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Re-evaluation Note

REV2007-05

Preliminary Risk Assessment of Trichlorfon

(publié aussi en français)

17 May 2007

This document is published by the Health Canada Pest Management Regulatory Agency. For further information, please contact:

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ISBN: H113-5/2007-5E (H113-5/2007-5E-PDF)
Catalogue number: 978-0-662-46056-5 (978-0-662-46057-2)

Foreword

Health Canada's pesticide re-evaluation program considers potential risks as well as the value of pesticide products, to ensure they meet modern standards established to protect human health and the environment. In 1999, Health Canada's Pest Management Regulatory Agency (PMRA) announced in Re-evaluation Note REV99-01, *Re-evaluation of Organophosphate Pesticides*, that 27 organophosphate active ingredients, including trichlorfon, would be re-evaluated in Canada. The PMRA has completed a preliminary risk assessment for trichlorfon.

Products containing trichlorfon are registered under the following use-site categories: Forest and Woodlands, Livestock for Food, Terrestrial Food Crops, Terrestrial Feed Crops, Ornamentals Outdoors, Greenhouse Food Crops, Industrial Oil Seed and Fibre Crops, Structural, and Human Habitat and Recreational Areas. Only uses supported by the registrant were considered in the health and environmental risk assessments of trichlorfon. The preliminary assessment presented in this document indicates a level of concern for workers. As such, the PMRA is requesting further data/information to finalize the risk assessment and to propose regulatory action.

This Re-evaluation Note summarizes the science evaluation of trichlorfon. By way of this document, the PMRA is soliciting information from all interested parties to refine this occupational exposure assessment and/or mitigate risks.

The PMRA will accept written comments and information on this preliminary assessment up to 60 days from the date of publication of this document. Please forward all comments to Publications (contact information indicated on the cover page of this document).

The PMRA will review the information received, revise the assessments as necessary and propose regulatory actions in a future Proposed Re-evaluation Decision document.

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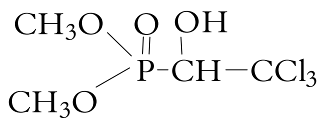
1.0 Introduction

Trichlorfon is one of the pesticides subject to re-evaluation in Canada as announced in Re-evaluation Document REV99-01, *Re-evaluation of Organophosphate Pesticides*. Trichlorfon is a broad spectrum, Resistance Management Group 1B (organophosphate) insecticide that inhibits the enzyme acetylcholinesterase and interrupts the transmission of nerve impulses. It works by contact and ingestion action.

Following the re-evaluation announcement for trichlorfon, Bayer CropScience Inc., the registrant of the technical grade active ingredient, indicated that it intended to discontinue all uses except for those on Balsam fir and spruce trees in farm woodlots, rights-of way, Christmas tree plantations and municipal parks, uses on beef and non-lactating dairy cattle and the uses on ornamentals. Only uses supported by the registrant were considered in the preliminary health and environmental risk assessments of trichlorfon.

2.0 The Active Substance, Its Properties and Uses

2.1 Identity of the Active Substance

Common name	Trichlorfon
Function	Insecticide
Chemical name	Dimethyl (2,2,2-trichloro-1-hydroxyethyl)phosphonate
Chemical family	Organophosphate
Chemical Abstracts Service registry number	52-68-6
Molecular formula	$C_4H_8Cl_3O_4P$
Molecular mass	257.4
Structural formula	
Purity of technical grade active ingredient	98% minimum
Registration number	22482
Basic manufacturer	Bayer do Brazil S.A.

Identity of relevant impurities of toxicological, environmental and/or other significance:	Based on the manufacturing process and on the starting materials used, the technical grade active ingredient is not known to contain impurities of toxicological concern as identified in Section 2.13.4 of Regulatory Directive DIR98-04 or Toxic Substances Management Policy (TSMP) Track 1 materials as identified in Appendix II of Regulatory Directive DIR99-03.

2.2 Physical and Chemical Properties of the Active Substance

Property	Result	
Colour and physical state	Colourless crystals	
Melting point/range	78.5°C	
Boiling point/range	Not applicable	
Specific gravity	1.73 at 20°C	
Vapour pressure	0.21 mPa at 20°C	
Ultraviolet (UV)–visible spectrum	Not expected to absorb UV at wavelength above 300 nm.	
Solubility in water at 20°C	120 g/L (20°C)	
Solubility (g/L) in organic solvents	**Solvent** Hexane Toluene 2-Propanol Methylene chloride	**g/L** 0.5 30 520 690
n-Octanol–water partition coefficient	Log K_{ow} = 0.43	
Dissociation constant	No dissociable functionality.	

2.3 Methods of Analysis

2.3.1 Methods for Analysis of the Active Substance as Manufactured

The active ingredient and impurities were quantitated by gas chromatography and high performance liquid chromatography. The method used for the active ingredient was found to be specific and precise for the determination.

2.4 Description of Registered Trichlorfon Uses

Appendix I lists all trichlorfon products registered under the authority of the *Pest Control Products Act*. Appendix II lists all the uses for which trichlorfon is presently registered, with an indication of which uses the registrant will continue to support, will no longer support or will partially support. Only uses supported by the registrant were considered in the health and environmental risk assessments of trichlorfon.

Products containing trichlorfon are registered under the following use-site categories: Forest and Woodlands, Livestock for Food, Terrestrial Food Crops, Terrestrial Feed Crops, Ornamentals Outdoors, Greenhouse Food Crops, Industrial Oil Seed and Fibre Crops, Structural, and Human Habitat and Recreational Areas.

3.0 Impact on Human and Animal Health

3.1 Toxicology Summary

The toxicology database supporting trichlorfon is based on studies from the registrant as well as numerous citations from the literature. In acute studies using laboratory animals, trichlorfon was highly to moderately toxic via the oral route and of low toxicity via the dermal and inhalation routes. Trichlorfon was moderately irritating to eyes, non-irritating to skin and was found to be a skin sensitizer. Acute toxic signs induced by trichlorfon are consistent with signs of cholinesterase intoxication and include tremors, salivation, diarrhea, decreased motor activity, respiratory distress and death. With oral exposure, trichlorfon was readily absorbed and rapidly eliminated with little tissue retention. Excretion occurred primarily via the urine and, to a lesser degree, in the feces and expired air. The identified urinary metabolites were demethyl trichlorfon, demethyl dichlorvos, dimethyl hydrogen phosphate, methyl hydrogen phosphate and phosphoric acid. Thus, the main degradation routes of trichlorfon are demethylation, phosphate-carbon cleavage and ester hydrolysis via dichlorvos. Trichlorfon rearranges via dehydrochlorination to form dichlorvos (a more potent cholinesterase inhibitor) under physiological conditions. The influence of gender on pharmacokinetics could not be ascertained from the available database.

Following single and repeated dosing, one of the most sensitive indicators of toxicity was the inhibition of acetylcholinesterase, an enzyme necessary for the proper functioning of the nervous system, progressing to clinical signs at higher doses. When tested in study animals (mouse, rat, rabbit, dog and monkey), acetylcholinesterase was affected by oral, dermal and inhalation routes, with no appreciable gender differences. The monkey appeared to be the most sensitive species to the cholinesterase inhibition, whereas the mouse was the least sensitive. Repeat-dose oral data suggest that increased duration of dosing results in a slight increase in toxicity with chronic exposure. At higher doses, trichlorfon affected the liver, kidney, lungs, spleen, gastrointestinal tract and hematological components.

In an acute oral study in chickens, no evidence of delayed neurotoxicity was evident; however, this study was considered supplemental due to study limitations. In a subchronic oral study in chickens, there were no clinical or behavioural signs of neurotoxicity, but slight axonal degeneration was noted at the highest dose tested. Neurotoxic esterase activity was not measured in this study. In the subchronic neurotoxicity study in the rat, minimal myelin degeneration of the spinal nerve roots was demonstrated at levels producing cholinesterase depression, clinical signs and neurobehavioural alterations.

A developmental neurotoxicity study conducted recently in rats showed functional changes in offspring (albeit transient) as well as effects on brain weight and size. These changes occurred at levels that also caused cholinesterase inhibition in the offspring as well as toxicity in the maternal animals. However, no convincing evidence was provided to demonstrate lactational transfer of trichlorfon; hence, there is residual uncertainty over the level of exposure received by the pups during the entire peak brain growth spurt period. While the study indicates that fetuses are unlikely to be more sensitive than maternal animals, the study may not adequately predict the potential effects associated with direct exposure of infants to trichlorfon.

Trichlorfon presented limited evidence of potential for carcinogenicity in the available database. Trichlorfon was evaluated for carcinogenicity in mice, rats and monkeys. In female mice, there was an increased incidence of mammary tumours at the high dose only; however, this dose was considered excessive based on increased mortality. In rats, increased incidences of alveolar/bronchiolar adenomas in males, alveolar/bronchiolar carcinomas in females and renal tubular adenomas in males were noted at the high dose; however, this dose exceeded the maximum tolerated dose. There was no significant pathology, including tumorigenicity, and no preneoplastic lesions in monkeys exposed to daily doses of trichlorfon for 10 years. Trichlorfon has also tested positive in various in vitro assays of cell damage and negative in an in vivo assay for clastogenicity.

Reproductive effects observed at the highest dose in the two-generation reproduction study included a reduction in live birth index. At this dose level, adults had toxicologically significant reductions in erythrocyte and brain cholinesterase as well as renal and pulmonary pathology but no clinical signs of cholinergic poisoning. Adults also showed cholinesterase inhibition at the low and mid-dose level. Effects observed in the high-dose offspring included reduced viability, brain cholinesterase and increased incidence of dilated renal pelvises. Based on the results of this study, there is no evidence of increased sensitivity of the offspring compared to the adults due to treatment with trichlorfon. Similar effects (e.g., a decrease in the live birth index and the viability index) were also observed at comparable dose levels in the developmental neurotoxicity study. The only effect indicative of endocrine toxicity is the decreased spermatogenesis observed in dogs treated for one year with trichlorfon.

All rat developmental studies conducted by gavage were considered supplemental due to various study limitations. In two supplemental gavage studies and one supplemental dietary study, maternal toxicity was evident as clinical signs, cholinesterase inhibition, mortality or decreased food intake at doses at or below those causing developmental toxicity. In a third gavage study using high-dose levels, fetal death and malformations were observed in the absence of effects on maternal weight gain or food intake. In an acceptable dietary study, delayed ossification and rib abnormalities were noted in fetuses at a level resulting in maternal toxicity (i.e., cholinesterase inhibition and decreased weight gain and food intake). In the rabbit developmental study, no treatment-related terata were observed; however, increases in resorptions as well as decreases in ossification and fetal weights were identified at a dose causing maternal toxicity (clinical signs, abortions and cholinesterase inhibition). In a published study, administration of trichlorfon to pregnant mice and hamsters resulted in an increase in malformations, but only at doses that were maternally toxic. The study in mice showed an effect on fetal weight in the absence of maternal toxicity; however, maternal animals were monitored for weight gain and food intake only. Several studies from the published literature raise concerns regarding the effects of trichlorfon on prenatal brain development in guinea pigs and pigs.

In general, organophosphate intoxication in humans is manifested by symptoms that appear in three stages. For those who survive the acute effects of organophosphate intoxication (characterized by peripheral muscarinic effects such as nausea, vomiting, anorexia, abdominal cramps, diarrhea and bradycardia), an intermediate syndrome can develop, which involves nicotinic effects such as muscle weakness, fatigability, twitching and paralysis affecting the neck flexors, proximal limb muscles, cranial nerve-innervated muscles and respiratory muscles. Symptoms develop 24 to 96 hours after the acute cholinergic phase and can last 2 to 3 weeks. A delayed syndrome can subsequently be observed, which worsens over several days to weeks and comprises central nervous system effects such as confusion, ataxia, slurred speech and central respiratory paralysis and a sensorimotor axonal polyneuropathy that is most severe distally. Death due to organophosphorus intoxication generally arises due to respiratory failure that is multifactorial in etiology and may involve pulmonary edema.

The human data available on trichlorfon are abundant with respect to poisoning cases, case studies following therapeutic administration for parasitic infestations and clinical trials for treatment of Alzheimer’s disease. These data substantiate that acute exposure to high doses of trichlorfon results in those effects typically associated with acute organophosphate intoxication. The data also support the premise that individuals who survive an acute poisoning episode could suffer from the delayed syndrome manifested as distal neuropathy. Of greater concern, however, are those individuals who have been exposed to non life-threatening doses that appear to develop the intermediate syndrome. The proximal muscle weakness associated with this intermediate syndrome can itself be life-threatening and recovery from this effect cannot be assured. This syndrome has been observed in humans at doses equal to or close to 0.65 mg/kg bw/day.

3.2 Occupational and Non-Occupational Preliminary Risk Assessment

Occupational and residential risk is estimated by comparing potential exposures with the most relevant endpoint from toxicology studies to calculate a margin of exposure (MOE). This is compared to a target MOE incorporating safety factors protective of the most sensitive subpopulation. If the calculated MOE is less than the target MOE, it does not necessarily mean that exposure will result in adverse effects. However, MOEs less than the target MOE require measures to reduce risk. For trichlorfon, the adverse toxicological endpoint of cholinesterase inhibition is the same regardless of exposure route; thus, it is appropriate to combine the route-specific exposures to generate a single risk estimate. Where the target MOEs for exposure routes are the same, a “combined-route MOE” may be generated.

Trichlorfon has been shown to cause central nervous system malformations following prenatal exposure, to affect brain weight in offspring (which does not appear to be related solely to general growth retardation) and to cause persistent functional changes as well as neuropathology in the offspring of pigs and guinea pigs. The developmental neurotoxicity study showed functional changes in offspring (albeit transient) as well as effects on brain weight and size. Trichlorfon has been shown to cause neuropathology in hens and humans that were directly exposed to this organophosphate. In addition, human data indicate that exposure to sublethal doses may subsequently lead to later development of an intermediate syndrome that includes proximal muscle weakness as well as a myriad of other possible neurological manifestions. On this basis, an additional safety factor of 3-fold was considered appropriate to address neurotoxicity concerns.

