Pest Management Regulatory Agency
Agence de réglementation de la lutte antiparasitaire

Re-evaluation Note REV2005-06

Preliminary Risk and Value Assessments of Diazinon

The purpose of this document is to inform registrants, pesticide regulatory officials and the Canadian public that Health Canada's Pest Management Regulatory Agency (PMRA) has completed preliminary risk and value assessments of diazinon. This Re-evaluation Note provides a summary of these preliminary assessments based on the data and information reviewed. The preliminary risk assessment indicates a level of concern for workers and the environment. The PMRA is requesting further data/information to finalize the risk and value assessments as well as to propose regulatory action.

Therefore, the PMRA is soliciting information that may be used to refine these preliminary assessments and/or mitigate risks. The PMRA will accept written comments and information up to 60 days from the date of publication of this document. All comments should be forwarded to the Publications Coordinator at the address below.

The PMRA will review the information received, revise the risk and value assessments as necessary and propose regulatory action in a future Proposed Acceptability for Continued Registration (PACR) document.

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Foreword

Health Canada's Pest Management Regulatory Agency (PMRA) has completed preliminary risk and value assessments for the active ingredient diazinon and its end-uses on food and non-food areas. The registrant of the technical grade active ingredient is Makhteshim-Agan of North America Inc.

The PMRA announced in June 1999 that organophosphate active ingredients, including diazinon, were subject to Re-evaluation under authority of Section 19 of the Pest Control Products Regulations[1].

Subsequent to that announcement, Novartis Crop Protection Canada Inc. and Makhteshim Chemical Works, registrants of diazinon technical in Canada in 2000 and primary data providers, agreed to phase out domestic class products as well as indoor and lawn uses (including uses on golf courses and sod farms) of commercial class products (Re-evaluation documents REV2000-07 and REV2000-08, *Update on Re-evaluation of Diazinon in Canada*).

Makhteshim-Agan of North America Inc., in consultation with growers, provided the PMRA with a list of label uses supported for continuing registration. The uses not supported by the registrant and consequently not included in the present risk assessment are the following:

Greenhouse	tomato, pepper and ornamentals
Seed treatments	onion, radish, sugarbeet and potato seed pieces
Feed crops	clover, grass, pastures, rangeland and green forage or hay from crop margins
Non-crop areas	wastelands, roadsides, ditch banks, fence rows and barrier strips
Certain food crops	field pepper, salsify, potato, tobacco (field), plums and prunes
Structural	farm buildings, food processing plants, poultry houses

The environmental and health risks and the value assessments presented in this document are preliminary.

[1] Re-evaluation Document REV99-01, *Re-evaluation of Organophosphate Pesticides*.

The preliminary assessments presented in this document indicate a level of concern for workers and the environment. The PMRA is requesting further information to finalize the risk and value assessments. Therefore, the PMRA is soliciting the public and all interested parties to submit information that may be used to refine these assessments and/or mitigate risks. The PMRA will review the information received, revise the assessments as necessary and propose regulatory actions in a future Proposed Acceptability for Continuing Registration (PACR) document.

The United States Environmental Protection Agency (USEPA) published an Interim Reregistration Eligibility Decision (IRED) document on diazinon in May 2004. To address concerns regarding the safety of workers, avian and other wildlife, the USEPA required mitigation measures including, but not limited to, phasing out granular registrations, foliar applications and seed treatment uses as well as requiring engineering controls and crop-specific restricted entry intervals for the remaining uses. Details on the USEPA diazinon assessment are available at www.epa.gov/REDs/diazinon_ired.pdf.

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1.0 Purpose

This document describes the PMRA's preliminary risk and value assessments of the insecticide diazinon and its end-uses. It includes a human health assessment, an environmental assessment and information on the value of diazinon to pest management in Canada. By way of this document, the PMRA is soliciting comments and input to the risk and value assessments of diazinon from interested parties. Such comments and input could include, for example, additional data or information to further refine the risk assessment, such as typical use pattern information, percent crop treated, areas treated per day, number of applications, rates, etc., or could address the PMRA's risk assessment approaches and assumptions as applied to diazinon. Further information on alternatives could refine the value assessment.

2.0 Re-evaluation of Diazinon

Diazinon is 1 of the 27 organophosphate pesticides subject to re-evaluation in Canada. The re-evaluation of diazinon was announced in Re-evaluation Document REV99-01, *Re-evaluation of Organophosphate Pesticides*. Diazinon is a broad-spectrum organophosphate insecticide that inhibits the enzyme acetylcholinesterase, interrupting the transmission of nerve impulses. It works by contact, ingestion and vapour action. Diazinon, also known by the trademark names "Diazol" and "Basudin", has been used in registered pest control products in Canada since 1954.

Subsequent to the announcement of the re-evaluation of diazinon, Novartis Crop Protection Canada Inc. and Makhteshim Chemical Works, registrants of diazinon technical in Canada in 2000 and primary data providers, agreed to phase out residential, indoor and lawn uses (including uses on golf courses and sod farms) (REV2000-07 and REV2000-08, *Update on Revaluation of Diazinon in Canada*). Consequently, those uses are not considered in the present risk assessment.

2.1 Chemical Identification

Chemical name

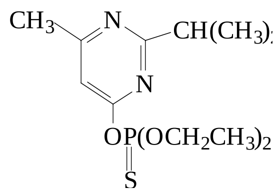
IUPAC O,O-diethyl O-2-isopropyl-6-methylpyrimidin-4-yl phosphorothiate

CAS O,O-diethyl O-[6- methyl -2-(1-methylethyl)-4-pyrimidinyl phosphorothiate

CAS number 333-41-5

Molecular formula $C_{12}H_{21}N_2O_3PS$

Structural formula



2.2 Description of Registered Diazinon Uses

Type of pesticide

Diazinon is an organophosphate insecticide.

2.2.1 Description of Uses Considered in the Risk Assessments

The following uses of diazinon are included in the risk assessment at request of the registrant.

Greenhouse (food, feed and tobacco)	greenhouse-grown tobacco seedlings and mushrooms growing in mushroom houses
Seed treatments	beans, corn and peas
Food crops	apple, apricot, beans, beets, blackberry, carrot, cherry, cole crops (foliar, granular and soil drench) broccoli, Brussels sprouts (soil drench and granular applications only), cabbage, cauliflower, grapes, hops, kale and kohlrabi, collards, cranberry, cucumber, currant, gooseberry, lettuce, loganberry, melons, onion (excluding seed treatment applications), parsley, parsnip, peach, pear, raspberry, radish (foliar and granular applications only), rutabaga, spinach, squash, strawberry, Swiss chard, turnip and tomato
Livestock	lactating and non-lactating dairy cattle as well as beef cattle
Ornamental crops	aralia, arborvitae, azalea, birch, boxwood, carnation, chrysanthemum, holly, juniper, ivy, oak, pine, rose and taxus
Forest and woodlot	Christmas tree plantations

Pest Considered in the Risk Assessments
All insects and mites currently listed on the registered labels for the sites listed above were included in the assessment of value. These arthropods belong to the following groups: ants, beetles, bees, butterflies, flies, mites, moths, sawflies, thrips, true bugs and wasps. Those insects for which diazinon was identified as being of "key" importance are discussed in Section 5.2.

Formulation Types/Packaging Assessed
The formulation types of end-use products registered for uses included in the assessment are the following:

a) emulsifiable concentrate (EC);
b) granular;
c) slow release (ear tag); and
d) solution and wettable powder packaged in soluble bags.

Application Equipment, Methods and Rates Assessed
In agriculture, ear tags, seed treatment equipment (dry or slurry), granular applicators, hydraulic sprayers (backpack, hand-held wand, boom, etc.) and mist blowers (hydraulic) are used. For application in mushroom houses, equipment such as paint brushes and hydraulic (backpack) sprayers are used. As mitigation measures, the registrant has proposed handling in a closed system only, and closed cabs for applicators. Table 2.2.1 summarizes the methods and rates of application of diazinon used in Canada that were assessed.

Table 2.2.1 Methods and Rates of Application of Diazinon Included in the Present Risk Assessment

Site	Application Method	Application Rate[1] (g a.i.)	Maximum No. of Application/ year[2]	Minimum Period Between Applications	Preharvest Interval (days)
Greenhouse food crops (tobacco seedlings, mushroom houses)	**Tobacco seedlings** backpack/hand-held sprayer	6.25/100 m^2	2 *(2)*	14 days	Not applicable
	Mushroom houses backpack/hand-held sprayer (wall treatment)	500–1000/100 L	*(1)* 1	Not applicable	Not stated

Site	Application Method	Application Rate[1] (g a.i.)	Maximum No. of Application/ year[2]	Minimum Period Between Applications	Preharvest Interval (days)
	Paint brush (bed, post and door treatment)	50/100 L	Re-apply as necessary	Re-apply as necessary	
Seed treatment (beans, corn, peas)	Seed treatment equipment (dry and slurry)	30–31.25/100 kg seed	1	Not applicable	Not applicable
Food crops (apple, apricot, beans, beets, blackberry, broccoli, Brussels sprouts, cabbage, cauliflower, carrot, cherry, collards, cranberry, cucumber, currant, gooseberry, grapes, hops, kale, kohlrabi, lettuce, loganberry, melons, onion, parsley, parsnip, peach, pear, raspberry, radish, rutabaga, spinach, squash, strawberry, Swiss chard, turnip, tomato)	Ground application: hydraulic sprayer, seedling drench, soil drench	250–3750/ha	Re-apply as necessary *1 (Beans, beet, broccoli, Brussels sprouts, cabbage, cauliflower, collards, currant, gooseberry kale, kohlrabi, rutabaga, strawberry, turnip)* *2 (Apple, apricot, blackberry, carrot, cherry, cucumber, grape, hops, lettuce, loganberry, melon, parsley, parsnip, peach, pear, raspberry, spinach, squash, Swiss chard, tomato)* *3 (Onion)* *4 (Cranberry)*	Re-apply as necessary except for: 7 days (tomato)	1 (tomato) 3 (squash) 3, 7 (bean) 5 (broccoli, cauliflower, strawberry) 7 (cabbage, collards, cranberry, cucumber, kale, kohlrabi) 10 (apricot, carrot, cherry, lettuce, melon, onion, parsley, parsnip, radish) 14 (apple, beet, Brussels sprouts, hops, pear, rutabaga, spinach, Swiss chard, turnip) 16 (grape) 20 (peach)

Site	Application Method	Application Rate[1] (g a.i.)	Maximum No. of Application/ year[2]	Minimum Period Between Applications	Preharvest Interval (days)
Food crops (broccoli, Brussels sprouts, cabbage, cauliflower, carrot, corn, onion, parsnip, radish, rutabaga, tomato)	Ground application: granular[3]	1035–2750/ha	1 (corn carrot, broccoli, Brussels sprouts, cabbage, cauliflower, onion, parsnip, radish) 2 (rutabaga) *1 (Rutabaga)* Re-apply as necessary (tomato) *2 (Tomato)*	Not applicable (corn, carrot, cole crops, onion, parsnip, radish) Variable: two weeks after thinning (rutabaga) 7 (tomato)	Not applicable 0 (tomato)
Livestock (food)	1–2 ear tags (slow release)	1.15–6/head	1	Not applicable	0
Christmas tree plantations	Ground application: mist blower	850/ha	Re-apply as necessary *1*	re-apply as necessary	Not applicable
Ornamentals (outdoor non-residential) Aralia, arborvitae, azalea, birch, boxwood, carnation, chrysanthemum, euonymus, holly, ivy juniper, oak, pine, rose, taxus	Ground application: hydraulic sprayer	483–1875 /1000 L	Re-apply as necessary *1 (Arborvitae, birch, boxwood, euonymus, oak, taxus)* *2 (Juniper, pine)* *4 (Aralia, azalea, carnation, chrysanthemum, holly, ivy, rose)*	Re-apply as necessary	Not applicable

NOTE: Except where noted, all information is summarized from current end-use product labels.

