UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

February 20, 2003

Memorandum

SUBJECT: **Carbaryl**: Revised Phase 5 Occupational and Residential Exposure Assessment and Recommendations for the Reregistration Eligibility Decision Document. PC Code 056801; Submission No. S533427; DP Barcode: D287251.

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Risk Assessment Review Committee (June 6, 2001 Report)

This document presents updated occupational and residential exposures/risks which have been calculated in response to comments received during Phase III of the Agency's RED process. Several issues in the comments were raised that resulted in specific changes including: the transfer coefficient for tree crop harvesters was reduced from 3000 to 1500 cm^2/hr; protective headgear was considered quantitatively for open cab airblast applicators; and additional characterization language was developed for large acreage applications. The Agency also considered recently submitted additional data in the development of this document including: a biomonitoring study of suburban resident carbaryl users and their families (MRID 45788501); documents associated with the biomonitoring study that address pharmacokinetics and metabolism (MRID 45788502) and an analysis of the data (MRID 45792001); an analysis of use and usage information from the Residential Exposure Joint Venture; preliminary probabilistic risk assessment results from Bayer; and a pet collar residue dissipation study (MRID 45792201). The methods used to calculate exposures to treated pets and exposures from mosquito control applications were also updated to reflect the most current approaches. Comments from other groups (e.g., advocacy and commodity organizations) were considered as appropriate.

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Executive Summary

Carbaryl [1-napthyl methylcarbamate] is one of the most widely used broadspectrum insecticides in agriculture, professional turf management, professional ornamental production, and in the residential pet, lawn and garden markets. Carbaryl formulations include baits, dusts, pet collars, flowable concentrates, emulsifiable concentrates, granulars, soluble concentrates, and wettable powders. Carbaryl is used in agriculture to control pests on terrestrial food crops including fruit and nut trees (e.g., apples, pears, almonds, walnuts, and citrus), many types of fruit and vegetables (e.g., cucumbers, tomatoes, lettuce, blackberries, and grapes), and grain crops (e.g., corn, rice, sorghum, and wheat). Carbaryl is also used for direct animal treatments to control pests on poultry and companion animals such as dogs and cats. There are other uses for ornamentals and turf, including production facilities such as greenhouses, golf courses, and residential sites that can be treated by professional applicators (e.g., annuals, perennials, shrubs). Carbaryl can also be used by homeowners on lawns, for home and garden uses, and on companion animals. There are no labels for indoor uses such as crack-and-crevice treatments of a residence. In agriculture, groundboom, airblast, and aerial applications are typical. Other applications can also be made using handheld equipment such as low pressure handwand sprayers, backpack sprayers, and turfguns. Homeowners can also use other types of application equipment including trigger sprayers, hose-end sprayers, and ready-to-use dust packaging. Carbaryl also has more specialized uses that can lead to exposures in the general population which were considered in this assessment such as an adulticide for mosquito control and for Ghost and Mud shrimp control in oyster beds in Washington State.

<u>Exposure Data Used In Assessmenrt</u>

A number of studies were considered in the development of the carbaryl risk assessment that include scenario- and/or chemical-specific handler exposure data for occupational uses and also for residential uses. Chemical-specific residue dissipation data were also considered for agricultural crops, turf, and the oyster bed uses. The occupational handler exposure studies that were used, quantified: exposure to pet groomers using a carbaryl containing shampoo; exposure during application of a granular with two different backpack devices and spoons; exposure from application with a trigger sprayer; and exposures from application to turf with high volume/low pressure handgun for liquid sprays and a granular spreader. Currently, there are no data compensation issues associated with any of these handler data. In all other cases, occupational handler exposure was addressed using PHED (Pesticide Handlers Exposure Database). The occupational postapplication assessment was completed using 5 different residue dissipation studies on 4 crops and turf. The dislodgeable foliar residue (DFR) dissipation studies were all conducted by the Agricultural Reentry Task Force (ARTF) using carbaryl on cabbage, olives, sunflowers, and tobacco. Again, there are no data compensation issues associated with the DFR data because Bayer is a member of the ARTF. The sunflower and tobacco data were used only to assess risks for their specific crop groups because of aerial application with the sunflowers and due to various features of the tobacco crop (e.g., leaf type and shape). The olive and cabbage data were generally used to complete the assessments for all tree crops and all other non-tree crops, respectively. The turf transferable residue (TTR) data were generated by the Bayer Corporation at sites in California, Georgia, and Pennsylvania. These chemical-specific dissipation data were all used in conjunction with the Agency's revised policy on transfer coefficients to calculate postapplication exposures and risks (August 7, 2000/Policy 003.1). All of the studies used by the Agency to assess occupational risks were considered to be the best source of data available for the scenario where it was used. These recent studies were all considered high quality based on current Agency guidance. The oyster bed uses were evaluated using sediment and water concentration data generated by the Washington State Department of Ecology or the Shoalwater Creek Indian Tribe.

