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Proposed Re-evaluation Decision

Carbaryl

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Overview

Proposed Re-evaluation Decision for Carbaryl:

After a re-evaluation of the insecticide carbaryl, Health Canada's Pest Management Regulatory Agency (PMRA), under the authority of the *Pest Control Products Act*, is proposing the continued registration of carbaryl products for sale and use in Canada. An evaluation of available scientific information found that, under the proposed conditions of use:

- Certain uses of carbaryl products have value in the food and crop industry and do not pose risks of concern to human health or the environment, that is, commercial products applied in agricultural, non-crop and forestry settings, other than those noted below. As a condition of the continued registration of these uses, new risk-reduction measures are proposed for the labels of carbaryl products. In addition, registrants will be requested to submit information to help refine the current risk assessment.

    - The PMRA is also seeking additional information on the typical use pattern of carbaryl (for example, typical rates, number of applications, survey information on critical worker activities, etc.) as well as feedback on the feasibility of proposed mitigation measures such as restricted entry intervals (REIs) or buffer zones.

- Some uses of carbaryl are proposed for phase-out since they are not supported by the technical registrant. These uses were not included in the risk assessment:

    - Indoor pest control uses including greenhouses, residences, food and feed handling establishments and barns and livestock production areas;
    - Aerosol products;
    - Agricultural dust uses;
    - Bran bait application to residential gardens;
    - Livestock for food;
    - Livestock for non-food;
    - Companion animals;
    - Granular bait products for ornamental gardens; and
    - Applications by hand, spoon and bellygrinder.

- Specific uses of carbaryl products do not meet the current standard for health protection and are proposed for phase-out. These uses are turf, golf courses and sod farms, residential ornamentals, fruit trees and vegetable gardens, tobacco and pick-your-own orchard operations.

The PMRA's pesticide re-evaluation program considers the potential risks as well as value of pesticide products to ensure that they meet modern standards established to protect human health and the environment. Regulatory Directive DIR2001-03, *PMRA Re-evaluation Program*,

presents the details of the re-evaluation activities and program structures. The re-evaluation draws on data from registrants and other regulatory agencies, published scientific reports and any other relevant information.

This proposal affects all end-use products registered in Canada that contain carbaryl. Once the final re-evaluation decision is made, registrants will be instructed on how to address any new requirements.

This Proposed Re-evaluation Decision is a consultation document[1] that summarizes the science evaluation for carbaryl and presents the reasons for the proposed re-evaluation decision. It also proposes additional risk-reduction measures to further protect human health and the environment.

The information is presented in two parts. The Overview describes the regulatory process and key points of the evaluation, while the Science Evaluation provides detailed technical information on the human health, environmental and value assessment of carbaryl.

The PMRA will accept written comments on this proposal up to 60 days from the date of publication of this document. Please forward all comments to Publications.

What Does Health Canada Consider When Making a Re-evaluation Decision?

The key objective of the *Pest Control Products Act* is to prevent risks of concern to people and the environment from the use of pest control products. Health or environmental risk is considered of no concern if there is reasonable certainty that no harm to human health, future generations or the environment will result from use or exposure to the product under its conditions or proposed conditions of registration[2]. The Act also requires that products have value[3] when used according to the label directions. Conditions of registration may include special precautionary measures on the product label to further reduce risk.

To reach its decisions, the PMRA applies hazard and risk assessment methods as well as policies that are rigorous and modern. These methods consider the unique characteristics of sensitive subpopulations in both humans (for example, children) and organisms in the environment (for example, those most sensitive to environmental contaminants). These methods and policies also consider the nature of the effects observed and the uncertainties present when predicting the impact of pesticides. For more information on how the PMRA regulates pesticides, as well as on the assessment process and risk-reduction programs, please visit the Pesticides and Pest Management portion of Health Canada's website at healthcanada.gc.ca/pmra.

Before making a re-evaluation decision on carbaryl, the PMRA will consider all comments received from the public in response to this consultation document[4]. The PMRA will then

1 "Consultation statement" as required by subsection 28(2) of the *Pest Control Products Act*

2 "Acceptable risks" as defined by subsection 2(2) of the *Pest Control Products Act*

3 "Value" as defined by subsection 2(1) of the *Pest Control Products Act*: "the product's actual or potential contribution to pest management, taking into account its conditions or proposed conditions of registration, and includes the product's (a) efficacy; (b) effect on host organisms in connection with which it is intended to be used; and (c) health, safety and environmental benefits and social and economic impact".

4 "Consultation statement" as required by subsection 28(2) of the *Pest Control Products Act*

publish a Re-evaluation Decision document[5] on carbaryl, which will include the decision, the reasons for it, a summary of comments received on the proposed registration decision and the PMRA's response to these comments.

For more details on the information presented in this overview, please refer to the Science Evaluation section of this consultation document.

What is Carbaryl?

Carbaryl is a broad spectrum Resistance Management Group 1A (carbamate) insecticide that also controls a number of secondary pests. It is applied by both ground and aerial equipment.

Health Considerations

Can Approved Uses of Carbaryl Affect Human Health?

Carbaryl is unlikely to affect human health when used according to the revised label directions, which include additional risk-reduction measures.

Potential exposure to carbaryl may occur through the diet (food and water), by applying the product or by entering treated sites. When assessing health risks, two key factors are considered: the dose at which no health effects occur and the levels to which people may be exposed. The dose levels used to assess risks are established to protect the most sensitive human population (for example, children and nursing mothers). The uses considered for continued registration are only those uses for which exposure is well below levels that cause no effects in animal testing.

Toxicology studies on laboratory animals describe potential health effects from varying levels of exposure to a chemical and identify the dose at which no effects are observed. The health effects noted in animals occur at doses more than 100-times higher (and often much higher) than levels to which humans are normally exposed when carbaryl products are used according to label directions.

The acute toxicity of carbaryl ranged from moderate to high via the oral route of exposure. It was of low acute toxicity via the dermal and inhalation routes of exposure. Carbaryl was mildly irritating to eyes, but non-irritating to skin and not a skin sensitizer.

Acute over-exposure to carbaryl can inhibit cholinesterase, an enzyme necessary for the normal functioning of the nervous system. This can produce a variety of symptoms in animals and humans including tremors, salivation, and sluggishness. With carbaryl, cholinesterase inhibition can occur rather rapidly with exposure, but this effect has been shown to reverse within hours. No pronounced gender differences were noted in the database.

[5] "Decision statement" as required by subsection 28(5) of the Pest Control Products *Act*

Based on the weight of evidence, carbaryl was not genotoxic, although carbaryl did cause cancer in mice and rats. However, in rats the tumors occurred at doses that caused severe systemic toxicity such that the cancer risk assessment was based only on the results in the mouse study.

Carbaryl did cause malformations in the fetus when given to pregnant mice, rabbits and dogs (not in rats), but only at high doses that were also toxic to the mother. An effect on offspring survival in the rat was also observed at the same dose that was toxic to the father but not the mother. This suggested sensitivity of the young, although there was no cholinesterase activity assessed. Brain cholinesterase was inhibited in rat fetuses at the same dose as their mothers in a developmental neurotoxicity study, suggesting that fetuses are susceptible to cholinesterase inhibition. However, the lack of detail precluded a definitive assessment of prenatal sensitivity to indirect exposures of carbaryl. In comparison, young rats were found to be more sensitive than adults to brain cholinesterase inhibition from a single direct oral exposure to carbaryl.

Published information suggests that carbaryl can cause other high-dose effects in animals such as immunotoxicity and toxicity to the male reproductive system, but results were considered inconclusive due to the limited nature of the studies. Cholinesterase inhibition occurred at lower doses than the above-noted effects and was considered the most sensitive indicator of toxicity. The risk assessment protects against these effects by ensuring that the level of human exposure is well below the lowest dose at which these effects occurred in animal tests.

In light of uncertainty with regards to whether the sensitivity of young animals to brain cholinesterase inhibition was evident upon dermal exposure, extra protective measures were included during the dermal risk assessment to further reduce the allowable level of human exposure to carbaryl.

Risks in Residential and Other Non-Occupational Environments

Residential risks from the use of carbaryl on turf and ornamentals are of concern.

Carbaryl is registered for use on turf, and on residential ornamental and vegetable gardens. Estimates of exposure using the PMRA default approach as well as carbaryl specific biomonitoring data do not achieve the target margin of exposure (MOE) and/or aggregate risk index (ARI) for adults and children for all postapplication exposure scenarios and some application scenarios, and are therefore of concern.

Cancer risks are not of concern.

Aggregate risk from exposure incurred by the public at "Pick-Your-Own" orchards is of concern.

"Pick-Your-Own (PYO)" facilities are considered commercial farming operations that allow public access for harvesting in large-scale fields or orchards treated with commercially labelled carbaryl products. Estimates of exposure that aggregate the dermal exposure incurred during fruit-picking and the dietary exposure from consuming fresh fruit do not reach the target margin of exposure and/or aggregate risk index for orchard crops, and are therefore of concern.

Cancer risks are not of concern.

Occupational Risks from Handling Carbaryl

Most occupational risks are not of concern provided that the proposed protective measures are followed.

Most occupational risks are not of concern for agricultural scenarios provided that additional protective measures are followed. Based on the precautions and directions for use on current carbaryl labels, the non-cancer risk estimates associated with mixing, loading and applying activities did not meet current standards and are of concern to the PMRA. However, the proposed additional protective measures, for example, engineering controls and personal protective equipment (PPE), could minimize potential exposure in most cases.

All non-cancer risk estimates for lawn care operators applying carbaryl to residential turf, as well as for golf course and sod farm workers applying carbaryl, did not reach the target margin of exposure and/or aggregate risk index for broadcast treatments even with maximum personal protective equipment and engineering controls, and are therefore of concern.

For commercial workers applying carbaryl to ornamentals, non-cancer risk is not of concern for all application equipment except high pressure handwand.

The majority of uses for agricultural scenarios have margins of exposure that are not of concern, provided that engineering controls or personal protective equipment are used. These measures are needed to minimize potential exposure and protect workers' health. For those uses that did not meet the target endpoints, further mitigation or discontinuation/removal of use is proposed.

Cancer risks are not of concern.

Most occupational postapplication risks are not of concern provided that the proposed protective measures are followed.

Postapplication occupational risk assessments consider exposures to workers entering treated sites in agriculture. Most occupational postapplication risks are not of concern if proposed protective measures are followed. Based on the precautions and directions for use on the current product labels for agricultural scenarios, non-cancer postapplication risks to workers performing activities such as thinning, pruning and harvesting of most crops, did not meet current standards and are of concern. However, when the proposed mitigation measures such as lengthened restricted entry intervals and restricting the number of applications are considered, the risks to postapplication workers are not of concern. Some of the proposed restricted entry intervals (up to 51 days) may not be considered agronomically feasible and the PMRA is requesting feedback on this aspect.

Based on the non-cancer risk assessment, the postapplication risks to workers performing high-exposure activities, such as mowing treated turf, and transplanting and harvesting sod, do not meet the target margin of exposure until 26 days after treatment. Risks to workers hand harvesting, pinching, pruning and thinning ornamentals do not meet the target even 30 days after treatment. These restricted entry intervals are not considered agronomically feasible for turf or ornamental garden scenarios.

Cancer risks are not of concern.

Although the risk assessment for the agricultural scenarios identified risks of concern based on the current use pattern, the postapplication non-cancer and cancer risk estimates include a number of conservative (health protective) assumptions that may overestimate exposure, and therefore, risk. The application of the proposed mitigation measures reduces the risk for postapplication activities. Proposed protective measures to reduce worker exposure require consultation with user groups to determine their acceptability to the agricultural community. Additional data such as information on typical use pattern (that is, typical rates, number of applications, survey information on critical worker activities, etc.) may help to refine the current risk assessment and could reduce the proposed restricted entry intervals.

Residues in Water and Food

Carbaryl residues in food are not of concern.

Acute exposure through drinking water exceeds the level of concern based on conservative upper bound estimates from modelling; however exposure is not of concern when available water monitoring data is considered.

Reference doses define levels to which an individual can be exposed over a single day (acute) or lifetime (chronic) and expect no adverse health effects. Generally, dietary exposure from food and water is not of concern if it is less than 100% of the acute reference dose or chronic reference dose (acceptable daily intake). An acceptable daily

intake is an estimate of the level of daily exposure to a pesticide residue that, over a lifetime, is believed to have no significant harmful effects.

Human exposure to carbaryl was estimated from residues in treated crops and drinking water, including the most highly exposed sub-population (for example, infants and children one to six years old). Recent data from the Canadian Food Inspection Agency, the USDA Pesticide Data Program (PDP), field trials, processing factors and updated percent crop treated (%CT) information were used to estimate food residues. As well, information on drinking water was used to estimate both the acute and chronic non-cancer and cancer aggregate exposures and risks. To determine the water contribution, both water modelling results and monitoring data were considered in the assessment.

Short term (acute), long term (chronic) and lifetime cancer exposure estimates were determined for different sub-populations representing different ages, genders and reproductive statues. The maximum degree of refinement possible, based on all available information, was used in both the acute and chronic cancer dietary assessments.

Based on the food contribution only, the acute and chronic exposure estimates for the general population were 29% and 1% of the reference doses, respectively. For the most sensitive population of children aged 1 to 2 years, the acute and chronic exposure estimates were 54% and 2% of the reference doses, respectively. The lifetime cancer risk estimate, based on the Q_1* approach, was 6.9×10^{-8} for the general population.

Aggregate exposure to carbaryl (that is, from food and drinking water) represents 2% of the chronic reference dose, while the lifetime cancer risk estimate, based on the Q_1* approach, was 7.1×10^{-8} for the general population. As a result, both chronic and cancer risks were below the level of concern of the PMRA.
When using the drinking water modelling data, the acute aggregate exposure estimate for carbaryl for all Canadian population subgroups ranged from 117% to 393% of the acute reference dose for the general population and all infants, respectively. However, the drinking water modelling data is considered an upper bound estimate, based on the conservative assumption that 100% of the watershed is treated. These estimates could be refined with “percent cropped area” data.

In addition, the acute aggregate exposure estimates for carbaryl ranged from 37% to 73% of the acute reference dose for the general population and all infants when using the 95th percentile of the maximum detected concentration from drinking water monitoring data. Although the monitoring data may not capture peak concentrations immediately after use, it is a large data set that contains samples collected over a number of years.

Environmental Considerations

What Happens When Carbaryl is Introduced Into the Environment?

Carbaryl poses a potential risk to terrestrial and aquatic organismsl; therefore, additional risk reduction measures need to be observed.

When carbaryl is released into the environment, some of it can be found in soil and surface water. However, carbaryl is rapidly broken down by soil microbes and by chemical reactions in water, and therefore it is not expected to persist in the environment. Laboratory studies indicate that carbaryl is mobile in soil. However, there is no field evidence that the use of this insecticide will result in groundwater contamination, most probably due to the rapid microbiological breakdown of carbaryl in soil.

Carbaryl poses a risk to terrestrial invertebrates, birds and mammals as well as to aquatic organisms like fish, amphibians and invertebrates. In order to minimize the potential exposure to aquatic species from drift, strips of land between the agricultural field and no/a target aquatic areas will be left unsprayed. The width of these spray buffer zones will be specified on the product label (Appendix XIX). Water monitoring data indicate that carbaryl can occur in runoff. However, the concentrations are low and do not pose a concern for aquatic environments.

Value Considerations

What is the Value of Carbaryl?

In Canada, carbaryl is registered to control a wide range of insect pests including beetles, butterflies, moths, fleas, flies, lice, mites, sawflies, crickets, earwigs, grasshoppers, millipedes, sow bugs, thrips, ticks and cockroaches. It is also registered in Canada for use in apple thinning.

Carbaryl is used on both agricultural and non-agricultural sites including feed crops, industrial oil seed and fibre crops, livestock, greenhouse tobacco seedlings, companion animals, structures, forestry, food crops, turf, lawns and ornamentals.

Carbaryl is important in the resistance management of pests for most uses. Furthermore, for some of the uses for which it is registered, there are few if any other effective registered alternatives.

Proposed Measures to Minimize Risk

Registered pesticide product labels include specific instructions for use. The directions include risk reduction measures to protect human and environmental health. These directions are required by law and must be followed.

Risk reduction measures are being proposed to address the potential risks identified in this assessment. These measures, in addition to those already identified on existing carbaryl product labels, are designed to further protect human health and the environment. The additional key risk reduction measures that are being proposed are as follows.

Human Health

Phase-out of domestic class products and residential applications of commercial products.

Phase-out of uses on field tobacco, Pick-Your-Own orchard operations, turf, golf courses and sod farms.

To further protect mixer/loader/applicators: additional protective equipment and the packaging of all carbaryl wettable powder products in water soluble packaging.

To further protect workers entering treated sites: restrictions on the number of applications, increased application intervals and restricted entry intervals.

To update the Toxicological Information section on labels: additional information about symptoms and treatment for exposed individuals.

Environment

To reduce the release of carbaryl into the environment for the protection of aquatic habitats that may contain sensitive species: add label statements, including precautionary statements and spray buffer zones for non-target aquatic habitats.

To reduce the potential for carbaryl in runoff to adjacent aquatic habitats: add label statements, to include precautionary statements for sites with characteristics that may be conducive to runoff as well as when heavy rain is forecasted.

What Additional Scientific Information is being Requested?

The human health risks and risks to the environment were found to be acceptable for certain uses of carbaryl with the addition of mitigation measures. However, the following information is being requested to help refine the risk assessment.

Human Health

- Data code 10.6: The modelled drinking water expected environmental concentrations could be potentially refined with the use of information on percent cropped area (PCA).

Next Steps

Before making a re-evaluation decision on carbaryl, the PMRA will consider all comments received from the public in response to this consultation document.

In particular, the PMRA is seeking comments on the feasibility of mitigation measures such as Restricted entry intervals or buffer zones and additional information on the typical use pattern of carbaryl (that is, typical rates, number of applications, survey information on critical worker activities, etc.).We would also consider quantitative and/or qualitative data on the economic and social importance of carbaryl to specific industries and information on the viability of alternative chemical and non-chemical pest management practices for the registered site and pest combinations that are proposed for phase-out.

The PMRA will then publish a Re-evaluation Decision Document, which will include the decision, the reasons for it, a summary of comments received on the proposed decision and the PMRA's response to these comments.

Once all carbamate pesticides have been re-evaluated, a cumulative risk assessment will be conducted that will consider potential exposure to all chemicals causing toxicity in the same manner.

Other Information

At the time that the re-evaluation decision is made, the PMRA will publish an Evaluation Report on carbaryl in the context of this re-evaluation decision (based on the Science Evaluation section of this consultation document). In addition, the test data on which the decision is based will also be available for public inspection, upon application, in the PMRA's Reading Room (located in Ottawa).

Science Evaluation

1.0 Introduction

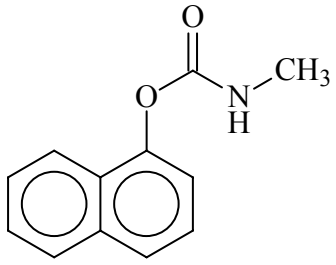
Carbaryl is one of the pesticides subject to re-evaluation in Canada as announced in Re-evaluation Document REV2002-06 *Re-evaluation of Selected Carbamate Pesticides*. Carbaryl is a broad spectrum, Resistance Management Group 1 (carbamate) insecticide that inhibits the enzyme acetylcholinesterase, interrupting the transmission of nerve impulses in insects. It works by contact, ingestion and slight systemic action. Carbaryl is also a plant growth regulator, used for apple thinning. Carbaryl is known by the Trademarks "Sevin", "Grub-B-Gon", "Bug-B-Gon", "Bugban-C" and "Grubout".

Carbaryl is registered in Canada for the control of a broad range of insect pests such as beetles, butterflies and moths, fleas, flies, lice, mites, sawflies, crickets, earwigs, grasshoppers, millipedes, sow bugs, thrips, ticks and cockroaches. Carbaryl is also registered in Canada for use in apple thinning.

2.0 The Active Substance, Its Properties and Uses

2.1 Identity of the Technical Grade Active Ingredient

Common name		Carbaryl
Function		Insecticide, Acaricide, Plant Growth Regulator
Chemical Family		Carbamate Insecticides
Chemical name		
1	**International Union of Pure and Applied Chemistry (IUPAC)**	1-naphthyl methylcarbamate
2	**Chemical Abstracts Service (CAS)**	1-naphthalenyl methylcarbamate
CAS Registry Number		63-25-2
Molecular Formula		$C_{12}H_{11}NO_2$

Structural Formula	
Molecular Weight	201.2 amu

Identity of relevant impurities of human health or environmental concern:

Based on the manufacturing process used, impurities of human health or environmental concern as identified in section 2.13.4 of Directive 98-04 and TSMP Track 1 substances identified in Appendix II of Directive 99-03 are not expected to be present in this product.

2.2 Physical and Chemical Properties of the Technical Grade Active Ingredient

Property	Result
Vapour pressure at 23.5^0C	4.16×10^{-5} Pa
Ultraviolet (UV)/visible spectrum	Not expected to absorb at $\lambda > 300$ nm, based on the spectrum of beta - carbaryl
Solubility in water at 20°C	pH (mg/L) Solubility 4 9.4 7 9.1 9 7.2
n-Octanol/water partition coefficient at 23°C	2.36
Dissociation constant (pKa)	10.4

2.3 Description of Registered Carbaryl Uses

Appendix I lists all carbaryl products that are registered under the authority of the *Pest Control Products Act*. Appendix II Table 1 lists all Commercial Class uses for which carbaryl is presently registered, while Appendices II Table 2 and II Table 3 list all Domestic Class uses for which carbaryl is presently registered. Also presented in Appendix II Table 1 is whether the use was added to the label through the PMRA Minor Use Program. While currently supported by the registrant, the data supporting the minor uses were originally generated by a user group.

The registrant is supporting the use of carbaryl on the following sites, which are included in the risk assessments.

Feed crops:	alfalfa, barley, canola (rapeseed), clover, corn (field), forage grasses, oats, pastures, rangeland, rye, sweet white lupin and wheat;
Food crops:	apple, apricot, asparagus, barley, beans (including snapbeans, green beans, wax beans, common beans and yellow beans), beets, blackberry, blueberry, boysenberry, broccoli, Brussels sprouts, cabbage, canola, carrot, cauliflower, celery, cherry, Chinese cabbage, chokecherry (in shelterbelts), collards, corn (field and sweet), cranberry, cucumber, dandelion, dewberry, eggplant, endive, grape, horseradish, kale, kohlrabi, lettuce, loganberry, melon, mustard greens, oats, parsley, parsnip, peach, pear, peas, pepper, plum, potato, prune, pumpkin, radish, raspberry, rutabaga, rye, salsify, spinach, strawberry, squash, Swiss chard, tobacco, tomato, turnip, watercress and wheat;
Industrial oil seed and fibre crops:	canola (rapeseed);
Forestry sites:	balsam fir, farm woodlots, forest, high value trees in urban and rural areas, lodgepole pine, municipal parks (national and provincial parks not included), pine, rights-of-way, spruce and woodlands;
Turf/Lawns:	ornamental and sports, golf courses and sod farms;
Ornamental crops:	arborvitae, azalea, balsam fir, birch, boxwood, carnation, chokecherry (shelterbelts), chrysanthemum, dogwood, elm, gladiolus, green ash, high value trees in urban and rural areas, holly, hydrangea, juniper, lilac, maple, oak, pine, rose, spruce and zinnia;
Other supported sites:	chokecherry (shelterbelt), ditchbanks, field borders, headlands, roadsides, rights-of-way and wastelands.

Uses that are not supported by the registrant and, while included in the value assessment, were not included in the risk assessments are as follows:

Livestock:	beef cattle, dairy cattle, sheep, swine, goats and horses;
Poultry:	poultry (chickens, ducks, turkey) and their quarters;
Structural:	quarters for chickens, ducks, turkeys;

Turf: broadcast application of liquid formulations to residential lawns (excluding golf courses and sod farms). The use of liquid formulations on residential lawns would be limited to spot treatments only (defined as an area 100 m^2 or less);

Pet care: all pet care use products (dusts and sprays), including flea collars.

3.0 Impact on Human and Animal Health

3.1 Toxicological Summary

Toxicology studies on laboratory animals describe potential health effects resulting from various levels of exposure to a chemical and identify dose levels at which no effects are observed. Unless there is evidence to the contrary, it is assumed that effects observed in animals are relevant to humans and that humans are more sensitive to the effects of a chemical than the most sensitive animal species. The health effects noted here were observed in animals at dose levels at least 100-fold (often much higher) above levels to which humans are normally exposed through the use of products containing this chemical.

A detailed review of the toxicological database for carbaryl was conducted. The database is extensive, consisting of the full array of toxicity studies currently required for hazard assessment purposes. The toxicology database confirms that carbaryl has anticholinesterase activity in various species and produces toxic signs typical of the carbamate class of chemicals.

With oral exposure in rats, carbaryl is rapidly and almost completely absorbed from the gastrointestinal tract (GI) tract and eliminated mainly in the urine with no tendency for tissue accumulation. In mammals, carbaryl is initially broken down by hydrolysis, hydroxylation and epoxidation, forming numerous metabolites. The metabolites are ultimately conjugated by sulfation or glucuronidation, and eliminated in the urine and feces. Species-specific differences in the quantitative pattern of metabolites occur, although, qualitatively, the pathways of metabolism appear similar in mammals. Dogs were unable to liberate 1-naphthol metabolites in one study, but there were numerous limitations to the study. Further studies confirmed some differences in the quantity and distribution of metabolites but did not definitively demonstrate that the dog was unique compared to the rat or human metabolism. Carbaryl is capable of nitrosation in vivo and in vitro under certain conditions to form N-nitrosocarbaryl. The adverse effects of N-nitrosocarbaryl are discussed in a following paragraph.

The acute toxicity studies suggest that carbaryl is moderately or highly toxic by the oral route and of low toxicity by the dermal and inhalation routes of exposure. It is mildly irritating to eyes, but non-irritating to skin and not a skin sensitizer. Acute toxic signs induced by carbaryl are consistent with those resulting from the inhibition of acetylcholinesterase activity, and include tremors, salivation, ataxia, bloody tears, piloerection, and sluggishness, which have generally subsided=by day 4 post-exposure.

The primary neurotoxic effects of carbaryl are related to cholinesterase inhibition and are usually transitory. An acute oral neurotoxicity study in rats resulted in cholinesterase inhibition

(BChE, EChE and PChE) at the lowest dose tested. Clinical signs, functional observation battery (FOB) alterations, depressed weight gain and food consumption were observed at higher doses. An acute subcutaneous neurotoxicity study in chickens showed transitory leg weakness. Quantitative sensitivity of postnatal day 11 rats to BChE inhibition was demonstrated in an acute oral comparative cholinesterase assay in male rats. In comparison, no age-related sensitivity was noted with respect to EChE inhibition. Motor activity was also decreased in postnatal day 17 juvenile rats at the highest dose tested. A developmental neurotoxicity study in rats resulted in maternal effects that included acetylcholinesterase (BChE, EChE and PChE) inhibition, FOB alterations and transiently depressed maternal weight gain during the gestation period, but no treatment-related developmental or pup effects were apparent. Some inconsistent changes of brain morphometric measurements were noted in the high dose F1 pups and F1 adults. However, these findings were not considered toxicologically significant due to the lack of consistent findings between males and females or between pups and adults. Additional brain morphometric measurements in the cerebellum and forebrain (neocortex) of the high dose F1 pups and F1 adults did not show any treatment-related developmental effects. These negative findings are in agreement with findings of no treatment-related effects on clinical signs, FOB observations, brain weights, brain tissue structure and neuropathology in these F1 pups and F1 adults. A 13-week neurotoxicity study in rats resulted in clinical signs (slight or moderate tremor and salivation), depressed body-weight gain and food intake, FOB alterations and decreased motor activity, but no pronounced treatment-related neuropathy was evident in the study. Brain cholinesterase inhibition was observed at the same doses in fetuses and dams in a developmental neurotoxicity study in rats, but details of the study were limited.

In rats, repeated dermal exposures resulted in cholinesterase inhibition. While there was no repeat dose inhalation study in the database, the inhalation route was not a significant contributor to risks associated with this use pattern and the lack of a study does not affect the risk assessment.

Long-term dietary studies showed that the inhibition of acetylcholinesterase was the most sensitive indicator of toxicity with the brain cholinesterase generally found to be affected in all animal species tested (mouse, rat and dog). Also observed were decreased weight gains (rats and dogs) and food consumption (dogs), increased clinical signs (dogs), increased kidney weights and pathology (mice) and urinary bladder pathology (mice) at higher doses. Excessive doses in rats also affected liver, kidney, lung, spleen, bladder, thyroid, nerve and muscle, and in mice affected liver, spleen and eyes. No consistent sex differences were apparent in the available data. The duration of dosing had little effect in rats (that is, comparing 1-week and 2-year dietary NOAELs/LOAELs or 13-week gavage neurotoxicity and gavage developmental neurotoxicity results). Slightly increased sensitivity to BChE inhibition with increased duration of exposure is suggested in dogs (that is, comparing 5-week to 1-year dietary NOAELs/LOAELs) but may be due to differences in the time that ChE was assayed. Dogs appear to be more sensitive than mice or rats based on available LOAEL values from dietary studies, but the differences could be due to the different feeding patterns of these animals. There were no clear species differences apparent in the in available data.

Chronic dietary feeding in mice and rats resulted in increased incidences of tumors. The tumors observed at the high dose in mice included renal tubular cell tumors in males (combined

adenomas/carcinomas), liver tumors in females (combined adenomas/carcinoma) and combined vascular tumors in both sexes; and at the high dose in rats included bladder tumors in both sexes (transitional cell papillomas and carcinomas) and hepatic adenomas in females. The high doses exceeded Maximum Tolerated Doses (MTDs) (that is, weight gain in mice was 62 to 68% of controls; in rats was 53 to 69% of controls), and thus are considered inappropriate for carcinogenicity testing. However, the mouse study also showed increased incidences of vascular tumors (hemangiomas and hemangiosarcomas mostly in the liver and spleen) in low and mid dose males (8% and 13% respectively compared to 3% in controls). The observed increases were statistically significant starting at the mid dose level ($\leq$0.05). Although historical data in mice were not available from the performing laboratory for a 24 month duration, hemangiosarcomas were the cause of death in a number of animals in the study. On the basis of the positive findings in the mouse carcinogenicity study, it would be prudent to consider carbaryl as a possible human carcinogen. Low dose extrapolation (Q_1*) is conducted for human risk characterization.

Carbaryl was not genotoxic in in vivo somatic cell, chromosome aberration and micronucleus assays. It also did not demonstrate DNA binding in in vivo assays. It was not genotoxic in most in vitro assays except a cytogenic assay in cultured Chinese hamster ovary cells with metabolic activation (negative without metabolic activation), and unscheduled DNA synthesis in human fibroblast cells. The negative findings from the in vivo assays, however, lessen the concern for a potential mutagenic hazard.

The developmental toxicity of carbaryl has been studied in a variety of animal species in published and unpublished reports; however, the studies are not all of equal quality. Collective data suggest teratogenic effects reported at equal or higher than maternally toxic doses in mice, rabbits and dogs administered carbaryl by oral gavage or in the diet, but no teratogenic effects in rats. In a developmental study in mice, increased incidences of fetuses with open eyes and enlarged renal pelves were observed at doses which induced maternal toxicity (increased mortality, excessive tremors and salivation, and reduced weight gain). There were also increased incidences of omphaloceles (fissures in the ventral body wall) in rabbits in the presence of maternal toxicity (diarrhea and reduced maternal weight gain). Two studies in dogs administered carbaryl in the diet throughout gestation resulted in a wide spectrum of birth defects at doses higher than maternally toxic doses. The maternal toxicity in dogs included dystocia (difficulty in giving birth) and associated clinical signs. The dog studies suffered from a number of limitations and accordingly, low confidence was attributed to the findings. Additional developmental effects observed at equal or higher than maternally toxic doses included decreased total number of implants and litter size (mice and rats), fetal weight (mice, rats and rabbits), ossification (mice and rats), pup/fetal viability (rats and dogs) and increased still births (dogs).

A two generation reproductive dietary toxicity study in rats resulted in offspring effects at dose levels equal to parental male toxic doses. Parental male effects at the LOAEL (mid-dose) included decreased weight gain and food efficiency. The offspring effects at the LOAEL included increased mortality, especially at postnatal day 4. No treatment-related reproductive effects were observed, although decreased absolute weight of epididymides was reported in F1 males; this was possibly related to the decreased terminal body weight in this group. Maternal effects occurred at the highest dose tested; the effects included weight loss (FO and Fl), decreased food efficiency (FO) and increased liver weights (FO). Based on the available data,

increased sensitivity of the offspring was evident with increased pup mortality in the absence of maternal toxicity. The results of the comparative cholinesterase assay in rats confirmed that there was sensitivity of postnatal day 11 rats compared to adults based on BChE inhibition. No age-related sensitivity was noted with respect to EChE inhibition.

In published literature, carbaryl was noted to have effects on the function of reproductive glands in rats (increased gonadotrophic function of the hypophysis, determined via tests in immature mice), reduced sperm motility and sperm count, and prolonged oestrous cycles. Further investigations of sperm and male reproductive organ toxicity indicated that carbaryl administered to male rats for 60 or 90 days by oral gavage resulted in decreased epididymal sperm count and sperm motility, and increased sperm morphological abnormalities and histopathological findings of the testes. In an epidemiological study, semen samples from 50 carbaryl production workers did not conclusively show that carbaryl had an effect on sperm quality or sperm morphology, but suggested a need for further investigations on exposed workers and experimental animals. A more recent epidemiology study investigated the effects of the exposure of male farmers in Ontario, Canada, to agricultural pesticides and pregnancy outcomes. Miscarriage risk was not associated with chemical activities overall but was increased in combination with the reported use of thiocarbamates, carbaryl and unclassified pesticides on the farm (odds ratio 1.9, 95% confidence interval 1.1–3.1). However, limitations in quantifying the exposure preclude the establishment of a causal relation.

Carbaryl was tested for immune responses in mice and rabbits in published studies. Collective data suggest that an acute or short-term oral (gavage or dietary) exposure of carbaryl resulted in a variety of non-life-threatening responses on the immune system, such as decreased humoral immunity, decreased antibody formation and decreased serum γ-globulin. However, the data were considered supplementary due to numerous limitations in the reports (i.e. lack of data on the purity of the test material, number of animals and dose, clinical signs, biochemical and/or hematological parameters, etc.). In a more recent published paper, a two-week exposure of carbaryl in male rats by the inhalation route produced clinical signs of neurotoxicity, and exposure to higher doses provided evidence of humoral suppression (dose-dependent decreases in serum antibody titre, IgM-plaque-forming cell counts, decreased thymus weight). In contrast, no change in IgM-plaque forming cell counts was observed by the oral or dermal route, although clinical signs of neurotoxicity and decreased liver weight were observed at the lowest dose by the oral route. This study was also limited (including lack of detail). Since the database indicates that cholinesterase inhibition is a more sensitive endpoint than clinical signs of toxicity by the oral and dermal route, it suggests that a risk assessment based upon the cholinesterase inhibition is protective of potential immunotoxicity for all routes of exposure.

Carbaryl can be nitrosated in the presence of nitro donor groups, such as sodium nitrate, to give a nitrosamide or nitrosocarbaryl that has been proven to be mutagenic and carcinogenic at high doses in animals. N-nitrosocarbaryl induced local tumors in rats, consisting of sarcomas at the site of injection and forestomach squamous-cell carcinomas after oral administration. It was active as a direct bacterial mutagen and interacted with human DNA in vitro, causing alkali-sensitive bonds and single-strand breakage. The conditions of carbaryl nitrosation include a strongly acidic pH (<2), which is comparable with the pH in the human stomach. Carbaryl has

been nitrosated in several studies, in vitro as well as in vivo, in the guinea pig, which has a stomach acidity similar to that in humans. The Potential for human exposure to N-nitrosocarbaryl, due to simultaneous dietary consumption of carbaryl and nitrite followed by nitrosation in the stomach, is theoretically possible but has not been documented. This may be due to the instability of N-nitrosocarbaryl at the pH of < 2; its maximal stability is between pH 3–5, at which no significant amount of carbaryl can be nitrosated. There is no available evidence to suggest that carbaryl is converted in the human stomach into sufficient quantities of nitrosocarbaryl to be of toxicological concern.

The results of the toxicity tests conducted on laboratory animals with carbaryl, along with the toxicology endpoints for use in the human health risk assessment, are summarized in Tables 1 and 2 of Appendix IV.

3.1.1 Pest Control Products Act Hazard Characterization

For assessing risks from potential residues in food or from products used in or around homes or schools, the *Pest Control Products Act* requires the application of an additional 10-fold factor to take into account the completeness of the data with respect to the exposure of and toxicity to infants and children, as well as potential pre- and post-natal toxicity. A different factor may be determined to be appropriate on the basis of reliable scientific data.

With respect to the completeness of the toxicity database, no additional studies are required at this time. Extensive data are available on carbaryl including developmental neurotoxicity studies in rats (two studies), as well as prenatal developmental toxicity studies in mice, rats, rabbits and dogs (two studies in each species). There is also a 2-generation reproduction study in rats, a 3-generation study in rats and a comparative cholinesterase assay in rats (examining pup and adult animals).

Regarding potential pre-and post-natal toxicity, decreases in pup rat viability in the 2-generation dietary reproduction study occurred at maternally non-toxic doses, suggesting increased susceptibility in the offspring. However, paternal toxicity was observed at the same dose as this offspring effect. Decreased viability was also observed in the supplemental 3-generation gavage study in rats but only at dose levels that produced significant parental toxicity. There was no evidence of sensitivity in a dietary and gavage mouse prenatal developmental toxicity study. However, in a third but limited developmental toxicity study in the mouse, there were effects in the offspring (increased resorptions and variations) in the absence of maternal toxicity, as well as malformations at maternally toxic levels. Two rabbit developmental toxicity studies did not indicate the sensitivity of the young although malformations were noted in one study at maternally toxic levels. Dystocia was noted in two dietary dog developmental toxicity studies along with effects on pup viability at the same or higher dose levels; malformations were also present at higher dose levels. The dog studies suffered from a number of limitations; accordingly, there was low confidence in the findings. In rats, the sensitivity of the young (decreased bodyweight, increased resorptions and fetal death) was noted in a supplemental gavage developmental toxicity study, but these effects were not confirmed at maternally toxic dose levels in a more robust study conducted with lower dose levels. No teratogenic effects were observed in rats. With the exception of one rabbit developmental

toxicity study (which showed that maternal cholinesterase inhibition occurred at lower levels than the fetal effects observed), none of the aforementioned studies included cholinesterase measurements.

In a gavage developmental neurotoxicity study in rats, testing was conducted at levels that produced maternal toxicity (cholinesterase inhibition and clinical signs). No sensitivity of the young was detected in this study, although cholinesterase inhibition was not measured in pups. The lack of sensitivity was confirmed in a second supplementary gavage developmental neurotoxicity study in rats that did examine cholinesterase inhibition. Brain cholinesterase was inhibited in fetuses at the same dose as their mothers, suggesting that fetuses are susceptible to indirect exposure to carbaryl. Unfortunately, this study was limited by a lack of detail; thus, there remains residual uncertainty that indirect exposure to carbaryl (i.e. fetuses and nursing offspring) results in increased sensitivity. In the absence of such information, it must be assumed that indirect exposure also results in the increased sensitivity of the young.

Information from a published study also suggested that young male rats are more sensitive than their adult counterparts to the effects on sperm parameters. These effects occurred at dose levels that would elicit a significant inhibition of cholinesterase activity.

Pups exhibited higher sensitivity to brain cholinesterase inhibition than juvenile or adult animals based on the acute comparative cholinesterase assay, in which rats of various ages were directly exposed to carbaryl by the oral route. Dose levels eliciting cholinesterase inhibition in young animals were lower than those levels producing developmental or sperm effects. Thus, regulating on the critical endpoint of cholinesterase inhibition in the young adequately addresses these effects. As the effects on cholinesterase activity levels were not assessed following indirect exposures to carbaryl during lactation, it is unknown whether sensitivity to cholinesterase inhibition exists in this scenario as well. Notwithstanding this lack of information, it is assumed that the nursing offspring of exposed mothers could demonstrate comparable sensitivity to the directly exposed young animals. Accordingly, using the point of departure for cholinesterase inhibition in the directly exposed young animal for risk assessment is considered to adequately address concerns relating to indirect exposures.

In summary, with regard to the *Pest Control Products Act* factor, the toxicity data are considered complete and the overall level of concern is low. This conclusion is based on the nature and level of concern for the endpoint and the fact that, for certain risk assessments, the endpoint was established from data on the most sensitive subpopulation. Where the endpoint from the most sensitive subpopulation was not used in the risk assessment, the application of other uncertainty factors serves to address residual concerns as noted above. Accordingly, the *Pest Control Products Act* factor can be reduced from 10-fold to 1-fold on the basis of these considerations.

3.2 Occupational and Non-Occupational Risk Assessment

Occupational and non-occupational risk is estimated by comparing potential exposures with the most relevant endpoint from toxicology studies to calculate a margin of exposure (MOE). This is compared to a target MOE incorporating uncertainty factors protective of the most sensitive subpopulation. If the calculated MOE is less than the target MOE, it does not necessarily mean that exposure will result in adverse effects. However, MOEs less than the target MOE require measures to mitigate (reduce) risk. For some scenarios, combined MOEs could not be calculated for combined dermal, inhalation and incidental oral exposures since each route of exposure had different NOAELs and target MOEs. Therefore, an aggregate risk index (ARI) was calculated. ARIs greater than or equal to one do not require risk mitigation.

3.2.1 Toxicology Endpoint Selection for Occupational and Residential Risk Assessment

3.2.1.1 Short-, intermediate-, and long-term dermal endpoint(s)

For short-, intermediate-, and long-term dermal risk assessments, the results of the 4-week dermal toxicity study in the rat were used for risk assessment of all populations (adult or child) and scenarios (residential or occupational). A NOAEL of 20 mg/kg bw/day was established, based on decreased BChE in males at the LOAEL of 50 mg/kg bw/day. Benchmark dose modelling was used to refine the point of departure. The BMD_{10} based on 10% BChE inhibition in both sexes is 51.7 mg/kg bw/day, and the $BMDL_{10}$ of 35.5 mg/kg bw/day was selected as the point of departure. The comparative cholinesterase assay illustrated that direct exposure to oral doses of carbaryl resulted in approximately twofold greater sensitivity to cholinesterase inhibition in the young than in adult animals. Since the dermal toxicity study was conducted solely on adults, there is uncertainty as to whether the sensitivity observed in the young through oral exposure would also be manifested via the dermal route. Furthermore, additional uncertainty arises as to whether sensitivity can occur in the fetus or nursing infant as a result of indirect exposure via the mother. This is a concern because the human population at risk of exposure (including workers) could include pregnant or lactating women, who could potentially pass an indirect dose of carbaryl to their offspring. Given the lack of appropriate dermal data (to confirm or refute the sensitivity) or data to assess the potential sensitivity of the fetus or nursing offspring, a threefold uncertainty factor in the form of a database deficiency is considered appropriate to protect the young. The magnitude of this factor is supported by the observation that the young are approximately twofold more sensitive than adults after direct oral exposure to carbaryl. The MOE is 300, accounting for standard uncertainty factors of 10-fold for interspecies extrapolation and 10-fold for intraspecies variability, as well as an extra threefold uncertainty factor in the form of a database deficiency. For the residential risk assessment, the *Pest Control Products Act* factor is reduced to onefold, as residual uncertainty with respect to the potential sensitivity of the young for cholinesterase effects by the dermal route was addressed through the use of the database deficiency factor. This MOE is considered to be protective of all adults and children including nursing infants and the unborn children of exposed women.

3.2.1.2 Short-, intermediate-, and long-term inhalation endpoint(s)

For short-, intermediate-, and long-term inhalation risk assessments, the most appropriate toxicological endpoint is cholinesterase inhibition, as in the oral and dermal risk assessments. However, no repeat-dose inhalation toxicity studies available. Thus, the acute comparative cholinesterase assay in rats is selected for risk assessment, with the assumption that absorption via inhalation is equivalent to oral absorption. A $BMDL_{10}$ of 1.13 mg/kg bw/day was established based on brain cholinesterase inhibition in male pups. A target MOE of 100 is required to account for standard uncertainty factors of 10-fold for inter-species extrapolation and 10-fold for intra-species variability. For the residential risk assessment, the *Pest Control Products Act* factor is reduced from 10-fold to 1-fold based on the rationale provided in the *Pest Control Products Act* Hazard Consideration Section. This MOE is considered to be protective of all adults and children including nursing infants and the unborn children of exposed women.

3.2.1.3 Non-dietary (incidental) oral endpoint(s)

For non-dietary (incidental) oral exposure (up to 6 months), the selected toxicological endpoint and the target MOE (100) are the same as for the acute reference dose (ARfD) and acceptable daily intake (ADI) determination (see Section 3.3.1). The PCPA factor is reduced to onefold because the point of departure is based on the most sensitive parameter (BChE inhibition) in the most sensitive population (post-natal day (PND) 11 pups). The selection of this study and MOE is considered protective of children exposed to carbaryl via the oral route.

3.2.1.4 Endpoint Selection for Risk Assessment from Biomonitoring Studies

Where exposure (of any duration) has been assessed via biomonitoring, the selected toxicological endpoint is the $BMDL_{10}$ of 1.13 mg/kg bw from the acute comparative cholinesterase assay in rats with a target MOE of 100. Biomonitoring studies include contributions from dermal, inhalation, and oral (including non-dietary incidental oral) routes of exposure, and this endpoint is considered more protective than the route-specific endpoints and accompanying MOEs. The *Pest Control Products Act* factor is reduced to onefold because the point of departure is based on the most sensitive parameter (BChE inhibition) in the most sensitive population (PND 11 pups). The selection of this study and MOE is considered protective of all populations, including children.

3.2.1.5 Endpoint Selection for Aggregate Assessment

Acute (one day) and short- to intermediate-term (up to six months) aggregate exposure to carbaryl is estimated based on contributions from food, drinking water and residential exposure (dermal, inhalation and oral components). Cholinesterase inhibition is the common endpoint via the oral and dermal route. Although it was not assayed directly by the inhalation route, cholinesterase inhibition is expected to be relevant to this route of exposure based on the clinical signs of neurotoxicity observed via inhalation exposure in the supplementary 2-week immunotoxicity study.

The endpoint for dietary, non-dietary oral, and inhalation risk assessment for adults or children is based on the BMDL10 of 1.13 mg/kg bw/day from a comparative cholinesterase assay in rats, with a target MOE of 100. This MOE consists of a 10-fold uncertainty factor for interspecies extrapolation and 10-fold uncertainty factor for intraspecies variability. The Pest Control Products Act factor is reduced to onefold based on the rationale provided in the Pest Control Products Act Hazard Consideration section (Section 3.1.1).

The endpoint for children and adult dermal exposure (both up to 6 months) is based on the BMDL10 of 35.5 mg/kg bw/day from a 4-week dermal toxicity study in rats, with a target MOE of 300. The target MOE of 300 is required to account for interspecies extrapolation (10-fold), intraspecies variability (10-fold) and an additional uncertainty factor of threefold in the form of a database deficiency to address the potential sensitivity in the young, which was not assessed in the dermal toxicity study. The Pest Control Products Act factor is reduced to onefold, as residual uncertainty with respect to the potential sensitivity of the young to cholinesterase effects by the dermal route was addressed through the use of the database deficiency factor.

3.2.1.6 Cancer Potency Factor

A quantitative cancer risk assessment was conducted on the vascular tumors noted in the long-term mouse study. The unit risk (Q_1*) is 1.08×10^{-3} $(mg/kg\ bw/day)^{-1}$ based on vascular tumors (combined hemangioma and hemangiosarcoma) in male mice.

3.2.1.7 Non-Dietary Cancer Risk Assessment

The cancer risk for both the general population and occupational workers was determined by calculating the lifetime average daily dose (LADD) values from dermal and inhalation exposure. The total lifetime LADD was then compared to the Q_1* to obtain cancer risk estimates. Calculated cancer risks that are below the threshold of 10^{-6} for the general population or 10^{-5} for occupational workers are not of concern to the Agency.

3.2.1.8 Dermal Absorption

Based on studies submitted by the registrant and other studies located in the scientific literature a weight of evidence approach was used to determine an estimate of dermal absorption. A value of 21% was determined to be appropriate for use in the carbaryl cancer assessment. A dermal absorption factor is not applicable for the non-cancer dermal risk assessment since the toxicological endpoint for dermal exposure was based on a dermal study.

3.2.2 Occupational Exposure and Risk Assessment

Workers can be exposed to carbaryl through mixing, loading or applying the pesticide as well as when entering a treated site to conduct activities such as scouting and/or handling treated crops and mowing and/or harvesting turf.

3.2.2.1 Mixer, Loader and Applicator Exposure and Risk Assessment

There are potential exposures to mixers, loaders and applicators. The following supported uses were assessed.

- Mixing/loading and applying liquid and wettable powder formulations to residential, golf course and sod farm turf;

- Mixing/loading and applying liquid and wettable powder formulations to residential ornamental and vegetable gardens;

- Mixing/loading of liquids for agricultural uses;

- Mixing/loading of wettable powders (in water soluble packaging) for agricultural uses;

- Aerial application to forests and woodlands, alfalfa, clover, barley, oats, rye, wheat, rapeseed, beans, beets, horseradish, radish, rutabaga, salsify, turnips, carrots, corn (field and sweet), broccoli, Brussels sprouts, cabbage, cauliflower, celery, lettuce, kohlrabi, beet tops, Chinese cabbage, dandelion, endive, kale, leaf lettuce, mustard greens, parsley, salsify (tops), spinach, Swiss chard, turnip (tops), watercress, potatoes, tomatoes, eggplants, peppers, apples, pears, blackberries, boysenberries, dewberries, loganberries, raspberries, blueberries, strawberries, cranberries, cherries, grapes, plums, cucumbers, melons, squash and tobacco;

- Groundboom application to alfalfa, clover, ditchbanks, field borders, rights-of-way, wastelands, headlands, forage grasses, pastures, rangelands, barley, oats, rye, wheat, rapeseed, sweet white lupin, asparagus, beans, beets, horseradish, radish, rutabaga, salsify, turnips, carrots, corn (field and sweet), broccoli, Brussel sprouts, cabbage, cauliflower, celery, lettuce, kohlrabi, beet tops, Chinese cabbage, dandelion, endive, kale, leaf lettuce, mustard greens, parsley, salsify (tops), spinach, Swiss chard, turnip (tops), watercress, parsnips, potatoes, snapbeans, tomatoes, eggplants, peppers, blackberries, boysenberries, dewberries, loganberries, raspberries, blueberries, strawberries, cranberries, cucumbers, melons, squash and tobacco;

- High pressure handwand applications to forests and woodlands, trap trees, ditchbanks, field borders, rights-of-way, wastelands, headlands, forage grasses, pastures, rangelands, azalea, carnations, chrysanthemums, gladiolus, holly, hydrangea, lilac, rose, zinnia, arborvitae, birch, boxwood, dogwood, elm, junipers, maple, oak, pines, green ash and high value trees;

- Low pressure handwand applications to forests and woodlands, trap trees, ditchbanks, field borders, rights-of-way, wastelands, headlands, forage grasses, pastures, rangelands, blackberries, boysenberries, dewberries, loganberries, raspberries, blueberries, cranberries, choke cherries, azalea, carnation, chrysanthemums, gladiolus, holly,

hydrangea, lilac, rose, zinnia, arborvitae, birch, boxwood, dogwood, elm, junipers, maple, oak, pines, green ash and high value trees;

- Backpack applications to trap trees, ditchbanks, field borders, rights-of-way, wastelands, headlands, forage grasses, pastures, rangelands, blackberries, boysenberries, dewberries, loganberries, raspberries, blueberries, cranberries, choke cherries, azalea, carnations, chrysanthemums, gladiolus, holly, hydrangea, lilac, rose, zinnia, arborvitae, birch, boxwood, dogwood, elm, junipers, maple, oak, pines, green ash and high value trees;

- Airblast application to balsam fir, apples, pears, apricots, peaches, cherries, plums, prunes, grapes, choke cherries, arborvitae, birch, boxwood, dogwood, elm, junipers, maple, oak, pines and green ash

- Right-of-way sprayer applications to ditchbanks, field borders, rights-of-way, wastelands, headlands, forage grasses, pastures, rangelands; and

- Solid broadcast spreaders applications to alfalfa, clover, barley, oats, rye, wheat, rapeseed, corn (field and sweet).

Due to the number of agricultural applications per year (ranging from one to three), exposure is likely to be short- to intermediate-term (i.e. up to several months) in duration. The PMRA estimated handler exposure based on different levels of personal protection.

A. Mixing, loading and applying to residential lawns, golf courses and sod farms:
Long pants, a long-sleeved shirt, chemical resistant gloves with or without cotton coveralls and engineering controls as applicable

B. Mixing, loading and applying to residential ornamentals:
Long pants, a long-sleeved shirt and chemical resistant gloves

C. Mixing, loading and applying bran bait for agricultural uses:
Cotton coveralls over a single layer, chemical resistant gloves, open cab broadcast spreader

D. Mixing and loading liquids for agricultural scenarios:
Closed mixing, maximum PPE (chemical resistant coveralls over long pants and a long-sleeved shirt and chemical resistant gloves)

E. Mixing and loading wettable powders for agricultural scenarios:
Open mixing, Water Soluble Packaging (WSP) and maximum PPE

F. Applying by air:
Cotton coveralls over a single layer

G. Applying by groundboom for agricultural scenarios:
Closed cab, cotton coveralls over a single layer.

H. Applying by airblast:
Open cab, maximum PPE with chemical resistant headgear.

or

Closed cab, cotton coveralls over a single layer.

I. Applying by right-of-way sprayer:
Open cab, maximum PPE.

J. Applying by handheld equipment for agricultural scenarios:
Maximum PPE with a respirator.

Occupational non-cancer and cancer risk estimates associated with applying, mixing and loading for agricultural uses generally meet the targets provided that engineering controls and/or PPE are used as summarized in Section 8. Tables 3, 4 and 5 of Appendix V summarize the calculated ARIs and cancer risks for mixers/loaders and applicators.

In most cases, the Pesticide Handlers Exposure Database did not contain appropriate data sets for estimating exposure to workers wearing chemical-resistant coveralls or a respirator. This was estimated by incorporating a 90% clothing protection factor for chemical resistant coveralls and 90% protection factor for a respirator into the unit exposure data. Similarly, a 90% protection factor was applied to head and neck dermal unit exposure values for chemical resistant head-gear. Chemical resistant head gear includes so'westers, or large brimmed, water proof hats, and hoods with sufficient neck protection. It is crucial to consider head-gear as a mitigation measure for this risk assessment as closed cab airblast equipment is not always feasible in orchards.

Inhalation exposures were based on light inhalation rates (17 litres per minute (LPM)) except for backpack applicator scenarios, which were based on moderate inhalation rates (27 LPM).

Mixer/loader/applicator exposure estimates are based on the best data available 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 acceptable chemical-specific handler exposure data were submitted for carbaryl; therefore, dermal and inhalation exposures were estimated using data from the PHED and the Outdoor Residential Exposure Task Force Database (ORETF). 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 ORETF is generated from several exposure studies that monitored the exposure of workers mixing, loading and applying pest control products to residential turf and gardens.

Occupational non-cancer risk estimates associated with mixing, loading and applying to turf on residential lawns, golf courses and sod farms have ARIs of less than the target of 1.0 for all

broadcast application scenarios, except for groundboom application on golf courses with closed cab tractors and closed mixing/loading engineering controls as summarized in Appendix VIII (Table 12, 13 and 14). The ARI for spot treatment with low pressure turf gun equipment is above the target of 1.0 and is therefore not of concern. Cancer risk estimates associated with the occupational mixing, loading and applying of carbaryl to turf and residential vegetable and ornamental gardens are not of concern (Appendix VIII, Tables 15 and 16).

3.2.2.2 Postapplication Worker Exposure and Risk Assessment

The postapplication occupational risk assessment considered exposures to workers entering treated sites. Based on the carbaryl use pattern, there is potential for short- to intermediate-term postapplication exposure to carbaryl residues for workers.

All submitted chemical-specific dislodgeable foliar residue (DFR) and turf transferable residue (TTR) data were considered. Activity specific transfer coefficients (TC) were used to estimate postapplication exposure resulting from contact with treated turf and foliage at various times after application. DFR and TTR data include the amount of residue that can be dislodged or transferred from a surface, such as the leaves of a plant or turf. A TC is a factor that relates worker exposure to dislodgeable residues. TCs are specific to a given crop and activity combination (for example, hand-harvesting apples, scouting late season corn) and reflect standard work clothing worn by adult workers. Postapplication exposure activities include (but are not limited to) aerating, fertilizing, pruning, scouting and mowing in turf; hand-harvesting, pinching, pruning and thinning for ornamental and agricultural crops; and transplanting and harvesting treated sod.