[1] The rates in this table represent the range of rates for the specific pests registered on each site.
[2] Numbers in *italics* are proposed by the registrant and considered in the present risk assessment.
[3] Granular formulations, no crop specified, are included in the environmental risk assessment. This list includes all registered uses of diazinon granular formulations on food crops.

2.2.2 Description of Uses Not Included in the Risk Assessment

The following uses are not supported by the registrant and are, therefore, not included in the health and environmental risk assessment for diazinon:

Greenhouse	tomato, pepper and ornamentals
Seed treatments	onion, radish, sugarbeet and potato seed pieces
Feed crops	clover, grass, pastures, rangeland and green forage or hay from crop margins
Non-crop areas	wastelands, roadsides, ditch banks, fence rows and barrier strips
Structural	farm buildings, food processing plants, poultry houses
Certain food crops	field pepper, salsify, potato, tobacco (field), plums and prunes

Formulation Types/Packaging Not Included in the Risk Assessment
The unsupported formulation types of end-use products are dust, micro capsule suspension, pressurized products and wettable powder not packaged in soluble bags.

Method of Application Not Included in the Risk Assessment
Fogging in greenhouses and aerial applications were not included in the risk assessments as they are not supported by the registrant.

3.0 Effects Having Relevance to Human Health

3.1 Toxicology Summary

The toxicology database confirms that diazinon has anticholinesterase activity in various species including rats, mice, rabbits, dogs and hens. Clinical signs of toxicity observed in laboratory animals are typical of the organophosphate class of chemicals.

Following oral administration to rats, diazinon was almost completely absorbed and eliminated, mainly in the urine. The main degradative pathway involves oxidase/hydrolase-mediated cleavage of the ester bond resulting in the liberation of the pyrimidinyl group that was further oxidized and excreted. Female rats appeared to excrete degradation products at a slower rate compared to males. Diazinon did not accumulate in tissues following single or multiple exposure. No dose-related differences appeared in the metabolism of diazinon.

In acute toxicity studies, diazinon was found to range from slight to moderate toxicity via oral exposure in rats. Dermal exposure resulted in low toxicity to rabbits. Exposure via inhalation resulted in low toxicity to the rat. Acute toxicity signs were consistent with cholinesterase inhibition and included: tremors, convulsions, salivation and dyspnea. Diazinon was found to be mildly irritating to the skin and minimally irritating to the eye. A positive result in a sensitization study in the guinea pig indicates diazinon is a potential skin sensitizer.

In subchronic and chronic toxicity studies conducted in mice, rats, rabbits and dogs, the most sensitive endpoint was inhibition of cholinesterase activity (plasma, erythrocyte and brain). The effect was typically dose-related as well as occurred by all routes of exposure and in studies of various durations. A slight increase in toxicity with increased study duration was indicated in the oral studies by decreased lowest observed adverse effect levels (LOAELs) for brain cholinesterase inhibition, particularly for male rats. Females (rats, dogs) also appeared to be slightly more sensitive with respect to brain cholinesterase inhibition, which could be related to the slower excretion and, hence, longer retention in females. Assessment of sensitivity relative to species revealed that the dog was slightly more sensitive to inhibition of erythrocyte and brain cholinesterase (based on the no observed adverse effect level [NOAEL]), although this may be a function of the dose levels tested as LOAELs were comparable. Neurobehavioural observations were associated with exposure to diazinon, however, there was no evidence of histopathological effects on the central nervous system in these studies. There was no evidence of delayed-type neurotoxicity in two hen studies (neurotoxic esterase [NTE] measured), and no evidence of histopathological lesions in the other subchronic/chronic studies.

Diazinon was found to inhibit cholinesterase activity in short-term studies by the dermal and inhalation route. The short-term dermal study was conducted in rabbits, a species which typically underestimates the dermal toxic potential of organophosphates due to unique physiological differences. Nonetheless, it was considered relevant in the case of diazinon due to supporting acute dermal cholinesterase data in the rat.

There was no evidence of carcinogenicity in rats or mice following long-term exposure via the diet. Diazinon was assessed for mutagenic potential in a variety of in vitro and in vivo studies, including gene mutation, chromosomal aberration, DNA repair and dominant lethal tests. Overall, the results indicate that diazinon is not genotoxic.

Developmental toxicity studies in rats and rabbits showed no evidence of teratogenicity. In one rat study, developmental effects (minimally increased resorptions) were observed at the highest dose tested (100 mg a.i. kg bw/day). However, significant maternal toxicity was also observed at this dose level. Therefore, it was determined that there was no additional sensitivity of the fetus following in utero exposure to diazinon. No sensitivity of the young was noted in the two-generation reproduction study. However, effects on offspring survival and development were evident at maternally toxic doses. Effects observed in maternal animals at this dose indicated cholinesterase inhibition, including tremors, soft stools and death in addition to significant decreases in body-weight gain. In addition, reproductive parameters including mating and fertility indices were also reduced at this dose level. It should be noted, however, that there was a lack of cholinesterase measurements for maternal animals and offspring in these studies. This precludes a more refined analysis of the sensitivity issue. There was no evidence of abnormalities in the development of the fetal nervous system in these studies. There was no evidence in the database to suggest that diazinon has an adverse effect on the endocrine system in mammals.

Although human studies were available for diazinon, the data are considered supplementary due to numerous study limitations in addition to ethical considerations and the lack of internationally approved pesticide guidelines. These studies did, however, confirm that the animal species tested are appropriate surrogates for assessing toxicity in humans. Diazinon has been one of the leading insecticides responsible for acute poisoning incidents reported in the United States. However, based on usage, the rate of poisoning for diazinon does not differ greatly from that of other cholinesterase-inhibiting insecticides.

Reference doses have been set based on NOAELs for the most sensitive indicator of toxicity, namely acetylcholinesterase inhibition. These reference doses incorporate various uncertainty factors to account for extrapolating between laboratory animals and humans and for variability within the human population. Overall, assessment of the available data did not indicate additional sensitivity of the young. However, due to the serious nature of the effects observed in the reproduction study (decreased mating and fertility indices, decreased litter size and viability) further consideration of these endpoints at the risk assessment was necessary to ensure adequate protection of relevant subpopulations.

The toxicology endpoints used in the risk assessment of diazinon are summarized in Appendix I.

3.2 Occupational and Residential Risk Assessment

Workers can be exposed to diazinon through mixing, loading or applying the pesticides, when re-entering a treated site to conduct agronomic activities or when conducting other pest application activities such as planting treated seed.

Occupational risk is estimated by comparing a calculated MOE to a target MOE incorporating safety factors protective of the most sensitive subpopulation. MOEs greater than or equal to the target MOE do not require risk mitigation. For diazinon, 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 MOE” may be generated. Where the target MOEs for exposure routes differ, an aggregate risk index (ARI) is calculated.

For workers entering a treated site, restricted entry intervals (REIs) are calculated to determine the minimum length of time required before workers or others can safely re-enter.

For short-term dermal risk assessment, the dermal NOAEL of 1.0 mg a.i./kg bw/day from a short-term (21-day) rabbit study was selected. Inhibition of brain cholinesterase was observed at the LOAEL of 5 mg a.i./kg bw/day in this study. The selected target MOE when using this study is 100 to account for standard uncertainty factors of 10× for interspecies extrapolation and 10× for intraspecies variability. The selection of this study was considered to be protective of all populations including pregnant women and their fetuses or nursing infants.

For intermediate- and long-term dermal risk assessment, the dermal NOAEL of 1.0 mg a.i./kg bw/day from a short-term (21-day) rabbit study was selected. Inhibition of brain cholinesterase was observed at the LOAEL of 5 mg a.i./kg bw/day in this study. The selected target MOE when using this study is 300 to account for standard uncertainty factors of 10× for interspecies extrapolation and 10× for intraspecies variability as well as an additional 3× to account for not having a dermal study of appropriate duration. The selection of this study was considered to be protective of all populations including pregnant women and their fetuses or nursing infants.

For short-, intermediate- and long-term inhalation risk assessment, the NOAEL of 0.026 mg a.i/kg bw/day (0.0001 mg a.i./L) was selected from a 21-day inhalation toxicity study in rats. A LOAEL of 0.2 mg a.i./kg bw/day was established on the basis of erythrocyte and brain cholinesterase inhibition. For short-, intermediate- and long-term exposure scenarios, the selected target MOE when using this study is 100; this accounts for standard uncertainty factors of 10× for interspecies extrapolation and 10× for intraspecies variability. No additional uncertainty factor was required for extrapolating the 21-day inhalation results to an intermediate- or long-term scenario as the increased duration of inhalation exposure did not significantly enhance toxicity in rat studies of varying duration. Furthermore, the inhalation NOAEL of 0.026 mg/kg bw/day with a MOE of 100 yields a similar value to the acceptable daily intake (ADI) value (see Section 3.3), assuming 100% absorption by the inhalation route. The selection of this study and target MOEs are considered protective of pregnant women and their fetuses or nursing infants.

3.2.1 Mixer/Loader/Applicator Exposure and Risk Assessment

There are potential exposures to mixers, loaders, applicators or other handlers. Based on typical use pattern, the major scenarios identified were as follows:

- mixing/loading wettable powder/emulsifiable concentrates for application to terrestrial field crops, fruit trees, outdoor ornamentals and Christmas trees;
- applying wettable powder/emulsifiable concentrates as sprays to field crops and outdoor ornamentals by groundboom;

- applying wettable powder/emulsifiable concentrates as sprays to fruit trees, outdoor ornamentals, Christmas trees and certain field crops by airblast;
- mixing/loading/applying wettable powder/emulsifiable concentrates to outdoor ornamentals, greenhouse tobacco and mushrooms by high-pressure handwand;
- mixing/loading/applying wettable powder/emulsifiable concentrates to outdoor ornamentals, greenhouse tobacco and mushrooms by low-pressure handwand;
- mixing/loading/applying wettable powder to outdoor ornamentals by backpack sprayer;
- mixing/loading/applying wettable powder/emulsifiable concentrates to mushroom houses by paintbrush; and
- seed treatment for beans, corn and peas (on-farm and commercial facilities).

Based on the number of applications, workers applying diazinon would generally have a short-term (< 30 days) duration of exposure. The exception would be for the indoor uses of diazinon (e.g., greenhouse and mushroom house), which could represent an intermediate- to long-term duration of exposure (> 30 days).

The PMRA estimated handler exposure based on the different levels of personal protection, as follows:

- Engineering controls: represents the use of an appropriate engineering control, such as closed tractor cab or closed loading system. Engineering controls do not apply to handheld application methods which have no known devices that can be used to routinely lower the exposures for these methods. For groundboom and airblast applicators, the engineering controls comprised closed cab and baseline PPE (long sleeves, long pants, no gloves), unless otherwise indicated.

- Maximum PPE: chemical-resistant coveralls over a long-sleeved shirt, long pants, gloves and a respirator with open mixing, for handheld application methods.

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

No chemical-specific handler exposure data were submitted for diazinon. Therefore, daily dermal and inhalation handler doses 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, mix/load systems and level of PPE.

