible parts not exposed – 3 weeks; berry fruits – not after flowering.
7. Has been evaluated in NZ also in carrots, swedes and for louse control.

<u>CHLORDANE</u>

1. Insecticide, organochlorine
2. Soil degradation half-life: Maximum – 3-8 years; Typical – 365 days; No NZ data available.
3. Used in NZ for grass grub control in pasture. Considerable work done by NIWA on the effect of Chlordane in benthic zone environment.
4. Detected in South Island stream survey.

Simpson et al. (1996) surveyed Manukau Harbour and found low levels of chlordane residues in several species of mollusc and polychaetes and in a shallow sediment core from an intertidal sandbank. Chlordane levels were lowest in surface sediments and increased with increasing sediment depth.

<u>DIELDRIN</u>

1. Insecticide, Halogenated hydrocarbon
2. Soil degradation half-life: Maximum – 5 years
3. Registered in NZ as 'Dieldrex 50% WP' (wettable powder) ; 'Dieldrin Prills'. Full registration.
4. Registered for control of black vine weevil larvae in berry fruit gardens; springtails and onion thrips.
5. Restricted Poison S3, Pt ll; A very highly hazardous material; Permit mandatory for its use and application. Highly toxic to bees and fish.
6. Withholding Period: Any crops on which permitted – edible parts exposed – 6 weeks; edible parts not exposed – 4 weeks; berry fruits – not after flowering.

Detected in groundwater surveys

Detected in South Island stream survey.

According to Shahpoury et al (2013) comparison of measured pesticide concentrations with sediment quality guidelines showed that, regardless of farming practice, mean pesticide concentrations were below the recommended toxicity thresholds. However, up to 23% of individual samples contained chlorpyrifos, endosulfan sulfate, Sigma DDT, dieldrin, or Sigma chlordane concentrations above these thresholds.

DDT

1. Insecticide, DDT type compound
2. Soil degradation half-life: Maximum 30 years
3. Registered as numerous commercial products as EC or WP. Full registration.
4. Registered for control of a wide range of chewing and sucking insects on horticultural crops and ornamentals and for grass grubs in lawns. Also registered for wireworms, cutworm and tobacco moth in tobacco. Also registered for use in home gardens.
5. Restricted Poison S4. Permit mandatory for its use and application of more than 60 g of DDT. Toxic to bees and fish. Not to apply to plants in flower. Must not be applied to pasture.
6. Withholding Period: Tomatoes – 7 days; Berry fruits – before flowering; all other crops – 4 weeks.

Detected in groundwater surveys
Detected in South Island stream survey.
Wightwick and Allinson (2007) reviewed pesticide residues in Victorian water ways and reported that DDT and chlorpyrifos were the most commonly detected pesticides.
Last known recommendation for use in 1983.

ENDOSULFAN

1. Insecticide/Acaricide, Organochlorine
2. Soil degradation half-life: Maximum – 126 days; NZ data available on residues in produce
3. Registered as Thiodan 35 EC; Flavylan 350EC, Malix 35 W; and Thiofor as emulsifiable concentrate. Full registration.
4. Registered for control of aphids, mites, thrips, and various beetles and caterpillars in vegetable crops, berry fruit, ornamentals and turf.
5. Restricted Poison S3 Pt l; Very highly hazardous; toxic to bees, not to be applied to plants in flower. Not to be applied to pasture or other areas to be grazed by livestock. Toxic to fish. Not to be applied by aircraft.
6. Withholding Period: 2-28 days, nil for potatoes.