For short- and intermediate-term dermal risk assessment in adults, the dermal no observed adverse effect level (NOAEL) of 100 mg/kg bw/day from a 21-day rabbit dermal study was selected. Inhibition of erythrocyte cholinesterase was observed at the lowest observed adverse effect level (LOAEL) of 300 mg/kg bw/day in this study. The target MOE selected when using this study is 300, accounting for standard uncertainty factors of 10-fold for interspecies extrapolation, 10-fold for intraspecies variability as well as an additional 3-fold safety factor for neurotoxicity concerns. This NOAEL and MOE is considered to be protective of all populations including pregnant women and their unborn children.

For assessment of short- and intermediate-term inhalation risk assessment in adults, the inhalation NOAEL of 3.5 mg/kg bw/day from a 21-day rat inhalation study was selected. Inhibition of plasma, erythrocyte and brain cholinesterase was observed at the LOAEL of 9.5 mg/kg bw/day in this study. The target MOE selected when using this study is 300, accounting for standard uncertainty factors of 10-fold for interspecies extrapolation, 10-fold for intraspecies variability as well as an additional 3-fold safety factor for neurotoxicity concerns. The selection of this study and MOE is considered to be protective of all populations including pregnant women and their unborn children.

3.2.1 Occupational Exposure and Preliminary Risk Assessment

Workers can be exposed to trichlorfon when mixing, loading or applying the pesticide. As trichlorfon degrades to dichlorvos, workers can be exposed to both when entering a treated site to conduct activities such as handling treated ornamentals and Christmas trees or when handling treated livestock.

3.2.1.1 Mixer/Loader/Applicator Exposure and Preliminary Risk Assessment

There is a potential for exposures in mixers, loaders, applicators and other handlers. Based on typical use patterns, the major scenarios identified for the wettable powder formulation include the following:

- Mixing/loading/applying by low-pressure handwand, high-pressure handwand and backpack;
- Mixing/loading for aerial application;
- Ultra-low volume (ULV) aerial application;
- Mixing/loading/applying by right-of-way sprayer;
- Mixing/loading/applying by airblast; and
- Mixing/loading/applying by groundboom.

The major scenario identified for the solution formulation includes the following:

- Pour-on (graduated applicator).

Based on the number of applications, workers applying trichlorfon would generally have a short- to intermediate-term duration of exposure (< 30 days to 1–3 months, respectively). The PMRA estimated handler exposure based on different levels of personal protection:

- Engineering Controls: Closed mixed/loading. Engineering controls cannot be used with handheld application methods because no known devices can be used to routinely lower the exposures for these methods.

- Baseline personal protective equipment (PPE): long-sleeved shirt and long pants, chemical-resistant gloves, with and without respirator and open or closed mixing.

- Mid-level PPE: cotton coveralls over long-sleeved shirt and long pants, chemical-resistant gloves, with and without respirator and open or closed mixing.

- Maximum PPE: chemical-resistant coveralls over long-sleeved shirt and long pants, chemical-resistant gloves, with respirator and open or closed mixing.

Mixer/loader/applicator exposure estimates are based on the best available data at this time. The assessment might be refined with exposure data more representative of modern application equipment and engineering controls. Biological monitoring data could also refine the assessment further.

No chemical-specific handler exposure data were submitted for trichlorfon. Consequently, dermal and inhalation exposures were estimated using data from the Pesticide Handlers Exposure Database (PHED), Version 1.1. The PHED is a compilation of generic mixer/loader applicator passive dosimetry data with associated software that facilitates the generation of scenario-specific exposure estimates based on formulation type, application equipment, mixing/loading systems and level of PPE. In most cases, the PHED did not contain appropriate data sets to estimate exposure to workers wearing chemical-resistant coveralls or a respirator. This was estimated by incorporating a 90% clothing protection factor for chemical-resistant coveralls and a 90% protection factor for a respirator into the unit exposure data.

PHED data for high and low-pressure handwand scenarios are representative of application to low and mid level shrubs, and may underestimate exposures to the head and upper body for application to trees. Additionally, there are no reliable PHED data for wettable powder with water-soluble packaging (WSP) (closed mixing/loading) for these scenarios or for backpack application scenarios. Mixing/loading/application data for liquid high- and low-pressure handwand and backpack were used to represent closed mixing/loading and open application; they are not believed to underestimate exposure.

Calculated MOEs (summarized in Appendix IV) exceed target MOEs for application, mixing and loading for current label uses, provided engineering controls and/or personal protective equipment are used.

3.2.1.2 Occupational Postapplication Exposure and Preliminary Risk Assessment

Forestry, Ornamentals and Christmas Tree Plantations

Based on the trichlorfon use pattern, there is potential for short-term (< 30 days) postapplication exposure to trichlorfon and dichlorvos. The postapplication occupational risk assessment considered exposures to workers entering treated sites, including forests, nurseries and Christmas tree plantations.

Given that trichlorfon degrades to dichlorvos, dislodgeable foliar residues (DFRs) of dichlorvos were also estimated. No relevant studies were available for estimating the DFRs of dichlorvos after application of trichlorfon on ornamentals. However, Murphy, Cooper and Clark (1996)[1] measured turf transferable residues (TTR) of dichlorvos after application of trichlorfon; this was examined to estimate a degradation value (percentage of trichlorfon residues that break down to dichlorvos residues). The highest TTR value reported in the study was 27%, which represents the percentage of total TTRs that was dichlorvos at 3 hours after application. This value was used to support an estimate of 50% (as opposed to 27%) because the study examined application on turf (not representative of ornamentals) as well as had a number of limitations.

Other data considered for the estimate of the amount of trichlorfon that degrades to dichlorvos were hydrolysis laboratory studies in which, at pHs levels between 7 and 9, dichlorvos made up 25.5 to 52% of the applied radioactivity. Based on a weight-of-evidence approach, a conservative value of 50% was estimated for the amount of trichlorfon that degrades to dichlorvos on the foliage.

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1 Murphy, K.C., R.J. Cooper and J.M. Clark. 1996. Volatile and dislodgeable residues following trichlorfon and isazofos application to turfgrass and implications for human exposure. *Crop Science*. 36(6): 1446–1454.

The default dissipation rate of 10% per day was increased to 50% per day based on the volatility of dichlorvos (vapour pressure = 1.2×10^{-2} to 3.2×10^{-2} mm Hg)[2] and its dissipation rate from a number of turf studies dichlorvos. Three proprietary TTR studies conducted in Ontario, California and Florida showed dissipation rates between 66% and 73% for dichlorvos applied on turf.

Inhalation exposure to trichlorfon is not considered to be a significant route of exposure for people entering treated forests, nurseries or Christmas tree plantations compared to the dermal routes. In addition, trichlorfon has low volatility based on a vapour pressure of 7.8×10^{-6} mm Hg at 20°C. Thus, a postapplication inhalation exposure assessment was not conducted.

However, dichlorvos—a breakdown product of trichlorfon—has a high vapour pressure, 1.2×10^{-2} mm Hg, under field conditions[3]. No relevant studies were available to determine the air concentrations of dichlorvos after trichlorfon is applied on ornamentals. However, Murphy, Cooper and Clark's study[1] in which trichlorfon was applied to irrigated and non-irrigated turf plots with a groundboom sprayer summarized air concentrations of dichlorvos on days one and two after application. Based on these air concentrations (0.23 µg a.i./m^3 on day 1 and 0.12 µg a.i./m^3 on day 2 corrected for the lower application rate in Canada for ornamentals and forestry), inhalation exposure is not expected to be of concern (see Table 3.2.2.1 below). Additional data would be needed to confirm air concentrations of dichlorvos are similar after application of trichlorfon on ornamentals, forestry and narcissus.

Table 3.2.2.1 Concentrations of Dichlorvos After Application With Trichlorfon on Turf

Day After Application on Turf	Air Concentration (mg/m^3)[a]	Respiratory Exposure (mg/kg bw/day)[b]	MOE[c]
2	0.0003528	0.0000403	1240
3	0.0001764	0.0000202	2480

a Maximum air concentration sampled 70 cm above centre of treated plot; corrected for application rate (from 9.2 to 1.8 kg a.i./ha).

b Where inhalation exposure = [concentration (mg a.i./m^3) × respiratory volume m^3/hour × 8 hrs/day] / 70 kg. Respiratory volume is based on the *Draft International Harmonisation Position Paper on Methodology Issues*[3] values for light activity 1.0 m^3/hour.

c Based on a short-term oral NOAEL of 0.05 mg/kg/day for dichlorvos established by the PMRA in 2004 assuming 100% absorption (target MOE of 1000).

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2 United States Environmental Protection Agency. Health Evaluation Division 2000. *Human Health Risk Assessment: Dichlorvos (DDVP).* Case # 0104. DP Barcode: D267106. Chemical No. 057901.

3 NAFTA. 18 January 1999. *Draft International Harmonisation Position Paper on Methodology Issues*. Occupational Exposure Assessment Section, Pest Management Regulatory Agency, Health Canada; Health Effects Division, Office of Pesticide Programs, United States Environmental Protection Agency; Worker Health and Safety Branch, Department of Pesticide Regulation, California Environmental Protection Agency. Unpublished.

Restricted-entry intervals (REIs) are calculated to determine the minimum length of time required before workers or others can safely re-enter a treated site. An REI is the duration of time that must elapse before residues on surfaces or in air decline to a level where performance of a specific activity results in exposures above the target MOE (i.e., > 300 for trichlorfon and > 1000 for dichlorvos for short-term exposure scenarios). REIs and postapplication exposure calculations for each use site are summarized in Appendix IV.

In the forestry and Christmas tree scenarios, calculated MOEs exceed target MOEs for postapplication exposure to trichlorfon at day 0, assuming 2 applications, 7 days apart, with the exception of hand-line irrigation (REI of 7 days). For postapplication exposure to dichlorvos, target MOEs were not met until day 7 (grading and tagging) to 11 (hand-line irrigation).

For ornamentals and narcissus, target MOEs for trichlorfon residues were not met until 28 days after application for ornamentals (assuming 2 applications, 7 days apart) and 33 days for narcissus. For dichlorvos residues, target MOEs were not met until day 14 for ornamentals and day 15 for narcissus.

The length of time that it takes for trichlorfon and dichlorvos residues to reach acceptable levels (i.e., when the target MOE is met) is not considered feasible for all crops (see Table 3.2.2.2). Postapplication exposure estimates are based on the best available data. The calculated REIs may be further refined with DFR studies that characterize the residues of both.

Table 3.2.2.2 Restricted-Entry Interval for Commercial Postapplication Activities

Crop	Activity	Transfer Coefficient[a]	Trichlorfon	Dichlorvos	Feasible REI[d]
			Proposed REI[b]	Proposed REI[c]	
Christmas trees	Hand-line irrigation	1100	7	11	7
Christmas trees	Hand pruning, scouting, pinching, tying, training, shaping	500	0	10	7
Christmas trees	Hand weeding, propping, grading/tagging Christmas trees	100	0	7	7
Forestry	Scouting, tying, training,	500	0	10	7
Forestry	Grading/tagging	100	0	7	7

Crop	Activity	Transfer Coefficient[a]	Trichlorfon	Dichlorvos	Feasible REI[d]
			Proposed REI[b]	Proposed REI[c]	
Ornamentals (cut flowers)	Hand harvesting, hand pruning, thinning, pinching	7000	25	14	1
Ornamentals (cut flowers)	Irrigation, scouting	4000	19	13	1
Ornamentals (cut flowers)	Irrigation, scouting, thinning, hand weeding	2500	15	12	1
Outdoor ornamentals (shrubs)	Transplant ball/burlap	10000	28	14	7
Outdoor ornamentals (shrubs)	Irrigate	4000	19	13	1 to 7
Outdoor ornamentals (shrubs)	Sort/pack	2500	15	12	7
Narcissus	Irrigation, scouting	4000	33	15	14

[a] Based on transfer coefficients as set out in Transfer Coefficients for Orchard Tree Crops and Christmas, *Science Advisory Council for Exposure Agricultural Transfer Coefficient* and *Science Advisory Council for Exposure Agricultural Default Transfer Coefficient*.

[b] Based on worker short-term dermal NOAEL of 100 mg/kg bw/day with a target MOE of 300 for trichlorfon and 2 applications, 7 days apart (except for narcissus where one application was assumed).

[c] Based on worker short-term oral NOAEL of 0.05 mg/kg bw/day with a target MOE of 1000 for dichlorvos and a dermal absorption of 30% where 50% of trichlorfon breaks down to dichlorvos with 50% dissipation per day.

[d] Feasible REIs based on crop-specific information.

Livestock Use Pattern

It is expected that postapplication exposure for livestock handlers would be less than that for individuals applying product. Therefore, a quantitative postapplication exposure assessment was not conducted.

3.2.2 Non-Occupational (residential) Exposure and Preliminary Risk Assessment

Residential risk assessment is concerned with estimating risks to the general population, including children, during or after pesticide application. Postapplication exposure may occur when thrichlorfon is used in outdoor residential and recreational areas. Although the registrant does not support trichlorfon use on ornamentals in residential areas, the registrant does support ground and aerial application of trichlorfon in municipal parks for the control of spruce budworm larvae.

There is potential for short-term exposure to adults and children during or immediately following application of trichlorfon (e.g., hikers entering treated municipal parks). There is insufficient data to estimate deposition rates or DFR values of trichlorfon (and dichlorvos) from aerial ULV or ground application in municipal parks. It was assumed that exposure of hikers would be similar to scouters entering a treated forest. Based on this re-entry activity, the calculated MOEs were 1315 for trichlorfon and 6 for dichlorvos, based on 2 hours of activity in a municipal park on day 0 (see Table 3.2.2.1).

Postapplication exposure in toddlers is expected to be greater than that of a hiker because postapplication activities associated with toddlers are considered more intensive (incidental non-dietary oral exposure resulting from hand-to-mouth transfer and direct ingestion of soil or turf). As well, these estimates do not include potential inhalation exposure to dichlorvos. Currently, no data are available to estimate air concentrations of dichlorvos following application of trichlorfon (day 0) on spruce and fir trees in municipal parks via ULV aerial or ground application equipment.