For workers entering a treated site, restricted entry intervals are calculated to determine the minimum length of time required before people can enter safely. An REI is the duration of time that must elapse before residues decline to a level where performance of a specific activity the results in exposures above the target MOE (i.e. greater than 300 for short- to intermediate-term exposure scenarios).

A TTR study conducted with a granular formulation of carbaryl was submitted by the registrant; however, the products registered for use on turf in Canada are liquids and wettable powders. TTR data from the application of a granular formulation is not considered applicable for representing expected residues from turf treated with liquid, dust or wettable powder formulations.

Turf transferable residue data was used to estimate postapplication exposure to treated turf at various times after application. A turf transferable residue and decline study was conducted at three field research facility sites in California, Georgia and Pennsylvania. Transferable residues were sampled using the Modified California Roller method. Residues were measured on turf following two applications of Dragon Sevin Liquid by groundboom sprayer, done seven days apart with irrigation following each application. This study is not considered to be relevant to Canadian use patterns since the turf was irrigated following application and Canadian labels for turf application state not to water for two days following application. For this reason, only the pre-irrigation residue data was considered for use in the risk assessment for turf.

Five dislodgeable foliar residue (DFR) studies were considered in the risk assessment for carbaryl. Four of these studies were completed by the Agricultural Re-entry Task Force (ARTF) as part of their data generation effort, and, as they were conducted with carbaryl, their chemical-specific dissipation data were considered in this assessment. These studies were performed on tobacco, cabbage, sunflowers and olives. An additional study performed on chrysanthemums was also submitted, but was determined to be of concern for use in the risk assessment due to study limitations.

Based on a comparison of application equipment, foliage type, application rate, crop canopy, study conditions and climatic zone, the olive, tobacco, and cabbage DFR studies were used to estimate dislodgeable foliar residues for Canadian agricultural crops and ornamentals. See Table 3.2.2.2 for a list of which studies were used to estimate residues on registered Canadian agricultural crops and ornamentals. The sunflower DFR was not used in the risk assessment as the other DFR studies were considered to be more representative of Canadian scenarios. None of the DFR studies was considered to be representative of grapes and residential ornamentals therefore, a default peak DFR value of 20% of the application rate with a default dissipation rate of 10% per day was used in the risk assessment.

Due to the limited number of acceptable DFR studies available to the PMRA for the postapplication risk assessment, the extrapolation of study DFR data to a wide variety of crops was required. Since the studies available are not necessarily representative of some Canadian crops, this extrapolation represents an uncertainty in the postapplication assessment.

Table 3.2.2.2 Available DFR Studies and their Application to Canadian Crops

Study	Study Data		Canadian Crops
	Initial Deposition at Day 0[a]	Daily Dissipation[b]	
ARTF Cabbage Weeding Study	10.6%	19.0%	Asparagus, beans, beet (root), horseradish, radish, rutabaga (root), salsify (root), turnip (root), carrot, broccoli, Brussels sprouts, cabbage, cauliflower, celery, lettuce, kohlrabi, beet tops, Chinese cabbage, dandelion, endive, kale, leaf lettuce, mustard greens, parsley, salsify (tops), spinach, Swiss chard, turnip (tops), watercress, parsnips, peas, potatoes, snapbeans, tomatoes, eggplants, peppers, cucumbers, melons, squash, azalea, carnation, chrysanthemums, gladiolus, holly, hydrangea, lilac, rose, zinnia
ARTF Tobacco Harvesting Study	19.0%	20.5%	Alfalfa, clover, ditch banks, field borders, rights-of way, wastelands, headlands, forage grasses, pastures, rapeseed (canola), sweet white lupin, barley, oats, rye, wheat, corn (field and sweet), tobacco, blackberries, boysenberries, dewberries, loganberries, raspberries, blueberries, cranberries,

			strawberries, cranberries
ARTF Olive Pruning Study	20% [c]	9.88%	Balsam fir, spruce, forests, trap trees, apples, pears, apricots, peaches, plums, prunes, cherries, choke cherries, green ash, high value trees, arborvitae, birch, boxwood, dogwood, elm, juniper, maple, oak, pine
PMRA Default Values [d]	20%	10%	Grapes, residential ornamentals

[a] Initial Deposition is considered to be the percentage of the application rate (kilograms per hectare) that is dislodgeable.
[b] Daily dissipation is the rate at which the dislodgeable foliar residue is lost to the environment; derived from the slope of the DFR curve (ln of dislodgeable residue vs. time).
[c] The initial deposition of 3.4% from the Olive Pruning Study was not considered representative of Canadian crops. Instead, the default value of 20% was applied.
[d] The available DFR data could not be extrapolated to some Canadian crops. Instead, default PMRA values were applied.

The postapplication risk estimates include a number of conservative inputs, such as the assumption that workers are exposed to carbaryl for eight hours a day following an application at the maximum rate. However, the DFR data are not considered conservative since the test sites most similar to the Canadian climate (North Dakota–Sunflower Study) had the highest peak DFR (32%).

The assessments could be refined and uncertainties reduced with the following data:

- Enhanced information on the carbaryl use pattern, including typical rates and number of applications per season;
- Survey information on critical worker activities that typically take place for each crop during the use season, and the timing of these activities with respect to crop growth and applications of carbaryl;
- DFR data for key Canadian crops conducted under typical Canadian use conditions; and
- Passive dosimetry or biological monitoring data.

With these additional data and information, it is expected that the estimated exposure and risk would decrease.

Based on the non-cancer risk assessment, the postapplication risks to workers performing high-exposure activities, such as mowing treated turf and transplanting and harvesting sod, do not meet the target MOE (i.e. MOE < 300) until 26 days after treatment (Appendix IX, Table 17). The postapplication risks to workers hand harvesting, pinching, pruning and thinning ornamentals do not meet the target even 30 days after treatment (Appendix IX, Table 18). These REIs are not considered feasible for residential, golf course or sod farm scenarios.

Based on, available data, for agricultural scenarios to achieve the target MOEs for postapplication workers, most current REIs would need to be significantly increased in length or new REIs would need to be added to the label. Appendix VI summarizes the calculated REIs for selected agricultural postapplication activities, based on the exposure data currently available and the target MOE of 300.

The postapplication risks to workers performing high-exposure activities, such as thinning, pruning and harvesting fruit trees, and low-exposure activities, such as scouting fruit trees, do meet the target MOE (i.e. MOE > 300) if risk mitigation measures are implemented. The newly calculated REIs are largely considered agronomically feasible, given the timing of application in relation to the crop cycle. However, some of these REIs may not be practical for growers.

Appendix VI shows the cancer and non-cancer risk estimates based on the proposed REIs.

Postapplication cancer risks for workers performing re-entry activities are not of concern (Appendix IX, Tables 19 and 20).

3.2.3 Non-Occupational and Residential Exposure and Risk Assessment

Non-occupational risk assessment estimates risks to the general population, including children, during or after pesticide application in and around the home. There are several domestic products containing carbaryl registered for use in Canada on turf, ornamentals and vegetable gardens.

3.2.3.1 Residential Mixer, Loader and Applicator Exposure and Risk Assessment

There are potential exposures for homeowners mixing, loading, and applying domestic class products containing carbaryl. The following uses were assessed:

- Mixing/loading and applying liquid and dust formulations to residential turf; and
- Mixing/loading and applying liquid and dust formulations to residential ornamental and vegetable gardens.

Based on the expected number of applications (two per year), homeowners applying carbaryl would generally have a short-term (1–30 days) duration of exposure. The PMRA estimated handler exposure based on homeowners wearing:

- short sleeves, short pants and no protective gloves; and
- short sleeves, long pants and no protective gloves.

Mixer/loader and applicator exposure estimates for homeowners were generated in two ways:

i) The PMRA's standard approach (using default and chemical-specific inputs), and

ii) Using a chemical specific biomonitoring study that included adult applicators.

In the standard approach, dermal and inhalation exposures were estimated using data from the Pesticide Handlers Exposure Database (PHED) and the Outdoor Residential Exposure Task Force Database (ORETF). Refer to Section 3.2.2.1 for information regarding PHED and ORETF data.

A biomonitoring study measured the exposure of homeowners and their families after domestic application of Sevin Garden Tech Ready-to-Spray (22.5% carbaryl liquid) to their residential lawns and gardens. A total of 23 families were monitored between two different sites: California and Missouri. Each family consisted of an applicator, spouse and at least one child between the ages of 4 and 17. The study participants included 23 applicators, 28 non-applicator adults, and 55 children aged 4 to 17. Total 24-hour urine samples were collected from each participant for two days prior to application and for four consecutive days starting at the time of application. Quality control and recovery analysis were also performed. The mean amount of carbaryl absorbed (adjusted for body weight) was 19.05 µg/kg bw for applicators.

Homeowner non-cancer risk estimates associated with mixing, loading and applying for current label uses do not meet the target ARI of 1.0 for most of the broadcast application scenarios to turf as summarized in Appendix IX, Table 21 and Appendix X, Table 23. Non-cancer risk estimates for homeowners mixing, loading and applying carbaryl to ornamental and vegetable gardens are above the target ARI (Appendix X, Table 22). The registrant did submit pharmacokinetic data to refine mixer/loader/applicator risk; however, these data were deemed of concern for refinement purposes.

Cancer risk estimates for homeowners mixing, loading and applying carbaryl to residential lawns and gardens are not of concern (Appendix X, Table 24).

3.2.3.2 Residential Postapplication Exposure and Risk Assessment

The residential postapplication risk assessment considered exposures to adults and children entering treated turf and gardens. Based on the carbaryl use pattern, there is potential for short- to intermediate-term postapplication exposure to carbaryl residues for these populations. Postapplication exposure activities include dermal exposure from contacting treated lawns and incidental oral exposure for toddlers from hand-to-mouth exposure to turf, turf mouthing and soil ingestion. Postapplication exposure estimates on residential lawns and ornamentals were generated in two ways:

i) Using PMRA's standard approach (using default and chemical-specific inputs); and
ii) using a chemical specific biomonitoring study that included children (ages 4 to 17) and non-applicator adults.

The residential lawn assessment includes the consideration of exposure on recreational turf such as parks, schools and public areas. See Section 3.2.3.1 for details of the biomonitoring study.

Based on the biomonitoring study, the mean amount of carbaryl absorbed (adjusted for body weight) was 8.07 µg/kg bw and 49.24 µg/kg bw for non-applicator adults and children (ages 4 to 17), respectively. Children were further subdivided by age. The youngest children, ages 4 to 5, had a total absorbed dose of 44.58 µg/kg bw. Children between the ages of 6 and 10 had the highest exposure of the whole population (78.26 µg/kg bw). Between the ages of 11 and 15, the mean exposure was 31.52 µg/kg bw. Children aged 16 to 17 had the lowest exposure of 3.7 µg/kg bw, although there were only three participants in this age group. The registrant did

submit pharmacokinetic data to refine the mixer/loader/applicator risk, however; these data were deemed of concern for refinement purposes.

For both approaches, all non-cancer risk estimates calculated for postapplication exposure to turf and ornamentals are below the target for adults, youths and toddlers (Appendix XI, Tables 25, 27 and 28) with the exception of golfer exposure (Appendix XI, Table 26) and exposure from treated ornamental trees. REIs are not considered feasible for residential scenarios.

Cancer risk estimates for postapplication exposure to turf and ornamentals are not of concern (Appendix XII, Tables 29 and 30).

No data are available to assess, the postapplication risk from dust formulations on turf and ornamentals; however, exposure is expected to be as high as exposure to liquids and is, therefore, expected to be of concern. Postapplication exposure was estimated assuming a single application. Carbaryl may be applied multiple times in one season, resulting in a potential for increased postapplication exposure and correspondingly lower MOEs and/or ARIs than those presented.

3.2.3.3 Exposure and Risk Assessment for Non-occupational Harvesters in Pick-Your-Own Operations

Pick-Your-Own (PYO) farms are those that allow the public to harvest their own fruits and vegetables. As PYO fruit and vegetable operations become more and more prevalent (recent research indicates that berry farms are more profitable with PYO seasons), the PMRA recognizes the need for a means of assessing exposure to pesticides during hand-harvesting by members of the public. For the purposes of this risk assessment, PYO facilities are considered to be commercial farming operations that allow public access for harvesting in large-scale fields or orchards treated with commercially labelled carbaryl products.

Although there are many PYO operations involving a wide variety of produce across Canada, only a few orchard and berry crops can be readily eaten in quantity during the harvest. For those PYO crops that do not represent acute dietary exposure, the hand harvest exposure is covered off by the occupational postapplication exposure assessment.

The PYO assessment for carbaryl focuses on apples and blueberries, which are likely candidates for consumption during harvest. In addition, the exposure incurred from harvesting or consuming apples and blueberries is considered representative of all orchard and berry crops to which carbaryl is applied to based on the current use pattern and dietary assessment (i.e. relatively high application rates, transfer coefficients, chronic and acute dietary exposure). As there is potential for a person to be exposed through contact with treated foliage as well as eating the fruits that they are harvesting, both dermal and dietary exposure were aggregated in the PYO non-cancer risk assessment. As there is a cancer risk associated with the use of carbaryl, a lifetime cancer risk assessment from harvesting and consuming PYO fruit was also conducted.

Since members of the public who harvest at PYO facilities may be of any age, the risk assessment was conducted for toddlers, youths and adults. Two exposure pathways were

considered: ingestion of fruit and dermal exposure through contact of the fruit while harvesting. Maximum residue limits (MRLs) were used to estimate the residue of fruits consumed. The MRL is the maximum residue found in field trials, as could potentially occur in a PYO scenario. DFR data were used to estimate the residue dislodged for dermal exposure during harvesting. Acute consumption of apples and blueberries was based on the USDA Continuing Surveys of Food Intakes by Individuals, 1994–1996 and 1998.

The PYO risk assessment for carbaryl aggregated the dermal exposure from hand harvesting fruit, oral exposure from consumption of fresh fruit during the harvest and chronic dietary exposure (to account for background exposure to carbaryl from all routes, including food and drinking water). Results of the aggregate non-cancer PYO risk assessment are presented in Table 10 of Appendix VII. As indicated in Table 10, the ARIs for non-cancer aggregate exposure do not meet the target ARI of 1.0 for apples, while the determined ARIs for blueberries were greater than 1.0 at the proposed restricted entry interval. The PYO risk assessments could be refined with the following data:

- Enhanced information on the carbaryl use pattern, including typical rates and number of applications per season;
- Crop-specific residue data for Canadian berry and orchard crops at harvest; and
- Consumption data for orchard crops and berries that occur in the field while harvesting.

The aggregate cancer risk for PYO operations was calculated by summing all the lifetime average daily dose (LADD) values from all routes of dermal and dietary exposure. The total lifetime LADD was then compared to the Q_1* to obtain cancer risk estimates. Results of the PYO exposure cancer risk assessment are summarized in Appendix VII Table 11. Provided that the determined REIs listed in Appendix VI Table 6 are observed, the calculated cancer risks from exposure incurred while hand harvesting at a PYO operation are below the threshold of 10^{-6} and are not of concern to the Agency.

3.3 Dietary 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. Exposure to carbaryl from potentially treated imports is also included in the assessment. These dietary assessments are age specific and incorporate the different eating habits of the population at various stages of life. For example, the assessments take into account differences in children's eating patterns, such as food preferences and the greater consumption of food relative to their body weight when compared to adults. Dietary risk is then determined by combining the exposure and toxicity assessments. High toxicity may not indicate high risk if the exposure is low. Similarly, there may be risk from a pesticide with low toxicity if the exposure is high. The PMRA considers limiting the use of a pesticide when the risk exceeds 100% of the reference dose. The PMRA's Science Policy Note SPN2003-03, *Assessing Exposure from Pesticides, A User's Guide*, presents detailed acute and chronic risk assessments procedures.

Surveillance data representative of the national food supply were used to derive a more accurate estimate of residues that may remain on food when it is purchased. These include the Canadian

Food Inspection Agency's National Chemical Residue Monitoring Program and the United States Department of Agriculture Pesticide Data Program (PDP). When no monitoring data were available, residue estimates used in the dietary risk assessment (DRA) may be conservatively based on field trial data representing the residues that may remain on food after treatment at the maximum label rate. Specific and empirical processing factors (DEEM defaults) as well as specific information regarding percent of crops treated were incorporated to the greatest extent possible.

Acute, chronic and cancer dietary risk assessments were conducted using the Dietary Exposure Evaluation Model (DEEM–FCID™, Version 2.03), which uses updated food consumption data from the United States Department of Agriculture's Continuing Surveys of Food Intakes by Individuals, 1994–1996 and 1998.

For more information on dietary risk estimates or residue chemistry information used in the dietary assessment, see Appendices XIII and XIV.

3.3.1 Determination of the Acute Reference Dose

The acute reference dose (ARfD) for carbaryl is based on decreased brain cholinesterase activity in postnatal day 11 male pups after a single gavage dose at the LOAEL of 3 mg/kg bw in a comparative cholinesterase assay in rats. Benchmark dose modelling was used to refine the point of departure. Accordingly, a $BMDL_{10}$ of 1.13 mg/kg bw was established for this endpoint. This endpoint is supported by the NOAEL of 1 mg/kg bw/day from the developmental neurotoxicity study, in which maternal rats exhibited cholinesterase inhibition (plasma, erythrocyte, and brain), as well as neurobehavioural effects and decreased weight gain at the LOAEL of 10 mg/kg bw/day. The standard uncertainty factor of 100 is required to account for interspecies extrapolation (10-fold) as well as intraspecies variability (10-fold). With respect to the *Pest Control Products Act* factor, all of the required studies relevant to assessing risks to infants and children were available for this assessment. While sensitivity in the young was demonstrated, the *Pest Control Products Act* factor can be reduced from 10-fold to 1-fold based on the rationale provided in Section 3.1.1 *Pest Control Products Act* Hazard. Therefore, the composite assessment factor (CAF, i.e. combined uncertainty and *Pest Control Products Act* factors) is 100-fold.

The ARfD is calculated to be 1.13 mg/kg bw ÷ 100 = 0.011 mg/kg bw and is considered to be protective of all populations including infants and children. This ARfD provides a margin of 282 to the developmental NOAEL of 3.1 mg/kg bw/day in dogs and 455 to the offspring NOAEL of 5 mg/kg bw/day from a reproductive toxicity study in rats.

3.3.2 Acute Dietary Exposure and Risk Assessment

Acute dietary risk was calculated considering the highest ingestion of carbaryl that would be likely on any one day, and using food consumption and food residue values. A statistical analysis allows all possible combinations of consumption and residue levels to be combined to estimate a distribution of the amount of carbaryl that might be consumed in a day. When the expected intake of residues is less than the ARfD, then acute dietary exposure is considered to be not of concern.

Probabilistic acute dietary exposure analyses were performed to determine the exposure and risk estimates resulting from the use of carbaryl on domestic and imported agricultural commodities.

For carbaryl, the acute dietary exposure risk estimates for all Canadian population groups at the 99.9^{th} percentile ranged from 29% for the general population to 54% for children 1–2 years old.

3.3.3 Determination of Acceptable Daily Intake

The acceptable daily intake (ADI) for carbaryl is again selected from the comparative cholinesterase assay in rats. This BMDL10 of 1.13 mg/kg bw is based on decreased brain cholinesterase activity in post-natal day 11 male pups. In the case of carbaryl, chronic daily exposure is considered to reflect a series of ongoing acute exposures, with each causing transient inhibition of cholinesterase. The quick acting and reversible nature of cholinesterase inhibition in carbamates is considered justification to default to the acute $BMDL_{10}$, which is similar to or lower than the subchronic or chronic NOAELs and lower than the NOAEL for offspring toxicity (5 mg/kg bw/day) noted in the reproductive toxicity study. The $BMDL_{10}$ of 1.13 mg/kg bw is also supported by the NOAEL of 1 mg/kg bw/day in both a Developmental Neurotoxicity Study and a subchronic neurotoxicity study, as well as by a LOAEL of 3.1 mg/kg bw/day from a one year dog study (the NOAEL was not determined). A total uncertainty factor of 100 is required to account for standard uncertainty factors of 10-fold for inter-species extrapolation and 10-fold for intra-species variability. Similar to the ARfD, the *Pest Control Products Act* factor is reduced to onefold, based on the rationale provided in the *Pest Control Products Act* Hazard Consideration section (section 3.1.1). Therefore, the CAF is 100-fold.

The resulting ADI is $1.13 \div 100 = 0.011$ mg/kg bw/day, and is considered to be protective of all populations including infants and children.

3.3.4 Chronic Dietary Exposure and Risk Assessment

The chronic dietary risk was calculated using the average consumption of different foods as well as the average residue values on those foods. The expected intake of residues was then compared to the ADI. When the expected intake of residues is less than the ADI, then chronic dietary exposure is not of concern.

Deterministic chronic dietary exposure analyses were performed to determine the exposure and risk estimates resulting from the use of carbaryl on domestic and imported agricultural commodities.

The chronic potential daily intake accounted for less than 1% of the ADI for all population groups and is, therefore, not of concern.

3.3.5 Carcinogenic Dietary Exposure and Risk Assessment

The cancer dietary risk was calculated using the average consumption of different foods and the average residue values on those foods. The expected intake of residues was then compared to the Q^*_1. Deterministic cancer dietary exposure analyses were performed in order to determine the exposure and risk estimates that result from the use of carbaryl on domestic and imported agricultural commodities. A lifetime cancer risk that is below 1×10^{-6} usually does not indicate a risk of concern for the general population when exposure occurs through pesticide residues in or on food, or to otherwise unintentionally exposed persons. Based on the Q^*_1 approach, the lifetime cancer risk estimate from dietary exposure is 6.9×10^{-8} for the general population and is not of concern.

3.4 Exposure from Drinking Water

3.4.1 Concentrations in Drinking Water

Concentrations of carbaryl in drinking water were estimated using both modelling results and monitoring data. Summary statistics from the modelling and monitoring are presented in Table 1. Monitoring data indicate concentrations known to exist in the environment but may not capture the peak concentrations due to the nature of sampling. Therefore, monitoring data are generally considered as a lower bound on the peak environmental concentration. Modelling estimates are developed with conservative assumptions and are generally considered upper bound estimates.

Table 1 Drinking Water Concentrations Estimated from Models and Monitoring Data

	Groundwater Concentration (µg/L)		Surface-Water Acute Concentration (µg/L)		Surface-Water Chronic Concentration (µg/L)	
	Acute	Chronic	Reservoir	Dugout	Reservoir	Dugout
Upper Bound	NA	NA	287 [3]	344 [3]	11.9 [5]	13.7 [5]
Lower Bound	0.73 [1]	0.03 [2]	14.3 [4]		0.1 [6]	

NA Modelling did not provide a reasonable upper bound estimate, as detections of carbaryl in groundwater were observed but not predicted by the modelling.

1 From monitoring data: 95th percentile of the maximum detected concentration in groundwater

2 From monitoring data: 95th percentile of the arithmetic means in groundwater (includes detects and non-detects at ½ LOD)

3 From modelling results: 90th percentile of the annual peak concentrations at Level 2

4 From monitoring data: 95th percentile of the maximum detected concentrations in surface water

5 From modelling results: 90th percentile of the annual average concentrations at Level 2

6 From monitoring data: 95th percentile of the arithmetic means in surface water (includes detects and non-detects at ½ LOD)

Surface-Water
Estimated environmental concentrations (EECs) in surface water were calculated using the PRZM/EXAMS models to simulate carbaryl runoff from a treated field into an adjacent water body as well as the fate of this pesticide within the water body. Level 2 EECs were modelled based on the turf use scenario at an annual application rate of 42 kg a.i./ha.

Given that this proposed re-evaluation decision (PRVD) is proposing the phase-out of turf uses of carbaryl, the scenario used for surface water modelling does not specifically represent the potential exposure following this implementation. The next highest application rates occur on field tobacco (16.31 kg a.i./ha), trees and ornamentals (14.67 kg a.i./ha), asparagus (11 kg a.i./ha), and fruits (10.95 kg a.i./ha). Based on preliminary modelling, it appears that these uses with the next highest application rates will generate more runoff than the turf scenario. Thus, the decrease in application rates will be partially counterbalanced by an increase in modelled runoff, and it is expected that the resulting drinking water EECs for other uses with lower application rates will not decrease greatly.

Surface water monitoring studies from both Canada and the United States (Appendix XVII) were reviewed and assessed. The majority of the Canadian monitoring data originated from Quebec, resulting in the monitoring data being regionalized. Despite the uncertainties associated with the monitoring data, this data set contains a large number of samples that were collected and analyzed over a number of years.

The surface water monitoring values used in this assessment include both the Canadian and American data. Although the United States data set contains some concentrations that are larger than those measured in Canada, the Unites States data were used in the assessment because the Canadian data are not as comprehensive.

Ground Water
Level 1 groundwater modelling of carbaryl was calculated using the LEACHM model, which resulted in no predicted residues of carbaryl reaching groundwater. However, monitoring data do indicate some detections of carbaryl in groundwater (see Appendix XVII). There are several possible explanations for the difference between groundwater modelling and monitoring. First, the model simulates leaching through soil as a porous medium and does not account for the potential “short-circuiting” of flow through preferential channels, such as soil cracks and worm burrows, which can allow for a more rapid transport of chemicals to the water table. Second, the model calculations were done using a hydrolysis rate at 24°C. Canadian soils are, on average, cooler than this temperature, and the hydrolysis rate is likely slower; thus, for groundwater, the modelled EECs are likely underestimates and larger concentrations were reported in the monitoring data. Nevertheless, the surface-water EECs are still greater than the groundwater EECs, and these were used in the dietary risk assessment.

Potential Model Refinement
The modelled drinking water EECs could be potentially refined with the use of information on percent cropped area (PCA). The water modelling conducted assumed that 100 percent of the watershed was treated with carbaryl, which is a conservative assumption that could potentially be refined with the PCA data. During this consultation process, the PMRA encourages the registrant to submit Canada-specific PCA data for use in refining the modelled EECs.

3.4.2 Drinking Water Exposure and Risk Assessment

Carbaryl residues in potential drinking water sources were estimated using the modelling estimates and monitoring data discussed in the previous section.

Chronic and Cancer Exposure
For chronic and/or cancer exposure assessments, average food and water exposures are generally considered when estimating exposures relevant for lifetime exposure. Monitoring data were used to assess the contribution of drinking water in the chronic and cancer scenarios because, in this case, the monitoring data are considered to be more representative of average concentrations than the upper bound modelling estimates. Additionally, groundwater modelling did not provide a reasonable upper bound estimate as detections of carbaryl in groundwater were observed but not predicted by the modelling.

Acute Exposure
In general, pesticide concentrations in water are highly variable in time and location. In this case, the modelling estimates, which were developed using conservative assumptions, are considered upper bound estimates that could potentially be refined with additional data. The available monitoring data may not capture the peak concentrations; therefore comparing monitoring results to modelling is not straightforward. The two types of data are complementary and should be considered in conjunction with each other when considering the potential acute exposure through drinking water.

3.5 Aggregate (Food and Water) Risk Assessment

Aggregate exposure is the total exposure to a single pesticide that may occur from food, drinking water, residential and other non-occupational sources as well as from all known or plausible exposure routes (oral, dermal and inhalation). Because it is proposed that residential uses of carbaryl be discontinued, the aggregate risk assessment is based on dietary and drinking water exposures only. For carbaryl, acute aggregate exposure is, therefore, derived from dietary and drinking water exposures (see Section 3.3 and Section 3.4).

3.5.1 Aggregate Acute Exposure and Risk Assessment

Acute exposure estimates are presented based on both modelling and monitoring drinking water data. When using the drinking water modelling results, the acute aggregate exposure for carbaryl for all Canadian population groups at the 99.9th percentile was 117% and 393% of the acute reference dose for the general population and all infants, respectively. Under this scenario, the

complete daily 50-year period distribution of acute concentrations was considered in the residue file editor of DEEM-FCID.

The drinking water modelling data is considered an upper bound estimate, based on the conservative assumption that 100% of the watershed is treated. This estimate could potentially be refined with "percent cropped area" data.

Based on the 95th percentile from surface water monitoring studies, exposures ranged from 37% of the acute reference dose for the general population to 73% for all infants. Although the monitoring data may not capture peak concentrations immediately after use, it is a data set that contains a large number of samples collected over a number of years (Appendix XIII, Table 32).

3.5.2 Aggregate Chronic Exposure and Risk Assessment

A deterministic aggregate chronic (food and water) exposure assessment resulted in less than 2% of the ADI for all sub-populations and is, therefore, not of concern (Appendix XIII, Table 31).

3.5.3 Aggregate Cancer Exposure and Risk Assessment

A deterministic aggregate cancer (food and water) exposure assessment showed that the lifetime cancer risk estimate based on the Q_1 approach was approximately 7.1×10^{-8} for the general population and is, therefore, not of concern (Appendix XIII, Table 31).

4.0 Impact on the Environment

4.1 Fate and Behaviour in the Environment

Based on its physical-chemical properties (Section 2.2), carbaryl is very soluble in water, is not likely to volatilize from moist soil or water surfaces under field conditions, and is not likely to bioaccumulate in organisms. Environmental fate data for carbaryl are summarized in Table 1 of Appendix XVIII. Carbaryl is relatively labile and dissipates from soil and aquatic systems by hydrolysis and biotransformation. Phototransformation is not an important route of transformation for carbaryl in water and soil. The major transformation product of carbaryl is 1-naphthol.

Laboratory studies on adsorption/desorption and soil column leaching indicate that carbaryl is very mobile in soil. Carbaryl met all criteria identifying it as leacher. In contrast, field studies conducted in Canada and the United States detected carbaryl and its transformation products in only the top 30 cm of soil. Leaching is most probably offset by microbial degradation. Canadian water monitoring data have shown trace detections in groundwater, whereas carbaryl was detected in groundwater in the United States.

Carbaryl can enter the aquatic environment through spray drift and runoff from the application field. Based on modelling results and monitoring data, carbaryl can impact the aquatic environment (Appendix XVIII). Once in the aquatic environment, carbaryl is not expected to persist based on the environmental fate data. Given the lack of persistence demonstrated by

carbaryl, the detections in the water monitoring data indicate recent additions of carbaryl to surface water bodies.

4.2 Effects on Non-target Species

The environmental risk assessment determines the potential for adverse ecological effects in each environmental compartment by comparing the ratio of the estimated environmental exposure to the ecotoxicological effect. The EEC is the initial or cumulative concentration of pesticide in the various sources of food, water and soil to which the organism is exposed. EECs are calculated using different methods for each medium (food, water or soil). If multiple applications of pesticide are used, cumulative EECs are determined by using the time taken to decline to 50% of the original application (DT_{50}) using the minimum time interval between applications for each environmental media.

The risk assessment is initially conducted using a screening level scenario that assumes maximum exposure (EEC) and the most sensitive toxicological endpoint for the organism of interest. This assumes direct application or overspray to the environmental media (food, water, soil) to which the organism is exposed. This is the most conservative scenario and generally does not reflect the exposure to which an organism would be subject when the pesticide is applied according to the label instructions. Risk to the environment is calculated as a risk quotient (RQ), which is the ratio between the environmental exposure and the toxicological endpoint for the organism (i.e. RQ = EEC/toxicological endpoint). The threshold or level of concern for potentially harmful effects on an organism is an RQ value of 1 where the exposure equals exactly the toxicological endpoint. RQ values greater than or equal to 1 are considered to equal or exceed the level of concern, which may result in potentially harmful effects to the organism. RQ values of less than 1 are considered to be of negligible risk to the organism because they are below the threshold for harmful effects. In the latter case, no further assessment is carried out. If the RQ is greater than or equal to 1, the level of concern, then a refinement of the risk assessment is carried out to assess the level of concern using scenarios that are a better approximation of exposure or toxicological effects as well as less conservative. Refinements can include (i) exposure from the fraction of pesticide that drifts onto non-target habitats, instead of assuming 100% overspray, and (ii) exposure from the amount of pesticide predicted in runoff, instead of assuming direct overspray to water (i.e. 100% exposure). The refinements may also consider different toxicity endpoints or a percentile of a species sensitivity distribution rather than the most sensitive endpoint. They may also consider the results of a mesocosm study using several species rather than the toxicity from a single species. Further refinements to the risk assessment may consider the use of monitoring data (Appendix XVIII, Tables 1 and 2) collected in the field rather than EECs generated by a model. The risk assessments are summarized in Appendix XVIII, Tables 3,4,5,6 and 7.

4.2.1 Effects on Terrestrial Organisms

The risk assessment for terrestrial organisms was based on an evaluation of toxicity data on carbaryl to earthworms, bees, two species of mammals and several species of birds. No data on the toxicity to plants were available for review. A summary of terrestrial toxicity data for carbaryl is presented in Table 2 (Appendix XVIII). For the assessment of risk, toxicity endpoints

chosen from the most sensitive species were used as surrogates for the wide range of species that can be potentially exposed following treatment with carbaryl.

The screening level risk assessment indicated that exposure to carbaryl poses a risk to earthworms, bees, mammals and birds. Table 3 (Appendix XVIII) summarizes the risk assessment from carbaryl to terrestrial organisms based on the conservative assumption that 100% of the diet is contaminated; however, given the mobile nature of birds and mammals, the exposure would be less. To better characterize the risk, an assessment that included scenarios representing exposure in non-target areas resulting from spray drift was also conducted (Table 4, Appendix XVIII).

4.2.2 Effects on Aquatic Organisms

Acute and chronic risk to aquatic organisms was based on an evaluation of toxicity data on carbaryl for thirteen freshwater species (three invertebrates, nine fish and one algae) and three estuarine/marine species (two invertebrates and one fish). A summary of the aquatic toxicity data for carbaryl and its major transformation product 1-naphthol is presented in Table 2 (Appendix XVIII). For the assessment of risk, toxicity endpoints chosen from the most sensitive species were used as surrogates for the wide range of species that can be potentially exposed following treatment with carbaryl.

The risk assessment was conducted using data for the most sensitive freshwater and marine/estuarine organisms. Table 5 (Appendix XVIII) summarizes the assessment of risk from carbaryl to aquatic organisms.

The screening level risk assessment indicated that carbaryl poses a risk to aquatic organisms: invertebrates, fish, algae and amphibians (based on surrogate data from fish studies). The LOC was exceeded many times (1.3–3000) at the cumulative application rate of 5.57 and 36 kg a.i./ha. Thus, a refined risk assessment was triggered that was conducted based on the EECs in the water from 11% of spray drift. The refinement reduced the exceedance of the LOC to <1-333. The refined risk assessment was also conducted with available surface water monitoring data as these were substantial. Acute and chronic exposure values (EECs) were estimated from monitoring data using the 95th percentiles of the maximum and arithmetic mean concentrations (including non-detects) measured in each monitoring study/site, respectively. It was determined that freshwater invertebrates are at risk (RQ 6) of acute adverse effect from carbaryl runoff. All other aquatic species are at negligible risk (RQ<1). Tables 5 and 6 (Appendix XVIII) summarize the refined risk to aquatic organisms from carbaryl spray drift and runoff, respectively.

Additional risk mitigation measures for aquatic environments in the form of buffer zones and label statements are required on the labels of products containing cabaryl (Appendix XIX). The largest buffer zones were 800 m and were for aerial application on forests, woodlands, berries and grapes. Buffer zones were calculated based on the toxicity endpoint for stone fly, the most sensitive species. There was insufficient toxicity data on other aquatic invertebrates to carry out a Species Sensitivity Distribution. Mesocosm studies were also unavailable.

5.0 Value

5.1 Commercial Class Products

Appendix I lists all carbaryl products registered in Canada as of June 2007. Appendix II, Table 1 lists all the Commercial Class product uses for which carbaryl is presently registered and shows which uses the registrant will or will not continue to support. Also presented in Appendix II, Table 1 is whether the use was added through the PMRA Minor Use Program. While currently supported by the registrant, the data supporting the minor uses were originally generated by a user group.

The uses of carbaryl belong to the following use-site categories: feed crops, food crops, industrial oil seed and fibre crops, forestry sites, turf and lawns, ornamental crops and greenhouse crops. Other supported sites include chokecherries (shelterbelt), ditchbanks, field borders, headlands, roadsides, rights-of-way and wastelands.

5.1.1 Commercial Class Uses for Which Information on the Value of Carbaryl is Sought

Appendix III lists those uses of carbaryl that the registrant continues to support but that have risk concerns as a result of this re-evaluation, as well as uses that are not supported by the registrant.

The PMRA welcomes feedback on the availability and extent of the use of chemical alternatives to carbaryl for the uses listed in Appendix III, as well as and information regarding the availability, effectiveness and extent of the use of non-chemical pest management practices for any of the registered uses of carbaryl. This information will allow the PMRA to refine sustainable pest management options for the listed site-pest combinations.

5.2 Domestic Class Products

Domestic Class uses of carbaryl that are supported by the registrant are listed in Appendix II, Tables 2 and 3.

5.2.1 Alternatives to Domestic Class Products

The public is welcome to comment on the viability of registered alternatives to Domestic Class uses of carbaryl that are not supported by the registrant or that pose risk concerns.

5.3 Value of Carbaryl

Agricultural Uses of Carbaryl
In Canada, carbaryl is registered for use on a wide range of crops. It is used for the control of Lepidoptera, Coleoptera and other chewing and sucking insects. Carbaryl is important to the resistance management of various pests in many use-sites. Carbaryl is also used as a growth regulator for the thinning of apples.

The following is based on the use information currently available to the PMRA.

In Canada, carbaryl is used on pome and stone fruit crops, particularly to control, the insect pests of apples and cherries. In addition, surveys of growers indicate carbaryl use for the control of leafhopper on apples.

Carbaryl (Sevin), is reported to be the easiest and safest thinner to use, however, it can be harsh to beneficial insects and mite predators. In British Columbia, the major use of carbaryl on apples is as a chemical fruit thinner followed by as a method of leafhopper control prior to harvest. It has also been shown to be effective in increasing fruit size.

Carbaryl is also reported to be used in Canada on broccoli, cabbage, carrot, cereal, corn, cauliflower, strawberries, raspberries, blueberries, potatoes and wine grapes. These and other uses may increase as a result of the discontinuation and phase-out of other insecticides that are under re-evaluation.

Non-Agricultural Uses of Carbaryl:
In residential settings, carbaryl is used by homeowners for lawn care and gardening (vegetables and ornamentals) as well as pet care. Carbaryl is also used by nursery, landscape, golf course industries on turf and annuals, perennials and shrubs (see Appendix II Table 1).

Alternatives to Carbaryl:
Although there are registered alternative insecticides for many, but not all, of the uses that appear on carbaryl labels, some of these alternatives are currently under re-evaluation. The registered use pattern of these active ingredients may change as their re-evaluation progresses. For example, alternatives containing azinphos-methyl (Update on re-evaluation of azinphos methyl.Re-evaluation Note REV2007-08), are scheduled to be phased out. Many uses of diazinon (Proposed re-evaluation decision on diazinon, PRVD2007-16) are also proposed for phase-out.

6.0 Toxic Substances Management Policy Considerations

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

During the review process, carbaryl was assessed in accordance with the PMRA Regulatory Directive DIR99-03, *The Pest Management Regulatory Agency's Strategy for Implementing the Toxic Substances Management Policy*. Substances associated with the use of carbaryl were also considered, including major transformation products formed in the environment, microcontaminants in the technical product and formulants in the end-use products. The PMRA has reached the following conclusions.

The log *n*-octanol-water partition coefficient (log K_{ow}) of carbaryl is 0.02, which is below the TSMP Track 1 cut-off criterion for log K_{ow} 5.0. As well, carbaryl does not meet the criteria for persistence as its half-life values in water (18-26 days) and soil (20 days) are below the TSMP Track 1 cut-off criteria for water (182 days), sediment (182 days) and soil (182 days).

Carbaryl-containing end-use products do not contain any formulants of health or environmental concern identified in Canada Gazette Part II, Volume 139, Number 24, pages 2641–2643: *List of Pest Control Product Formulants and Contaminants of Health or Environmental Concern*.

Technical grade carbaryl does not contain any contaminants of health or environmental concern identified in Canada Gazette Part II, Volume 139, Number 24, pages 2641–2643: *List of Pest Control Product Formulants and Contaminants of Health or Environmental Concern*.

Therefore, the use of carbaryl is not expected to result in the entry of Track 1 substances into the environment

7.0 Summary

7.1 Human Health and Safety

The toxicology database submitted for carbaryl is adequate to define the majority of toxic effects that may result from human exposure. There were no clear differences between rat and dog or between genders, to the neurotoxic effects of carbaryl. The most sensitive parameter is acetylcholinesterase inhibition, followed by clinical symptoms at same or higher doses, with no evidence of pathological changes to the brain, spinal cord, or peripheral nerve. Post-natal sensitivity of the young to carbaryl was evident based on the increased sensitivity of pups to brain cholinesterase inhibition relative to adults. Brain cholinesterase was inhibited in rat fetuses at the same dose as their mothers, suggesting that fetuses are susceptible to indirect exposure to carbaryl. However, the lack of detail precluded a definitive assessment of prenatal sensitivity to carbaryl. Carbaryl may affect the male reproductive system and the immune system in animals, but the evidence was inconclusive.

Based on the weight of evidence, carbaryl was not genotoxic, although carbaryl did cause cancer in mice and rats. However, tumors in rats occurred at doses that caused severe systemic toxicity such that the cancer risk assessment was based only on the results in the mouse study. The risk assessment is conducted to ensure that the level of human exposure is well below the lowest dose at which these effects occurred in animal tests.

7.1.1 Occupational Risk

Non-cancer risk estimates for lawn care operators applying carbaryl to residential turf, golf courses and sod farms do not reach the target MOE and/or ARI, even when engineering controls and personal protective equipment are used, except for groundboom broadcast application on golf courses and spot treatment using handwands. Postapplication non-cancer risks for workers were of concern; mitigation measures that would diminish the risk are not considered agronomically feasible

Non-cancer risk estimates associated with applying, mixing and loading activities for most proposed agricultural label uses are not of concern provided that engineering controls or personal protective equipment are used. Postapplication risks for workers are not of concern when the proposed mitigation measures are applied. However, a number of proposed REIs may not be considered agronomically feasible.

Cancer risk was not of concern for all uses at the proposed restricted entry interval.

7.1.2 Dietary Risk from Food

The aggregate (food and water) chronic and cancer dietary risk assessments demonstrate that there were no dietary concerns for any population group in Canada, including infants, children, teenagers, adults and seniors. In addition, no dietary concerns were evident for nursing or pregnant females or based on gender in general.

7.1.3 Dietary Risk from Drinking Water

The acute aggregate risks were assessed using both modelling and monitoring drinking water data. The use of modelling drinking water data resulted in an exposure above the level of concern for all infants. However, the use of limited drinking water monitoring data at the 95th percentile of the maximum detected concentrations indicates a risk that is not of concern. As mentioned earlier, the modelling data is considered an upper bound estimate, based on the conservative assumption that 100% of the watershed is treated, while the the monitoring data may underestimate acute exposure “peaks”. Additional data (percent cropped area) may refine the exposure estimates based on drinking water modelling.

7.1.4 Non-Occupational Risk

Non-cancer risk estimates associated with most mixing, loading and applying activities and postapplication scenarios for all populations for the proposed label uses of carbaryl are of concern.

Non-cancer risks estimates from hand harvesting and consuming fresh orchard fruits pick-your own’ facilities are of concern.

7.1.5 Aggregate Risk (Food and Water)

Aggregate chronic and cancer risk assessments are not of concern. However, the aggregate acute risk assessment may be of concern when using drinking water modelling data.

7.2 Environmental Risk

Carbaryl is non-persistent in most soils and water systems. There is a potential for carbaryl to appear in surface water through runoff. The risk assessment of carbaryl indicates adverse effects on non-target terrestrial and aquatic plants. Carbaryl presents a risk to wild birds, mammals, bees and other arthropods, as well as to aquatic organisms like fish, amphibians, algae and invertebrates. To reduce the effects of carbaryl in the environment, mitigation in the form of precautionary label statements and buffer zones is required to protect non-target terrestrial and aquatic organisms.

7.3 Value

Carbaryl is an insecticide that is registered for a wide range of uses on both agricultural and non-agricultural sites to control various chewing and sucking insects. Carbaryl is also registered in Canada for use in apple thinning. It has been noted that current carbaryl labels recommend a wide variation of application rates for this use, which should be corrected.

Carbaryl is important in the resistance management of pests for most uses. In addition, for some of the uses for which it is registered, there are few if any other effective registered alternatives.

For further details, all carbaryl products registered in Canada as of June 2007 are listed in Appendix I. Appendix II Table 1 lists all the currently registered Commercial Class uses, while Appendices II Table 2 and II Table 3 list all of the Domestic Class uses.

8.0 Proposed Regulatory Decision

After a re-evaluation of the insecticide carbaryl, Health Canada's Pest Management Regulatory Agency (PMRA), under the authority of the *Pest Control Products Act*, is proposing the continued registration of carbaryl products for sale and use in Canada provided that the mitigation measures to protect health and the environment described in this document are implemented. Additional data are being requested to refine the risk assessment. The proposed mitigation measures and use limitations are presented in Appendix XIX.

Further measures may be proposed in the future, pending the outcome of the cumulative risk assessment for all carbamates.

8.1 Proposed Regulatory Actions

8.1.1 Proposed Regulatory Action Related to Human Health

For most agricultural uses, the PMRA has determined that most worker risks during mixing, loading and application and during postapplication activities are not of concern, provided that the mitigation measures listed in Appendix XIX are implemented.

For those agricultural uses where risks of concern were identified during mixing, loading and application and/or during post-application activities, further discussions with registrants may be warranted to discuss potential mitigation measures, as discussed in Appendix XVI, Table 35.

The PMRA has, however, identified a health risk concern for all residential uses of carbaryl, as well as commercial turf uses, tobacco and pick-your-own operations. Therefore, the PMRA is proposing that domestic products be discontinued and that these uses of commercial products be phased out.

Additional information on typical use patterns of carbaryl (i.e. typical rates, number of applications, survey information on critical worker activities, etc.) could refine the occupational risk assessment and possibly reduce some of the proposed restrictions.

With respect to drinking water exposure estimates, the modelled drinking water EECs could be potentially refined with the use of information on percent cropped area (PCA).

With respect to the risk to aquatic organisms, toxicity data on additional species of aquatic invertebrates would allow the aquatic risk assessment to be refined.

8.1.1.1 Toxicological Information

The labels of pesticide products carry statements regarding the symptoms of poisoning and treatment, which are especially important for those who may be overexposed when working with the product in a commercial or industrial setting (for example, mixers/loaders who handle more concentrated forms). Based on the toxicological assessments, the label text of carbaryl-containing products should be expanded and/or standardized.

8.1.1.2 Residue Definition for Risk Assessment and Enforcement

Division 15, Table II, of the Food and Drug Regulations currently identifies 1-napthyl-methylcarbamate as the residue for risk assessment and enforcement. Based on plant metabolism studies, the proposed residue definition for plant commodities is carbaryl (1-napthyl-methylcarbamate). Based on animal metabolism studies, the proposed residue definition for livestock commodities should be amended to carbaryl and its free and conjugate forms 5,6-dihydro-5,6-dihydroxy carbaryl, and 5-methoxy-6-hydroxy carbaryl. The proposed residue definition for meat, milk, poultry and eggs is based on secondary residues from treated feed.

8.1.1.3 Maximum Residue Limits for Carbaryl in Food

In general, when the re-evaluation of a pesticide has been completed, the PMRA intends to update the Canadian maximum residue limits (MRL) and remove MRLs that are no longer supported.

As all dermal livestock uses are no longer supported by the registrant, it is recommended that the MRL of 5 ppm for poultry be amended or withdrawn.

The PMRA recognizes, however, that interested parties may want to retain an MRL in the absence of a Canadian registration to allow the legal importation of treated commodities into Canada. The PMRA requires similar chemistry and toxicology data for such import MRLs as those required to support Canadian food use registrations. In addition, the PMRA requires residue data that are representative of the use conditions in exporting countries, in the same manner that representative residue data are required to support the domestic use of the pesticide. These requirements are necessary so that the PMRA may determine whether the requested MRLs are needed and to ensure that they would not result in health risks of concern.

Division 15, Table II, of the *Food and Drug Act* and Regulations currently provides the definition of the residue of concern for carbaryl. Table 8.1.1.3 summarizes the current MRLs established for carbaryl. Where no specific MRL is established for a pest control product under the *Food and Drug Act* and Regulations, subsection B.15.002(1) applies. This subsection requires that residues do not exceed 0.1 ppm, which is considered a general MRL for enforcement purposes. However, changes to this general MRL may be implemented in the future, as indicated in Discussion Document DIS2006- 01, *Revocation of 0.1 ppm as a General Maximum Residue Limit for Food Pesticide Residues [Regulation B.15.002(1)]*.

Table 8.1.1.3 Current Carbaryl MRLs established under the Food and Drug Regulations in Canada

Commodity	MRL (ppm)
Apricots, asparagus, beet tops, blackberries, boysenberries, cherries, Chinese cabbage, citrus fruits, collards, cranberries, dandelions, dewberries, endives, kale, lettuce, loganberries, mustard greens, nuts (whole in shells), okra, olives (raw), parsley, peaches, nectarines, plums, raspberries, salsify tops, spinach, swiss chard, turnip tops, watercress	10
Blueberries, strawberries	7
Apples, bananas, beans, beet roots, broccoli, Brussels sprouts, cabbages, carrots, cauliflower, celery, eggplants, grapes, horseradish, kohlrabi, parsnips, pears, peas, peppers, poultry meat, radishes, salsify roots, tomatoes, turnip roots	5
Cucumbers, melons, pumpkins, squash	3
Barley, oats, rye, wheat	2

Corn, nuts (shelled)	1
Potatoes	0.2

Parties interested in supporting MRLs for residues of carbaryl should contact the PMRA during the comment period of this document to discuss the submission of appropriate data. For supplemental MRL information regarding the international situation and trade implications, refer to Appendix XV.

8.1.1.4 Proposed Mitigation for Mixer, Loader and Applicator Exposure and Postapplication Exposure

The use of carbaryl on tobacco crops is proposed for phase out due to risks to workers.

It is also proposed that all label directions concerning the application of carbaryl to turf or residential settings be replaced with the following statement:

> Not for use on turf, golf courses, sod farms, residential ornamentals or residential vegetable gardens.
>
> Not for use in greenhouse, including on ornamentals.

Number of Applications:
In discussions with the PMRA, Bayer CropScience has proposed to identify the maximum number of applications for all registered commercial commodities as three per year (with the exception of chokecherry shelterbelts at a maximum of once per year) with a 7 to 10 day interval unless otherwise stated. However, due to the limited number of DFR studies available, some crops could only be assessed according to the number of applications and application intervals described in the DFR studies. It is, therefore, necessary to limit use for these crops accordingly (Appendix XIX).

Use Precautions:
Bystander exposure to carbaryl is potentially of concern. In the interest of minimizing public exposure, the following statement is proposed for all labels with the exception of those for bran bait:

> Apply only when the potential for drift to areas of human habitation or areas of human activity (houses, cottages, schools and recreational areas) is minimal. Take into consideration wind speed, wind direction, temperature, application equipment and sprayer settings.

Accidental exposure to carbaryl is a possibility that necessitates the following label statement for all products:

> Keep the following personal protective equipment immediately available for use in case of emergency (i.e. a broken package, spill or equipment breakdown): chemical-resistant coveralls, chemical-resistant gloves, chemical-resistant head gear and a respirator.

'Pick Your Own (PYO)' Label Statement
Due to the potential risk of exposure to the public at pick-your-own orchards (See Section 3.2.3.3 for details), the following label statement is proposed for products used on fruit trees:

> Carbaryl is not for use on any commercial orchard crop that is a "U-PICK" or "PICK-YOUR-OWN" or similar operation.

Wettable Powder in Water Soluble Packaging (WSP):
All carbaryl wettable powder products must be contained in water soluble packaging. The label language should be clarified to indicate directions for water soluble packaging.

Engineering Controls and Personal Protective Equipment
Label statements (Appendix XIX) are proposed to include appropriate engineering controls and personal protective equipment for various use scenarios in order to mitigate the risk of worker exposure to carbaryl.

Restricted Entry Intervals
Based on the postapplication risk to workers, new REIs (Appendix XIX) have been proposed, some of which may not be considered agronomically feasible. The proposed protective measures proposed to reduce worker exposure require consultation with user groups to determine their acceptability to the agricultural community. Additional data such as information on typical use patterns (i.e. typical rates, number of applications, survey information on critical worker activities) may help to refine the current risk assessment and could reduce the proposed REIs.

8.1.2 Proposed Regulatory Action Related to the Environment

The risk assessment has indicated that adverse effects on non-target terrestrial and aquatic organisms are expected. To reduce the effects of carbaryl in the environment, mitigation in the form of precautionary label statements and aquatic buffer zones are required. Environmental mitigation statements are listed in Appendix XIX .

8.1.3 Proposed Regulatory Action Related to Value

Registrants are requested to clarify use directions for small fruit crops and apples.

Due to the wide variation in rates of application for apple thinning found on current carbaryl labels (see Appendix II Table 1), the registrants are requested to propose a new rate range for this use and to provide data and/or a scientific rationale to support these rates.

9.0 Additional Data Requirements

9.1 Data Requirements Related to Chemistry, Toxicology, Occupational Exposure Chemistry, Environmental Assessment

No additional data for carbaryl are required at this time.

9.2 Data Requirements Related to Drinking Water Exposure Assessment

- DACO 10.6: The modelled drinking water EECs could be potentially refined with the use of information on percent cropped area (PCA). During this consultation process, the PMRA encourages the registrant to submit Canada-specific PCA data for use in refining the modelled EECs.