Scorza Junior et al (2013) observed that endosulfan did not leach beyond 10 cm depth and there was a rapid dissipation resulting in a quantity in the soil profile (100 cm) less than 1% of the applied dose at 41 days after application. In laboratory TD50 values for endosulfan ranged from 17 to 26 days and endosulfan sulfate 26-59 days.
Evaluated in NZ also for Citrus whitefly, brassicas, chrysanthemums, grapes, strawberries,
Detected in South Island stream survey.
Hose et al (2003) said fish and several insect taxa are the most sensitive organisms to endosulfon. Sensitivities of these taxa suggest that the current levels of contamination in the Australian freshwater environment could have significant ecological effects.
Kataoka and Takagi (2013) mentioned that endosulfan is transformed in the environment into endosulfan sulfate, which is a toxic and persistent metabolite
Weber (2010) has shown from his review that endosulfan is present at low concentrations (relative to the pesticide, lindane) in surface Arctic Ocean waters, with the atmosphere likely to be the major contemporary source. Residues of endosulfan have been detected in marine biota for different geographical regions of the Arctic, with higher bioaccumulation factors (>10(3)-10(7)) for zooplankton and various species of fish, compared to studies in warmer/temperate systems. Endosulfan is present in marine mammals, although there is uncertainty in the various Arctic biota datasets due to differences in analytical techniques. There is little if any evidence of trophic magnification of alpha-endosulfan in well-defined marine food webs, with some evidence of bio-dilution at higher trophic levels, presumably due to increased metabolism. Endosulfan does fulfil several of the

criteria under the UNEP Stockholm Convention for designation as a persistent organic pollutant.

HEPTACHLOR

1. Insecticide, halogenated cyclodiene
2. Soil degradation half-life: Maximum - 730 days
3. Has been evaluated in NZ for white fringed weevil and grass grub.

Hughes and Fenemore (1967) reported that residues of heptachlor and heptachlor epoxide were found in fresh grass 9-12 months later even after several mowings. At the lowest three rates of treatment, 0.1 part heptachlor epoxide per million of grass was still present after 15, 35 and 50 weeks. Heptachlor residues had fallen to this level after 10, 30 and 40 weeks. These results indicated that there would be a continuous intake of small amounts of heptachlor and its epoxide by stock placed on treated pastures within a year of treatment. The amounts of toxicant ingested might be higher than those indicated by the residues, as the stock would also ingest appreciable amounts of soil. It is suggested that the residues found in the grass are due partly to contamination by soil particles blown by the wind or splashed by rain. Solly et al (1968) reported that treatment of soil with heptachlor prior to sowing to pasture resulted in lower residues in stock than treatment of established pasture. However, neither treatment would meet the requirement for complete absence of heptachlor and its principal metabolite in animal fats.

HEPTACHLOR EPOXIDE

1. Insecticide, halogenated cyclodiene
2. Soil degradation half-life: no data, probably as per heptachlor
3. Believed to have been evaluated in NZ in pasture, very little is recorded of its testing.

HEXACHLOROBENZENE

1. Fungicide, halogenated aromatic
2. Soil degradation half-life: Maximum - 7.5 years; Has been evaluated in NZ in oats, very little is recorded of its testing.

LINDANE

1. Insecticide/acaricide, organochlorine
2. Soil degradation half-life: Maximum – 980 days
3. Registered as numerous commercial products as WP, dust EC, pellet formulations. Full registration.
4. Registered for control of chewing and sucking insects in horticulture, home gardens and agriculture.
5. Restricted Poison S3 Pt l; Permit mandatory for its use and application of more than 60 g of lindane. Highly toxic to bees. Not to be used on plants in flower. Not be applied to live stock or around dairy sheds, holding pens or silage stacks. Not to be applied on land to be used for grazing dairy stock, or fattening stock within 1-2 months to slaughter.
6. Withholding Period: 4 weeks

Has also been evaluated in NZ for control of grasshoppers in pasture.

PENTACHLOROPHENOL

1. Herbicide, substituted phenol
2. Soil degradation half-life: 63 days

3. Was registered as Croseal Mosskiller, IWD Mosskiller, Shell Mosskiller and Yates Moss and Slime killer, as aqueous concentrate or emulsifiable concentrate.
4. Registered for control of moss in lawns, playing and bowling greens. Also for moss control of moss, mould, lichen and algal slime on roofs, paths, fences and walls.
5. Restricted Poison S3 pt ll. Strongly phytotoxic. Toxic to fish.
6. Withholding Period. Not applicable.

<u>TOXAPHENE</u>

1. Acaricide/insecticide, chlorinated camphene
2. Soil degradation half-life: no data
3. Hoy (1960) suggested that toxaphene could be used while clover is in flower because of its low toxicity to bees. The outcome of this recommendation is unknown.