A number of other studies were submitted by the Bayer Corporation that focused on quantifying exposures during the application of homeowner products and other residential exposures. Three studies used carbaryl-containing products to quantify exposures during application of a dust to dogs, application of various products to gardens (i.e., dusts, trigger sprayer, and liquid application with hose-end sprayer or low pressure handwand), and application of a liquid to trees and shrubs using a hose-end sprayer or low pressure handwand sprayer. In addition to these studies, which were all conducted by the Bayer Corporation, an additional study completed by the ORETF that quantified exposures during granular application to turf with a rotary spreader and during liquid spray application to turf with a hose-end sprayer was used. Bayer is a member of the ORETF so there are no data compensation issues associated with the use of this study. For postapplication exposures, Bayer also submitted a study which quantified dermal exposure on turf using oxadiazon (Ronstar formulation). The Agency did not use this study in the risk assessment because of technical issues including levels of transferability compared to the carbaryl TTR data and the dormant timing of the application which is not typical for carbaryl use. In cases where chemical- or scenario-specific data were unavailable, the Agency relied on guidance provided in the *SOPs For Residential Exposure Assessment* and various supporting documents. The studies described above for residential exposures all rely on the use of passive dosimetry/deterministic approaches to quantify exposures. In addition to these studies, Bayer Corporation conducted an extensive biological monitoring study of suburban residences where carbaryl was used to treat lawns along with either gardens or ornamental plants. Those who applied, their spouses and other adults living in the selected homes, and children who lived there were monitored. Bayer also submitted an analysis of carbaryl use information from the Residential Exposure Joint Venture survey of residential pesticide users. In addition to these data various supporting information were submitted including a position document focused on the pharmacokinetics of carbaryl in humans and Bayer's analysis of the biomonitoring data. Readers are encouraged to consider the results of the deterministic assessment in conjunction with the results of the suburban resident biological monitoring study.

Hazard Concerns

This risk assessment incorporates the recent revisions by the HIARC and reconsideration of the FQPA safety factor based on recently revised policies. Calculations have been completed for short-term and intermediate-term exposures for all occupational scenarios. Chronic exposures have also been calculated for a limited number of scenarios in the ornamental/greenhouse industry where such exposure patterns might be expected. Risks for residential handlers are considered to be short-term in nature only because homeowner uses are expected to be infrequent. Residential postapplication risks have been calculated based on short-term and intermediate-term exposures because repeated postapplication exposures are likely while they are not for handlers based on use patterns. Cancer risks were calculated for all adults scenarios using a linear, low-dose extrapolation approach (LADD or Lifetime Average Daily Dose and Q_1*). The short- and intermediate-term dermal risk assessments for carbaryl were based on a 21-day dermal toxicity study in rats that used technical material where decreases in red blood cell and brain cholinesterase were observed

(NOAEL = 20 mg/kg/day). The short-term inhalation and nondietary ingestion risk assessments for carbaryl were based on a developmental neurotoxicity study in rats where alterations in FOB parameters on the first day of dosing were observed (NOAEL = 1 mg/kg/day). The results of this study were applied to short-term exposure durations of up to 30 days. This endpoint was also used to calculate risks from the suburban resident biomonitoring study because it eliminated route-to-route extrapolation; the dose values from the study could be attributed to various exposure routes; oral absorption is fast and essentially quantitative; and, when adjusted for absorption, the effective NOAEL from the dermal toxicity study is similar to that observed in the oral study. The intermediate-term inhalation and non-dietary ingestion risk assessments for carbaryl are based on a subchronic neurotoxicity study in (NOAEL = 1 mg/kg/day). The effects that were observed and selected as the basis for the endpoint used in risk assessment included decreases in plasma, red blood cell, whole blood and brain cholinesterase activity and changes in functional observational battery (FOB) parameters. The results of this study were applied to exposure durations greater than 30 days up to several months. The chronic risk assessments for carbaryl were based on a 1 year dog feeding study (LOAEL = 3.1 mg/kg/day). The effects that were observed and selected as the basis for the endpoint used in risk assessment included decreases in plasma, and brain cholinesterase activity. The results of this study were applied to chronic exposure durations and to all routes of exposure (i.e., dermal, inhalation, and non-dietary ingestion). Carbaryl was classified as a Class C carcinogen and was assessed for carcinogenic risk from exposure using a linear, low dose extrapolation approach with a Q_1* of 8.75×10^{-4} $(mg/kg/day)^{-1}$. A dermal absorption factor of 12.7 percent was selected from a rat dermal absorption study using radiolabeled ^{14}C. A 100 percent inhalation absorption factor was used to convert all inhalation exposures to an oral equivalent inhalation dose.