Table 3.2.2.1 Residential Postapplication Exposure for Adults in Municipal Parks[a]

Activity	Day After Application	Transfer Coefficient[b] (cm^2/hour)	DFR[c] (μg/cm^2)		Duration (hours per day)	Dermal Exposure (μg/kg bw/day)		MOE	
			TRI	DVP		TRI[d]	DVP[e]	TRI[d]	DVP[e]
Scouting/ hiker (adult)	0	500	5.3	1.8	2	76.03	7.77	1315	6
	7	500	2.5	0	2	36.36	0.06	2750	823
	8	500	2.3	0	2	32.73	0.03	3056	1646

*Shaded cells indicate MOE < target MOE.

a Estimates do not include potential inhalation exposure.

b Transfer coefficients for orchard tree crops and Christmas trees.

c Based on 2 applications, 7 days apart and a default of 20% of the maximum application rate with 10% dissipation per day for trichlorfon; based on the assumption that 50% of trichlorfon breaks down to dichlorvos with 50% dissipation per day.

d Based on a short-term dermal NOAEL of 100 mg/kg bw/day with a target MOE of 300.

e Based on a short-term oral NOAEL of 0.05 mg/kg bw/day with a target MOE of 1000 and a dermal absorption of 30%.

As the REIs summarized above for adults are not considered feasible for municipal parks, a postapplication assessment for children was not pursued. In addition, children's exposure is expected to be higher, and the application of safety factors may be more stringent.

3.3 Dietary Exposure and Risk Assessment

In a dietary exposure assessment, the PMRA determines how much of a pesticide residue, including residues in milk and meat, may be ingested with the daily diet. These dietary assessments are age-specific and incorporate the different eating habits of the population at various stages of life. For example, the assessments take into account differences in children's eating patterns, such as food preferences and the greater consumption of food relative to their body weight when compared to adults. Dietary risk is then determined by the combination of the exposure and the toxicity assessments. High toxicity may not indicate high risk if the exposure is low. Similarly, there may be risk from a pesticide with low toxicity if the exposure is high.

The PMRA considers limiting use of a pesticide when risk exceeds 100% of the reference dose. The PMRA's Science Policy Note SPN2003-03, *Assessing Exposure from Pesticides, A User's Guide*, presents detailed acute and chronic risk assessment procedures.

Acute and chronic dietary exposure and risk estimates were generated using Dietary Exposure Evaluation Model (DEEM®) software and updated consumption data from the United Sates Department of Agriculture's Continuing Survey of Food Intakes by Individuals 1994–1998.

3.3.1 Acute Dietary Exposure and Risk Assessment

Acute dietary risk is calculated considering food consumption and food residue values. A probabilistic statistical analysis allows all possible combinations of consumption and residue levels to be combined to estimate a distribution of the amount of trichlorfon residue that might be eaten in a day. A value representing the high end (99.9th percentile) of this distribution is compared to the acute reference dose, which is the dose at which an individual could be exposed on any given day and expect no adverse health effects. When the expected intake from residues is less than the acute reference dose, the expected intake is not considered to be of concern.

To estimate acute dietary risk (1 day), the NOAEL of 10 mg/kg bw/day from the acute neurotoxicity study in rats was selected for risk assessment based on clinical signs, alteration in functional observational battery, decreased motor activity, and significant erythrocyte and brain cholinesterase inhibition at 50 mg/kg bw/day. Standard uncertainty factors were used for a total uncertainty factor of 100 (10-fold for interspecies extrapolation and 10-fold for intraspecies variability). An additional uncertainty/safety factor of 3-fold, as discussed in Section 3.2, was also applied. The acute reference dose was calculated to be 0.03 mg/kg bw. It is the opinion of PMRA that uncertainty associated with the direct exposure of non-nursing infants is accommodated within the additional 3-fold safety factor for neurotoxicity concerns.

This reference dose provides a margin of safety of 3400 to the lowest developmental NOAEL of 102 mg/kg bw/day from a rat dietary study and ~1200 to the lowest developmental NOAEL of 35 mg/kg bw/day from the rabbit gavage study. This reference dose also provides a margin of safety of ~1700 to the NOAEL of 50 mg/kg bw/day for increased stillbirths in the reproduction and developmental neurotoxicity studies. Thus, this value is considered protective of all populations including pregnant females and their unborn children. In supplemental human studies, a single oral dose of 5 mg/kg bw of trichlorfon has been shown to inhibit erythrocyte cholinesterase inhibition by > 20%, yielding a margin of exposure of ~170 to the acute reference dose.

The acute dietary exposure was assessed in a mixed tier probabilistic assessment using anticipated residue data from dermal application studies with livestock. This represents the only supported food use of trichlorfon. The acute potential daily intake accounts for 1.3% (99.9th percentile) of the acute reference dose for the general population and 2.1% of the acute reference dose for children three to five years of age. Therefore, the acute dietary risk from trichlorfon is not considered to be of concern.

3.3.2 Chronic Dietary Exposure and Risk Assessment

The chronic dietary risk was calculated by using the average consumption of different foods, and the average residue values on those foods, over a 70-year lifetime. This expected intake of residues was compared to the acceptable daily intake, which is the dose at which an individual could be exposed over the course of a lifetime and expect no adverse health effects. When the expected intake from residues is less than the acceptable daily intake, the expected intake is not considered to be of concern.

The 10-year chronic toxicity/oncogenicity Rhesus monkey study was selected to estimate dietary risk from repeat exposure. A LOAEL was established at 0.2 mg/kg bw/day based on decreased erythrocyte and brain cholinesterase activity in the males. It is worth noting that in two clinical trials, similar maintenance doses of 0.2–0.25 mg/kg bw/day produced significant erythrocyte cholinesterase inhibition in humans.

For all populations, standard uncertainty factors were used (10-fold for interspecies extrapolation and 10-fold for intraspecies variability) as well as an additional factor of 10-fold. The additional factor accounted for the use of a LOAEL instead of a NOAEL as well as for the neurotoxicity concerns (see Section 3.3.1) resulting in an overall factor of 1000 and an acceptable daily intake of 0.0002 mg/kg bw/day. It is the opinion of the PMRA that uncertainty associated with the direct exposure of non-nursing infants is accommodated within the additional 10-fold safety factor.

This reference dose provides a margin of exposure of > 3000 to the dose at which the intermediate syndrome of organophosphate intoxication has been observed in humans.

The chronic dietary exposure was assessed using anticipated residue data from livestock dermal application studies, which represents the only supported food use of trichlorfon. Chronic dietary exposure as a percentage of the acceptable daily intake is 7% for the general population and 13% for the most affected subpopulations—children one to two years of age and children three to five years of age. Therefore, the chronic dietary risk from trichlorfon is not considered to be of concern.

3.4 Exposure From Drinking Water

3.4.1 Concentrations in Drinking Water

The forestry use of trichlorfon is not expected to result in significant contamination of drinking water sources. Forestry applications are usually carried out in remote locations and away from human habitations. The spray programs are infrequent and may be required only once every few years depending on the pest pressure. The amount of pesticide that would reach the soil would be much less than in an agricultural field because of the heavy canopy in a forest. The forest floor usually has an organic layer formed from dead leaves and pine needles, which covers the soil beneath. This organic layer would be expected to decrease any potential runoff. In addition, the relatively short half-lives for dichlorvos and trichlorfon in surface water further decrease the potential for contamination of drinking water sources.

The livestock and ornamental outdoors uses of trichlorfon are also not expected to result in significant contamination of drinking water. Both uses would only be spot treatments and would result in minimal exposure to soil; hence, these uses would result in limited potential for contamination of drinking water sources.

3.4.2 Drinking Water Exposure and Risk Assessment

The supported uses of trichlorfon are not expected to result in any significant drinking water exposure. Therefore, drinking water risks are not of concern. Nonetheless, drinking water levels of comparison (DWLOC) were determined for all subpopulations. The DWLOCs can only be calculated if other relevant exposures are not of concern to the PMRA as they simply express the difference between the reference dose and the non-drinking water exposure. The DWLOC values were compared to model estimates of potential water exposure. The acute DWLOC values ranged from 294 µg/L for children three to five years of age, to 1037 µg/L for the general population. The chronic DWLOCs ranged from 1.7 µg/L for the most affected subpopulations—children from 1 to 2 years of age and children 3 to 5 years of age—to 6.5 µg/L for the general population.

3.5 Aggregate Exposure and Risk Assessment

The dietary exposure estimates encompass all potential non-occupational exposures from trichlorfon. There are no residential uses of trichlorfon and there is no expectation of exposure through drinking water. The use in municipal parks is unacceptable based on health risks, and the PMRA is proposing to phase out this use (see sections 7.0 and 8.0). Given that dietary exposure is acceptable for all populations and durations (see Section 3.3), aggregate risk is not of concern.

4.0 Impact on the Environment

In assessing the environmental risk of trichlorfon, a deterministic assessment was conducted. In this assessment, risk was characterized by the quotient method, calculated as the ratio of the estimated environmental concentration to the effects endpoints of concern. Quotient values less than one are considered to indicate a low risk to non-target organisms, whereas values greater than one are considered to indicate that some degree of risk exists for non-target organisms.

Estimated environmental concentrations for aquatic and terrestrial ecosystems were determined for the forestry and ornamental outdoors uses of trichlorfon based on the range of application rates and number of applications listed on the current registered labels. The livestock uses were not expected to result in appreciable exposure to nontarget terrestrial and aquatic organisms; therefore, an assessment was not conducted for this use pattern. Effects toxicity endpoints (acute and chronic) were chosen for the most sensitive species tested and used as surrogates for the wide range of species that could be exposed following treatment with trichlorfon.

4.1 Environmental Fate

In terrestrial environments, trichlorfon is expected to be non-persistent in soil, with aerobic biotransformation being an important route of dissipation and hydrolysis contributing in neutral to acidic environments. There is a high potential for mobility due to the very high solubility in water and weak adsorption to soil. In aquatic environments, trichlorfon is also expected to be non-persistent. Trichlorfon has a minimal potential for bioaccumulation in biota.

Table 4.1.1 Summary of the Physicochemical Properties, Transformation and Fate of Trichlorfon

Property/Process	Result	Interpretation
Solubility in water at 20°C	120 000 mg/L (20°C)	Very soluble.
Vapour pressure	1.58×10^{-6} mm Hg at 20°C	Relatively nonvolatile under field conditions.
Henry's law constant 1/H	4.46×10^{-12} atm m^3 mol^{-1} at 20°C 5.0×10^9	Not likely to volatilize from water or moist soil.
n-Octanol–water partition coefficient	Log K_{ow} = 0.43	Minimal potential for bioaccumulation.
Hydrolysis half-life	pH 5 104 days pH 7 1.4 days pH 9 31 minutes	Stable at pH levels below 5, rapidly transformed at pH levels > 7. Dichlorvos major transformation product.
Aerobic soil biotransformation	DT_{50} 1 to 27 days	Important route of transformation. Hydrolysis may have contributed.
Anaerobic soil biotransformation	DT_{50} 1.8 days	Observed transformation probably due to hydrolysis. Dichlorvos major transformation product.
Aerobic aquatic biotransformation	DT_{50} 8 hours	Observed transformation may have been due to hydrolysis.
Soil adsorption	K_{oc} values 19–38	Does not adsorb strongly to soil and sediment.
Canadian field dissipation	Not detected in soil 2 weeks following aerial application.	Non-persistent in soil.

Dichlorvos is the major transformation product resulting from the hydrolysis of trichlorfon. Pest control products with dichlorvos as the active ingredient are registered for the control of a number of insect pests in Canada.

Table 4.1.2 Summary of the Physicochemical Properties, Transformation and Fate of Dichlorvos

Property/Process	Result	Interpretation
Solubility in water at 20°C	15 000 mg/L at 25°C	Very soluble.
Vapour pressure	1.2×10^{-2} mm Hg at 20°C (1.6 Pa)	Intermediate to high volatility under field conditions.
Henry's law constant 1/H	2.32×10^{-7} atm.m^3/mol 9.63×10^4	Slightly volatile from water or moist soil.
n-Octanol–water partition coefficient	1.47	Low potential for bioaccumulation.
UV–visible absorption spectrum	Does not absorb UV light above 240 nm	Photolysis not expected to be important route of transformation.
Hydrolysis half-life	pH 5 12 days pH 7 5 days pH 9 0.88 days	Hydrolysis is pH dependant and an important route of transformation at alkaline pH levels.
Aerobic soil biotransformation	DT_{50} 1 hour to 19 days	Important route of transformation.
Anaerobic soil biotransformation	DT_{50} 6.3 days	Important route of transformation.
Aerobic aquatic biotransformation	DT_{50} ≤ 1 day	Important route of transformation.
Soil adsorption	K_{oc} values 0–150	Potential for very high mobility.

4.2 Environmental Toxicology

Trichlorfon

The lethal dose 50% (LD_{50}) to the honeybee (*Apis mellifera*) is 3.6 µg a.i./bee. No data are available to characterize toxicity to earthworms.

Acute oral toxicity values for birds range from 22.4 mg a.i./kg bw for the bobwhite quail (*Colinus virginianus*) to 123 mg a.i./kg bw for the rock dove (*Columbia livia*). Acute dietary toxicity values for birds range from 720 mg a.i./kg diet for the bobwhite quail (*Colinus virginianus*) to > 5000 mg a.i./kg diet for the mallard duck (*Anas platyrhnchos*). Avian reproduction studies indicate that trichlorfon can affect reproduction at levels as low as 30 mg a.i./kg diet with a reported no observed effect concentration (NOEC) of 9 mg a.i./kg diet.

Trichlorfon acute oral toxicity to mammals ranges from 136 to 800 mg a.i./kg bw in rats and mice. Acute dietary data indicates a NOAEL of 50 mg a.i./kg bw in rats based on cholinesterase inhibition. A 2-generation reproduction study with rats indicates a reproductive NOAEL of 175 mg a.i./kg bw in rats.

Trichlorfon acute lethal concentration 50% (LC_{50}) values to freshwater crustaceans and insects ranges from 0.18 µg a.i./L *(Daphnia* spp.) to 150 µg a.i./L (dragonfly). Snails and crayfish were less sensitive, with LC_{50} values ranging from 1800 µg a.i./L to 25 000 µg a.i./L, respectively. A chronic study on *Daphnia magna* indicates a NOEC of 0.0056 µg a.i./L. A wide range of acute toxicity values with both end-use products and technical grade trichlorfon are observed for freshwater fish species, with LC_{50} values ranging from 230 µg a.i./L to 110 000 µg a.i./L.