The PHED data are inadequate to estimate either on-farm or commercial seed treatment. For on-farm treatment, a published study, which examined exposure to workers carrying out on-farm seed treatment with lindane, was available. Workers (12 replicates) were monitored to assess exposure to lindane dust formulation during manual wheat seed treatment. The registered diazinon formulations are wettable powder formulations that would be comparable to the dust formulations used in the lindane study. The registrant proposed a mitigation measure of packaging the products in water-soluble bags, resulting in lower exposure potential compared to what was used in the study. In the absence of further data, it is assumed that exposure from treatment of wheat seed would be similar to treatment of peas, beans and corn. The workers were wearing long-sleeved shirts, work pants, impermeable gloves and a respirator. This study only monitored the actual treating of seed; seed was not planted as part of the study, and clean-up activities were also not monitored. Potential exposure was estimated using the unit exposure estimates from the study, the rate of application for each seed type and the amount of seed handled per day. Data were not available to estimate exposure in commercial seed treatment facilities. However, based on professional judgement, the unit exposure in some types of these scenarios may be comparable or higher than the on-farm seed treatment scenario, as commercial seed treatment facilities tend to handle much larger amounts of seed.

Occupational risk estimates associated with application, mixing and loading for most current uses are acceptable, provided engineering controls or PPE are used, as summarized in Appendix II. However, for some uses, calculated MOEs are less than the target MOEs, even after consideration of maximum feasible engineering controls, PPE and clothing; therefore, the calculated MOEs exceed the level of concern. For seed treatment on-farm, the calculated MOE was below the target MOE after consideration of maximum PPE. For seed treatment in commercial facilities, it would be expected that the target MOE also would not be reached.

No exposure data were available to conduct a quantitative assessment for applying ear tags. However, considering the nature of the worker exposure, the design of the product and the requirement to wear gloves when handling tags, potential worker exposure is expected to be lower than for other uses assessed. No further data are required.

3.2.2 Postapplication Exposure Risk Assessment

The postapplication occupational risk assessment considered exposures to workers entering treated agricultural sites. Based on the diazinon use pattern, there is potential for short-term (< 30 days) postapplication exposure to diazinon residues for workers outdoors. For indoor scenarios (tobacco and mushroom), there is potential for intermediate- to long-term exposure (> 30 days).

Workers who re-enter treated sites to conduct activities involving foliar contact (e.g., pruning, thinning, harvesting and scouting) may be exposed to diazinon. Potential exposure to re-entry workers was estimated using activity-specific transfer coefficients (TCs) and dislodgeable foliar residue (DFR) data. TCs measure the relationship between exposure and DFRs for individuals engaged in a specific activity (e.g., scouting or harvesting) for a specific crop or crop group. The registrant is a member of the Agricultural Re-entry Task Force (ARTF), which is finalizing a substantial database of TCs. When available, the PMRA used conservative default TCs based on the ARTF data pending full review of the ARTF database by the PMRA. Default transfer coefficients were not available for greenhouse tobacco or mushrooms.

DFR data were available for citrus, Chinese cabbage and broccoli foliage, and are described in the United States Environment Protection Agency (USEPA) Registration Eligibility Decision (RED) for diazinon (2000). The DFR dissipation curves predicted from these studies as well as Canadian conditions of use (e.g., application rates and number of applications), were used to derive REIs for each crop/activity combination. A REI is the duration of time that must elapse before dislodgeable residues decline to such a level that entry into a treated area to perform a specific activity does not result in exposures with MOEs below the target (100 for short-term exposure scenarios). REIs and postapplication exposure calculations for each crop are summarized in Appendix II.

Postapplication exposure estimates are based on the best available data. Data being generated by the ARTF and/or other data such as passive dosimetry, biological monitoring and additional DFR data might permit refinement of the assessment. The calculated REIs for outdoor scenarios are considered agronomically feasible. For indoor scenarios (greenhouse tobacco and mushrooms), REIs were not calculated, because target MOEs were not reached for mixer/loaders/applicators and because TCs as well as indoor DFR data were not available. Following seed treatment, postapplication exposure could occur during planting of treated seed. Data were not available to estimate exposure for this scenario. If data were submitted to refine seed treatment exposure estimates, a study assessing exposure during planting of treated seed would also be needed.

3.2.3 Residential Exposure and Risk Assessment

Because diazinon use in residential areas is being phased out, a residential risk assessment was not required.

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 risk assessments are age-specific and incorporate the different eating habits of the population at various stages of life. For example, 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.

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

Acute dietary risk is calculated considering food consumption and residue values in food. A probabilistic statistical analysis allows all possible combinations of consumption and residue levels to be combined to estimate a distribution of the amount of diazinon residue that might be eaten in a day. An exposure value representing the high end (99.9^{th} percentile) of this distribution is compared to the acute reference dose (ARfD), 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 ARfD, the expected intake is not considered to be of concern.

To estimate acute dietary risk (one day), three acute neurotoxicity studies in rats were considered for risk assessment. Based on these studies, a LOAEL of 2.5 mg a.i./kg bw was established. A NOAEL was then set at the next lower dose of 0.25 mg a.i./kg bw based on inhibition of erythrocyte cholinesterase at 2.5 mg a.i./kg bw. Standard uncertainty factors of 10× for interspecies extrapolation and 10× for intraspecies variability were used. The ARfD was calculated to be 0.0025 mg a.i./kg bw (0.25 mg a.i./kg bw ÷ 100). Effects on reproductive outcome (mating, fertility and viability indices) as noted in the multi-generation reproduction study were not considered in this reference dose as these effects were not believed to be attributable to a single dose.

The acute dietary exposure was assessed in a mixed tier probabilistic assessment, using residue data from monitoring and market basket survey for commodities on which diazinon is registered in the United States and in Canada. Percent crop treated data were used for domestic and imported crops, and processing factors were used for relevant matrices. The acute potential daily intake (PDI) accounted for < 76% (99.9^{th} percentile) of the ARfD for all subpopulations.

The chronic dietary risk is calculated by using the average consumption of different foods, and average residue values on those foods, over a 70-year lifetime. This expected intake of residues is compared to the ADI, 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 ADI, the expected intake is not considered to be of concern.

To estimate dietary risk from repeat dietary exposure, the NOAEL of 0.02 mg a.i./kg bw/day from the 52-week dog study was selected for risk assessment. The NOAEL is based on inhibition of brain cholinesterase at the next highest dose of 4.5 mg a.i./kg bw/day. In addition, a chronic study in the rat resulted in a NOAEL of 0.06 mg a.i./kg bw/day based on inhibition of brain cholinesterase at the next highest dose of 5 mg a.i./kg bw/day. This would suggest there are limited differences in species sensitivity. Standard uncertainty factors of 10× for interspecies extrapolation and 10 × for intraspecies variability were used. The ADI was calculated to be 0.0002 mg a.i./kg bw/day (0.02 mg/kg bw/day ÷ 100). In consideration of the serious nature of the outcome (ability to successfully reproduce) observed in the reproduction study, there was a margin of safety > 33,000 between this ADI and the reproductive/offspring NOAEL of 6.7 mg a.i./kg bw/day. The ADI is therefore protective of women of child-bearing age as well as the young.

The chronic dietary exposure was assessed using residue data from monitoring and market basket survey for commodities on which diazinon is registered in the United States and in Canada. Percent crop treated data were used for domestic and imported crops, and processing factors were used for relevant matrices. The chronic PDI accounted for < 31% of the ADI for all population subgroups.

As none of the dietary exposure estimates exceed the relevant chronic or acute reference dose, the dietary exposure is acceptable.

3.4 Drinking Water Exposure

Drinking water exposure was addressed by calculating drinking water levels of comparison (DWLOC). DWLOCs can only be calculated if all other exposures are not of concern to the Agency, as the DWLOC simply expresses the difference between the reference dose and the non-drinking water exposure. The DWLOC values were compared to the available monitoring data and to model estimates of potential drinking water exposure.

The acute DWLOC values ranged from 9–54 µg a.i./L for the most sensitive subpopulation of children one to six years of age and the total population, respectively. The chronic DWLOCs ranged from 1.6 µg a.i./L for the most sensitive subpopulation of non-nursing infants, to 6.0 µg a.i./L for the total population. Estimated concentrations in drinking water based on refined (level 2) modelling data exceeded the DWLOCs (Section 5.3). Estimates based on the limited available monitoring data were 0.98 µg a.i./L for groundwater (acute and chronic), 3.3 and 0.06 µg a.i./L for acute and chronic surface water, respectively. Confirmatory monitoring data would be required to confirm that all drinking water exposure estimates are not of concern.

3.5 Aggregate Exposure and Risk Assessment

Aggregate exposure is the total exposure to a single pesticide that may occur from dietary (food and drinking water), residential and other non-occupational sources as well as from all known or plausible exposure routes (oral, dermal and inhalation). As all domestic and indoor residential uses of diazinon are being phased out, the aggregate risk assessment for diazinon would consider food and water only, as described above.

Drinking water, chronic and acute dietary risk assessments demonstrated that there were no non-occupational health concerns for any population subgroup in Canada, including infants, children, teenagers, adults and seniors. In addition no non-occupational health concerns were evident for nursing or pregnant females or based on gender in general.

4.0 Environmental Assessment

This assessment considered data from the USEPA's Environmental Fate and Effects Division, *Reregistration Eligibility Document Chapter* (1999); United Kingdom Ministry of Agriculture, Fisheries and Food, Pesticides Safety Division, *Evaluation of Diazinon* (1991); the USEPA's *Guidance for the Reregistration of Pesticide Products Containing Diazinon as the Active Ingredient* (1988); the World Health Organization (1998), *Environmental Health Criteria 198: Diazinon*.

In characterizing the environmental risk of diazinon, the PMRA utilized a deterministic approach that characterizes the risk by the quotient method, in which, a risk quotient (RQ) is calculated as the ratio of the estimated environmental concentration (EEC) to the toxicity endpoint of concern. RQs less than one are considered as a low risk to non-target organisms whereas, RQs greater than one indicates some degree of risk.

Initial and cumulative EECs were calculated for soil, water and wildlife food sources for the spray formulations of diazinon. A range of application rates were used to calculate the EECs along with the maximum number of applications and minimum interval between applications. The cumulative EECs were estimated by adjusting the sum of the applications for dissipation between applications using the time for 50% decline (DT_{50}) for the appropriate environmental media. Effects endpoints included both acute and chronic and were chosen from the range of toxicity tests on species available. Effects endpoints, chosen as the most sensitive species, were used as surrogates for the wide range of species that can be potentially exposed following treatment with diazinon.

4.1 Environmental Fate

Diazinon is soluble in water (60 mg a.i./L), volatile (vp = 1.4×10^{-4} mm Hg), slightly volatile from moist surfaces or water (Henry's Law constant = 9.3×10^{-7} atm m^3/mole) and has the potential to bioaccumulate (log K_{ow} = 3.3). Under most circumstances abiotic transformation does not play an important factor in the dissipation of diazinon from the environment. Hydrolysis is highly pH dependent and is an important route only under highly acidic conditions ($t_{½}$ = 0.49 d at pH 3.1, 184.5 day at pH 7 and 6.0 day at pH 10.4). At environmentally relevant pHs (pH 5–9) hydrolysis of diazinon is not important. The hydrolysis half-life of the transformation product, diazoxon, ranges from 0.02 day at pH 3.1, 28.9 d at pH 7.4, and 0.42 day at pH 10.4. Phototransformation in water is not an important route ($t_{½}$ = 84.5 day) although phototransformation of diazinon on the surface of soil may be an important route of transformation with a half-life of 20 hours. Under aerobic conditions diazinon is classified as non-persistent to slightly persistent in soil (DT_{50} = 5–80 day). The biotransformation half-life under anaerobic conditions indicates that diazinon is classified as slightly persistent (DT_{50} = 34 day). In the aquatic environment under aerobic conditions diazinon is classified as non-persistent in pond or lake water (DT_{50} = 3–15 day). The major transformation product in the biotransformation studies was identified as oxypyrimidine.