5.2 Metal based pesticides (Table 4)

<u>MSMA</u>

1. Herbicide, arsenic compound
2. Soil degradation half-life: the arsenic in this compound will persist indefinately
3. Registered as Pasma 80, as Aqueous concentrate formulation. Provisional B registration – for field assessment only.
4. Registered for suppression of paspalum seed heads on golf fairways, tees and green surrounds. (Used overseas for post-emergence weed control in cotton).
5. Restricted Poison S3 Pt l. Permit required for aerial application.
6. Do not feed any part of treated vegetation to livestock.

If applied more than 5 times, will exceed NES for soil.

5.3 Pesticides currently used in New Zealand for which there is insufficient data to categorise them as ‘persistent’ (Table 5)

<u>CHLORPYRIFOS</u>

1. Insecticide/acaricide, organophosphate
2. Soil degradation half-life: Maximum - 141 days; Typical – 50 days; More persistent in acidic soils. NZ data available on residues in produce
3. Registered as Lorsban 50 EC, Chlor-P-480EC, Hortcare Chlorpyrifos and Pychlorex 48 EC. Full registration.
4. Registered for control of certain insect pests of fruit crops, ornamentals, pasture and fodder crops, and for use in industrial pest control.
5. Restricted Poison S3 Pt ll; Toxic to bees and fish. Not to be applied to crops in flower. Toxic to bees.
6. Withholding period: 7–28 days for vegetables and fruits; 8 weeks for cereals for grain.

Has been evaluated in NZ on several horticultural crops for efficacy and residues.
Used overseas in vineyards
By early 1990s tests were being done on resistance to chlorpyrifos.
Detected in South Island stream survey.
A NZ study (Cetin et al 2007) showed that chlorpyrifos induces cardiac dysfunction in rabbits.

Wightwick and Allinson (2007) reviewed pesticide residues in Victorian water ways and reported that DDT and chlorpyrifos were the most commonly detected pesticides

PROCYMIDONE

1. Fungicide, substituted amide, dicarboximide
2. Soil degradation half-life: Maximum – 2381 days; Typical – 7 days; NZ data – 184-850 days; more persistent in acidic soils
3. Registered as Sumisclex as a wettable powder formulation. Full registration.
4. Registered for control of Sclerotinia and Botrytis in field tomatoes and beans; Botrytis in grapes.
5. Poisons Schedule: Not scheduled.
6. Withholding Period: 1-3 days.

Evaluated in NZ also in vegetables, berries and stone fruit.
Detected in groundwater surveys
In studies by Close (2005) procymidone was much less mobile than the tracers but was very persistent, with significant amounts still present in the profile after 18 months.

5.4 Pesticides registered for use in New Zealand which would be classified as persistent according to their long half-lives but for we have few records of actual use here (Table 7)

DICLORAN

1. Fungicide, chlorinated nitroaniline
2. Soil degradation half-life: Maximum – 617 days; Typical – 401 days; European data: 258 days
3. Registered as Botran 75WP as a wettable powder formulation.
4. Registered for control of rhizopus rots in berry fruit, grapes, kumara and stone fruit.
5. Restricted Poison, very toxic to aquatic organisms, harmful to terrestrial vertebrates.
6. Withholding Period: NIL for all crops

Evaluated in NZ on kumara and nectarines.
Used also on tomatoes overseas
Low to medium mobility; Low toxicity; toxic to aquatic organisms.

EPOXICONAZOLE

1. Fungicide, triazole
2. Soil degradation half-life: Maximum – 2235 days; Typical – 354 days
3. Registered as Opus in the form of a suspension concentrate and as Opus Ultimate in the form of an emulsifiable concentrate.

Used overseas in various cereal crops.

In August 2013 BASF launched a new application for this a.i. as Adexar for disease control in wheat and barley?.

Registered for the control of leaf, stem and ear diseases in barley, wheat, maize and ryegrass seed crops.