An early life-stage study on rainbow trout using technical trichlorfon reported a NOEC of 110 µg a.i./L . For marine invertebrates and fish, LC_{50} values ranged from 0.36 µg a.i./L for pink shrimp up to 1110 µg a.i./L for cherry salmon. No data are available to address toxicity to algae, vascular plants and amphibians.

Dichlorvos

The 14-day LC_{50} of dichlorvos (purity 99.8%) to the earthworm *Eisenia foetida foetida* was 80.9 mg a.i./kg dry soil, with a NOEC of < 12.3 mg a.i./kg dry soil. Laboratory tests show toxicity to honeybees (*Apis mellifera*), with topical application or oral dosing giving LD_{50} values ranging from 0.052 mg a.i./bee to approximately 0.9 mg a.i./bee.

LD_{50}s from a single acute oral dose of dichlorvos to a wide range of bird species range from 2.5 mg a.i./kg bw for canaries to 42.1 mg a.i./kg bw for starlings. Acute/subacute avian dietary toxicity studies indicate LC_{50}s in the diet ranging from 298 to > 5000 mg a.i./kg. Chronic early life/reproductive toxicity studies with dichlorvos indicated a NOEC of 30 mg a.i./kg diet to bobwhite quail (*Colinus virginianus*), a NOEC of 20 mg a.i./kg diet to Japanese quail (*Coturnix japonica*) and NOECs of < 2 and < 12 mg a.i./kg diet to the mallard duck (*Anas platyrhynchos*) in two separate studies.

LC_{50} values for aquatic invertebrates from studies with a range of freshwater and estuarine/marine crustacea, molluscs and aquatic insects are from 0.066 mg a.i./L to 881 mg a.i./L for exposure periods of 24–96 hours.

Available data on the chronic or reproductive toxicity of dichlorvos to aquatic invertebrates include a 14-day study with the water flea (*Daphnia magna*), where the NOEC for adult immobilisation was the highest concentration tested, 0.00256 mg a.i./L. However, where there was a significant delaying effect of dichlorvos on the length of time for the appearance of the first brood (NOEC = 0.00016 mg a.i./L, lowest observed effect concentration [LOEC] = 0.00064 mg a.i./L, effect concentration 50% [EC_{50}] > 0.00256 mg a.i./L). Thus, dichlorvos may have subtle effects on aquatic invertebrate populations at concentrations well below lethal levels. Studies with the common lobster *(Homarus gammarus)* indicates a 23-day LC_{50} of 1.25 mg a.i./L and 23-day NOEC of 0.63 mg a.i./L.

The range in acute toxicity (LC_{50}) of dichlorvos (as the technical grade active ingredient or various formulations) to a wide variety of freshwater and estuarine/marine species of fish from various studies is ~200 µg a.i./L to > 40 000 µg a.i./L. African catfish exposed to sublethal concentrations of dichlorvos for 30 days have a NOEC of 30 mg a.i./L. A 61-day LOEC of 10.1 µg a.i./L is observed for rainbow trout.

The reported EC_{50} of 52 800 µg a.i./L based on 96-hour biomass production for the algae *(Scenedesmus subspicatus*) is consistent with values (48-hour EC_{50} = 14 000–100 000 µg a.i./L for four algal/diatom species) listed by the United States Environmental Protection Agency. No studies with dichlorvos and aquatic plants are available.

The 48-hour LC_{50} for an EC formulation of dichlorvos to tadpoles of the toad *Bufo bufo japonicus* is reported as 76 000 µg a.i./L. The United States Environmental Protection Agency's Aquatic Information Retrieval (AQUIRE) database lists 48-hour LC_{50} values to tadpoles of the frog species *Rana hexadactyla* and *Rana limnocharis* of 9700 and 10 000 µg a.i./L, respectively.

4.2.1 Terrestrial Risk Assessment

It was not possible to determine the risk of trichlorfon to earthworms because no acceptable toxicity data were available. Honeybees may be at risk during sprays using the higher rates of trichlorfon.

Standard exposure scenarios on vegetation and other food sources based on correlations in Hoerger and Kenaga (1972) and Kenaga (1973) and modified according to Fletcher et al. (1994) were used to determine the risk to birds and small mammals due to the consumption of contaminated food items.

Single or multiple applications of trichlorfon at 1800 g a.i./ha to control insect pests in forests and woodlots as well as single or multiple applications of trichlorfon at 1200 g a.i./ha or 1800 g a.i./ha to control insect pests on ornamentals could present a risk from acute exposure to bird species such as bobwhite quail from the consumption of contaminated food. It would only take 1.2 hours of continuous feeding to reach the NOEL. Larger species such as the mallard duck would not be at risk due to acute exposure.

Acute dietary risk quotients (RQs) for birds such as the bobwhite quail ranged from 2.9 to 5.9 for single and multiple forestry applications of 1800 g a.i./ha and all applications used on ornamentals indicating they would be at moderate risk. The percentage of contaminated diet required to result in risk ranged from 17 to 35%; this indicates that they would only need to consume a portion of their diet contaminated with trichlorfon to be at risk. It is expected that smaller species of birds such as songbirds would be at even greater risk than species with a body weight similar to the bobwhite quail due to the consumption of contaminated food items following trichlorfon applications.

Dermal exposure may be a very important route of exposure for birds frequenting the forest canopy following forestry aerial applications. Mineau (2002) used data from avian field studies to model the probability that bird mortality may occur after treatment with a pesticide. A forestry model incorporating oral and dermal toxicity was used to estimate the likelihood of avian mortality in trichlorfon treated forests. The model results indicated avian mortality may occur in 83–93% of forests treated at the application rates used to control forest insect pests on conifers (1.155–1.8 kg a.i./ha), indicating use of trichlorfon will result in high bird mortality.

Based on the RQs, species of birds such as bobwhite quail are at moderate risk (RQ = 5.5–7.4) due to chronic exposure from applications of 283.5 g a.i./ha to control insect pests in forestry as well as at high risk (RQ = 35–47) due to chronic exposure from forestry applications of 1800 g a.i./ha and all applications used on ornamentals (RQ = 23.3–53.0). Larger bird species such as mallard ducks are at low risk (RQ = 0.36–0.48) due to chronic exposure from applications of 283.5 g a.i./ha to control insect pests in forestry as well as at moderate risk (RQ = 2.3–3.0) due to chronic exposure from forestry applications of 1800 g a.i./ha and all applications used on ornamentals (RQ = 1.5–3.4). There is uncertainty, however, concerning risk from chronic exposure to birds following trichlorfon applications because trichlorfon is not persistent on vegetation (half-lives ranging from 1.6 to 4.6 days). Therefore, birds will not be chronically exposed to trichlorfon residues in contaminated food following most uses. Of possible concern would be using high rates with four applications for outdoor ornamentals; a month of continuous exposure could pose a risk due to reproductive effects for smaller bird species.

Single and multiple applications of 1800 g a.i./ha trichlorfon in forestry and all applications on outdoor ornamentals could result in risk from acute exposure to small wild mammals feeding on contaminated vegetation because it would only take approximately one hour of continuous feeding to reach the NOEL.

Acute dietary RQs for small wild mammals ranged from 11.1–22.3 for single and multiple forestry applications of 1800 g a.i./ha and all applications used on ornamentals, indicating ornamentals would be at high risk. The percentage of contaminated diet required to result in risk ranged from 5% to 9% indicating that they would only need to consume a small portion of their diet contaminated with trichlorfon to be at risk.

Applications of 283.5 g a.i./ha in forestry are expected to result in a low risk (RQ = 0.82–0.97) from chronic exposure to small mammals. Single and multiple applications of 1800 g a.i./ha in forestry and all applications on outdoor ornamentals are expected to result in a moderate risk

(RQ = 3.2–6.4) from chronic exposure to small mammals feeding on contaminated vegetation. Similar to birds, there is uncertainty concerning the risk due to chronic exposure for small wild mammals because they would not be exposed chronically to trichlorfon because of the short half-life observed on plants (1.6–4.6 days). Of possible concern would be using high rates with four applications for outdoor ornamentals; a month of continuous exposure could pose a chronic risk to small mammals feeding on contaminated vegetation.

4.2.2 Aquatic Risk Assessment

Trichlorfon is rapidly transformed in water under aerobic conditions (DT_{50} = 8 hours); therefore, any toxicity and resulting risks to aquatic organisms is due to both trichlorfon and its transformation products including dichlorvos.

In this initial deterministic assessment for aquatic organisms, RQs were calculated for aquatic invertebrates, fish and algae. Estimated environmental concentrations in water were calculated for the different rates and numbers of applications for a screening level scenario assuming a direct application to a body of water 15 cm deep for the forestry uses and 80 cm deep for the outdoor ornamental uses. The effects endpoint used was the NOEC of the most sensitive species tested.

The acute RQs for aquatic invertebrates ranged from 10 600 to 66 700 for the forestry uses and from 22 200 to 34 400 for the outdoor ornamental uses. Freshwater aquatic invertebrates are, therefore, at an extremely high risk from acute exposure to trichlorfon, even at the lowest rates of application for use in forestry and outdoor ornamentals based on this assessment.

The chronic RQs for aquatic invertebrates ranged from 33 900 to 214 000 for the forestry uses and from 71 400 to 111 000 for the outdoor ornamentals uses. Based on these RQs, freshwater aquatic invertebrates are at an extremely high risk from chronic exposure to trichlorfon, even at the lowest rates of application for use in forestry and outdoor ornamentals. It should be noted that trichlorfon is rapidly hydrolysed at pH levels above 7 (half-life 1.4 days); therefore, chronic exposure may not occur under these conditions. Chronic exposure could occur in acidic waters where the half-life of trichlorfon is 104 days at pH level 5.

Freshwater fish are at moderate risk (RQ = 8.3) due to acute exposure from applications of 283.5 g a.i./ha trichlorfon to control insect pests in forests as well as at high risk (RQ = 17.4–52.2) due to acute exposure from applications of 1800 g a.i./ha in forestry and for all applications to control insect pests on ornamentals.

Based on the RQs, freshwater fish are at moderate risk (RQ = 1.7) due to chronic exposure from applications of 283.5 g a.i./ha trichlorfon to control insect pests in forests, at high risk (RQ = 10.9) due to chronic exposure from applications of 1800 g a.i./ha in forestry and at moderate risk (RQ = 3.6–5.6) due to chronic exposure for all applications to control insect pests on ornamentals. Chronic exposure would only be a concern in acidic waters, however, as DT_{50} values of trichlorfon increase substantially in water of pH level 7 and lower.

4.3 Environmental Assessment Conclusions

Pollinators are at risk following applications of trichlorfon at the higher rates to control insect pests in forestry and on ornamentals.

Single or multiple applications of trichlorfon at 1800 g a.i./ha to control insect pests in forests and woodlots present a high risk to smaller bird species from acute exposure from the consumption of contaminated food. Single or multiple applications of trichlorfon at 1200 g a.i./ha or 1800 g a.i./ha to control insect pests on ornamentals present a high risk to smaller bird species due to acute exposure from the consumption of food contaminated with trichlorfon. Dermal exposure may be a very important route of exposure for birds frequenting the forest canopy following forestry aerial applications. A forestry model incorporating oral and dermal toxicity indicated avian mortality may occur in 83–93% of forests treated at the application rates used to control forest insect pests on conifers (1.155–1.8 kg a.i./ha), indicating a potentially high frequency of bird mortality following these applications.

All applications of trichlorfon in forestry and on outdoor ornamentals could result in risk from acute exposure to small wild mammals feeding on contaminated vegetation.

Freshwater aquatic invertebrates are at an extremely high risk from acute and chronic exposure to trichlorfon, even at the lowest rates of application for use in forestry and outdoor ornamentals. It should be noted that trichlorfon is rapidly hydrolysed to dichlorvos at pH levels above 7 (half-life 1.4 days); therefore, chronic exposure will not occur under these conditions. Chronic exposure could occur in acidic waters where the half-life of trichlorfon was observed to be 104 days at pH level 5.

Freshwater fish are at moderate risk due to acute exposure from applications of 283.5 g a.i./ha trichlorfon to control insect pests in forests as well as at high risk due to acute exposure from applications of 1800 g a.i./ha in forestry and for all applications to control insect pests on ornamentals. Freshwater fish are at moderate risk due to chronic exposure from applications of 283.5 g a.i./ha trichlorfon to control insect pests in forests, at high risk due to chronic exposure from applications of 1800 g a.i./ha in forestry and at moderate risk from chronic exposure for all applications to control insect pests on ornamentals. Chronic exposure would only be a concern in acidic waters, however, as DT_{50} values of trichlorfon increase substantially in water of pH level 7 and lower.

The aquatic risk assessment is conservative particularly for aerial applications in forestry because estimated environmental concentrations in water were calculated for the different rates and numbers of applications assuming a direct application to a body of water 15 cm deep. However, even if 50% forest canopy interception is assumed, the calculated RQs still indicate risk from acute exposure to aquatic organisms.

The aerial application in forestry is of particular concern because the risk to pollinators, birds and small wild mammals cannot be mitigated. It is also difficult to mitigate the risk to aquatic organisms using buffer zones because the high toxicity of trichlorfon and the transformation product dichlorvos result in large buffer zones that are operationally unfeasible (see Table 4.3).

Buffer zones were capped at 800 m, which only mitigates 7% and 13% of the risk to aquatic invertebrates inhabiting shallow waterbodies (< 1 metre) for applications by fixed-wing and rotary-wing aircraft, respectively. Dermal exposure would probably be the main route of exposure to birds following aerial application in forestry and a model incorporating this route of exposure indicated a potentially high frequency of bird mortality following these applications.

Table 4.3 Buffer Zones Required for the Protection of Aquatic Habitat Following Applications of Trichlorfon

The buffer zones are required between the point of direct application and the closest downwind edge of sensitive freshwater habitats (such as lakes, rivers, sloughs, ponds, prairie potholes, creeks, marshes, streams, reservoirs, and wetlands) and estuarine/marine habitats.