Adsorption–desorption studies indicate that diazinon has a low to moderate potential for mobility in a variety of soil types (K_{oc} = 7752–440). The field studies indicate that diazinon ranges from non-persistent to slightly persistent under field conditions (DT_{50} = 5–17 d) and did not leach to below 30 cm of soil depth. Oxypyrimidine was identified as the primary transformation product and was found to leach to 180 cm, posing therefore a concern to groundwater. Available Canadian monitoring data indicate that diazinon is readily reaching surface water within Canada (supported by the detections of diazinon in American water systems). The maximum surface water concentration detected in Canada was reported as 25 µg a.i./L with a maximum reported detection in the United States of 9.1 µg a.i./L.

4.2 Environmental Toxicology

Available toxicity studies for wildlife indicate that diazinon is highly toxic to honeybees (LD_{50} = 0.1–0.37 µg a.i./bee). On an acute oral basis diazinon is highly to very highly toxic to birds (LD_{50} = 40.8–1.1 mg a.i./kg bw) and slightly (Canada goose LC_{50} = 3912 mg a.i./kg diet) to very highly toxic (mallard duck LC_{50} = 32 mg a.i./kg diet) to birds on an acute dietary basis. Adverse effects on reproduction in birds are expected to occur at dietary concentrations greater than 16.3 mg a.i./kg diet. Laboratory studies indicate that diazinon is slightly to moderately toxic to mammals (LD_{50} = 1250–82 mg a.i./bw diet), depending on the size of the organisms, on an acute oral basis. Adverse effects on reproduction of mammals are expected to occur at dietary concentrations greater than 10 mg a.i./kg diet. Diazinon affected seedling emergence and vegetative vigour at high application rates. The EC_{25} for seedling emergence ranged from 5896 g a.i./ha (oat) to 24 770 g a.i./ha (tomato). The EC_{25} for vegetative vigour ranged from 3620 g a.i./ha (cucumber) to > 7857 g a.i./ha (tomato, carrot and lettuce).

Acute laboratory studies indicate that diazinon is classified as highly (LC_{50} = 620 µg a.i./L for crayfish) to very highly toxic (LC_{50} = 0.83 µg a.i./L for *Daphnia*) to freshwater invertebrates on an acute basis. Adverse effects to *Daphnia magna* are expected to occur following chronic exposures at concentrations > 0.32 µg a.i./L. Marine and estuarine invertebrates appear to be less sensitive to diazinon with the most sensitive species being the mysid shrimp (LC_{50} = 4.8 µg a.i./L), classified as very highly toxic. Chronic exposure to diazinon at concentrations greater than 3.2 µg a.i./L results in reduced growth and reproduction in the mysid.

On an acute basis, diazinon ranges from slightly (LC_{50} = 15 900 µg a.i./L for *Tilapia mossambica*) to very highly toxic (LC_{50} = 90 µg a.i./L for Rainbow trout) to freshwater fish. Marine and estuarine fish appear to be similarly sensitive to diazinon. Diazinon acute toxicity is classified as moderately toxic (LC_{50} = 1400 µg a.i./L for sheepshead minnow) to very highly toxic (LC_{50} = 150 µg a.i./L for striped mullet) to estuarine and marine fish. Chronic exposure of diazinon results in reproduction impairment at concentrations of 0.47 µg a.i./L or higher in sheepshead minnow.

Other recently reported sublethal effects from exposure to diazinon include diminished olfactory response resulting in a reduced response to pheromones in Atlantic salmon and reduced response to predatory events and homing response in Chinook Salmon. Reduction in olfactory response to pheromones and predatory events was detected at nominal concentrations as low as 1 µg a.i./L whereas, the homing response in the Chinook salmon was significantly reduced at nominal concentrations as low as 10 µg a.i./L. The relevance of this information depends on the concentration of diazinon that may be present in salmon streams. Water monitoring data from salmon streams is required to determine exposure and the potential risk.

An aquatic microcosm study that was reviewed, investigated the aquatic community response to exposure to diazinon. Concentration related effects were noted in all species groups studied except aquatic plants. The microcosm no observed effect concentration (NOEC) was determined as 4.3 µg a.i./L and the lowest observed effect concentration (LOEC) was determined to be 9.2 µg a.i./L. The microcosm NOEC occurs at a 70-day average concentration just above the 10^{th} percentile of the acute LC_{50} values of the species used in the study. The LOEC occurs at approximately the 18^{th} percentile of the LC_{50} values. Effects to individual organism groups were noted at all treatment levels.

4.3 Concentrations in Drinking Water

Residues of diazinon in drinking water sources in Canada were estimated using the Level 1 Leaching Estimation and Chemistry Model (LEACHM) as well as the Pesticide Root Zone Model / Exposure Analysis Modeling System (PRZM/EXAMS). The LEACHM was used to estimate the residues in groundwater whereas, the residues in reservoirs and dugouts were estimated using PRZM/EXAMS. At Level 1, the LEACHM predicted that 1.1 µg a.i./L will reach groundwater resources. For reservoirs the Level 1 estimated acute concentration ranged from 64.5 to 89.1 µg a.i./L and the chronic values ranged from 6.4 to 8.9 µg a.i./L. The acute and chronic concentrations for dugouts were determined to be 13 µg a.i./L and 0.89 µg a.i/L, respectively. As the estimated values for reservoirs exceed the DWLOC, more realistic scenarios were modelled. The resulting refined (or Level 2) acute and chronic concentrations for reservoirs range from 9.1 to 23.5 µg a.i./L and 1.4 to 3.2 µg a.i./L, respectively. In addition to the modelling, limited available Canadian and American monitoring data for diazinon were assessed. The concentration of diazinon that is predicted to reach groundwater based on the monitoring data is 0.98 µg a.i./L. The acute and chronic concentrations of diazinon in surface water determined using the monitoring data were 3.3 µg a.i./L and 0.06 µg a.i./L, respectively.

The monitoring values do not represent dugouts; therefore, they should not be used to assess the risk of diazinon in drinking water from dugouts. Confirmatory data would be required to confirm these concentrations.

4.4 Terrestrial Assessment

Studies conducted in the United States in ten apple orchards and golf courses with regard to foliar applications and in carrot fields and golf courses with regard to granular applications showed adverse effects to wildlife in the areas of application. Outcomes of these studies are detailed in the following sections.

4.4.1 Foliar Application

Diazinon is highly toxic to honeybees (*Apis mellifera*). The application rate at which 50% of the bees die was determined to be 112 g a.i./ha. The foliar spray application rates currently registered for diazinon range from 500 to 4000 g a.i./ha. Therefore, honeybees and other pollinating insects are at high risk from application of diazinon when the bees are actively foraging.

The acute oral toxicity to birds indicates that diazinon is highly toxic on an acute basis. Taking into account the diet preference of various bird species and the LD_{50}, it was determined that the mallard duck would require approximately one day consumption of 100% contaminated food in order to reach the LD_{50} determined during the laboratory studies, whereas for upland game and song birds it would take less than one day (0.03–0.76) of consumption of contaminated food sources to reach the LD_{50}. Based on the acute dietary toxicity of diazinon to birds, and using standard exposure scenarios, quotients ranged from 2.7 to 33.3 for a single foliar application of diazinon. The risk associated with this exposure is classified as moderate to high. The available dietary toxicity data was for waterfowl and upland game birds and did not allow an assessment of the effects on smaller bird species such as songbirds, which are more typical in the agricultural areas where diazinon is used.

Quotients for mammals exposed to contaminated diets resulting from foliar spray range from 0.5 to 33.3, indicating a low to high risk of acute effects. Quotients were largest for small, mouse-sized (0.033 kg) mammals and smallest for large, rabbit-sized (2 kg) mammals.

Assessment of chronic toxicity to birds resulted in quotients ranging from 3.1 to 20, indicating a moderate to high risk of chronic effects. Quotients for chronic exposure of mammals to diazinon ranged from 20.4 to 200. These quotients indicate a high to very high risk of chronic effects from exposure to diazinon.

Results from the following field studies have demonstrated that foliar application of diazinon adversely affects birds in the treatment area.

a) A study was conducted as part of ecotoxicology studies in apple orchards in Washington and Pennsylvania states. Ten orchards were selected in each state in addition to control sites. Six and five applications (nominal 3.4 kg a.i./ha per applications) were applied to each of the Pennsylvania and Washington sites, respectively. The timing of the sprays was done according to common practice in these states beginning with a dormant spray. Diazinon residues were on vegetation and other areas within the orchards following spraying.

The concentrations in earthworms collected from the treated orchards were high enough so that birds that consume earthworms ingest enough diazinon to cause adverse ecological effects. Of the 109 starling nestlings collected in the Pennsylvania orchards 40% contained detectable residues of diazinon. Similarly, of the 154 starling nestlings collected in the Washington orchards, 27% contained detectable residues in their gastrointestinal tracts. A carcass search was also conducted for potential mortalities as a result of the diazinon application. A total of 121 bird carcasses were found throughout the study. These were analyzed for diazinon with detections ranging from traces (< 0.007 µg .a.i./g) to 1.82 µg a.i./g in the gastrointestinal tracts of these birds. The limit of detection for animal tissues was 0.007 µg a.i./g. Examples of the dead birds included 35 robins, 18 cardinals, 13 grackles and 12 Canada geese.

b) In a field study conducted in a golf course in Washington, diazinon was applied at 2240 g a.i./ha. Approximately 30 minutes following the application of Diazinon AG500, a flock of American wigeon began feeding on the freshly treated fairways. As a result, 85 birds died. The investigators hazed the birds to prevent further mortality and thus, the 85 birds found is considered to be a smaller number than would have resulted if the experiment were allowed to continue. No carcass search was conducted, therefore, it is not known if all of the resulting mortality was noted. This study clearly indicates the severe hazard of diazinon to birds[2].

c) Diazinon AG500 was sprayed on urban lawns in South Carolina. Wildlife mortality searches were conducted daily, and any carcasses found were analyzed for cholinesterase activity and tissue and gastrointestinal tract residues. The birds that were impacted were species that forage on turf for insects and seeds including blackbirds, cowbirds and meadowlarks (family Icteridae) as well as starlings (family Sturnidae). The enzyme and chemical analysis of carcasses indicated that both adult and nestling birds were exposed to diazinon[2].

4.4.2 Granular Applications

In addition to foliar applications, an assessment of granular applications was also conducted for terrestrial ecosystems. It was concluded that granular diazinon presents a very high risk for acute effects to small birds such as the house sparrow and red-winged blackbird as it would require the consumption of as few as five granules to reach the LD_{50}. Risk quotients for small birds were determined as ranging between 94 to 803, indicating that these small birds are at high to very high risk of acute effects. For larger birds such as the mallard and Canada goose, the risk is low to moderate with quotients ranging from 0.7 to 8.7. The number of granules that would need to be consumed in order to reach the LD_{50} for the mallard duck is 464 and for the Canada goose, 1228. Granular diazinon applications present a moderate to high risk for smaller, mouse-sized mammals with quotients ranging from 6.3 to 30.3 and a lower risk to larger mammals (rats, rabbit and guinea pig size) with quotients ranging from 0.1 to 0.8.