The Agency's level of concern for noncancer risks (i.e., target level for MOEs or Margins of Exposure) is defined by the uncertainty factors that are applied to the assessment. The Agency applies a factor of 100 in cases to account for inter-species extrapolation to humans from the animal test species and to account for intra-species sensitivity. In cases where a NOAEL was not identified and a LOAEL was used for risk assessments, an additional uncertainty factor of 3 was applied. Based on the requirements of the 1996 Food Quality Protection Act, the Agency must also consider sensitive populations in its non-occupational risk assessments. The Agency reduced the FQPA safety factor to 1x for non-occupational exposures to carbaryl because there are no residual concerns regarding pre- or post-natal toxicity or with the completeness of the toxicity or exposure databases. The total uncertainty factors that have been applied to different noncancer risk assessments include 100 for short-term and intermediate-term occupational scenarios. Chronic occupational exposures, which are very limited in scope, have an uncertainty factor of 300 because a LOAEL from the chronic dog study has been used for risk assessment purposes. Since the FQPA safety factor is 1x, all residential scenarios have the same factors applied to each duration of exposure as well. Cancer risk levels were evaluated based on 1996 Agency guidance by then office director Dan Barolo that stipulates a risk concern ranging from 1×10^{-4} to 1×10^{-6} for occupational settings and 1×10^{-6} for residential settings.

Occupational Handler Risks

For occupational handlers, most scenarios have risks associated with them that meet or exceed the Agency's uncertainty factors for noncancer risk assessments (i.e., 100 for short-term and intermediate-term and 300 for chronic) and requirements for cancer risk results (i.e., range of $1x10^{-6}$ to $1x10^{-4}$ as defined by Office Director Barolo in 1996) at some level of personal protection. Current carbaryl labels typically require that handlers wear long pants, long-sleeved shirts, and gloves. Respirators are generally not required. For most scenarios, the noncancer risks for this personal protection ensemble do not meet Agency risk requirements and additional levels of personal protection are required to achieve Agency risk targets. In fact, in many cases engineering controls such as closed loading systems or closed cab tractors are needed. The Agency does have risk concerns over the use of carbaryl in some agricultural and other occupational settings (i.e., MOEs at any level of personal protection are <100 or <300, depending on the duration). As expected, these scenarios with the highest associated risk also have high daily chemical use based on application rates or high acreages treated or the exposures for the scenarios in question are relatively high. Generally, the areas that appear to be problematic include: large acreage aerial and chemigation applications in agriculture or for wide area treatments such as mosquito control; airblast applications at higher rates; pet grooming; and the use of certain handheld equipment for applications to turf or gardens (e.g., bellygrinder). This general trend was essentially the same for both short-term and intermediate-term exposures. Risks for corresponding scenarios based on cancer concerns were generally less than noncancer results across all scenarios. In fact, in all but one scenario, cancer risks were $<1x10^{-4}$ at current carbaryl label requirements of single layer clothing, gloves, and no respirator for both private growers and commercial applicators. Higher levels of personal protection reduce this risk to $<1x10^{-4}$ for all scenarios in both populations. If a $1x10^{-6}$ risk level is specified as a concern, results are similar in that risks for a majority of scenarios are $<1x10^{-6}$ at current label requirements. In fact, only 8 of the 128 scenarios considered for private applicators have cancer risks $>1x10^{-6}$ (and less than $1x10^{-4}$) even when the most protective ensembles of either protective clothing or engineering controls are considered. For commercial applicators, results indicate that risks for about half of the scenarios considered are $<1x10^{-6}$ at current label requirements and that only 21 of the 128 scenarios considered have cancer risks $>1x10^{-6}$ (and less than $1x10^{-4}$) even when the most protective ensembles of either protective clothing or engineering controls are considered. Several data gaps were also identified in many different use areas that include: dust use for animal grooming and in agriculture; various specialized hand equipment application methods (e.g., powered backpack, power hand fogger, and tree injection); and nursery operations such as seedling dips.