Method of Application	Use Pattern	Buffer Zone (metres) Required for the Protection of Aquatic Habitat:		
		< 1 m	1–3 m	> 3 m
Field sprayer*	Ornamentals	20	20	10
Airblast (early growth stage)	Forests, woodlots, ornamentals	50	45	35
Airblast (late growth stage)	Forests, woodlots, ornamentals	40	35	25
Aerial (fixed-wing)	Forests, woodlots	800**	800**	600
Aerial (rotary-wing)	Forests, woodlots	800**	800**	375

* For field sprayer application, buffer zones can be reduced with the use of drift reducing spray shields. When using a spray boom fitted with a full shield (shroud, curtain) that extends to the crop canopy or ground, the labelled buffer zone can be reduced by 70%. When using a spray boom where individual nozzles are fitted with cone-shaped shields that are no more than 30 cm above the crop canopy or ground, the labelled buffer zone can be reduced by 30%.

** Buffer zones were capped at 800 m (limit of AGDISP prediction).

5.0 Value

5.1 Commercial and/or Restricted Class Products

5.1.1 Alternatives to Trichlorfon

The registered chemical alternatives for unsupported uses of trichlorfon or for the supported uses of trichlorfon that have risk concerns are listed in Appendix V. While these chemical control methods are registered, the PMRA has not commented on the availability and extent of use of these options.

Most sources of non-chemical alternatives are focussed on general cultural practices (including weed control, crop rotation, resistant varieties, appropriate soil cultivation and natural enemies). The PMRA searched the information available for specific site-pest combinations and found a number of non-chemical measures of pest control. The effectiveness and extent of use of these non-chemical control measures are not verified. These measures are as follows:

- using sprinkler irrigation to discourage the development of diamondback larvae on Brussels sprouts, cabbage, cauliflower, rutabaga and turnip;
- removing horse nettle to decrease populations of pepper maggot on peppers;
- harvesting alfalfa early to decrease crop loss due to alfalfa webworm, alfalfa caterpillar and other pests;
- planting beans away from alfalfa to decrease lygus bug populations;
- pruning out caterpillar tents on blueberries in the fall to decrease caterpillar populations;
- providing float row covers to prevent diamondback moths from laying eggs in small cabbage and cauliflower fields;
- using physical barriers or ditches filled with water to stop migrating caterpillars in lettuce and kale fields; and
- intercropping corn and soybean to decrease European corn borer populations.

The PMRA welcomes feedback on the availability and extent of use of the chemical alternatives to trichlorfon in Appendix V and further information regarding the availability, effectiveness and extent of use of non-chemical control methods for any of the site-pest combinations listed in the appendix.

6.0 Toxic Substances Management Policy Considerations

6.1 Toxic Substances Management Policy

The management of toxic substances is guided by the federal government's Toxic Substances Management Policy, which puts forward a preventive and precautionary approach to deal with substances that enter the environment and could harm the environment or human health. The policy provides decision makers with direction and sets out a science-based management framework to ensure that federal programs are consistent with its objectives. One of the key management objectives is virtual elimination from the environment of toxic substances that result predominantly from human activity and that are persistent and bioaccumulative. These substances are referred to in the policy as Track 1 substances.

Trichlorfon does not meet the TSMP Track 1 criteria because the reported half-life values in soil and water are below the TSMP Track 1 cut-off criteria for persistence. No data were provided for the persistence of trichlorfon in air. The reported log K_{ow} for trichlorfon also falls below the TSMP Track 1 cut-off criterion for bioaccumulation. It has also been determined that dichlorvos does not meet the TSMP Track 1 criteria because the reported log K_{ow} for dichlorvos (1.47) falls below the TSMP Track 1 cut-off criterion for bioaccumulation. The reported half-life values in soil (19.3 days) and water (1 day) are also below the TSMP Track 1 cut-off criteria for persistence.

Products containing trichlorfon are subject to all the requirements in Regulatory Directive DIR2006-02, *Formulants Policy and Implementation Guidance Document*, published on 31 May 2006.

7.0 Summary of the Preliminary Risk Assessment

The preliminary risk assessment conducted with the information available to the PMRA at this time indicates a level of concern for workers. Additional information and any other relevant data will be considered to determine if the evaluations presented in this document can be refined. The PMRA is soliciting all interested parties to submit information that may be used to refine these assessments and/or mitigate exposure risks. The PMRA will review all information received, revise the preliminary risk assessment as necessary and propose mitigation measures in a future proposed re-evaluation decision document.

7.1 Human Health and Safety

7.1.1 Occupational Risk

Occupational exposure risk estimates associated with applying, mixing and loading activities are not of concern. Ornamental postapplication worker risks are of concern based on the length of time required for residues to decrease to an acceptable level. For some uses, the REIs required to meet the target MOEs are unfeasible. Postapplication worker exposure estimates are based on the best available data and calculated REIs may be further refined with additional data.

7.1.2 Dietary Risk From Food

Acute and chronic dietary risk assessments demonstrate that there are no dietary concerns for any population subgroup in Canada, including infants, children, teenagers, adults and seniors.

7.1.3 Dietary Risk From Drinking Water

The potential for the contamination of drinking water with trichlorfon is expected to be minimal. Therefore, drinking water risks are not of concern.

7.1.4 Residential Risk

For residential uses (municipal parks), the calculated MOEs are less than the target MOEs. The PMRA is, therefore, proposing to phase out this use.

7.1.5 Aggregate Risk

Aggregate exposure from all relevant sources is not considered a health concern.

7.2 Environmental Risk

Trichlorfon is expected to be non-persistent in soil and aquatic environments. However, the use of trichlorfon poses a concern to the following terrestrial organisms: birds, small wild mammals, bees, as well as to aquatic organisms such as fish and aquatic invertebrates.

8.0 Information Needed to Refine the Preliminary Risk Assessment for Trichorfon

The following data would be required to refine the occupational exposure and risk estimates, and possibly refine the occupational exposure assessment.

Mixer/Loader/Applicator Exposure

- Exposure data representative of modern application equipment and engineering controls (e.g., passive dosimetry, biological monitoring) (DACO 5.4 and/or 5.5).
- Exposure data for all hand-held equipment including rights-of-way, aerial application, mix and load with water-soluble packaging, high-pressure handwand, low-pressure handwand and backpack equipment (e.g., passive dosimetry, biological monitoring) including equipment cleaning and maintenance activities (DACO 5.4 and/or 5.5).

Postapplication Exposure

- Transfer coefficients, air concentrations and dislodgeable foliar residues (for both trichlorfon and dichlorvos) for application to Balsam fir and spruce trees in farm woodlots, rights-of-way, Christmas tree plantations and municipal parks as well as ornamentals (DACO 5.6, 5.7, 5.9 and 5.10).
- Additional data to refine/confirm calculated REIs. (DACO 5.6, 5.7, 5.9 and 5.10).

List of Abbreviations

µg	microgram(s)
°C	degree(s) Celsius
a.i.	active ingredient
AGDISP	AGricultural DISPersal
atm	atmospheres
bw	body weight
cm	centimetre(s)
DACO	data code
DEEM®	Dietary Exposure Evaluation Model
DFR	dislodgeable foliar residue
DT_{50}	dissipation time to 50% (the dose required to observe a 50% decline in the test population)
DWLOC	drinking water level of comparison
g	gram(s)
ha	hectare(s)
Hg	mercury
K_d	adsorption coefficient
kg	kilogram(s)
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol–water partition coefficient
LC_{50}	lethal concentration to 50% (a concentration causing 50% mortality in the test population)
LD_{50}	lethal dose to 50% (a dose causing 50% mortality in the test population)
L	litre(s)
LOAEL	lowest observed adverse effect level
LOEC	lowest observed effect concentration
m	metre(s)
m^3	metre(s) cubed
mg	milligram(s)
M/L	mixer/loader
M/L/A	mixer/loader/applicator
mm	millimetre(s)
MOE	margin of exposure
MRL	maximum residue limit
N/A	not applicable
NOAEL	no observed adverse effect level
NOEC	no observed effect concentration
Pa	Pascal
PHI	preharvest interval
pH	-log10 hydrogen ion concentration
PHED	Pesticide Handlers Exposure Database
PMRA	Pest Management Regulatory Agency
PPE	personal protective equipment
ppm	parts per million
REI	restricted-entry interval

RQ	risk quotient
SF	safety factor
TSMP	Toxic Substances Management Policy
TTR	turf transferable residue
UF	uncertainty factor
ULV	ultra-low volume
USEPA	United States Environmental Protection Agency
UV	ultraviolet
WSP	water-soluble packaging

Appendix I Registered Trichlorfon Products as of 13 February 2006

Registration Number	Class	Registrant	Product Name	Formulation Type	Guarantee
16387	Commercial and Restricted	Bayer CropScience Inc.	Dylox 420 Liquid Insecticide	Solution	420 g/L
9827	Commercial and Restricted	Bayer CropScience Inc.	Dylox 80% Soluble Powder Insecticide	Soluble Powder	80%
9419	Commercial	Bayer Inc.	Neguvon Pour-On Cattle Insecticide	Solution	8%
22482	Technical	Bayer CropScience Inc.	Dipterex Technical Insecticide	Solid	98%

Appendix II Canadian Registered Commercial and Restricted Class Uses of Trichlorfon (as of 30 December 2004)

Site(s)	Pests(s)	Marketing Class	Formula-tion Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applica-tions per Year	Typical Number of Days Between Applications	Registrant Supports Uses[a]	Comments
					Maximum Single	Maximum Cumulative				
Use-Site Category 4: Forests and Woodlands; Use-Site Category 27: Ornamentals Outdoors										
Balsam fir and spruce trees in farm woodlots, rights-of way, Christmas tree plantations, municipal parks	Spruce budworm larvae	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1800	Not able to calculate	Not stated	Not stated	Partial support	The registrant does not support the use of trichlorfon in residential areas, nor does the registrant support the use of the Solution formulation type.
Deciduous trees	Forest tent caterpillar	Commercial + Restricted	Solution	Aircraft or ground application	283.5	Not able to calculate	Not stated	Not stated	No	—
Forest and shade trees	Gypsy moth larvae (instars I to II only)	Commercial + Restricted	Solution	Aircraft or ground application	1155	Not able to calculate	Not stated	Not stated	No	—
Spruce and fir forest plantations or young regeneration situations	Yellowheaded spruce sawfly	Commercial + Restricted	Solution	Aircraft or ground application	751.8	751.8	1	Not applicable	No	—
Use-Site Category 5: Greenhouse Food Crops; Use-Site Category 14: Terrestrial Food Crops										
Tobacco	Darksided cutworms, redbacked cutworms	Commercial + Restricted	Solution, soluble powder	Spot treatment	37.8 g/100 m^2	37.8 g/100 m^2	1	Not applicable	No	—
	Black cutworms	Commercial + Restricted	Solution	Spot treatment	37.8 g/100 m^2	37.8 g/100 m^2	1	Not applicable	No	—

Site(s)	Pests(s)	Marketing Class	Formulation Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applications per Year	Typical Number of Days Between Applications	Registrant Supports Uses[a]	Comments
					Maximum Single	Maximum Cumulative				
Use-Site Category 7: Industrial Oil Seed Crops and Fibre Crops; Use-Site Category 13: Terrestrial Feed Crops; Use-Site Category 14: Terrestrial Food Crops										
Canola (rapeseed)	Beet webworm	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	630	Not able to calculate	Not stated	Not stated	No	—
	Diamondback moth	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1200	Not able to calculate	Not stated	Not stated	No	—
	Lygus bugs	Commercial + Restricted	Solution	Aircraft or ground application	575.4	Not able to calculate	Not stated	Not stated	No	—
Flax	Beet webworm, variegated cutworm, bertha armyworm	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1200	Not able to calculate	Not stated	Not stated	No	—
	Armyworm (true), western yellowstriped armyworm	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	630	Not able to calculate	Not stated	Not stated	No	—
Use-Site Category 8: Livestock for Food										
Beef and non-lactating dairy cattle	Cattle grubs, lice (reduction)	Commercial	Solution	Pour-on	2.6 g/ 100 kg bw	Not able to calculate	Not stated	Not stated	Yes	—

Site(s)	Pests(s)	Marketing Class	Formulation Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applications per Year	Typical Number of Days Between Applications	Registrant Supports Uses[a]	Comments
					Maximum Single	Maximum Cumulative				
Use-Site Category 13: Terrestrial Feed Crops; Use-Site Category 14: Terrestrial Food Crops										
Alfalfa	Alfalfa webworm, beet armyworm, variegated cutworm, lygus bugs, stink bugs, tarnished plant bug	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1200	Not able to calculate	Not stated	Not stated	No	—
	Alfalfa caterpillar	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	630	Not able to calculate	Not stated	Not stated	No	—
Barley, oats, wheat	Beet webworm, variegated cutworm, bertha armyworm	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1200	Not able to calculate	Not stated	Not stated	No	—
	Armyworm (true), western yellowstriped armyworm	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	630	Not able to calculate	Not stated	Not stated	No	—
Beans (dry, lima, snap)	Armyworms, imported cabbageworm, dipterous leafminers, lygus bugs, Mexican bean beetle, stink bugs, variegated cutworm	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1800	Not able to calculate	Not stated	Not stated	No	—

Site(s)	Pests(s)	Marketing Class	Formulation Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applications per Year	Typical Number of Days Between Applications	Registrant Supports Uses[a]	Comments
					Maximum Single	Maximum Cumulative				
Blueberry	Larval flea beetle, blueberry sawfly, blueberry casebeetle, currant spanworm, whitemarked tussock moth	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1200	2400	2	30	No	—
	Blueberry fleabeetle, blueberry spanworm	Commercial + Restricted	Solution	Aircraft or ground application	1155	2310	2	30	No	—
Brussels sprouts, cabbage, cauliflower	Imported cabbageworm, variegated cutworm, diamondback moth	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1200	Not able to calculate	Not stated	Not stated	No	—
Carrot, rutabaga, salsify, turnip	Dipterous leafminers, imported cabbageworm, variegated cutworm, diamondback moth	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1200	Not able to calculate	Not stated	Not stated	No	—
	Beet webworm	Commercial + Restricted	Solution	Aircraft or ground application	1155	Not able to calculate	Not stated	Not stated	No	—
	Beet armyworm, salt-marsh caterpillar	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1800	Not able to calculate	Not stated	Not stated	No	—