Results from the following field studies have demonstrated that granular application of diazinon adversely affects birds and mammals in the treatment area.

a) Diazinon 14G (granular) was added to carrot fields in Texas at an application rate of 4483.4 g a.i./ha and worked into the soil to a depth of 5 to 20 cm prior to planting. Results of chemical analyses of avian carcasses showed concentrations of < 0.05–2.0 µg a.i./ha of diazinon. There were four bird carcasses found during the study.

b) Diazinon 14G (granular) was applied to carrot fields in Wisconsin and worked into the soil to a depth of 5–20 cm prior to planting. A dead mouse was recovered from the treatment field that contained detectable diazinon residues in its gastrointestinal tract.

c) In addition to foliar application with Diazinon AG500, as described previously, the granular formulations of Diazinon 2G and 5G were applied with a spreader on urban lawns in South Carolina. Wildlife mortality searches were conducted daily and any carcasses found were analyzed for cholinesterase activity and tissue and gastrointestinal tract residues. The birds that were impacted were species that forage on turf for insects and seeds including blackbirds, cowbirds and meadowlarks (family Icteridae) and starlings (family Sturnidae). The enzyme and chemical analysis of carcasses indicated that both adult and nestling birds were exposed to diazinon. Results demonstrated that mortality was significantly elevated on the granular treated sites compared to the sites sprayed with Diazinon AG500[2].

2 Diazinon use on turf (including lawns, golf courses and sod farms) is being discontinued as a result of re-evaluation (REV2000-07 and REV2000-08, *Update on Re-evaluation of Diazinon in Canada*).

4.4.3 Seed Treatment

An assessment of seed treatment applications was conducted for terrestrial systems. For small birds (i.e., red-winged black bird, house sparrow, etc.), the number of treated seeds that these birds need to consume in order to reach the LD_{50} is very small (1–20 seeds). Quotients calculated for the consumption of treated seed (assuming 100% of the seeds consumed are treated with diazinon) range from 6 to 4292, indicating a moderate to extremely high risk to birds. When the proportion of seeds consumed by the mallard duck and bobwhite quail is considered (rather than 100%) moderate to extremely high risk was identified. The number of seeds a mouse would have to consume to reach the LD_{50} range from 420 to 7180 depending on the type of seed treated.

In summary, the preliminary terrestrial assessment concluded that for birds, mammals and beneficial insects (i.e., bees), risks from agricultural uses of diazinon ranged from low to extremely high for both acute and chronic effects. The preliminary assessment has shown that the risk of diazinon from foliar and granular applications and from seed treatments to birds is of concern. The assessment only considers risk from oral exposure; however, there would also be risk from dermal and inhalation exposure.

4.5 Aquatic Assessment

In the preliminary aquatic assessment, quotients were calculated for aquatic invertebrates and fish. Estimated environmental concentrations were determined using a simplistic model to determine concentrations for the different rates and numbers of applications. For freshwater fish, quotients for single application ranged from 20 to 93 for acute effects and indicate a high risk. The calculated quotients of 287 to 2270 for chronic effects indicate a very high to extremely high risk. Similar values were obtained for estuarine species. For aquatic invertebrates, single application quotients ranged from 327 to 1490 for acute effects, indicating a very high to extremely high risk. Chronic exposure resulted in quotients ranging from 18 400 to 47 800 for chronic effects, indicating an extremely high risk for aquatic organisms.

For agricultural uses, available monitoring data was limited. A monitoring program in the Niagara fruit belt detected diazinon in 56 of 76 surface water samples with a maximum concentration of 25 µg a.i./L, during the period of diazinon application. Diazinon was detected at a maximum concentration of 9.05 µg a.i./L in the United States Geological Survey National Water Quality Assessment database. Using the 25 µg a.i./L, resulting risk quotients indicate a low risk (RQ = 0.28) for acute effects to freshwater fish and a high risk (RQ = 45.5) of chronic effects for freshwater fish. Freshwater invertebrates quotients determined using monitoring data indicate a high risk (RQ = 45.5) of acute effects and a very high risk (RQ = 142.9) of chronic effects. Recent literature has suggested that there is a potential of sublethal effects from diazinon to salmon at environmentally relevant concentrations. It was noted that the fishes homing behaviour and response to hormones were significantly reduced at 10 µg a.i./L and 1 µg a.i./L, respectively.

4.6 Environmental Assessment Conclusions

Based on this preliminary assessment, diazinon is likely to be slightly persistent in the environment and to impact water resources including surface and groundwater. This is supported by the Canadian modelling and monitoring data along with the USEPA water resource assessment where diazinon was detected in close to 40% of the surface water samples analyzed. In addition, diazinon was identified as having the ability to be volatile, which is supported by the detection of diazinon in rain samples taken from British Columbia. The USEPA identified diazinon as the most common organophosphate pesticide detected in air, rain and fog.

a) **Diazinon is highly acutely toxic to honeybees** and, therefore, is likely to have an impact on honeybees that are present during or following the application of diazinon.

b) **Risks to birds from foliar uses of diazinon are of concern.**
There is a high chance that wild birds will be exposed to diazinon because of their ubiquitous nature and feeding habits. Birds feed on vegetation, insects and seeds that could potentially all be contaminated with diazinon. Diazinon has a high acute toxicity to birds and there is no apparent relationship between the formulation and the risk to birds associated with exposure. In this assessment, it was determined that birds smaller than the mallard duck will have to feed on a contaminated diet for less than one day in order to reach the LD_{50} estimated from the laboratory study. For acute exposure, risk quotients calculated following one application indicate that birds are at moderate to high risk from the consumption of food contaminated with diazinon. The half-life of diazinon in the environment ranges between 5 days on plants to 80 days on soil, thus, residues remain on food sources long enough for birds to obtain an acute dose over an extended period of time. The assessment addressed exposure through oral means only, but wild birds can also be exposed through dermal and inhalation exposures. Currently, the PMRA is exploring acceptable methods to assess the potential risk associated with inhalation and dermal exposure to birds.

c) **Risks to birds from granular formulations of diazinon are of concern.**
In addition to exposure through residues remaining on food sources following the application of diazinon as a foliar spray, birds can be exposed to diazinon in the granular formulation. Many bird species consume grit to aid in the digestion of food. Birds are at risk of poisoning from consumption of the granular form of diazinon either intentionally as grit, inadvertently by mistaking as food or attached to food sources. Small birds are at particular risk from this application form as it would be quite easy for them to consume enough granules to result in a lethal dose. Consumption of five granules of diazinon by a red-winged blackbird would result in an acute dose equivalent to the LD_{50} determined in the laboratory study.

The registrant has chosen to only support in-furrow applications of diazinon; therefore, most granules will be buried in the seed furrows. Despite this measure, enough granules will remain on the surface to result in moderate to very high risk for birds.

d) **Risks to birds from seeds treated with diazinon are of concern.**
Consumption of seeds treated with diazinon use poses a very high risk to birds. The risk assessment shows that the consumption of one seed treated with diazinon could result in death in some smaller bird species (e.g., red-winged blackbird). During the planting of seeds, some seeds may remain on the surface as a result of insufficient burial or from spillage when the machinery is turned or filled. In addition, some birds are capable of probing into the soil to extract the planted seeds. Granivorous mammals are also at high risk of adverse ecological effects from exposure to diazinon treated seeds.

Despite the lack of a comprehensive adverse effect incident reporting system in Canada, as is present in the United States, 14 mortality incidents resulting from diazinon exposure have been investigated. All of the mortality incidents that have been reported in Canada involved waterfowl (Canada goose, mallard duck and wigeon) following application of diazinon on domestic lawns, golf courses and in fruit orchards. Details on incident reports from the United States were obtained from the USEPA Ecological Incident Information System (EIIS) covering the period 1950 to 2000. There were 133 mortality incident reports related to diazinon occurring between 1950 and 1989 entered in the USEPA EIIS. Since 1990, there have been 221 mortality incidents related to diazinon entered into the USEPA EIIS. Of these, 96 were classified as highly probable, 77 as probable, 32 as possible, and 16 were as a result of intentional misuse. The number of individuals involved in each of these incidents range from one to hundreds in the larger kills. The larger kills usually involve waterfowl mostly because of their preference for travelling in large numbers. The incident reports from the United States included 174 on birds including waterfowl, 8 on fish, 2 on bees and 30 on plants (grass, ornamentals, vegetables).

Given the number of incident reports of avian mortalities, in both Canada and the United States, it is evident that the exposure of birds to diazinon (regardless of formulation) frequently causes mortality. It has been suggested that the reported incidents related to diazinon may only represent a small portion of the actual mortality caused by exposure to diazinon. Intoxicated birds could move away from the site to die, thus never being detected. Other issues that could result in a reduced number of reported incidents are scavengers quickly removing carcasses from the site, agricultural fields that are not usually being searched for mortalities and individuals not knowing how to report kills that are discovered.

e) **There is high acute and chronic risk from foliar applications of diazinon to small (mouse-sized) mammals. Risk to small mammals from granular applications is high and from seed treatments is low.**

Despite the moderate toxicity of diazinon to mammals the acute risk of exposure is high to small mouse-sized mammals as a result of the high application rates of non-granular products. Although the number of days to reach the LD_{50} range from between less than 1 day to 18 days, the number of days to reach the no observed effect level (NOEL) for mammals is less than one for the majority of the application rates considered. Even though the chance of mortality of mammals as a result of label use of diazinon is low, subacute effects may occur.

The risk to mammals as a result of granular applications is low except for small mouse-sized mammals for which it is high. Mammals by nature do not naturally consume grit-like material. Therefore, consumption of granules is likely to only occur as a result of inadvertent consumption of granules stuck to food. Consequently, it is perceived that the actual risk of mammals to granular applications is less than the calculated risk. Mammals can be exposed to granular diazinon through dermal absorption, inhalation or through secondary poisoning which the current risk assessment methods do not consider.

f) **The risk from foliar applications of diazinon to aquatic invertebrates and fish varies from very high to extremely high.**

Aquatic organisms can be exposed to diazinon from overspray and drift of non-granular formulations and run-off from the application sites where the wettable powder, granular, seed treatment and EC formulations were used. The risk of acute effects in freshwater and marine fish and invertebrates based on overspray and drift scenarios is very high to extremely high. The water concentrations determined from the monitoring data indicate that the risk of acute effects from exposure to these concentrations range from low to moderate for freshwater fish and from moderate to high for freshwater invertebrates on an acute basis. Because multiple applications of diazinon may occur, there is a potential for repeated exposure of aquatic organisms. The calculated risk quotients for chronic exposure of freshwater and marine invertebrates, from overspray scenarios, indicate an extremely high risk whereas, the chronic risk quotients calculated for fish indicate a very high to extremely high risk. Chronic exposure to the concentration determined through monitoring pose a moderate to high risk to freshwater fish and a high to very high risk to freshwater invertebrates.

5.0 Preliminary Value Assessment

5.1 Evaluation Method

5.1.1 Agricultural Uses of Diazinon

The importance of diazinon end-use products for managing specific pests on specific crops in Canada was evaluated based on the availability of registered pesticides that are potential alternatives. The use of diazinon in agriculture in recent years in Canada was assessed by surveying crop production specialists, provincial agricultural officials, growers' associations and other stakeholders about diazinon use.

Uses of diazinon were classified into two value classes as follows:

Key Uses
Some uses of diazinon were considered "key uses" because they matched one or more of the following criteria:

- a User Requested Minor Use Label Expansion (URMULE) was granted in the last two years and there are no registered alternatives, OR
- there was reported use of > 5% on the given crop and there are no registered alternatives, OR
- there was reported use of at least 10% on the given crop and there are registered alternatives; however, diazinon is the primary active ingredient for control of the pest, OR
- maintaining registration was considered key for resistance management and/or plays an important role in integrated pest management programs, OR
- the site of use is of great importance to the economy of Canada.

Non-key Uses
Uses of diazinon were considered to be "non-key uses" either because they did not match the "key use" criteria, or because the information available to the PMRA indicated little or no use in Canada.

5.1.2 Non-agricultural Uses of Diazinon

Information regarding the extent of non-agricultural use of diazinon was obtained from consultation with provincial governments and crop protection specialists. The following discussion is based on the information available to the PMRA. These uses were also categorized into "key uses" and "non-key uses" based on the above criteria.