List of Abbreviations

↓	decrease
↑	increase
^{o}C	degree(s) Celsius
♂	male
♀	female
λ	wavelength(s)
AD	administered dose
ADD	Absorbed daily dose
ADI	acceptable daily intake
a.i.	active ingredient
ALT	synonym: serum glutamic pyruvic transaminase
amu	atomic mass units
ARfD	acute reference dose
ARI	aggregate risk index
ARTF	Agricultural Re-entry Task Force
ASAE	American Society of Agricultural Engineers
AST	aspartate aminotransferase
ATPD	area treated per day
BB	bran bait
BChE	brain acetylcholinesterase
$BMDL_{10}$	lower one-sided confidence limit on the benchmark dose
BUN	blood urea nitrogen
bw	body weight
CAF	composite assessment factor
CAS	Chemical Abstract Service
CFIA	Canadian Food Inspection Agency
ChE	acetylcholinesterase
CHO	Chinese hamster ovary cells
cm	centimetre(s)
cm^2	centimetres squared
cont'd	continued
CPK	creatine phosphokinase
%CT	percent crop treated
d	day(s)
DA	dermal absorption
DACO	data code
DER	data evaluation record
DEEM-FCID	dietary exposure evaluation model–food consumption intake database
DFR	dislodgeable foliar residue
DNA	deoxiribonucleic acid
DNT	developmental neurotoxicity study
DRA	dietary risk assessment
DT	dust
DTS	dial type sprayer

DT_{50}	dissipation time to 50% (the dose required to observe a 50% decline in the test population)
DU	dust
dw	dry weight
EC	emulsifiable concentrate
EC_{50}	exposure concentration to 50% (a concentration causing 50% adverse effects in the test population
EChE	erythrocyte acetylcholinesterase
EDE	estimated daily exposure
EEC	expected environmental concentration
EP	end-use product
EPA	Environmental Protection Agency
et al	and others
EUPs	end-use products
F0	parental generation
F1	first filial generation
F2	second filial generation
FDA	Food and Drug Administration
FIR	food ingestion rate
FOB	functional observational battery
g	gram(s)
GD	gestation day
GI	gastrointestinal
GR	granular
h/hours	hour(s)
ha	hectare
HAFT	highest average field trial
HDPY	harvest days per year
Hb	hemoglobin
HGPRT	hypoxanthine-guanine phosphoribosyl transferase
hp	high pressure
HPLC	high performance liquid chromatography
IgM	immunoglobulin
ILV	independent laboratory validation
IUPAC	International Union of Pure and Applied Chemistry
i.v.	intravenous
kg	kilogram
km	kilometre(s)
K_{oc}	organic carbon partition coefficient
Kow	*n*-octanol–water partition coefficient
L	litre(s)
LADD	lifetime average daily dose
LD	lactation day
LDH	lactic dehydrogenase
LD_{50}	lethal dose to 50% (a dose causing 50% mortality in the test population)
LEACHM	leaching estimation and chemistry model

LC_{50}	lethal concentration to 50% (a concentration causing 50% mortality in the test population
LOAEL	lowest observed adverse effect level
LOC	level of concern
LOD	limit of detection
lp	low pressure
LPM	litres per minute
M/L	mixer/loader
M/L/A	mixer/loader/applicator
mg	milligram(s)
mL	millilitre(s)
mM	millimolar
mm	millimetre(s)
mm Hg	millimetres of mercury
MOE	margin of exposure
MRID	document identifier for the USEPA
MRL	maximum residue limit
MTD	maximum tolerated doses
N/A	not applicable
nd	no detection
nm	nanometre(s)
NOEC	no observed effect concentration
NOAEL	no observed adverse effect level
ORETF	Outdoor Residential Exposure Task Force
Pa	Pascal
PAM	pesticide analytical manual
PChE	plasma butyrylcholinesterase
PCPA	*Pest Control Products Act*
PCA	percent cropped area
PDP	pesticide data program
PFC	plaque forming cells
pH	-log10 hydrogen ion concentration
PHED	pesticide handlers exposure database
pKa	dissociation constant
PMRA	Pest Management Regulatory Agency
PND	post-natal day
PPE	personal protective equipment
ppm	part per million
PRVD	proposed re-evaluation decision
PRZM/EXAMS	pesticide root zone model/exposure analysing modeling system
PT	particulate
PYO	pick your own facilities
Q^*_1	lifetime cancer risk estimate
r.a.n.	repeat as necessary
RBC	red blood cells
REI	restricted entry interval

RI_D	dermal risk index
RI_I	inhalation risk index
RQ	risk quotient
RTU	ready-to-use
S9	mammalian metabolic activation system
SA	surface area
SDH	sorbitol dehydrogenase
SEF	saliva extraction factor
SO	solid
SN	solution
SU	suspension
$T_{1/2}$	half-life
TC	transfer coefficient
TRR	total radioactive residues
TSMP	Toxic Substances Management Policy
TTR	turf transferable residues
µCi	microCurrie(s)
µg	microgram(s)
µM	micromolar
URMULE	user requested minor use label expansion
USA	United States of America
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
UV	ultraviolet/visible spectrum
WBC	white blood cells
WP	wettable powder formulation
WSP	water soluble packaging

Appendix I Registered Carbaryl Products As of June 2007[1]

Registrant Number	Class[2]	Registrant	Product Name	Formulation Type[3]	Guarantee[4]
6839	C + R	Bayer Crop Science Inc.	Sevin Brand 50W Carbaryl Insecticide Wettable Powder	WP	CAB 50%
9042	C	Dominion Veterinary Ltd.	Sevin Dispersible Powder Insecticide(Veterinary Use Only)	DU	CAB 50%
9061	C	Dominion Veterinary Ltd.	Dominion Dusting Powder For (Veterinary Use Only)	DU	CAB 5%
9986	D	King Home and Garden Inc.	King Fruit Tree and Garden Spray	DU	CAB 10%, MAL 5%, CAP 10%
10565	D	Spectrum Brands IP Inc.	Wilson Rose Doctor Insecticide-Fungicide	DU	CAB 5%, MAL 4%, FOL 5%
11514	D	Manchester Products Ltd.	Manchester Bug Killer Dust	DU	CAB 5%
12135	D	Spectrum Brands IP Inc.	Wilson Sevin Garden Dust Insecticide	DU	CAB 5%
14573	D	Wellmark International	Vet-Kem Flea and Tick Powder	DU	CAB 5%
14851	D	King Home and Garden Inc.	Gardal Rose, Flower and Evergreen Dust	DU	CAB 5%, TPM 3%, MAL 4%, CAP 5%
14852	D	Spectrum Brands IP Inc.	Wilson Bulb and Soil Dust	DU	CAB 5%, CAP 5%
16653	C	Bayer Crop Science Inc.	Sevin SL Carbaryl Insecticide Liquid Suspension	SU	CAB 43%
17189	D	Wellmark International	Zodiac Flea and Tick Powder	DU	CAB 5%
17424	D	Spectrum Brands IP Inc.	Wilson Garden Doctor Insecticide-Fungicide	DU	CAB 5%, CUB 7%
17534	C	Spectrum Brands IP Inc.	Wilson Sevin 5-Day Insecticide Dust	DU	CAB 5%
17971	D	Spectrum Brands IP Inc.	Wilson Liquid Sevin Carbaryl Insecticide	SU	CAB 22.5%
18187	C	Vetoquinol N.A. Inc.	Sevin Poultry Insect Dust 5%	DU	CAB 5%
18463	T	Bayer Crop Science Inc.	Sevin Brand 99% Technical Carbaryl Insecticide	SO	CAB 99%
19228	D	Spectrum Brands IP Inc.	Wilson Earwig and Cutworm Destroyer	GR	CAB 5%
19351	MC	Bayer Crop Science	Sevin Brand 97.5% Manufacturing Concentrate	SO	CAB 97.5%

Registrant Number	Class[2]	Registrant	Product Name	Formulation Type[3]	Guarantee[4]
		Inc.			
19531	C + R	Bayer Crop Science Inc.	Sevin Brand XLR Plus Carbaryl Insecticide	SU	CAB 42.8% (466 g/L)
19684	C	Spectrum Brands IP Inc.	Wilson Vet-Tek Louse Powder	DU	CAB 5%
21296	D	Spectrum Brands IP Inc.	Wilson Flea and Tick Powder	DU	CAB 5%, PYR 0.1%, PBU 1%
22115	D	Sergeant's Pet Care Products Inc.	Sergeant's Flea and Tick Powder For Dogs	DU	CAB 5%, PYR 0.1%, PBU 1%
22116	D	Sergeant's Pet Care Products Inc.	Sergeant's Flea and Tick Powder For Cats	DU	CAB 5%, PYR 0.1%, PBU 1%
22339	C	Bayer Crop Science Inc.	Chipco Sevin RP2 Carbaryl Insecticide Liquid Suspension	SU	CAB 22.5% (240 g/L)
23860	D	Spectrum Brands IP Inc.	Later's Sevin Liquid Insecticide	SU	CAB 22.5%
24973	C	Bayer Crop Science Inc.	Sevin Bran Bait Carbaryl Insecticide	BB	CAB 5%
25815	C	Peacock Industries	Eco Bran Grasshopper Insecticide Agricultural	GR	CAB 2%
25870	D	Bayer Crop Science Inc.	Sevin RP2 Carbaryl Insecticide Liquid Suspension	SU	CAB 22.5% (240 g/L)
26698	D	Spectrum Brands IP Inc.	Wilson Sevin Grubout Ant and Grub Killer Concentrate	EC	CAB 22.5%
26699	D	Spectrum Brands IP Inc.	Wilson Sevin Grubout Ant and Grub Killer	EC	CAB 22.5%
26700	D	Spectrum Brands IP Inc.	C-I-L Grubout Ant and Grub Killer Concentrate	EC	CAB 22.5%
26701	D	Spectrum Brands IP Inc.	Wilson Sevin Grubout Ant and Grub Killer Concentrate	EC	CAB 22.5%
26702	D	Spectrum Brands IP Inc.	Grubout - Ant and Grub Killer C-I-L	EC	CAB 22.5%
26873	C	Bayer Crop Science Inc.	Chipco Sevin T and O Carbaryl Insecticide	SU	CAB 42.8% (466 g/L)
26923	D	Spectrum Brands IP Inc.	Wilson Ant Out Ant Killer Dust	DU	CAB 5%
26924	D	Spectrum Brands IP Inc.	C-I-L Ant Killer Dust	DU	CAB 5%
27068	D	Spectrum Brands IP Inc.	Later's Bugban-C Ant Killer Dust	DU	CAB 5%
27206	D	Scotts Canada Ltd.	Ortho Grub-B-Gon Max Grub Eliminator Ready-To-Spray	SU	CAB 22.5%

Registrant Number	Class[2]	Registrant	Product Name	Formulation Type[3]	Guarantee[4]
27207	D	Scotts Canada Ltd.	Ortho Bug-B-Gon for Lawns, Trees, Gardens Ready-To-Spray	SN	CAB 22.5%
27208	D	Scotts Canada Ltd.	Ortho Bug-B-Gon for Lawns, Trees, Gardens Concentrate	SN	CAB 22.5%
27876	C+R	Bayer Crop Science Inc.	Sevin Brand XLR Insecticide	SU	CAB 42.8% (466 g/L)
28195	D	Scotts Canada Ltd.	Grub-B-Gon Max Grub Eliminator Concentrate (Ortho)	SN	CAB 22.5%
28261	D	Scotts Canada Ltd.	Ortho Ant-B-Gon Max (TM) Ant Eliminator Dust	DU	CAB 5%

[1] Excluding discontinued products and products with a submission for discontinuation.
[2] C = Commercial Class Products, D = Domestic Class Products, T = Technical Class, MC = Manufacturing Concentrate, R = Restricted Class.
[3] Formulation types based on PMRA database: DU = Dust or Powder, EC = Emulsifiable Concentrate or Emulsion, GR = Granular, BB = Bran Bait, SN = Solution, SO = Solid, SU= Suspension, WP = Wettable Powder.
[4] CAB = Carbaryl, CAP = Captan, FOL = Folpet, MAL = Malathion, PBU = Piperonyl Butoxide, PYR = Pyrethrins, TPM = Thiophanate-Methyl.

Appendix II

Table 1 Registered Commercial Class Uses of Carbaryl as of June 2007 from the PMRA Electronic Label Collection

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications /Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cumulative			
Trap trees (standing, dead or dying) that are not to be harvested in lodgepole pine forest stands (RESTRICTED USE)	Mountain pine beetles (to control small infestations)	SU	0.466 kg/24 L	Can not be calculated	1	n/a	Y, M
		WP	0.5 kg/25 L				
Forest and Woodland (RESTRICTED USE)	Gypsy moth	SU	1.0718 kg/3–5 L/ha	3.2154 kg/3–5 L/ha	r.a.n. *(3)*	7	Y
Balsam fir, spruce (for Christmas tree plantations), farm woodlots, municipal parks (national and provincial parks not included), rights-of-way	Spruce budworm	WP	0.275–0.55 kg/500 L	Can not be calculated			
High value trees in urban and rural areas	Mountain pine beetles	WP	20 g/m^2	20 g/m^2	1	n/a	Y
		SU	18.64 kg/1000 L 18.64 g/m^2	18.64 g/m^2			
			19.2 g/m^2	19.2 g/m^2			
Rapeseed (canola)	Flea beetles (seedling application only)	SU	0.233 kg/ha	0.699 kg/ha	r.a.n. *(3)*	7	Y
			0.6 kg/ha	1.8 kg/ha			
Canola (seedlings only)	Grasshoppers	BB	0.1 kg/ha	0.3 kg/ha			
		GR	0.04–0.08 kg/ha	0.12–0.24 kg/ha			
Alfalfa, Clover	Cereal leaf beetles	WP	1.125 kg/ha	3.375 kg/ha	r.a.n. *(3)*	7	Y
	Alfalfa weevil larvae		1.625 kg/ha	4.875 kg/ha			
	Blister beetles, Flea beetles, Leafhoppers, Three cornered alfalfa hopper	WP	1.125–1.625 kg/ha	3.375–4.875 kg/ha			
		SU	1.2–1.92 kg/ha	3.6–5.76 kg/ha			
			1.165–1.864 kg/ha	3.495–5.592 kg/ha			
	Alfalfa caterpillar, Armyworms, Cutworms (climbing), Sweet clover weevil, Webworms	WP	1.125–2.25 kg/ha	3.375–6.75 kg/ha			
	Alfalfa caterpillar, Armyworms, Webworms	SU	1.2–2.52 kg/ha	3.6–7.56 kg/ha			
			1.165–2.4465 kg/ha	3.495–7.3395 kg/ha			
	Grasshoppers	WP	0.55–1.125 kg/ha	1.65–3.375			

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications /Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cumulative			
				kg/ha			
		SU	0.6–1.2 kg/ha	1.8–3.6 kg/ha			
			0.5825–1.165 kg/ha	1.748–3.495 kg/ha			
		BB	0.1 kg/ha	0.3 kg/ha			
		GR	0.04–0.08 kg/ha	0.12–0.24 kg/ha			
	Flea beetles	SU	1.165–1.864 kg/ha	3.495–5.592 kg/ha			
Sweet white lupin	Blister beetles	SU	1.165–1.864 kg/ha	3.495–5.592 kg/ha	3	7	Y, M
	Grasshoppers (nymphs or sparse vegetation)		0.5592–1.0718 kg/ha	1.678–3.215 kg/ha			
	Grasshoppers (nymphs on dense vegetation) Grasshoppers (adults on sparse or dense vegetation)		1.0718–1.631 kg/ha	3.215–4.893 kg/ha			
	Grasshoppers	GR	0.04–0.08 kg/ha	0.12–0.24 kg/ha	r.a.n. *(3)*		Y, M
		BB	0.1 kg/ha	0.3 kg/ha			Y
Field borders, Headlands, Rights-of-way, Roadsides, Wastelands	Grasshoppers	GR	0.04–0.08 kg/ha	0.12–0.24 kg/ha	r.a.n. *(3)*	7	Y
		BB	0.1 kg/ha	0.3 kg/ha			
Ditchbanks, Field borders, Rights-of-way, Wastelands, Headlands	Grasshoppers (nymphs or sparse vegetation)	SU	0.5592–1.0718 kg/ha	1.6776–3.2154 kg/ha			
	Grasshoppers (nymphs on dense vegetation) Grasshoppers (adults on sparse or dense vegetation)		1.0718–1.631 kg/ha	3.2154–4.893 kg/ha			
Forage grass, Pasture, Rangeland	Grasshoppers (nymphs or sparse vegetation)	SU	0.5592–1.0718 kg/ha	1.6776–3.2154 kg/ha	r.a.n. *(3)*	7	Y
	Grasshoppers (nymphs on dense vegetation) Grasshoppers (adults on sparse or dense vegetation)		1.0718–1.631 kg/ha	3.2154–4.893 kg/ha			
Pasture, Rangeland or forage grass, Forage crops	Grasshoppers	GR	0.04–0.08 kg/ha	0.12–0.24 kg/ha			
		BB	0.1 kg/ha	0.3 kg/ha			
Barley	Grasshoppers	GR	0.04–0.08 kg/ha	0.12–0.24 kg/ha	r.a.n. *(3)*	7	Y
		BB	0.1 kg/ha	0.3 kg/ha			
		WP	0.55–1.125 kg/ha	1.65–3.375 kg/ha			
		SU	0.5825–1.165 kg/ha	1.7475–3.495 kg/ha			

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications /Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cumulative			
	Flea beetle		1.165–1.864 kg/ha	3.495–5.592 kg/ha			
	Cereal leaf beetle	WP	1.125 kg/ha	3.375 kg/ha			
	Alfalfa weevil larvae	WP	1.625 kg/ha	4.875 kg/ha			
	Blister beetle, Flea beetles, Leafhoppers, Three cornered alfalfa hopper		1.125–1.625 kg/ha	3.375–4.875 kg/ha			
		SU	1.2–1.92 kg/ha	3.6–5.76 kg/ha			
			1.165–1.864 kg/ha	3.495–5.592 kg/ha			
	Alfalfa caterpillar, Armyworms, Cutworms (climbing), Sweet clover weevil, Webworm	WP	1.125–2.25 kg/ha	3.375–6.75 kg/ha			
	Alfalfa caterpillar, Armyworms, Webworm	SU	1.165–2.4465 kg/ha	3.495–7.3395 kg/ha			

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
Barley, Oats, Rye, Wheat	Alfalfa caterpillar, Armyworms, Webworm	SU	1.2–2.52 kg/ha	3.6–7.56 kg/ha	r.a.n. *(3)*	7	Y
	Grasshoppers		0.6–1.2 kg/ha	1.8–3.6 kg/ha			
Oats, Rye, Wheat	Cereal leaf beetle	WP	1.125 kg/ha	3.375 kg/ha			
	Alfalfa weevil larvae		1.625 kg/ha	4.875 kg/ha			
	Blister beetle, Flea beetles, Leafhoppers, Three cornered alfalfa hopper		1.125–1.625 kg/ha	3.375–4.875 kg/ha			
		SU	1.2–1.92 kg/ha	3.6–5.76 kg/ha			
			1.165–1.864 kg/ha	3.495–5.592 kg/ha			
	Alfalfa caterpillar, Armyworms, Cutworms (climbing), Sweet clover weevil, Webworm	WP	1.125–2.25 kg/ha	3.375–6.75 kg/ha			
	Alfalfa caterpillar, Armyworms, Webworm	SU	1.165–2.4465 kg/ha	3.495–7.3395 kg/ha			
	Flea beetle		1.165–1.864 kg/ha	3.495–5.592 kg/ha			
	Grasshoppers	WP	0.55–1.125 kg/ha	1.65–3.375 kg/ha			
		SU	0.5825–1.165 kg/ha	1.7475–3.495 kg/ha			
		GR	0.04–0.08 kg/ha	0.12–0.24 kg/ha			
		BB	0.1 kg/ha	0.3 kg/ha			
Asparagus (seedlings, spears)	Asparagus beetles, Cutworms (climbing)	WP	1.125–2.25 kg/ha	3.375–6.75 kg/ha	r.a.n. *(3)*	3	Y
		SU	1.2–3.072 kg/ha	3.6–9.216 kg/ha			
			1.165–2.9824 kg/ha	3.495–8.9472 kg/ha			
			12.48–30 g/100 m^2 =1.248-3.0 kg/ha	3.744-9.0 kg/ha			
	Asparagus beetles	DU	1.1–2.75 kg/ha	3.3–8.25 kg/ha			
Asparagus (ferns)	Asparagus beetles	WP	2.25–4.5 kg/ha	6.75–13.5 kg/ha			
		DU	2.75–5.5 kg/ha	8.25–16.5 kg/ha			
Beans	Mexican bean beetle	WP	0.55–0.7 kg/ha	1.65–2.1 kg/ha	r.a.n. *(3)*	7	Y
		DU	1.5 kg/ha	4.5 kg/ha			
		SU	0.6–0.72 kg/ha	1.8–2.16 kg/ha			
			0.5825–0.699	1.7475–2.097			

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
			kg/ha	kg/ha			
			6–7.2 g/100 m^2 =0.6–0.72 kg/ha	1.8–2.16 kg/ha			
	Flea beetles, Leafhoppers	WP	1.125 kg/ha	3.375 kg/ha	r.a.n. *(3)*	7	Y
		DU	2.0 kg/ha	6.0 kg/ha			
		SU	1.2 kg/ha	3.6 kg/ha			
			1.165 kg/ha	3.495 kg/ha			
			12.48 g/100 m^2 =1.248 kg/ha	3.744 kg/ha			
	Lygus bugs, Stink bugs	WP	2.25 kg/ha	6.75 kg/ha			
		DU	2.25–2.75 kg/ha	6.75–8.25 kg/ha			
		SU	2.52–3.072 kg/ha	7.56–9.216 kg/ha			
			2.4465–2.9824 kg/ha	7.3395–8.9472 kg/ha			
			24.96–30 g/100 m^2 =2.5–3.0 kg/ha	7.5–9.0 kg/ha			
	Cutworms (climbing)	WP	13.75–16.25 g/100 m row =1.511–1.785 kg/ha	4.533–5.355 kg/ha			
		SU	13.98–16.31 g/100 m row =1.536–1.785 kg/ha	4.608–5.355 kg/ha			
	Grasshoppers	BB	0.1 kg/ha	0.3 kg/ha			
		GR	0.04–0.08 kg/ha	0.12–0.24 kg/ha			
Snapbeans, Common (including green beans, yellow beans, wax beans)	European corn borer	WP	2.25 kg/ha	6.75 kg/ha	r.a.n. *(3)*	7	Y
		SU	2.4465 kg/ha	7.3395 kg/ha			
Beet (root), Horseradish, Radish, Rutabaga (root), Salsify (root), Turnip (root)	Flea beetles, Leafhoppers	WP	0.55–1.125 kg/ha	1.65–3.375 kg/ha	r.a.n. *(3)*	7	Y
		SU	0.6–1.2 kg/ha	1.8–3.6 kg/ha			
			0.5825–1.165 kg/ha	1.7475–3.495 kg/ha			
			6–12.48 g/100 m^2 =0.6–1.25 kg/ha	1.8–3.75 kg/ha			
	Six spotted leafhopper	WP	1.125–1.625 kg/ha	3.375–4.875 kg/ha		5	

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
		SU	0.50328–0.72696 kg/ha	1.5098–2.18088 kg/ha		7	
	Armyworms, Cabbage looper, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebugs, Stink bugs	WP	1.125–2.25 kg/ha	3.375–6.75 kg/ha		5	
	Armyworms, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebug, Stink bugs	SU	1.2–2.52 kg/ha	3.6–7.56 kg/ha		7	
			1.165–2.4465 kg/ha	3.495–7.3395 kg/ha			
			12.48–24.96 g/100 m^2 =0.6–1.248 kg/ha	1.8–3.744 kg/ha			
Broccoli, Brussels sprouts, Cabbage, Cauliflower, Celery, Head lettuce, Kohlrabi	Flea beetles, Leafhoppers	WP	0.55–1.125 kg/ha	1.65–3.375 kg/ha	r.a.n. *(3)*	7	Y
	Armyworms, Cabbage lopper, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebug, Stink bugs		1.125–2.5 kg/ha	3.375–7.5 kg/ha			
	Six spotted leafhopper		1.125–1.625 kg/ha	3.375–4.875 kg/ha		5	
	Flea beetles, Leafhoppers, Corn earworm, Imported cabbageworm, Cabbage looper, Armyworms, Meadow spittle bug, Lygus bug, Stink bugs	DU	1.75–2.25 kg/ha	5.25–6.75 kg/ha	Not stated *(3)*	5	Y
Broccoli, Brussels sprouts, Cabbage, Cauliflower, Celery, Kohlrabi	Flea beetles, Leafhoppers	SU	0.6–1.2 kg/ha	1.8–3.6 kg/ha	r.a.n. *(3)*	7	Y
			6.0–12.48 g/100 m^2 =0.6–1.248 kg/ha	1.8–3.744 kg/ha			
	Armyworms, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebug, Stink bugs		1.2–2.52 kg/ha	3.6–7.56 kg/ha			
			12.48–24.96 g/100 m^2 =1.248–2.496 kg/ha	3.744–7.488 kg/ha			
Broccoli, Brussels sprouts, Celery, Head lettuce, Kohlrabi	Flea beetles, Leafhoppers		0.5825–1.165 kg/ha	1.7475–3.495 kg/ha			
	Armyworms, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow		1.165–2.4465 kg/ha	3.495–7.3395 kg/ha			

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
	spittlebug, Stink bugs						
	Six spotted leafhopper		0.50328–0.72696 kg/ha	1.5098–2.18088 kg/ha			
Cabbage, Cauliflower	Flea beetles, Leafhoppers	SU	0.582–1.165 kg/ha	1.746–3.495 kg/ha	r.a.n. *(3)*	7	Y
	Armyworms, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebug, Stink bugs		1.165–2.45465 kg/ha	3.495–7.3395 kg/ha			
	Six spotted leafhopper		0.50328–0.72696 kg/ha	1.50984–2.18088 kg/ha			
Carrot	Flea beetles, Leafhoppers	WP	0.55–1.125 kg/ha	1.65–3.375 kg/ha	r.a.n. *(3)*	7	Y
		SU	0.6–1.2 kg/ha	1.8–3.6 kg/h			
			0.5825–1.165 kg/ha	1.7475–3.495 kg/ha			
			6–12.48 g/100 m^2 =0.6–1.25 kg/ha	1.8–3.75 kg/ha			
	Armyworms, Cabbage looper, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebug, Stink bugs	WP	1.125–2.25 kg/ha	3.375–6.75 kg/ha			
	Armyworms, Corn Earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebug, Stink bugs	SU	1.2–2.52 kg/ha	3.6–7.56 kg/ha			
			1.165–2.4465 kg/ha	3.495–7.3395 kg/ha			
			1.248–2.496 kg/ha	3.744–7.488 kg/ha			
	Six spotted leafhopper	WP	1.125–1.625 kg/ha	3.375–4.875 kg/ha		5	
		SU	0.50328–0.72696 kg/ha	1.50984–2.18088 kg/ha		7	
	Flea beetles, Leafhoppers, Six spotted leafhopper (aster yellows vector), Corn earworm, Imported cabbageworm, Cabbage looper, Armyworms, Meadow spittle bug, Lygus bugs, Stink bugs	DU	1.75–2.25 kg/ha	5.25–6.75 kg/ha	Not stated *(3)*	5	
Parsnip	Flea beetles, leafhoppers	SU	0.5825–1.165 kg/ha	1.7475–3.495 kg/ha	r.a.n.	7	Y
	Armyworms, Corn Earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus		1.165–2.4465 kg/ha 0.50328–0.72696	3.495–7.3395 kg/ha 1.50984–	*(3)*		

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
	bugs, Meadow spittlebug, Stink bugs, Six spotted leafhopper		kg/ha	2.18088 kg/ha			
Beet (tops), Chinese cabbage, Dandelion, Collards, Endive, Kale, Leaf lettuce, Mustard greens, Parsley, Parsnip, Salsify (tops), Spinach, Swiss chard, Turnip (tops), Watercress	Flea beetles, Leafhoppers	WP	0.55–1.125 kg/ha	1.65–3.375 kg/ha	r.a.n. *(3)*	7	Y
	Six spotted leafhopper		1.125–1.625 kg/ha	3.375–4.875 kg/ha		5	
	Armyworms, Cabbage looper, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebug, Stink bugs		1.125–2.25 kg/ha	3.375–6.75 kg/ha			
Beet (tops), Chinese cabbage, Dandelion, Endive, Kale, Leaf lettuce, Mustard greens, Parsley, Parsnip, Salsify (tops), Spinach, Swiss chard, Turnip (tops), Watercress	Flea beetles, Leafhoppers	SU	0.6–1.2 kg/ha	1.8–3.6 kg/ha	r.a.n. *(3)*	7	Y
			6.0–12.48 g/100 m^2 =0.6–1.25 kg/ha	1.8–3.75 kg/ha			
	Armyworms, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebug, Stink bugs		1.2–2.52 kg/ha	3.6–7.56 kg/ha			
			12.48–24.96 g/100 m^2 =1.25–2.5 kg/ha	3.75–7.5 kg/ha			
Beet (tops), Chinese cabbage, Dandelion, Endive, Kale, Leaf lettuce, Mustard greens, Parsley, Salsify (tops), Spinach, Swiss chard, Turnip (tops), Watercress	Flea beetles, Leafhoppers	SU	0.5825–1.165 kg/ha	1.7475–3.495 kg/ha	r.a.n. *(3)*	7	Y
	Six spotted leafhopper		0.50328–0.72696 kg/ha	1.50984–2.18088 kg/ha			
	Armyworms, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebug, Stink bugs		1.165–2.4465 kg/ha	3.495–7.3395 kg/ha			
Corn (field, sweet)	Corn earworm, European corn borer, Fall armyworms, Northern corn rootworm (adults)	DU	1.1–1.75 kg/ha	4.4–7.0 kg/ha	4 (European corn borer)	2 (Corn earworm) 5 (European corn borer)	Y
		WP	1.125–1.625 kg/ha	3.375–4.875 kg/ha	r.a.n. *(3)*	2	Y
		SU	1.2–1.92 kg/ha	3.6–5.76 kg/ha			
			1.165–1.864 kg/ha	3.495–5.592 kg/ha			
			12.48–19.92 g/100 m^2 =1.25–1.99 kg/ha	3.75–5.97 kg/ha			
	Cereal leaf beetle	WP	1.125 kg/ha	3.375 kg/ha			
	Cutworms (climbing)		21.25 g/100 m row =2.335 kg/ha	7.005 kg/ha		7	

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
		SU	20.97 g/100 m row =2.304 kg/ha	6.912 kg/ha		2	
	Grasshoppers		0.5825–1.165 kg/ha	1.7475–3.495 kg/ha			
		BB	0.1 kg/ha	0.3 kg/ha		7	
		GR	0.04–0.08 kg/ha	0.12–0.24 kg/ha			
Cucumber, Melons, Pumpkin, Squash	Cucumber beetles, Squash bug, Flea beetles, Leafhoppers	DU	1.5–2.25 kg/ha	4.5–6.75 kg/ha	r.a.n. *(3)*	7	Y
	Cucumber beetles, Cutworms (climbing), Flea beetles, Leafhoppers, Squash bug	WP	1.125 kg/ha	3.375 kg/ha			
		SU	1.2 kg/ha	3.6 kg/ha			
			1.165 kg/ha	3.495 kg/ha			
			12.48 g/100 m^2 =1.25 kg/ha	3.75 kg/ha			
Peas	Alfalfa looper	WP	2.25 kg/ha	6.75 kg/ha	r.a.n. *(3)*	7	Y
		SU	2.1902 kg/ha	6.5706 kg/ha			
Potato	Colorado potato beetle	WP	0.55 kg/ha	1.65 kg/ha	r.a.n. *(3)*	7	Y
		SU	0.6 kg/ha	1.8 kg/ha			
			0.5825 kg/ha	1.7475 kg/ha			
			6 g/100 m^2 =0.6 kg/ha	1.8 kg/ha			
	European corn borer, Fall armyworms, Tomato hornworm, Tomato fruitworm	WP	1.125–2.25 kg/ha	3.375–6.75 kg/ha			
		SU	1.2–2.52 kg/ha	3.6–7.56 kg/ha			
			1.165–2.4465 kg/ha	3.495–7.3395 kg/ha			
			12.48–24.96 g/100 m^2 =1.25–2.45 kg/ha	3.75–7.35 kg/ha			
	Stink bugs, Tarnished plant bug	DU	2.25–2.75 kg/ha	6.75–8.25 kg/ha			
		WP	2.25 kg/ha	6.75 kg/ha			
		SU	2.52–3.072 kg/ha	7.56–9.216 kg/ha			
			2.4465–2.9824 kg/ha	7.3395–8.9472 kg/ha			
			24.96–30 g/100 m^2 =2.45–3.0 kg/ha	7.35–9.0 kg/ha			
	Leafhoppers, Potato flea beetle	WP	1.125 kg/ha	3.375 kg/ha			
		DU	1.1 kg/ha	3.3 kg/ha			

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
	Flea beetles, Leafhoppers	SU	1.165 kg/ha	3.495 kg/ha			
	Cutworms (climbing)	WP	42.5 g/100 m row =2.335 kg/ha	7.005 kg/ha			
		SU	48–60 g/300 m row =1.758–2.198 kg/ha	5.274–6.594 kg/ha			
			20.97 g/100 m row =2.304 kg/ha	6.912 kg/ha			
			19.92–24.96 g/100 m^2 =1.99–2.49 kg/ha	5.97–7.47 kg/ha			
	Colorado potato beetle, Tomato fruitworm, Fall armyworms, Tomato hornworm, European corn borer	DU	1.1–2.25 kg/ha	3.3–6.75 kg/ha	not stated *(3)*		
Tomato	Colorado potato beetle, Tomato fruitworm, Fall armyworms, Tomato hornworm, European corn borer	DU	1.1–2.25 kg/ha	3.3–6.75 kg/ha	not stated *(3)*	7	Y
	Potato flea beetle, Leafhoppers		1.1 kg/ha	3.3 kg/ha			
	Tarnished plant bugs, Stink bugs		2.25–2.75 kg/ha	6.75–8.25 kg/ha			
Eggplant, Pepper, Tomato	Colorado potato beetle	WP	0.55 kg/ha	1.65 kg/ha	r.a.n. *(3)*	7	Y
		SU	0.6 kg/ha	1.8 kg/ha			
			0.5825 kg/ha	1.7475 kg/ha			
			6 g/100 m^2 =0.6 kg/ha	1.8 kg/ha			
	European corn borer, Fall armyworms, Tomato hornworm, Tomato fruitworm	WP	1.125–2.25 kg/ha	3.375–7.56 kg/ha			
		SU	1.2–2.52 kg/ha	3.6–7.56 kg/ha			
			1.165–2.4465 kg/ha	3.495–7.3395 kg/ha			
			12.48–24.96 g/100 m^2 =1.25–2.49 kg/ha	3.75–7.47 kg/ha			
	Stink bugs, Tarnished plant bug	WP	2.25 kg/ha	6.75 kg/ha			
		SU	2.52–3.072 kg/ha	7.56–9.216 kg/ha			
			2.4465–2.9824 kg/ha	7.3395–8.9472 kg/ha			

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
			24.96–30 g/100 m^2 =2.49–3.0 kg/ha	7.47–9.0 kg/ha			
	Leafhoppers, Potato flea beetle	WP	1.125 kg/ha	3.375 kg/ha			
	Leaf beetles, Leafhoppers	SU	1.165 kg/ha	3.495 kg/ha			
	Cutworms (climbing)	WP	42.5 g/100 m row =2.335 kg/ha	7.005 kg/ha			
		SU	48–60 g/300 m row =1.758–2.198 kg/ha	5.274–6.594 kg/ha			
			20.97 g/100 m row =2.304 kg/ha	6.912 kg/ha			
			19.92–24.96 g/100 m^2 =1.99–2.49 kg/ha	5.97–7.47 kg/ha			
Apple (for apple thinning)	N/A	WP	0.125–2.5 kg/500 L =0.75–1.5 kg/ha	0.75–1.5 kg/ha	1	N/A	Y
			0.25–0.5 kg/500 L =1.5–3.0 kg/ha	1.5–3.0 kg/ha			
		SU	46.6–93.2 g/ha	46.6–93.2 g/ha			
			23.3–46.6 g/ha	23.3–46.6 g/ha			Y, M
Apple, Pear	Apple leafhopper, Apple leafroller, Codling moth, Eyespotted bud moth, Mealybug, redbanded leafroller (1st brood)	WP	0.25 kg/500 L =1.5 kg/ha	4.5 kg/ha	r.a.n. *(3)*	7	Y
		SU	0.576 kg/1000 L =1.728 kg/ha	5.184 kg/ha			
			1.4446 kg/ha	4.3338 kg/ha		7	
	Apple maggot, Eastern tent caterpillar, Fruit tree leafroller, Green fruitworm, Lecanium scale, Oyster shell scale, Pear leaf blister mite, Pear psylla, Pear slug, Pistol case bearer, Plum curculio, Redbanded leafroller (2nd brood), Rust mites, San Jose scale, Tarnished plant bug, Tentiform leafminer, Wooly apple aphid	WP	0.5 kg/500 L =3.0 kg/ha	9.0 kg/ha		(10 days for apple maggot)	
		SU	2.9125 kg/ha	8.7375 kg/ha			

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
	Apple maggot, Eastern tent caterpillar, Fruit tree leafroller, Green fruitworm, Pear leaf blister mite, Pear psylla, Pear slug, Pistol case bearer, Plum curculio, Redbanded leafroller (2nd brood), Rust mites, Tarnished plant bug, Tentiform leafminer, Woolly apple aphid		1.104 kg/1000 L =3.312 kg/ha	9.936 kg/ha			
	Apple leafhopper, Apple leafroller, Codling moth, Eyespotted bud moth, Apple maggot, Eastern tent caterpillar, Fruit tree leafroller, Green fruitworm, Pear leaf blister mite, Pear psylla, Pear slug, Pistol case bearer, Mealybug, redbanded leafroller (1st brood)		0.6 g/L =1.8 kg/ha	5.4 kg/ha			
	Plum curculio, Redbanded leafroller (2nd brood), Rust mites, Tarnished plant bug, Tentiform leafminer, Woolly apple aphid		1.248 g/L =3.74 kg/ha	11.22 kg/ha			
Apricot, Peach	Cat-facing insects, Codling moth, European earwig, European fruit lecanium, Fruit tree leafroller, Lesser peach tree borer, Oriental fruit moth, Peach silver mite, Peach twig borer, Plum curculio, Redbanded leafroller, Scale insects	WP	0.5 kg/500 L =3 kg/ha	9.0 kg/ha	r.a.n. *(3)*	7	Y
		SU	1.104 kg/1000 L =3.312 kg/ha	9.936 kg/ha			
			1.248 g/L =3.74 kg/ha	11.22 kg/ha			
			2.9125 kg/ha	8.7375 kg/ha			
Cherry, Plum, Prune	Codling moth, Eastern tent caterpillar, Oak Leafhopper, Prune leafhopper	WP	0.25–0.375 kg/500 L =1.5–2.25 kg/ha	4.5–6.75 kg/ha	r.a.n. *(3)*	7	Y
	Apple maggot, Black cherry aphid, Cherry fruit flies, Cherry fruitworm, Eyespotted bud moth, Fruit tree leafroller, Lesser peach tree borer, Mealy plum aphid, Peach twig borer, Plum curculio, Redbanded leafroller,		0.5 kg/500 L =3.0 kg/ha	9.0 kg/ha			

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
	Scale insects						
Cherry, Plum	Codling moth, Eastern tent caterpillar, Oak leafhopper, Prune leafhopper	SU	0.816–0.96 kg/1000 L =2.45–2.88 kg/ha	7.35–8.64 kg/ha	r.a.n. *(3)*	7	Y
			1.4446–2.1902 kg/ha	4.3338–6.5706 kg/ha			
			0.744–0.864 g/L =2.23–2.59 kg/ha	6.69–7.77 kg/ha			
	Apple maggot, Black cherry aphid, Cherry fruit fly, Cherry fruitworm, Eye spotted bud moth, Fruit tree leafroller, Lesser peach tree borer, Mealy plum aphid, Peach twig borer, Plum curculio, Red banded leafroller, Scale insects		1.104 kg/1000 L =3.312 kg/ha	9.936 kg/ha			
			1.248 g/L =3.744 kg/ha	11.232 kg/ha			
			2.9125 kg/ha	8.7375 kg/ha			
Blackberry, Boysenberry, Dewberry, Loganberry, Raspberry	Blackberry Leafminer, Japanese beetle, Leafhoppers, Leafrollers, Rose stem girdler, Spotted winged raspberry aphid	DU	2.75–5.5 kg/ha	8.25–16.5 kg/ha	r.a.n. *(3)*	7	Y
		WP	2.25 kg/ha	6.75 kg/ha			
	Blackberry leafminer, Japanese beetle, Leafhoppers, Leafroller aphid, Rose stem girdler, Spotted winged raspberry aphid	SU	2.52 kg/ha	7.56 kg/ha			
			2.4465 kg/ha	7.3395 kg/ha			
			24.96 g/100 m^2 =2.496 kg/ha	7.488 kg/ha			
Blueberry	Blueberry maggot, Cranberry fruitworm, Lecanium scale	WP	1.625 kg/ha	4.875 kg/ha	r.a.n. *(3)*	10	Y
		SU	1.92 kg/ha	5.76 kg/ha			
			19.92 g/100 m^2 =1.99 kg/ha	5.97 kg/ha			
	Blueberry maggot, Cranberry fruitworm, Cherry fruitworm, Lecanium scale	DU	2.25 kg/ha	6.75 kg/ha			
	Blueberry maggot, Cranberry fruitworm, Lecanium scale, Leafrollers, Bruce spanworm	SU	1.864 kg/ha	5.592 kg/ha			Y, M
Cranberry	Bluntnosed cranberry Leafhopper, Cranberry	WP	3.125–3.375 kg/ha	9.375–10.125 kg/ha	r.a.n.	7	Y

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
	fruitworm, Cutworms (climbing), Fireworms	SU	3.072–3.648 kg/ha	9.216–10.944 kg/ha	*(3)*		
			2.9824–3.5416 kg/ha	8.9472–10.6248 kg/ha			
			30–33.6 g/100 m^2 =3.0–3.36 kg/ha	9.0–10.08 kg/ha			
	Cranberry fruitworm, Fireworms, Climbing cutworm, Bluntnosed cranberry leafhopper	DU	3.75–4.25 kg/ha	11.25–12.75 kg/ha			
Grape	Grape berry moth, Leafhoppers	WP	2.25 kg/ha	6.75 kg/ha	r.a.n. *(3)*	7	Y
		SU	2.52–3.072 kg/ha	7.56–9.216 kg/ha			
			2.4465–2.9824 kg/ha	7.3395–8.9472 kg/ha			
			24.96–30 g/100 m^2 =2.496–3.0 kg/ha	7.488–9.00 kg/ha			
Strawberry	Meadow spittlebug, Strawberry leafroller	WP	1.25–2.25 kg/ha	3.75–6.75 kg/ha	r.a.n. *(3)*	7	Y
		DU	1.75–2.75 kg/ha	5.25–8.25 kg/ha			
		SU	1.2–2.784 kg/ha	3.6–8.352 kg/ha			
			1.165–2.7028 kg/ha	3.495–8.1084 kg/ha			
			12.48–30 g/100 m^2 =1.25–3.0 kg/ha	3.75–9.00 kg/ha			
Chokecherry (shelterbelts)	Prairie tent caterpillar	SU	0.493 kg/1000 L =1.48 kg/ha	1.48 kg/ha	1	n/a	Y, M
	Ugly nest caterpillar						
	Fruit tree leafroller						
Tobacco	Tobacco flea beetle	WP	62.5 g in 29 L spray volume/100 m^2 =6.25 kg/ha	18.75 kg/ha	r.a.n. *(3)*	7	Y
		SU	72–84 g in 33 L spray volume/100 m^2 =7.2-8.4 kg/ha	21.6–25.2 kg/ha			
			69.9–81.55 g in 33 L spray volume/100 m^2 =6.99–8.155 kg/ha	20.97–24.465 kg/ha			
	Cutworms	WP	2.25 kg/ha	6.75 kg/ha			
		SU	2.52 kg/ha	7.56 kg/ha			
			2.4465 kg/ha	7.3395 kg/ha			

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
	Fea beetles, Hornworms, Tobacco budworm	WP	0.875–1.125 kg/ha	2.625–3.375 kg/ha			
		SU	0.932–1.2815 kg/ha	2.796–3.8445 kg/ha			
	Flea beetles, Hornworms		0.96–1.32 kg/ha	2.88–3.96 kg/ha			
Tobacco (field)	Flea beetles, Hornworms	DU	1.5–1.75 kg/ha	4.5–5.25 kg/ha			
Tobacco (greenhouse in plant beds)	Tobacco flea beetle		0.11 kg/100 m^2 =11 kg/ha	33.0 kg/ha			
Arborvitae, Azalea, Birch, Boxwood, Carnations, Chrysanthemums, Dogwood, Elm, Gladiolus, Holly, Hydrangea, Juniper, Lilac, Maple, Oak, Pines, Roses, Zinnia	Bagworms, Birch leafminer, Black vine weevil, Blister beetles, Boxelder bug, Boxwood leaf miner, Canker worms, Elm leaf aphid, Elm leaf beetle, Flea beetles, Japanese beetle, June beetle, Lace bugs, Leafhoppers, Leafrollers, Mealybugs, Pine sawflies, Plant bugs, Psyllids, Rose aphid, Rose chafer, Rose slug, Scale insects, Tent caterpillars, Thrips (exposed), Willow leaf beetle	WP	0.50–0.75 kg/500 L =1.0–1.5 kg/ha (not trees) =3.0–4.5 kg/ha (trees)	3.0–4.5 kg/ha (not trees) 9.0–13.5 kg/ha (trees)	Not stated *(3)*	7	Y
		SU	1.104–1.68 kg/ha (not trees) 3.312–5.04 kg/ha (trees)	3.312–5.04 kg/ha (not trees) 9.936–15.12 kg/ha (trees)			
	Bagworms, Birch leafminer, Black vine weevil (Taxus weevil), Blister beetles, Boxelder bug, Boxwood leafminer, Cankerworms, Cooley spruce gall aphid, Eastern spruce gall aphid, Elm leaf aphid, Elm leaf beetle, Elm spanworm, Eriophyid mites, Flea beetles, Gypsy moth, Japanese beetle, June beetle, Lace bugs, Leafhoppers, Leafrollers, Mealybugs, Pine sawflies, Plant bugs, Psyllids, Rose aphid, Rose chafer, Rose slug, Scale insects, Tent caterpillars, Thrips (exposed), Webworms, Willow leaf beetle		1.0718–1.631 kg/ha (not trees) 3.22–4.89 kg/ha (trees)	3.2154–4.893 kg/ha (not trees) 9.66–14.67 kg/ha (trees)			
			1.248–1.5 g/L 1.248–1.5 kg/ha (not trees) 3.74–4.5 kg/ha (trees)	3.744–4.5 kg/ha (not trees) 11.22–13.5 kg/ha (trees)			
Green ash	Ash plant bug	SU	1.2116 kg/1000 L	7.27 kg/ha	2	7	Y, M

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
			=3.635 kg/ha				
Turf (ornamental and sports)	Ants, Chinch bugs Cutworms (climbing) Earwigs, Fall army worm, Fleas Leafhoppers, Millipedes, Mosquitoes, Sod wet worms	WP	100 g/150–200 L of water/100m^2 =10 kg/ha	30 kg/ha	Not stated *(3)*	14	Y
		SU	1.0–1.39 g/m^2 =10–13.9 kg/ha	30.0–41.7 kg/ha			
			0.98–1.35 g/m^2 =9.8–13.5 kg/ha	29.4–40.5 kg/ha			
			0.9–1.25 g/m^2 =9.0–12.5 kg/ha	27.0–37.5 kg/ha			
Turf	European Chafer, Japanese Beetle (suppression of population)	SU	1.0–1.39 g/m^2 =10–13.9 kg/ha	30.0–41.7 kg/ha	Not stated *(3)*	7	Y
			0.98–1.35 g/m^2 =9.8–13.5 kg/ha	29.4–40.5 kg/ha			
	Leatherjackets (larvae of crane flies; *Tipula oleracea and Tipula paludosa*)		0.93 g/m^2 =9.3 kg/ha	9.3 kg/ha	1		Y, M
Turf (including golf course)	Leatherjackets, (larvae of crane flies: *Tipula paludosa, and Tipula oleracea* (larvae of crane flies; *Tipula oleracea and Tipula paludosa*)	SU	0.96 g/m^2 =9.6 kg/ha	9.6 kg/ha	1	7	Y, M
			0.93 g/m^2 =9.3 kg/ha	9.3 kg/ha			
Chickens, Ducks, Geese, Partridges, Pheasants, Pigeons, Turkeys	Lice, Northern fowl mite and as a supplement to premises treatment for chicken mites, Fleas, Fowl ticks	WP	0.5 kg/100 L of water	Can not be calculated	Not stated	7	N
		SU	0.576 kg/100 L of water				
Roosts and Buildings	Bed bugs, Fleas, Chicken mites	WP	0.5 kg/100 L of water				
		SU	0.576 kg/100 L of water				
	Fowl ticks	WP	2.0 kg/100 L of water				
Roosts and Buildings (poultry houses)	Lesser mealworm	WP	0.625 kg/100 mL of water				
Beef cattle, Goats, Hogs, Horses, Sheep	Fleas, Hornfly, Lice, Winter ticks	WP	0.5 kg/100 L of water	Can not be calculated	Not stated	14	N

Site(s)	Pest(s)	Formulation Type[1]	Application Rate[2] a.i.		Maximum Number of Applications/ Season[3]	Minimum Interval Between Applications (Days)	Supported Use[4]
			Single	Cummulative			
		SU	0.576 kg/100 L of water				
Dairy cattle		WP	0.5 kg/100 L of water				
		SU	0.576 kg/100 L of water				
Beef and dairy cattle, Goats, Hogs, Horses, Sheep		DU	5 g/L of water at a rate of 4.5 L/head				
Chicken, Ducks, Geese, Turkeys and domestic game birds	Northern fowl mites and lice, Fleas and fowl ticks	DU	5 g/L of water at a rate of 4.5 ml/bird	Can not be calculated	Not stated	7	N

r.a.n. = repeat as necessary

[1] DU = Dust or Powder; GR = Granular; BB = Bran Bait; SU = Suspension; WP = Wettable Powder; n/a = not applicable

[2] The typical maximum water volume of spray solution is assumed to be 3000 L/ha unless other wise stated on the label.

[3] Numbers in italics are proposed by the registrant.

[4] Y = use is supported by the registrant; N = use is not supported by the registrant; P = the registrant partially supports the use pattern; and M = use was registered as a User Requested Minor Use Label Expansion (URMULE).

Table 2 Registered Domestic Class Uses of Carbaryl as of June 2007 from the PMRA Electronic Label Collection. The Following are Uses of Products Formulated with Carbaryl Only

Site(s)	Pest(s)	Formulation Type[1]	Single Application Rate (g a.i.)	Maximum Number of Applications/ Season	Minimum Interval Between Applications (Days)	Supported Use[2]
Asparagus, Beans, Broccoli, Brussels sprouts, Cabbage, Carrots, Cauliflower, Celery, Corn, Horseradish, Kohlrabi, Parsley, Pea, Pepper, Potato, Pumpkin, Radish, Squash, Tomato, Beet roots, Eggplant	Armyworms, Asparagus beetles, Cabbageworm, Cabbage loopers, Colorado potato beetle, Corn borers, Corn earworm, Corn rootworm adults, Cucumber beetle, Cutworms, Flea beetles, Hornworms, Leafhoppers, Mexican bean beetles, Spittlebugs, Squash bugs, Stink bugs, Tarnished plant bug, Tomato fruit worms	DU	Not stated	r.a.n.	7	Y
Asparagus, Beans, Beets, Broccoli, Brussels sprouts, Cabbage, Carrots, Cauliflower, Celery, Chinese cabbage, Corn, Cucumber, Eggplant, Endive, Horseradish, Kale, Kohlrabi, Lettuce, Melons, Parsley, Parsnip, Pepper, Potato, Pumpkin, Radishes, Rutabagas, Spinach, Squash, Swiss chard, Tomato, Turnip, Watercress.	Asparagus beetles, Flea beetles, Leafhoppers, Mexican bean beetles, Colorado potato beetles, Corn earworms, Corn borers, Cucumber beetles, Squash bugs	SU	1.2 g/10 m^2	r.a.n.	7	Y
	Armyworms, Fruit worms, Tomato Hornworms, Stink bugs		1.68 g/10 m^2			
	Climbing cutworms		2.4 g/10 m^2			
Asparagus (seedlings, spears)	Asparagus beetle, Climbing cutworms	SU	1.248–3 g/10 m^2	r.a.n.	3	Y
			1.2–2.4 g/10 m^2			
		SN	1.25–3 g/10 m^2			
			1.2–2.4 g/10 m^2			
			1.25–3.01 g/10 m^2			
Bean	Mexican bean beetles	SU	0.6–0.72 g/L	r.a.n.	7	Y
			0.6–0.72 g/10 m^2			
		SN	0.48–0.72 g/10 m^2			
			0.6–0.72 g/10 m^2			
			0.06–0.072 g/m^2			
	Flea beetles, Leafhoppers	SU	1.2 g/10 m^2			
			1.248 g/10 m^2			
		SN	1.2 g/10 m^2			
			1.25 g/10 m^2			
			1.252 g/10 m^2			

Site(s)	Pest(s)	Formulation Type[1]	Single Application Rate (g a.i.)	Maximum Number of Applications/ Season	Minimum Interval Between Applications (Days)	Supported Use[2]
	Lygus bugs, Stink bugs	SN	2.41 g/10 m^2			
			2.5–3 g/10 m^2			
		SU	2.4–2.89 g/10 m^2			
		SN	2.502–3.009 g/10 m^2			
Carrot	Flea beetles, Leafhoppers	SU	0.72–2.4 g/10 m^2	Not listed	Not listed	Y
			0.6–1.248 g/10 m^2	r.a.n.	7	
		SN	0.48–1.2 g/10 m^2			
			0.6–1.25 g/10 m^2			
			0.602–1.252 g/10 m^2			
	Armyworms, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebug, Stink bugs	SU	1.2–2.4 g/10 m^2			
			1.25–2.5 g/10 m^2			
Broccoli, Brussels sprouts, Cabbage, Cauliflower, Celery, Kohlrabi	Flea beetles, Leafhoppers	SU	0.72–2.4 g/10 m^2	r.a.n.	7	Y
			0.6–1.248 g/10 m^2			
	Armyworms, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebug, Stink bugs		1.2–2.4 g/10 m^2			
			1.248–2.5 g/10 m^2			
Beet roots, Horseradish, Radish, Rutabaga root, Salsify roots, Turnip roots	Flea beetles, Leafhoppers	SU	0.72–2.4 g/10 m^2	r.a.n.	7	Y
			0.6–1.248 g/10 m^2			
	Armyworms, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebug, Stink bugs		1.2–2.4 g/10 m^2			
			1.248–2.5 g/10 m^2			
Beet tops, Chinese cabbage, Dandelion, Endive, Kale, Leaf lettuce, Mustard greens, Parsnip, Salsify, Spinach, Swiss chard, Turnips, Watercress	Armyworms, Asparagus beetle, Cabbageworm, Cabbage loopers, Colorado potato beetle, Corn borers, Corn earworm, Corn rootworm adults, Cucumber beetle, Cutworms, Flea beetles, Hornworms, Leafhoppers, Mexican bean beetle, Spittle bugs, Squash bugs, Stink bugs, Tarnished plant bug, Tomato fruit worm	DU	Not stated	r.a.n.	7	Y

Site(s)	Pest(s)	Formulation Type[1]	Single Application Rate (g a.i.)	Maximum Number of Applications/ Season	Minimum Interval Between Applications (Days)	Supported Use[2]
Beet tops, Chinese Cabbage, Dandelion, Endive, Kale, Lettuce leaf, Mustard Greens, Parsley, Parsnip, Salsify tops, Spinach, Swiss Chard, Turnip tops, Watercress	Flea beetles, Leafhoppers	SU	0.72–2.4 g/10 m^2	r.a.n.	7	Y
			0.6–1.248 g/10 m^2			
	Armyworms, Corn earworm, Diamondback moth (larvae), Imported cabbageworm, Lygus bugs, Meadow spittlebug, Stink bugs		1.2–2.4 g/10 m^2			
			1.248–2.5 g/10 m^2			
Corn (field and sweet)	Corn earworm, Northern corn rootworm adults, European corn borer, Fall armyworm	SU	1.2–1.926 g/10 m^2	3 or more	2	Y
			1.248–1.992 g/10 m^2			
		SN	1.2–1.44 g/10 m^2			
			1.25–2 g/10 m^2			
			1.252–1.998 g/10 m^2			
Broccoli, Brussels sprouts, Cabbage, Cauliflower, Celery	Flea beetles, Leafhoppers	SN	0.602–1.252 g/10 m^2	r.a.n.	7	Y
			0.48–1.2 g/10 m^2			
			0.6–1.25 g/10 m^2			
Cabbage, Cauliflower	Flea beetles, Cabbage loopers	DU	25 g/100 m^2 (2.5 g/10 m^2)			
Beet tops and beet roots	Flea beetles, Leafhoppers	SN	0.602–1.252 g/10 m^2	r.a.n.	7	Y
			0.48–1.2 g/10 m^2			
			0.6–1.25 g/10 m^2			
Chinese cabbage, Dandelion, Endive, Kale, Leaf lettuce, Mustard greens, Parsley, Parsnips, Salsify tops, Spinach, Swiss chard, Turnip top, Watercress, Kohlrabi, Horseradish, Radishes, Rutabaga roots, Salsify, Turnip roots	Armyworms, Corn earworm, Diamondback moth (larvae), Imported cabbage worm, Lygus bugs, Meadow spittlebug, Stink bugs	SN	1.252–2.503 g/10 m^2	r.a.n.	7	Y
			1.2–2.4 g/10 m^2			
			1.25–2.5 g/10 m^2			
Cucumbers, Squash, Melons, Pumpkins	Cucumber beetles, Cutworms (climbing), Flea beetles, Leafhoppers, Squash bugs	SU	1.2 g/10 m^2	r.a.n.	7	Y
			1.248 g/10 m^2			
		SN	1.2 g/10 m^2			
			1.25 g/10 m^2			
			1.252 g/10 m^2			
Potatoes	Flea beetles, Leaf hoppers and	DU	25 g/100 m^2	Not listed	7	Y

Site(s)	Pest(s)	Formulation Type[1]	Single Application Rate (g a.i.)	Maximum Number of Applications/ Season	Minimum Interval Between Applications (Days)	Supported Use[2]
	Colorado beetles		(2.5 g/10 m^2)			
Tomatoes	Flea beetles, Tomato hornworm, Tomato fruit worm	DU	25 g/100 m^2 (2.5 g/10 m^2)	Not listed	7	Y
Potato, Tomato, Eggplant, Pepper	Colorado potato beetle	SU	0.6 g/10 m^2	r.a.n.	7	Y
	Colorado potato beetle	SN	0.48 g/10 m^2			
			0.6 g/10 m^2			
			0.6 g/10 m^2			
	European corn borer, Fall armyworm, Tomato hornworm, Tomato fruitworm	SU	1.2–2.4 g/10 m^2			
			1.248–2.5 g/10 m^2			
		SN	1.2–2.4 g/10 m^2			
			1.25–2.5 g/10 m^2			
			2.5–3.0 g/10 m^2			
	Stink bugs, Tarnished plant bug	SU	2.4–2.889 g/10 m^2			
			2.5–3 g/10 m^2			
		SN	2.4 g/10 m^2			
			2.5–3 g/10 m^2			
	Cutworms (climbing)	SU	1.926–2.4 g/10 m^2			
			1.992–2.5 g/10 m^2			
		SN	1.44–2.4 g/10 m^2			
			2–2.5 g/10 m^2			
Vegetable, Fruit gardens	Earwigs, Sowbugs, Crickets, Cutworms, Sap beetles, Wood roaches and millipedes	GR	0.5–1 g/covered bait stations	Not listed	Not listed	Y
Apples, Apricots, Cherries, Peaches, Pears, Plums	Aphids, Apple maggots, Codling moths, Cherry fruit flies, Fruit worms, Leafhoppers, Leafminers, Leafrollers, Mealybugs, Pear slugs, Scale insects (crawlers), Tent caterpillars	SU	1.2 g/L	r.a.n.	7	Y
Apples, Pears	Apple leafhopper, Apple leafroller, Codling moth, Eyespotted bud moth, Mealybug, Redbanded leafroller (first brood)	SU	0.6 g/L	r.a.n.	7 (10 days for apple maggot)	Y
	Apple maggot, Eastern tent caterpillar, Fruit tree leafroller, Green fruitworm, Pear leaf blister mite, Pear psylla, Pear slug, Pistol case bearer, Plum curculio, Redbanded leafroller (2nd brood), Rust mites, Tarnished plant bug, Tentiform leafminer, Woolly apple aphid		1.2 g/L			
	Apple leafhopper, Apple leafroller, Codling moth, Eyespotted bud moth, Pistol case bearer, Mealybug, Redbanded leafroller (1st brood), Apple maggot, Eastern tent caterpillar, Fruit tree leafroller, Green fruitworm, Pear leaf blister mite, Pear psylla, Pear slug, Pistol case bearer, Plum curculio, Redbanded leafroller (2nd brood), Rust mites, Tarnished plant bug, Tentiform leafminer, Woolly apple aphid	SN	1.107 g/10 m^2			
			1.2 g/10 m^2			
			1.1g/10 m^2			
			3.32 g/10 m^2			
			3.61 g/10 m^2			
		SU	1.104 g/10 m^2			
			3.312 g/10 m^2			
Blackberries,	Climbing cutworms, Leafhoppers,	SU	1.92	r.a.n.	7	Y