Site(s)	Pests(s)	Marketing Class	Formulation Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applications per Year	Typical Number of Days Between Applications	Registrant Supports Uses[a]	Comments
					Maximum Single	Maximum Cumulative				
Collards, kale, lettuce, spinach	Beet webworm, dipterous leafminers, thrips, variegated cutworm	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1200	Not able to calculate	Not stated	Not stated	No	—
	Armyworms, salt-marsh caterpillar	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1800	Not able to calculate	Not stated	Not stated	No	—
Corn (field, sweet, popcorn)	Armyworms, cutworms	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1200	3600	3	Not stated	No	—
Corn (sweet)	European corn borer (Quebec only)	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	2000	6000	3	7	No	—
Pepper	Dipterous leafminers, pepper maggot	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1200	Not able to calculate	Not stated	Not stated	No	—
Sugar beet	Beet webworm	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	630	Not able to calculate	Not stated	Not stated	No	—
	Dipterous leafminers, variegated cutworm	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1200	Not able to calculate	Not stated	Not stated	No	—
	Alfalfa webworm, beet armyworm	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1800	Not able to calculate	Not stated	Not stated	No	—

Site(s)	Pests(s)	Marketing Class	Formulation Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applications per Year	Typical Number of Days Between Applications	Registrant Supports Uses[a]	Comments
					Maximum Single	Maximum Cumulative				
Table beet	Beet webworm, dipterous leafminers, variegated cutworm, alfalfa webworm	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1200	Not able to calculate	Not stated	Not stated	No	—
	Beet armyworm, salt-marsh caterpillar	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1800	Not able to calculate	Not stated	Not stated	No	—
Tomato	Dipterous leafminers	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application	1200	Not able to calculate	Not stated	Not stated	No	—
Use-Site Category 14: Terrestrial Food Crops										
Tobacco	Darksided cutworm, redbacked cutworm	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application or backpack sprayer	3200	3200	1	Not applicable	No	—
	Hornworms, tarnished plant bugs	Commercial + Restricted	Solution, soluble powder	Aircraft or ground application or backpack sprayer	1200	1200	1	Not applicable	No	—
	Black cutworm	Commercial + Restricted	Solution	Aircraft or ground application or backpack sprayer	3045	3045	1	Not applicable	No	—

Site(s)	Pests(s)	Marketing Class	Formulation Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applications per Year	Typical Number of Days Between Applications	Registrant Supports Uses[a]	Comments
					Maximum Single	Maximum Cumulative				
Use-Site Category 20: Structural										
Farm buildings, dairy barns, stock pens, garbage areas, refuse areas	Housefly	Commercial + Restricted	Soluble powder	Backpack sprayer	1.28 g/ 100 m^2	Not able to calculate	Not stated	7 to 14	No	—
Use-Site Category 27: Ornamentals Outdoors										
Narcissus	Narcissus bulb fly	Commercial + Restricted	Solution, soluble powder	Drench at base of plant	1575 g/ 1000 m row	1575 g/ 1000 m row	1	Not applicable	Partial support	The registrant does not support the use of trichlorfon in residential areas, nor does the registrant support the use of the Solution formulation type.
Ornamental flowers, shrubs and trees	Armyworms, bagworms, boxelder bug, cutworms, leafminers, lygus bugs, stink bugs, tarnished plant bug, webworms	Commercial + Restricted	Solution, soluble powder	Ground application	1800	Not able to calculate	Not stated	Not stated	Partial support	

[a] For partial support of use pattern, see comments for details.

Appendix III Toxicology Endpoints for Health Risk Assessment for Trichlorfon

Exposure Scenario	Endpoint	Study	Dose (mg/kg bw/day)	UF/SF or MOE[a]
Acute Dietary	Clinical signs, ↓ motor activity, alterations in functional observational battery, brain and erythrocyte cholinesterase inhibition	Acute neurotoxicity—rat	NOAEL = 10	300
	Acute reference dose = 0.03			
Chronic Dietary	Brain and erythrocyte cholinesterase inhibition (♂)	10-year chronic toxicity and carcinogenicity—monkey	LOAEL = 0.2	1000
	Acceptable daily intake = 0.0002			
Short[b]- and Intermediate[c]-Term Dermal	Erythrocyte cholinesterase inhibition	21-day dermal toxicity—rabbit	Dermal NOAEL = 100	300
Short[b]- and Intermediate[c]-Term Inhalation	Brain and erythrocyte cholinesterase inhibition	21-day inhalation toxicity—rat	Inhalation NOAEL = 3.5	300

[a] UF/SF refers to total of uncertainty and/or safety factors for dietary assessments; MOE refers to desired margin of exposure for occupational or residential assessments.

[b] Duration of exposure is 1–30 days.

[c] Duration of exposure is one month to several months.

Appendix IV Summary of Occupational Risk Estimates for Trichlorfon

Crop	Equipment	Formulation	Rate (a.i.)	Amount Handled / Day	PPE + System[a]	Margins of Exposure		
						M/L/A[b]	Postapplication[c] (proposed REI)	
Use-Site Category 4: (Forestry and Woodlots)							Trichlorfon[d]	Dichlorvos[e]
Balsam fir and spruce trees in farm woodlots, Christmas tree plantations, and rights-of-way	Airblast	Wettable powder	1.8 kg/ha	24 ha	Mid-level PPE + respirator + WSP	313	0	7 to 10 days
			1.8 kg/ha	24 ha	Maximum PPE + respirator	164	0	7 to 10 days
	Rights-of-way		0.0088 kg/L	3750 L	Mid-level PPE + WSP	312	0	7 to 10 days
			0.0088 kg/L	3750 L	Maximum PPE + respirator	219	0	7 to 10 days
	Low-pressure handwand		0.00144 kg/L	150 L	Mid-level PPE + WSP	15991	0	7 to 10 days
			0.00144 kg/L	150 L	Baseline PPE	537	0	7 to 10 days
	High-pressure handwand		0.00144 kg/L	3750 L	Mid-level PPE + respirator + WSP	449	0	7 to 10 days
			No data for engineering controls				0	7 to 10 days
	Backpack		0.00144 kg/L	150 L	Mid-level PPE + WSP	7414	0	7 to 10 days
			No data for engineering controls				0	7 to 10 days
	ULV Aerial M/L		1.8 kg/ha	1000 ha	Maximum PPE + WSP	377	0	7 to 10 days
			1.8 kg/ha	1000 ha	Maximum PPE + respirator	8	0	7 to 10 days
	ULV Aerial Application		1.8 kg/ha	1000 ha	Baseline PPE	334	0	7 to 10 days
Use-Site Category 8: Livestock For Food								
Beef and non-lactating cattle	Pour-on (graduated applicator)	Solution	0.0026 kg/ 100 kg bw	100 animals	Baseline PPE (chemical-resistant gauntlets)	27360	N/A	N/A

Crop	Equipment	Formulation	Rate (a.i.)	Amount Handled / Day	PPE + System[a]	Margins of Exposure		
						M/L/A[b]	Postapplication[c] (proposed REI)	
Use-Site Category 25 and/or 27: Human Habitat and Recreational Areas, and Ornamentals Outdoors								
Ornamentals—trees, shrubs and flowers	Low-pressure handwand	Wettable powder	0.00144 kg/L	150 L	Mid-level PPE + WSP	11513	15 to 28 days	12 to 14 days
			0.00144 kg/L	150 L	Baseline PPE	386	15 to 28 days	12 to 14 days
	Backpack		0.00144 kg/L		Mid-level PPE + WSP	5338	15 to 28 days	12 to 14 days
			No data for engineering controls				15 to 28 days	12 to 14 days
	High-pressure handwand		0.00144 kg/L	3750 L	Mid-level PPE + respirator + WSP	324	15 to 28 days	12 to 14 days
			No data for engineering controls				15 to 28 days	12 to 14 days
	Airblast		1.8 kg/ha	24 ha	Mid-level PPE +respirator +WSP	313	15 to 28 days	12 to 14 days
			1.8 kg/ha	24 ha	Maximum PPE +respirator	164	15 to 28 days	12 to 14 days
Municipal parks	Low-pressure handwand	Wettable powder	0.00144 kg/L	150 L	Mid-level PPE + WSP	15991	0	7 to 10 days
			0.00144 kg/L	150 L	Baseline PPE	537	0	7 to 10 days
	Backpack		0.00144 kg/L		Mid-level PPE + WSP	7414	0	7 to 10 days
			No data for engineering controls				0	7 to 10 days
	High-pressure handwand		0.00144 kg/L	3750 L	Mid-level PPE + respirator + WSP	449	0	7 to 10 days
			No data for engineering controls				0	7 to 10 days
	ULV Aerial M/L		1.8 kg/ha	1000 ha	Maximum PPE + WSP	377	0	7 to 10 days
			1.8 kg/ha	1000 ha	Maximum PPE + respirator	8	0	7 to 10 days
	ULV Aerial Application		1.8 kg/ha	1000 ha	Baseline PPE	334	0	7 to 10 days

Crop	Equipment	Formulation	Rate (a.i.)	Amount Handled / Day	PPE + System[a]	Margins of Exposure		
						M/L/A[b]	Postapplication[c] (proposed REI)	
Narcissus	Groundboom		11.5 kg/ha	13 ha	Baseline PPE + WSP	540	33	15
			11.5 kg/ha	13 ha	Maximum PPE + respirator	90	33	15

[a] For mixer/loaders and applicators: Baseline PPE (long-sleeved shirt, long pants, gloves); Mid-level PPE (coveralls over long-sleeved shirt, long pants); Maximum PPE = chemical-resistant coveralls over long-sleeved shirt, long pants, chemical-resistant gloves; WSP = water-soluble packaging.

[b] Combined MOE for trichlorfon calculated using a dermal NOAEL of 100 mg/kg/day and an inhalation NOAEL of 3.5 mg/kg/day. Target MOE = 300.

[c] If hand-line irrigation is expected, REI would be day 7 for trichlorfon and day 11 for dichlorvos.

[d] Trichlorfon exposure based on short-term dermal NOAEL of 100 mg/kg/day with a target MOE of 300 (2 applications, 7 days apart, except for narcissus where one application was assumed).

[e] Dichlorvos exposure based on short-term oral NOAEL of 0.05 mg/kg/day with a dermal absorption of 30% and a target MOE of 1000 for dichlorvos where 50% of trichlorfon breaks down to dichlorvos with 50% dissipation per day.

Appendix V Alternative Registered Active Ingredients to Trichlorfon for Those Site-Pest Combinations of Commercial and Restricted Class Products That Are Not Supported by the Technical Registrant or for Which Risk Concerns Have Been Identified (registered alternatives as of 7 December 2004)

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
Use-Site Category 4: Forests and Woodlots						
Balsam fir and spruce in farm woodlots	Spruce budworm larvae	No data	Group 1A: carbaryl[f], methomyl[f] Group 1B: dimethoate[f] Group 3: permethrin Group 11: *Bacillus thuringiensis* Group 18: tebufenozide	Partial support[d]	Partial risk[e]	Due to agriculturally infeasible mitigation measures, this use has risk concerns for aerial applications only.
Balsam fir and spruce in rights-of-way	Spruce budworm larvae	No data	Group 1A: carbaryl[f], methomyl[f] Group 3: permethrin Group 11: *Bacillus thuringiensis* Group 18: tebufenozide	Partial support[d]	Partial risk[e]	
Balsam fir and spruce in Christmas tree plantations	Spruce budworm larvae	No data	Group 1A: carbaryl[f], methomyl[f] Group 1B: malathion[f], diazinon[f], dimethoate[f] Group 3: permethrin Group 11: *Bacillus thuringiensis* Group 18: tebufenozide	Partial support[d]	Partial risk[e]	
Balsam fir and spruce trees in municipal parks	Spruce budworm larvae	No data	Group 1A: carbaryl[f], methomyl[f] Group 1B: malathion[f], diazinon[f] Group 3: permethrin Group 11: *Bacillus thuringiensis* Group 18: tebufenozide	No	—	
Deciduous tree	Forest tent caterpillar	No data	Group 1A: carbaryl[f, g] Group 1B: chlorpyrifos[f, g], acephate[f, g], malathion[f], phosmet[f, g], diazinon[f] Group 3: *d*-trans allethrin, permethrin Group 11: *Bacillus thuringiensis*	No	—	