Occupational Post-application Worker Risks

Current label requirements specify 12 hour Restricted Entry Intervals (REIs) while Pre-Harvest Intervals (PHIs) are less than 7 days for most crops with some as long as 28 days. For all but the lowest exposure scenarios in some crops, MOEs do not meet or exceed required uncertainty factors until several days after application. If short-term risks are considered, MOEs meet or exceed the Agency uncertainty factor generally in the range of 3 to 5 days after application for lower to medium exposure activities and from 8 to 12 days after application in most higher exposure scenarios. If intermediate-term risks are considered, MOEs are not of concern based on a 30 day average exposures except for higher level exposures such as harvesting in some crops. Chronic exposures are of concern for the cut flower industry but not for other general greenhouse and nursery production activities based on the most recent ARTF data. Cancer risks were calculated for private growers and professional farmworkers with the only difference being the annual frequency of exposure days. Cancer risks for private growers and commercial farmworkers are generally in the 10^{-8} to 10^{-6} range on the day of application. If a $1x10^{-4}$ cancer risk is the target, the current REI would be adequate for all scenarios considered in the assessment. If a $1x10^{-6}$ cancer risk is used, then durations longer than the current REI should be considered for some cases which are not considered low to medium exposures. It should be noted that the cancer risk calculations are less restrictive than noncancer risk estimates for the same scenarios in all cases. It should also be noted that the preliminary results of the biological monitoring study conducted for tree fruit harvesters and thinners essentially confirms the results for those populations.

Many mechanized or partially mechanized processes are possibly associated with the use of carbaryl that may limit or eliminate exposures (e.g., combines for grain harvest). Mechanized practices can be divided into fully mechanized activities that meet the definition of “No contact” in the Agency’s Worker Protection Standard (WPS) and mechanically assisted practices with potential for exposure. In the case of fully mechanized activities, the Agency does not complete a quantitative exposure assessment but applies criteria outlined in the Agency’s Worker Protection Standard (WPS). In cases of partially mechanized activities where the potential for exposure exists, the Agency assesses the resulting exposures similarly to those resulting from hand labor activities. The Agency also acknowledges that there is some potential for exposure because individuals engaged in fully mechanized activities have short-term excursions from the protected area for various reasons (e.g., unclogging machinery or equipment inspection for breakage). In these cases, the WPS §170.112(c) *Exception for short-term activities* applies. Several data gaps exist such as an incomplete DFR database and a lack of exposure data on partially mechanized cultural practices where there is a potential for exposure. Additionally, because of the number and breadth of carbaryl uses, there may be many exposure pathways where the transfer coefficient approach is not an appropriate model (e.g., hand transplanting where no foliar contact occurs) that have not been quantitatively addressed due to a lack of data.

Residential Handler Risks Calculated Using Deterministic Methods

For residential handlers, MOEs associated with most scenarios (40 of 52 considered) are generally not of concern because they exceed the Agency’s uncertainty factors for noncancer risk assessments (i.e., MOE = 100). The scenarios of concern involve the use of dusts (in gardens and on pets) and for some liquid sprays on gardens. Cancer risks were calculated for a single day of use then the allowable annual number of days exposure was defined based on a cancer risk limit of $1x10^{-6}$. Based on a single day of exposure, cancer risks for most scenarios are in the 10^{-8} to 10^{-10} range although there is one scenario where the risks slightly exceed $1x10^{-6}$ (dusting dogs - $1.09x10^{-6}$) even for a single day of use. It should be noted that there are 5 scenarios where the allowable days per year of exposure is less than or equal to 5 which should be considered in conjunction with the use/usage data from Bayer that indicates 5 uses per year is the 84th percentile. The database for carbaryl is fairly complete compared to many other chemicals. Recent, high quality data generated by the Bayer Corporation and the ORETF, of which Bayer is a member, have been used to address the key residential uses of carbaryl on lawns, flower and vegetable gardens, and pets. Use and usage inputs also appear to be essentially consistent with the information provided by the Bayer Corporation at the 1998 SMART meeting. No key data gaps have been identified by the Agency at this time for residential handlers. However, it is likely that there are scenarios that remain unaddressed by the Agency at this time due to a lack of data or other meta information. The Agency will address other appropriate scenarios as they are identified. It should also be noted that information from the Residential Exposure Joint Venture survey of residential pesticide users does not contradict or in anyway supercede the use information considered in this assessment. Readers are encouraged to consider the results of the deterministic assessment in conjunction with results of both the REJV and the suburban resident biological monitoring study.