Site(s)	Pest(s)	Formulation Type[1]	Single Application Rate (g a.i.)	Maximum Number of Applications/ Season	Minimum Interval Between Applications (Days)	Supported Use[2]
Blueberries, Boysenberries, Loganberries, Raspberries, Strawberries and Grapes	Leafrollers, Fruit worms, Spittlebugs		g/10 m^2			
Blackberries, Boysenberries, Dewberries, Loganberries, Raspberries	Blackberry leafminer, Japanese beetle, Leafhoppers, Leafroller aphid, Rose stem girdler, Spotted winged raspberry aphid	SU	2.4 g/10 m^2	r.a.n.	7	Y
	Blackberry leafminer, Japanese beetle, Leafhoppers, Leafroller aphid, Rose stem girdler, Spotted winged raspberry aphid	SU	2.5 g/10 m^2			
		SN	2.41 g/10 m^2			
			2.5 g/10 m^2			
			2.5 g/10 m^2			
Blueberries	Blueberry maggot, Cranberry fruit worm, Lecanium scale	SU	1.926 g/10 m^2	2	10	Y
			1.992 g/10 m^2			
		SN	1.44 g/10 m^2			
			2 g/10 m^2			
			2 g/10 m^2			
Cranberries	Bluntnosed cranberry leafhopper, Cranberry fruitworm, Cutworms (climbing), Fireworms	SU	2.889–3.37 g/10 m^2	r.a.n.	7	Y
			3–3.36 g/10 m^2			
		SN	3.61 g/10 m^2			
			3–3.37 g/10 m^2			
			3–3.37 g/10 m^2			
Plums, Cherries	Codling moth, Eastern tent caterpillar, Oak leafhopper, Prune leafhopper	SU	0.72–0.84 g/L	r.a.n.	7	Y
			2.208 g/10 m^2			
		SN	2.4 g/10 m^2			
			2.21 g/10 m^2			
			2.21 g/10 m^2			
	Apple maggot, Black cherry aphid, Cherry fruitfly, Cherry fruitworm, Eyespotted bud moth, Fruit tree leafroller, Lesser peach tree borer, Mealy plum aphid, Peach twig borer, Plum curculio, Redbanded leafroller, Scale insects	SU	3.312 g/10 m^2			
			1.2 g/L			
		SN	3.61 g/10 m^2			
			3.32 g/10 m^2			
Grapes, Raspberry, Strawberry	Aphids, Fruit flies, Grape berry moth, Japanese beetle, Leafhoppers, Leafrollers, Spittlebugs.	DU	Not stated	r.a.n.	7	Y
Grapes	Grape berry moth, Leaf hoppers	SU	2.4–2.889 g/10 m^2	r.a.n.	7	Y
			2.5–3 g/10 m^2			
		SN	2.4 g/10 m^2			
			2.5-3 g/10 m^2			
			2.5–3 g/10 m^2			
Strawberries	Meadow spittlebug, Strawberry leafroller	SU	1.2–2.4 g/10 m^2	r.a.n.	7	Y
			1.248–3 g/10 m^2			
		SN	1.2–2.4 g/10 m^2			
			1.25–3 g/10 m^2			
			1.25–3 g/10 m^2			

Site(s)	Pest(s)	Formulation Type[1]	Single Application Rate (g a.i.)	Maximum Number of Applications/ Season	Minimum Interval Between Applications (Days)	Supported Use[2]
Apricots, Peaches	Catfacing insects, Codling moth, European earwig, European fruit lecanium, Fruit tree leafroller, Lesser peach tree borer, Oriental fruit moth, Peach silver mite, Peach twig borer, Plum curculio, Scale insects	SU	1.2 g/L	r.a.n.	7	Y
	Catfacing insects, Codling moth, European earwig, European fruit lecanium, Fruit tree leafroller, Lesser peach tree borer, Oriental fruit moth, Peach silver mite, Peach twig borer, Plum curculio, Scale insects, Redbanded leafroller		3.312 g/10 m^2			
		SN	3.6 g/10 m^2			
			3.3 g/10 m^2			
			3.32 g/10 m^2			
Shrubbery, Flower gardens	Earwigs, Sowbugs, Crickets, Cutworms, Sap beetles, Wood roaches and millipedes	GR	0.5–1 g/covered bait stations	Not listed	Not listed	Y
Ornamentals (Flowers, Shrubs, Perennials)	Aphids, Bagworms, Cankerworm, Gypsy moth, Japanese beetle, Lace bugs, Leaf beetles, Leafhoppers, Leafminers, Leafrollers, Mealybugs, Plant bugs, Psyllids, Roseslugs, Scale Insects, Tent caterpillars, Thrips and many more	DU		r.a.n.	7	Y
Arborvitae, Azalea, Birch, Boxwood, Carnations, Chrysanthemum, Dogwood, Elm, Gladiolus, Holly, Hydrangea, Juniper, Lilac, Maple, Oak, Pines, Roses, Zinnia	Bagworm, Birch leafminer, Black vine weevil (Taxus weevil), Blister beetles, Box elder bug, Boxwood leafminers, Cankerworms, Flea beetle, Elm leaf aphid, Elm leaf beetle, Japanese beetle, June beetles, Lace bugs, Leafhoppers, Leafrollers, Mealybugs, Pine sawflies, Plant bugs, Psyllids, Rose aphid, Rose chafer, Rose slug, Scale insects, Tent caterpillars, Thrips (exposed), Willow leaf beetle	SU	1.2–1.44 g/L	r.a.n.	7	Y
			1.248–1.5 g/10 m^2			
		SN	1.2–1.44 g/10 m^2			
			1.25–1.5 g/10 m^2			
			1.25–1.5 g/10 m^2			
	Rose aphids, Bagworms, Birch Leafminers, Black vine weevils, Blister beetles, Box elder bugs, Boxwood leafminers, Cankerworms, Elm Leaf beetles, Flea beetles, Gypsy moths, Japanese beetles, June beetles, Lace bugs, Leaf hoppers, Leaf rollers, Mealybugs, Pine saw flies, Plant bugs, Psyllids, Rose chafer, Rose slugs, Scale insects (crawlers), Spruce budworms, Tent caterpillars, Thrips (exposed), Willow leaf beetles	SU	1.2 g/L			
Lawns	Earwigs, Ants, Millipedes, Fleas, Fall armyworms, Leafhoppers, Sowbugs, Chinch bugs, Sod webworms	DU	12.5 g/10 m^2	r.a.n.	Not listed	P[3]
	Ants, Armyworms, Chinch bugs, Earwigs, Fleas, Millipedes, Mosquitoes, Sod webworms (Lawn moths) and others		25 g/20 m^2 (12.5 g/10 m^2)		14	
			25 g/20 m^2 (12.5 g/10 m^2)			
	Ants, Chinch bugs, Earwigs, Fall armyworms, Fleas, Leaf hoppers, Millipedes, Mosquitoes, Sod-webworms		12 g/10 m^2			
	White grubs (European Chafer and suppression of Japanese Beetle)	EC	10.11–13.96 g/10 m^2		Not listed	
			120.4 g/119 m^2 (10.1 g/10 m^2)			

Site(s)	Pest(s)	Formulation Type[1]	Single Application Rate (g a.i.)	Maximum Number of Applications/ Season	Minimum Interval Between Applications (Days)	Supported Use[2]
	Ants, Chinch bugs, Climbing cutworms, Earwigs, Fall armyworm, Fleas, Leafhoppers, Millipedes, Mosquitoes and Sod webworms		9.03–12.52 g/10 m^2		14	
			9.05–12.54 g/10 m^2)			
Turf/Lawns (ornamental and sports)	Ants, Chinch bugs, Climbing cutworms, Earwigs, Fall armyworm, Fleas, Leafhoppers, Millipedes, Mosquitoes, Sod webworms	SU	12.0375 g/10 m^2	r.a.n.	14	P[3]
			9.12–12.48 g/10 m^2			
			9.15–12.54 g/10 m^2			
		SN	0.48–0.72 g/10 m^2			
			9.1–12.5 g/10 m^2			
			9–12.5 g/10 m^2			
Gardens, Ant Hills and Trails	Ants, Chinch bugs, Climbing cutworms, Earwigs, Fall armyworm, Fleas, Leafhoppers, Millipedes, Mosquitoes, Sod webworms	DU	25 g/20 m^2	r.a.n.	14	Y
Turf	European Chafer, Japanese Beetle suppression of population	SU	10.08–13.92 g/10 m^2	r.a.n.	7	P[3]
	White grubs, European Chafer, Japanese Beetle (suppression of population)	SN	0.48–0.963 g/10 m^2			
			10.1–14 g/10 m^2			
Turf/Lawns	White grubs,European chafer, Japanese beetle (suppression of population)	SU	10.1–14 g/10 m^2	r.a.n.	7	P[3]
	Ants, Chinch bugs, Climbing cutworms, Earwigs, Fall armyworm, Fleas, Leafhoppers, Millipedes and Sod webworms (lawn moths)	DU	25 g/25 m^2	Not listed	Not listed	Y
			25 g/25 m^2 (10 g/10 m^2)	r.a.n.	14	Y
Building foundations, Under porches	Earwigs, Sowbugs, Crickets, Cutworms, Sap beetles, Wood roaches and Millipedes	GR	0.5–1 g/covered bait stations	Not listed	Not listed	Y
Kennels, Dog houses and sleeping pads	Fleas, Brown dog ticks and American dog ticks	DU	Not stated	Not listed	Not listed	N
dogs and cats	Fleas, Brown dog ticks and American dog ticks	DU	Not stated	r.a.n.	7	N
	Dog fleas, Cat fleas, American dog ticks, Brown dog ticks					
	Fleas, Ticks					

[1] DU = Dust or Powder; EC = Emulsifiable Concentrate or Emulsion; GR = Granular; SN = Solution; SU = Suspension.

[2] Y = use is supported by the registrant; N = use is not supported by the registrant; P = the registrant partially supports the use pattern; M = use was registered as a User Requested Minor Use Label Expansion (URMULE).

[3] The broadcast application of liquid formulations on residential lawns was proposed for discontinuation by the registrant. It would be limited to spot treatment only.

r.a.n. = repeat as necessary

n/a = not applicable

Table 3 Registered Domestic Class Uses of Carbaryl as of June 2007 from the PMRA Electronic Label Collection. The Following are Uses of Products Formulated with Carbaryl and Fungicide Active Ingredients

Site(s)	Pest(s)	Formulation Type[1]	Single Application Rate (a.i.)	Maximum Number of Applications/ Season	Minimum Interval Between Applications (Days)	Supported Use[2]
Apples, Apricots, Blackberries, Cherries, Strawberries, Cucumbers, Peppers, Tomatoes Ornamentals: Outside only	Most diseases and insects	DU	Not stated 1 g/L of water	not listed	10	Y
Grape	**Diseases:** Black rot, Dead arm, Downy mildew **Insects:** Berry moth, Leafhoppers	DU	Not stated	r.a.n.	7	Y
Strawberry	**Disease:** Leaf spot **Insects:** Spittle bugs, Leafrollers	DU	Not stated	r.a.n.	7	Y
Iris, Tulip, Daffodil, Narcissus, Crocus and Hyacinth bulbs, Dahlia and Begonia tubers and Gladiolus corms	**Diseases:** Damping-off, Bulb rot **Insects:** Thrips (exposed)	DU*	Not stated	1	N/A	Y
	Diseases: Damping-off, Root rot		5 g/2 m^2 or 2.5 g/8 m row			
Ornamentals (rose)	**Diseases:** Black spot, Powdery mildew, Downy mildew **Insects:** Beetles, Leafhoppers, Leafrollers, Plant bugs, Rose aphid, Rose chafer, Rose slug	DU	Not stated	r.a.n.	7	Y
Roses and Other flowers and Ornamentals	**Insects:** Aphids, Flea beetles, Young grasshoppers, Leafhoppers, Leafminer, Mites, Rose chafer, Tarnished plant bug, Thrips, Caterpillars, Leafroller, Loopers, Scale insects (crawler stage only) **Insects:** Black spot of roses, Powdery mildew, Anthracnose	DU	Not stated	r.a.n.	7	Y
Roses, Evergreens, Conifers, Junipers and Other ornamental flowers and Shrubs	**Diseases:** Black spot, Powdery mildew, Blight **Insects:** Aphids, mites, Rose chafers, Leafhoppers, Sawfly, Spruce budworm, Tent caterpillars, Leaf miners and other chewing insects	DU	Not stated	r.a.n.	7	Y
Bean	**Diseases:** Anthracnose, Leaf spot, Downy mildew	DU*	Not stated	r.a.n.	7	Y
Beet	**Diseases:** *Cercospora* leaf spot	DU*	Not stated	r.a.n.	7	Y
Broccoli, Cabbage, Brussels sprouts, Cauliflower	**Diseases:** Black leaf spot, Grey leaf spot, downy mildew, leaf spot **Insects:** Flea beetles, Leafhoppers, Armyworms, Cabbage loopers, Diamond back moth, Imported cabbageworm, Spittlebug, Stink bug	DU	Not stated	r.a.n..	7	Y
Carrot	**Diseases:** *Cercospora* leaf spot	DU*	Not stated	r.a.n.	7	Y
Celery	**Diseases:** Early blight, Late blight	DU*	Not stated	r.a.n.	7	Y
Cucumber, Melon, Squash	**Diseases:** Anthracnose, Leaf spot, Scab **Insects:** Cucumber beetle, Climbing cutworm, Flea beetle, Leafhoppers, Squash bugs	DU	Not stated	r.a.n.	7	Y
Eggplant, Pepper	**Diseases:** Early blight, Late blight **Insects:** Colorado potato beetle, Corn	DU	Not stated	r.a.n.	7	Y

Site(s)	Pest(s)	Formulation Type[1]	Single Application Rate (a.i.)	Maximum Number of Applications/ Season	Minimum Interval Between Applications (Days)	Supported Use[2]
	borer, Fall armyworm, Tomato hornworm, Tomato fruitworm, Leafhoppers, Flea beetles, Stink bugs, Plant bugs, Climbing cutworm					
Potatoes	**Diseases:** Early and Late blight **Insects:** Colorado potato beetle, Flea beetle and Leaf hoppers	DU	25 g/100 m^2	Not stated	Less than 7 days	Y
	Diseases: Early blight, Late blight **Insects:** Colorado potato beetle, Corn borer, Fall armyworm, Tomato hornworm, Tomato fruitworm, Leafhoppers, Flea beetles, Stink bugs, Plant bugs, Climbing cutworm		Not stated	r.a.n.	5	Y
	Diseases: Early and Late blight **Insects:** Colorado potato beetle and Flea beetle		15–22.5 g/100 m^2		7	
Tomato	**Diseases:** Anthracnose, Early blight, Late blight, *Septoria* leaf spot **Insects:** Colorado potato beetle, Corn borer, Fall armyworm, Tomato hornworm, Tomato fruitworm, Leafhoppers, Flea beetles, Stink bugs, Plant bugs, Climbing cutworm	DU	Not stated	r.a.n.	7	Y
Spinach	**Diseases:** Downy mildew, White rust	DU*	Not stated	r.a.n.	7	Y

[1] DU=Dust or Powder; SU=Suspension
[2] Y=use is supported by the registrant
* insect pest claims are not made on the labels
r.a.n. = repeat as necessary
N/A = not applicable

Appendix III Uses of Carbaryl for Those Site-Pest Combinations of Commercial and/or Restricted Class Products That Are Not Supported By the Technical Registrant or for which Risk Concerns Have Been Identified

Site(s)	Pest	Supported Use[1]	Concerns From Risk Assessments[2]	Identification of Risk Assessment Concerns
Chickens, Ducks, Geese, Partridges, Pheasants, Pigeons, Turkeys	Lice, Northern fowl mite and as a supplement to premises treatment for chicken mites, Fleas, Fowl ticks	N	N/A	N/A
Beef cattle, Goats, Hogs, Horses, Sheep	Fleas, Hornfly, Lice, Winter ticks	N	N/A	N/A
Roosts and Buildings	Bed bugs, Fleas, Chicken mites, Fowl ticks	N	N/A	N/A
Poultry houses	Lesser mealworm	N	N/A	N/A
Turf	Ants, Chinch bugs, Climbing cutworms, Earwigs, Fall armyworm, Fleas, Leafhoppers, Millipedes, Mosquitoes, Sod webworms	Y, M	P	See Section 8.0
Trap trees	Mountain pine beetle (to control small infestations)	Y	P	See Section 8.0
Alfalfa and clover	Cereal leaf beetle, Blister beetles, Flea beetles, Leafhoppers, Three cornered alfalfa hopper, Alfalfa caterpillar, Armyworms, cutworms (climbing), Sweet clover weevil, Webworms	Y	P	See Section 8.0
Barley	Blister beetle, Flea beetles, Leafhoppers, Three cornered alfalfa hopper	Y	P	See Section 8.0
Ditchbanks, Field borders, Rights-of-way, Wastelands, Headlands, Wastelands, Forage grasses, Pastures, Rangelands	Grasshoppers (nymphs or sparse vegetation), Grasshoppers (nymphs on dense vegetation), Grasshoppers (adults on sparse or dense vegetation)	Y	P	See Section 8.0
Barley, Oats, Rye, Wheat	Alfalfa caterpillar, Armyworms, Webworm, Grasshoppers	Y	P	See Section 8.0

Site(s)	Pest	Supported Use[1]	Concerns From Risk Assessments[2]	Identification of Risk Assessment Concerns
Beet (root), Horseradish, Radish, Rutabaga (root), Salsify (root), Turnip root	Flea beetles, Leafhoppers	Y	P	See Section 8.0
Carrots	Asparagus beetles, Fleabeetles, Leafhoppers, Mexican bean beetles, Colorado potato beetles, Corn earworms, Corn borers, Cucumber beetles, Squash bugs	Y	P	See Section 8.0
Corn (field and sweet)	Corn earworm, Northern corn rootworm adults, European corn borer, Fall armyworm	Y	P	See Section 8.0
Leafy vegetables	Flea beetles, leafhoppers, Corn earworm, Imported cabbageworm, Cabbage looper, Armyworms, Meadow spittle bug, Lygus bug, Stink bugs	Y	P	See Section 8.0
Potatoes	Colorado potato beetle, Flea beetle and Leaf hoppers	Y	P	See Section 8.0
Snapbeans	European corn borer	Y	P	See Section 8.0
Berries	Climbing Cutworms, Leafhoppers, Leafrollers, Fruit worms, Spittlebugs	Y	P	See Section 8.0
Blueberries	Blueberry maggot, Cranberry fruit worm, Lecanium scale	Y, M	P	See Section 8.0
Cranberries	Bluntnosed cranberry leafhopper, Cranberry fruitworm, Cutworms (climbing), Fireworms	Y	P	See Section 8.0
Grapes	Grape berry moth, Leaf hoppers	Y	P	See Section 8.0
Strawberries	Meadow spittlebug, Strawberry leafroller	Y	P	See Section 8.0
Tobacco	Flea beetles, Hornworms, Tobacco budworm, Cutworms	Y	P	See Section 8.0

Site(s)	Pest	Supported Use[1]	Concerns From Risk Assessments[2]	Identification of Risk Assessment Concerns
Arborvitae, Birch, Boxwood, Dogwood, Elm, Juniper, Maple, Pines	Bagworms, Birch leafminer, Black vine weevil (Taxus weevil), Blister beetles, boxelder bug, Boxwood, Leafminer, Cankerworms, Elm leaf aphid, Elm leaf beetle, Flea beetles, Japanese beetle, June beetle, Lace bugs, Leafhoppers, Leafrollers, Mealybugs, Pine sawflies, Plant bugs, Psyllids, Rose aphid, Rose chafer, Rose slug, Scale insects, Tent caterpillars, Thrips (exposed), Willow leaf beetle	Y	P	See Section 8.0
High value trees	Mountain pine beetle	Y	P	See Section 8.0

[1] Y=use is supported by the registrant; N=use is not supported by the registrant; P=the registrant partially supports the use pattern; M=use was registered as a User Requested Minor Use Label Expansion (URMULE).

[2] Y=there are risk concerns for this use; N=there are no risk concerns for this use; P= partial risk concern for the use (e.g. The PMRA has risk concerns only for some application methods of the use); N/A = not applicable.

Appendix IV

Table 1 Toxicology Profile For Carbaryl[a]

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
Metabolism/Toxicokinetic Studies			
Excretion, distribution and metabolism–mice (9–10 ♂/dose)	Dietary non-labelled dose of 0, 10, 100, 1000 or 8000 ppm for 14 days followed by a single radiolabelled gavage dose (1-naphthyl-^{14}C) on day 15 >98% and 99% pure for labelled and unlabelled carbaryl, respectively		**Excretion:** Excreted primarily in the urine in the first 48 hours post dosing (urine ~55.8–68.9%, feces ~12.2–18.6% of the dose). **Distribution:** Minimal tissue retention (carcass: 0.24–0.82% of the dose, blood: <0.01% of the dose). **Metabolism:** Identified urinary metabolites: dihydro, dihydroxy-naphthyl sulphate, hydroxy-carbaryl glucuronide, 5,6-dihydro-5,6-dihydroxy carbaryl, naphthyl sulphate and naphthyl glucuronide. Excretion, distribution and metabolites were independent of dose.
Absorption, distribution, metabolism and excretion–Sprague-Dawley rats (5/sex/group)	Single radiolabelled i.v. dose (naphthyl-^{14}C): 1 mg/kg bw Single labelled gavage dose: 1 mg/kg bw; or 50 mg/kg bw (reduced from 100 mg/kg bw due to severe toxic effects and replaced with 10 additional animals) 14 daily non-labelled gavage doses: 1 mg/kg bw, followed by a single labelled gavage dose of 1 mg/kg bw >98% and 99.8% pure for labelled and unlabelled carbaryl, respectively		**Absorption and excretion:** Rapidly absorbed and excreted primarily in the urine (urine 88–95% and feces ~8.4–12.5% of the dose in 24 hours or 48 hours after treatment). Absorption and elimination were independent of dose, route and length of administration or sex. **Distribution**: Minimal tissue retention (<1% of administered dose 7 days post-dosing) with kidney and blood having the highest concentration of radioactivity. **Metabolism**: Ring hydroxylation and hydrolysis are the main metabolic pathways to produce various metabolites that are conjugated and form water soluble sulphate, glucuronides and mercapturates. In the high dose group, the following urinary metabolites were identified: • 11% of administered dose (AD) as free metabolites (5,6-dihydro-5,6- dihydroxycarbaryl, 5-hydroxycarbaryl and N-hydroxymethylhydroxycarbaryi >1% AD) • 46% AD as conjugated metabolites including 29% AD as enzyme-hydrolyzed metabolites, ie. those representing a glucuronic acid or sulfate conjugate (~half from hydrolysis pathway) and 18% AD as acid-hydrolyzed metabolites (<2% AD from hydrolysis pathway). In the high dose group, fecal metabolites were largely unidentified, with most metabolites <1% AD.
Excretion, distribution,	Single oral gavage radiolabelled dose (naphthyl-^{14}C): 50 mg/kg bw		**Excretion**: Rapidly excreted mainly in the urine (79–89%) and small amounts in the feces (7–10%) for all groups.

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
Metabolism– Sprague-Dawley rats (5 ♂/group, 15 months of age at the beginning of the study	Daily oral gavage radiolabelled dose: 2 mg/kg bw/day for 7 days, following a 83-day dietary administration of non-labelled carbaryl at 0, 250, 1500 or 7500 ppm (=0, 12.5, 75, or 375 mg/kg bw/day) 100% pure		**Distribution**: Minimal tissue retention for all groups (4% of administered dose 7 days post-dosing excluding skin/fur) with kidney having the highest concentration of radioactivity. **Metabolism**: In 24-hour urine samples, 23 metabolites were detected with the following identified (daily maximums): • <6% AD as trans-5,6-dihydro-5,6-dihydroxycarbaryl (free metabolites) • 60–76% AD as conjugated metabolites including glucuronide of dihyroxy-dihydroxycarbaryl (18–28% AD), naphthyl glucuronide (16–21% AD) and naphthyl sulfate (18–30% AD) • Average recovery of naphthyl sulfate is lower in the 7500 ppm group (12% AD) than in others (23–27% AD), suggestive of saturation of a sulfate conjugation pathway In 24-hour fecal samples, 20 metabolites were detected with only parent carbaryl identified (1.5% AD).
Absorption, distribution-Sprague-Dawley rats 4 ♂/dose/timepoint/route	Single dose of naphthyl-^{14}C-carbaryl by gavage (1 or 8 mg/kg bw), dermal (17 or 103 mg/kg bw) or i.v. route (0.8 or 9.2 mg/kg bw). The total peak total radioactive residue levels in whole blood, plasma, erythrocytes, and brain were assessed, as well as the amount of carbaryl in fat and liver at the high doses only. 100% pure		**Absorption**: The time to peak in tissues: Oral route: 0.25 hours at the low dose, 0.5 hours at the high dose Dermal route: 4 hours at the low dose, 12 hours at the high dose Intravenous: 5 minutes at either dose. **Distribution**: Carbaryl was found in brain, fat, and liver, 1-naphthol was in all the tissues, and 1-naphthol sulfate was in the plasma.
Metabolism-rats, guinea pigs, rabbits, monkeys, dogs and humans			All mammals tested have essentially similar metabolic pathways. Carbaryl is initially broken down by hydrolysis or by hydroxylation. Carbaryl metabolites are ultimately conjugated by sulfation or glucuronidation, and eliminated in the urine and feces. Although the nature of the metabolites is fairly consistent, there are variations among species in the quantity and order of distribution, with some species producing metabolites not found in others. In man, the primary mechanism of the carbaryl metabolism appears to be hydrolysis (major urinary metabolites of 1-naphthyl glucuronide and 1-naphthyl sulfate) as well as hydroxylation (4-hydroxy-carbaryl glucuronide).
Absorption, excretion and distribution– Beagle dogs (l/sex/dose)	Single labelled (1-naphthyl-^{14}C carbaryl) and unlabelled oral dose: 2.5 and 25 mg/kg bw in gelatin capsules. 99% and 99.8% pure for labelled and unlabelled carbaryl, respectively		**Absorption**: It peaked within 2 hours post dosing for both dose levels then gradually decreased over the 4-day period. The peak plasma levels of the low dose were fivefold higher than those of the high dose suggesting that "a higher proportion of the dose in dogs treated with the labelled low dose carbaryl was absorbed". **Excretion**: In urine, 30–35 % of the low dose was recovered in 24 hours and 33–43% by

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
			day 4; 9–12 % of the high dose was recovered in 24 hours and 14–15 % by day 4. In feces, 30–43% of the low dose recovered in 24 hours and 33–45 % by day 4 (note: "Technical difficulties in sampling nonhomogeneous samples precluded meaningful quantitative recovery data in the feces). **Distribution**: <1% of the dose found in the liver by day 4 (0.10–0.17 % of the high dose and 0.025–0.052 % of the low dose) Note: supplementary due to few animals tested.
Absorption, excretion and distribution–Beagle dogs (l/sex/dose)	Single i.v. labelled (1-naphthyl-^{14}C carbaryl) dose: 0 and 1.0 mg/kg bw, in propylene glycol purity not stated		**Absorption**: Estimated plasma half-life=6–7 hours. **Excretion**: In urine, 56–61 % of the dose in 24 hours, and 60–65 % of the dose by day 4. In feces: 6–12 % of the dose in 24 hours, and 8–13% of the dose by day 4. **Distribution**: < 0.04% of the dose found in the liver by day 4. Note: supplementary due to few animals tested.
Excretion and metabolism–dogs	Single labelled (1-naphthyl-^{14}C carbaryl) oral dose: 2.5 and 25 mg/kg bw, purity not stated		The metabolic pathways identified involved hydrolysis, N-methyl oxidation, ring hydroxylation and conjugation. No significant qualitative differences were found between male and female dogs or between high and low dosage levels. Fecal elimination accounted for 30–60% of the applied dose and was found to be primarily the result of incomplete absorption from the intestinal tract of the solid material and subsequent elimination of unchanged carbaryl.
Urinary metabolites–rats and dogs	Single labelled (1-naphthyl-^{14}C carbaryl) oral dose: 2.5 mg/kg bw, purity not stated		Similar urinary metabolites were identified in dogs and rats from 24-hour urine samples, with differences in quantity only. **Urinary metabolites in rats**: 18% AD as free metabolites (5-hydroxy carbaryl, 5,6-dihydrodihydroxy naphthol, 5,6-dihydrodihydroxy carbaryl and 4-hydroxy carbaryl >1% AD). 45% AD as conjugated metabolites including 39% AD as enzyme-hydrolyzed metabolites (i.e. 16% AD from hydrolysis pathway) and 6% AD as acid-hydrolyzed metabolites (<1% AD from hydrolysis pathway). **Urinary metabolites in dogs**: 10% of AD as free metabolites (carbaryl, 5-hydroxy carbaryl, 5,6-dihydrodihydroxy naphthol, and 5,6-dihydrodihydroxy carbaryl >1% AD). 43% of AD as conjugated metabolites including 28%AD as enzyme-hydrolyzed metabolites (i.e. ~3% AD from hydrolysis pathway), and 15% AD as acid-hydrolyzed metabolites (~1.5% AD from hydrolysis pathway).
Excretion and	25 mg/kg bw radiolabelled carbaryl		**Excretion**: Naphthyl and N-methyl labels: 40 and 23% of the dose, respectively, in urine;

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
metabolism–Beagle dogs (3 ♀)	(1-naphthyl-^{14}C and N-methyl-^{14}C) by oral gavage (gelatin capsules), purity not stated		and 35% and 11% of the dose, respectively, in feces in 7 days. **Metabolism**: Isolated (by chromatography) but most metabolites not identified except one described as 1-naphthyl methylimido carbonate O-glucuronide and later identified as 5.6-dihydroxy carbaryl glucuronide. Another metabolite was chromatographed at the 1-naphthyl glucuronide position, but lacked characteristic fluorescence. The major urinary metabolites associated with hydrolysis via 1-naphthol generally found in the rat urine [naphthyl glucuronide, naphthyl sulfate and 4-(methylcarbamoy1oxy)-1-naphthyl glucuronide] were not found in the dog. Note: considered supplementary as only 3 ♀ dogs tested, fecal metabolites not investigated with 35% of the naphthyl labelled dose excreted in the dog feces, the majority of urinary metabolites not identified, question of reproducibility with only one urinary sample analyzed.
In vivo and in vitro chromatographic profiles of carbaryl anionic metabolites–man, guinea pig, rat and dog			Carbaryl metabolite profiles by in vitro technique using liver tissues qualitatively reflect those urinary metabolites from in vivo metabolic processes of carbaryl in animals and humans (quantitative data between the two techniques not available). In vitro derived conjugated metabolites with naphthyl-^{14}C: naphthyl glucuronide (31%, 33%, 7.5% and 16%* of the dose, in man, guinea pig, rat and dog respectively) and naphthyl sulfate (l%, 12%, 20% and 2.5% of the dose, in man, guinea pig, rat and dog respectively). (*: chromatographed as naphthyl glucuronide in the dog, but did not fluoresce as this compound should. It is possible that the absence of fluorescence for 1-naphthyl glucuronide in dogs may be due to the presence of an unknown metabolite with fluorescent-quenching properties cochromatographed with 1-naphthol metabolites. The identity of fecal metabolites in dogs was not investigated) . In vitro derived conjugated metabolites with methyl-^{14}C: glucuronide of dihydro-dihydroxycarbaryl + unknown (11%, 26%, 17%, 19% of the dose in man, guinea pig, rat and dog, respectively) and hydroxycarbaryl glucuronide + unknown (7%, 4%, 1%, 5% in man, guinea pig, rat and dog, respectively).

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
Acute Toxicity Studies			
Acute oral toxicity-various species			Rat LD_{50}: 200–850 mg/kg bw Mouse LD_{50}: 175–600 mg/kg bw Cat LD_{50}: 150 mg/kg bw Signs of toxicity observed within one hour post treatment included mild tremors, sluggishness, salivation, lacrimation, piloerection and red discoloration of the eyes, nose and month. All survivors had recovered by day 4. Necropsy of animals that died in the study included mottled red and dark red lungs and liver, hydronephrosis of kidney, yellow intestines and liquid filled stomach. **MODERATE OR HIGH TOXICITY**
Acute dermal toxicity–rats and rabbits			Rabbit dermal LD_{50}: ≥2000 mg/kg bw Rat dermal LD_{50}: >4000 mg/kg bw Slight sluggishness noted at day 1 and subsided by day 3. **LOW TOXICITY**
Acute inhalation toxicity–Sprague-Dawley rats	0, 3.4 mg/L for 4 hours 99.0% pure		LC_{50} >3.4 mg/L (the maximum attainable concentration) Mortality: 2/5 ♀ in the 4 hours of exposure Clinical signs: ataxia and chromodacryorrhea observed within 1 hour followed by salivation and tremors lasting for four hours after exposure. Gross pathological findings: lung congestion, emphysema and edema observed in the 2 deaths. **LOW TOXICITY**
Dermal irritation–New Zealand White rabbits			Non irritating to skin
Eye irritation–New Zealand White rabbits			Mildly irritating to eyes–mild irritation in the iris and conjunctiva which subsided within 3 days post treatment.
Dermal sensitization-guinea pigs			Non skin sensitizer

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
Short-Term Toxicity Studies			
1-week dietary toxicity–Harlen rats	0, 10, 50, 250 or 500 mg/kg bw/day 98% pure	10 mg/kg bw/day	≥50 mg/kg bw/day: ↓ EChE 500 mg/kg bw/day: ↓ weight gain
5-week dietary toxicity–Beagle dogs (6/sex/group)	0, 20, 45 or 125 ppm (=0, 0.6/0.6, 1.4/1.5 or 3.8/4.1 mg/kg bw/day, ♂/♀) 99.3% pure	3.8/4.1 mg/kg bw/day, ♂/♀	3.8 mg/kg bw/day: ↓ PChE (♂) No treatment-related adverse effects identified. Note: limited parameters measured, no histopathology conducted.
4-week dermal toxicity–Sprague-Dawley rats (10/sex/dose)	0, 20, 50 or 100 mg/kg bw/day for 6 hours/day, 5 days/week 99.5% pure PChE was not assessed.	$BMDL_{10}$=35.5 mg/kg bw/day based on 10% ↓ BChE in both sexes. (BMD_{10}=51.7 mg/kg bw/day)	≥50 mg/kg bw/day: ↓ BChE (♂) 100 mg/kg bw/day: ↓ EChE, ↓ body-weight gain (days 5–12) (♂); ↓ BChE (♀)
Neurotoxicity Studies			
Comparative Cholinesterase Assay–Long-Evans rats [8, 10 or 6 ♂ rats/dose, for postnatal day (PND) 11, 17 or 97 rats, respectively]	0, 3, 7.5, 15, or 30 mg/kg bw by gavage in corn oil ≥99% pure Only EChE and BChE were tested. Animals were sacrificed at 40 minutes post-dosing. Motor activity was also tested at 15 minutes post-dosing in PND 17 rats only.	NOAEL was not determined. $BMDL_{10}$=1.13 mg/kg bw based on 10% ↓ BChE in PND 11 male pups (BMD_{10} =1.45 mg/kg bw/day).	≥3 mg/kg bw (♂): ↓ BChE (PND 11), EChE (PND 11, PND 17 and adults) ≥7.5 mg/kg bw (♂): ↓ BChE (PND 17 and adults) 30 mg/kg bw (♂): ↓ motor activity (PND 17) Motor activity data only was supplementary due to study deviations.
Acute Neurotoxicity Study–Sprague-Dawley rats (12/sex/group)	0, 10, 50 or 125 mg/kg bw	10 mg/kg bw (LOAEL)	≥10 mg/kg bw: ↓ BChE, EChE and PChE 50 mg/kg bw: ↑ tremors and ataxia, FOB changes (↓ body temperature, arousal and motor activity) 125 mg/kg bw: salivation, FOB changes (forelimb and hindlimb strength, ↓ motor activity), ↓ weight gain (days 0–7) and food consumption
Acute Neurotoxicity Study–Long-Evans	0, 3.0, 7.5, 15.0, 30, 50 mg/kg bw (actual concentration=0.2, 4.6, 8.5, 16, 29 and 53		≥4.6 mg/kg bw (♂): ↓ BChE ≥16 mg/kg bw (♂): ↓ EChE, ↓ motor activity

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
rats (10 ♂/group)	mg/kg bw) Motor activity tested in all animals at 15 minutes post-dosing. BChE and EChE activity tested at 40 minutes post-doing (only 5 males/dose)		Note: supplementary (lack of individual data and approximation of results from figures).
Acute Neurotoxicity Study–Long-Evan rats (5 ♂/group at 0.5, 1, 2, 4 or 6 hours post-dosing, 4 ♂/group at 24 hours post-dosing)	0 or 30 mg/kg bw in corn oil by gavage 99% pure Assessed only BChE and EChE activity		30 mg/kg bw (♂):↓ BChE (0.5 to 2 hours post-dosing), ↓ EChE (0.5 to 6 hours post-dosing, second inhibition phase at 4 and 6 hours). Note: supplementary (lack of individual data and approximation of results from figures).
Acute oral neurotoxicity (ChE inhibition)–Beagle dogs (l/sex/dose)	Single labelled (1-naphthyl-^{14}C carbaryl) and unlabelled oral dose: 2.5 and 25 mg/kg bw in gelatin capsules. 99% and 99.8% % pure for labelled and unlabelled carbaryl, respectively		22.5 mg/kg bw: ↓ PChE and EChE at 2 hours post-dosing and returning to normal after 4–8 hours for the low dose and up to 96 hours for the high dose. Note: supplementary due to few animals tested and BChE not measured.
Acute neurotoxicity (subcutaneous injection)–chickens	800 or 1600 mg/kg bw under atropine protection		1600 mg/kg bw: leg weakness occurred within 24 hours post-dosing and was recovered by day 24. Note: ChE activity and histopathology not conducted.
13-week oral (gavage) neurotoxicity–Sprague-Dawley rats (12/sex/group + 5/sex/group for ChE assessments)	0, 1, 10 or 30 mg/kg bw/day 99.1% pure	1 mg/kg bw/day	≥10 mg/kg bw/day: ↓ BChE, EChE and PChE, clinical signs (slight or moderate tremors, and salivation), ↑ FOB alterations (gait alterations, pinpoint pupils, ↓ pinna reflex, ↓ number of rearings, ↓ vocalization, ↓ body temperature and ↓ forelimb grips) 30 mg/kg bw/day: weight loss, ↓ weight gain, ↓ food consumption, ↓ motor activity (♂ at week 4, ♀ at weeks 4 and 8). ↑ pathological findings (dark areas in the meninges and hemorrhage in ♂, retinal atrophy in one ♀)

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
Oral (gavage) developmental neurotoxicity–pregnant Sprague-Dawley rats (26 ♀/group + 6 ♀/group for ChE ssessments at pre and post-dosing periods)	0, 0.1, 1.0 or 10 mg/kg bw/day by oral gavage from gestation day (GD) 6 through lactation day (LD) 10 99.1% pure	1 mg/kg bw/day (maternal) 10 mg/kg bw/day (developmental)	**Maternal** 10 mg/kg bw/day: ↓ BChE (LD10), EChE (GD 20 and LD 10) and whole blood ChE (GD 20 and LD 20), transitory ↓ weight gain (GD 6–9), alterations in FOB measurements (slight tremors, ataxic gait/overall gait incapacity and ↑ pinpoint pupil size) **Developmental** 10 mg/kg bw/day: no treatment-related effects were apparent Note: ChE not measured in pups
Oral (gavage) developmental neurotoxicity–pregnant Sprague-Dawley rats (total ♀: 36 or 38 as stated)	0, 6, 12 or 25 mg/kg bw/day on gestation days (GD) 14-postnatal day (PND) 7 for dams; pups directly dosed with the same dose levels to PND 21 (weaning) or PND 42 purity not stated		**Maternal** ≥12 mg/kg bw/day: ↓ BChE and blood ChE (GD 19) **Developmental/pup** ≥12 mg/kg bw/day: ↓ fetal BChE (GD 19) 25 mg/kg bw/day: ↓ live pup/litter (PND 0, 7 and 21), ↓ pup weight (PND 1,7, 14 and 21), ↓pup brain weight (PND 21, but not on PNDs 0, 7 and 47) Note: supplementary due to insufficient group size and no morphometry measured in pups.
Chronic Toxicity/Oncogenicity Studies			
1 year dietary toxicity Beagle dogs (6/sex/group)	0, 125, 400 or 1250 ppm (= 0, 3.1, 10.0 or 31.3 mg/kg bw/day) 99% pure	3.1 mg/kg bw/day, (LOAEL)	≥3.1 mg/kg bw/day: ↓ BChE ≥10.0 mg/kg bw/day: ↓ EChE; ↓ PChE (♂) 31.3 mg/kg bw/day: clinical signs (emesis, lacrimation, salivation and tremors), ↓ weight gain and food consumption; ↓ serum albumin (♂); ↓ PChE, ↑ WBC and segmented neutrophil counts, ↑ absolute liver weight (♀)
2-year dietary chronic toxicity and carcinogenicity–CD-1 mice (80/sex/group	0, 100, 1000 or 8000 ppm (=0/0, 14.7/18.1, 146/181 or 1249/1441 mg/kg bw/day, ♂/♀) 99.3% pure	14.7/18.1 mg/kg bw/day (♂/♀) (chronic toxicity)	≥14.7 mg/kg bw/day: ↑ vascular tumors (hemangiomas and hemangiosarcomas mostly found in the liver and spleen (♂) ≥146/181 mg/kg bw/day: ↓ BChE (weeks 53 and 105, ↑ incidence of intracytoplasmic (protein-like) droplets in the superficial transitional epithelium of the urinary bladder; ↓ EChE (week 53), 1incidence of

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
including 10/sex/group sacrificed at week 53)			chronic progressive nephropathy, 1 relative kidney weight (weeks 53 and 105) (♂) 1249/1441 mg/kg bw/day: clinical signs (thin or languid appearance, hunched posture, squinted and opaque eyes, urine stains, redness in various body areas, rough hair coat, soft feces and low body temperature), weight loss, ↓ weight gains, ↓ RBC, ↓ Hb and packed cell volume (♂ at week 105; ♀ at week 53), ↑ liver weights (weeks 53 and 105), ↑ severity of extramedullary hematopoiesis and pigment in the spleen, ↑ incidences of uni and/or bilateral cataracts; ↑ renal neoplasms (♂); ↑ WBC, lymphocytes and eosinophil (week 53), ↓ platelet counts (week 105), ↓ ovary weights (week 53), ↑ vascular tumors (week 105), and ↑ hepatic neoplasms (♀) Carbaryl is carcinogenic to mice with ↑ tumor incidences in the liver (high dose ♀), kidney (high dose ♂) and vascular system (all dose ♂ and high dose ♀). **EVIDENCE OF CARCINOGENICITY**
2-year dietary chronic toxicity and carcinogenicity– Sprague-Dawley rats (70/sex/group + 0/sex/group for interim sacrifice at week 53 + 10/sex in the control and high groups as a recovery group treated for 53 weeks and then followed by a 4-week recovery)	0, 250, 1500 or 7500 ppm (=0/0, 10.0/12.6, 60.2/78.6 or 350/485 mg/kg bw/day, ♂/♀) 99% pure	10.0/12.6 mg/kg bw/day ♂/♀ (chronic toxicity)	60.2/78.6 mg/kg bw/day: ↓ BChE and EChE; weight loss, ↓ weight gain and ↑ incidences of dark urine (♀) 350/485 mg/kg bw/day: clinical signs (hunched posture, thin appearance, alopecia, chromodacryorrhea, and urine stain), weight loss (weeks 13–104) and ↓ weight gain, ↓ food consumption (reversed in the recovery group) and ↓ food efficiency, ↓ BChE, EChE and PChE (reversed in the recovery group); ↑ cholesterol and BUN, ↓ AST, ALT and CPK, ↓ WBC and lymphocyte count, ↑ occult blood and dark urine, ↑ liver, kidneys, lungs and spleen weights, ↑ cataracts (unilateral and bilateral), ↑ pathology findings of bladder (transitional cell hyperplasia, squamous metaplasia, high mitotic index, atypia, benign transitional cell papilloma and transitional cell carcinomas), lungs (focal pneumonitis, foamy macrophages), thyroid (↑follicular cell hypertrophy), sciatic nerve and skeletal muscle (↑ severity of degeneration); ↑ urine erythrocytes, ↑ kidney transitional cell hyperplasia (♂); ↑ liver pathology (hepatocytic hypertrophy, eosinophilic foci and pigment, and adenomas) (♀)

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
			Carbaryl was carcinogenic to rats with ↑ tumor incidences in the liver (♀) and bladder (both sexes) at the high dose level. **EVIDENCE OF CARCINOGENICITY AT LEVEL EXCEEDING MAXIMUM TOLERATED DOSE**
Reproductive and Developmental Toxicity Studies			
Oral (gavage) and dietary developmental toxicity–CF-1 pregnant mice	Gavage: 0, 100 or 150 mg/kg bw/day in cotton seed oil Dietary: 0, 5660 ppm (=1166 mg/kg bw/day) containing cotton seed oil on days 6–15 of gestation 99.0% pure	Oral gavage NOAEL=100 mg/kg bw/day (maternal) and >150 mg/kg bw/day (developmental) Dietary LOAEL =1166 mg/kg bw/day (maternal, developmental)	**Maternal-oral gavage** 150 mg/kg bw/day: clinical signs (salivation, ataxia and lethargy), ↑ mortality (10/37), ↓ weight gain (days 6–9 of gestation) **Maternal-dietary** 1166 mg/kg bw/day: ↓ weight gain (days 10–15 of gestation) **Developmental-dietary** 1166 mg/kg bw/day: ↓ fetal weight and crown-rump length Note: cholinesterase activity not measured. **NO EVIDENCE OF TERATOGENICITY**
Oral (gavage) developmental toxicity– Swiss Albino mice (10 pregnant ♀/single or multiple doses)	0, 100, 150, or 200 mg/kg bw/day in corn oil for a single day exposure (day 8 or day 2 of gestation) or multiple days exposure (days 6 to 15 of gestation) Technical grade noted		**Maternal** ≥150 mg/kg bw/day: ↓ maternal mortality and ↓ maternal weight gain (days 8 and 12, days 6–15) 200 mg/kg bw/day: excessive salivation and ataxia resulting in death in 40% of treated 8 (days 6–15) **Developmental** ≥100 mg/kg bw/day: ↑ resorbed fetuses (days 8 and 12, days 6–15), ↑ partially ossified skull, metacarpals and metatarsals (days 6–15); ↑ partially ossified phalanges of the forelimb (day 12) and hindlimb (days 8 and 12) ≥150 mg/kg bw/day: ↑ gross abnormality (open eye) and enlarged renal pelves (days 6–15) 200 mg/kg bw/day: ↑ total number of implants (day 8), ↓ litter size (days 8 and 12), ↓ fetal weight (day 12 and days 6–15) Note: supplementary (ChE not assessed, historical control data not provided, insufficient data and number of animals per dose group). **EVIDENCE OF TERATOGENICITY AT MATERNALLY TOXIC DOSE**

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
Oral (gavage) developmental toxicity–Sprague-Dawley rats (25 pregnant ♀/group)	0, 1, 4 or 30 mg/kg bw/day in an aqueous methylcellulose suspension on gestation days (GDs) 6–20 >90% pure	4 mg/kg bw/day (maternal and developmental)	**Maternal** 30 mg/kg bw/day: transient salivation (GDs 13–20), ↓ weight gain and food consumption during treatment period **Developmental** 30 mg/kg bw/day: ↓ fetal body weight, ↑ incidences of incomplete ossification of multiple bones (the 5th sternebra and the 7th cervical centrum) and unossified bones (the 1st metatarsal and the 7th cervical centrum) Note: cholinesterase activity not measured. **NO EVIDENCE OF TERATOGENICITY**
Oral (gavage) developmental toxicity–Fischer 344 rats (16 pregnant ♀/group)	0, 78 or 104 mg/kg bw/day on gestation days (GD) 6–19 purity not provided		**Maternal** ≥78 mg/kg bw/day: clinical signs (tremors, motor depression and lacrimation during the first 3 days of treatment, and jaw clonus throughout treatment period), maternal weight loss (GD 6–8) 104 mg/kg bw/day: maternal weight loss (GD 6–20), ↓ uterine weight **Developmental** ≥78 mg/kg bw/day: ↓ pup weight (PND 1 and PND 6) 104 mg/kg bw/day: ↑ resorptions, ↑ prenatal mortality Note: supplementary due to insufficient number of doses (only two doses) and inappropriate dose levels tested. **NO EVIDENCE OF TERATOGENICITY**
Oral (gavage) developmental toxicity–New Zealand White rabbits (22 pregnant ♀/group)	0, 5, 50 or 150 mg/kg bw/day in an aqueous methylcellulose suspension on gestation days (GDs) 6-29 99 % pure	5 mg/kg bw/day (maternal) and 50 mg/kg bw/day (developmental)	**Maternal** ≥50 mg/kg bw/day: ↓ EChE and PChE, ↓ weight gain (GDs 3–30) **Developmental** 150 mg/kg bw/day: ↓ fetal weight Note: BChE in dams and ChE activities in fetuses not measured in the study. **NO EVIDENCE OF TERATOGENICITY**
Oral (gavage) developmental toxicity–New Zealand White rabbits (13–20	0, 150 or 200 mg/kg bw/day in cotton seed oil on days 6–18 of gestation 99.0% pure	150 mg/kg bw/day (maternal LOAEL and developmental NOAEL)	**Maternal** ≥150 mg/kg bw/day: ↓ weight gain (GDs 6–11) 200 mg/kg bw/day: diarrhea **Developmental** 200 mg/kg bw/day: ↑ fetal malformation [umbilical hernia

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
pregnant ♀/group)			(omphalocele) Note: cholinesterase activity not measured. **EVIDENCE OF TERATOGENICITY AT MATERNALLY TOXIC DOSE**
Dietary developmental toxicity–Beagle dogs (2–16 pregnant ♀ with litters/group)	0, 3.1, 6.3, 12.5, 25 or 50 mg/kg bw/day on days 3 or 6 and throughout the gestation period, study continued until weaning of pups 99.9% pure		**Maternal-dietary** ≥3.1 mg/kg bw/day: dystocia (difficult births accompanied by anorexia, feverishness, restlessness and the presence of a green-black, foul-smelling discharge from the vagina) **Developmental and offspring-dietary** ≥3.1 mg/kg bw/day: ↓ pup/fetal viability ≥6.25 mg/kg bw/day: birth defects (broad spectrum defects including abdominal-thoracic fissures with varying degrees of intestinal agenesis and displacement, varying degrees of brachygnathia, lack of tail, failure of skeletal formation and superfluous phalanges) Note: considered supplementary (insufficient numbers of pregnant dogs with litters tested in the high dose group (2 dogs vs. 7–16 dogs in the remaining groups), a lack of clear dose-related malformations when an individual type was investigated, an unknown number of males used to impregnate females. Cholinesterase activity was not measured in dams or pups.
Dietary developmental toxicity–Beagle dogs 7–9 pregnant ♀/group)	0, 2, 5 or 12.5 mg/kg bw/day from day 1 of gestation until weaning of the pups at 5 weeks of age 99.8% pure		**Maternal-dietary** ≥2 mg/kg bw/day: difficult labour, one female died during delivery in each mid and high dose group and one female in the low dose group was found moribund and sacrificed at day 48 post exposure **Developmental-dietary** ≥5 mg/kg bw/day: ↑ still births, ↑ birth defects (umbilical hernia, cleft palate and gastrointestinal anomalies) 12.5 mg/kg bw/day: ↓ birth weight **Offspring-dietary** ≥15 mg/kg bw/day: ↑ neonatal mortality from birth to 48 hours and at weaning

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
			Note: considered supplementary. Limitations of this study included female dogs used from three different suppliers, insufficient number of pregnant females/dose level which may be related to the insufficient number of males (four) used for breeding, extended exposure period, lack of dose response for number of live births/litter, lack of increased stillborn and dead fetuses between mid and high doses, lack of food consumption data, lack of many other aspects of developmental toxicity, and no historical data to assess potential influence of infection. Cholinesterase activity was not measured in dams or pups.
2-generation, 1 litter/generation dietary reproductive toxicity–Sprague-Dawley rats (30/sex/dose)	0, 75, 300 or 1500 ppm (0/0, 5.23/5.99, 27.4/31.6 or 108.4/123.2 mg/kg bw/day, ♂/♀ average intake during prebreed exposure period) 99.1% pure	5.23 mg/kg bw/day (parental ♂ and offspring), 31.6 mg/kg bw/day (maternal), 123.2 mg/kg bw/day (reproductive)	**Parental** ≥27.4/31.6 mg/kg bw/day: ↓ weight gain (FO and F1 ♂), ↓ food efficiency (FO and F1 ♂) 108.4/123.2 mg/kg bw/day: weight loss (FO and F1, gestation FO and Fl), ↓ food efficiency (FO ♀), ↑ liver weight (abs. and rel. wts., FO ♀) **Reproductive** None **Offspring** ≥27.4131.6 mg/kg bw/day: ↑ mortality (F1 and F2) 108.4/123.2 mg/kg bw/day: ↓ pup weight (F1 and F2), delayed preputial separation (F1 ♂; F2 ♂ not examined), delayed vaginal patency (F1♀, F2♀ not examined) Note: ChE not measured in parental animals and pups. **EVIDENCE OF INCREASED SENSITIVITY OF THE YOUNG**
3-generation, 3 litter/generation oral gavage) and dietary reproductive toxicity–Wistar rats (17–21/group)	Gavage: 0, 3,7, 25 or 100 mg/kg bw/day in corn oil Dietary: 0, 7, 25, 100 or 200 mg/kg bw/day (5 day/week for both routes of exposure) 99.6% pure		**Parental-gavage** 100 mg/kg bw/day: ↑ parental mortality (FO), ↑ cholinergic signs, ↓ parental weight gain (before first mating), ↑ gestation period (FO-Flb) **Reproductive and offspring-gavage** 100 mg/kg bw/day: ↓ fertility index (FO→Flb), ↓ litter size (Flb), ↓ pup viability (Fa,F3a), ↑ resorption sites (F2a→F3b), ↓ pup weight (Fla, F2b and F2c) **Parental-dietary**

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
			200 mg/kg bw/day: ↓ parental weight gain (before first mating period), ↑ gestation period (Fla→F2a) **Reproductive and offspring-dietary** 200 mg/kg bw/day: ↓ pup weight (Fla, F2b and F2c) Note: supplementary due to exposure not continuous, multiple parameters not measured including ChE activity, body weight during gestation and lactation periods, and general poor health of the animals suspected with high and early parental mortality observed.
Special Studies			
60-day oral (gavage) sperm toxicity–adult and young Druckery Albino rats (6 adult ♂ or 6 young ♂/group)	0, 25, 50 or 100 mg/kg bw/day in peanut oil, 5 days/week 99.2% pure	25 mg/kg bw/day ♂	50 mg/kg bw/day: ↓ body weight; ↓ sperm motility and sperm count, ↑ sperm shape abnormalities (spermatozoa head, neck or tail region) 100 mg/kg bw/day: ↓ absolute weights of testes, epididymides, seminal vesicle and ventral prostate, ↓ absolute weight of coagulating gland (young rats only). Young male rats were more sensitive than adult male rats with the increased incidence or severity of the sperm and testes effect. Note: exposure not continuous.
90-day oral (gavage) male reproductive organ toxicity–albino rats (8 ♂/group)	0, 50 or 100 mg/kg bw/day in peanut oil, 5 days/week 99.2% pure	50 mg/kg bw/day ♂ (LOAEL)	≥50 mg/kg bw/day: lethargy, ↑ enzymatic changes (y-glutamyl transpeptidase, LDH), ↓ sperm count, ↓ sperm motility, ↑ sperm shape abnormalities (spermatozoa head, neck or tail region), ↑ histopathological findings of the testes (slight to moderate congestion and edema, predominantly in the peripheral region at the low dose, and increased intensity of the reactions in both peripheral and central regions at the high dose; moderate atrophy and loss of sperm in a few seminiferous tubules with prominent interstitial spaces at the low dose, most of the tubules had disturbed spermatogenesis as well as accumulation of cellular masses in their lumen at the high dose) 100 mg/kg bw/day: ↓ body weight loss (after 60 days), ↓ testicular SDH (sorbitol dehydrogenase) and glucose-6-phosphate dehydrogenase. Note: exposure not continuous.
1-year oral	0, 7, 14 or 70 mg/kg bw/day		≥7 mg/kg bw/day: ↑ (dose-related) gonadotropic function of the

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
endocrine toxicity–rats (24/sex/group)			hypophysis determined by testing LOAEL immature mice administered the hypophyseal homogenate from rats given carbaryl at 7 mg/kg bw/day for 12 months, resulting in accelerated maturation, dose-related ↑ ovary and uterus weights), ↑ changes in adenohypophyseal cells (↑ size, loss of granules and hyalinization of the cytoplasm, indicative of an increase in the activity of the cells producing a luteinizing gonadotrophy), ↑ changes in adrenal glands (↑ size and mitotic activity of cells in the zona glomerulus, enlarged cells with two nuclei present in the fascicular zone). ≥14 mg/kg bw/day: ↓ weight gain, ↓ blood ChE (PChE, EChE and butyrylcholinesterase), ↓ (dose-related) spermatozoa motility (during 6, 9 and 12 months at 14 mg/kg bw/day, and in all observation periods at 70 mg/kg bw/day), ↑ histological changes in the testes (oedema of interstitial tissue, destruction and desquamation of germinal epithelium), ↓ (dose-related) spermatocytes and spermatids, prolonged estrus cycle, ↑ corpora lutea and atrophic follicles in the ovaries. 70 mg/kg bw/day: impairment of thyroid gland activity [$\downarrow^{131}$I absorption, excretion and recovery, and histological findings (↑ size of follicles and more dense and basophilic colloid)] Note: BChE not measured.
6-month dietary toxicity–heterozygous p^{53}–deficient mice (20♂/group)	0, 10,30, 100, 300, 1000 or 4000 ppm (0, 1.8, 5.2, 17.5, 51.2, 165 or 717 mg/kg bw/day)	5.2 mg/kg bw/day (p^{53}- deficient ♂)	≥17.5 mg/kg bw/day: ↑ incidence and severity of globular deposits in the urinary bladder 717 mg/kg bw/day: ↓ (slight) body weight and food consumption
2-Week Immunotoxicity Crl:CD BR rats Oral: 5 ♂/group for treated groups and 7 ♂ for vehicle control group Dermal: 6 ♂/group	Oral (gavage): 0 (corn oil)10, 25, 50 mg/kg bw/day Dermal: 0 (acetone),100, 500, 1000 mg/kg bw/day Inhalation (nose-only): 0 (air, acetone/air), 36, 137, or 335 mg/m³ (=0.036, 0.137 or 0.335		<u>Oral</u> ≥10 mg/kg bw/day: ↓ liver weight, neurotoxicity that decreased with daily carbaryl exposures (including tremors, salivation, diarrhea, slow righting reflex, abnormal gait, decreased muscle tone, lacrimation) ≥25 mg/kg bw/day: ↓ WBC 50 mg/kg bw/day: ↑ RBC

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
for treated groups and 8 ♂ for vehicle control group Inhalation: 10 ♂/group for treated groups and 5 ♂ for acetone control group and 10 ♂ for air only control group	mg/L) Assessed humoral immunological parameters, including the IgM-plaque forming cell (IgM-PFC) assay for all routes of exposure, and also serum IgM levels for the dermal route. Also assayed clinical signs, spleen, thymus, and liver weights, as well as RBC and WBC counts. Exposure was 5 days/week for all routes of exposure, 6 hours/day for dermal and inhalation routes) 98% pure		<u>Dermal</u> No adverse effect. <u>Inhalation</u> ≥ 0.137 mg/L: neurotoxicity that decreased with daily carbaryl exposures (including tremors, salivation, diarrhea, slow righting reflex, abnormal gait, decreased muscle tone) 0.335 mg/L: ↓ spleen cell number, ↓ PFC/spleen, ↓ thymus weight, slight ↓ PFC/106 splenocytes, slight ↓ serum antibody tier Note: exposure not continuous, cholinesterase activity not measured. Considered supplementary due to study limitations.
Genotoxicity Studies			
S. tvphimurium TA98, TA1535, TA1537 and TA1538 E. coli (WP2)	Up to 5000 µg/plate (± S9) 99.3% pure	Negative (± S9)	
S. typhimurium TA98, TA100, TA1535, TA1537 and TA1538	5, 25, 125, 325 or 635 µg/ml (-S9) 5, 10, 50, 250 or 1250 µg/plate (+S9) technical grade	Negative (± S9)	
Forward mutation - Chinese hamster ovary cells /HGPRT	0, 1–300 µg/ml (-S9) 0, 10–300 µg/ml (+S9) 99.3% pure	Negative (±S9) in surviving cells, more severe cytotoxicity under -S9 conditions (25% survival at 50 µg/ml) than +S9 conditions (47% survival at 100 µg/ml)	
In vitro cytogenetic assay–Chinese Hamster ovary cells	Nonactivation (-S9): 0, 5–100 µg/ml (7 doses) harvested at 20 hours post treatment Activation (+S9): 0, 25–300 µg/ml	Positive (+S9)–Increase in aberration/cell, % cells with aberrations and % cells with >1 aberration at both harvest times.	