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
Forest trees	Gypsy moth larvae (instars 1st to 2nd only)	No data	Group 1A: carbaryl[f] Group 1B: acephate[f, g] Group 3: permethrin[g] Group 5: spinosad Group 11: *Bacillus thuringiensis*	No	—	
Shade trees	Gypsy moth larvae (instars 1st to 2nd only)	No data	Group 1A: carbaryl[f, g] Group 1B: acephate[f, g] Group 3: permethrin[g] Group 5: spinosad Group 11: *Bacillus thuringiensis*	No	—	
Spruce forest plantations or young regeneration situations	Yellowheaded spruce sawfly	No data	Group 1B: acephate[f] Group 3: permethrin	No	—	
Fir forest plantations	Yellowheaded spruce sawfly	No data	Group 1B: malathion[f] Group 3: permethrin	No	—	
Fir in young generation situations	Yellowheaded spruce sawfly	No data	Group 3: permethrin	No	—	
Use-Site Category 5: Greenhouse Food Crops						
Tobacco	Hornworms	No data	Group 1A: carbaryl[f], methomyl[f] Group 1B: malathion[f], acephate[f] Group 11: *Bacillus thuringiensis*	No	—	
	Tarnished plant bug	No data	None			
Use-Site Category 7: Industrial Oil Seed Crops and Fibre Crops; Use-Site Category 13: Terrestrial Feed Crops; Use-Site Category 14: Terrestrial Food Crops						
Canola (rapeseed)	Beet webworm	British Columbia, Alberta, Saskatchewan, Manitoba—minor	Group 1A: methomyl[f] Group 3: deltamethrin[h]	No	—	
	Diamondback moth	British Columbia, Alberta, Saskatchewan, Manitoba—moderate	Group 1B: malathion[f], chlorpyrifos[f] Group 3: deltamethrin[h]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
	Lygus bugs	British Columbia, Alberta, Saskatchewan, Manitoba—minor	Group 3: lambda-cyhalothrin, deltamethrin[h]			
Flax	True armyworm	Alberta, Saskatchewan, Manitoba—minor	Group 1B: chlorpyrifos[f]	No	—	
	Western yellowstriped armyworm	Alberta, Saskatchewan, Manitoba—minor	Group 1B: chlorpyrifos[f]			
	Beet webworm	Alberta, Saskatchewan, Manitoba—minor	Group 3: deltamethrin[h]			
	Variegated cutworm	Alberta, Saskatchewan, Manitoba—minor to major	Group 1B: chlorpyrifos[f] Group 3: deltamethrin[h]			
	Bertha armyworm	Alberta, Saskatchewan, Manitoba—minor to major	Group 1A: methomyl[f] Group 1B: chlorpyrifos[f]			
Use-Site Category 13: Terrestrial Feed Crops; Use-Site Category 14: Terrestrial Food Crops						
Alfalfa	Alfalfa caterpillar	No data	Group 1A: carbaryl[f]	No	—	
	Alfalfa webworm	No data	Group 1A: carbaryl[f]			
	Beet armyworm	No data	Group 1A: carbaryl[f] Group 1B: malathion[f]			
	Variegated cutworm	No data	Group 1A: carbaryl[f]			
	Lygus bugs	Alberta—minor	Group 1A: pirimicarb Group 1B: dimethoate[f], naled[f], malathion[f], azinphos-methyl[i] Group 3: lambda-cyhalothrin, deltamethrin[h]			
	Stink bugs	No data	None			
	Tarnished plant bug	No data	Group 1B: dimethoate[f], malathion[f], azinphos-methyl[i] Group 3: lambda-cyhalothrin, deltamethrin[h]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
Barley	True armyworm	British Columbia, Alberta, Saskatchewan, Manitoba—sporadic and unpredictable pest	Group 1A: methomyl[f], carbaryl[f] Group 1B: chlorpyrifos[f], malathion[f]	No	—	
	Western yellowstriped armyworm	British Columbia, Alberta, Saskatchewan, Manitoba—sporadic and unpredictable pest	Group 1A: carbaryl[f] Group 1B: malathion[f], chlorpyrifos[f]			
	Beet webworm	No data	Group 1A: carbaryl[f]			
	Variegated cutworm	British Columbia, Alberta, Saskatchewan, Manitoba—sporadic and localized	Group 1A: carbaryl[f] Group 3: deltamethrin[h]			
	Bertha armyworm	British Columbia, Alberta, Saskatchewan, Manitoba—sporadic and unpredictable pest	Group 1A: carbaryl[f] Group 1B: malathion[f], chlorpyrifos[f]			
Beans (dry)	Armyworms	Alberta, Saskatchewan, Manitoba—minor	Group 1B: diazinon[f]	No	—	
	Imported cabbageworm	No data	Group 1B: malathion[f], diazinon[f]			
	Dipterous leafminers	No data	Group 1B: dimethoate[f], diazinon[f]			
	Lygus bugs	Alberta, Saskatchewan, Manitoba—moderate	Group 1A: carbaryl[f] Group 1B: dimethoate[f]			
	Mexican bean beetle	No data	Group 1A: carbaryl[f] Group 1B: dimethoate[f], malathion[f], diazinon[f], dichlorvos[f] Group 2A: endosulfan[f]			
	Stink bugs	No data	Group 1A: carbaryl[f]			
	Variegated cutworm	No data	Group 1A: carbaryl[f] Group 1B: diazinon[f]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
Beans (lima)	Armyworms	No data	Group 1B: diazinon[f]	No	—	
	Imported cabbageworm	No data	Group 1B: diazinon[f], malathion[f]			
	Dipterous leafminers	No data	Group 1B: dimethoate[f], malathion[f], diazinon[f]			
	Lygus bugs	No data	Group 1A: carbaryl[f] Group 1B: dimethoate[f]			
	Mexican bean beetle	No data	Group 1A: carbaryl[f] Group 1B: dimethoate[f], malathion[f], diazinon[f] Group 2A: endosulfan[f]			
	Stink bugs	No data	Group 1A: carbaryl[f]			
	Variegated cutworm	No data	Group 1A: carbaryl[f] Group 1B: diazinon[f]			
Beans (snap)	Armyworms	Manitoba—minor	Group 1B: diazinon[f]	No	—	
	Imported cabbageworm	Manitoba—minor	Group 1B: diazinon[f], malathion[f]			
	Dipterous leafminers	Manitoba—minor	Group 1B: dimethoate[f], malathion[f], diazinon[f]			
	Lygus bugs	Manitoba—minor	Group 1A: carbaryl[f] Group 1B: dimethoate[f]			
	Mexican bean beetle	Manitoba—minor	Group 1A: carbaryl[f] Group 1B: dimethoate[f], malathion[f], diazinon[f] Group 2A: endosulfan[f]			
	Stink bugs	Manitoba—minor	Group 1A: carbaryl[f]			
	Variegated cutworm	Manitoba—minor	Group 1A: carbaryl[f] Group 1B: diazinon[f]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
Blueberry	Larval flea beetle	New Brunswick, Nova Scotia—major (low bush) Prince Edward Island—major	None	No	—	
	Blueberry sawfly	No data	None			
	Blueberry casebeetle	New Brunswick, Nova Scotia—major (low bush) Prince Edward Island—minor	None			
	Currant spanworm	New Brunswick, Nova Scotia—major (low bush)	None			
	Whitemarked tussock moth	Prince Edward Island—minor New Brunswick, Nova Scotia—major (low bush)	Group 11: *Bacillus thuringiensis*			
	Blueberry flea beetle	New Brunswick, Nova Scotia—major (low bush) Prince Edward Island—major	None			
	Blueberry spanworm	New Brunswick, Nova Scotia—major (low bush)	Group 1A: carbaryl[f] Group 1B: phosmet[f]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
Brussels sprouts	Imported cabbageworm	Nova Scotia—moderate British Columbia, Ontario—major	Group 1A: carbaryl[f], methomyl[f] Group 1B: naled[f], malathion[f], azinphos-methyl[i], diazinon[f], acephate[f], methamidophos[f] Group 2A: endosulfan[f] Group 3: lambda-cyhalothrin, deltamethrin[h], permethrin, cypermethrin Group 5: spinosad Group 11: *Bacillus thuringiensis*	No	—	
	Variegated cutworm	British Columbia, Quebec—major Ontario—minor to major	Group 1B: diazinon[f]			
Brussels sprouts	Diamondback moth	Quebec—major British Columbia, Ontario—major (for larval stage)	Group 1A: carbaryl[f], methomyl[f] Group 1B: naled[f], diazinon[f], azinphos-methyl[i], acephate[f], methamidophos[f] Group 2A: endosulfan[f] Group 3: lambda-cyhalothrin, deltamethrin[h], permethrin, cypermethrin Group 5: spinosad Group 11: *Bacillus thuringiensis*	No	—	
Cabbage	Imported cabbageworm	British Columbia, Ontario—major Nova Scotia—moderate	Group 1A: carbaryl[f], methomyl[f] Group 1B: naled[f], diazinon[f], azinphos-methyl[i], acephate[f], methamidophos[f], malathion[f] Group 2A: endosulfan[f] Group 3: lambda-cyhalothrin, deltamethrin[h], permethrin, cypermethrin Group 5: spinosad Group 11: *Bacillus thuringiensis*	No	—	
	Variegated cutworm	British Columbia, Quebec—major Ontario—minor to major	Group 1B: diazinon[f]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
	Diamondback moth	British Columbia, Ontario—major (for larvae) Quebec—major	Group 1A: carbaryl[f], methomyl[f] Group 1B: naled[f], diazinon[f], azinphos-methyl[i], acephate[f], methamidophos[f] Group 2A: endosulfan[f] Group 3: lambda-cyhalothrin, deltamethrin[h], permethrin, cypermethrin Group 5: spinosad Group 11: *Bacillus thuringiensis*			
Cauliflower	Imported cabbageworm	Nova Scotia—moderate British Columbia, Ontario—major	Group 1A: carbaryl[f], methomyl[f] Group 1B: naled[f], diazinon[f], azinphos-methyl[i], acephate[f], methamidophos[f], malathion[f] Group 2A: endosulfan[f] Group 3: lambda-cyhalothrin, deltamethrin[h], permethrin, cypermethrin Group 5: spinosad Group 11: *Bacillus thuringiensis*	No	—	
	Variegated cutworm	Ontario—minor to major Quebec—major	Group 1B: diazinon[f]			
	Diamondback moth	Quebec—major British Columbia, Ontario—major (for larvae)	Group 1A: carbaryl[f], methomyl[f] Group 1B: naled[f], diazinon[f], azinphos-methyl[i], acephate[f], methamidophos[f] Group 2A: endosulfan[f] Group 3: lambda-cyhalothrin, deltamethrin[h], permethrin, cypermethrin Group 5: spinosad Group 11: *Bacillus thuringiensis*			
Carrot	Dipterous leafminers	No data	Group 1B: diazinon[f]	No	—	
	Imported cabbageworm	No data	Group 1A: carbaryl[f] Group 1B: malathion[f], diazinon[f]			
	Variegated cutworm	No data	Group 1B: diazinon[f]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
	Diamondback moth	No data	Group 1A: carbaryl[f] Group 1B: diazinon[f]			
	Beet armyworm	No data	Group 1A: carbaryl[f] Group 1B: diazinon[f]			
	Salt-marsh caterpillar	No data	Group 1B: diazinon[f]			
Collards	Beet webworm	No data	None	No	—	
	Dipterous leafminers	No data	Group 1B: malathion[f]			
	Thrips	No data	Group 3: cypermethrin			
	Variegated cutworm	No data	None			
	Armyworms	No data	Group 1A: carbaryl[f]			
	Salt-marsh caterpillar	No data	None			
Corn (field)	Armyworms	No data	Group 1A: carbaryl[f, j] Group 3: lambda-cyhalothrin[j]	No	—	
	Cutworms	Quebec—moderate	Group 1A: carbaryl[f, j] Group 1B: chlorpyrifos[f, j] Group 3: lambda-cyhalothrin, tefluthrin[j], permethrin[j], cypermethrin[j] Group 4: clothianidin[j]			
Corn (sweet)	Armyworms	No data	Group 1A: carbaryl[f, j] Group3: lambda-cyhalothrin[j], permethrin[j]	No	—	
	Cutworms	Quebec—moderate	Group 1A: carbaryl[f, j] Group 1B: chlorpyrifos[f, j] Group 3: lambda-cyhalothrin, tefluthrin[j], permethrin[j], cypermethrin[j] Group 4: clothianidin[j]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
	European corn borer (Quebec only)	New Brunswick—minor Ontario, Quebec—major	Group 1A: carbaryl[f], methomyl[f], carbofuran[f] Group 1B: acephate[f] Group 3: lambda-cyhalothrin, deltamethrin[h], permethrin, cypermethrin Group 5: spinosad Group 11: *Bacillus thuringiensis*			
Corn (popcorn)	Armyworms	No data	Group 3: lambda-cyhalothrin[j]	No	—	
	Cutworms	No data	Group 1B: chlorpyrifos[f] (aid in suppression only) Group 3: lambda-cyhalothrin, permethrin[j], cypermethrin[j] Group 4: clothianidin[j]			
Lettuce	Beet webworm	Manitoba—minor British Columbia—moderate	Group 1B: diazinon[f]	No	—	
	Dipterous leafminers	Manitoba—minor	Group 1B: diazinon[f] Group 4: acetamiprid			
	Thrips	Manitoba—minor	None			
	Variegated cutworm	British Columbia—moderate Manitoba—minor	Group 1B: diazinon[f]			
	Armyworms	British Columbia—moderate	Group 1A: carbaryl[f], methomyl[f] Group 1B: diazinon[f]			
	Salt-marsh caterpillar	British Columbia—moderate Manitoba—minor	Group 1B: diazinon[f]			
Kale	Beet webworm	No data	Group 1B: diazinon[f]	No	—	
	Dipterous leafminers	No data	Group 1B: diazinon[f] Group 4: acetamiprid			
	Thrips	No data	Group 3: cypermethrin			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
	Variegated cutworm	No data	Group 1B: diazinon[f]			
	Armyworms	No data	Group 1A: carbaryl[f] Group 1B: diazinon[f]			
	Salt-marsh caterpillar	No data	Group 1B: diazinon[f]			
Oats	True armyworm	British Columbia, Alberta, Saskatchewan, Manitoba—minor	Group 1A: methomyl[f], carbaryl[f] Group 1B: chlorpyrifos[f], malathion[f]	No	—	
	Western yellowstriped armyworm	British Columbia, Alberta, Saskatchewan, Manitoba—minor	Group 1A: carbaryl[f] Group 1B: malathion[f], chlorpyrifos[f]			
Oats	Beet webworm	No data	Group 1A: carbaryl[f]	No	—	
	Variegated cutworm	British Columbia, Alberta, Saskatchewan, Manitoba—minor	Group 1A: carbaryl[f] Group 3: deltamethrin[h]			
	Bertha armyworm	British Columbia, Alberta, Saskatchewan, Manitoba—minor	Group 1A: carbaryl[f] Group 1B: malathion[f], chlorpyrifos[f]			
Pepper	Dipterous leafminers	Manitoba—minor	Group 1B: diazinon[f]	No	—	
	Pepper maggot	Manitoba, Ontario—minor	Group 1B: dimethoate[f], malathion[f], acephate[f] Group 2A: endosulfan[f]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
Rutabaga	Dipterous leafminers	Manitoba—minor	Group 1B: diazinon[f]	No	—	
	Imported cabbageworm	Nova Scotia, Manitoba—minor	Group 1A: carbaryl[f] Group 1B: malathion[f], diazinon[f] Group 2A: endosulfan[f] Group 5: spinosad Group 11: *Bacillus thuringiensis*			
	Variegated cutworm	Manitoba–major Ontario—minor Quebec—unknown	Group 1B: diazinon[f]			
	Diamondback moth	Manitoba—minor	Group 1A: carbaryl[f] Group 1B: diazinon[f] Group 2A: endosulfan[f] Group 5: spinosad			
	Beet armyworm	Manitoba—minor	Group 1A: carbaryl[f] Group 1B: diazinon[f]			
	Salt-marsh caterpillar	Manitoba—minor	Group 1B: diazinon[f]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
Salsify	Dipterous leafminers	No data	Group 1B: diazinon[f]	No	—	
	Imported cabbageworm	No data	Group 1A: carbaryl[f] Group 1B: diazinon[f]			
	Variegated cutworm	No data	Group 1B: diazinon[f]			
	Diamondback moth	No data	Group 1A: carbaryl[f] Group 1B: diazinon[f]			
	Beet armyworm	No data	Group 1A: carbaryl[f] Group 1B: diazinon[f]			
	Salt-marsh caterpillar	No data	Group 1B: diazinon[f]			
Spinach	Beet webworm	Manitoba, British Columbia—minor	Group 1B: diazinon[f]	No	—	
	Dipterous leafminers	Manitoba—moderate	Group 1B: diazinon[f], malathion[f] Group 4: acetamiprid			
	Thrips	Manitoba—minor	None			
	Variegated cutworm	British Columbia, Manitoba—minor	Group 1B: diazinon[f]			
	Armyworms	British Columbia, Manitoba—minor	Group 1A: carbaryl[f] Group 1B: diazinon[f]			
	Salt-marsh caterpillar	Manitoba—minor	Group 1B: diazinon[f]			
Sugar beet	Beet webworm	Alberta—moderate Manitoba—minor	Group 1B: diazinon[f] Group 2A: endosulfan[f]	No	—	
	Dipterous leafminers	Manitoba—moderate Ontario—major	Group 1B: malathion[f], diazinon[f]			
	Variegated cutworm	Alberta, Manitoba, Ontario—minor	Group 1B: diazinon[f] Group 3: deltamethrin[h]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
	Alfalfa webworm	Manitoba—minor	Group 1B: diazinon[f]			
Sugar beet	Beet armyworm	Manitoba—minor	Group 1A: carbaryl[f] Group 1B: diazinon[f]	No	—	
Table beet	Beet webworm	Manitoba—minor	Group 1A: carbaryl[f] Group 1B: diazinon[f]	No	—	
	Dipterous leafminers	Manitoba—moderate	Group 1B: malathion[f], diazinon[f]			
	Variegated cutworm	Manitoba—minor	Group 1B: diazinon[f] Group 3: deltamethrin[h]			
	Alfalfa webworm	Manitoba—minor	Group 1B: diazinon[f]			
	Beet armyworm	Manitoba—minor	Group 1A: carbaryl[f] Group 1B: diazinon[f]			
	Salt-marsh caterpillar	Manitoba—minor	Group 1B: diazinon[f]			
Tobacco	Darksided cutworm	No data	Group 1A: carbaryl[f] Group 1B: chlorpyrifos[f], acephate[f] Group 3: lambda-cyhalothrin, deltamethrin[h], cypermethrin, permethrin	No	—	
	Redbacked cutworm	No data	Group 1A: carbaryl[f] Group 1B: chlorpyrifos[f] Group 3: deltamethrin[h], cypermethrin			
	Black cutworm	No data	Group 1B: chlorpyrifos[f] Group 3: deltamethrin[h], cypermethrin			
Tomato	Dipterous leafminers	Manitoba—minor	Group 1B: naled[f], malathion[f], diazinon[f]	No	—	
Turnip	Dipterous leafminers	Manitoba—minor	Group 1B: diazinon[f]	No	—	
	Imported cabbageworm	Nova Scotia, Manitoba—minor	Group 1A: carbaryl[f] Group 1B: malathion[f], diazinon[f] Group 2A: endosulfan[f] Group 5: spinosad Group 11: *Bacillus thuringiensis*			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
	Variegated cutworm	Manitoba—major Ontario–minor Quebec—unknown	Group 1A: carbaryl[f] Group 1B: diazinon[f]			
	Diamondback moth	Manitoba—minor	Group 1A: carbaryl[f] Group 1B: diazinon[f] Group 2A: endosulfan[f] Group 5: spinosad Group 11: *Bacillus thuringiensis*			
	Beet armyworm	Manitoba—minor	Group 1A: carbaryl[f] Group 1B: diazinon[f]			
	Salt-marsh caterpillar	Manitoba—minor	Group 1B: diazinon[f]			
Wheat (durum)	True armyworm	Alberta—minor to moderate	Group 1A: methomyl[f], carbaryl[f] Group 1B: chlorpyrifos[f], malathion[f]	No	—	
	Western yellowstriped armyworm	Alberta—minor to moderate	Group 1A: carbaryl[f] Group 1B: malathion[f], chlorpyrifos[f]			
	Beet webworm	No data	Group 1A: carbaryl[f]			
	Variegated cutworm	Alberta—minor, sporadic and not widespread	Group 1A: carbaryl[f] Group 3: deltamethrin[h]			
	Bertha armyworm	Alberta—minor to moderate	Group 1A: carbaryl[f] Group 1B: malathion[f], chlorpyrifos[f]			
Wheat (spring)	True armyworm	British Columbia, Alberta, Saskatchewan—minor to moderate	Group 1A: methomyl[f], carbaryl[f] Group 1B: chlorpyrifos[f], malathion[f]	No	—	
	Western yellowstriped armyworm	British Columbia, Alberta, Saskatchewan—minor to moderate	Group 1A: carbaryl[f] Group 1B: malathion[f], chlorpyrifos[f]			
	Beet webworm	No data	Group 1A: carbaryl[f]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
	Variegated cutworm	British Columbia, Alberta, Saskatchewan—minor, sporadic and not widespread	Group 1A: carbaryl[f] Group 3: deltamethrin[h]			
	Bertha armyworm	British Columbia, Alberta, Saskatchewan—minor to moderate	Group 1A: carbaryl[f] Group 1B: malathion[f], chlorpyrifos[f]			
Wheat (winter)	True armyworm	British Columbia, Alberta, Saskatchewan, Manitoba—minor	Group 1A: methomyl[f], carbaryl[f] Group 1B: chlorpyrifos[f], malathion[f]	No	—	
	Western yellowstriped armyworm	British Columbia, Alberta, Saskatchewan, Manitoba—minor	Group 1A: carbaryl[f] Group 1B: malathion[f], chlorpyrifos[f]			
	Beet webworm	No data	Group 1A: carbaryl[f]			
	Variegated cutworm	British Columbia, Alberta, Saskatchewan, Manitoba—major	Group 1A: carbaryl[f] Group 3: deltamethrin[h]			
	Bertha armyworm	British Columbia, Alberta, Saskatchewan, Manitoba—minor	Group 1A: carbaryl[f] Group 1B: malathion[f], chlorpyrifos[f]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
Use-Site Category 20: Structural						
Dairy barns	Housefly	No data	Group 1A: methomyl[f] Group 1B: dimethoate[f], azamethiphos, malathion[f], naled[f], dichlorvos[f], tetrachlorvinphos[k] Group 3: pyrethrins, *d*-trans allethrin, permethrin, cyfluthrin Other: (z)-9-tricosene[k]	No	—	
Farm buildings	Housefly	No data	Group 1B: dimethoate[f], malathion[f], chlorpyrifos[f] Group 3: pyrethrins, permethrin, *d*-trans allethrin	No	—	
Garbage areas/refuse area	Housefly	No data	Group 1A: propoxur[f], methomyl[f] Group 1B: dimethoate[f], malathion[f], naled[f], tetrachlorvinphos[k] Group 3: pyrethrins, permethrin Other: (z)-9-tricosene[k]	No	—	
Stock pens	Housefly	No data	Group 1A: methomyl[f] Group 1B: dimethoate[f], naled[f], malathion[f], azamethiphos, chlorpyrifos[f], dichlorvos[f], tetrachlorvinphos[k] Group 3: permethrin, pyrethrins Other: (z)-9-tricosene[k]	No	—	
Use-Site Category 27: Ornamentals Outdoors						
Narcissus	Narcissus blub fly	No information	None	Partial support[d]	Yes	
Ornamental flowers	Armyworms	No information	Group 1B: diazinon[f], acephate[f, g] Group 3: permethrin, pyrethrins[g], *d*-trans allethrin[g]	Partial support[d]	Yes	Due to agriculturally infeasible mitigation measures, this use has risk concerns.
	Bagworms	No information	Group 1A: carbaryl[f, g] Group 1B: malathion[f], diazinon[f] Group 3: permethrin, pyrethrins[g]			
	Boxelder bugs	No information	Group 1A: carbaryl[f, g]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
	Cutworms	No information	Group 1B: diazinon[f] Group 3: permethrin, pyrethrins[g], *d*-trans allethrin[g, j]			
Ornamental flowers	Leafminers	No information	Group 1A: carbaryl[f, g, j] Group 1B: dimethoate[f, g], naled[f, g, j], malathion[f], diazinon[f, g], acephate[f, g] Group 3: pyrethrins[g], permethrin Group 4: acetamiprid[j] Other: soap[k, j]	Partial support[d]	Yes	Due to agriculturally infeasible mitigation measures, this use has risk concerns.
	Lygus bugs	No information	Group 1A: carbaryl[f, g] Group 1B: malathion[f]			
	Stink bugs	No information	Group 3: pyrethrins[g]			
	Tarnished plant bugs	No information	Group 1A: carbaryl[f, g] Group 1B: malathion[f]			
	Webworms	No information	Group 1A: carbaryl[f, g] Group 1B: diazinon[f] Group 3: permethrin, pyrethrins[g]			
Ornamental shrubs	Armyworms	No information	Group 1B: diazinon[f], acephate[f, g, j] Group 3: permethrin, pyrethrins[g], *d*-trans allethrin[j]	Partial support[d]	Yes	Due to agriculturally infeasible mitigation measures, this use has risk concerns.
	Bagworms	No information	Group 1A: carbaryl[f, g] Group 1B: dimethoate[f, g], malathion[f], diazinon[f], acephate[f, g] Group 3: permethrin, pyrethrins[g] Group 11: *Bacillus thuringiensis*			
	Boxelder bugs	No information	Group 1A: carbaryl[f, g]			
	Cutworms	No information	Group 1B: diazinon[f] Group 3: permethrin, pyrethrins[g], *d*-trans allethrin[j]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
Ornamental shrubs	Leafminers	No information	Group 1A: carbaryl[f, g, j] Group 1B: dimethoate[f, g, j], naled[f, g, j], malathion[f], diazinon[f], acephate[f, g] Group 3: permethrin, pyrethrins[g] Group 4: acetamiprid[j] Other: soap[k, j]	Partial support[d]	Yes	Due to agriculturally infeasible mitigation measures, this use has risk concerns.
	Lygus bugs	No information	Group 1A: carbaryl[f, g] Group 1B: malathion[f]			
	Stink bugs	No information	Group 3: pyrethrins[g]			
	Tarnished plant bugs	No information	Group 1A: carbaryl[f, g] Group 1B: malathion[f]			
	Webworms	No information	Group 1A: carbaryl[f, g] Group 1B: diazinon[f] Group 3: permethrin, pyrethrins[g]			
Ornamental trees	Armyworms	No information	Group 1B: acephate[f, g], diazinon[f] Group 3: pyrethrins[g], permethrin, *d*-trans allethrin[j]	Partial support[d]	Yes	Due to agriculturally infeasible mitigation measures, this use has risk concerns.
	Bagworms	No information	Group 1A: carbaryl[f, g] Group 1B: dimethoate[f, g], malathion[f], diazinon[f], acephate[f, g] Group 3: permethrin, pyrethrins[g] Group 11: *Bacillus thuringiensis*			
	Boxelder bugs	No information	Group 1A: carbaryl[f, g]			
	Cutworms	No information	Group 1A: carbaryl[f, g]			
Ornamental trees	Leafminers	No information	Group 1A: carbaryl[f, g, j] Group 1B: dimethoate[f, g, j], naled[f, g, j], malathion[f], diazinon[f], phosmet[f, g, j], acephate[f, g] Group 3: permethrin, pyrethrins[g] Group 4: acetamiprid[j] Other: soap[k, j]	Partial support[d]	Yes	Due to agriculturally infeasible mitigation measures, this use has risk concerns.
	Lygus bugs	No information	Group 1A: carbaryl[f, g] Group 1B: malathion[f]			