Residential Post-application Risks Calculated Using Deterministic Methods

The Agency considered a number of residential postapplication exposure scenarios for different segments of the population including toddlers, youth-aged children and adults. Short-term and intermediate-term noncancer risks were calculated for all scenarios. Additionally, cancer risks were calculated for the exposure scenarios involving adults. In residential settings, the Agency does not use REIs or other mitigation approaches to limit exposures because they are viewed as impractical and not enforceable. As such, risk estimates on the day of application are the key concern.

The Agency considered a number of exposure scenarios for products that can be used in the residential environment representing different segments of the population including toddlers, youth-aged children and adults. Short-term and intermediate-term noncancer MOEs were calculated for all scenarios. Chronic exposures from pet collars were also considered. Additionally, cancer risks were calculated for the exposure scenarios involving adults where methods are currently available. Cancer risks were not calculated for children per Agency policy. In residential settings, the Agency does not use REIs or other mitigation approaches to limit exposures because they are viewed as impractical and not enforceable. As such, risk estimates on the day of application are the key concern.

The Agency has short-term risk concerns for exposures to adults doing heavy yardwork, for toddlers playing on treated lawns, and for toddlers that have contact with pets treated with dust or liquid products. Activities associated with home gardening (e.g., harvesting) and golfing for adults, home gardening for youth-aged children, toddler contact with pets wearing carbaryl collars, or any age or activity considered in the adulticide mosquito control or oyster assessment do not have risk concerns even on the day of application (i.e., MOEs $\geq$100 on the day of application). For adults, the MOEs for heavy yardwork do not meet or exceed risk targets (i.e., MOE = 100) up to 5 days after application. For toddlers, the Agency has concerns for pet treatments (non-collars) and also for lawn uses. In fact, pet uses never reach acceptable levels even 30 days after application (using Agency approach on pets) and not until 18 days at the maximum application rate considered on turf. Toddler

MOEs from pet and turf uses represent total exposures from many pathways. For the pet uses, dermal and hand-to-mouth exposures essentially both equally contribute to the overall estimate. For the turf uses, dermal and hand-to-mouth exposures are also the key contributors to the overall estimates.

The Agency does not have intermediate-term risk concerns for adults and youth-aged children for any of the uses considered including lawncare, home gardens, golfing, and any aspect of adulticide mosquito control or oyster bed uses. Likewise, the Agency does not have concerns for children's contact with pets treated with carbaryl collars. In contrast, the Agency does have intermediate-term risk concerns for all toddler exposure scenarios considered except pet collars (i.e., pet treatments and lawncare uses). As with the short-term MOEs, pet (non-collar) and turf uses represent total exposures where the significant contributions to overall exposures are again made equally from the dermal and hand-to-mouth exposure pathways.

Cancer risks were calculated only for adults and were found to be in the 10^{-8} to 10^{-12} range, regardless of the scenarios considered, on the day of application (e.g., lawncare, golfing and gardening). Risks did not exceed 1×10^{-6} on the day of application for any scenario considered. All postapplication cancer risks were calculated based on an annual frequency of 1 exposure per year. It is likely that additional events could occur but data linking postapplication activities and carbaryl use patterns are not available. To address this issue, the Agency calculated the number of exposures that can occur under a cancer risk ceiling of 1×10^{-6} and determined that from 20 days per year to exposures every day of the year could occur depending upon the scenario. Results indicate most activities can occur from every day of the year even at residue levels present on the day of application..

Unlike many residential risk assessments, the postapplication residential assessment for carbaryl is based on a number of chemical-specific studies that have been used to calculate risks from turf uses (e.g., TTR study) and in gardens (i.e., DFR data). There are no transferable residue data available for pet uses, except collars, which is a key data gap. Additional data could potentially be used to refine risk estimates for the other settings such as additional DFR data on different crops and TTR data which are more appropriate for hand-to-mouth and object-to-mouth exposures.