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
(CHO-WBL)	harvested at 30 hours post treatment; 0, 100–300 µg/ml harvested at 20 hours post treatment 99.3% pure		
Mouse micronucleus assay–5/sex/group	0, 50, 100 or 200 mg/kg bw/day in 0.5% carboxymethyl cellulose (=0, 34, 79 or 180 mg/kg bw/day by analytical determinations) for 2 days by oral gavage 99.9%pure	Negative–No deaths were observed. Transitory lethargy and incidental signs of eye closure and/or eye discharge were also reported at 200 mg/kg bw/day.	
In vivo chromosomal aberration–bone marrow cells from Sprague-Dawley rats (5/sex/group/exposure period)	0*, 30, 60 or 120 mg/kg bw; killed at 6, 24, 48 hours (0*: vehicle, 0.25% carboxy-methylcellulose) 99.7% pure	Negative–120 mg/kg bw induced lethargy and tremors in rats	
Unscheduled DNA synthesis–primary rat hepatocytes	Up to 25 µg/ml 99.3% pure	Negative	
Unscheduled DNA synthesis detected by autoradiograph and bromodeoxyuridine photolysis (BrdUrd)–SV-40	Autoradiograph assay: 1–1000 µM for 8 hours (±S9) Photolysis assay: 1–100 µM for 24 hours (±S9)	Autoradiograph assay: positive (± S9) Photolysis assay: positive (-S9) and negative (+S9) Note: information on cytotoxic dose and purity of carbaryl not provided.	

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
transform human fibroblast cells (VA-4)			
DNA binding–CD-1 mice (4 ♂/group)	Non-pretreated group: a single gavage dose of 0, 75 mg/kg bw ^{14}C-carbaryl (8 mCi/kg bw) Pretreated group: pretreated daily dietary unlabelled dose of 8000 ppm (=1143 mg/kg bw/day) for 2 weeks followed by a single gavage radiolabelled dose of 75 mg/kg bw >98% pure	Negative–No significant interaction/binding of carbaryl with DNA in the liver of treated male mice (pretreated or non-pretreated) was evident based on the reported low Covalent Binding Index (<0.1); no difference on the percentage of carbaryl excreted in urine or in exhaled breath between pretreated and non-pretreated mice; ↓ body-weight gain and food consumption reported in pretreated animals during the treatment period only (transient).	
Carbaryl Metabolite–*N-nitrosocarbaryl*			
Acute Toxicity Studies–*N-nitrosocarbaryl*			
Acute oral toxicity (gavage)–rats (total 37/sex)	200–1500 mg/kg bw* in a 10% starch paste by single gavage (*N-nitrosocarbaryl from in vitro nitrosation of carbaryl 99.9% pure)	200–1500 mg/kg bw: no tumors noted up to 21 months after treatment. Note: limited information provided; the study's purpose was to assess tumor occurrences only after single exposure.	
Acute subcutaneous (injection) toxicity–rats (total 8/sex)	1000 mg/kg bw* by single dermal injection (*N-nitrosocarbaryl from in vitro nitrosation of carbaryl 99.9% pure)	1000 mg/kg bw: mortality (14/16 animals died by day 450), ↑ polymorphic-cell sarcomas, a spindle-cell sarcoma and a palpable plum-size growth tumor at injection sites Note: limited information provided; the study's purpose was to assess tumor occurrences only after single exposure.	
Subchronic Toxicity Studies–*N-nitrosocarbaryl*			
10 and 20-week oral (gavage) carcinogenicity–	40 mg/♀ total dose in 10 weeks [=0.2 mi of 10 weeks]; 0. 11 mM in olive oil	40 mg/♀ total weeks; 260 mg/♂ total 20 weeks (carcinogenic	40 mg/♀ (total) for 10 weeks: ↑ incidences of tumors (mostly invasive squamous carcinomas in the stomach) 260 mg/♂ (total) for 20 weeks: ↑ incidences of tumors (mostly invasive squamous carcinomas in the stomach) and males with

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
Sprague-Dawley rats (12 ♀ and 15 ♂/group)	260 mg/♂ total once weekly for 20 weeks (=1.3 mM/♂ total dose, twice weekly for 20 weeks) Purity not stated	LOAEL)	tumors died earlier (~ 20 weeks earlier than above females). Note: the study intended to assess tumors' occurrence only, no data provided on non-neoplastic lesions, age of the animals not specified, only one dose level per treated period tested, and limited parameters assessed.
Chronic Toxicity/Oncogenicity Studies–*N-nitrosocarbaryl*			
104-week dermal carcinogenicity–mice 65 ♀/group)	0 (untreated), 0 (acetone), 12.5, 50.0 or 200 µg/mouse in acetone, twice/week, dermally applied on a clipped interscapular region Purity not stated	12.5 µg/mouse (carcinogenic LOAEL)	≥12.5 µg/mouse: ↑ tumors (papilloma and squamous cell carcinomas at treated sites). ≥50.0 µg/mouse: ↑ tumors (sarcomas at treated sites), median tumor induction time=63 weeks at 50.0 µg/mouse and 45 weeks at 200 µg/mouse), ↓ median survival time (67 weeks at 50.0 pg/mouse, and 49 weeks at 200 µg/mouse vs. 76–77 weeks in controls). Note: The study intended to assess tumors' occurrence only, male mice not tested, no data provided on non-neoplastic lesions, and limited parameters assessed.
Lifetime oral (gavage) carcinogenicity–Sprague-Dawley rats (32 rats, sexes not specified)	0, 130 mg/kg bw twice weekly in vegetable oil Purity not stated		130 mg/kg bw twice weekly: hyperkeratoses, papillomas and squamous-cell carcinomas of the fore-stomach in 17 out of 32 rats. The mean tumor induction time was 167 days. Note: Considered as supplementary due to limited information provided, limited parameters examined and only one dose tested.
Genotoxicity Studies–*N-nitrosocarbaryl*			
S. typhimurium TA 98, TA 100, TA 1535	0.001–11 µg/plate (±S9) Purity not stated	Positive in TA 100 and TA 1535 (±S9), and TA 98 (±S9)	
S. typhimurium	0.5-100 µg/plate	Positive in TA 1535, TA 1537 and TA 1538 (±S9)	

Study/Species/ Number of Animals Per Group	Dose Levels/Purity of Test Material	NOAEL or $BMDL_{10}$ [mg/kg bw (/day)]	Results/Effects
TA 1535, TA 1536, TA 1537 and TA 1538	Purity not stated		
DNA binding–cultured human cells (skin fibroblasts)	0.1 µCi/ml ^{14}C methyl labelled, and 0.4 µCi/ml ^{3}H ring labelled–nitrosocarbaryl Purity not stated		Positive - the ^{14}Cmethyl labelled nitrosocarbaryl was detected as associated with cellular DNA, whereas the ^{3}H labelled nitrosocarbaryl was not. The nitrosocarbaryl molecule was split and a resultant methyl group alkylated the DNA.

[a] Depression of PChE is not considered by the PMRA to be a toxicologically adverse effect; it can be viewed as a marker of exposure. Depression of EChE can be viewed as a surrogate for adverse changes in the peripheral nervous tissue in acute and some short-term studies. In studies of longer duration, depression of EChE is not considered by the PMRA to be a toxicologically adverse effect. Effects noted are known or assumed to occur in both sexes unless otherwise specified.

Table 2 Toxicological Endpoints for Use in Health Risk Assessment for Carbaryl

Exposure Scenario	Dose	Endpoint	Study	CAF or Target MOE [a]
Acute Dietary, Chronic Dietary or Non-Dietary Oral	$BMDL_{10}$ = 1.13 mg/kg bw	Brain cholinesterase inhibition in postnatal day 11 male pups.	Comparative Cholinesterase Assay in rats	100
	Acute Reference Dose = 0.011 mg/kg bw Acceptable Daily Intake = 0.011 mg/kg bw/day			
Short-, Intermediate- or Long-term Dermal	$BMDL_{10}$ = 35.5 mg/kg bw/day	Brain cholinesterase inhibition in male and female adults.	Four week dermal toxicity study in rats	300
Short-, Intermediate- or Long-Term Inhalation	$BMDL_{10}$ = 1.13 mg/kg bw	Brain cholinesterase inhibition in male PND 11 pups.	Comparative Cholinesterase Assay in rats	100
Aggregate	Same route-specific endpoints and MOEs as specified above.			
Biomonitoring (all durations)	$BMDL_{10}$ = 1.13 mg/kg bw	Brain cholinesterase inhibition in male PND 11 pups.	Comparative Cholinesterase Assay in rats	100
Cancer (Oral, Dermal, Inhalation)	$Q^*_1 = 1.08 \times 10^{-3}$ $(mg/kg\ bw/day)^{-1}$ based on vascular tumors in the long term mouse study. The incidence of hemangiomas and hemangiosarcomas was combined.			

[a] Explanation of Abbreviations: CAF = composite assessment factor (refers to combined uncertainty and PCPA factors), MOE = margin of exposure (Exposure scenarios), $BMDL_{10}$ = Lower one-sided confidence limit on the benchmark dose, which in this table is a modelled dose estimate resulting in 10% decreased brain cholinesterase inhibition.

Appendix V

Table 3 Agricultural M/L/A Exposure Estimates with Engineering Controls and Additional Protection Equipment[a]

Crop	Form[b]	Application Equipment[c]	Application Rates[d] (kg a.i./ha) or (kg a.i./L)	Area[e] treated Per Day (ha) or (L)	Daily Exposure (µg/kg/day)		Margins of Exposure		Aggregate Risk Indices[j]
					Dermal[f]	Inhalation[g]	Dermal[h]	Inhalation[i]	
Balsam fir, Spruce	WP	airblast	3.30	16	49.92	4.51	711	250	1.22
Forests and Woodlands	SU	aerial–M/L	1.07	490	58.07	0.83	611	1369	1.77
		aerial–Apply			72.48	0.53	490	2152	1.52
		HP handwand		5	139.88	1.16	254	977	0.78
		LP handwand		2	21.24	0.14	1671	8164	5.22
Trap trees	SU	HP handwand	1.94E-02 (kg a.i./L)	3750 L	1900.87	15.71	19	72	0.06
		LP handwand		150 L	28.86	0.19	1230	6008	3.84
		backpack		150 L	84.37	0.26	421	4373	1.36
	WP	HP handwand	2.00E-02 (kg a.i./L)	3750 L	1957.64	16.18	18	70	0.06
		LP handwand		150 L	29.73	0.19	1194	5833	3.73
		backpack		150 L	86.89	0.27	409	4246	1.32
Alfalfa, Clover	SU	aerial–M/L	2.52	490	136.53	1.94	260	582	0.75
		aerial–Apply			170.40	1.23	208	915	0.65
		groundboom		300	131.33	1.84	270	615	0.79
	WP	groundboom	2.25	300	92.57	2.33	383	484	1.01
	BB	broadcast	0.10	80	20.53	0.30	1729	3771	5.00
Ditchbanks, Field borders, Rights-of-way, Wastelands, Headlands Forage grasses, Pastures, Rangelands	SU	groundboom	1.63	300	85.00	1.19	418	951	1.21
		r-o-w sprayer	4.66E-03 (kg a.i./L)	3750 L	115.35	1.28	308	886	0.92
		HP handwand		3750 L	456.13	3.77	78	300	0.24
		LP handwand		150 L	6.93	0.05	5126	25036	15.99
		backpack		150 L	20.24	0.06	1754	18222	5.66
Field borders, Headlands , Roadsides, Wastelands, Livestock entry to pastures, Rangelands, Forage grasses	BB	broadcast	0.10	80	20.53	0.30	1729	3771	5.00
Rapeseed (canola)	SU	aerial–M/L	0.60	490	32.51	0.46	1092	2446	3.17
		aerial–Apply			40.57	0.29	875	3844	2.71
		groundboom		300	31.27	0.44	1135	2585	3.30

Crop	Form[b]	Application Equipment[c]	Application Rates[d] (kg a.i./ha) or (kg a.i./L)	Area[e] treated Per Day (ha) or (L)	Daily Exposure (µg/kg/day)		Margins of Exposure		Aggregate Risk Indices[j]
					Dermal[f]	Inhalation[g]	Dermal[h]	Inhalation[i]	
	BB	broadcast	0.10	80	20.53	0.30	1729	3771	5.00
Sweet white lupin	SU	groundboom	1.86	300	97.14	1.36	365	832	1.06
	BB	broadcast	0.10	80	20.53	0.30	1729	3771	5.00
Asparagus (ferns)	WP	groundboom	4.50	150	92.57	2.33	383	484	1.01
Asparagus (spears, seedlings)	SU	groundboom	3.07	150	80.05	1.12	443	1010	1.29
	WP	groundboom	2.25	150	46.29	1.17	767	968	2.02
Barley, Oats, Rye, Wheat	SU	aerial–M/L	2.52	490	136.53	1.94	260	582	0.75
		aerial–Apply			170.40	1.23	208	915	0.65
		groundboom		300	131.33	1.84	270	615	0.79
	BB	broadcast	0.10	80	20.53	0.30	1729	3771	5.00
Oats, Rye, Wheat	WP	groundboom	2.25	300	79.75	2.33	445	484	1.14
Beans	SU	aerial–M/L	3.07	490	166.44	2.37	213	478	0.62
		aerial–Apply			207.73	1.51	171	751	0.53
		groundboom		150	80.05	1.12	443	1010	1.29
	WP	groundboom	2.25	150	46.29	1.17	767	968	2.02
	BB	broadcast	0.10	30	7.70	0.11	4611	10056	13.33
Beet (root), Horseradish, Radish, Rutabaga (root), Salsify (root), Turnip (root)	SU	aerial–M/L	2.52	490	136.53	1.94	260	582	0.75
		aerial–Apply		490	170.40	1.23	208	915	0.65
		groundboom		150	65.66	0.92	541	1231	1.57
	WP	groundboom	2.25	150	46.29	1.17	767	968	2.02
Carrots	SU	aerial–M/L	2.52	490	136.53	1.94	260	582	0.75
	SU	aerial–Apply			170.40	1.23	208	915	0.65
	SU	groundboom		150	65.66	0.92	541	1231	1.57
	WP	groundboom	2.25	150	46.29	1.17	767	968	2.02
Corn (field, sweet)	SU	aerial–M/L	1.92	490	104.03	1.48	341	764	0.99
		aerial–Apply			129.83	0.94	273	1201	0.85
		groundboom	2.30	150	60.04	0.84	591	1346	1.72
	WP	groundboom	2.34	150	48.03	1.21	739	933	1.95
	BB	broadcast	0.10	80	20.53	0.30	1729	3771	5.00
Cole crops	SU	aerial–M/L	2.52	490	136.53	1.94	260	582	0.75
Broccoli, Brussels sprouts, Cabbage,		aerial–Apply			170.40	1.23	208	915	0.65

Crop	Form[b]	Application Equipment[c]	Application Rates[d] (kg a.i./ha) or (kg a.i./L)	Area[e] treated Per Day (ha) or (L)	Daily Exposure (µg/kg/day)		Margins of Exposure		Aggregate Risk Indices[j]
					Dermal[f]	Inhalation[g]	Dermal[h]	Inhalation[i]	
Cauliflower, Celery, Lettuce, Kohlrabi		groundboom		150	65.66	0.92	541	1231	1.57
	WP	groundboom	2.50	150	51.43	1.30	690	872	1.82
Leafy vegetables	SU	aerial–M/L	2.52	490	136.53	1.94	260	582	0.75
Beet and Salsify and Turnip tops, Chinese cabbage, Dandelion, Endive, Kale, Leaf lettuce, Mustard greens, Parsley, Spinach, Swiss chard, Watercress		aerial–Apply			170.40	1.23	208	915	0.65
		groundboom		150	65.66	0.92	541	1231	1.57
	WP	groundboom	2.25	150	46.29	1.17	767	968	2.02
Parsnips	SU	groundboom	2.45	150	63.75	0.89	557	1268	1.62
Peas	SU	groundboom	2.19	150	57.07	0.80	622	1416	1.81
	WP	groundboom	2.25	150	46.29	1.17	767	968	2.02
Potato	SU	aerial–M/L	3.07	490	166.44	2.37	213	478	0.62
		aerial–Apply			207.73	1.51	171	751	0.53
		groundboom		150	80.05	1.12	443	1010	1.29
	WP	groundboom	2.25	150	46.29	1.17	767	968	2.02
Snapbeans	SU	groundboom	2.45	150	63.75	0.89	557	1268	1.62
	WP	groundboom	2.25	150	46.29	1.17	767	968	2.02
Tomatoes, Eggplant, Peppers	SU	aerial–M/L	3.07	490	166.44	2.37	213	478	0.62
		aerial–Apply			207.73	1.51	171	751	0.53
		groundboom		150	80.05	1.12	443	1010	1.29
	WP	groundboom	2.25	150	46.29	1.17	767	968	2.02
Apples, Pears	SU	aerial–M/L	1.73	490	93.62	1.33	379	849	1.10
		aerial–Apply			116.85	0.85	304	1335	0.94
		airblast	3.74	16	58.76	5.05	604	224	1.06
	WP	airblast	3.00	16	45.38	4.10	782	275	1.34
Apples (thinning)	SU	airblast	0.09	16	1.46	0.13	24243	8975	42.52
	WP	airblast	3.00	16	45.38	4.10	782	275	1.34
Apricot, peach	SU	airblast	3.74	16	58.76	5.05	604	224	1.06
	WP	airblast	3.00	16	45.38	4.10	782	275	1.34
Berries	SU	aerial–M/L	2.52	490	136.53	1.94	260	582	0.75
(Blackberries, Boysenberries, Dewberries, Loganberries, Raspberries)		aerial–Apply			170.40	1.23	208	915	0.65
		groundboom		150	65.66	0.92	541	1231	1.57

Crop	Form[b]	Application Equipment[c]	Application Rates[d] (kg a.i./ha) or (kg a.i./L)	Area[e] treated Per Day (ha) or (L)	Daily Exposure (µg/kg/day)		Margins of Exposure		Aggregate Risk Indices[j]
					Dermal[f]	Inhalation[g]	Dermal[h]	Inhalation[i]	
		air blast		16	39.59	3.40	897	332	1.57
		LP handwand		2	49.94	0.33	711	3472	2.22
		backpack		2	145.97	0.45	243	2527	0.79
	WP	groundboom	2.25	150	46.29	1.17	767	968	2.02
		air blast		16	34.04	3.08	1043	367	1.79
		LP handwand		2	44.59	0.29	796	3889	2.48
		backpack		2	130.33	0.40	272	2831	0.88
Blueberries	SU	aerial–M/L	1.99	490	107.82	1.53	329	737	0.96
		aerial–Apply			134.56	0.98	264	1159	0.82
		groundboom		150	51.85	0.72	685	1559	1.99
		air blast		16	31.27	2.69	1135	420	1.99
		LP handwand		2	39.44	0.26	900	4397	2.81
		backpack		2	115.27	0.35	308	3200	0.99
	WP	groundboom	1.63	32	33.43	0.84	1062	1341	2.80
		air blast		16	24.58	2.22	1444	509	2.47
		LP handwand		2	32.20	0.21	1102	5385	3.44
		backpack		2	94.13	0.29	377	3919	1.22
Cherries, Plums	SU	aerial–M/L	3.31	490	179.44	2.55	198	443	0.57
		aerial–Apply			223.96	1.62	159	696	0.49
		airblast	3.74	16	58.83	5.06	603	223	1.06
Cherries, Plums, Prunes	WP	airblast	3.00	16	45.38	4.10	782	275	1.34
Cucumbers, Melons, Pumpkin, Squash	SU	aerial–M/L	1.20	490	65.02	0.92	546	1223	1.58
		aerial–Apply			81.14	0.59	437	1922	1.36
		groundboom	1.25	150	32.57	0.46	1090	2482	3.17
	WP	groundboom	1.13	150	23.14	0.58	1534	1937	4.05
Cranberries	SU	aerial–M/L	3.65	490	197.65	2.81	180	402	0.52
		aerial–Apply			246.68	1.79	144	632	0.45
		groundboom		150	95.06	1.33	373	850	1.09
		chemigation		140	56.47	0.80	629	1408	1.82
		LP handwand		2	72.29	0.47	491	2399	1.53
		backpack		2	211.31	0.65	168	1746	0.54

Crop	Form[b]	Application Equipment[c]	Application Rates[d] (kg a.i./ha) or (kg a.i./L)	Area[e] treated Per Day (ha) or (L)	Daily Exposure (µg/kg/day)		Margins of Exposure		Aggregate Risk Indices[j]
					Dermal[f]	Inhalation[g]	Dermal[h]	Inhalation[i]	
	WP	groundboom	3.38	150	69.43	1.75	511	646	1.35
		chemigation		140	34.97	1.23	1015	920	2.47
		LP handwand		2	66.88	0.44	531	2593	1.66
		backpack		2	195.49	0.60	182	1887	0.59
Grapes	SU	aerial–M/L	3.07	490	166.44	2.37	213	478	0.62
		aerial–Apply			207.73	1.51	171	751	0.53
		airblast	3.07	16	48.27	4.15	735	272	1.29
	WP	airblast	2.25	16	34.04	3.08	1043	367	1.79
Strawberries	SU	aerial–M/L	2.78	490	150.84	2.14	235	527	0.68
		aerial–Apply			188.25	1.36	189	828	0.58
		groundboom	3.00	150	78.17	1.09	454	1034	1.32
		chemigation		140	46.44	0.66	764	1712	2.22
	WP	groundboom	2.25	150	46.29	1.17	767	968	2.02
		chemigation		140	23.31	0.82	1523	1380	3.71
Tobacco	SU	aerial–M/L	8.40	490	455.11	6.47	78	175	0.23
		aerial–Apply			568.01	4.12	62	275	0.19
		groundboom		300	437.76	6.12	81	185	0.24
	WP	groundboom	6.25	300	257.14	6.48	138	174	0.36
Choke cherries	SU	airblast	1.48	16	23.25	2.00	1527	565	2.68
		LP handwand		2	29.33	0.19	1210	5912	3.78
		backpack		2	85.73	0.26	414	4303	1.34
Arborvitae, Birch, Boxwood, Dogwood, Elm, Juniper, Maple, Oak, Pines	SU	airblast	5.04	16	79.19	6.81	448	166	0.79
		HP handwand	5.04E-03 (kg a.i./L)	3750 L	493.33	4.08	72	277	0.22
		LP handwand		150 L	7.49	0.05	4739	23148	14.79
		backpack		150 L	21.90	0.07	1621	16849	5.24
	WP	airblast	4.50	16	68.07	6.15	522	184	0.89
		HP handwand	4.50E-03 (kg a.i./L)	3750 L	440.47	3.64	81	310	0.25
		LP handwand		150 L	6.69	0.04	5308	25926	16.56
		backpack		150 L	19.55	0.06	1816	18870	5.86
Azalea, Carnation, Chrysanthemums, Gladiolus, Holly, Hydrangea, Lilac,	SU	airblast	1.68	16	26.40	2.27	1345	498	2.36
		HP handwand	1.68E-03	3750 L	164.44	1.36	216	831	0.66

Crop	Form[b]	Application Equipment[c]	Application Rates[d] (kg a.i./ha) or (kg a.i./L)	Area[e] treated Per Day (ha) or (L)	Daily Exposure (µg/kg/day)		Margins of Exposure		Aggregate Risk Indices[j]
					Dermal[f]	Inhalation[g]	Dermal[h]	Inhalation[i]	
Rose, Zinnia		LP handwand	(kg a.i./L)	150 L	2.50	0.02	14217	69444	44.36
		backpack		150 L	7.30	0.02	4864	50546	15.71
	WP	airblast	1.50	16	22.69	2.05	1565	551	2.68
		HP handwand	1.50E-03 (kg a.i./L)	3750 L	146.82	1.21	242	931	0.74
		LP handwand		150 L	2.23	0.01	15924	77778	49.69
		backpack		150 L	6.52	0.02	5448	56611	17.59
Green ash	SU	airblast	3.64	16	57.11	4.91	622	230	1.09
		HP handwand	1.21E-03 (kg a.i./L)	3750 L	118.59	0.98	299	1153	0.92
		LP handwand		150 L	1.80	0.01	19714	96291	61.52
		backpack		150 L	5.26	0.02	6744	70086	21.78
High value trees	SU	HP handwand	1.92E-02 (kg a.i./L)	3750 L	1879.33	15.53	19	73	0.06
		LP handwand		150 L	28.54	0.19	1244	6076	3.88
		backpack		150 L	83.41	0.26	426	4423	1.37
	WP	HP handwand	2.00E-02 (kg a.i./L)	3750 L	1957.64	16.18	18	70	0.06
		LP handwand		150 L	29.73	0.19	1194	5833	3.73
		backpack		150 L	86.89	0.27	409	4246	1.32

[a] See Section 3.2.2.1 for details of the personal protective equipment worn for each use scenario.

[b,c] WP = Wettable Powder (For the purpose of exposure mitigation, assumed to be in Water Soluble Packaging); SU = Suspension; BB = bran bait; LP = Low Pressure, HP = High Pressure

[d] Maximum listed label rate in kilograms of active ingredient per hectare (kg a.i./ha) unless specified as kilograms of active ingredient per litre (kg a.i./L).

[e] Based on default assumptions

[f] Where dermal exposure µg/kg/day = (unit exposure × area treated × rate)/70 kg bw

[g] Where inhalation exposure µg/kg/day = (unit exposure × area treated × rate)/70 kg bw; includes a 90% protection factor for respirators during backpack and handwand applications.

[h] Based on a $BMDL_{10}$ of 35.5 mg/kg bw/day from a dermal study and a target dermal MOE of 300

i Based on a BMDL10 of 1.13 mg/kg bw/day from an oral study and a target inhalation MOE of 100

j Aggregate Risk Index = 1 /[(1/Dermal Risk Index)+(1/Inhalation Risk Index)]. Dermal Risk Index = Dermal MOE/Target Dermal MOE. Inhalation Risk Index = Inhalation MOE/Target Inhalation MOE. Table cells are shaded when the ARI < 1.0. If the ARI exceeds 1.0, the risk is below the level of concern.

Table 4 Agricultural M/L/A Exposure Estimates and ARIs for Closed Cab Airblast Applicators Wearing Cotton Coveralls over a Long-Sleeved Shirt and Long Pants with Chemical-resistant Gloves

Crop	Form[a]	Application Equipment[b]	Application Rates[c] (kg a.i./ha) or (kg a.i./L)	Area treated Per Day[d] (ha)	Daily Exposure (µg/kg/day)		Margins of Exposure		Aggregate Risk Indices[i]
					Dermal[e]	Inhalation[f]	Dermal[g]	Inhalation[h]	
Balsam fir, Spruce	WP	Airblast	3.30	16	33.08	4.51	1073	251	1.47
Apples, Pears	SU	Airblast	3.74	16	39.67	5.05	895	224	1.28
	WP	Airblast	3.00	16	30.07	4.10	1181	276	1.62
Apples (thinning)	SU	Airblast	0.09	16	0.99	0.13	35907	8975	51.29
	WP	Airblast	3.00	16	30.07	4.10	1181	276	1.62
Apricot, Peach	SU	Airblast	3.74	16	39.67	5.05	895	224	1.28
	WP	Airblast	3.00	16	30.07	4.10	1181	276	1.62
Berries (Blackberries, Boysenberries, Dewberries, Loganberries, Raspberries)	SU	air blast	2.52	16	26.73	3.40	1328	332	1.90
	WP	air blast	2.25	16	22.55	3.08	1574	367	2.16
Blueberries	SU	air blast	1.99	16	21.11	2.69	1682	420	2.40
	WP	air blast	1.63	16	16.29	2.22	2180	509	2.99
Cherries, Plums	SU	Airblast	3.74	16	39.72	5.06	894	223	1.28
Cherries, Plums, Prunes	WP	Airblast	3.00	16	30.07	4.10	1181	276	1.62
Grapes	SU	Airblast	3.07	16	32.59	4.15	1089	272	1.56
	WP	Airblast	2.25	16	22.55	3.08	1574	367	2.16
Choke Cherries	SU	Airblast	1.48	16	15.70	2.00	2261	565	3.23
Arborvitae, Birch, Boxwood, Dogwood, Elm, Juniper, Maple, Oak, Pines	SU	Airblast	5.04	16	53.46	6.81	664	166	0.95
	WP	Airblast	4.50	16	45.10	6.15	787	184	1.08
Azalea, Carnation, Chrysanthemums, Gladiolus, Holly, Hydrangea, Lilac, Rose, Zinnia	SU	Airblast	1.68	16	17.82	2.27	1992	498	2.85
	WP	Airblast	1.50	16	15.03	2.05	2361	551	3.24
Green ash	SU	Airblast	3.64	16	38.56	4.91	921	230	1.32

[a,b] WP = Wettable Powder (For the purpose of exposure mitigation, assumed to be in Water Soluble Packaging); SU = Suspension; airblast application by closed cab only

[c] Maximum listed label rate in kilograms of active ingredient per hectare (kg a.i./ha).

[d] Based on default assumptions

[e] Where dermal exposure µg/kg/day = unit exposure × area treated × rate)/70 kg bw

[f] Where inhalation exposure µg/kg/day = (unit exposure × area treated × rate)/70 kg bw; includes a 90% protection factor for respirators during backpack and handwand applications.

[g] Based on a $BMDL_{10}$ of 35.5 mg/kg bw/day from a dermal study and a target dermal MOE of 300

h Based on a BMDL10 of 1.13 mg/kg bw/day from an oral study and a target inhalation MOE of 100

i Aggregate Risk Index = 1/[(1/Dermal Risk Index)+(1/Inhalation Risk Index)]. Dermal Risk Index = Dermal MOE/Target Dermal MOE. Inhalation Risk Index = Inhalation MOE/Target Inhalation MOE. Table cells are shaded when the ARI < 1.0. If the ARI exceeds 1.0, the risk is below the level of concern.

Table 5 Agricultural Mixer/Loader/Applicator Cancer Risk Assessment

Crop	Form[a]	Application Equipment[b]	Active Ingredient Handled Per Day (kg)	Total Absorbed Daily Dose[c] (ADD) (mg/kg/day)	Treatment Days Per Year	Total Lifetime Absorbed Daily Dose[d] (LADD) (mg/kg bw)	Cancer Risk[e]
Balsam fir, Spruce, Woodlots, Parks, Rows	WP	airblast	53	1.50E-02	30	5.75E-04	6.21E-07
Forests and Woodlands	SU	aerial–M/L	525	1.30E-02	30	4.99E-04	5.39E-07
		aerial–Apply	525	1.57E-02		6.04E-04	6.52E-07
		HP handwand	5	3.05E-02		1.17E-03	1.26E-06
		LP handwand	2	4.60E-03		1.76E-04	1.91E-07
Trap trees	SU	HP handwand	73	4.15E-01	30	1.59E-02	1.72E-05
		LP handwand	3	6.25E-03		2.40E-04	2.59E-07
		backpack	3	1.80E-02		6.89E-04	7.45E-07
	WP	HP handwand	75	4.27E-01		1.64E-02	1.77E-05
		LP handwand	3	6.44E-03		2.47E-04	2.67E-07
		backpack	3	1.85E-02		7.10E-04	7.67E-07
Alfalfa, Clover	SU	aerial–M/L	1235	3.06E-02	30	1.17E-03	1.27E-06
		aerial–Apply	1235	3.70E-02		1.42E-03	1.53E-06
		groundboom	756	2.94E-02		1.13E-03	1.22E-06
	WP	groundboom	675	2.18E-02		8.35E-04	9.02E-07
	BT	broadcast	8	4.61E-03		1.77E-04	1.91E-07
Ditchbanks, Field borders, Rights-of-way, Wastelands, Headlands, Forage grasses, Pastures, Rangelands	SU	groundboom	245	9.52E-03	30	3.65E-04	3.94E-07
		r-o-w sprayer	17	2.55E-02		9.78E-04	1.06E-06
		HP handwand	17	9.96E-02		3.82E-03	4.12E-06
		LP handwand	1	1.50E-03		5.75E-05	6.21E-08
		backpack	1	4.31E-03		1.65E-04	1.79E-07
Feld borders, Headlands, Roadsides, Wastelands, Livestock entry to pastures, etc	BB	broadcast	8	4.61E-03	30	1.77E-04	1.91E-07
Sweet white lupin	SU	groundboom	559	2.18E-02	30	8.35E-04	9.01E-07
	BB	broadcast	8	4.61E-03		1.77E-04	1.91E-07
Rapeseed (canola)	SU	aerial–M/L	294	7.29E-03	30	1.21E-04	1.30E-07
		aerial–Apply	294	8.81E-03		1.77E-04	1.91E-07
		groundboom	180	7.00E-03		2.69E-04	2.90E-07
	BB	broadcast	8	4.61E-03		1.77E-04	1.91E-07
Asparagus (ferns)	WP	groundboom	675	2.18E-02	30	8.35E-04	9.02E-07

Crop	Form[a]	Application Equipment[b]	Active Ingredient Handled Per Day (kg)	Total Absorbed Daily Dose[c] (ADD) (mg/kg/day)	Treatment Days Per Year	Total Lifetime Absorbed Daily Dose[d] (LADD) (mg/kg bw)	Cancer Risk[e]
Asparagus (spears, seedlings)	SU	groundboom	461	1.79E-02	30	6.88E-04	7.43E-07
	WP	groundboom	338	1.09E-02		4.18E-04	4.51E-07
Barley, Oats, Rye, Wheat	SU	aerial–M/L	1235	3.06E-02	30	1.17E-03	1.27E-06
		aerial–Apply	1235	3.70E-02		1.42E-03	1.53E-06
		groundboom	756	2.94E-02		1.13E-03	1.22E-06
	BB	broadcast	8	4.61E-03		1.77E-04	1.91E-07
Oats, Rye, Wheat	WP	groundboom	675	2.18E-02	30	8.35E-04	9.02E-07
Beans	SU	aerial–M/L	1505	3.73E-02	30	1.43E-03	1.55E-06
		aerial–Apply	1505	4.51E-02		1.73E-03	1.87E-06
		groundboom	461	1.79E-02		6.88E-04	7.43E-07
	WP	groundboom	338	1.09E-02		4.18E-04	4.51E-07
	BB	broadcast	8	4.61E-03		1.77E-04	1.91E-07
Beet (root), Horseradish, Radish, Rutabaga (root), Salsify (root), Turnip (root)	SU	aerial–M/L	1235	3.06E-02	30	1.17E-03	1.27E-06
		aerial–Apply	1235	3.70E-02		1.42E-03	1.53E-06
		groundboom	378	1.47E-02		5.64E-04	6.09E-07
	WP	groundboom	338	1.09E-02		4.18E-04	4.51E-07
Carrots	SU	aerial–M/L	1235	3.06E-02	30	1.17E-03	1.27E-06
	SU	aerial–Apply	1235	3.70E-02		1.42E-03	1.53E-06
	SU	groundboom	378	1.47E-02		5.64E-04	6.09E-07
	WP	groundboom	338	1.09E-02		4.18E-04	4.51E-07
Corn (field, sweet)	SU	aerial–M/L	941	2.33E-02	30	8.95E-04	9.66E-07
		aerial–Apply	941	2.82E-02		1.08E-03	1.17E-06
		groundboom	346	1.34E-02		5.16E-04	5.57E-07
	WP	groundboom	350	1.13E-02		4.33E-04	4.68E-07
	BB	broadcast	8	4.61E-03		1.77E-04	1.91E-07
Cole crops Broccoli, Brussels sprouts, Cabbage, Cauliflower, Celery, Lettuce, Kohlrabi	SU	aerial–M/L	1235	3.06E-02	30	1.42E-03	1.53E-06
		aerial–Apply	1235	3.70E-02		1.42E-03	1.53E-06
		groundboom	378	1.47E-02		5.64E-04	6.09E-07
	WP	groundboom	375	1.21E-02		4.64E-04	5.01E-07
Leafy vegetables	SU	aerial - M/L	1235	3.06E-02	30	1.17E-03	1.27E-06
Beet tops, Chinese cabbage, Dandelion,		aerial–Apply	1235	3.70E-02		1.42E-03	1.53E-06

Crop	Form[a]	Application Equipment[b]	Active Ingredient Handled Per Day (kg)	Total Absorbed Daily Dose[c] (ADD) (mg/kg/day)	Treatment Days Per Year	Total Lifetime Absorbed Daily Dose[d] (LADD) (mg/kg bw)	Cancer Risk[e]
Endive, Kale, Leaf lettuce, Mustard greens, Parsley, Salsify (tops), Spinach, Swiss chard, Turnip (tops), Watercress		groundboom	378	1.47E-02		5.64E-04	6.09E-07
	WP	groundboom	338	1.09E-02		4.18E-04	4.51E-07
Parsnips	SU	groundboom	367	1.43E-02	30	5.48E-04	5.91E-07
Peas	SU	groundboom	329	1.28E-02	30	4.90E-04	5.30E-07
	WP	groundboom	338	1.09E-02		4.18E-04	4.51E-07
Potato	SU	aerial–M/L	1505	3.73E-02	30	1.43E-03	1.55E-06
		aerial–Apply	1505	4.51E-02		1.73E-03	1.87E-06
		groundboom	461	1.79E-02		6.88E-04	7.43E-07
	WP	groundboom	338	1.09E-02		4.18E-04	4.51E-07
Snapbeans	SU	groundboom	367	1.43E-02	30	5.48E-04	5.91E-07
	WP	groundboom	338	1.09E-02		4.18E-04	4.51E-07
Tomatoes, Eggplant, Peppers	SU	aerial–M/L	1505	3.73E-02	30	1.43E-03	1.55E-06
		aerial–Apply	1505	4.51E-02		1.73E-03	1.87E-06
		groundboom	461	1.79E-02		6.88E-04	7.43E-07
	WP	groundboom	338	1.09E-02		4.18E-04	4.51E-07
Apples, Pears	SU	aerial–M/L	847	2.10E-02	30	8.05E-04	8.70E-07
		aerial–Apply	847	2.54E-02		9.74E-04	1.05E-06
		airblast	60	1.74E-02		6.67E-04	7.20E-07
	WP	airblast	48	1.36E-02		5.23E-04	5.65E-07
Apples (thinning)	SU	airblast	1	4.33E-04	30	1.66E-05	1.80E-08
	WP	airblast	48	1.36E-02		5.23E-04	5.65E-07
Apricot, Peach	SU	airblast	60	1.74E-02	30	6.67E-04	7.20E-07
	WP	airblast	48	1.36E-02		5.23E-04	5.65E-07
Berries	SU	aerial–M/L	1235	3.06E-02	30	1.17E-03	1.27E-06
(Blackberries, Boysenberries, Dewberries, Loganberries, Raspberries)		aerial–Apply	1235	3.70E-02		1.42E-03	1.53E-06
		groundboom	378	1.47E-02		5.64E-04	6.09E-07
		air blast	40	1.17E-02		4.49E-04	4.85E-07
		LP handwand	5	1.08E-02		4.15E-04	4.48E-07
		backpack	5	3.11E-02		1.19E-03	1.29E-06
	WP	groundboom	338	1.09E-02		4.18E-04	4.51E-07
		air blast	36	1.02E-02		3.92E-04	4.24E-07

Crop	Form[a]	Application Equipment[b]	Active Ingredient Handled Per Day (kg)	Total Absorbed Daily Dose[c] (ADD) (mg/kg/day)	Treatment Days Per Year	Total Lifetime Absorbed Daily Dose[d] (LADD) (mg/kg bw)	Cancer Risk[e]
		LP handwand	5	9.65E-03		3.70E-04	4.00E-07
		backpack	5	2.78E-02		1.07E-03	1.15E-06
Blueberries	SU	aerial–M/L	975	2.42E-02	30	9.27E-04	1.00E-06
		aerial–Apply	975	2.92E-02		1.12E-03	1.21E-06
		groundboom	299	1.16E-02		4.45E-04	4.81E-07
		air blast	32	9.25E-03		3.55E-04	3.83E-07
		LP handwand	4	8.54E-03		3.28E-04	3.54E-07
		backpack	4	2.46E-02		9.42E-04	1.02E-06
	WP	groundboom	52	7.86E-03		3.02E-04	3.26E-07
		air blast	26	7.38E-03		2.83E-04	3.06E-07
		LP handwand	3	6.97E-03		2.67E-04	2.89E-07
		backpack	3	2.01E-02		7.69E-04	8.31E-07
Cherries, Plums	SU	aerial–M/L	1623	4.02E-02	30	1.54E-03	1.67E-06
		aerial–Apply	1623	4.87E-02		1.87E-03	2.02E-06
		airblast	60	1.74E-02		6.68E-04	7.21E-07
Cherries, Plums, Prunes	WP	airblast	48	1.36E-02	30	5.23E-04	5.65E-07
Cucumbers, Melons, Pumpkin, Squash	SU	aerial–M/L	588	1.46E-02	30	5.59E-04	6.04E-07
		aerial–Apply	588	1.76E-02		6.76E-04	7.30E-07
		groundboom	188	7.30E-03		2.80E-04	3.02E-07
	WP	groundboom	169	5.44E-03		2.09E-04	2.25E-07
Cranberries	SU	aerial–M/L	1788	4.43E-02	30	1.70E-03	1.84E-06
		aerial–Apply	1788	5.36E-02		2.06E-03	2.22E-06
		groundboom	547	2.13E-02		8.17E-04	8.82E-07
		chemigation	511	1.27E-02		4.86E-04	5.24E-07
		LP handwand	7	1.57E-02		6.00E-04	6.48E-07
		backpack	7	4.50E-02		1.73E-03	1.87E-06
	WP	groundboom	506	1.63E-02		6.26E-04	6.76E-07
		chemigation	473	8.57E-03		3.29E-04	3.55E-07
		LP handwand	7	1.45E-02		5.55E-04	6.00E-07
		backpack	7	4.17E-02		1.60E-03	1.73E-06
Grapes	SU	aerial–M/L	1505	3.73E-02	30	1.43E-03	1.55E-06
		aerial–Apply	1505	4.51E-02		1.73E-03	1.87E-06

Crop	Form[a]	Application Equipment[b]	Active Ingredient Handled Per Day (kg)	Total Absorbed Daily Dose[c] (ADD) (mg/kg/day)	Treatment Days Per Year	Total Lifetime Absorbed Daily Dose[d] (LADD) (mg/kg bw)	Cancer Risk[e]
		airblast	49	1.43E-02		5.48E-04	5.92E-07
	WP	airblast	36	1.02E-02		3.92E-04	4.24E-07
Strawberries	SU	aerial–M/L	1364	3.38E-02	30	1.30E-03	1.40E-06
		aerial–Apply	1364	4.09E-02		1.57E-03	1.69E-06
		groundboom	450	1.57E-02		6.03E-04	6.51E-07
		chemigation	420	1.04E-02		3.99E-04	4.31E-07
	WP	groundboom	338	1.09E-02		4.18E-04	4.51E-07
		chemigation	315	5.71E-03		2.19E-04	2.37E-07
Tobacco	SU	aerial–M/L	4116	1.02E-01	30	3.91E-03	4.23E-06
		aerial–Apply	4116	1.23E-01		4.73E-03	5.11E-06
		groundboom	2520	9.80E-02		3.76E-03	4.06E-06
	WP	groundboom	1875	6.05E-02		2.32E-03	2.51E-06
Choke cherries	SU	airblast	24	6.88E-03	30	2.64E-04	2.85E-07
		LP handwand	3	6.35E-03		2.44E-04	2.63E-07
		backpack	3	1.83E-02		7.01E-04	7.57E-07
Arborvitae, Birch, Boxwood, Dogwood, Elm, Juniper, Maple, Oak, Pines	SU	airblast	81	2.34E-02	30	8.99E-04	9.71E-07
		HP handwand	19	1.08E-01		4.13E-03	4.46E-06
		LP handwand	1	1.62E-03		6.22E-05	6.72E-08
		backpack	1	4.67E-03		1.79E-04	1.93E-07
	WP	airblast	72	2.04E-02		7.84E-04	8.47E-07
		HP handwand	17	9.61E-02		3.69E-03	3.98E-06
		LP handwand	1	1.45E-03		5.55E-05	6.00E-08
		backpack	1	4.17E-03		1.60E-04	1.73E-07
Azalea, Carnation, Chrysanthemums, Gladiolus, Holly, Hydrangea, Lilac, Rose, Zinnia	SU	airblast	27	7.81E-03	30	3.00E-04	3.24E-07
		HP handwand	6	3.59E-02		1.38E-03	1.49E-06
		LP handwand	0.3	5.41E-04		2.07E-05	2.24E-08
		backpack	0.3	1.56E-03		6.48E-04	7.00E-07
	WP	airblast	24	6.82E-03		2.61E-04	2.82E-07
		HP handwand	6	3.20E-02		1.23E-03	1.33E-06

Crop	Form[a]	Application Equipment[b]	Active Ingredient Handled Per Day (kg)	Total Absorbed Daily Dose[c] (ADD) (mg/kg/day)	Treatment Days Per Year	Total Lifetime Absorbed Daily Dose[d] (LADD) (mg/kg bw)	Cancer Risk[e]
		LP handwand	0.2	4.83E-04		1.85E-05	2.00E-08
		backpack	0.2	1.39E-03		5.33E-05	5.75E-08
Green ash	SU	airblast	58	1.69E-02	30	6.48E-04	7.00E-07
		HP handwand	5	2.59E-02		9.93E-04	1.07E-06
		LP handwand	0.2	3.90E-04		1.50E-05	1.62E-08
		backpack	0.2	1.12E-03		4.30E-05	4.65E-08
High value trees	SU	HP handwand	72	1.85E-01	30	1.57E-02	1.70E-05
		LP handwand	3	6.18E-03		2.37E-04	2.56E-07
		backpack	3	1.78E-02		6.82E-04	7.36E-07
	WP	HP handwand	75	1.92E-01		1.64E-02	1.77E-05
		LP handwand	3	6.44E-03		2.47E-04	2.67E-07
		backpack	3	1.85E-02		7.10E-04	7.67E-07

[a] SU = suspension, WP = wettable powder (in water soluble packaging); BB = bran bait.

[b] See Section 3.2.2.1 for specifics on Personal Protective Equipment and the level of mitigation required for the non-cancer risk assessment. M/L = Mix/Load, HP = high pressure, LP = low pressure.

[c] Absorbed Daily Dose = daily dermal dose + daily inhalation dose, as determined by PHED scenarios. A dermal absorption factor of 21% was applied to the dermal route of exposure.

[d] LADD = ADD × treatment frequency × working duration/(365 days × 75 years). Treatment frequency = 30 days/year to encompass both farmers and custom applicators, Working duration = 35 years

[e] Risk = LADD × Q_1*; Q_1* = 1.08×10^{-3} $(mg/kg/day)^{-1}$

Appendix VI

Table 6a Agricultural Postapplication Exposure Estimates, MOEs and REIs

Crop	Applications Per Year		Rates[c] (kg a.i./ha)	Activity	Transfer Coefficient[d] (cm^2/hr)	DFR[e] (µg/cm^2)	Dermal Exposure[f] (µg/kg bw/day)	MOE[g]	REI[h] (days)
	Number[a]	Interval[b] (days)							
Balsam fir, Spruce in farm woodlots, Municipal parks, Rights-of-way	r.a.n.	7	3.30	Thinning	3000	0.33	112.99	314	34
				Hand-line irrigation	1100	0.93	117.25	303	24
				Hand pruning, scouting, pinching, tying, training, shaping	500	1.93	110.39	322	17
				Hand weeding, propping, baiting, grading/tagging	100	10.21	116.64	304	1
Forests and Woodlots	r.a.n.	7	1.07	Hand-line irrigation	1100	0.95	119.59	297	13
				Hand pruning, scouting, pinching, tying, training	500	1.97	112.59	315	6
				Hand weeding, propping	100	3.68	42.04	845	0.5
Trap trees	1	N/A	2.00	Hand-line irrigation	500	1.93	110.35	322	7
Alfalfa, Clover	2	8	2.52	Irrigating, scouting	1500	0.62	105.76	336	10
Ditch banks, etc	2	8	1.63	Scouting	500	2.06	117.53	302	2
Rapeseed (canola)	2	8	0.60	Irrigating, scouting	1500	0.62	105.68	336	3
Sweet white lupin	2	8	1.86	Weeding, thinning, harvesting	2000	0.46	104.31	340	10
				Irrigating, scouting	1300	0.69	102.14	348	8
Asparagus	2	7	3.07	Irrigating, hand weeding	300	3.26	111.61	318	0.5
			2.25	Irrigating, hand weeding	300	2.38	81.75	434	0.5
			4.50	Irrigating, hand weeding	300	3.26	111.76	318	2
Barley, Oats, Rye, Wheat	2	8	2.52	Irrigating, scouting	1500	0.62	105.76	336	10

Beans	2	7	3.07	Hand harvesting	2500	0.40	114.79	309	11
				Irrigating, scouting	1500	0.59	100.75	352	9
				Hand weeding	100	0.23	2.60	13680	0.5

[a] Where the labels list the number of applications as repeat as necessary (r.a.n.), the risk assessment has been conducted assuming three applications per year for all trees. The number of applications for all other crops was limited to two per year based on the available DFR data.

[b] A minimum interval of seven days between applications was assumed in the risk assessment for those applications to trees where an interval was not specified. A seven or eight day interval was applied to all other crops based on the available DFR data.

[c] Maximum listed label rates expressed in kilograms a.i./hectare.

[d] Transfer coefficients are based on the PMRA's default values.

[e] Estimated Dislodgeable Foliar Residue (DFR) is based on DFR data, at × days after application, where × is the day when an MOE ≥300 is determined for the proposed REI (restricted entry interval).

[f] Dermal exposure = DFR × TC × 8 hr/70 kg.

[g] The resulting MOE on the recommended REI day. Based on the short- and intermediate-term dermal $BMDL_{10}$ of 35.5 mg/kg/day.

[h] Day at which the dermal exposure results in an MOE ≥300. REI = Restricted Entry interval.