5.2 Preliminary Evaluation Results

5.2.1 Agricultural Sites with Key Uses of Diazinon

The following uses were identified as being "key uses" of diazinon.

Apple
Registered alternative active ingredients to control mullein bug are azinphos-methyl, methomyl, imidacloprid, cypermethrin, deltamethrin and permethrin. Diazinon is the preferred active ingredient to control mullein bug on apples because azinphos-methyl re-evaluation is complete, and its use on apples is being phased out (Re-evaluation Decision Document, RRD2004-05, *Azinphos-methyl*). The synthetic pyrethroids promote outbreaks of secondary pests. Methomyl is not registered for use on early McIntosh, Summer Glo or Wealthy apple varieties. Additionally, methomyl is toxic to predacious mites and arthropods and is also currently under re-evaluation. Imidacloprid has been registered recently for control of mullein bug on apple. However, diazinon will be important for rotation with imidacloprid for resistance management.

Bean (edible, green (snap), dry) and soybean
The control of seedcorn maggot on beans is a key use of diazinon because there are no registered alternative active ingredients for the control of this insect on these crops.

Beet
The control of dipterous leafminer on beets is a key use of diazinon. Two other organophosphates, malathion and trichlorfon, are registered alternatives and are also under re-evaluation. Diazinon is preferred over the alternatives due to its perceived greater efficacy according to communication with extension representatives.

Blackberry
The control of fruitworms on blackberries is a key use of diazinon. Malathion is the only alternative active ingredient available. However, diazinon is the preferred active ingredient due to its perceived greater efficacy according to communication with extension representatives.

Blackberry, raspberry
The control of raspberry crown borer on blackberries and raspberries was identified as a key use of diazinon. Azinphos-methyl is the only registered alternative active ingredient. Azinphos-methyl use on blackberries and raspberries is being phased out. Diazinon is the preferred active ingredient for preharvest applications. As diazinon is not registered for postharvest applications, azinphos-methyl is preferred for postharvest applications to control raspberry crown borer.

Carrot (fresh, processing)
To control carrot rust fly, diazinon is applied as a foliar application with sufficient water to ensure complete coverage of the leaves, crown and surrounding soil. Cypermethrin is the only registered alternative active ingredient for control of adult carrot rust fly on carrots. Diazinon is the preferred active ingredient as diazinon is toxic to the eggs, larvae and adults of the carrot rust fly, whereas cypermethrin is toxic only to the adults.

Granular diazinon incorporated into the soil is used to control carrot rust fly maggots. There are no registered alternatives for the control of carrot rust fly maggots on carrots.

Corn (sweet)
The control of seedcorn maggot on corn (sweet) is a key use of diazinon. Terbufos and tefluthrin are the alternative active ingredients. However, the use of terbufos on corn is being discontinued as a result of re-evaluation (RRD2004-04). Diazinon is important for rotation with tefluthrin for resistance management.

Parsnips
Diazinon is used as a foliar spray to control carrot rust fly and as a granular application to control carrot rust fly maggots. There are no registered alternatives for the control of carrot rust fly or maggots on parsnips.

Pea (green)
The control of seedcorn maggot on peas (green) is a key use of diazinon. There are no registered alternatives for this pest on peas.

Radish
Diazinon use is key for the control of aphids, cabbage maggot and seedcorn maggot on radish. Malathion is a registered alternative to control aphids on radish and chlorpyrifos is a registered alternative for control of cabbage maggot on radish. However, diazinon has perceived greater efficacy according to communication with extension representatives than either alternative and is the preferred active ingredient. There are no registered alternatives to control seedcorn maggot on radish.

Raspberry
The control of fruitworms and raspberry sawfly on raspberries are key uses of diazinon. Malathion is an alternative active ingredient registered for the control of fruitworms. However, diazinon is preferred over malathion for the control of fruitworms due to perceived greater efficacy according to communication with extension representatives. There are no registered alternative active ingredients for raspberry sawfly on raspberries.

Spinach
The control of dipterous leafminer on spinach is a key use of diazinon. Malathion is the only registered alternative. Due to its perceived greater efficacy according to extension representatives, diazinon is preferred over malathion.

Strawberry
Diazinon use is key for the control of omnivorous leaftier on strawberries. There are no registered alternative active ingredients to control this pest on strawberries.

Diazinon use is also key for the control of strawberry leafroller on strawberries. Registered alternatives are carbaryl, azinphos-methyl and malathion. Diazinon was preferred to malathion due to perceived greater efficacy according to communication with extension representatives. Azinphos-methyl is being phased out for use on strawberries. Carbaryl is currently under re-evaluation.

5.2.2 Agricultural Sites with Non-key Uses of Diazinon

The following agricultural sites were identified as having no "key uses" of diazinon: apricot, broccoli, Brussels sprouts, cabbage, cantaloupe, cattle (beef and dairy: lactating and non-lactating), cauliflower, cherry, collards, corn, cranberry, cucumber, currants, gooseberry, grape, green forage and hay from crop margins, hops, kale, kohlrabi, lettuce, loganberry, melon, onion (bulb and green), parsley, pastures (grass and clover), peach, pear, pepper (greenhouse), plum, potato, prune, rangeland, rutabaga, salsify, squash, Swiss chard, tobacco (greenhouse seedlings, field), tomato, turnip and watermelon.

5.2.3 Non-agricultural Sites with Key Uses of Diazinon

Forest and woodlot
Diazinon is a key use in the control of Balsam gall midge in forests and woodlots. Diazinon is the only active ingredient registered to control Balsam gall midge in Christmas tree plantations. Forestry use information (2000–2002) reported the need for and use of diazinon in plantations in Manitoba, Quebec, New Brunswick and Nova Scotia. Minimal use of diazinon has been reported in British Columbia, Saskatchewan and Ontario. No data are available for Alberta and Newfoundland.

5.2.4 Non-agricultural Sites with Non-key Uses of Diazinon

Greenhouse non-food crop
Alternative active ingredients are available for greenhouse-grown ornamental plants, shrubs and trees.

Non-crop areas
Alternative active ingredients are registered for grasshopper control on non-crop lands such as wastelands, roadsides, ditch banks, fence rows and barrier strips.

6.0 Other Assessment Considerations

6.1 Toxic Substances Management Policy

During the review of diazinon, the PMRA has taken into account the federal Toxic Substances Management Policy[3] and has followed its Regulatory Directive DIR99-03[4]. In this review the following was considered:

- Diazinon is not bioaccumulative. Studies have shown that the bioconcentration factor (BCF) is 542, which is below the Toxic Substances Management Policy (TSMP) Track 1 cut-off criterion of BCF $\geq$ 5000; and the log octanol-water partition coefficient (log K_{ow}) is 3.3, which is below the TSMP Track 1 cut-off criterion of log $K_{ow} \geq 5.0$.

- Diazinon does not meet the criteria for persistence as its half-life values in water (up to 15 days) and soil (up to 80 days) are below the TSMP Track 1 cut-off criteria for water ($\geq$ 182 days) and soil ($\geq$ 182 days). No data were provided for persistence of diazinon in air.

- The toxicity of diazinon is discussed in Sections 3 and 4.2.

- The major transformation product oxypyrimidine is not likely to meet the TSMP Track 1 cut-off criterion for bioaccumulation. Although, no data were available on the bioaccumulation potential, oxypyrimidine is not expected to bioaccumulate based on its chemical structure. Although, oxypyrimidine appears to be slightly more persistent in soil than diazinon (42% of applied diazinon after 90 days), it decreased to 2% at 180 days post-treatment. This indicates that the half-life will be less than the Track 1 criterion cut-off for persistence in soil ($\geq$ 182 days). No data were available on the persistence of oxypyrimidine in water, sediment and air or on its toxicity.

- There was not enough information to fully assess the major transformation product diazoxon according to TSMP. It has a half-life in water of up to 28 days that does not meet the persistence criterion for water ($\geq$ 182 days). No data were available on its persistence in soil and air or on its bioaccumulation potential.

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3 The federal Toxic Substances Management Policy is available through Environment Canada's website at www.ec.gc.ca/toxics.

4 Regulatory Directive DIR99-03, *The Pest Management Regulatory Agency's Strategy for Implementing the Toxic Substances Management Policy*, is available through the Pest Management Information Service. Phone: 1 800 267-6315 within Canada or (613) 736-3799 outside Canada (long distance charges apply); Fax: (613) 736-3758; E-mail: pmra_infoserv@hc-sc.gc.ca; or through our website at www.pmra-arla.gc.ca.

It has been determined that diazinon does not meet TSMP Track 1 criteria because it does not meet the criteria for bioaccumulation (log $K_{ow} \geq 5$). Data are not available to determine the TSMP status of the transformation products oxypyrimidine and diazoxon.

6.2 Formulant Issues

Formulant issues are being addressed through implementation of the PMRA's Formulants Program, as published in Regulatory Directive DIR2004-01, on 9 January 2004.

7.0 Summary of the Preliminary Risk Assessment and Consultation

The registrant of diazinon technical grade active ingredient in Canada and primary data provider, Makhteshim-Agan of North America Inc., is no longer supporting continuing registration of the following agricultural uses of diazinon:

Greenhouse	tomato, pepper and ornamentals
Seed treatments	onion, radish, sugarbeet and potato seed pieces
Feed crops	clover, grass, pastures, rangeland and green forage or hay from crop margins
Non-crop areas	wastelands, roadsides, ditch banks, fence rows and barrier strips
Structural	farm buildings, food processing plants, poultry houses
Certain food crops	field pepper, salsify, potato, tobacco (field), plums and prunes

These uses are not included in the present risk assessment and will be proposed for discontinuation.

Results of the preliminary risk assessment of the uses indicate that, for certain uses of diazinon, potential risks to human health and the environment are acceptable. These uses include the following:

- ear tag use on cattle and soil drench application on blackberry;
- loganberry;
- raspberry;
- onion;
- rutabaga;
- turnip; and
- cole crops (broccoli, cabbage, Brussels sprouts, cauliflower).

Mitigation measures will be finalized and proposed in a Proposed Acceptability for Continuing Registration (PACR) document.

The preliminary risk assessment conducted with the information available to the PMRA at this time indicates a level of concern for workers and the environment for the remaining uses of diazinon. Additional use pattern 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 the public and 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 risk assessments as necessary and propose mitigation measures in a future PACR document.

7.1 Information Needed to Refine the Preliminary Risk and Value Assessments for Diazinon

1. Reports of adverse environmental effects and bird kills.

2. Limitations to the registered alternatives to diazinon, including, but not limited to:
   a) pest biology that would affect efficacy of the alternatives
   b) pest resistance
   c) resistance management alternatives
   d) compatibility with integrated pest management

3. Hectarage of crop grown in each province and the total hectarage grown in Canada

4. Pests (including those that may be secondary targets) typically controlled with diazinon

5 Percentage of crop treated with diazinon to control a given pest

6. Typical area treated per day with diazinon (for both custom applicators and farmers)

7. Integrated pesticide practices used
   a) Is diazinon being used as a border spray?
   b) Is it used in integrated pest management programs?

8. Pesticide application equipment
   a) typical application equipment used (sprayer, airblast, etc.)
   b) new spray technologies used (cowls, sprayer types, etc.)
   c) use of automated or remotely operated equipment
   d) practicality of the use of shrouds on sprayers

9. Pesticide application
    a) typical spray volume used (existing and new technologies)
    b) typical rate of application (and maximum rate of application used)
    c) number of applications (if fewer than the numbers currently used in the assessments)

10. Typical interval between applications (and the minimum interval between applications).

11. Details on the typical REI and postapplication activities.

12. Details on the practicality of wearing PPE (i.e., gloves) for activities conducted during the REI.

Table 1 Identified Crop Uses for Which Further Use Information Is Required to Validate the Risk Assessment and/or Assess Mitigation Measures

Note 1: Any information not described herein that could be used to refine the preliminary risk assessment should also be submitted.