Site(s)	Pest	Pest Status / Incidence[a]	Alternative Registered Active Ingredients (resistance management group number)[b, c]	Registrant Supports Use of Trichlorfon?	Concerns From the Risk Assessments?	Identification of Risk Assessment Concerns
	Stink bugs	No information	Group 3: pyrethrins[g]			
	Tarnished plant bugs	No information	Group 1A: carbaryl[f, g] Group 1B: malathion[f]			
	Webworms	No information	Group 1A: carbaryl[f, g] Group 1B: diazinon[f], acephate[f, g, j] Group 3: permethrin, pyrethrins[g] Group 11: *Bacillus thuringiensis*[j]			

a Data from end-user surveys and PMRA research.

b This is a list of registered options only. The PMRA does not endorse any of the options listed. The PMRA welcomes feedback on the viability of the options listed.

c Resistance Management Group Numbers for Insecticides: 1A = acetylcholinesterase inhibitors; 1B = acetylcholinesterase inhibitors; 2A = gamma-amiobutyric acid (GABA)-gated chloride channel antagonists; 3 = sodium channel modulators; 4 = acetylcholine receptor agonists/antagonists; 5 = acetylcholine receptor nodulators; 11 = microbial disruptors of insect mid-gut membranes.

d Partial support for the use (e.g., the PMRA has risk concerns only for some application methods of the use).

e Partial risk concern for the use (e.g., PMRA has risk concerns only for some application methods of the use).

f These active ingredients are under re-evaluation.

g This active ingredient is only valid for specific species of plants and this pest.

h Deltamethrin use is restricted to certain areas of Canada, including Eastern Canada, the Prairie Provinces, the Peace River region of British Columbia. and/or British Columbia in general. Refer to specific labels for area restrictions.

i The re-evaluation of azinphos-methyl is complete (see RRD2004-05). Azinphos-methyl is to be phased out. Sites on the trichlorfon use pattern will be phased out by 31 December 2007 (REV2006-04).

j This active ingredient is only valid for specific species of this pest complex on this site.

k Re-evaluation of the following active ingredients is complete: tetrachlorvinphos (see RRD2004-14), (z)-9-tricosene (see RRD2004-06), insecticidal soap (see RRD2004-26).