Table 6b Agricultural Postapplication Exposure Estimates, MOEs and REIs

Crop	Applications Per Year		Rates[c] (kg a.i./ha)	Activity	Transfer Coefficient[d] (cm^2/hr)	DFR[e] (µg/cm^2)	Dermal Exposure[f] (µg/kg bw/day)	MOE[g]	REI[h] (days)
	Number[a]	Interval[b] (days)							
Beet (root), Horseradish, Radish, Rutabaga (root), Salsify (root), Turnip (root)	2	7	2.52	Hand harvesting	2500	0.40	113.89	312	10
				Hand weeding, irrigating, scouting, thinning	300	2.67	91.56	388	0.5
			2.25	Hand harvesting	2500	0.36	101.69	349	10
				Hand weeding, irrigating, scouting, thinning	300	2.38	81.75	434	0.5
Carrots	2	7	2.52	Hand harvesting	2500	0.40	113.89	312	10
				Scouting, weeding, irrigating	300	2.67	91.56	388	0.5
			2.25	Hand harvesting	2500	0.36	101.69	349	10
				Scouting, weeding, irrigating	300	2.38	81.75	434	0.5
Corn (sweet and field)	2	8	2.34	Irrigating, scouting, hand weeding	1000	1.06	120.81	294	7
Corn (field)	2	8	2.34	Hand detasseling	17000	0.06	116.61	304	21
Cole crops Broccoli, Brussels sprouts, Cabbage, Cauliflower, Celery, Lettuce, Kohlrabi	2	7	2.52	Hand pruning, hand harvesting, topping	5000	0.19	106.44	334	14
				Scouting	4000	0.23	102.99	345	13
				Weeding, thinning, irrigation	2000	0.48	110.20	322	9
			2.50	Hand pruning, hand harvesting	5000	0.18	105.59	336	14
				Scouting	4000	0.22	102.17	347	13
				Weeding, thinning, irrigating	2000	0.48	109.32	325	9
Leafy vegetables	2	7	2.52	Hand harvesting, hand pruning, thinning	2500	0.40	113.89	312	10
Beet tops, Chinese cabbage, Dandelion, Endive, Kale, Leaf lettuce, Mustard greens, Parsley, Salsify (tops), Spinach, Swiss chard, Turnip (tops), Watercress				Irrigating, scouting	1500	0.71	120.90	294	7
				Hand weeding	500	1.83	104.31	340	2
			2.25	Hand harvesting, hand pruning, thinning	2500	0.36	101.69	349	10
				Irrigating, scouting	1500	0.63	107.95	329	7
				Hand weeding	500	1.97	112.65	315	1
Parsnips	2	7	2.45	Hand harvesting, hand pruning,	2500	0.39	110.57	321	10

Crop	Applications Per Year		Rates[c] (kg a.i./ha)	Activity	Transfer Coefficient[d] (cm^2/hr)	DFR[e] (µg/cm^2)	Dermal Exposure[f] (µg/kg bw/day)	MOE[g]	REI[h] (days)
	Number[a]	Interval[b] (days)							
				thinning					
				Irrigating, scouting	1500	0.68	117.38	302	7
				Hand weeding	500	1.77	101.27	351	2
Peas	2	7	2.25	Hand harvesting	2500	0.36	101.69	349	10
				Irrigating, scouting	1500	0.63	107.95	329	7
				Thinning, hand weeding	100	2.38	27.25	1303	0.5
Potato	2	7	3.07	Irrigating, scouting	1500	0.71	121.86	291	8
				Hand weeding	300	3.26	111.61	318	0.5
Snapbeans	2	7	2.45	Hand harvesting	2500	0.39	110.57	321	10
				Irrigation, scouting	1500	0.68	117.38	302	7
				Hand weeding	100	2.59	29.63	1198	0.5
Tomato, Eggplants, Peppers	2	7	3.07	Hand harvesting, pruning, staking, thinning, training, tying	1000	1.04	118.84	299	6
				Irrigating, scouting	700	1.52	121.70	292	4
				Hand weeding	500	1.84	105.14	338	3
Apples	1	N/A	0.09	Hand harvesting	1500	0.19	31.95	1111	0.5
				Hand line irrigation	1100	0.19	23.43	1515	0.5
				Hand pruning, scouting, pinching, tying, training	500	0.19	10.65	3333	0.5
	1	N/A	3.00	Thinning	3000	0.33	111.75	318	28
				Hand harvesting	1500	0.68	115.74	307	21
				Hand line irrigation	1100	0.92	115.96	306	18
				Hand pruning, scouting, pinching, tying, training	500	1.91	109.18	325	11
Apples, Pears, Apricot, Peach, Cherries, Plums	r.a.n.	7	3.74	Thinning	3000	0.34	115.41	308	35
				Hand harvesting	1500	0.70	119.52	297	28
				Hand line irrigation	1100	0.95	119.76	296	25
				Hand pruning, scouting, pinching, tying, training	500	1.97	112.75	315	18
				Mechanical harvest (cherries)	200	5.03	115.03	309	9

Table 6c Agricultural Postapplication Exposure Estimates, MOEs and REIs

Crop	Applications Per Year		Rates[c] (kg a.i./ha)	Activity	Transfer Coefficient[d] (cm^2/hr)	DFR[e] (µg/cm^2)	Dermal Exposure[f] (µg/kg bw/day)	MOE[g]	REI[h] (days)
	Number[a]	Interval[b] (days)							
Berries	2	8	2.52	Hand harvesting, pinching, pruning, training	1500	0.62	105.76	336	10
				Irrigating, weeding, scouting, thinning	500	2.11	120.54	295	4
Blueberries	2	8	1.92	Hand harvesting, pinching, pruning, training	1500	0.60	102.51	346	9
				Irrigating, weeding, scouting, thinning	400	2.51	114.72	309	2
Prunes	r.a.n.	7	3.00	Thinning	3000	0.33	113.98	311	33
				Hand harvesting	1500	0.69	118.05	301	26
				Hand line irrigation	1100	0.94	118.28	300	23
				Hand pruning, scouting, pinching, tying, training	500	1.95	111.36	319	16
Cucumbers, Melons, Squash	2	7	1.25	Hand harvesting and pruning, thinning	2500	0.42	120.89	294	6
				Irrigating, scouting, weeding	1500	0.62	106.11	335	4
Cranberries	2	8	3.65	Irrigating, pruning, weeding, scouting, thinning, harvesting	400	2.49	113.73	312	5
Grapes	r.a.n.	7	3.07	Cane turning and girdling	19300	0.05	107.30	331	51
				Hand harvesting, training, thinning, hand pruning, tying, leaf pulling	8500	0.13	121.98	291	42
				Hand line irrigation	1100	0.93	116.86	304	23
				Scouting, hand weeding	700	1.42	113.34	313	19
Strawberries	2	8	3.00	Hand harvesting, pinching, pruning, training	1500	0.60	102.58	346	11
				Irrigating, weeding, scouting, thinning	400	2.51	114.80	309	4
Tobacco	2	8	8.40	Hand harvesting, hand pruning, thinning, topping, hand weeding	2000	0.49	112.01	317	17
				Irrigating, scouting	1300	0.74	109.68	324	15
			6.25	Hand harvesting, hand pruning,	2000	0.45	102.29	347	16

Crop	Applications Per Year		Rates[c] (kg a.i./ha)	Activity	Transfer Coefficient[d] (cm^2/hr)[d]	DFR[e] (µg/cm^2)	Dermal Exposure[f] (µg/kg bw/day)	MOE[g]	REI[h] (days)
	Number[a]	Interval[b] (days)							
				thinning, topping, hand weeding					
				Irrigating, scouting	1300	0.83	122.94	289	13
Choke cherries	1	N/A	1.48	Thinning	3000	0.33	114.20	311	21
				Hand harvesting	1500	0.69	118.27	300	14
				Hand line irrigation	1100	0.94	118.50	300	11
				Hand pruning, scouting, pinching, tying, training	500	1.95	111.57	318	4
				Mechanical harvesting	200	2.96	67.66	525	0.5
Arborvitae, Birch, Boxwood, Dogwood, Elm, Juniper, Maple, Oak, Pines	r.a.n.	7	5.04	Hand line irrigation	1100	0.94	118.12	301	28
				Pruning, scouting	500	1.95	111.21	319	21
				Weeding	100	10.28	117.50	302	5
Azalea, Carnation, Chrysanthemums, Gladiolus, Holly, Hydrangea, Lilac, Rose, Zinnia	2	7	1.68	Hand harvesting, pinching, pruning, thinning	7000	0.15	120.15	295	13
				Irrigation, scouting	4000	0.27	121.48	292	10
				Hand weeding	2500	0.39	111.07	320	8
Green ash	2	7	3.64	Hand line irrigation	1100	0.89	111.61	318	24
				Pruning, scouting	500	2.04	116.60	304	16
				Weeding	100	9.71	111.03	320	1
High value trees	1	N/A	2.00	Scouting	500	1.93	110.35	322	7

[a] Maximum listed label rates expressed in kilograms/hectare.

[b] Postapplication activity transfer coefficients are based on the PMRA's default values.

[c] Absorbed Daily Dose = daily dermal dose + daily inhalation dose, as determined by PHED scenarios. A dermal absorption factor of 21% was applied.

[d] LADD=ADD × treatment frequency × working duration/(365 days × 75 years). Treatment frequency = 30 days/year to encompass both farmers and custom applicators, Working duration = 35 years

[e] Risk = LADD × Q_1*; Q_1* = 1.08×10^{-3} $(mg/kg/day)^{-1}$

[f] Based on the dermal exposure incurred (see Section 3.2.2.2), at × days after application, where × is the day when an MOE ≥300 is determined or the proposed REI day at which the dermal exposure results in an MOE ≥300.
N/A not available; r.a.n. repeat as necessary

[g] The resulting MOE on the recommended REI day. Based on the short and intermediate term dermal $BMDL_{10}$ of 35.5 mg/kg/day.

[h] Day at which the dermal exposure results in an MOE ≥ 300. REI= Restricted Entry interval.

Table 7 Agricultural Postapplication Cancer Risk Estimates

Crop	Applications Per Year		Rates[a] (kg a.i./ha)	Activity[b]	Total Absorbed Daily Dose[c] (mg/kg/d)	Post-Appli-cation Days Per Year	Total Lifetime Absorbed Daily Dose[d] (mg/kg bw)	Cancer Risk[e]	REI[f] (days)
	Number	Interval (days)							
Balsam fir, Spruce in farm woodlots, Municipal parks, Rights-of-way	r.a.n.	7	3.30	Thinning	2.37E-02	30	9.10E-04	9.83E-07	34
				Hand-line irrigation	2.46E-02		9.44E-04	1.02E-06	24
				Hand pruning, scouting, pinching, tying, training, shaping	2.32E-02		8.89E-04	9.60E-07	17
				Hand weeding, propping, baiting, grading/tagging	2.45E-02		9.39E-04	1.01E-06	1
Forests and Woodlots	r.a.n.	7	1.07	Hand-line irrigation	2.51E-02	30	9.63E-04	1.04E-06	13
				Hand pruning, scouting, pinching, tying, training	2.36E-02		9.07E-04	9.79E-07	6
				Hand weeding, propping	8.83E-03		3.39E-04	3.66E-07	0.5
Trap trees	1	N/A	2.00	Scouting	2.32E-02	30	8.89E-04	9.60E-07	7
Alfalfa, Clover	r.a.n.	7	2.52	Irrigating, scouting	2.22E-02	30	8.52E-04	9.20E-07	10
Ditch banks, etc	r.a.n.	7	1.63	Scouting	2.47E-02	30	9.47E-04	1.02E-06	2
Rapeseed (canola)	r.a.n.	7	0.60	Irrigating, scouting	2.22E-02	30	8.51E-04	9.19E-07	3
Sweet white lupin	r.a.n.	7	1.86	Weeding, thinning, harvesting	2.19E-02	30	8.40E-04	9.07E-07	10
				Irrigating, scouting	2.14E-02		8.23E-04	8.89E-07	8
Asparagus	r.a.n.	3	3.07	Irrigating, hand weeding	2.34E-02	30	8.99E-04	9.71E-07	0.5
			2.25	Irrigating, hand weeding	1.72E-02		6.58E-04	7.11E-07	0.5
			4.50	Irrigating, hand weeding	2.35E-02		9.00E-04	9.72E-07	2
Barley, Oats, Rye, Wheat	r.a.n.	7	2.52	Irrigating, scouting	2.22E-02	30	8.52E-04	9.20E-07	10
Beans	r.a.n.	7	3.07	Hand harvesting	2.41E-02	30	9.25E-04	9.99E-07	11
				Irrigating, scouting	2.12E-02		8.12E-04	8.76E-07	9
				Hand weeding	5.45E-04		2.09E-05	2.26E-08	0.5
Beet (root),	r.a.n.	7	2.52	Hand harvesting	2.39E-02	30	9.17E-04	9.91E-07	10

Crop	Applications Per Year		Rates[a] (kg a.i./ha)	Activity[b]	Total Absorbed Daily Dose[c] (mg/kg/d)	Post-Appli-cation Days Per Year	Total Lifetime Absorbed Daily Dose[d] (mg/kg bw)	Cancer Risk[e]	REI[f] (days)
	Number	Interval (days)							
Horseradish, Radish, Rutabaga (root), Salsify (root), Turnip (root)				Hand weeding, irrigating, scouting, thinning	1.92E-02		7.37E-04	7.96E-07	0.5
		5	2.25	Hand harvesting	2.14E-02		8.19E-04	8.85E-07	10
				Hand weeding, irrigating, scouting, thinning	1.72E-02		6.58E-04	7.11E-07	0.5
Carrots	r.a.n.	7	2.52	Hand harvesting	2.39E-02	30	9.17E-04	9.91E-07	10
				Scouting, weeding, irrigating	1.92E-02		7.37E-04	7.96E-07	0.5
		5	2.25	Hand harvesting	2.14E-02		8.19E-04	8.85E-07	10
				Scouting, weeding, irrigating	1.72E-02		6.58E-04	7.11E-07	0.5
Corn (sweet and field)	r.a.n.	2	2.34	Irrigating, scouting, hand weeding	2.54E-02	30	9.73E-04	1.05E-06	7
Corn (sweet)	r.a.n.	2	2.34	Hand harvesting, hand detasseling	2.45E-02	30	9.39E-04	1.01E-06	21
Cole crops (Broccoli, Brussel sprouts, Cabbage, Cauliflower, Celery, Lettuce, Kohlrabi)	r.a.n.	7	2.52	Hand pruning, hand harvesting, topping	2.24E-02	30	8.57E-04	9.26E-07	14
				Scouting	2.16E-02		8.30E-04	8.96E-07	13
				Weeding, thinning, irrigating	2.31E-02		8.88E-04	9.59E-07	9
		5	2.50	Hand pruning, hand harvesting	2.22E-02		8.51E-04	9.19E-07	14
				Scouting	2.15E-02		8.23E-04	8.89E-07	13
				Weeding, thinning, irrigatiing	2.30E-02		8.81E-04	9.51E-07	9
Leafy vegetables	r.a.n.	7	2.52	Hand harvesting, hand pruning, thinning	2.39E-02	30	9.17E-04	9.91E-07	10
				Irrigating, scouting	2.54E-02		9.74E-04	1.05E-06	7
				Hand weeding	2.19E-02		8.40E-04	9.07E-07	2
		5	2.25	Hand harvesting, hand pruning, thinning	2.14E-02		8.19E-04	8.85E-07	10
				Irrigating, scouting	2.27E-02		8.70E-04	9.39E-07	7
				Hand weeding	2.37E-02		9.07E-04	9.80E-07	1

Crop	Applications Per Year		Rates[a] (kg a.i./ha)	Activity[b]	Total Absorbed Daily Dose[c] (mg/kg/d)	Post-Application Days Per Year	Total Lifetime Absorbed Daily Dose[d] (mg/kg bw)	Cancer Risk[e]	REI[f] (days)
	Number	Interval (days)							
Parsnips	r.a.n.	7	2.45	Hand harvesting, hand pruning, thinning	2.32E-02	30	8.91E-04	9.62E-07	10
				Irrigating, scouting	2.46E-02		9.45E-04	1.02E-06	7
				Hand weeding	2.13E-02		8.16E-04	8.81E-07	2
Peas	r.a.n.	7	2.25	Hand harvesting	2.14E-02	30	8.19E-04	8.85E-07	10
				Irrigating, scouting	2.27E-02		8.70E-04	9.39E-07	7
				Thinning, hand weeding	5.72E-03		2.19E-04	2.37E-07	0.5
Potato	r.a.n.	7	3.07	Irrigating, scouting	2.56E-02	30	9.82E-04	1.06E-06	8
				Hand weeding	2.34E-02		8.99E-04	9.71E-07	0.5
Snapbeans	r.a.n.	7	2.45	Hand harvesting	2.32E-02	30	8.91E-04	9.62E-07	10
				Irrigating, scouting	2.46E-02		9.45E-04	1.02E-06	7
				Hand weeding	6.22E-03		2.39E-04	2.58E-07	0.5
Tomato, Eggplants, Peppers	r.a.n.	7	3.07	Hand harvesting, pruning, staking, thinning, training, tying	2.50E-02	30	9.57E-04	1.03E-06	6
				Irrigating, scouting	2.56E-02		9.80E-04	1.06E-06	4
				Hand weeding	2.21E-02		8.47E-04	9.15E-07	3
Apples	1	N/A	0.09	Hand harvesting	6.71E-03	30	2.57E-04	2.78E-07	0.5
				Hand line irrigation	4.92E-03		1.89E-04	2.04E-07	0.5
				Hand pruning, scouting, pinching, tying, training	2.24E-03		8.58E-05	9.27E-08	0.5
	1	N/A	3.00	Thinning	2.35E-02		9.64E-04	1.04E-06	28
				Hand harvesting	2.43E-02		9.32E-04	1.01E-06	21
				Hand line irrigation	2.44E-02		9.34E-04	1.01E-06	18
				Hand pruning, scouting, pinching, tying, training	2.29E-02		8.79E-04	9.50E-07	11

Crop	Applications Per Year		Rates[a] (kg a.i./ha)	Activity[b]	Total Absorbed Daily Dose[c] (mg/kg/d)	Post-Application Days Per Year	Total Lifetime Absorbed Daily Dose[d] (mg/kg bw)	Cancer Risk[e]	REI[f] (days)
	Number	Interval (days)							
Apples, Pears, Apricot, Peach, Cherries, Plums	r.a.n.	7	3.74	Thinning	2.42E-02	30	9.30E-04	1.00E-06	35
				Hand harvesting	2.51E-02		9.63E-04	1.04E-06	28
				Hand line irrigating	2.51E-02		9.65E-04	1.04E-06	25
				Hand pruning, scouting, pinching, tying, training	2.37E-02		9.08E-04	9.81E-07	18
				Mechanical harvesting (cherries)	2.42E-02		9.27E-04	1.00E-06	9
Berries	r.a.n.	7	2.52	Hand harvesting, pinching, pruning, training	2.22E-02	30	8.52E-04	9.20E-07	10
				Irrigating weeding, scouting, thinning	2.53E-02		9.71E-04	1.05E-06	4
Blueberries	r.a.n.	10	1.99	Hand harvesting, pinching, pruning, training	2.15E-02	30	8.26E-04	8.92E-07	9
				Irrigating, weeding, scouting, thinning	2.41E-02		9.24E-04	9.98E-07	2
Prunes	r.a.n.	7	3.00	Thinning	2.39E-02	30	9.18E-04	9.92E-07	33
				Hand harvesting	2.48E-02		9.51E-04	1.03E-06	26
				Hand line irrigating	2.48E-02		9.53E-04	1.03E-06	23
				Hand pruning, scouting, pinching, tying, training	2.34E-02		8.97E-04	9.69E-07	16
Cucumbers, Melons, Squash	r.a.n.	7	1.25	Hand harvesting, hand pruning, thinning	2.54E-02	30	9.74E-04	1.05E-06	6
				Irrigating, scouting, weeding	2.23E-02		8.55E-04	9.23E-07	4
Cranberries	r.a.n.	7	3.65	Irrigating, pruning, weeding, scouting, thinning, harvesting	2.39E-02	30	9.16E-04	9.89E-07	5

Crop	Applications Per Year		Rates[a] (kg a.i./ha)	Activity[b]	Total Absorbed Daily Dose[c] (mg/kg/d)	Post-Application Days Per Year	Total Lifetime Absorbed Daily Dose[d] (mg/kg bw)	Cancer Risk[e]	REI[f] (days)
	Number	Interval (days)							
Grapes	r.a.n.	7	3.07	Cane turning and girdling	2.25E-02	30	8.64E-04	9.33E-07	51
				Hand harvesting, training, thinning, hand pruning, tying, leaf pulling	2.56E-02		9.83E-04	1.06E-06	42
				Hand line irrigating	2.45E-02		9.41E-04	1.02E-06	23
				Scouting, hand weeding	2.38E-02		9.13E-04	9.86E-07	19
Strawberries	r.a.n.	7	3.00	Hand harvesting, pinching, pruning, training	2.15E-02	30	8.26E-04	8.92E-07	11
				Irrigating, weeding, scouting, thinning	2.41E-02		9.25E-04	9.99E-07	4
Tobacco	r.a.n.	7	8.40	Hand harvest, hand pruning, thinning, topping, hand weeding	2.35E-02	30	9.02E-04	9.74E-07	17
				Irrigating, scouting	2.30E-02		8.83E-04	9.54E-07	15
			6.25	Hand harvesting, hand pruning, thinning, topping, hand weeding	2.15E-02		8.24E-04	8.90E-07	16
				Irrigating, scouting	2.58E-02		9.90E-04	1.07E-06	13
Choke cherries	1	N/A	1.48	Thinning	2.40E-02	30	9.20E-04	9.93E-07	21
				Hand harvesting	2.48E-02		9.53E-04	1.03E-06	14
				Hand line irrigating	2.49E-02		9.54E-04	1.03E-06	11
				Hand pruning, scouting, pinching, tying, training	2.34E-02		8.99E-04	9.71E-07	4
				Mechanical harvesting	1.42E-02		5.45E-04	5.89E-07	0.5
Arborvitae, Birch, Boxwood, Dogwood, Elm, Juniper, Maple, Oak, Pines	r.a.n.	7	5.04	Hand line irrigating	2.48E-02	30	9.51E-04	1.03E-06	28
				Pruning, scouting	2.34E-02		8.96E-04	9.67E-07	21
				Weeding	2.47E-02		9.46E-04	1.02E-06	5

Crop	Applications Per Year		Rates[a] (kg a.i./ha)	Activity[b]	Total Absorbed Daily Dose[c] (mg/kg/d)	Post-Appli-cation Days Per Year	Total Lifetime Absorbed Daily Dose[d] (mg/kg bw)	Cancer Risk[e]	REI[f] (days)
	Number	Interval (days)							
Azalea, Carnation, Chrysanthemums, Gladiolus, Holly, Hydrangea, Lilac, Rose, Zinnia	r.a.n.	7	1.68	Hand harvest, pinching, pruning, thinning	2.52E-02	30	9.68E-04	1.05E-06	13
				Irrigating, scouting	2.55E-02		9.79E-04	1.06E-06	10
				Weeding	2.33E-02		8.95E-04	9.66E-07	8
Green ash	2	7	3.64	Hand line irrigating	2.34E-02	30	8.99E-04	9.71E-07	24
				Pruning, scouting	2.45E-02		9.39E-04	1.01E-06	16
				Weeding	2.33E-02		8.94E-04	9.66E-07	1
High value trees	1	N/A	2.00	scouting	2.32E-02	30	8.89E-04	9.60E-07	7

[a] aximum listed label rates expressed in kilograms/hectare.

[b] ostapplication activity transfer coefficients based on the PMRA's default values.

[c] bsorbed Daily Dose = daily dermal dose + daily inhalation dose, as determined by PHED scenarios. A dermal absorption factor of 21% was applied.

[d] ADD=ADD × treatment frequency × working duration/(365 days × 75 years). Treatment frequency = 30 days/year to encompass both farmers and custom applicators, Working duration = 35 years

[e] isk = LADD × Q_1*; Q_1* = 1.08 × 10^{-3} $(mg/kg/day)^{-1}$

[f] ased on the dermal exposure incurred (see Section 3.2.2.2), at × days after application, where × is the day when an MOE ≥300 is determined or the proposed REI day at which the dermal exposure results in an MOE ≥300.

Appendix VII

Table 8 Non-Cancer Dermal Exposure for PYO Operations

Crop[a]	Subject[b]	Applications Per Season		Application Rate[e] (kg a.i./ha)	Activity	Transfer Coefficient[f] (cm^2/hr)	DFR[g] (ug/cm^2)	REI[h]	Dermal Exposure[i] (ug/kg bw/day)	MOE[j]
		Maximum Number[c]	Minimum Interval[d] (days)							
Apples	Toddler	3	7	3.74	Hand harvesting	639	0.70	28	59.43	597
	Youth					1034	0.70		36.79	965
	Adult					1500	0.70		29.88	1188
Blueberries	Toddler	2	7	1.92	Hand harvesting	639	0.63	9	50.97	696
	Youth					1034	0.63		31.55	1125
	Adult					1500	0.63		25.63	1385

[a] Apples and blueberries are considered to be representative of all PYO orchard and berry crops for the purposes of assessing exposure.
[b] Three different age groups were assessed for PYO exposure. The body weights are as follows: 15 kg for toddlers, 39.1 kg for youth, and 70 kg for adults.
[c] Where the labels list the number of applications as repeat as necessary (r.a.n.), the risk assessment has been conducted assuming two or three applications per year depending on available DFR data.
[d] A minimum interval of seven days between applications was assumed in the risk assessment for those applications where an interval was not specified.
[e] Maximum listed label rates expressed in kilograms a.i./hectare.
[f] Transfer coefficients are based on the PMRA's default values. Transfer coefficients expressed in cm^2/hr. For adults the TC for hand harvesting berries and orchard fruits is 1500 cm^2/hr. Since this TC was based on the surface area of an adult, it was scaled for the surface area of a youth (correction factor 12700 cm^2/hr /18440 cm^2/hr = 68.9%) and a toddler (correction factor 7860 cm^2/hr /18440 cm^2/hr = 42.6%). As such, the TC for youth and toddlers are 1034 and 639 cm^2, respectively.
[g] DFR data (see Section 3.2.2.2), at × days after application, where × is the day when an MOE ≥300 is determined for agricultural postapplication workers, for the proposed REI.
[h] Restricted Entry Intervals are dictated by the REIs recommended for agricultural postapplication workers (see Appendix VI-Table 6 for details).
[i] Dermal exposure = DFR × TC × 2 hr /70 kg.
[j] Based on the short- and intermediate-term dermal $BMDL_{10}$ of 35.5 mg/kg/day and a target MOE of 300.

Table 9 Non-Cancer Dietary Exposure for PYO Operations

Crop[a]	Subject[b]	Application Rate[c] (kg a.i./ha)	Acute Dietary Exposure[d] (µg/kg bw/day)	Chronic Dietary and Drinking Water Exposure[e] (µg/kg bw/day)	Total Dietary Exposure (µg/kg bw/day)	Dietary MOE[f]
Apples	Toddler	3.74	39.93	29.47	69.40	16
	Youth		23.35	10.94	34.29	33
	Adult		9.14	4.26	13.40	84
Blueberries	Toddler	1.92	1.46	3.80	5.27	215
	Youth		1.08	2.60	3.68	307
	Adult		0.24	2.44	2.68	422

[a] Apples and blueberries are considered to be representative of all PYO orchard and berry crops for the purposes of assessing exposure.
[b] Three different age groups were assessed for PYO exposure. The body weights are as follows: 15 kg for toddlers, 39.1 kg for youth, and 70 kg for adults.
[c] Maximum listed label rates expressed in kilograms a.i./hectare.
[d] Acute dietary exposure is derived using MRLs from the specific crop and acute (one day) consumption of the crop from the USDA Continuing Survey of Food Intakes 1994–1996, 1998.
[e] Chronic dietary and drinking water exposure is derived from the PMRA's dietary risk assessment.
[f] Based on the oral $BMDL_{10}$ of 1.13 mg/kg/day and a target MOE of 100. Shaded cells indicate those MOEs that did not reach the target.

Table 10 Non-Cancer Aggregate Exposure for PYO Operations

Crop[a]	Subject[b]	Application Rate[c] (kg a.i./ha)	Activity	Dermal MOE	Dermal Risk Index[d]	Dietary MOE	Dietary Risk Index[e]	Aggregate Risk Index[f]
Apples	Toddler	3.74	Hand harvesting	597	1.99	16	0.16	0.15
	Youth			965	3.22	33	0.33	0.30
	Adult			1188	3.96	84	0.84	0.70
Blueberries	Toddler	1.92	Hand harvesting	696	2.32	215	2.15	1.12
	Youth			1125	3.75	307	3.07	1.69
	Adult			1385	4.62	422	4.27	2.21

[a] Apples and blueberries are considered to be representative of all PYO orchard and berry crops for the purposes of assessing exposure.
[b] Three different age groups were assessed for PYO exposure. The body weights are as follows: 15 kg for toddlers, 39.1 kg for youth, and 70 kg for adults.
[c] Maximum listed label rates expressed in kilograms a.i./hectare.
[d] Dermal Risk Index (RI_D)= Dermal MOE/Dermal Target MOE.
[e] Dietary Risk Index (RI_I) = Dietary MOE/Dietary Target MOE.
[f] Aggregate Risk Index (ARI) = 1/[(1/Dermal Risk Index)+(1/Dietary Risk Index)]. Table cells are shaded when the ARI < 1.0. If the ARI exceeds 1.0, the risk is below the level of concern.

Table 11 Cancer Risk from Dermal Exposure for PYO Operations

Crop[a]	Subject[b]	Application Rate[c] (kg a.i./ha)	Activity	REI[d]	Daily Absorbed Dermal Dose[e] (ADD) (mg/kg/day)	Total Daily Dietary Exposure[e] (ADD) (mg/kg/day)	Total Absorbed Daily Dose[g] (ADD) (mg/kg/day)	Harvest Days Per Year (HDPY)	Age Group Absorbed Daily Dose[h]	Lifetime Absorbed Daily Dose[i] (LADD)	Lifetime Cancer Risk[j]
Apples	Toddler	3.74	Hand harvesting	28	1.25E-02	6.94E-02	8.19E-02	2	3.59E-05	3.08E-04	3.33E-07
	Youth				7.73E-03	3.43E-02	4.20E-02	5	4.60E-05		
	Adult				6.28E-03	1.34E-02	1.97E-02	5	2.26E-04		
Blueberries	Toddler	1.92	Hand harvesting	9	1.07E-02	5.27E-03	1.60E-02	2	7.00E-06	1.11E-04	1.20E-07
	youth				6.63E-03	3.68E-03	1.03E-02	5	1.13E-05		
	adult				5.38E-03	2.68E-03	8.06E-03	5	9.27E-05		

[a] Apples and blueberries are considered to be representative of all PYO orchard and berry crops for the purpose of assessing exposure.
[b] Three different age groups were assessed for PYO exposure. The body weights are as follows: 15 kg for toddlers, 39.1 kg for youth, and 70 kg for adults.
[c] Maximum listed label rates expressed in kilograms a.i./hectare.
[d] Restricted Entry Intervals are dictated by the REIs recommended for agricultural postapplication workers (see Appendix VI-Table 6 for details).
[e] Absorbed Daily Dose = daily dose as determined by postapplication scenarios. A dermal absorption factor of 21% was applied to the dermal route of exposure.
[f] Total Absorbed Daily Dose = Sum of the Daily Absorbed Dermal Dose and the Total Daily Dietary Exposure.
[h] $LADD_A$ is the absorbed dose over the span of years covered by the age group. $LADD_A$ = ADD × postapplication frequency × working duration/(365 days × number of years). Postapplication frequency = 2 days/year for toddlers, 5 days/year for youths and adults. Working Duration = 6 years for toddlers and youths, 63 years for adults.
[i] LADD is the Lifetime Absorbed Daily Dose = Sum of the age group absorbed daily doses.
[j] Risk = LADD × Q^*_1; $Q^*_1 = 1.08 \times 10^{-3}$ $(mg/kg/day)^{-1}$

Appendix VIII

Table 12 Lawn Care Occupational M/L/A Short-term Non-Cancer Exposure Estimates and Margins of Exposure for Turf

Application Equipment	Data Source[a]	Formulation (kg a.i./ha)	Area Treated (ha/day)	Dermal Unit Exposure (µg/kg handled)	Dermal Exposure[b] (µg/kg/day)	Inhalation Unit Exposure (µg/kg handled)	Inhalation Exposure[c] (µg/kg/day)	Dermal MOE[d]	Inhalation MOE[d]	Combined ARI[e]
Residential Lawns: Commercial Lawn Care Operator wearing long pants, long sleeves, gloves										
Low pressure turf gun	ORETF	Liquid (13.9)	2	785	312.21	4	1.59	114	710	0.36
Low pressure turf gun	ORETF		0.4	785	62.44	4	0.32	569	3552	1.8
Backpack	PHED		0.4	5446	433.19	62.1	4.94	82	229	0.24
Low pressure turf gun	ORETF	Wettable powder (10)	2	1242	354.86	153	43.71	100	26	0.15
			0.4	1242	70.97	153	8.74	500	129	0.73
Residential Lawns: Commercial Lawn Care Operator wearing coveralls over long pants, long sleeves, gloves										
Low pressure turf gun	ORETF	Liquid (13.9)	2	301.1	119.75	4	1.59	296	710	0.87
Low pressure turf gun	ORETF		0.4	301.1	23.95	4	0.32	1482	3552	4.3
Backpack	PHED		0.4	2597	206.57	62.1	4.94	172	229	0.46
Low pressure turf gun	ORETF	Wettable powder (10)	2	381.5	109.00	153	43.71	326	26	0.21
			0.4	381.5	21.80	153	8.74	1628	129	1.04

[a] Median unit exposures are used from ORETF Best-Fit unit exposures are used from PHED.

[b] Where dermal exposure µg/kg/day = unit exposure × area treated × use rate/70 kg bw.

[c] Where inhalation exposure µg/kg/day = unit exposure × area treated × use rate)/70 kg bw

[d] Based on a dermal $BMDL_{10}$ of 35.5 mg/kg bw/day for dermal exposure and an oral $BMDL_{10}$ of 1.13 mg/kg/day for inhalation exposure; target MOE is 300 for dermal exposure and 100 for inhalation exposure.

[e] Combined ARI = $1/(300/MOE_{Dermal} + 100/MOE_{Inhalation})$. Table cells are shaded when the ARI < 1.0. If the ARI exceeds 1.0, the risk is below the level of concern.

Table 13 Golf Course and Sod Farm Mixer/Loader/Applicator Short-term Non-Cancer Exposure Estimates and Margins of Exposure for Turf

Application Equipment	Data Source[a]	Formulation (kg a.i./ha)	Area Treated (ha/day)	Dermal Unit Exposure (µg/kg handled)	Dermal Exposure[b] (µg/kg/day)	Inhalation Unit Exposure (µg/kg handled)	Inhalation Exposure[c] (µg/kg/day)	Dermal MOE[d]	Inhalation MOE[d]	Combined ARI[e]
Golf Courses: Commercial M/L/A wearing long pants, long sleeves, gloves										
Low pressure turf gun	ORETF	Liquid (13.9)	2	785	312.21	4	1.59	114	710	0.36
Low pressure turf gun	ORETF		0.4	785	62.44	4	0.32	569	3552	1.8
Backpack	PHED		0.4	5446	433.19	62.1	4.94	82	229	0.24
Groundboom open cab/open M/L	PHED		16	83.63	266.09	2.6	8.27	133	137	0.340
Groundboom open cab/closed M/L	PHED		16	51.9	165.23	1.07	3.40	215	332	0.59
groundboom closed cab/open M/L	PHED		16	62.2	197.87	1.66	5.28	179	214	0.47
groundboom closed cab/closed M/L	PHED		16	30.0	95.45	0.17	0.54	372	2089	1.17
low pressure turf gun	ORETF	Wettable powder (10)	2	1242	354.86	153	43.71	100	26	0.15
			0.4	1242	70.97	153	8.74	500	129	0.73

Application Equipment	Data Source[a]	Formulation (kg a.i./ha)	Area Treated (ha/day)	Dermal Unit Exposure (µg/kg handled)	Dermal Exposure[b] (µg/kg/day)	Inhalation Unit Exposure (µg/kg handled)	Inhalation Exposure[c] (µg/kg/day)	Dermal MOE[d]	Inhalation MOE[d]	Combined ARI[e]
groundboom open cab/open M/L	PHED		16	564	1289.14	57.16	130.65	28	9	0.05
groundboom open cab/closed M/L	PHED		16	54.6	124.78	1.14	2.61	285	434	0.78
Groundboom closed cab/open M/L	PHED		16	542.4	1239.84	56.26	128.59	29	9	0.05
Groundboom closed cab/closed M/L	PHED		16	32.7	74.65	0.24	0.55	476	2060	1.47
Golf Courses: Commercial M/L/A wearing coveralls over long pants, long sleeves and gloves										
Low pressure turf gun	ORETF	Liquid (13.9)	2	301.1	119.75	4	1.59	296	710	0.87
			0.4	301.1	23.95	4	0.32	1482	3552	4.3
Backpack	PHED		0.4	2597	206.57	62.1	4.94	172	229	0.46
Ground boom	PHED		16	53.81	171.21	2.6	8.27	56	14	0.08
Low pressure turf gun	ORETF	Wettable powder (10)	2	381.5	109.00	153	43.71	326	26	0.21
			0.4	381.5	21.80	153	8.74	1628	129	1.04
Groundboom	PHED		16	392.18	896.41	57.16	130.65	40	9	0.05

Application Equipment	Data Source[a]	Formulation (kg a.i./ha)	Area Treated (ha/day)	Dermal Unit Exposure (µg/kg handled)	Dermal Exposure[b] (µg/kg/day)	Inhalation Unit Exposure (µg/kg handled)	Inhalation Exposure[c] (µg/kg/day)	Dermal MOE[d]	Inhalation MOE[d]	Combined ARI[e]
Sod Farms: Commercial M/L/A wearing long pants, long sleeves, gloves										
Low pressure turf gun	ORETF	Liquid (13.9)	2	785	312.21	4	1.59	114	710	0.36
Groundboom open cab/open M/L	PHED		30	83.63	498.91	2.6	15.51	71	73	0.18
Groundboom open cab/closed M/L	PHED		30	51.93	309.8	1.07	6.38	115	177	0.31
Groundboom closed cab/open M/L	PHED		30	62.19	371.0	1.66	9.90	96	114	0.25
Groundboom closed cab/closed M/L	PHED		30	30.0	179.0	0.17	1.01	198	1114	0.62
Low pressure turf gun	ORETF	Wettable powder (10)	2	1242	354.86	153	43.71	100	26	0.15
Groundboom open cab/open M/L	PHED		30	564	2417.14	57.16	244.97	15	4.6	0.02
Groundboom open cab/closed M/L	PHED		30	54.59	234.0	1.14	4.89	152	231	0.42

Application Equipment	Data Source[a]	Formulation (kg a.i./ha)	Area Treated (ha/day)	Dermal Unit Exposure (µg/kg handled)	Dermal Exposure[b] (µg/kg/day)	Inhalation Unit Exposure (µg/kg handled)	Inhalation Exposure[c] (µg/kg/day)	Dermal MOE[d]	Inhalation MOE[d]	Combined ARI[e]
Groundboom closed cab/open M/L	PHED		30	542.43	2324.7	56.26	241.11	15	5	0.02
Groundboom closed cab/closed M/L	PHED		30	32.66	140.0	0.24	1.03	254	1099	0.79
Sod Farms: Commercial M/L/A wearing coveralls over long pants, long sleeves, gloves										
Low pressure turf gun	ORETF	Liquid (13.9)	2	301.1	119.75	4	1.59	296	710	0.87
Ground boom	PHED		30	53.81	230.61	2.6	11.14	154	101	0.34
Low pressure turf gun	ORETF	Wettable powder (10)	2	381.5	109	153	43.71	326	26	0.21
Ground boom	PHED		30	392.18	1680.77	57.16	244.97	21	4.6	0.03

[a] Median unit exposures are used from ORETF Best-Fit unit exposures are used from PHED.
[b] Where dermal exposure µg/kg/day = unit exposure × area treated × use rate/70 kg bw.
[c] Where inhalation exposure µg/kg/day = (unit exposure × area treated × use rate)/70 kg bw
[d] Based on a dermal $BMDL_{10}$ of 35.5 mg/kg bw/day for dermal exposure and an oral $BMDL_{10}$ of 1.13 mg/kg/day for inhalation exposure; target MOE is 300 for dermal exposure and 100 for inhalation exposure.
[e] Combined ARI = $1/(300/MOE_{Dermal} + 100/MOE_{Inhalation})$. Table cells are shaded when the ARI < 1.0. If the ARI exceeds 1.0, the risk is below the level of concern.
M/L = mixer/loader

Table 14 Commercial Mixer/Loader/Applicator Short-term Non-Cancer Exposure Estimates and Margins of Exposure for Residential Ornamentals

Application Equipment	Data Source[a]	Formulation (g a.i./L)	Amount Handled Per Day (L/day)	Dermal Unit Exposure (µg/kg handled)	Dermal Exposure[b] (µg/kg/day)	Inhalation Unit Exposure (µg/kg handled)	Inhalation Exposure[c] (µg/kg/day)	Dermal MOE[d]	Inhalation MOE[e]	Combined ARI[f]
Residential Ornamentals: Commercial M/L/A wearing long sleeves, long pants, gloves										
Low pressure handwand	PHED	WP (1.5)	150	19744.88	63.47	1423.00	4.57	559	247	1.1
		liquid (1.68)	150	943.37	3.40	45.20	0.16	10450	6944	23
High pressure handwand	PHED	liquid (1.68)	3750	5585.49	502.69	151.00	13.59	71	83	0.18
Backpack	PHED	liquid (1.68)	150	5445.85	19.61	62.10	0.22	1811	5055	5
Turf gun	ORETF	WP (1.5)	500	1242	13.31	153.00	1.64	2668	689	4
		liquid (1.68)	500	785	9.42	4.00	0.048	3769	23540	12
Handheld pump sprayer[g]	ORETF	liquid (1.68)	150	586	2.11	23.66	0.09	16830	13270	39
Residential Trees and Ornamental Shrubs: Commercial M/L/A wearing long sleeves, long pants, gloves										
Handheld sprayer[g]	ORETF	liquid (1.68)	150	7134	25.68	6.37	0.02	1382	49280	5

[a] Median unit exposures are used from ORETF Best-Fit unit exposures are used from PHED

[b] Where dermal exposure µg/kg/day = unit exposure × volume used × use rate/70 kg bw. The use rate for liquids is 1.68 g a.i./L and for wettable powder is 1.5 g a.i./L.

[c] Where inhalation exposure µg/kg/day = unit exposure × volume used × use rate/70 kg bw

[d] Based on a dermal $BMDL_{10}$ of 35.5 mg/kg bw/day; target MOE is 300

[e] Based on a $BMDL_{10}$ of 1.13 mg/kg/day from an oral study; target MOE is 100

[f] Combined ARI = $1/(300/MOE_{Dermal} + 100/MOE_{Inhalation})$. Table cells are shaded when the ARI < 1.0. If the ARI exceeds 1.0, the risk is below the level of concern.

[g] ORETF data for homeowners applying to ornamentals and vegetable gardens using handheld spray equipment. May not be entirely applicable for commercial applicators applying to residential gardens.

Table 15 Cancer Exposure and Risk Estimates for Commercial Applicators on Turf

Application Scenario	Rate (kg a.i./ha)	Area Treated (ha)	Dermal Unit Exposure	Dermal ADD[a] (µg/kg/day)	Inhalation Unit Exposure	Inhalation ADD[b] (µg/kg/day)	Treatment Frequency (days/year)	LADD[c] (mg/kg/day)	Estimated Cancer Risk[d]
Clothing Scenario: Long pants, long sleeves and gloves									
Low pressure turf gun	Liquid 13.9	2	2098	175	4.1	1.63	60	1.4×10^{-2}	1.5×10^{-5}
		0.4 (spot tx)		35.0		0.33		2.7×10^{-3}	2.9×10^{-6}
Back pack		0.4 (spot tx)	5446	90.8	62.1	4.93	60	7.3×10^{-3}	7.9×10^{-6}
Groundboom		16 (golf course)	83.63	55.8	2.56	8.13	2	1.6×10^{-4}	1.8×10^{-7}
		30 (sod farm)	83.63	104.6	2.56	15.25	2	3.1×10^{-4}	3.3×10^{-7}
Low pressure turf gun	WP 10	2	2626	157.6	395	112.9	60	2.1×10^{-2}	2.2×10^{-5}
		0.4 (spot tx)		31.5		22.6		4.2×10^{-3}	4.5×10^{-6}
Groundboom		16 (golf course)	563.87	270.6	57.16	130.6	2	1.0×10^{-3}	1.1×10^{-7}
		30 (sod farm)	563.87	507.5	57.16	245.0	2	1.9×10^{-3}	2.1×10^{-6}

Application Scenario	Rate (kg a.i./ha)	Area Treated (ha)	Dermal Unit Exposure	Dermal ADD[a] (µg/kg/day)	Inhalation Unit Exposure	Inhalation ADD[b] (µg/kg/day)	Treatment Frequency (days/year)	LADD[c] (mg/kg/day)	Estimated Cancer Risk[d]
Clothing Scenario: Coveralls over long pants, long sleeves and gloves									
Low pressure turf gun	Liquid 13.9	2	577	48.12	4.1	1.63	60	3.8×10^{-3}	4.1×10^{-6}
		0.4 (spot tx)		9.62		0.33		7.6×10^{-4}	8.2×10^{-7}
Backpack		0.4 (spot tx)	2597	43.32	62.1	4.93	60	3.7×10^{-3}	4.0×10^{-6}
Low pressure turf gun	WP 10	2	734	44.04	395	112.9	60	1.2×10^{-2}	1.3×10^{-5}

[a] A dermal absorption factor of 21% was incorporated into dermal exposure estimates. Where dermal exposure µg/kg/day = (unit exposure × area treated × use rate × dermal absorption)/70 kg bw

[b] Where inhalation exposure µg/kg/day = (unit exposure × area treated × use rate)/70 kg bw

[c] LADD=ADD × treatment frequency × working duration/(365 days × 75 years); working duration = 35 years

[d] Risk = LADD × Q^*_1; $Q^*_1 = 1.08 \times 10^{-3}$ $(mg/kg/day)^{-1}$

[tx] = treatment

Table 16 Commercial Mixer/Loader/Applicator Cancer Risk Assessment for Residential Ornamentals

Application Equipment	Data Source[a]	Formulation (g a.i./L)	Amount Handled per day (L/day)	Dermal Unit Exposure (µg/kg handled)	Dermal ADD[b] (µg/kg/day)	Inhalation Unit Exposure (µg/kg handled)	Inhalation ADD[c] (µg/kg/day)	Treatment Frequency (days/year)	LADD[d] (mg/kg/day)	Estimated Cancer Risk[e]
Residential Ornamentals: Commercial M/L/A wearing long sleeves, long pants, gloves										
Low pressure handwand	PHED	WP (1.5)	150	19745	13.33	1423.00	4.57	60	1.4 × 10-3	1.5×10^{-6}
		Liquid (1.68)	150	943.4	0.71	45.20	0.16	60	6.6 × 10-5	7.2×10^{-8}
High pressure handwand	PHED	Liquid (1.68)	3750	5585	105.6	151.00	13.59	60	9.1×10^{-3}	9.9×10^{-6}
Backpack	PHED	Liquid (1.68)	150	5446	4.12	62.10	0.22	60	3.3×10^{-4}	3.6×10^{-7}
Turf gun	ORETF	WP (1.5)	500	2626	5.91	395.0	4.23	60	7.8×10^{-4}	8.4×10^{-7}
		Liquid (1.68)	500	2098	5.28	4.1	0.049	60	4.1×10^{-4}	4.4×10^{-7}
Hand held pump sprayer [f]	ORETF	Liquid (1.68)	150	933.4	0.71	20.26	0.073	60	6.0×10^{-5}	6.4×10^{-8}
Residential Trees and Ornamental Shrubs: Commercial M/L/A wearing long sleeves, long pants, gloves										
Hand held sprayer [f]	ORETF	Liquid (1.68)	150	11870	8.97	11.88	0.043	60	6.9×10^{-4}	7.5×10^{-7}

[a] Arithmetic mean unit exposures are used from ORETF, Best-Fit unit exposures are used from PHED.

[b] A dermal absorption factor of 21% was incorporated into dermal exposure estimates. Where dermal exposure µg/kg/day = (unit exposure × volume used × use rate × dermal absorption)/70 kg bw. The use rate for liquids is 1.68 g a.i./L and for wettable powder is 1.5 g a.i./L.

[c] Where inhalation exposure µg/kg/day = (unit exposure × volume used × use rate)/70 kg bw

[d] LADD=ADD × treatment frequency × working duration/(365 days × 75 years); working duration = 35 years

[e] Risk = LADD × Q^*_1; $Q^*_1 = 1.08 \times 10^{-3}$ $(mg/kg/day)^{-1}$

[f] ORETF data for homeowners applying to ornamentals and vegetable gardens using hand held spray equipment. May not be entirely applicable for commercial applicators applying to residential gardens.

Appendix IX

Table 17 Worker Postapplication Non-Cancer Exposure and Risk on Golf Course and Sod Farm Turf

Scenario	Transfer Coefficient (cm^2/hr)	TTR Data[a]	Dermal Exposure[b] Absorbed (µg/kg/d)	Dermal MOE[c]
		% TTR		
Golf Courses/Sod Farms: aerating, fertilizing, pruning, scouting				
Short-term exposure (day 0)	500	1.65	131.25	271
Short-term exposure (1-day Restricted Entry Interval)	500	1.49	118.52	300
Sod Farms: harvesting, transplanting, mowing				
Short-term exposure (day 0)	6800	1.65	1785	20
Short-term exposure (26-day Restricted Entry Interval)	6800	0.11	119.00	298

[a] Chemical specific data from Turf Transferable Residue study assuming a 10% dissipation rate.
[b] Dermal exposure = % TTR × rate of 139 µg/cm^2 × TC × 8 hr duration/70 kg bw.
[c] Based on a dermal $BMDL_{10}$ of 35.5 mg/kg/day; target MOE for short- and intermediate-term estimates is 300. Shaded cells indicate scenarios where the target MOE was not met.

Table 18 Worker Postapplication Non-Cancer Exposure and Risk on Residential Ornamentals

Scenario	Transfer Coefficient scaled for surface area (cm^2/hr)	DFR Data[a]	Dermal Exposure[b] Absorbed (µg/kg/d)	Dermal MOE[c]
		% DFR		
Ornamentals: hand harvesting, pinching, pruning and thinning cut flowers				
Short-term exposure (Day 0)	7000	20	5856	6.1
Short-term exposure (30-day Restricted Entry Interval)	7000	0.85	248.9	143
Ornamental Trees: hand pruning, scouting, pinching				
Short-term exposure (Day 0)	500	3.58	74.87	474

[a] Default DFR value assuming a 10% dissipation rate.
[b] Dermal exposure = % DFR × rate of 36.6 µg/cm^2 × TC × 8 hour duration/70 kg bw.
[c] Based on a dermal $BMDL_{10}$ of 35.5 mg/kg/day; target MOE for short- to intermediate-term (up to several months) estimates is 300. Shaded cells indicate scenarios where the target MOE was not met.

Table 19 Commercial Turf Worker Postapplication Cancer Risk Assessment

Scenario	ADD[a] (µg/kg/day)	Exposure Frequency (days/year)	LADD[b] (mg/kg/day)		Estimated Cancer Risk[c]
Turf Liquid (13.9 kg a.i./ha)					
Golf Course and Sod farms: aerating, fertilizing, pruning, scouting	8.51	14	35 years exposure	1.5×10^{-4}	1.6×10^{-7}
Sod farm: harvesting, transplanting, mowing	115.7	14	35 years exposure	2.1×10^{-3}	2.2×10^{-6}
Turf Wettable Powder (10 kg a.i./ha)					
Golf Course and Sod farms: aerating, fertilizing, pruning, scouting	6.12	14	35 years exposure	1.1×10^{-4}	1.2×10^{-7}
Sod farm: harvesting, transplanting, mowing	83.2	14	35 years exposure	1.5×10^{-3}	1.6×10^{-6}

[a] A dermal absorption factor of 21% was incorporated into dermal exposure estimates. Dermal exposure = TTR of 0.51 % × rate of 139 µg/cm^{2}for liquids and 100 µg/cm^2 for wettable powders × TC × 8 hr duration × DA/70 kg bw. TC = 500 cm^2/hr for aerating, fertilizing, pruning scouting and 6800cm^2/hr for mowing, harvesting and transplanting treated sod.

[b] LADD=ADD × exposure frequency × working duration/(365 days × 75 years).

[c] Risk = LADD × Q^*_1; $Q^*_1 = 1.08 \times 10^{-3}$ (mg/kg/day)$^{-1}$

Table 20 Commercial Turf Worker Aggregate Cancer Risk Estimates

Exposure Scenario		MLA Cancer Risk	Postapplication Cancer Risk	Aggregate Cancer Risk
Golf course workers	Groundboom application, aerating, fertilizing, pruning, scouting	1.8×10^{-7}	1.6×10^{-7}	3.4×10^{-7}
	Groundboom application, mowing	1.8×10^{-7}	2.2×10^{-6}	2.4×10^{-6}
Sod farm workers	Groundboom application, aerating, fertilizing, pruning, scouting	3.3×10^{-7}	1.6×10^{-7}	4.9×10^{-7}
	Groundboom application, harvesting, transplanting, mowing	3.3×10^{-7}	2.2×10^{-6}	2.5×10^{-6}

Appendix X

Table 21 Homeowner Mixer/Loader/Applicator Short-term Non-Cancer Exposure Estimates, MOEs and ARIs for Turf

Application Equipment	Data Source[a]	Formulation (kg a.i./ha)	Area Treated (ha/day)	Dermal Unit Exposure (µg/kg handled)	Dermal Exposure[b] (µg/kg bw/day)	Inhalation Unit Exposure (µg/kg handled)	Inhalation Exposure[c] (µg/kg bw/day)	Dermal MOE[d]	Inhalation MOE[e]	Combined ARI[f]
Residential Lawns: Homeowner wearing short sleeves, short pants, no gloves										
Low pressure handwand/ handpump [h]	ORETF	Liquid (13.9)	0.2	82741	3286.0	23.66	0.94	11	1203	0.04
			0.01		164.30		0.05	216	24050	0.72
Ready-to-use sprayer	ORETF		0.2	6875	273.04	32.2	1.28	130	884	0.41
			0.01		13.65		0.06	2600	17670	8.3
Dial-type hose-end sprayer	ORETF		0.2	21525	854.85	35.6	1.41	41	799	0.14
			0.01		42.74		0.07	831	15980	2.7
Backpack [g]	PHED		0.2	10149.19	403.07	62.1	2.47	88	458	0.28
			0.01		20.15		0.12	1761	9164	5.5
Residential Lawns: Homeowner wearing short sleeves, long pants, no gloves										
Low pressure handwand/ handpump [h]	ORETF	Liquid (13.9)	0.2	33612	1335	23.66	0.94	26.59	1203	0.09
			0.01		66.74		0.05	532	24050	1.8
Ready-to-use sprayer	ORETF		0.2	1162	46.15	32.2	1.28	769	884	2
			0.01		2.08		0.06	15385	17670	40
Dial-type	ORETF		0.2	15218	604.4	35.6	1.41	58.74	799	0.19

Application Equipment	Data Source[a]	Formulation (kg a.i./ha)	Area Treated (ha/day)	Dermal Unit Exposure (µg/kg handled)	Dermal Exposure[b] (µg/kg bw/day)	Inhalation Unit Exposure (µg/kg handled)	Inhalation Exposure[c] (µg/kg bw/day)	Dermal MOE[d]	Inhalation MOE[e]	Combined ARI[f]
hose-end sprayer			0.01		30.22		0.07	1175	15980	3.8
Backpack [g]	PHED		0.2	6007	238.6	62.1	2.47	149	458	0.45
			0.01		11.93		0.12	2976	9164	9.0

[a] Median unit exposures are used from ORETF Best-Fit unit exposures are used from PHED.
[b] Where dermal exposure µg/kg bw/day = (unit exposure × area treated × use rate)/70 kg bw.
[c] Where inhalation exposure µg/kg/day = (unit exposure × area treated × use rate)/70 kg bw.
[d] Based on a dermal $BMDL_{10}$ of 35.5 mg/kg/day; target MOE is 300.
[e] Based on an oral $BMDL_{10}$ of 1.13 mg/kg/day; target MOE is 100.
[f] Combined ARI = $1/(300/MOE_D + 100/MOE_I)$ Table cells are shaded when the ARI < 1.0. If the ARI exceeds 1.0, the risk is below the level of concern.
[g] The backpack application clothing scenario is long pants, short sleeves and gloves (no non-gloved data), EPA SOPs state that this data is not completely applicable for application to lawns.
[h] Low pressure handwand/handpump unit exposure is based on application to garden vegetables and may not be entirely applicable to turf application.