Note 2: All diazinon uses except soil drench applications were identified as posing risk to the environment.

Crop[1] (registered formulation types) and Registered Application Methods[2]	**Pest(s)[3, 4]**	**Occupational Exposure: Target MOE (100) or ARI (1.0) Was Not Met**	**Use Information Required by the PMRA[7]**
USC 4 Forests and Woodlots			
Christmas tree plantations	**Balsam gall midge** Balsam twig aphid	Airblast	1, 3, 5–7, 9, 11, 12
USC 5 Greenhouse Food Crops			
Tobacco (seedlings) (WP) Foliar spray and soil drench	Ants	Handwand	3, 5, 6, 8a,b,c, 9b,c, 10, 11, 12
Mushroom houses (EC, WP, SN) Spray and paint on	Phorid flies Sciarid flies	Handwand	2, 3, 5, 6, 8a,b,c, 9, 11, 12

Crop[1] (registered formulation types) and Registered Application Methods[2]	Pest(s)[3, 4]	Occupational Exposure: Target MOE (100) or ARI (1.0) Was Not Met	Use Information Required by the PMRA[7]
USC 14 Terrestrial Food Crops			
Apple (EC, WP, SN) Foliar spray	**Mullein bug** Mites Blister mite Mealybug Scale insects (crawlers) Stink bugs	Airblast	All (except 8c)
Apricot (EC, WP, SN) Foliar spray	Aphid Clover mite Twospotted spider mite	Airblast	All (except 8c, d)
Bean (EC, WP, SN) Foliar spray	Aphid Black bean aphid Dipterous leafminer Leafhopper Mite		1–7, 9, 11, 12
Beet (EC, WP, SN) Foliar spray	Aphids **Dipterous leafminer**		1–3, 5, 6, 9, 11, 12
Blackberry (EC, WP, SN) Foliar spray	Aphid **Fruitworm** Leafhoppers Raspberry sawfly Thrips **Raspberry crown borer**[6]	Airblast	All (except 8c)
Broccoli (EC, WP, SN) Foliar spray	Aphids Diamondback moth Imported cabbageworm		1–7, 9–12
Cabbage (EC, WP, SN) Foliar spray	Aphids Diamondback moth Imported cabbageworm		1–7, 9–12
Cauliflower (EC, WP, SN) Foliar spray	Aphids Diamondback moth Imported cabbageworm		1–7, 9–12
Carrot (EC, WP, SN) Foliar spray	Aphids **Carrot rust fly**		1–6, 7b, 8a,b,d, 9–12

Crop[1] (registered formulation types) and Registered Application Methods[2]	Pest(s)[3, 4]	Occupational Exposure: Target MOE (100) or ARI (1.0) Was Not Met	Use Information Required by the PMRA[7]
Cherry (EC, WP, SN) Foliar spray	Black cherry aphid Cherry fruit fly		All (except 8c)
Collard (EC, SN) Foliar spray	Aphid Diamondback moth Imported cabbageworm		1–6, 9, 12
Cranberry (EC, WP, SN) Foliar spray	Cranberry fruitworm Blackheaded fireworm *Sparganothis sulfureana* (*Sparganothis* fruitworm)	Groundboom	1, 6, 7b, 8b,d, 9–12
Cucumber (EC, WP, SN) Foliar spray	Aphid Cucumber beetle Spider mite Thrips	Groundboom (EC)	All (except 8c)
Currant (EC, WP, SN) Foliar spray	Aphid Lecanium scale (crawlers) Sawfly	Airblast	1–7, 8a,b,d, 9, 11, 12
Gooseberry (EC, WP, SN) Foliar spray	Aphid Lecanium scale (crawlers) Sawfly	Airblast	1–7, 8a,b,d, 9, 11, 12
Grape (EC, WP, SN) Foliar spray	Grape berry moth Grape leaffolder Leafhopper Mealybug	Airblast	All (except 8c)
Hop (EC, WP, SN) Foliar spray	Aphid Mite	Groundboom (EC) Airblast	All (except 8c)
Kale (EC, WP, SN) Foliar spray	Aphids Diamondback moth Imported cabbageworm		1–6, 9–12
Kohlrabi (EC, WP, SN) Foliar spray	Aphids Diamondback moth Imported cabbageworm		1–6, 9–12

Crop[1] (registered formulation types) and Registered Application Methods[2]	Pest(s)[3, 4]	Occupational Exposure: Target MOE (100) or ARI (1.0) Was Not Met	Use Information Required by the PMRA[7]
Lettuce (EC, WP, SN) Foliar spray	Aphid Dipterous leafminer		1–6, 9–12
Loganberry (EC, WP, SN) Foliar spray	Aphid Fruitworm Leafhoppers Raspberry sawfly Thrips	Airblast	All (except 8c)
Melon (EC, WP, SN) Foliar spray	Aphid Cucumber beetle Thrips Leafhoppers Mites	Groundboom (EC and SN)	All (except 8c)
Onion (EC, WP, SN) Foliar spray	Onion maggot (adult)		1–6, 7b, 8a,b,d, 9–12
Parsley (EC, WP, SN) Foliar spray	Aphid Diamondback moth Imported cabbageworm		1–7, 9–12
Parsnip (EC, WP, SN) Foliar spray	Aphid Dipterous leafminer Flea beetle **Carrot rust fly**		1–7, 9–12
Peach (EC, WP, SN) Foliar spray	Aphid Clover mite Twospotted spider mite	Airblast	All (except 8c, d)
Pear (EC, WP, SN) Foliar spray	Mites Blister mite Mealybug Pear leafminer Scale insects (crawlers) Stink bug	Airblast	All (except 8c, d)
Raspberry (EC, WP, SN) Foliar spray	Aphid **Fruitworm** Leafhoppers **Raspberry sawfly** Thrips **Raspberry crown borer**[6]	Airblast	All (except 8c)

Crop[1] (registered formulation types) and Registered Application Methods[2]	**Pest(s)[3, 4]**	**Occupational Exposure: Target MOE (100) or ARI (1.0) Was Not Met**	**Use Information Required by the PMRA[7]**
Radish (EC, WP) Foliar spray	**Aphid** Dipterous leafminer Flea beetle		All (except 8c)
Rutabaga (EC, WP, SN) Foliar spray	Aphid Dipterous leafminer Flea beetle		1–6, 9, 11, 12
(EC, WP, SN) Foliar/soil spray	Root maggots (adult)		1–6, 9, 11, 12
Spinach (EC, WP, SN) Foliar spray	Aphid **Dipterous leafminer**		1–6, 9–12
Squash (EC, WP, SN) Foliar spray	Aphid Cucumber beetle Leafhopper Thrips Mite[5]	Groundboom (EC and SN)	All (except 8c)
Strawberry (EC, WP, SN) Foliar spray	Aphid **Strawberry leafroller** Spittlebug **Omnivorous leaftier**[6]		1–6, 7b, 9, 11, 12
Swiss chard (EC, WP, SN) Foliar spray	Aphid Diamondback moth Imported cabbageworm		1–6, 9–12
Turnip (EC, WP, SN) Foliar spray	Aphid Dipterous leafminer Flea beetle		1–6, 9, 12
Tomato (EC, WP, SN) Foliar spray	Aphids Dipterous leafminer Vinegar flies (*Drosophila* sp.)	Groundboom (EC and SN)	1–6, 7a, 8a,b, 9–12

Crop[1] (registered formulation types) and Registered Application Methods[2]	Pest(s)[3, 4]	Occupational Exposure: Target MOE (100) or ARI (1.0) Was Not Met	Use Information Required by the PMRA[7]
USC 27 Ornamentals Outdoor			
Shrubs, trees (aralia, arborvitae, azalea, birch, boxwood, euonymus, ivy, juniper, oak, pines, roses, taxus) (EC, WP, SN) Foliar spray	Aralia: privet mite Arborvitae: bagworms, leafminers, scale insects (crawlers) Azalea: leafminer, privet mite Birch: leafminer Boxwood: leafminer Euonymus: scale insects Ivy: privet mite Juniper: bagworms, European pine shoot moth, scale insects Oak: leafminer Pine: European pine shoot moth, scale insects	High-pressure handwand Groundboom (EC) Airblast	All (except 8c)
Shrubs, trees (continued)	Rose: aphid, rose chafer Taxus (yew): European pine shoot moth, scale insects		All (except 8c)
Flowers (carnation, chrysanthemum) (EC, WP, SN) Foliar spray	Carnation: aphids, caterpillars, leafminers, spider mites, thrips Chrysanthemum: aphids, caterpillars, leafminers, spider mites, thrips	Low-pressure handwand High-pressure handwand	All (except 8c)
Holly (EC, WP, SN) Foliar spray	Aphids, budmoths, leafminers, coccus scale, pulvinaria scale	High-pressure handwand Groundboom Airblast	All (except 8c)

[1] The following crops not supported by the registrant are not included in this table: feed crops, ornamentals (greenhouse), pepper (greenhouse and field), plum, potato, prune, salsify, tobacco (field grown) and tomato (greenhouse).

[2] Excluding granular applications and seed treatments.

[3] Pests identified as "key" in the value assessment are presented in **bold** text.

[4] Pests listed are supported by the registrant or included in the assessment at the request of the registrant in response to the growers' interest.

[5] Registered use for EC and SN formulations only.

[6] Pest was not supported by the registrant or requested to be assessed by the grower groups but was assessed as a result of the "key" status for value.

[7] Numbers refer to list outlined in Section 7.1.

List of Abbreviations

ADI	acceptable daily intake
a.i.	active ingredient
ARfD	acute reference dose
ARI	aggregate risk index
ARTF	Agricultural Re-entry Task Force
atm	atmospheres
bw	body weight
CAS	Chemical Abstracts Service
CEPA	*Canadian Environmental Protection Act*
CSFII	Continuing Survey of Food Intakes by Individuals
cm	centimetre(s)
d	day(s)
DEEM®	Dietary Exposure Evaluation Model
DFR	dislodgeable foliar residue
DNA	deoxyribonucleic acid
DT_{50}	dissipation time to 50%
DWLOC	drinking water levels of comparison
EC	emulsifiable concentrate
EC_{25}	effect concentration at 25%
EEC	expected environmental concentration
EXAMS	Exposure Analysis Modeling System
g	gram(s)
h	hour(s)
H	Henry’s constant
ha	hectare
Hg	mercury
ILSI	International Life Sciences Institute
kg	kilogram(s)
K_{oc}	organic carbon partition coefficient
L	litre
LC_{50}	lethal concentration to 50%
LD_{50}	lethal dose to 50%
LEACHM	Leaching Estimated and Chemistry Model
LOAEL	lowest observed adverse effect level [mg a.i./kg bw]
LOEC	lowest observed effect concentration [mg a.i./kg diet or mg a.i./L]
log K_{ow}	log Octanol-water partition coefficient
m	metre
m^3	metre(s) cubed
min	minute(s)
mg	milligram
mm	millimetre(s)
mm Hg	millimetre mercury
MOE	margin of exposure
NOAEL	no observed adverse effect level

NOEC	no observed effect concentration
NOEL	no observed effect level
NTE	neurotoxic esterase
PACR	Proposed Acceptability Continuing Registration
PDI	potential daily intake
pH	-log10 hydrogen ion concentration
PHED	Pesticide Handlers Exposure Database
pKa	-log10 acid dissociation constant
PMRA	Pest Management Regulatory Agency
PPE	personal protective equipment
ppm	parts per million
PRZ	Pesticide Root Zone Model
RED	Registration Eligibility Decision
REI	restricted entry interval
ROC	residue(s) of concern
RQ	risk quotient
SN	solution
$t_{½}$	half-life
TC	transfer coefficient
TSMP	Toxic Substances Management Policy
URMULE	User Requested Minor Use Label Expansion
USC	use-site category
USEPA	United States Environmental Protection Agency
vp	vapour pressure
WP	wettable powder