The Agency combines or aggregates risks resulting from exposures to individual chemicals when it is likely they can occur simultaneously based on the use pattern and the behavior associated with the exposed population. For carbaryl, the Agency has combined risk values (i.e., MOEs) for different kinds of exposures associated with the turf (dermal, hand-to-mouth, object-to-mouth, and soil ingestion) and pet scenarios (dermal and hand-to-mouth). These represent the standard set of exposures that are typically added together when chemicals are used on turf or on pets because it is logical they can co-occur. Typically, the Agency only adds exposures from different exposure scenarios together (e.g., spraying and gardening) when risks from both are not already a concern. For carbaryl, there are risk concerns for many residential handler scenarios already so the Agency did not add risk values from any postapplication exposure together with applicator risks.

Residential Risks Calculated Based On Suburban Resident Biological Monitoring Study

The suburban resident biological monitoring study for carbaryl has been used by the Agency to examine the exposure patterns and associated risks that can occur in households where the lawn and gardens or ornamentals have been treated. This study quantified absorbed dose levels of carbaryl to 106 people in 23 households in California and Missouri. Adult applicators, adult non-applicators, and children (ages 4 to 17) were monitored. Lawns were treated at each residence. Additionally gardens or ornamental plants were also treated at each residence. The results of this study should be considered in conjunction with the results of the deterministic assessments described above. Based on use information alone (provided in an analysis of the Residential Exposure Joint Venture survey), the population which was monitored in the study could be construed to represent a population which has the highest possible exposures associated with it because of the concurrent applications to different areas which were examined (i.e., in all cases lawns and another area was treated). However, the Agency believes that the lawn use was the key contributor to overall exposures which should be considered with the associated risks.

As with the companion deterministic assessments which have been completed for residential settings, noncancer risks are of most concern to the Agency when compared to cancer risks. There are different possible methods for calculating risks from this study because of the random nature of the exposure patterns and what the pharmacokinetics analysis determined about the excretion profile for carbaryl. The Agency placed individuals into likely groups for its analysis that included applicators, non-applicator adults, and children of various ages. The Agency also considered a number of possible approaches for evaluating the data in conjunction with the information about pharmacokinetics. The Agency recommended an approach in which post-application total dose values (i.e., daily outputs added together since the study monitored residues for 96 hours after application which is the time it takes for single carbaryl dose to be eliminated from the body) with the knowledge that this approach could overestimate exposure if multiple exposure events occurred early in the monitoring period. It should be noted, however, that if the key exposure events occurred later in the monitoring period that the total value could underestimate exposure due to incomplete sample collection. The Agency also used the data in same manner as Bayer which was using individual daily dose values, not corrected for mass balance, which would more than likely underestimate dose based on what is known about the pharmacokinetics and excretion profile for carbaryl.

It is clear that the manner in which noncancer risks are calculated has an impact on the resulting risks. For both calculation techniques; however, the Agency has a concern (i.e., MOEs<100) at the upper percentiles of exposure regardless of how the dose estimate was calculated for adults and children alike (e.g., 95^{th} %tile and up). In the Agency's approach, risks are still of concern based on whatever measure of central tendency is considered for all populations except older children. If single day values are considered, risks are not of concern based on geometric mean values but are of concern if the arithmetic mean is considered for children under 10 years of age. Risks are of most concern for applicators and the youngest children because they have the highest dose levels as would be expected (i.e., applicators are in proximity to product and young children spent time outdoors on treated lawns). The results of this assessment should be considered in the context of the population which was monitored as described by the Agency's interpretation of the *Residential Exposure Joint Venture* use survey (i.e., about 1.2 percent of the general population uses carbaryl on lawns and concurrent use of vegetable and ornamentals further lowers that figure to 0.18 and 0.44 percent, respectively). In summary, the biological monitoring study clearly illustrates that exposures leading to risks of concern for applicators and younger children can occur in households where carbaryl is used. Additionally, risks are of concern at the highest percentiles of exposure (95^{th} %tile and up) regardless of how dose estimates are calculated. If the Agency approach for calculating total dose is considered, risks at the central tendency are also of concern (regardless of which specific exposure statistic is selected) . If the Bayer approach for calculating risks based on single day dose values is considered, risks are of not of concern based on certain measures of central tendency but it should be kept in mind that this approach does not account for mass balance as defined in the pharmacokinetic analysis of the excretion profile for carbaryl. Additionally, it should be noted that cancer risks are not a concern compared to the noncancer risk estimates and that the risks calculated based on the biological monitoring data support those calculated in the deterministic assessments (i.e., body burden and associated risk numbers are very close).