Table 22 Homeowner Mixer/Loader/Applicator Short-term Non-Cancer Exposure Estimates, MOEs and ARIs for Ornamentals

Application Equipment	Data Source[a]	Formulation[b] (g a.i./L)	Amount Handled Per Day (kg/day)	Dermal Unit Exposure (µg/kg handled)	Dermal Exposure[c] (µg/kg/day)	Inhalation Unit Exposure (µg/kg handled)	Inhalation Exposure[d] (µg/kg/day)	Dermal MOE[e]	Inhalation MOE[f]	Combined ARI[g]
Residential Ornamentals: Homeowner wearing short sleeves, short pants, gloves[h]										
Low pressure handwand	PHED	Liquid (2.40)	0.05	4 435.27	3.04	45.20	0.03	11670	36460	35
Backpack	PHED	Liquid (2.40)	0.05	10 149.19	6.96	62.10	0.04	5101	26540	16

Application Equipment	Data Source[a]	Formulation[b] (g a.i./L)	Amount Handled Per Day (kg/day)	Dermal Unit Exposure (µg/kg handled)	Dermal Exposure[c] (µg/kg/day)	Inhalation Unit Exposure (µg/kg handled)	Inhalation Exposure[d] (µg/kg/day)	Dermal MOE[e]	Inhalation MOE[f]	Combined ARI[g]
Residential Trees and Ornamental Shrubs: Homeowner wearing short sleeves, short pants, no gloves										
Handheld sprayer	ORETF	Liquid (2.40)	0.05	109 089	74.80	6.37	0.003	475	258700	1.6
Hose-end sprayer	ORETF		0.05	105 732	72.50	3.57	0.002	490	461600	1.6
Residential Ornamental and Vegetable Gardens: Homeowner wearing short sleeves, short pants, no gloves										
Handheld sprayer	ORETF	Liquid (2.40)	0.05	8 2741	56.74	23.66	0.02	626	69650	2
Hose-end sprayer	ORETF		0.05	71 068	48.73	5.14	0.002	728	320600	2
Ready-to-use pump sprayer	ORETF		0.05	130 123	89.23	78.40	0.05	398	21020	1.3
Garden pump duster	ORETF	Dust (5%)	0.03	354 446	126.59	2711	0.97	280	1167	0.9

[a] Median unit exposures are used from ORETF, Best-Fit unit exposures are used from PHED.
[b] The amount handled per day = rate × 20 L for liquids and 500 g (one container) × 5% for dust.
[c] Where dermal exposure µg/kg/day = (unit exposure × volume used × use rate)/70 kg bw.
[d] Where inhalation exposure µg/kg/day = (unit exposure × volume used × use rate)/70 kg bw.
[e] Based on a dermal $BMDL_{10}$ of 35.5 mg/kg/day; target MOE is 300.
[f] Based on an oral $BMDL_{10}$ of 1.13 mg/kg/day; target MOE is 100.
[g] Combined ARI = $1/(300/MOE_D + 100/MOE_I)$. Table cells are shaded when the ARI < 1.0. If the ARI exceeds 1.0, the risk is below the level of concern.
[h] PHED scenarios for low pressure handwand and backpack are presented with workers wearing gloves since there is no non-gloved data available. This is expected to underestimate exposure for homeowners applying carbaryl without gloves.

Table 23 Homeowner Non-Cancer Mixer/Loader/Applicator and Postapplication Exposure: Short-Term Exposure Estimates and Margins of Exposure from Application of a Ready-to-Use Spray Formulation to Turf and Ornamentals Based on Biomonitoring Data

Formulation	Area Treated (ha)	Application Rate (kg a.i./ha)	Amount Handled (kg a.i./day)	Unit Exposure[c] (µg a.i./kg a.i. handled)	Daily Exposure (µg a.i./kg bw)	MOE[a]
Mean biomonitoring values (Not Adjusted)						
Ready-to-use pump sprayer	0.053	21.8	0.32	4572.06	19.05	59
Mean biomonitoring exposure values normalized for Canadian application rate and default area treated per day[b]						
Ready-to-use pump sprayer	0.2 (broadcast)	13.9	2.78	4572.06	181.6	6
	0.01 (spot)	13.9	0.139	4572.06	9.08	124

[a] Based on an oral $BMDL_{10}$ of 1.13 mg/kg/day; target MOE is 100. Shaded cells indicate scenarios where the target MOE was not met.

[b] Biomonitoring exposure values were normalized for the Canadian application rate and area treated per day. Area treated per day is based on default values. The application rate is the maximum Canadian registered rate for a domestic liquid product. Daily exposure µg/kg/day = (unit exposure × area treated × use rate)/70 kg bw.

[c] Value includes exposure from mixing/loading and applying, and from any postapplication activities that occurred during the study duration (96 hours). Both turf and ornamentals were treated. Exposure includes dermal, oral and inhalation routes.

Table 24 Cancer Exposure and Risk Estimates for Homeowner Mixer/Loader/Applicator

Application Equipment	Data Source[a]	Formulation	Area Treated ha/day	Dermal Unit Exposure µg/kg handled	Dermal Exposure[b] µg/kg/day	Inhalation Unit Exposure µg/kg handled	Inhalation Exposure[c] µg/kg/day	ADD µg/kg/day	Treatment Frequency Number/year	LADD[d] mg/kg/day	Cancer Risk[e]
Residential Lawns: Homeowner wearing short sleeves, long pants, no gloves											
Low pressure handwand/ handpump [g]	ORETF	Liquid (13.9 kg a.i./ha)	0.045 [f]	61191	114.8	25.5	0.23	115.0	2	4.2×10^{-4}	4.5×10^{-7}
Hose-end sprayer RTU	ORETF	Liquid (13.9 kg a.i./ha)	0.045 [f]	2307	4.32	40.5	0.36	4.68	2	1.8×10^{-5}	2.0×10^{-8}
Hose-end sprayer DTS	ORETF	Liquid (13.9 kg a.i./ha)	0.045 [f]	18946	35.55	53.0	0.47	36.02	2	1.3×10^{-4}	1.4×10^{-7}
Ornamental and Vegetable Gardens: Homeowner wearing short sleeves, long pants, no gloves											
Handheld	ORETF	Liquid (2.4 g a.i./L)	20 L/day	82 690	11.91	3.84	0.0026	11.91	2	4.4×10^{-5}	4.7×10^{-8}
Hose-end sprayer	ORETF	Liquid (2.4 g a.i./L)	20 L/day	122 126	17.59	12.03	0.0082	17.60	2	6.4×10^{-5}	6.9×10^{-8}
Ready-to-use pump sprayer	ORETF	Liquid (2.4 g a.i./L)	20 L/day	171871	24.75	211.04	0.14	24.89	2	9.1×10^{-5}	9.8×10^{-8}
Garden pump duster	ORETF	Dust (5%)	0.03 kg/day	482901	43.46	4349	1.86	45.32	2	1.7×10^{-4}	1.8×10^{-7}

[a] Arithmetic mean unit exposures are used from ORETF.
[b] Where dermal exposure µg/kg/day = (unit exposure × area treated × use rate × dermal absorption of 21%)/70 kg bw.
[c] Where inhalation exposure µg/kg/day = (unit exposure × area treated × use rate)/70 kg bw.
[d] LADD=ADD (in mg/kg bw/day) × treatment frequency × working duration/(365 days × 75 years). Assumes a working duration of 50 years.
[e] Cancer risk = LADD × Q^*_1; $Q^*_1 = 1.08 \times 10^{-3}$ $(mg/kg/day)^{-1}$
[f] Area for a broadcast treatment.
[g] Low pressure handwand/handpump unit exposure is based on application to garden vegetables and may not be entirely applicable to turf application.

RTU = ready-to-use
DTS = dial type sprayer

Appendix XI

Table 25 Adult and Child Postapplication Exposure Estimates for Non-Cancer Risk on Residential Lawns

Application Equipment	Scenario	Dermal Exposure[a] (µg/kg/day)	Oral Exposure (µg/kg/d)			Dermal MOE[e]	Oral MOE[e]	Combined ARI[f]
			Hand-to-Mouth[b]	Turf Mouthing[c]	Ingestion of Soil[d]			
Adult (70 kg)								
Liquid (13.9 kg a.i./ha)	Acute (1-day)	951.53	N/A	N/A	N/A	37	N/A	N/A
WP (10 kg a.i./ha)		683.57	N/A	N/A	N/A	52	N/A	N/A
Liquid (13.9 kg a.i./ha)	Short- to Intermediate-term (up to several months)	148.07	N/A	N/A	N/A	240	N/A	N/A
WP (10 kg a.i./ha)		106.37	N/A	N/A	N/A	334	N/A	N/A
Toddler (15 kg)								
Liquid (13.9 kg a.i./ha)	Acute (1-day)	1592.45	185.60	11.60	0.62	22	6	0.03
WP (10 kg a.i./ha)		1144	133.33	8.33	0.45	31	8	0.05
Liquid (13.9 kg a.i./ha)	Short- to Intermediate-term (up to several months)	246.11	27.23	7.00	0.19	144	33	0.2
WP (10 kg a.i./ha)		176.80	19.63	5.00	0.14	201	46	0.3

[a] Dermal exposure = %TTR × application rate (µg/cm^2) × TC × duration/bw (70 kg for adults, 15 kg for toddlers). TCs are 14 500 and 5200 cm^2/hr for adults and toddlers respectively for acute scenarios and 7300 and 2600 cm^2/hr for adults and toddlers respectively for short to intermediate term scenarios. Exposure duration is 2 hours. TTR value = 1.65 % for acute scenarios and 0.51 % for intermediate-term scenarios.

[b] Exposure = DFR × application rate × surface area (SA) × hand-to-mouth events × Saliva extraction factor (SEF) × duration/15 kg bw. Based on 20 hand-to-mouth events/hr for acute scenarios and 9.5 events/hr for intermediate term scenarios, a surface area (SA) of 20 cm^2. Saliva extraction factor (SEF) of 50%, DFR = 5% for acute assessment and 1.55% for intermediate assessment.

[c] Exposure = DFR × application rate × turf ingestion/15 kg bw. DFR = 5% for acute assessment and 3% for intermediate assessment. Ingestion = 25 cm^2 turf/day.

[d] Exposure = application rate × fraction of pesticide in soil × ingestion rate × soil density/15 kg bw. Based on 100% application rate available/cm soil for acute assessment, 31% application rate available/cm soil for intermediate-term assessment; an ingestion of 0.1 g soil/day; and 0.67 cm^3/g soil weight to volume conversion factor.

[e] Based on a dermal $BMDL_{10}$ of 35.5 mg/kg/day (target MOE is 300) for dermal exposures and an oral $BMDL_{10}$ of 1.13 mg/kg for inhalation exposures for toddlers (target MOE is 100) for acute dermal and short- to intermediate-term scenarios.

[f] Combined ARI = $1/(300/MOE_D + 100/MOE_O)$. Table cells are shaded when the ARI < 1.0. If the ARI exceeds 1.0, the risk is below the level of concern.

N/A = not applicable

Table 26 Postapplication Exposure and Non-Cancer Risk Assessment for Golfers

Scenario		Dermal Exposure[a] (µg/kg/day)	Dermal MOE[b]
Adults (70 kg)			
Acute	Liquid (13.9 kg a.i./ha)	65.62	541
Short- to intermediate-term	Liquid (13.9 kg a.i./ha)	20.28	1750
Youths (39 kg)			
Acute	Liquid (13.9 kg a.i./ha)	81.12	438
Short- to intermediate-term	Liquid (13.9 kg a.i./ha)	25.07	1416

[a] Dermal exposure = %TTR × rate of 139 µg/cm^2 × TC × duration/bw (70 kg for adults, 39 kg for adolescents). The TTR value is 1.65 % for the acute scenarios and 0.51 % for the intermediate-term scenarios, based on the TTR study and assuming a 10% dissipation rate. TC is 500 cm^2/hr based on generic transfer coefficients for turf. Transfer coefficients are scaled for the surface area of a 39 kg body weight (68.9% correction factor). Duration is four hours.

[b] Based on a dermal $BMDL_{10}$ of 35.5 mg/kg/day (target MOE is 300). Based on dermal deposition as risk estimates are calculated with a dermal

Table 27 Adult and Youth Postapplication Exposure Estimates for Non-Cancer Risk for Residential Ornamentals and Gardens

Formulation/Rate	Exposure Duration	Transfer Coefficient	Dermal Exposure[a] Absorbed (µg/kg/day)	Dermal MOE[b]
Adults (70 kg)				
Liquid (2.4 g a.i./L)	Ornamental Flowers and Vegetables: acute exposure	7000	714.22	50
WP (1.5 g a.i./L)		7000	446.22	80
Liquid (2.4 g a.i./L)	Ornamental Flowers and Vegetables: short- to intermediate-term exposure	7000	221.77	160
WP (1.5 g a.i./L)		7000	138.55	256
Liquid (2.4 g a.i./L)	Ornamental Trees: acute exposure	500	51.02	696
WP (1.5 g a.i./L)		500	31.87	1114
Liquid (2.4 g a.i./L)	Ornamental Trees: short- to intermediate-term exposure	500	15.84	2241
WP (1.5 g a.i./L)		500	9.90	3587
Youths (39 kg)				
Liquid (2.4 g a.i./L)	Ornamental Flowers and Vegetables: acute exposure	4821	882.89	40
WP (1.5 g a.i./L)		4821	551.60	64
Liquid (2.4 g a.i./L)	Ornamental Flowers and Vegetables: short- to intermediate-term exposure	4821	274.14	130
WP (1.5 g a.i./L)		4821	171.27	207
Liquid (2.4 g a.i./L)	Ornamental Trees: acute exposure	344	63.06	563
WP (1.5 g a.i./L)		344	39.40	901
Liquid (2.4 g a.i./L)	Ornamental Trees: short- to intermediate-term exposure	344	19.58	1813
WP (1.5 g a.i./L)		344	12.23	2902

[a] Dermal exposure = %DFR × rate of 53.3 (liquid) or 33.3 (WP) µg/cm^2 × TC × duration/bw (70 kg for adults, 39 kg for children). A default DFR value of 20% was used for acute/short-term scenarios and a value of 6.21% was used for intermediate-term scenarios based on a 10% dissipation rate. Exposure duration is 0.67 hours. Transfer coefficients are scaled for the surface area of a 39 kg body weight (68.9% correction factor).

[b] Based on a dermal $BMDL_{10}$ of 35.5 mg/kg/day for adults (target MOE is 300). Based on dermal deposition as risk estimates are calculated with a dermal $BMDL_{10}$. Shaded cells indicate scenarios where the target MOE was not met.

Table 28 Adult and Children Postapplication Exposure and Corresponding Non-Cancer Risk Estimates Based on Biomonitoring Study after Treatment of Residential Lawns and Ornamentals

Population		Application Rate[a] (kg a.i./ha)	Amount of Time Spent Outside[b] (Minutes)	Exposure[c] (µg a.i./kg bw)	MOE[d]
Non-Applicator Adults		20.9	84	8.07	140
Children[e] (Ages)	All (4–17 years)	22.4	201	49.24	24
	4–5 years	16.0	256	44.58	25
	6–10 years	15.3	213	78.26	14
	11–15 years	35.0	143	31.52	36

[a] Mean application rate for each population.

[b] The mean amount of time each population spent outdoors during the 96 hours after application.

[c] Postapplication exposure was estimated after a single application of carbaryl from total 96-hour urine voids, which is the time required for the complete elimination of carbaryl, and adjusted for individual body weights. Both turf and/or ornamentals were treated. Values represent the arithmetic mean for each population. Exposure includes dermal, oral, and inhalation routes.

[d] Postapplication exposure is expected to be short- to intermediate-term in duration, MOEs were based on an oral $BMDL_{10}$ of 1.13 mg/kg/day for adults and children (target MOE is 100). Shaded cells indicate scenarios where the target MOE was not met.

[e] Children were stratified into groups based on age. Children aged 16 to 17 years were not separated out due to the low number of replicates (n=3).

Appendix XII

Table 29 Single Day Exposure Estimates for Residential Postapplication Cancer Risk Assessment

Scenario	Formulation	TTR/DFR (µg/cm^2)	Transfer Coefficient (cm^2/hr)	Dermal Exposure[a] (µg/kg bw/day)	Oral Exposure (µg/kg bw/day)			Total Oral Exposure[e] (µg/kg bw/day)	Total systemic Exposure[f] (µg/kg bw/day)
					Hand to Mouth[b]	Turf to Mouth[c]	Ingestion of Soil[d]		
Turf									
Adult (70 kg)	Liquid (13.9 kg a.i./ha or 139 µg/cm^2)	0.71	7300	31.10	N/A	N/A	N/A	N/A	31.10
Youth (39 kg)		0.71	5028	38.44	N/A	N/A	N/A	N/A	38.44
Toddler (15 kg)		0.71	2600	51.69	27.23	6.96	0.19	34.38	86.07
Golfer (70 kg)		0.71	500	4.26	N/A	N/A	N/A	N/A	4.26
Golfer (39 kg)		0.71	344	5.26	N/A	N/A	N/A	N/A	5.26
Ornamental Plants									
Adult (70 kg)	Liquid (53.3 µg/cm^2)	3.34	7000	46.99	N/A	N/A	N/A	N/A	46.99
Youth (39 kg)		3.34	4821	58.09	N/A	N/A	N/A	N/A	58.09
Ornamental Trees									
Adult (70 kg)	Liquid (53.3 µg/cm^2)	3.34	500	3.36	N/A	N/A	N/A	N/A	3.36
Youth (39 kg)		3.34	344	4.16	N/A	N/A	N/A	N/A	4.16

[a] Based on a dermal absorption factor of 21% . Dermal exposure = %TTR × rate of 139 µg/cm^2 × TC × duration × 21% dermal absorption/bw (70 kg for adults, 39 kg for youth, 15 kg for toddlers). Exposure duration is 2 hours for turf, 4 hours for golfers and 0.67 hours for ornamentals. TTR value = 0.51% for short-term turf scenarios and 6.21% for ornamental scenarios.

[b] Based on 9.5 hand to mouth events/hr, a surface area of 20 cm^2, saliva extraction factor (SEF) of 50%. Exposure = DFR × surface area (SA) × hand-to-mouth events × SEF × duration/15 kg bw.

[c] Based on an ingestion of 25 cm^2 turf/day and a saliva extraction factor (SEF) of 50%. Exposure = DFR (3% of application rate) × 25 × SEF/15 kg bw.

[d] Based on an ingestion of 0.1 g soil/day, depth of 1 cm, 100% available/cm soil, 0.67 cm^3/g soil weight to volume conversion factor. Exposure = application rate × 0.1 × 0.67 × 1/15 kg bw.

[e] Total oral exposure = hand to mouth + turf to mouth + ingestion of turf exposure.

[f] Total systemic exposure = dermal exposure + total oral exposure.

Table 30 Cancer Exposure and Risk Estimates for Residential Postapplication Exposure

Scenario	Formulation	Annual Exposure Frequency (days)	Duration of Exposure (years)	Dermal Exposure[a] (ug/kg bw/day)	Total Oral Exposure[b] (ug/kg bw/day)	LADD[c] (mg/kg/day)	Lifetime Cancer Risk[d]
Turf							
Adult–dermal	Liquid (139 µg/cm^2)	14	50	31.10	N/A	1.2×10^{-3}	1.2×10^{-6}
Youth–dermal		14	6	38.44	N/A		
Toddler–dermal + oral		14	6	51.69	34.38		
Golfer (70 kg)–dermal		14	50	4.26	N/A	1.3×10^{-4}	1.4×10^{-7}
Golfer (39 kg)–dermal		14	6	5.26	N/A		
Ornamental Plants							
Adult–dermal	Liquid (53.3 µg/cm^2)	3	50	46.99	N/A	3.0×10^{-4}	3.2×10^{-7}
Youth–dermal		3	6	58.09	N/A		
Ornamental Trees							
Adult–dermal	Liquid (53.3 µg/cm^2)	3	50	3.36	N/A	2.1×10^{-5}	2.2×10^{-8}
Youth–dermal		3	6	4.16	N/A		

[a] From previous table (Appendix XII - Table 29).

[b] Total oral exposure = hand to mouth + turf to mouth + ingestion of soil exposure. From previous table (Appendix XII–Table 29).

[c] LADD = ADD (average daily dose) (in mg/kg bw/day) × treatment frequency × working duration/(365 days × 75 years). Assumes 6 years of dermal exposure as a toddler, 6 years of exposure as a youth, 50 years applicator/postapplication exposure as an adult over a 75 year lifespan. A dermal absorption value of 21% was considered appropriate for use in the cancer risk assessment. LADDs for toddlers (where applicable), youths and adults are combined for each scenario.

[d] Cancer risk = LADD × Q^*_1; $Q^*_1 = 1.08 \times 10^{-3}$ (mg/kg/day)$^{-1}$

Appendix XIII

Table 31 Chronic and Cancer Aggregate Dietary (Food and Water) Exposure and Risk Estimates for Carbaryl

Chronic			Cancer	
ADI = 0.011 (mg/kg bw/day)			Q_1* is 1.08×10^{-3} $(mg/kg\ bw/day)^{-1}$	
Population	**Exposure (mg/kg bw/day)**	**%ADI**	**Exposure (mg/kg bw/day)**	**Lifetime**
Canadian population	0.000066	1	0.000066	7.14 E-08
All infants (<1 year)	0.000117	1		
Children 1–2 yrs	0.000187	2		
Children 3–5 yrs	0.000149	2		
Children 6–12 yrs	0.000093	1		
Youth 13–19 yrs	0.000057	1		
Adults 20–49 yrs	0.000052	1		
Adults 50 + yrs	0.000050	1		
Females 13–49 yrs	0.000053	1		

Table 32 Acute Aggregate Dietary (Food and Water) Exposure and Risk Estimates For Carbaryl

Acute Aggregate Exposure and Risk						
ARfD = 0.011 mg/kg bw						
Population	Water Monitoring		Highest Water Monitoring Data		Water Modeling	
	Exposure (mg/kg bw/day)	%ARfD	Exposure (mg/kg bw/day)	%ARfD	Exposure (mg/kg bw/day)	%ARfD
Canadian population	0.004059	37	0.009494	86	0.012859	117
All infants (<1 year)	0.008047	73	0.02282	208	0.043202	393
Children 1–2 yrs	0.006552	60	0.010087	92	0.020336	185
Children 3–5 yrs	0.005419	49	0.011745	107	0.018037	164
Children 6–12 yrs	0.005419	49	0.006365	58	0.012608	115
Youth 13–19 yrs	0.003421	31	0.006306	57	0.009737	89
Adults 20–49 yrs	0.003451	31	0.007086	64	0.012241	111
Adults 50 + yrs	0.003525	32	0.005771	52	0.011323	103
Females 13–49 yrs	0.003603	33	0.007399	67	0.012974	118

Appendix XIV–Residue Chemistry Summary for Carbaryl

It should be noted that the residue chemistry summary is based on data submitted up to 2003. Any data submitted after 2003 were not included in this review.

1.1 Metabolism

The nature and magnitude of the residue in plants and livestock are adequately understood. The PMRA concurs with the conclusions made by the United States Environmental Protection Agency.

1.1.1 Plant Metabolism

Based on the USEPA assessment, the plant metabolism requirements are fulfilled. Studies conducted on lettuce, radish and soybean were reviewed by the USEPA in order to determine the degradation pathway of carbaryl as well as the nature and magnitude of residues using radio labelled. The PMRA has concluded that the qualitative nature of the residues of carbaryl is adequately understood.

In these studies (all conducted at onefold rates), surface residues on radish tops, lettuce, and soybean forage accounted for 38-67% of the total radioactive residues (TRR), and virtually all of these residues were unconjugated carbaryl. Unconjugated carbaryl ranged from 36-95% of the TRR in all commodities of radish, lettuce and soybean, with the exception of soybean seed, in which the parent accounted for only 4% of the TRR. Other unconjugated residues, including N-(hydroxymethyl) carbaryl (N-OH-Me carbaryl), 1-naphthol and 5,6-dihydro-dihydroxy-1-naphthol, were present in minor amounts ($\leq$3.4% of the TRR).

Conjugated carbaryl accounted for $\leq$2.8% of the TRR in the tested commodities. Other conjugates detected in plants included a malonylglycoside conjugate of 1-naphthol comprising 26% of the TRR in soybeans; a hexose conjugate of N-OH-Me carbaryl accounting for 17% and 12.2% of the TRR in soybeans and soybean hay; and several minor conjugates of desmethyl carbaryl, 5-hydroxycarbaryl, and 4-hydroxycarbaryl, each at $\leq$2.7% of the TRR.

Based on the available metabolism data the USEPA determined that the carbaryl metabolite, N-hydroxymethyl carbaryl does not need to be regulated because it is expected to have considerably less potential as a cholinesterase inhibitor, based on in vitro studies. As noted above, conjugated carbaryl does not contribute significantly to the TRR and is not of concern.

Plant metabolism data should be submitted to the PMRA for review.

1.1.2 Livestock Metabolism

The USEPA has reviewed livestock metabolism studies conducted on ruminant and poultry in order to determine the degradation pathway of carbaryl as well as the nature and magnitude of residues.

Based on the USEPA assessment, the livestock metabolism requirements needed to assess oral metabolism are fulfilled. Acceptable metabolism studies depicting the qualitative nature of the residues in ruminants and poultry have been evaluated by the USEPA. The metabolic pathways for carbaryl in plants and livestock are similar, but are more extensive in livestock. These studies or the relevant DERs should be submitted to the PMRA. The data requirements for the dermal use of carbaryl on swine, poultry and ruminants are not fulfilled; however, it is noted that the registrant does not support this use.

In a ruminant metabolism study reviewed by the USEPA, lactating cows were orally dosed with 1-naphthyl-[^{14}C] carbaryl at dietary levels of 10-100 ppm for 14 days. The high-dose group represents approximately a 0.8-fold feeding level based on current United States tolerance levels. A dairy cattle feeding study at 114-1140 ppm (0.5-4.7-fold the theoretical maximum dietary burden) was reviewed by the USEPA. When acid hydrolysis was not used, residues below or near the limit of detection (LOD) of 0.02 ppm were determined. Re-analysis of tissue samples with acid hydrolysis revealed significantly higher residues of compounds included in the proposed residue definition. The combined concentration of residues from a 28-day ruminant (dairy cow) feeding study, normalized to onefold the maximum theoretical dietary burden, increased from <0.02 ppm without acid hydrolysis, to 0.6, 0.1, 1.3, 3.4 and 0.6 ppm in milk, fat, liver, kidney and muscle tissues, respectively, after acid hydrolysis. In milk and muscle, 5,6-dihydro-5,6-dihydroxy carbaryl and 5-methoxy-6-hydroxy carbaryl accounted for >90% of the total residue definition, and 40-80% in organ tissue.

Animal metabolism data should be submitted to the PMRA for review.

1.1.3 Residue Definition

The residue for carbaryl (1-naphthyl N-methyl carbamate) was previously defined in Canada as the parent compound for all commodities. However, the PMRA recommends that the carbaryl residue in plants be defined as the parent compound only, and that the residue in meat and milk be defined as the free and conjugated forms of carbaryl, 5,6-dihydro-5,6-dihydroxy carbaryl and 5-methoxy-6-hydroxy carbaryl. The rationale is that these free and conjugated forms of carbaryl retain the intact carbamate moiety and are likely to contribute to the toxicological effects of concern.

1.2 Analytical Methods

The available methods for MRL enforcement (PAM, Volume II, Method I through IV, A and B) measure the total combined residues of the parent compound, carbaryl and 1-napthol, calculated as carbaryl. The requirement for acceptable enforcement methods that determines the residues of carbaryl in plants and livestock remains outstanding.

1.2.1 Methods for the Residue Analysis of Plants and Plant Products

The PMRA has reviewed analytical methodology capable of determining the residues of carbaryl in plants. The registrant has proposed an HPLC enforcement method identified as Method CACR-0194, which quantifies carbaryl in plant matrices. Residue data on most crop plants and processed commodities have been collected using the above HPLC method with only minor modifications involving changes in solvents and cleanup procedures. This method has undergone successful independent laboratory validation (ILV) using samples of representative plant commodities (oily and non-oily matrices) and has also been successfully radio validated using samples from plant metabolism studies.

The method and validation data should be submitted to the PMRA for review.

1.2.2 Methods for the Residue Analysis of Food of Animal Origin

The registrant should also propose an enforcement method for determining the residues of free and conjugated forms of carbaryl, 5,6-dihydro-5,6-dihydroxy carbaryl and 5-methoxy-6-hydroxy carbaryl in livestock commodities. An adequate HPLC data collection method (Aventis File Number 45186) used to determine the residues of carbaryl (free and conjugated) and its metabolites in livestock commodities is available and has undergone a successful ILV.

The method and validation information should be submitted to the PMRA for review.

1.2.3 Multi-Residue Analytical Methods

The Food and Drug Administration PEST DATA database indicates that residues of the parent compound, carbaryl, are completely recovered using FDA Multiresidue Protocols A and D (Pesticide Analytical Methods; PAM I sections 242.2 and 232.4). No data are available concerning the recovery of carbaryl by Protocol E (PAM I section 211.1 and 211.2). These PAM I methods are not expected to recover conjugated carbaryl residues. The CFIA carbamate multiresidue method quantifies carbaryl residues in fruits and vegetables; however, no method is available for animal commodities that quantifies all residues in the residue definition.

Therefore, the registrant needs to develop, validate and submit suitable methods of analysis to the PMRA for review.

1.3 Food Residues

1.3.1 Storage Stability

Storage Stability Data-Plants
The USEPA concluded that the requirements for storage stability data are not satisfied for the purposes of reregistration. Additional data are required that depicts the storage stability of carbaryl in an oilseed, the processed commodities of an oily crop, and a dried fruit stored for up to 10 months.

In addition, the registrant is relying on earlier magnitude of the residue studies that are not supported by the existing storage stability data; therefore, additional storage stability data are required. The required data should reflect storage intervals of 18 months for alfalfa commodities, 15 months for potatoes, 17 months for cottonseed, 22 months for wheat commodities and 33 months for rangeland grass. In addition, if the registrant wishes to rely on the previously submitted sugar beet processing study, information pertaining to sample conditions and intervals for the study should be submitted.

Adequate storage stability data indicated that residues of carbaryl are relatively stable under frozen storage conditions (-20°C) for up to 12 months in/on pearled barley and barley flour, head lettuce, potatoes, tomatoes and tomato processed commodities, wheat forage, hay and straw. Residue decline was observed in tomato dry pomace after three months of storage (~30-40%), and in barley grain and peanut hulls after three months of storage (~50% and 40%, respectively); these commodities are no longer considered to be significant livestock feed items. In a separate study, carbaryl residues were shown to be stable in/on wheat grain stored at -20°C for up to seven months.

Adequate storage stability data indicated that weathered residues of carbaryl are stable at -20°C for at least 15 months in/on apple fruit, juice and wet and dry pomace; 13 months in/on grapes; 12 months in/on processed raisins; 11 months in/on almond nut meat and hulls, and on dry bean hay and 10 months in/on dry bean vines.

Plant storage stability data should be submitted to the PMRA for review.

Storage Stability Data-Livestock
The USEPA concluded that the requirements for storage stability data for carbaryl residues in livestock commodities are partially satisfied. Additional information on the storage intervals prior to analysis for metabolite residues in the cattle feeding study is required. Samples from the feeding study were analyzed for carbaryl within the interval of the known stability of free carbaryl residues.

The PMRA concurs with the USEPA's conclusions regarding livestock storage and stability. The storage stability studies conducted to date indicate that residues of unconjugated carbaryl and metabolites are less stable than conjugated residues. A storage stability study submitted in conjunction with the ruminant feeding study indicated that residues of carbaryl are relatively stable in frozen storage for up to three months in milk, fat and muscle and up to one month in kidney. Residues of carbaryl in liver declined

~69% after two weeks of storage and continued to decline over the three month storage interval (94% decline). Tissue and milk samples from the ruminant feeding study were stored frozen for ≤21 days (9 days for liver) prior to carbaryl analysis. The data indicate that conjugated carbaryl-related residues are relatively stable in frozen storage for up to 158 days in muscle, 173 days in liver, 196 days in kidney, 215 days in fat and 248 days in milk. A method equivalency study using samples from the feeding study adequately demonstrated that unconjugated residues are not a significant portion of carbaryl residues in liver.

Animal storage stability data should be submitted to the PMRA for review.

1.3.2 Crop Residues

For the purpose of reregistration, the USEPA has concluded that an adequate magnitude of residue data are available on the following crops that have registered uses in Canada: alfalfa, asparagus, beans (dried and succulent), blueberries, broccoli, cabbage, celery, cherries, clover, corn (sweet and field), cucurbits (cantaloupe, cucumber and squash), cranberries, grapes, head and leaf lettuce, mustard greens, peas (dried and succulent), peppers, pome fruits, potatoes, raspberries, spinach, stone fruits, strawberries and sweet potato. These data or the equivalent USEPA DER should be submitted to the PMRA.

The USEPA reported that an adequate magnitude of residue data is available for the following commodities that have Canadian import MRLs: almonds, citrus fruits, pecans, pistachios and walnuts.

The USEPA reported that an adequate magnitude of residue data is available for the following commodities that have no registered Canadian uses or MRLs: flax, okra, soybeans, tobacco, peanuts, prickly pear cactus, sunflowers, sorghum and rice. The registrant should petition the PMRA for import MRLs if these uses on imported commodities are supported.

An acceptable magnitude of residue data is required for the following registered commodities: canola, eggplant, oats, pumpkin, turnip, rye and wheat.

The USEPA reported that data is available on brassica and leafy vegetables that may be adequate to support uses on other vegetable commodities. If the data is submitted and deemed of concern, broccoli residue data may be translated to support uses on Brussels sprouts, cauliflower and kohlrabi; residue data on spinach may be translated to support uses on dandelions and parsley; and reside data on lettuce may be translated to endive. The USEPA further reported that the adequacy of residue data for alfalfa, apples, potatoes, processed wheat commodities and grasses are contingent upon acceptable storage stability data.

These data or the equivalent USEPA DER should be submitted to the PMRA.

1.3.3 Livestock Residues

Dermal uses
As dermal uses on livestock are not supported by the registrant, residue data for this use are not required.

Residues from treated feed
Adequate magnitude of residue data is available to support the use of treated feed for ruminants, swine and poultry, based on USEPA dietary burden estimates. As contemporary Magnitude of Residue (MOR) data for treated Canadian feed stuffs is not available, and MRLs are generally not established for animal feeds, the American values were used as a best estimate of dietary burden.

Based on the USEPA review, an adequate ruminant feeding study is available reflecting the dosing of dairy cattle for 28 days at levels equivalent to 114, 342, and 1140/570 ppm in the diet (the high-dose level was reduced to 570 ppm on Day 5 due to toxic effects observed in study animals). These dosing levels represent 0.4-fold, 1.3-fold, and 4.2/2.2-fold the theoretical dietary burden for cattle, and 6.5-fold, 19.5-fold, and 65.1/32.6-fold the theoretical dietary burden for swine. Calculation of the maximum dietary burden is tentative because data remain outstanding for pasture grass forage. It is believed that the American dietary burden estimates of 257 ppm for cattle (beef and dairy) and 17.5 ppm (swine) will not underestimate exposure in Canadian livestock and are therefore conservative estimates. The dietary burden estimates based on Canadian MRLs are 21.7, 15.3 and 3.8 ppm for beef cattle, dairy cattle and swine, respectively. This estimate was based on turnip tops, apples and peas, which are potential feed commodities with MRLs.

Based upon the results of this feeding study, the United States tolerances for residues of carbaryl in livestock (excluding swine) due to the secondary residues from treated feed commodities were established as follows: 1.0 ppm for milk, 0.5 ppm for fat, 1.0 ppm for meat and 3.0 ppm for meat by-products. The USEPA concluded that the results of the feeding study support MRLs of carbaryl in swine commodities due to the secondary residues from treated feed as follows: 0.05 ppm for fat, 0.1 ppm for meat and 0.5 ppm for meat by-products. As these values are based on American dietary burden calculations, additional residue data is required to determine the equivalent Canadian estimates. Insufficient data is available to propose MRLs to cover the dermal uses of carbaryl on livestock.

The animal feeding studies or the USEPA Data Evaluation Records (DERs) should be submitted by the registrant to the PMRA.

1.3.4 Confined Accumulation in Rotational Crops

An adequate confined rotational crop study should be submitted to the PMRA to determine what plant back restrictions should be placed on rotational field crops. American label statements prohibit the planting of rotational and feed crops in soil that has been treated with carbaryl, unless those crops are listed on a valid carbaryl label.

1.3.5 Processed food

The USEPA concluded that, pending adequate resolution of the outstanding storage stability issues noted above, the requirements for the magnitude of the residue data in processed food/feed commodities are fulfilled for citrus fruits, corn, cottonseed, flaxseed, grapes, olives, peanuts, plums, pome fruits, rice, sorghum, soybeans, sugar beets, sunflower, potatoes, tomatoes and wheat.

In a tomato processing study, carbaryl residues concentrated by twofold in puree. However, the USEPA concluded that when this concentration factor is applied to the highest average field trial (HAFT) residues of 2.45 ppm for tomatoes, the resulting value is lower than the reassessed USEPA tolerance (5.0 ppm) for residues in/on fruiting vegetables. Therefore, the USEPA did not require a separate tolerance for residues in puree.

In an apple processing study, carbaryl residues concentrated in wet apple pomace by 1.3-fold. Based on this concentration factor and the current HAFT residues of 10.6 ppm in/on apples, the USEPA concluded that the estimated residue for carbaryl residues in wet apple pomace is 15.0 ppm. Residues did not concentrate in apple juice.

Data from the citrus fruit processing study indicate that residues of carbaryl concentrate in citrus oil by 2.4-fold. Based on this concentration factor and the current HAFT residues of 8.09 ppm in/on citrus fruit, the USEPA recommended a tolerance of 20 ppm for carbaryl residues in citrus oil. Residues did not concentrate in dried pulp or juice.

Data from adequate grape processing studies indicate that residues of carbaryl do not concentrate in grape juice; however, carbaryl residues concentrate by 1.4-fold in raisins. Based on the current HAFT residues of 7.94 ppm in/on grapes, the USEPAconcluded that carbaryl residues in raisins could be expected to reach 11.1 ppm. The USEPA recommended a tolerance of 12 ppm for carbaryl residues in raisins. Residues did not concentrate in dried pulp or juice.

Data from a wheat processing study indicate that carbaryl residues in/on wheat aspirated grain fractions are 11.8-fold higher than in/on wheat grain. Based on HAFT residues of 0.27 ppm, the USEPA concluded that residues of carbaryl may be expected to reach 3.2 ppm in wheat aspirated grain fractions. The USEPA also concluded that adequate soybean aspirated grain fraction data are available that indicate that residues of carbaryl in/on soybean aspirated grain fractions are 5.6-fold higher than in soybean seed. Based on HAFT residues of 0.15 ppm, residues of carbaryl may be expected to reach 0.8 ppm in soybean aspirated grain fractions. For grain sorghum, the concentration factor between the aspirated grain fractions and the whole grain samples was 7.4-fold. Based on HAFT residues of 9.55 ppm, residues of carbaryl could be expected to reach 70.2 ppm in sorghum aspirated grain fractions. As carbaryl residues were non-detectable (<0.02 ppm) in/on all samples of field corn grain from field trials conducted at the maximum labelled use rate (9.0 kg/ha), the USEPA concluded that no carbaryl residue data on aspirated grain fractions derived from field corn grain are required. Based on these data, the estimated residue of carbaryl in/on aspirated grain fractions is 70 ppm.

Processing data should be submitted to the PMRA for review.

Appendix XV Supplemental Maximum Residue Limit (MRL) Information-International Situation and Trade Implications

MRLs may vary from one country to another for a number of reasons, including differences in pesticide use patterns and the locations of the field crop trials used to generate residue chemistry data. For animal commodities, differences in MRLs can be due to different livestock feed items and practices.

Carbaryl MRLs established under the Food and Drug Regulations were not reassessed during this re-evaluation process. However, the MRL for poultry should be withdrawn.

Table 33 Comparison Between MRLs in Canada and in Other Jurisdictions for Carbaryl

Crop	Canadian MRL*	United States Tolerance		CODEX MRL	EU MRL	USEPA Tolerance Reassignment
		Proposed	Current			
Almonds		Reassign	1			Nut, tree crop group (0.1 ppm)
Apples	5		10	5	3	
Apricots	10	Reassign	10	10	3	Fruits, stone crop group (10 ppm)
Asparagus	10	15	10	10	1	
Aubergine					1	
Bananas	5	5	10	5	1	
Beef, meat and fat			0.1			
Beef, organs			1			
Beans	5	Reassign	10	5	1	Edible podded legumes vegetable (1 ppm)
Beet roots	5	Reassign	5	2	1	Vegetable root and tuber crop group. (2 ppm)
Beet tops	10	Reassign	12		1	Leaves of vegetable root and tuber crop group (75 ppm)
Blackberries	10	Reassign	12	10	1	Caneberry (12 ppm)
Blueberries	7	Reassign	10	7		Bushberry (3 ppm)
Boysenberries	10	Reassign	12	10		Caneberry (12 ppm)
Broccoli	5		10			
Brussels sprouts	5		10		3	
Cabbage	5	21	10	5	3	
Carrots	5	Reassign	10	2	1	Vegetable root and tuber (2 ppm)

Crop	Canadian MRL*	United States Tolerance		CODEX MRL	EU MRL	USEPA Tolerance Reassignment
		Proposed	Current			
Cattle, goats, horses and sheep: fat		0.5	0.1			
Cattle, goats, horses and sheep: meat		1	0.1			
Cattle, goats, horses and sheep: organs		Reassign	1			Meat by-products (3 ppm)
Cattle, goats, horses and sheep: meat		Reassign	0.1			Meat by-products (3 ppm)
Cauliflower	5		10		3	
Celery	5	Reassign	10		1	Leaf petioles (3 ppm)
Casabas	3		10			
Cherries	10	Reassign	10	10	1	Fruit stone grp (10 ppm)
Chestnuts		Reassign	1			Nut, tree grp (0.1 ppm)
Chinese cabbage	10		10		3	Vegetable brassica leafy grp (10 ppm)
Corn sweet	1	0.1	5			
Corn grain	1	0.02	5			
Corn forage		185	100			
Crabapple			10			
Crenshaws	3					
Cress					1	
Citrus fruit, oil		20	None			
Citrus fruits	10		10	7	1	
Collards	10	Reassign	12			Vegetable brassica, leafy group (10 ppm)
Cowpea			5			
Cranberries	10	3	10			
Cucumbers	3	Reassign	10	3		Vegetable curcubit group (3 ppm)
Dandelions	10	22	12			
Dates					1	
Dewberries	10	Reassign	12			Caneberry group (12 ppm)
Dill (fresh)			0.2			
Eggs			0.5	0.5		
Eggplants	5	Reassign	10	5		Vegetable, fruiting group (5 ppm)

Crop	Canadian MRL*	United States Tolerance		CODEX MRL	EU MRL	USEPA Tolerance Reassignment
		Proposed	Current			
Endive	10		10			
Filberts (hazelnuts)		Reassign	1			Nut, tree group (0.1 ppm)
Figs					1	
Flax seed		0.5	5			
Goat, meat and fat			0.1			
Goat, organs			1			
Grapes	5		10	5	3	
Grapes, raisins		12	None			
Grapes (wine)					3	
Grasses			100			
Grasses, hay		15	100			
Herbs					1	
Hog, fat		0.05	0.1			
Hog, meat		1	0.1			
Hog, organs		Reassign	1			Hog meat by-products (0.5 ppm)
Hog, meat by-products		Reassign	0.1			Hog meat by-products (0.5 ppm)
Horse, meat and fat			0.1			
Horse, organs			1			
Horseradish	5	Reassign	5		1	Vegetable root and tuber group (2 ppm)
Kale	10	Reassign	12		3	Vegetable brassica, leafy group (10 ppm)
Kiwi fruit				10	1	
Kohlrabi	5		10			
Kumquats					1	
Leafy vegetables				10		
Leeks					1	
Lentils		Reassign	10			Pea and bean, dried shelled, except soybean group (1 ppm)
Lettuce	10		10		3	
Liver and kidney of cattle, goats, horses			1			
Loquats			10			

Crop	Canadian MRL*	United States Tolerance		CODEX MRL	EU MRL	USEPA Tolerance Reassignment
		Proposed	Current			
Loganberries	10	Reassign	12	10	1	Caneberry crop group (12 ppm)
Mangoes					1	
Meat, fat, and meat by-products of cattle, goats, horses, sheep and swine	0.1		0.1	0.2		
Melons	3	Reassign	10	3	1	Vegetable curcubit group (3 ppm)
Millet					0.5	
Milk		1	0.3	0.1		
Mushrooms					1	
Mustard greens	10	Reassign	12			Vegetable brassica, leafy group (10 ppm)
Nectarines		Reassign	10	10		Fruit stone group (10 ppm)
Nuts (shelled)	1		1	1	1	
Nuts (whole in shells)	10			10		
Oats, grain	2	Revoke	None			
Okra	10	4	10	10		
Olives (raw)	10		10	10		
Olives, processed				1	1	
Oysters			0.25			
Parsley	10	22	12		1	
Parsnips	5	Reassign	5	2	1	Vegetable root and tuber group (2 ppm)
Peaches	10	Reassign	10	10	3	Fruit stone group (10 ppm)
Peanuts		0.05	5	2		
Pears	5		10	5	3	Pome fruit
Peas, cowpeas		Reassign	5			Dried, shelled peas and beans group (1 ppm)
Peas, with pods	5	Reassign	10	5	1	Vegetable legume, edible, podded subgroup (10 ppm)
Pecans	1	Reassign	1			Nuts, tree group (0.1 ppm)
Peppers	5	Reassign	10	5	1	Vegetable fruiting group (5 ppm)
Pineapples			2			
Pistachio	1	0.1	1			

Crop	Canadian MRL*	United States Tolerance		CODEX MRL	EU MRL	USEPA Tolerance Reassignment
		Proposed	Current			
Plums	10	Reassign	10	10	3	Fruit stone group (10 ppm)
Potatoes	0.2	Reassign	0.2	0.2		Vegetable root and tuber group (2 ppm)
Poultry	5		5	0.5		
Prickly pear cactus (pod)		12	12			
Prickly pear cactus (fruit)		5	12			
Proso millet grain			3			
Prunes			10			
Pumpkins	3	Reassign	10	3		Vegetable curcubit group (3 ppm)
Quinces					1	
Radishes	5		5	2	1	Vegetable root and tuber group (2 ppm)
Raspberries	10	Reassign	12	10	1	Caneberry group (12 ppm)
Rice		15	5	5	0.5	
Rutabagas		Reassign	5			Vegetable root and tuber group (2 ppm)
Rye, grain	2	Revoke	0	5	0.5	
Salsify roots	5	Reassign	5			Vegetable root and tuber group (2 ppm)
Salsify tops	10	Reassign	10		1	Leaves of vegetable root and tuber group (75 ppm)
Sheep, meat and fat				0.1		
Sheep, organs				1		
Sorghum grain			10			
Soybeans		0.5	5	1		
Spinach	10	22	12		1	
Squash, winter	3	Reassign	10	3		Vegetable curcubit group (3 ppm)
Squash, summer	3	Reassign	10	3		Vegetable curcubit group (3 ppm)
Strawberries	7	4	10	7	1	
Sugar beet		0.5	None			
Sunflower seed		0.5	1			
Swede				2	1	

Crop	Canadian MRL*	United States Tolerance		CODEX MRL	EU MRL	USEPA Tolerance Reassignment
		Proposed	Current			
Sweet corn (kernels)	1			1		
Sweet potatoes			0.2		1	
Swine, meat and fat				1		
Swine, organs				0.1		
Swiss chard	10	Reassign	12			Leaf petioles (3 ppm)
Tea						
Tomatoes	5	Reassign	10	5	1	Vegetable fruiting group (5 ppm)
Turnip roots	5	Reassign	5			Vegetable root and tuber group (2 ppm)
Turnip tops	10	Reassign	12		1	Leaves of vegetable root and tuber group (75 ppm)
Walnuts	1		1			
Watercress	10					
Watermelons	3				1	
Wheat, grain	2	1	3	5	0.5	

* 0.1 ppm Canadian MRL covered under the Food and Drug Regulation B.15.002

Table 34 Residue Definition in Canada and Other Jurisdictions

Jurisdiction	Residue Definition	
	Plant	Animal
Canada	1-naphthylmethylcarbamate	carbaryl, 5,6-dihydro-5,6-dihydroxy carbaryl and 5-methoxy-6-hydroxy carbaryl
United States	1-naphthylmethylcarbamate	carbaryl, 5,6-dihydro-5,6-dihydroxy carbaryl and 5-methoxy-6-hydroxy carbaryl
Codex	1-naphthylmethylcarbamate	Carbaryl

Appendix XVI Agricultural M/L/A Engineering controls, Additional Protection Equipment and Recommended Mitigation

The following uses do not meet the target ARI of 1.0 and will require further mitigation pending discussions with stakeholders (see attached Appendix XV, Table 34 for details):

- Liquids applied by air to alfalfa, clover, barley, oats, rye, wheat, beans, beet (root), horseradish, radish, rutabaga (root), salsify (root), turnip (root), carrots, beet and salsify and turnip tops, Chinese cabbage, dandelion, endive, kale, leaf lettuce, mustard greens, parsley, spinach, Swiss chard, watercress, corn (field, sweet), broccoli, Brussels sprouts, cabbage, cauliflower, celery, lettuce, kohlrabi, potatoes, tomatoes, eggplants, peppers, apples, pears, blackberries, boysenberries, dewberries, loganberries, raspberries and blueberries;

- Liquids applied by groundboom to alfalfa, clover, barley, oats, rye and wheat;

- Liquids and wettable powders applied by airblast to arborvitae, birch, boxwood, dogwood, elm, juniper, maple, oak and pines;

- Liquids applied by right-of-way sprayer to ditchbanks, field borders, rights-of-way, wastelands, headlands, forage grasses, pastures and rangelands;

- Liquids applied by high pressure handwand to forests and woodlands, azalea, carnation, chrysanthemums, gladiolus, holly, hydrangea, lilac, rose and zinnia; and

- Liquids and wettable powders applied by backpack to blackberries, boysenberries, dewberries, loganberries and raspberries.

The following uses do not meet the target ARI of 1.0 and will likely be phased out pending discussions with stakeholders (see attached Appendix XV,Table 34 for details):

- Liquids applied by air to cherries, plums, cranberries, grapes, strawberries and tobacco;
- Liquids and wettable powders applied by groundboom to tobacco;

- Liquids and wettable powders applied by high pressure handwand to trap trees, high value trees, birch, boxwood, dogwood, elm, juniper, maple, oak and pines;

- Liquids applied by high pressure handwand to ditchbanks, field borders, rights-of-way, wastelands, headlands, forage grasses, pastures and rangelands; and

- Liquids and wettable powders applied by backpack to cranberries.

Table 35 Agricultural M/L/A Engineering controls, Additional Protection Equipment and Recommended Mitigation[a]

Crop	Form[b]	Application Equipment[c]	Application Rates[d] (kg a.i./ha) or (kg a.i./L)	ATPD[e] (ha) or (L)	ARIs[f]	Recommended Engineering Controls and PPE[g]	Applied[h]		REIs[i]	Amount of a.i. Handled Per Day		Required Rate[l] (kg a.i/ha) or (kg a.i./L)
							Number	Interval		Current Amount[j] (kg a.i./day)	Amount Required[k] (kg a.i./day)	
Forests and woodlands	SU	HP handwand	1.07	5	0.78	Max PPE + respirator	3	7	13	5	4	0.83
Trap trees	SU	HP handwand	1.94E-02 kg a.i./L	3750 L	0.06	Max PPE + respirator	1	n/a	7	73	4	1.10E-03 kg a.i./L
	WP	HP handwand	2.00E-02 kg a.i./L	3750 L	0.06	Max PPE + respirator				75	4	1.10E-03 kg a.i/L
Alfalfa, clover, barley, oats, rye, wheat	SU	aerial-M/L	2.52	490	0.75	Closed mixing, Max PPE	2	8	10	1235	932	1.90
		aerial-Apply			0.65	Cotton coveralls, no gloves				1235	797	1.63
		groundboom		300	0.79	M/L: Closed, Max PPE. Apply: Closed, cotton coveralls				756	594	1.98
Ditchbanks, etc	SU	r-o-w sprayer	4.66E-03 kg a.i./L	3750 L	0.92	M/L: Closed, Max PPE. Apply: Open, Max PPE	2	8	2	17	16	4.30E-03
		HP handwand			0.24	Max PPE + respirator				17	4	1.10E-03 kg a.i./L
Beans	SU	aerial-M/L	3.07	490	0.62	Closed mixing, Max PPE	2	7	11	1505	932	1.90
		aerial-Apply			0.53	Cotton coveralls, no gloves				1505	797	1.63
Beet roots, etc., carrots, leafy vegetables	SU	aerial-M/L	2.52	490	0.75	Closed mixing, Max PPE	2	7	10	1235	932	1.90
		aerial-Apply			0.65	Cotton coveralls, no gloves				1235	797	1.63
Corn (field, sweet)	SU	aerial-M/L	1.92	490	0.99	Closed mixing, Max PPE	2	8	7	941	932	1.90
		aerial-Apply			0.85	Cotton coveralls, no gloves				941	797	1.63
Cole crops	SU	aerial-M/L	2.52	490	0.75	Closed mixing, Max PPE	2	7	14	1235	932	1.90
		aerial-Apply			0.65	Cotton coveralls, no gloves				1235	797	1.63
Potato	SU	aerial-M/L	3.07	490	0.62	Closed mixing, Max PPE	2	7	8	1505	932	1.90
		aerial-Apply			0.53	Cotton coveralls, no gloves				1505	797	1.63
Tomatoes, eggplant, peppers	SU	aerial-M/L	3.07	490	0.62	Closed mixing, Max PPE	2	7	6	1505	932	1.90
		aerial-Apply			0.53	Cotton coveralls, no gloves				1505	797	1.63

Crop	Form[b]	Application Equipment[c]	Application Rates[d] (kg a.i./ha) or (kg a.i./L)	ATPD[e] (ha) or (L)	ARIs[f]	Recommended Engineering Controls and PPE[g]	Applied[h]		REIs[i]	Amount of a.i. Handled Per Day		Required Rate[l] (kg a.i/ha) or (kg a.i./L)
							Number	Interval		Current Amount[j] (kg a.i./day)	Amount Required[k] (kg a.i./day)	
Apples, pears	SU	aerial-M/L	1.73	490	1.10	Closed mixing, Max PPE	3	7	35	847	932	1.90
		aerial-Apply			0.94	Cotton coveralls, no gloves				847	797	1.63
Berries (blackberries, boysenberries, dewberries, loganberries, raspberries)	SU	aerial-M/L	2.52	490	0.75	Closed mixing, Max PPE	2	8	10	1235	932	1.90
		aerial-Apply			0.65	Cotton coveralls, no gloves				1235	797	1.63
		backpack		2	0.79	Max PPE + respirator				5	4	1.98
	WP	backpack	2.25	2	0.88	Max PPE + respirator				5	4	1.98
Blueberries	SU	aerial-M/L	1.99	490	0.96	Closed mixing, Max PPE	2	8	9	975	932	1.90
		aerial-Apply			0.82	Cotton coveralls, no gloves				975	797	1.63
Cherries, plums	SU	aerial-M/L	3.31	490	0.57	Closed mixing, Max PPE	3	7	35	1623	932	1.90
		aerial-Apply			0.49	Cotton coveralls, no gloves				1623	797	1.63
Cranberries	SU	aerial-M/L	3.65	490	0.52	Closed mixing, Max PPE	2	8	5	1788	932	1.90
		aerial-Apply			0.45	Cotton coveralls, no gloves				1788	797	1.63
		backpack		2	0.54	Max PPE + respirator				7	4	1.98
	WP	backpack	3.38	2	0.59	Max PPE + respirator				7	4	1.98
Grapes	SU	aerial-M/L	3.07	490	0.62	Closed mixing, Max PPE	3	7	51	1505	932	1.90
	SU	aerial-Apply			0.53	Cotton coveralls, no gloves				1505	797	1.63
Strawberries	SU	aerial-M/L	2.78	490	0.68	Closed mixing, Max PPE	2	8	11	1364	932	1.90
		aerial-Apply			0.58	Cotton coveralls, no gloves				1364	797	1.63
Tobacco	SU	aerial-M/L	8.40	490	0.23	Closed mixing, Max PPE	2	8	17	4116	932	1.90
		aerial-Apply			0.19	Cotton coveralls, no gloves				4116	797	1.63
		groundboom		300	0.24	M/L: Closed, Max PPE. Apply: Closed, cotton coveralls				2520	594	3.96
	WP	groundboom	6.25	300	0.36	M/L: Max PPE. Apply: Closed, cotton coveralls				1875	683	2.28
Ornamental trees	SU	airblast	5.04	16	0.79	M/L: Closed, Max PPE. Apply: Open, Max PPE + respirator	3	7	28	81	63	3.96

Crop	Form[b]	Application Equipment[c]	Application Rates[d] (kg a.i./ha) or (kg a.i./L)	ATPD[e] (ha) or (L)	ARIs[f]	Recommended Engineering Controls and PPE[g]	Applied[h]		REIs[i]	Amount of a.i. Handled Per Day		Required Rate[l] (kg a.i/ha) or (kg a.i./L)
							Number	Interval		Current Amount[j] (kg a.i./day)	Amount Required[k] (kg a.i./day)	
		HP handwand	5.04E-03 kg a.i./L	3750 L	0.22	Max PPE + respirator				19	4	1.10E-03 kg a.i./L
	WP	airblast	4.50	16	0.89	M/L: Max PPE. Apply: Open, Max PPE + respirator				72	64	4.02
		HP handwand	4.50E-03 kg a.i./L	3750 L	0.25	Max PPE + respirator				17	4	1.10E-03 kg a.i./L
Ornamental shrubs and flowers	SU	HP handwand	1.68E-03 kg a.i./L	3750 L	0.66	Max PPE + respirator	2	7	13	6	4	1.10E-03 kg a.i./L
	WP	HP handwand	1.50E-03 kg a.i./L	3750 L	0.74	Max PPE + respirator				6	4	1.10E-03 kg a.i./L
Green ash	SU	HP handwand	1.21E-03 kg a.i./L	3750 L	0.92	Max PPE + respirator	2	7	24	5	4	1.10E-03 kg a.i./L
High value trees	SU	HP handwand	1.92E-02 kg a.i./L	3750 L	0.06	Max PPE + respirator	1	n/a	7	72	4	1.10E-03 kg a.i./L
	WP	HP handwand	2.00E-02 kg a.i./L	3750 L	0.06	Max PPE + respirator				75	4	1.10E-03 kg a.i./L

[a] See Section 3.2.2.1 for details of personal protective equipment worn for each use scenario.