Appendix I Toxicology Endpoints for Risk Assessment for Diazinon

EXPOSURE SCENARIO	DOSE (mg./kg bw/day)	ENDPOINT	STUDY	UF/SF or MOE[a]
Acute dietary	NOAEL = 0.25	Erythrocyte cholinesterase inhibition	Acute neurotoxicity—rat	100
	ARfD = 0.0025 mg/kg bw			
Chronic dietary	NOAEL = 0.02	Brain cholinesterase inhibition	52-week dietary toxicity—dog	100
	ADI = 0.0002 mg/kg bw/day			
Short-term[b] dermal	Dermal NOAEL = 1.0	Brain cholinesterase inhibition	21-day dermal toxicity—rabbit	100
Intermediate[c]- and long[d] -term dermal	Dermal NOAEL = 1.0	Brain cholinesterase inhibition	21-day dermal toxicity—rabbit	300
Short[b]-, intermediate[c] and long[d]-term inhalation	Inhalation NOAEL = 0.026	Brain and erythrocyte cholinesterase inhibition	21-day inhalation toxicity—rat	100

[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 > 30 days

[d] Duration of exposure is > 6 months

Appendix II Summary of Occupational Risk Estimates for Diazinon

Crop	Scenario/ Formulation	Formulation	Rate kg a.i. /ha	Area Treated ha/day	Maximum No. of Applications/ Season	PPE + System[1]	Margins of Exposure[6]		
							Combined MOE[2] or ARI[3] for M/L/A	REI (days)	Dermal MOE at Re-entry Day[2]
USC 4: Forests and Woodlots									
Christmas trees	Airblast	EC	0.85	16	1	Min + closed	**59**	4	**105**
USC 5: Greenhouse Food Crops									
Tobacco	Low-pressure handwand	WP	1.25	0.4	2/crop	Max + open + WSP	**ARI = 0.62[3]**	24	Not determined[4]
	High-pressure Handwand						**ARI = 0.23[3]**		
Mushroom houses	Low-pressure handwand	EC and WP	1 kg/100L	150 L/day	1/crop	Max + open + WSP (if applicable)	**ARI = 0.21[3]**	24	Not determined[4]
	High-pressure handwand	EC and WP		3800 L/day			**ARI = 0.003[3]**		
	Paintbrush	EC		19 L/day			**ARI = 0.027[3]**		
		WP					**ARI = 0.027[3]**		
USC 8: Livestock for Food									
Cattle	Eartags–Qualitative assessment was conducted. Worker exposure is expected to be lower than other agricultural scenarios, provided gloves are worn when handling eartags.								
USC 10: Seed Treatments Food and Seed									
Corn	On-farm[5]	WP	0.3125 g /kg seed	1320 kg seed	1	Min + gloves + resp + WSP	**8**	N/A	N/A
Beans	On-farm[5]	WP	0.3125 g/ kg seed	9300 kg seed	1	Min + gloves + resp + WSP	**1**	N/A	N/A
Peas	On-farm[5]	WP	0.3125 g/ kg seed	12,000 kg seed	1	Min + gloves + resp + WSP	**1**	N/A	N/A
USC 14: Terrestrial Food Crops									
Apple	Airblast	EC	1.75	16	2	Min + closed	**29**	4	**118**
		WP				Max (M/L) + min (A) + closed + WSP	**36**		
Pear	Airblast	EC	2.5	16	2	Min + closed	**20**	5	**108**
		WP				Max (M/L) + min (A) + closed +WSP	**25**		

Crop	Scenario/ Formulation	Formulation	Rate kg a.i. /ha	Area Treated ha/day	Maximum No. of Applications/ Season	PPE + System[1]	Margins of Exposure[6]		
							Combined MOE[2] or ARI[3] for M/L/A	REI (days)	Dermal MOE at Re-entry Day[2]
Apricot, peach, plum, prune	Airblast	EC	1.625	16	2	Min + closed	**31**	4	**127**
		WP				Max (M/L) + min (A) + closed + WSP	**39**		
Cherry	Airblast	EC	1	6	2	Min + closed	**134**	4	**127**
		WP	1.625			Max (M/L) + min (A) + closed + WSP	**103**		
Grapes	Airblast	EC	1.75	10	2	Min + closed	**46**	7	**128**
		WP	1.68			Max (M/L) + min (A) + closed + WSP	**60**		
Strawberry	Groundboom	EC	2.25	5	1	Min + closed	**170**	4	**104**
		WP				Max (M/L) + min (A) + closed + WSP	**324**		
Raspberry Blackberry Loganberry	Groundboom	EC	2.25	5	2	Min + closed	**170**	6	**107**
		WP				Max (M/L) + min (A) + closed + WSP	**324**		
	Airblast	EC				Min + closed	**71**		
		WP				Max (M/L) + min (A) + closed + WSP	**89**		
Gooseberry Currant	Groundboom	EC	2.25	5	1	Min + closed	**170**	6	**109**
		WP				Max (M/L) + min (A) + closed + WSP	**324**		
	Airblast	EC				Min+closed	**71**		
		WP				Max (M/L) + min (A) + closed + WSP	**89**		
Cranberry	Groundboom	EC	3.75	16	4	Min + closed	**32**	3	**126**
		WP				Max (M/L) + min (A) + closed + WSP	**61**		
Broccoli, cabbage, cauliflower, kohlrabi	Groundboom	EC	0.55	30	2	Min + closed	**116**	4	**127**
		WP				Max (M/L) + min (A) + WSP	**221**		

Crop	Scenario/ Formulation	Formulation	Rate kg a.i. /ha	Area Treated ha/day	Maximum No. of Applications/ Season	PPE + System[1]	Margins of Exposure[6]		
							Combined MOE[2] or ARI[3] for M/L/A	REI (days)	Dermal MOE at Re-entry Day[2]
Brussel sprouts	Groundboom	EC	0.55	30	1	Min + closed	**116**	4	**129**
		WP				Max (M/L) + min (A) + closed + WSP	**221**		
Kale, lettuce, parsley, spinach, Swiss chard	Groundboom	EC	0.55	30	2	Min + closed	**116**	3	**137**
		WP				Max (M/L) + min (A) + closed + WSP	**221**		
Collards	Groundboom	EC	0.55	30	1	Min + closed	**116**	3	**139**
		WP				Max (M/L) + min (A) + closed + WSP	**221**		
Carrot, radish, parsnip	Groundboom	EC	0.55	30	2	Min + closed	**116**	3	**137**
		WP				Max (M/L) + min (A) + closed + WSP	**221**		
Beets (table)	Groundboom	EC	0.55	30	1	Min + closed	**116**	3	**137**
		WP				Max (M/L) + min (A) + closed + WSP	**221**		
Bean	Groundboom	EC	0.55	30	1	Min + closed	**116**	3	**139**
		WP				Max (M/L) + min (A) + closed + WSP	**221**		
Tomato	Groundboom	EC	0.875	30	2	Min + closed	**73**	2	**116**
		WP				Max (M/L) + min (A) + closed + WSP	**139**		
Cucumber	Groundboom	EC	1.125	30	2	Min + closed	**57**	4	**124**
		WP				Max (M/L) + min (A) + closed + WSP	**108**		
Melons, (cantaloupe, watermelon, muskmelon) and squash	Groundboom	EC	1	30	2	Min + closed	**64**	4	**140**
		WP				Max (M/L) + min (A) + closed + WSP	**121**		
Onion	Groundboom	EC	0.55	30	2	Min + closed	**116**	3	**137**
		WP				Max (M/L) + min (A) + closed + WSP	**221**		

Crop	Scenario/ Formulation	Formulation	Rate kg a.i. /ha	Area Treated ha/day	Maximum No. of Applications/ Season	PPE + System[1]	Margins of Exposure[6]		
							Combined MOE[2] or ARI[3] for M/L/A	REI (days)	Dermal MOE at Re-entry Day[2]
Hops	Groundboom	EC	1.125	30	2	Min+closed	**57**	4	**156**
		WP				Max (M/L) + min (A) + closed + WSP	**108**		
	Airblast	EC		16		Min + closed	**45**		
		WP				Max (M/L) + min (A) + closed + WSP	**56**		
Rutabaga, turnip	Groundboom	EC	1.1	5	1	Min + closed	**348**	4	**129**
		WP				Max (M/L) + min (A) + closed + WSP	**662**		
USC 27: Ornamentals Outdoor									
Aralia, arborvitae, azalea, birch, boxwood, carnation, chrysanthe mum, euonymus, ivy, juniper, oak, pines, roses, taxus	Low- pressure handwand	EC and WP	750 G/1000L	150 L/day	4	Max + open + WSP	**717**	7	**100**
	High- pressure handwand			3800 L/day			**10**		
	Backpack			200 L/day			**205**		
Trees and shrubs, not including holly	Airblast	EC	0.75	16	4	Min + closed	**67**	7	**100**
		WP				Max (M/L) + min (A) + closed + WSP	**83**		
	Groundboom	EC		30		Min + closed	**85**		
		WP				Max (M/L) + min (A) + closed +WSP	**162**		
Flowers	Groundboom	EC	0.75	10	4	Min + closed	**255**	7	**100**
		WP				max (M/L) + min (A) + closed + WSP	**485**		

Crop	Scenario/ Formulation	Formulation	Rate kg a.i. /ha	Area Treated ha/day	Maximum No. of Applications/ Season	PPE + System[1]	Margins of Exposure[6]		
							Combined MOE[2] or ARI[3] for M/L/A	REI (days)	Dermal MOE at Re-entry Day[2]
Holly	Low-pressure handwand	EC and WP	1875 g/1000L	150 L/day	4	Max + open + WSP	**287**	7	**100**
	High-pressure handwand			3800 L/day			**4**		
	Backpack			200 L/day			**82**		
	Airblast	EC	1.875	16		Min + closed	**27**		
		WP				Max (M/L) + min (A) + closed + WSP	**33**		
	Groundboom	EC		30		Min + closed	**34**		
		WP				Max (M/L) + min (A) + closed + WSP	**65**		

1 For mixer/loaders and applicators. Min = minimum PPE (long sleeves, long pants, no gloves unless otherwise indicated); Max PPE = chemical-resistant coveralls over long sleeves, long pants, chemical-resistant gloves and a respirator; Open = open mix/load systems and open cabs; Closed = closed mix/load systems and closed cabs; WSP = water-soluble packaging; M = mixer; L = loader; A = applicator.

2 Based on an dermal NOAEL of 1.0 mg/kg/day and on an inhalation NOAEL of 0.026 mg/kg/day; Combined MOE = $1/(1/MOE_D + 1/MOE_I)$, target combined MOE = 100. Shaded areas are those with combined MOE $\leq$100.

3 Aggregate risk index based on an dermal NOAEL of 1.0 mg/kg/day, target MOE = 300 and on an inhalation NOAEL of 0.026 mg/kg/day, target MOE = 100. Target ARI = 1

4 Indoor DFR data were not available to calculate REIs. In the interim, it is proposed that a REI of two days for crop contact activities be added to labels for greenhouse tobacco and mushroom houses' use.

5 Data only available to assess on-farm seed treatment scenario. Data not available to assess commercial seed treatment or planting of treated seed.

6 Shaded areas indicate calculated MOEs or ARIs of concern (MOEs < target or ARI < 1)