Companion Probabilistic Risk Assessments

As the Agency understands the current situation, Bayer Crop Sciences is in the process of completing assessments using the CARES and Lifeline models, both of which have been reviewed by the FIFRA Science Advisory Panel. The Agency will evaluate the inputs and analysis for both of these when and if they are submitted and if all appropriate criteria for submission have been met. For example, the public availability of any model used for probabilistic assessments is required.

Overall Risk Summary

This risk assessment applied the latest exposure data, toxicology information, and use data. The overall results indicate that the Agency has risk concerns for essentially every marketplace where carbaryl is used. Occupational handler risks can be mitigated through the use of additional protective measures over and above the current label such as engineering controls (e.g., closed cabs or loading systems). Current label REIs are 12 hours. For almost every crop/activity combination considered except some low exposure activities, the current REI appears to be inadequate. Residential handler and postapplication risks also are of concern across many areas.

1.0 Occupational and Residential Exposure/Risk Assessment

1.1 Purpose

This document is the occupational and residential non-dietary exposure and risk assessment for carbaryl which will be used in the reregistration process.

1.2 Criteria for Conducting Exposure Assessments

An occupational and/or residential exposure assessment is required for an active ingredient if (1) certain toxicological criteria are triggered and (2) there is a potential for exposure to handlers (mixers, loaders, applicators) during use or to persons entering treated sites after application is complete. Toxicological endpoints were selected for short-, intermediate-, and long-term exposures (e.g., NOAEL for short- and intermediate-term dermal exposures is 20.0 mg/kg/day based on a 21-day dermal administration toxicity study in rats). Additionally, carbaryl has been classified as a Group C possible human carcinogen (i.e., $Q_1^* = 8.75 \times 10^{-4}$ $(mg/kg/day)^{-1}$). There is a significant potential for exposure in a variety of agricultural, commercial, and residential settings. Therefore, risk assessments are required for occupational and residential handlers and for occupational and residential postapplication exposures that can occur as a result of carbaryl use.

1.3 Summary of Hazard Concerns

The toxicological endpoints that were used to complete the occupational and residential risk assessments are summarized below and in Table 1 which has been extracted from the latest HIARC document detailing the April 2002 meeting, the revised Q_1^* memo of November 8, 2001 (Brunsman, TXR No. 0050265), and the latest FQPA SFC committee report from April 2002. Effects were identified at different durations of exposure ranging from short-term (up to 30 days) to chronic durations (every working day). Carbaryl was classified as a Class C carcinogen and is assessed for carcinogenic risk using a linear, low dose extrapolation approach with a Q_1^* of 8.75×10^{-4} $(mg/kg/day)^{-1}$.

Carbaryl is a widely used carbamate insecticide where the use patterns can vary widely ranging from shorter-term exposures through uses on virtually every working day. As such, when the HIARC recently evaluated the carbaryl hazard database, endpoints were selected to address each duration of exposure. Exposures can occur to occupational users and the general population so both were considered in this assessment.

The short- and intermediate-term dermal risk assessments for carbaryl are based on a NOAEL of 20.0 mg/kg/day which was defined in a dermal toxicity study in rats (MRID 45630601) where decreases in RBC and brain cholinesterase in males and females were observed. The results of this study were used to calculate risks based on passive dosimetry approaches in dermal risk assessment (e.g., using PHED or transfer coefficients to calculate exposures to the skin and associated risks). Bayer submitted a biological monitoring study of suburban residents which quantified exposures to carbaryl based on urinary output of the metabolite 1-naphthol over the course of the study. The Agency calculated risk estimates from the results of this study through the use of the same endpoint used for the short-term inhalation and nondietary ingestion risk assessments. All of these assessments are based on a NOAEL of 1.0 mg/kg/day defined in a developmental neurotoxicity study in rats (MRIDs 44393701, 45456701, 45456702, and 45456703) based on decreased body weight gain, alterations in FOB measurements, and cholinesterase inhibition (plasma, whole blood, and brain). The LOAEL for this study was observed at 10 mg/kg/day. The results of this study were applied to exposure durations of up to 30 days. The Agency used the oral instead of dermal toxicity study to calculate risks based on the biomonitoring study (see *Section 3.3: Carbaryl Suburban Resident Biomonitoring Study, Associated Data & Risks*) because: (1) this approach eliminates the uncertainty of extrapolation based on the dermal absorption study; (2) oral absorption is close to 100 percent, based on the results of the rat metabolism study, which indicates small differences between associated effects and to-the-tissue dose estimates in the biomonitoring study; (3) for other types of exposure, the use of an oral endpoint is more appropriate as absorbed dose values from the biomonitoring study can be attributed to different types of exposure (e.g., oral, inhalation, and dermal), although it is likely that dermal exposure is likely predominant contributor; and (4) the oral endpoints for all durations of exposure have an effective NOAEL of approximately 1mg/kg/day which is slightly lower than if the NOAEL of 20 mg/kg/day was "adjusted" to account for dermal absorption of 12.7 percent resulting in a NOAEL of 2.5 mg/kg/day (which is the highest absorption rate observed in the study and the least conservative approach for estimating a NOAEL) - if the lowest estimate of absorption is used (approximately 5 percent in the dermal absorption study) the effective dermal NOAEL becomes 1 mg/kg/day which is equivalent to the oral NOAEL of 1 mg/kg/day.