[b,c] WP = Wettable Powder (For the purpose of exposure mitigation, assumed to be in Water Soluble Packaging); SU = Suspension, LP = Low Pressure, HP = High Pressure, M/L = Mix/Load

[d] Maximum listed label rate in kilograms of active ingredient per hectare (kg a.i./ha) unless specified as kilograms of active ingredient per litre (kg a.i./L)

[e] Based on default assumptions. Listed in hectares unless otherwise specified as litres.

[f] Aggregate Risk Index = 1/[(1/Dermal Risk Index) + (1/Inhalation Risk Index)]. Dermal Risk Index = Dermal MOE/Target Dermal MOE. Inhalation Risk Index = Inhalation MOE/Target Inhalation MOE. Table cells are shaded when the ARI < 1.0. If the ARI exceeds 1.0, the risk is below the level of concern. Based on a $BMDL_{10}$ of 35.5 mg/kg bw/day from a dermal study and a target dermal MOE of 300. Based on a $BMDL_{10}$ of 1.13 mg/kg bw/day from an oral study and a target inhalation MOE of 100.

[g] PPE = Personal Protective Equipment, See Section 3.2.2.1 for details. Max PPE = Chemical resistant coveralls over a long-sleeved shirt, long pants, shoes, socks and chemical resistant gloves.

[h] The number of applications and the interval between applications used in the risk assessment.

[i] Day at which the dermal exposure results in an MOE ≥ 300. REI = Restricted Entry Interval.

[j] Current amount of active ingredient handled at the assessed application rate.

[k] Amount of active ingredient handled required to meet the target ARI of 1.0. Shaded cells indicate that mitigation is likely not feasible.

[l] The rate of application required to meet the target ARI of 1.0 listed in kilograms of active ingredient per hectare (kg a.i./ha) unless specified as kilograms of active ingredient per litre (kg a.i./L) Shaded cells indicate that mitigation is likely not feasible.

Appendix XVII Water Modelling and Monitoring for Use in Drinking Water Risk Assessment

Modelling Results

Estimated environmental concentrations (EECs) of carbaryl in potential drinking water sources (groundwater and surface water) were estimated using computer simulation models. An overview of how EECs are estimated is provided in the PMRA's Science Policy Notice SPN2004-01, *Estimating the Water Component of a Dietary Exposure Assessment*. EECs of carbaryl in groundwater were calculated using the LEACHM model to simulate leaching through a layered soil profile over a 50-year period. EECs of carbaryl in surface water were calculated using the PRZM/EXAMS models, which simulate pesticide runoff from a treated field into an adjacent water body and the fate of a pesticide within that water body. Pesticide concentrations in surface water were estimated in two types of vulnerable drinking water sources: a small reservoir and a prairie dugout.

The surface water EECs predicted by Level 1 modelling were large enough for Level 2 modelling to be conducted. The refinement for Level 2 modelling was to use a scenario representing turf instead of the standard Level 1 scenario. The Level 2 EEC estimate is thus crop-specific and does not allow for future use expansion into other crops at the 42 kg a.i./ha application rate. In this case, lower runoff from turf results in lower EECs. Table 1 provides a summary of the Level 2 modelled EECs for carbaryl in potential sources of drinking water.

Water Monitoring Data

A search for carbaryl water monitoring data in Canada resulted in a number of samples with detections being reported.

American databases were also searched for detections of carbaryl. American data are important to consider in the Canadian drinking water assessment given the extensive monitoring programs that exist in the United States.

Data from Canadian and American water monitoring are summarized in Table 2.

An important limitation of the monitoring data set is that, in many cases, the data were not accompanied with use data for carbaryl. For instance, the application rate applied, when the application occurred and weather conditions prior to sampling were not known or reported. Without this information, it is difficult to conclude whether non-detects were a result of non-transport or more simply a result of inappropriate timing of sampling. In addition, because concentrations vary in time and space, sampling is unlikely to capture the absolute maximum concentration that would be observed.

Despite the uncertainties associated with the monitoring data outlined, these data contain a large number of samples collected and analyzed over a number of years, and therefore provide a degree of reliability that is not of concern. As a result, these databases were considered in the assessment.

Modeling VS Monitoring

Monitoring data and modelling estimates provide different types of information; therefore, they are not directly comparable. In general, pesticide concentrations in water are highly variable in time and location, and monitoring data usually do not capture the peak concentrations. As a result, comparing monitoring results to modelling is not straightforward. Nevertheless, these two types of data are complementary and should be considered in conjunction with each other when estimating the potential exposure to humans through drinking water.

Table 1 provides the drinking water exposure estimates as determined through water modelling and monitoring. In general, the water modelling data represent a reasonable upper bound exposure estimate for drinking water exposure, while the monitoring data represent a reasonable lower bound exposure estimate for drinking water exposure. For carbaryl, the groundwater modelling did not provide a reasonable upper bound estimate, as detections of carbaryl in groundwater were observed but not predicted by the modelling. There are several possible explanations for the difference between groundwater modelling and monitoring. First, the model simulates leaching through soil as a porous medium, and does not account for potential "short-circuiting" of flow through preferential channels, such as soil cracks and worm burrows, which can allow more rapid transport of chemicals to the water table. Second, the model calculations were done using a hydrolysis rate at 24°C. Canadian soils are, on average, cooler than this temperature and the hydrolysis rate is likely slower; thus, for groundwater, the modelled EECs could be underestimates and should be considered as a lower bound.

Table 1 Drinking Water Concentrations Estimated from Models and Monitoring Data for Use in the Dietary Risk Assessment

	Groundwater Concentration (µg/L)		Surface-Water Acute Concentration (µg/L)		Surface-Water Chronic Concentration (µg/L)	
	Acute	**Chronic**	**Reservoir**	**Dugout**	**Reservoir**	**Dugout**
Upper Bound	N/A	N/A	287[3]	344[3]	11.9[5]	13.7[5]
Lower Bound	0.73[1]	0.03[2]	14.3[4]		0.1[6]	

N/A Modelling did not provide a reasonable upper bound estimate, as detections of carbaryl in groundwater were observed but not predicted by the modelling.

1 From monitoring: 95th percentile of the maximum detected concentration in groundwater.

2 From monitoring data: 95th percentile of the arithmetic means in groundwater (includes detects and non-detects at ½ LOD).

3 From modelling results: 90th percentile of the annual peak concentrations at Level 2.

4 From monitoring data: 95th percentile of the maximum detected concentrations in surface water.

5 From modelling results: 90th percentile of the annual average concentrations at Level 2.

6 From monitoring data: 95th percentile of the arithmetic means in surface water (includes detects and non-detects at ½ LOD).

Table 2 Summary of Available Monitoring Studies for Carbaryl

Location		Minimum Detection or Detection Limit (µg/L)	Number of Systems Tested (or Absolute Number of Samples)	Number of Systems or Samples With Detections	Detection Frequency%	Concentration (µg/L) (Analysis Includes Only Data With Detections)			Arithmetic Mean Including Non-Detects at ½ LOD
						Arithmetic Mean	95th percentile	Maximum	
Carbaryl Residues in Municipal drinking Water Sources									
PEI groundwater		0.5	12 samples	0	0	—	—	—	0.250
Wells in potato growing region of Quebec	1991	0.02	35	0	0	—	—	—	0.010
	1992	0.02	46	0	0	—	—	—	0.010
	1993	0.02	34	0	0	—	—	—	0.010
Water distribution systems in Quebec		0.01-0.6	213 systems	1	0.47	—	—	0.05	—
Saskatchewan water (1985-2002)		0.05-1	15	0	0	—	—	—	—
Community and private water wells in the Upper Fraser Valley, Central Fraser Valley and part of the Boundary Health Units (1992-1993)		1	74	0	0.0	—	—	—	—
Municipal water supplies in New Brunswick, surface and groundwater (2003)	Spring	0.02	7	0	0.0	—	—	—	0.010
	Summer	0.7	6	0	0.0	—	—	—	—
	Fall	1	6	0	0.0	—	—	—	—

Location		Minimum Detection or Detection Limit (µg/L)	Number of Systems Tested (or Absolute Number of Samples)	Number of Systems or Samples With Detections	Detection Frequency%	Concentration (µg/L) (Analysis Includes Only Data With Detections)			Arithmetic Mean Including Non-Detects at ½ LOD
						Arithmetic Mean	95th percentile	Maximum	
Groundwater (1992-2006)	Urban land area	0.003-0.06	2707	37	1.4	0.015	0.043	0.091	0.009
	Agricultural land use	0.003-0.06	4520	16	0.4	0.011	0.026	0.028	0.009
	Mixed land use	0.003-0.06	5611	33	0.1	0.041	0.124	0.539	0.009
	Other land use	0.003-0.06	2494	23	0.9	0.046	0.025	0.781	0.013
Finished tap water in the United States (1999-2000)		0.003	228	2	0.9	—	—	0.041	—
Public water systems in 16 States, surface and groundwater (1984-1999)		not reported	12679	28	0.2	0.562	—	3	—
Carbaryl Residues in Ambient Water that May Serve as a Drinking Water Source									
Wells near apple orchards (1994-1996)		0.05-0.07	42 wells	1	2.3	—	—	Trace amounts	—
Déversant du Lac Stream, Rougement	1994	0.015	12	4	33.3	0.06	0.14	0.16	0.026
	1995	0.015	15	6	40	0.21	0.71	0.89	0.089
	1996	0.03	23	12	52.2	0.27	1.09	2.2	0.238
Boffin Stream, Frelighsburg	1994	0.015	12	1	8.3	—	—	0.03	0.009
	1995	0.015	13	1	7.7	—	—	1.3	0.107
	1996	0.03	24	0	0	—	—	—	0.015

Location		Minimum Detection or Detection Limit (µg/L)	Number of Systems Tested (or Absolute Number of Samples)	Number of Systems or Samples With Detections	Detection Frequency%	Concentration (µg/L) (Analysis Includes Only Data With Detections)			Arithmetic Mean Including Non-Detects at ½ LOD
						Arithmetic Mean	95th percentile	Maximum	
Abbott's Corner Stream	1994	0.015	12	0	0	—	—	—	0.008
Ruisseau Corbin	1996	0.03	17	1	5.9	—	—	0.04	0.020
	1997	0.03	34	8	23.5	0.260	0.790	0.88	0.070
Ruisseau Saint-Pierre	1996	0.03	1	0	0	—	—	—	0.015
Rivière de l'Achigan	1996	0.03	18	0	0	—	—	—	0.015
	1997	0.03	29	0	0	—	—	—	0.015
Rivière Yamaska	1992	0.2	10	0	0	—	—	—	0.100
Rivière Noire	1992	0.2	10	0	0	—	—	—	0.100
Rivière Noire (Témoin)	1992	0.2	10	0	0	—	—	—	0.100
Rivière Blanche	1992	0.2	10	0	0	—	—	—	0.100
Rivière Saint-Zéphirin	1992	0.2	10	0	0	—	—	—	0.100
	1993	0.2	30	0	0	—	—	—	0.100
Rivière Saint-Germain	1992	0.2	24	0	0	—	—	—	0.100
	1993	0.2	33	0	0	—	—	—	0.100
Rivière Salvail	1992	0.2	24	0	0	—	—	—	0.100
	1993	0.2	33	0	0	—	—	—	0.100
Rivière Chibouet	1992	0.2	23	0	0	—	—	—	0.100
	1993	0.2	45	0	0	—	—	—	0.100
Rivière des Hurons	1992	0.2	24	0	0	—	—	—	0.100

Location		Minimum Detection or Detection Limit (µg/L)	Number of Systems Tested (or Absolute Number of Samples)	Number of Systems or Samples With Detections	Detection Frequency%	Concentration (µg/L) (Analysis Includes Only Data With Detections)			Arithmetic Mean Including Non-Detects at ½ LOD
						Arithmetic Mean	95th percentile	Maximum	
	1993	0.2	44	0	0	—	—	—	0.100
Rivière L'Acadie	1992	0.2	10	0	0	—	—	—	0.100
	1993	0.2	30	0	0	—	—	—	0.100
Rivière de la Tortue	1993	0.2	30	0	0	—	—	—	0.100
Rivière à la Barbue	1992	0.2	76	0	0	—	—	—	0.100
	1993	0.2	43	0	0	—	—	—	0.100
Rivière Saint-Régis	1993	0.2	30	0	0	—	—	—	0.100
Rivière des Fèves	1993	0.2	26	0	0	—	—	—	0.100
Rivière Saint-Zéphirin	1994	0.015	37	0	0.0	—	—	—	0.008
	1995	0.015	38	0	0.0	—	—	—	0.008
Rivière Chibouet	1994	0.015	45	1	2.2	—	—	0.02	0.008
	1995	0.015	38	0	0.0	—	—	—	0.008
Rivière des Hurons	1994	0.015	47	14	29.8	0.090	0.300	0.52	0.030
	1995	0.015	34	14	41.2	0.050	0.140	0.17	0.020
Rivière Saint-Régis	1994	0.015	34	3	8.8	0.060	0.090	0.09	0.010
	1995	0.015	35	7	20.0	0.160	0.440	0.51	0.030
Rivière Saint-Esprit	1994	0.015	9	0	0.0	—	—	—	0.008
	1995	0.015	6	0	0.0	—	—	—	0.008
Rivière des Anges	1994	0.015	10	0	0.0	—	—	—	0.008
	1995	0.015	2	0	0.0	—	—	—	0.008

Location		Minimum Detection or Detection Limit (µg/L)	Number of Systems Tested (or Absolute Number of Samples)	Number of Systems or Samples With Detections	Detection Frequency%	Concentration (µg/L) (Analysis Includes Only Data With Detections)			Arithmetic Mean Including Non-Detects at ½ LOD
						Arithmetic Mean	95th percentile	Maximum	
Rivière Bayonne	1994	0.015	9	0	0.0	—	—	—	0.008
Rivière Yamaska	1994	0.015	8	0	0.0	—	—	—	0.008
	1995	0.015	2	1	50.0	—	—	0.05	0.030
Rivière Nicolet	1994	0.015	4	0	0.0	—	—	—	0.008
Rivière Châteauguay	1994	0.015	1	0	0.0	—	—	—	0.008
Rivière Chibouet	1996	0.03	40	0	0	—	—	—	0.015
	1997	0.03	37	1	2.7	—	—	0.04	0.020
	1998	0.03	42	0	0	—	—	—	0.015
Rivière des Hurons	1996	0.03	41	11	26.8	0.04	0.10	0.1	0.015
	1997	0.03	39	7	17.9	0.05	0.13	0.16	0.020
	1998	0.03	45	4	8.9	0.07	0.14	0.15	0.020
Rivière Saint-Régis	1996	0.03	41	9	22.0	0.04	0.06	0.07	0.020
	1997	0.03	40	5	12.5	0.05	0.07	0.07	0.020
	1998	0.03	51	8	15.7	0.03	0.03	0.03	0.020
Rivière Saint-Zéphirin	1996	0.03	39	0	0	—	—	—	0.015
	1997	0.03	39	0	0	—	—	—	0.015
	1998	0.03	48	0	0	—	—	—	0.015
Rivière Yamaska	1996	0.03	17	0	0	—	—	—	0.015
	1997	0.03	8	0	0	—	—	—	0.015
	1998	0.03	49	2	4.1	0.03	0.030	0.03	0.020

Location		Minimum Detection or Detection Limit (µg/L)	Number of Systems Tested (or Absolute Number of Samples)	Number of Systems or Samples With Detections	Detection Frequency%	Concentration (µg/L) (Analysis Includes Only Data With Detections)			Arithmetic Mean Including Non-Detects at ½ LOD
						Arithmetic Mean	95th percentile	Maximum	
Rivière Chibouet	1999	0.03	45	1	2.2	—	—	0.04	0.016
	2000	0.04	40	0	0	—	—	—	0.020
	2001	0.05	46	0	0	—	—	—	0.025
Rivière des Hurons	1999	0.03	45	10	22.2	0.15	0.500	0.64	0.046
	2000	0.04	42	10	23.8	0.15	0.470	0.71	0.051
	2001	0.05	44	5	11.4	0.20	0.310	0.33	0.045
Rivière Saint-Régis	1999	0.03	45	4	8.9	0.18	0.510	0.59	0.029
	2000	0.04	43	8	18.6	0.71	2.790	3.7	0.149
	2001	0.05	45	3	6.7	0.23	0.400	0.42	0.039
Rivière Saint-Zéphirin	1999	0.03	45	0	0	—	—	—	0.015
	2000	0.04	43	0	0	—	—	—	0.020
	2001	0.05	46	0	0	—	—	—	0.025
Rivière Yamaska	1999	0.03	45	1	2.2	—	—	0.03	0.015
	2000		Not reported			—	—	—	—
	2001	0.05	43	0	0	—	—	—	0.025
Private wells, Bas Saint-Laurent (Region 1)	1999	0.06	7	0	0	—	—	—	0.030
	2000	0.03	7	0	0	—	—	—	0.015
	2001	0.03	7	0	0	—	—	—	0.015

Location		Minimum Detection or Detection Limit (µg/L)	Number of Systems Tested (or Absolute Number of Samples)	Number of Systems or Samples With Detections	Detection Frequency%	Concentration (µg/L) (Analysis Includes Only Data With Detections)			Arithmetic Mean Including Non-Detects at ½ LOD
						Arithmetic Mean	95th percentile	Maximum	
Private wells, Saguenay Lac Saint-Jean (Region 2)	1999	0.06	12	0	0	—	—	—	0.030
	2000	0.03	12	0	0	—	—	—	0.015
	2001	0.03	12	0	0	—	—	—	0.015
Private wells, Québec (Region 3)	1999	0.06	9	0	0	—	—	—	0.030
	2000	0.03	9	0	0	—	—	—	0.015
	2001	0.03	9	0	0	—	—	—	0.015
Private wells, Estrie (Region 5)	1999	0.06	3	0	0	—	—	—	0.030
	2000	0.03	3	0	0	—	—	—	0.015
	2001	0.03	3	0	0	—	—	—	0.015
Private wells, Lanaudière (Region 14)	1999	0.06	25	0	0	—	—	—	0.030
	2000	0.03	25	0	0	—	—	—	0.015
	2001	0.03	25	0	0	—	—	—	0.015
Private wells, Centre du Québec (Region 17)	1999	0.06	23	0	0	—	—	—	0.030
	2000	0.03	23	0	0	—	—	—	0.015
	2001	0.03	23	0	0	—	—	—	0.015
Rivière Chibouet	2002	0.03	43	1	2.3	—	—	0.04	0.016
	2003	0.03	41	0	0	—	—	—	0.015
	2004	0.03	41	0	0	—	—	—	0.015

Location		Minimum Detection or Detection Limit (µg/L)	Number of Systems Tested (or Absolute Number of Samples)	Number of Systems or Samples With Detections	Detection Frequency%	Concentration (µg/L) (Analysis Includes Only Data With Detections)			Arithmetic Mean Including Non-Detects at ½ LOD
						Arithmetic Mean	95th percentile	Maximum	
Rivière des Hurons	2002	0.03	42	11	26.2	0.08	0.140	0.16	0.031
	2003	0.03	41	4	9.7	0.07	0.138	0.18	0.027
	2004	0.03	41	11	26.8	0.08	0.130	0.36	0.022
Rivière Saint-Régis	2002	0.03	40	7	17.5	0.12	0.158	0.17	0.034
	2003	0.03	39	19	48.7	0.12	0.230	0.47	0.015
	2004	0.03	39	15	13.5	0.13	0.296	0.33	0.018
Rivière Saint-Zéphirin	2002	0.03	42	0	0	—	—	—	0.015
	2003	0.03	39	0	0	—	—	—	0.015
	2004	0.03	39	0	0	—	—	—	0.015
Envirodat database PEI groundwater		0.001	151	0	0.0	—	—	—	0.0005
Envirodat database PEI freshwater		0.001	33	0	0.0	—	—	—	0.0005
Lake Ontario tributaries (2001)		0.01	119	0	0.0	—	—	—	0.005
Raw water intake in the United States (1999-2000)		0.003	323	7	2.2	—	—	0.05	—
Lake Ontario tributaries (2000)		0.01	75	0	0.0	—	—	—	0.005
Five stations in the Quebec Region (2003-2005)		0.05	Not reported	0	0.0	—	—	—	0.025
Groundwater from Prince Edward Island (2003-2004)		0.05	230	0	0.0	—	—	—	0.020
Groundwater from two Nova Scotia farm wells (2004)		0.04	6	0	0.0	—	—	—	0.020

Location		Minimum Detection or Detection Limit (µg/L)	Number of Systems Tested (or Absolute Number of Samples)	Number of Systems or Samples With Detections	Detection Frequency%	Concentration (µg/L) (Analysis Includes Only Data With Detections)			Arithmetic Mean Including Non-Detects at ½ LOD
						Arithmetic Mean	95th percentile	Maximum	
6 streams in Prince Edward Island (2003-2005)		0.04	82	0	0.0	—	—	—	0.025
4 sites in Annapolis Valley area, Nova Scotia (2003-2005)		0.04	19	0	0.0	—	—	—	0.025
4 systems in New Brunswick (2003-2005)		0.04	41	0	0.0	—	—	—	0.025
Rivière Richelieu		0.2	6	0	0.0	—	—	—	0.100
Rivière de la Tortue		0.2	17	1	5.9	—	—	1.4	0.176
Rivière Yamaska		0.2	18	0	0.0	—	—	—	0.100
Rivière Nicolet		0.2	18	0	0.0	—	—	—	0.100
United States surface water (1991-2006)	Urrban land use	0.003-1.0	5673	2432	42.9	0.10	0.33	5.5	0.046
	Agricultural land use	0.003-1.0	10940	1244	11.4	0.09	0.19	33.5	0.016
	Mixed land use	0.003-1.0	9494	1854	19.5	0.10	0.09	45.2	0.104
	Other land use	0.003 - 1.0	2661	358	13.5	0.05	0.13	16.5	0.026
Carbaryl Residues in Ambient Water that are Unlikely to Serve as a Drinking Water Source									
Station d'épuration de Laval	2001	0.02	25	10	40	0.22	0.71	1.1	0.090
Station d'épuration de Repentigny		0.02	27	17	63	0.19	0.48	1.	0.130

Location		Minimum Detection or Detection Limit (µg/L)	Number of Systems Tested (or Absolute Number of Samples)	Number of Systems or Samples With Detections	Detection Frequency%	Concentration (µg/L) (Analysis Includes Only Data With Detections)			Arithmetic Mean Including Non-Detects at ½ LOD
						Arithmetic Mean	95th percentile	Maximum	
Station d'épuration de la CUQ (est)		0.02	27	8	30	0.11	0.21	0.26	0.040
Station d'épuation de la CUQ (ouest)		0.02	28	18	64	0.16	0.23	0.26	0.110
Station d'épuration de Saint-Hyacinthe	2002	0.02	27	12	44	0.05	0.06	0.07	0.030
Station d'épuration de Granby		0.02	28	8	29	0.04	0.07	0.08	0.020
Station d'épuration de Sherbrooke		0.02	28	11	39	0.07	0.14	0.18	0.030
Eight urban streams in the United States (1993-1994)		0.01	215		43.7	—	—	3.200	—

NOTE: Studies in bold were used in the assessment.
"—" = not applicable or cannot be calculated based on available data.

Appendix XVIII

Table 1 Environmental Fate of Carbaryl

Study Type	Test Material	Study Conditions	Value or Endpoint	Interpretation	Major Transformation Products
Abiotic Transformation					
Hydrolysis	^{14}C-Carbaryl		pH 5 stable pH 7 12 days pH 8 4-7 days pH 9 0.13 day	Stable under acidic conditions	1-naphthol
Phototransformation-soil	^{14}C-Carbaryl	30 d under artificial light	Half-life 41 days	Not a major route of transformation	
Phototransformation-water	^{14}C-Carbaryl	Sterile distilled water, pH 5	Half-life 21 days	Not a major route of transformation, but may be important if near the surface	1-naphthol
		Natural water, near the surface	Half-life 2-7 days		
Biotransformation					
Soil-aerobic	^{14}C-Carbaryl	Sandy loam Clay loam	Half-life 4-17 days Half-life 21-27 days	Non persistent	1-naphthol
Soil-anaerobic		Aquatic sediment	Half-life 72 days	Moderately persistent	
Water/sediment-aerobic		Clay loam	Half-life 4.9 days	Non persistent	
Water-aerobic		Pond water, pH 6-7	Half-life 12-30 days		
		River water, pH 7	Half-life <6 days		
Water/sediment-anaerobic			Half-life 72 days	Moderately persistent	

Study Type	Test Material	Study Conditions	Value or Endpoint	Interpretation	Major Transformation Products
Mobility					
Adsorption/desorption	^{14}C-Carbaryl	Aged soils	K_{OC} 100-600	Low to high mobility	
Volatility	Carbaryl		1.36×10^{-6} mmg Hg at 25°C	Non volatile	

Table 2 Environmental Toxicity of Carbaryl

Organism	Study Type	Species	Test Material	Endpoint	Value (effect)	Effect of Concern
Terrestrial Species						
Invertebrate	Acute	Honeybee (oral)	Carbaryl Technical	48-hours LD_{50}	0.11-0.14 µg a.i./bee	Mortality
			Carbaryl (EC formulation)		1.57 µg a.i./bee	
		Honeybee (contact)	Carbaryl Technical	48-hours LD_{50}	1.1-1.3 µg a.i./bee	
			Carbaryl (EC formulation)		4.02 µg a.i./bee	
		Other non-target insects	Carbaryl (EC formulation)	Mortality rate	69-85%	
		Earthworm	Carbaryl Technical	LC_{50}	106 mg a.i./kg soil	
Birds	Acute oral	Mallard duck	Carbaryl Technical 85-99.1%	LD_{50}	>2500 mg a.i./kg bw	Mortality
		Ring-necked pheasant			>2000 mg a.i./kg bw	
		Red-winged blackbird			56 mg a.i./kg bw	
		European starling			16 mg a.i./kg bw	
		Domestic chicken			197 mg a.i./kg bw	
	Subacute dietary	Mallard duck		LC_{50}	>5000 mg a.i./kg diet	Mortality
		Northern bobwhite			>5000 mg a.i./kg diet	
		Japanese quail			>5000 mg a.i./kg diet	

Organism	Study Type	Species	Test Material	Endpoint	Value (effect)	Effect of Concern
	Chronic	Mallard duck		NOEC	300 mg a.i./kg diet	Egg production
Mammals	Acute oral	Rat	Carbaryl Technical	LD_{50}	200-850 mg a.i./kg bw	Mortality
		Mouse		LD_{50}	175-600 mg a.i./kg bw	
	Acute dermal	Rat		LD_{50}	>4000 mg a.i./kg bw	
		Rabbit		LD_{50}	>2000 mg a.i./kg bw	
	Subchronic dietary (1 week)	Rat		NOEC	10 mg a.i./kg bw/day	
	Chronic toxicity (dietary)	Rat	Carbaryl Technical	NOEC	10.0/12.6 mg a.i./kg bw/day♂/♀	
		Mouse		NOEC	14.7/18.1 mg a.i./kg bw/day ♂/♀	
	Chronic toxicity (reproduction)	Rat	Carbaryl Technical	NOEL	4.0 mg a.i./kg bw/day	Maternal and developmental
		Mouse		NOEL	100 mg a.i./kg bw/day	Reproductive
				NOEL	150 mg a.i./kg diet	Develpmental
Freshwater Organisms						
Invertebrate	Acute	*Daphnia magna*	Carbaryl Technical 99.5%	48-hour EC_{50}	0.0056 mg a.i./L	Immobility
			Carbaryl Technical 81.5%		0.0072 mg a.i./L	
			43.7% formulated product		0.0067 mg a.i./L	
			1-naphthol		0.73 mg a.i./L	
		Stonefly	Carbaryl Technical 99.1-99.5%	96-hour EC_{50}	0.0036 mg a.i./L	Mortality
		Scud			0.026 mg a.i./L	
	Chronic	*Daphnia magna*	Carbaryl Technical 99%	21-day NOEC	0.0015 mg a.i./L	Reproduction

Organism	Study Type	Species	Test Material	Endpoint	Value (effect)	Effect of Concern
Fish	Acute	Rainbow trout	Carbaryl Technical 99.1-99.9%	96-hour LC_{50}	1.2 mg a.i./L	Mortality
			1-naphthol		1.4 mg a.i./L	
		Bluegill sunfish	Carbaryl Technical 99.1-99.9%		5.0 mg a.i./L	
			1-naphthol		0.76 mg a.i./L	
		Channel catfish	Carbaryl Technical 99.1-99.9%		7.8 mg a.i./L	
		Fathead minnow			7.7 mg a.i./L	
		Atlantic salmon			0.25 mg a.i./L	
		Coho salmon			2.4 mg a.i./L	
		Yellow perch			0.35 mg a.i./L	
		Cutthroat trout			0.97 mg a.i./L	
		Lake trout			0.69 mg a.i./L	
	Chronic (Early Life Stage)	Fathead minnow	Carbaryl Technical 99%	NOEC LOEC	0.21 mg a.i./L 0.68 mg a.i./L	Survival and reproduction
			1-naphthol	NOEC LOEC	0.10 mg a.i./L 0.20 mg a.i./L	Larval survival/growth
Algae	Acute	Green algae	Carbaryl Technical	NOEC	0.37 mg a.i./L	Cell count
				EC_{50}	1.1 mg a.i./L	
			Sevin XLR Plus	NOEC	1.8 mg a.i./L	
				EC_{50}	3.2 mg a.i./L	

Organism	Study Type	Species	Test Material	Endpoint	Value (effect)	Effect of Concern
Marine/Estuarine Organisms						
Invertebrate	Acute	Eastern oyster	Carbaryl Technical 99.7%	96-hour LC_{50}	>0.002 mg a.i./L	Shell deposition
			1-naphthol	48-hour LC_{50}	2.1 mg a.i./L	
		Mysid shrimp	Carbaryl Technical 99.7%	96-hour LC_{50}	0.0057 mg a.i./L	Mortality
			1-naphthol	48-hour LC_{50} NOEC	0.21 mg a.i./L 0.06 mg a.i./L	
Fish	Acute	Sheepshead minnow	Carbaryl Technical 99.7%	96-hour LC_{50}	2.6 mg a.i./L	Mortality

Table 3 Summary of Screening Level Risk Assessment of Carbaryl to Terrestrial Organisms (In-Field)

Organism	Exposure	Endpoint Reported	Endpoint Value for RA	Single Rate (g a.i./ha)	Cumulative Rate[1] (g a.i./ha)	EEC/EDE[2]	RQ[3]
Invertebrates							
Earthworm	Acute	LC_{50} = 106 mg a.i./kg soil	10.6	2250	—	1.0 mg a.i./kg soil	>0.1
				2250	5700.8	2.53 mg a.i./kg soil	0.24
				14 000	35471.7	15.76 mg a.i./kg soil	**1.5**
Honeybee	Acute oral	LD_{50} = 1.57 µg a.i./bee (1.75 kg a.i./ha)	1.75	2250	—	2.25 kg a.i./ha	**1.3**
				2250	5700.8	5.7 kg a.i./ha	**3.3**
				14 000	35471.7	35.5 kg a.i./ha	**20.2**
Birds							
Red-winged blackbird	Acute oral	LD_{50} = 56 mg a.i./kg bw	5.6	2250	—	43.65 mg a.i./kg bw/day	**8**
				2250	5700.8	110.6 mg a.i./kg bw/day	**20**
				14000	35471.7	688.6 mg a.i./kg bw/day	**122**
Mallard	Acute oral	LD_{50}>2000 mg	>200	2250	—	3.91 mg a.i./kg bw/day	<0.1

Organism	Exposure	Endpoint Reported	Endpoint Value for RA	Single Rate (g a.i./ha)	Cumulative Rate[1] (g a.i./ha)	EEC/EDE[2]	RQ[3]
		a.i./kg bw		2250	5700.8	9.92 mg a.i./kg bw/day	<0.1
				14000	35471.7	61.78 mg a.i./kg bw/day	<0.3
Northern bobwhite	Dietary	LC_{50}> 5000 mg a.i./kg diet	>500	2250	—	393.93 mg a.i./kg dw/day	<**1.3**
				2250	5700.8	998.1 mg a.i./kg dw/day	**<2.0**
				14000	35471.7	6210.4 mg a.i./kg dw/day	**<12**
Mallard	Reproduction	NOEC = 300 mg a.i./kg diet	300	2250	—	76.1 mg a.i./kg dw/day	<0.25
				2250	5700.8	192.8 mg a.i./kg dw/day	**1.6**
				14000	35471.7	1199.65 mg a.i./kg dw/day	**4**
Mammals							
Mouse	Acute	LD_{50} = 175 mg a.i./kg bw	17.5	2250	-	208.51 mg a.i./kg bw	**12**
				2250	5700.8	528.30 mg a.i./kg bw	**30**
				14000	35471.7	3290.75 mg a.i./kg bw	**188**
Rat	Dietary	NOEC = 10 mg a.i./kg diet	10	2250	-	1135.12 mg a.i./kg dw/day	**113**
				2250	5700.8	2876.0 mg a.i./kg dw/day	**288**
				14000	35471.7	17895.34 mg a.i./kg dw/d	**1790**
Rat	Chronic (Reproduction)	NOEL = 4 mg a.i./kg diet	4	2250	-	1135.12 mg a.i./kg dw/day	**283**
				2250	5700.8	2876.0 mg a.i./kg dw/day	**719**
				14000	35471.7	17895.34 mg a.i./kg dw/day	**4470**

[1] Based on foliar $t_{1/2}$ of 27days (3 applications @ 2.25 and 14 kg a.i./ha with 7 day intervals).

[2] EDE (estimated daily exposure) for acute birds and mammals exposure from conversion of EEC according to the following formula: EDE = (FIR/BW) × EEC; where FIR = food ingestion rate; bw = body weight; dw = dry weight.

[3] Bold fonts indicates exceedance of LOC.

Table 4 Summary of Risk Assessment of Carbaryl to Birds and Mammals from Spray Drift (Off-Field)

Organism	Effect	Endpoint Value for RA	Application rate[1] (kg a.i./ha)	EEC/EDE[2]	RQ[3]
Birds					
Red-winged blackbird	Acute	5.6 mg a.i./kg/bw (1/10 of LD_{50})	0.247	4.8 mg a.i./kg bw/day	0.85
			0.627	13 mg a.i./kg bw/day	**2**
			3.902	75.7 mg a.i./kg bw/day	**13.5**
Mallard duck	Acute	>200 mg a.i./kg/bw (1/10 of LD_{50})	0.247	0.43 mg a.i./kg bw/day	<0.1
			0.627	1.2 mg a.i./kg bw/day	<0.1
			3.902	6.8 mg a.i./kg bw/day	<0.1
Mallard duck	Reproduction	NOEC = 300 mg a.i./kg diet	0.247	8.37 mg a.i./kg dw/day	<0.1
			0.627	21.2 mg a.i./kg dw/day	<0.1
			3.902	132 mg a.i./kg dw/day	0.4
Northern bobwhite	Dietary	>500 mg a.i./kg diet (1/10 of LC_{50})	0.247	43.3 mg a.i./kg dw/day	<0.1
			0.627	109.8 mg a.i./kg dw/day	<0.2
			3.902	683.15 mg a.i./kg dw/day	**<1.4**
Mammals					
Mouse	Acute oral	17.5 mg a.i./kg bw (1/10 of LD_{50})	0.247	22.95 mg a.i./kg bw/day	**1.3**
			0.627	58.2 mg a.i./kg bw/day	**3**
			3.902	362 mg a.i./kg bw/day	**20**

Organism	Effect	Endpoint Value for RA	Application rate[1] (kg a.i./ha)	EEC/EDE[2]	RQ[3]
Rat	Dietary	NOEC = 10 mg a.i./kg bw/day	0.247	124.9 mg a.i./kg dw/day	**12.5**
			0.627	316.3 mg a.i./kg dw/day	**32**
			3.902	1968.5 mg a.i./kg dw/day	**196**
	Reproduction	NOEC = 4 mg a.i./kg bw/day (maternal and developmental)	0.247	124.9 mg a.i./kg dw/day	**31**
			0.627	316.3 mg a.i./kg dw/day	**79**
			3.902	1968.5 mg a.i./kg dw/day	**492**

1 Based on 11% spray drift for a default droplet size of fine (insecticides).
2 EDE (estimated daily exposure) for acute birds and mammals exposure from conversion of EEC according to the following formula: EDE = (FIR/BW) × EEC; where FIR = food ingestion rate; bw = body weight; dw = dry weight
3 Bold fonts indicates exceedance of LOC.

Table 5 Summary of Screening Level Risk Assessment of Carbaryl to Aquatic Organisms

Organism	Exposure	Species	Endpoint reported (mg a.i./L)	Endpoint for RA* (mg a.i./L)	Single rate (g a.i./ha)	Cumulative rate[1] (g a.i./ha)	EEC** (mg a.i./L)	RQ[2]
Freshwater Species								
Invertebrate	Acute	*D. magna*	EC_{50} = 0.0056	0.0028	2250	—	0.28	**100**
					2250	5792.35	0.72	**257**
					14000	36041.3	4.5	**161**
		Stonefly	EC_{50} = 0.0036	0.0018	2250	—	0.28	**155**
					2250	5792.35	0.72	**400**
					14000	36041.3	4.5	**2500**
	Chronic	*D. magna*	NOEC = 0.0015	0.0015	2250	—	0.28	**187**
					2250	5792.35	0.72	**480**
					14000	36041.3	4.5	**3000**

Organism	Exposure	Species	Endpoint reported (mg a.i./L)	Endpoint for RA* (mg a.i./L)	Single rate (g a.i./ha)	Cumulative rate[1] (g a.i./ha)	EEC** (mg a.i./L)	RQ[2]
Fish	Acute	Rainbow trout	LC_{50} = 1.2	0.12	2250	—	0.28	**2**
					2250	5792.35	0.72	**6**
					14000	36041.3	4.5	**37.5**
		Atlantic salmon	LC_{50} = 0.25	0.025	2250	—	0.28	**11**
					2250	5792.35	0.72	**29**
					14000	36041.3	4.5	**180**
	Chronic	Fathead minnow (Early Life Cycle)	NOEC = 0.21	0.21	2250	—	0.28	**1.3**
					2250	5792.35	0.72	**9.6**
					14000	36041.3	4.5	**31**
Amphibian	Acute	Southern leopard frog	LC_{50} = 8.4	0.84	2250	—	1.5	**1.8**
					2250	5792.35	3.86	**4.6**
					14000	36041.3	24	**28.6**
	Chronic	Fish Early Life Cycle (surrogate)	NOEC = 0.21	0.21	2250	—	1.5	**7**
					2250	5792.35	3.86	**18**
					14000	36041.3	24	**114**
Plant	Acute	Green algae	EC_{50} = 1.1	0.55	2250	—	0.28	0.5
					2250	5792.35	0.72	**1.3**
					14000	36041.3	4.5	**8**

Organism	Exposure	Species	Endpoint reported (mg a.i./L)	Endpoint for RA* (mg a.i./L)	Single rate (g a.i./ha)	Cumulative rate[1] (g a.i./ha)	EEC** (mg a.i./L)	RQ[2]
Estuarine/Marine Species								
Invertebrate	Acute	Mysid shrimp	LC_{50} = 0.057	0.028	2250	-	0.28	**10**
					2250	5792.35	0.72	**25.7**
					14000	36041.3	4.5	**161**
Fish		Shipshead minnow	LC_{50} = 2.6	0.26	2250	-	0.28	**1.1**
					2250	5792.35	0.72	**2.8**
					14000	36041.3	4.5	**17**

* Endpoints used in the acute exposure risk assessment (RA) are derived by dividing the EC_{50} or LC_{50} from the appropriate laboratory study by a factor of two (2) for aquatic invertebrates and plants, and by a factor of ten (10) for fish and amphibians.

** EEC based on a 15 cm water body depth for amphibians and a 80 cm water depth for all other aquatic organisms.

[1] Based on aerobic water DT_{50} (3 applications @ 3 and 14 kg a.i./ha with 7 day intervals).

[2] Bold fonts indicates exceedance of LOC.

Table 6 Refined Risk Assessment of Carbaryl to Aquatic Organisms from Spray Drift

Organism	Exposure	Endpoint for RA (mg a.i./L)	Rate (g a.i./ha)	Drift EEC* (mg a.i./L)	RQ[1]
Freshwater Species					
Invertebrate	Acute	0.0018	2250	0.03	**17**
			5792.35	0.08	**44**
			36041.3	0.495	**275**
	Chronic	0.0015	2250	0.03	**20**
			5792.35	0.08	**53**
			36041.3	0.495	**330**
Fish	Acute	0.025	2250	0.03	**1.2**
			5792.35	0.08	**3**
			36041.3	0.495	**20**
	Chronic	0.21	2250	0.03	0.14
			5792.35	0.08	0.4
			36041.3	0.495	**2**
Amphibian	Acute	0.84	2250	0.165	0.2
			5792.35	0.42	0.5
			36041.3	2.6	**3**
	Chronic	0.21	2250	0.165	0.8
			5792.35	0.42	**2**
			36041.3	2.6	**12**
Plant	Acute	0.635	2250	0.03	<0.1
			5792.35	0.08	0.1
			36041.3	0.495	0.8
Estuarine/Marine Species					
Invertebrate	Acute	0.028	2250	0.03	**1.1**
			5792.35	0.08	**3**
			36041.3	0.495	**18**
Fish	Acute	0.26	2250	0.03	0.1
			5792.35	0.08	0.3
			36041.3	0.495	**2**

* Based on drift of 11% for a default droplet size of fine (insecticides).
[1] Bold fonts indicates exceedance of LOC.

Table 7 Risk Assessment of Carbaryl for Aquatic Organisms from Runoff

Toxicity Endpoint	EEC (µg a.i./L)*	Endpoint (µg a.i./L)	RQ**
Freshwater Organisms			
Invertebrates			
Acute	11	1.8	**6**
Chronic	0.11	15	0.007
Amphibians			
Acute	11	840	0.01
Chronic	0.11	210	0.0001
Fish			
Acute	11	25	0.44
Chronic	0.11	210	0.0005
Plants			
Acute	11	550	0.02
Marine/Estuarine Organisms			
Invertebrates			
Acute	11	28	0.4
Fish			
Acute	11	260	0.04

* 95th percentile of the maximum and arithmetic mean concentration for each study/site including ½ LOD for non-detects for acute and chronic, respectively.

** Bolded number indicates risk of concern.

Appendix XIX Label Amendments for Products Containing Carbaryl

The label amendments presented below do not include all label requirements for individual end-use products, such as first aid statements, disposal statements, precautionary statements and supplementary protective equipment. Additional information on labels of currently registered products should not be removed unless it contradicts the label statements below.

A submission to request label revisions will be required within 90 days of finalization of the re-evaluation decision.

The labels of end-use products in Canada must be amended to include the following statements to further protect workers and the environment.

The following uses should be removed from all current labels:

- Indoor pest control uses including greenhouse, use in residences, food and feed handling establishments and barns and livestock production areas;
- Aerosol products;
- Dust uses covers pets, agricultural and domestic;
- All residential uses;
- Livestock for food;
- Livestock for non-food;
- Companion animals;
- Applications by hand, spoon and bellygrinder; and
- Tobacco crops.

Wettable Powder in Water Soluble Packaging (WSP):

All carbaryl products currently listed as wettable powders must be contained in water soluble packaging. Label language should be clarified to indicate directions for water soluble packaging.

TOXICOLOGICAL INFORMATION

Labels of pesticide products carry statements regarding symptoms of poisoning and treatment, which are especially important for those who may be overexposed when working with the product in a commercial or industrial setting e.g. mixers/loaders who handle more concentrated forms. Based on the toxicological assessments, the label text of the carbaryl-containing products should be expanded and/or standardized, as follows:

Toxicological Information

Carbaryl is a carbamate which is a cholinesterase inhibitor. Typical symptoms of overexposure to cholinesterase inhibitors include malaise, muscle weakness, dizziness and sweating. Headache, salivation, nausea, vomiting, abdominal pain and diarrhea are often prominent. A life-threatening poisoning is signified by loss of consciousness, incontinence, convulsions and respiratory depression with a secondary cardiovascular component. Treat symptomatically. If

exposed, plasma and red blood cell cholinesterase tests may indicate degree of exposure (baseline data are useful). However, if a blood sample is taken several hours after exposure, it is unlikely that blood cholinesterase activities will be depressed, due to rapid reactivation of cholinesterase. Atropine, only by injection, is the preferable antidote. Do not use pralidoxime. In cases of severe acute poisoning, use antidotes immediately after establishing an open airway and respiration. With oral exposure, the decision of whether to induce vomiting or not should be made by an attending physician.

PRECAUTION STATEMENTS

The following label statement must be added to all labels:

Keep the following personal protective equipment immediately available for use in case of emergency (i.e. a broken package, spill or equipment breakdown): chemical-resistant coveralls, chemical-resistant gloves, chemical-resistant head gear and a respirator.

Not for use in greenhouses, including on ornamentals.

The following statement must be added to all labels with the exception of those for bran bait:

Apply only when the potential for drift to areas of human habitation or areas of human activity (houses, cottages, schools and recreational areas) is minimal. Take into consideration wind speed, wind direction, temperature, application equipment and sprayer settings.

The following label statement must be added to the appropriate labels:

Carbaryl is not for use on any commercial orchard crop that is turned into a "U-PICK" or "PICK YOUR OWN" or similar operation.

Engineering Controls and Personal Protective Equipment

Label statements must be amended (or added) to include the following directions to the appropriate labels:

Mixing/Loading

A. Mixing and Loading Bran Bait:
Wear cotton coveralls over long pants and a long-sleeved shirt, shoes plus socks and chemical resistant gloves.

B. Mixing and Loading liquids:
Use a closed mixing system.
Wear chemical resistant coveralls over long pants and a long-sleeved shirt, shoes plus socks and chemical resistant gloves.

C. Mixing and Loading Wettable Powders in Water Soluble Packaging:
Wear chemical resistant coveralls over long pants and a long-sleeved shirt, shoes plus socks and chemical resistant gloves.

Applying

A. Applying Bran Bait:
Use an open or closed cab broadcast spreader.
Wear cotton coveralls over long pants and a long-sleeved shirt, shoes plus socks and chemical resistant gloves.

B. Applying by air:
Wear cotton coveralls over long pants and a long-sleeved shirt, shoes plus socks.

C. Applying by groundboom:
During groundboom application use a closed cab that provides both a physical barrier and respiratory protection (i.e dust/mist filtering and/or vapour/gas purification system). The closed cab must have a chemical resistant barrier that totally surrounds the occupant and prevents contact with pesticides outside the cab.

Wear cotton coveralls over long pants and a long-sleeved shirt, shoes plus socks. Have chemical resistant gloves ready for leaving the cab during calibration, repair or cleaning of equipment.

D. Applying by airblast:
During airblast application, use a closed cab that provides both a physical barrier and respiratory protection (i.e dust/mist filtering and/or vapour/gas purification system). The closed cab must have a chemical resistant barrier that totally surrounds the occupant and prevents contact with pesticides outside the cab. Wear cotton coveralls over long pants and a long-sleeved shirt, shoes plus socks. Have chemical resistant gloves ready for leaving the cab during calibration, repair or cleaning of equipment.

If a closed cab is not feasible, wear chemical resistant coveralls over long pants and a long-sleeved shirt, shoes plus socks, chemical resistant gloves and chemical-resistant headgear. Chemical resistant headgear includes So'Westers, or large brimmed, water-proof hats, and hoods with sufficient neck protection. Avoid touching face or other unprotected parts of the body during application.

E. Applying by right-of-way sprayer:
Wear chemical resistant coveralls over long pants and a long-sleeved shirt, shoes plus socks and chemical resistant gloves.

F. Applying by handheld equipment:
Wear chemical resistant coveralls over long pants and a long-sleeved shirt, shoes plus socks, chemical resistant gloves and NIOSH approved respiratory protection.

Add to ENVIRONMENTAL HAZARDS:

TOXIC to bees. Do not apply when bees are actively foraging.

TOXIC to birds, mammals and aquatic organisms. Observe buffer zones specified under DIRECTIONS FOR USE.

To reduce runoff from treated areas into aquatic habitats, consider the characteristics and conditions of the site before treatment. Site characteristics and conditions that may lead to runoff include, but are not limited to: heavy rainfall, moderate to steep slope, bare soil, poorly draining soil (e.g. soils that are compacted or fine textured such as clay).

Contamination of aquatic areas as a result of runoff may be reduced by including a vegetative strip between the treated area and the edge of the water body.

Avoid application of this product when heavy rain is forecast.

Add to DIRECTIONS FOR USE:

All label directions concerning the application of carbaryl to turf or residential settings be removed and replaced with the following statement:

- Not for use on turf, golf courses, sod farms, residential ornamentals or residential vegetable gardens.

The March 2006 label (Registration Number 6839 and 16653) rates for small fruit crops need to be revised.

Sevin Brand 50W Carbaryl Insecticide Wettable Powder (Registration Number 6839).

The column heading should be changed from Kilograms of Sevin 50W/500 litres to Kilograms of Sevin 50W/Hectare.

Crop	Insect	Kilograms of Sevin 50W/Hectare	Pre-harvest interval (days)	Specific Directions

Sevin SL Carbaryl Insecticide Liquid Suspension (Registration Number 16653).
The column heading should be changed from Kilograms of Sevin 50W/1000 litres to Kilograms of Sevin 50W/Hectare.

Crop	Insect	Kilograms of Sevin 50W/Hectare	Pre-Harvest Interval (days)	Specific Directions

Apple thinning rates also need to be revised:

Sevin Brand 50W Carbaryl Insecticide Wettable Powder (Registration Number 6839).

The information for apple thining in the column Kilograms of Sevin 50W/500 must be changed from 0.25 to 5.0 to 0.25 to 0.5.

Crop	Kilograms of Sevin 50W/500 litres	Pre-Harvest Interval (days)	Specific Directions
Apple thinning	0.25 to 0.5	1	Apply in one full coverage spray timed between 10 to 25 days after full bloom. If factors such as tree age, variety, nutrition, previous crop, pruning, bloom and degree of set, favour excessive fruit thinning with SEVIN BRAND 50W CARBARYL INSECTICIDE WETTABLE POWDER, exercise caution to avoid possible yield reduction. For easily thinned varieties including Cortland, Grimes, Jonathan, McIntosh, Orleans, Rome Beauty, Puritan, Red Delicious, Winesap and Yellow Newton.
Apple Only	0.5 to 1.0	1	For difficult to thin varieties including Baldwin, Ben Davis, Duchess, Early McIntosh, Golden Delicious, Lady Apple, Northern Spy, Rhode Island Greening, Steele Red, Turley, Wealthy, Yellow Transparent and York Imperial.

Consult Table 1 for the maximum number of applications and minimum application intervals proposed per crop:

Table 1 Recommended Applications per Year and Application Intervals

Crop	Applications Per Year	
	Number	Interval (Days)
apples (specific targets, see labels for details)	1	N/A
trap trees; choke cherries; high value trees	1	N/A
alfalfa, clover; ditch banks, etc; rapeseed (canola); sweet white lupin; barley, oats, rye, wheat; corn (sweet and field); blackberries, boysenberries, dewberries, loganberries, raspberries; blueberries; cranberries; strawberries; tobacco	2	8
beet tops, Chinese cabbage, dandelion, endive, kale, leaf lettuce, mustard greens, parsley, salsify (tops), spinach, Swiss chard, turnip (tops), watercress, parsnips; asparagus; broccoli, Brussels sprouts, cabbage, cauliflower, celery, lettuce, kohlrabi; beans; beet (root), horseradish, radish, rutabaga (root), salsify (root), turnip (root); carrots, peas, potatoes, snapbeans, tomato, eggplants, peppers, cucumbers, melons, squash; azalea, carnation, chrysanthemums, gladiolus, holly, hydrangea, lilac, rose, zinnia; green ash	2	7
balsam fir, spruce in farm woodlots, municipal parks, rights-of-way; forests; apples, pears; apricot, peach, cherries, plums, prunes; grapes; arborvitae, birch, boxwood, dogwood, elm, juniper, maple, oak, pines, ornamentals	3	7

These following restricted entry intervals are proposed in Table 2.

Table 2 Recommended Restricted Entry Intervals

Crop	REI (Days)
balsam fir, spruce	34
forests	13
trap trees	7
alfalfa, clover	10
ditch banks, etc	2
rapeseed (canola)	3
sweet white lupin	10
asparagus	2
barley, oats, rye, wheat	10
beans	11
root crops	10
carrots	10
corn (sweet and field)	7
corn (field)	21
cole crops	14
leafy vegetables	10
parsnips	10
peas	10
potato	8
snapbeans	10
Tomato, eggplants, peppers	6
apples, pears, apricot, peach, cherries, plums	35
berries	10
blueberries	9
prunes	33
cucumbers, melons, squash	6
cranberries	5
grapes	51
strawberries	11
tobacco	17
choke cherries	21
ornamental trees	28
ornamental shrubs and flowers	13
green ash	24
high value trees	7
all bran bait applications	12 hours

Field sprayer application: **DO NOT** apply during periods of dead calm. Avoid application of this product when winds are gusty. **DO NOT** apply with spray droplets smaller than the American Society of Agricultural Engineers (ASAE) fine classification. Boom height must be 60 cm or less above the crop or ground.

Airblast application: **DO NOT** apply during periods of dead calm. Avoid application of this product when winds are gusty. **DO NOT** direct spray above plants to be treated. Turn off outward pointing nozzles at row ends and outer rows. **DO NOT** apply when wind speed is greater than 16 km/hr at the application site as measured outside of the treatment area on the upwind side.

Aerial application: **DO NOT** apply during periods of dead calm. Avoid application of this product when winds are gusty. **DO NOT** apply when wind speed is greater than 16 km/hr at flying height at the site of application. **DO NOT** apply with spray droplets smaller than the American Society of Agricultural Engineers (ASAE) fine classification. To reduce drift caused by turbulent wingtip vortices, the nozzle distribution along the spray boom length **MUST NOT** exceed 65% of the wing- or rotorspan.

Buffer Zones:

Use of the following spray methods or equipment **DO NOT** require a buffer zone: hand-held or backpack sprayer and spot treatment.

The buffer zones specified in the table below are required between the point of direct application and the closest downwind edge of sensitive terrestrial habitats (such as grasslands, forested areas, shelter belts, woodlots, hedgerows, riparian areas and shrublands), sensitive freshwater habitats (such as lakes, rivers, sloughs, ponds, prairie potholes, creeks, marshes, streams, reservoirs and wetlands) and estuarine/marine habitats.

Table 3 Buffer Zones

Method of Application	Crop		Buffer Zones (metres) Required for the Protection of:			
			Freshwater Habitat of Depths:		Estuarine/Marine Habitats of Depths:	
			Less than 1 m	Greater than 1 m	Less than 1 m	Greater than 1 m
Field sprayer*	Cereals, Potato, Alfalfa		20	10	15	5
	Corn, Turnip		25	10	20	10
	Ornamentals		30	15	20	10
	Berries		30	15	20	10
	Turf		90	40	60	30
Airblast	Grapes	Early growth stage	50	40	45	35
		Late growth stage	40	30	35	25
	Apple, Pear, Peach, Strawberry	Early growth stage	55	45	50	40
		Late growth stage	45	35	40	30
Aerial	Field crops, Forages,	Fixed wing	350	200	275	175

Method of Application	Crop		Buffer Zones (metres) Required for the Protection of:			
			Freshwater Habitat of Depths:		Estuarine/Marine Habitats of Depths:	
			Less than 1 m	Greater than 1 m	Less than 1 m	Greater than 1 m
	Cereals, Vegetables, Tobacco	Rotary wing	325	200	250	150
	Corn	Fixed wing	325	200	250	175
		Rotary wing	325	200	250	150
	Forests, Woodlands	Fixed wing	800	725	800	575
		Rotary wing	800	675	800	550
	Berries, Grapes	Fixed wing	800	575	725	475
		Rotary wing	800	575	700	450

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

When a tank mixture is used, consult the labels of the tank-mix partners and observe the largest (most restrictive) buffer zone of the products involved in the tank mixture.

Appendix XX List of References

A. Information Considered for the Chemistry Risk Assessment

Studies/Information Submitted By Applicant/Registrant (Unpublished)

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Additional Information Considered

Published Information

PMRA Reference Number	Reference
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B. Information Considered for the Toxicological Risk Assessment

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