4. Restricted Poison, Low toxicity.
5. Withholding Period: 28 days for silage and 42 days for grain. For grazing ryegrass 35 days.

Used overseas in various cereal crops.

FENARIMOL

1. Fungicide, substituted pyrimidine
2. Soil degradation half-life: Maximum – 1360 days; Typical – 250 days
3. Registered as Rubigan 12 EC; Rubigan Flo as suspension concentrate, Full registration in 2005 Manual.
4. Registered for control of powdery mildew of grapes, apples and peas, and black spot of pip fruit.
5. Restricted Poison, Low toxicity.
6. Waiting Period: Peas – 14 days; Grapes – 30 days; Pipfruit –35 days.

NZ data available on residues in strawberries.
Evaluated in NZ on apples, strawberries, lemons and in vineyards.
Recommended for use in Australian viticulture.
Gower & Co, USA announced it will cease manufacturing Rubigan from December 2012.
Used overseas in apples, peaches, cherries, grapes, bananas, strawberries, tomatoes, cucumber, melons, pumpkins.

FLUPROPANATE

1. Herbicide, halogenated aliphatic acid.
2. Soil degradation half-life: typical 365 days
3. Registered as Taskforce, 745 g/L as a water soluble concentrate
4. Registered for control of Chilean needlegrass, Nasella tussock and Kangaroo grass in pasture and waste areas.
5. Restricted Poison. Very toxic to aquatic organisms. Also very toxic to soil environment. Acute Oral LD_{50} >11,900 mg/kg; Acute dermal LD_{50} >400 mg/kg
6. Withholding Period: No grazing for 14 days on spot-treated pasture and 120 days for broadcast treated pasture. No grazing of treated areas by lactating animals.

A very slow acting herbicide Desired weed control may take 6-9 months depending on weather conditions. Length of residual control will depend on soil type and rainfall.

FLUSILAZOLE

1. Fungicide, triazole
2. Soil degradation half-life: Maximum – 392 days; Typical – 300 days
3. Registered as Novall 20WG, Nustar and Megastar.
4. Registered for control of black spot and powdery mildew of pip fruit, brown rot of stone fruit and scab of citrus.
5. Restricted Poison, Low toxicity
6. Withholding Period: Apples and pears 35 days; stone fruit: not to be applied after the start of shuckfall; citrus: not to be applied within 14 days of harvest.

Beresford (2013) mentions that it is one of the five DMI active ingredients currently registered for use in apples in NZ.
Evaluated in NZ on apples, stone fruit and carnations.

IMIDACLOPRID

1. Insecticide, neonicotinoid
2. Soil degradation half-life: Maximum – 341 days; Typical – 191 days
3. Registered as Confidor, Cyrus, Kohinor 350 and Nuprid. Also registered earlier as Gaucho.

4. Registered for use in onions, non-bearing grapevines and lettuce. Gaucho was registered for use as a seed treatment on cereals, forage brassicas, grass seed, maize, sweet corn, potatoes, pumpkin and winter squash.
5. Restricted Poison, Treated seed not to be used for human or animal consumption.
6. Withholding Period: Onions- 7 days, Lettuce- 35 days, vegetable brassicas- 70 days. For grazing stock- 6 weeks.

Has been evaluated in NZ for control of greenhouse thrips, lettuce aphid. Work reported in potatoes and vineyards.

Decourtye and Devillers (2010) found it was very toxic to bees.

MYCLOBUTANIL

1. Fungicide, DMI/triazole
2. Soil degradation half-life: Maximum – 1216 days. (EU data: 191-574 days)
3. Registered as Indar Duopart B, Pipstar encaps, Prostar, Systhane 125, Systhane 200 EW, Systhane 400 WP and Validus 200 EW.
4. Registered for curative and protectant activity for control of powdery mildew and black spot on pip fruit, grapes .
5. Restricted Poison, Low toxicity
6. Withholding Period: Grapes – 28 days; Pipfruit – 56 days.

Beresford (2013) mentions that it is one of the five DMI active ingredients currently registered for use in apples in NZ and is widely used.

Overseas used in grapes and apples.

Medium to low mobility.

Very toxic to aquatic organisms.

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