The intermediate-term inhalation and nondietary risk assessments for carbaryl (i.e., durations that exceed 30 days but are not chronic in nature) are also based on a NOAEL of 1.0 mg/kg/day that was defined in a subchronic neurotoxicity study in rats (MRID 441226-01). The LOAEL for this study is also 10 mg/kg/day. The effects that were observed and selected as the basis for the endpoint used in risk assessment included decreases in plasma, whole blood, red blood cell, and brain cholinesterase activity and FOB changes. The results of this study were also applied only to the inhalation and nondietary ingestion routes of exposure. The chronic risk assessments for carbaryl are based on a 1 year dog feeding study (MRIDs 401667-01 and 420228-01). The effects that were observed and selected as the basis for the endpoint used in risk assessment included decreases in plasma, and brain cholinesterase activity. A NOAEL was not defined in the study so the endpoint that was selected was the LOAEL. The results of this study were applied to chronic exposure durations and have been applied to all routes of exposure (i.e., dermal, inhalation, and non-dietary ingestion).

A dermal absorption factor of 12.7 percent was selected from a rat dermal absorption study using radiolabeled ^{14}C; this value was used to calculate the oral equivalent dermal dose for noncancer chronic duration exposures and for the calculation of cancer risks. No inhalation toxicity studies were selected for risk assessment purposes so a route-to-route extrapolation was used to address risks from inhalation exposures. No inhalation absorption study was conducted, therefore a 100 percent inhalation absorption factor is used to convert all inhalation exposures to an oral equivalent inhalation dose.

The Agency's level of concern for noncancer risks (i.e., target level for MOEs) is defined by the uncertainty factors that are applied to the assessment. The Agency applies a factor of 100 in cases to account for inter-species extrapolation to humans from the animal test species and to account for intra-species sensitivity. In cases where a NOAEL is not identified and LOAEL values have to be used for risk assessments, the Agency generally applies an additional factor of 3 as was done with carbaryl for chronic duration exposures. Based on the requirements of the 1996 Food Quality Protection Act, the Agency must also consider sensitive populations in its non-occupational risk assessments. The Agency removed the FQPA 1x safety factor for non-occupational exposures to carbaryl (April 3, 2002 FQPA SFC report).

Table 1. Endpoints for Assessing Non-Dietary Risks for Carbaryl

Type of Exposure	Study	Dose	Endpoint	UF
Short- and Intermediate-term Dermal Deterministic Assessment (1 day to several months)	21 Dermal Toxicity Study Using Technical Grade Carbaryl - Rats (MRID 45630601)	20 mg/kg/day (NOAEL)	Significant decreases in RBC and brain cholinesterase (ChE)	100 for residential and 100 for occupational
Short-term Inhalation & Non-dietary Ingestion Deterministic Assessments & Suburban Resident Biomonitoring Study (1 to 30 days)	Developmental Neurotoxicity Study - Rats (MRIDs 44393701, 45456701, 45456702, 45456703) & Acute Neurotoxicity Study - Rats (MRIDs 438452-01/04)	1 mg/kg/day (NOAEL)	Decreased body weight gain; FOB changes; and decreases in plasma, RBC, whole blood, and brain cholinesterase (ChE)	100 for residential and 100 for occupational
Intermediate-term Inhalation & Non-dietary Ingestion (30 days to several months)	Subchronic Neurotoxicity Study - Rats (MRID 441226-01)	1 mg/kg/day (NOAEL)	Decreases in plasma, RBC and brain cholinesterase (ChE) and FOB changes	100 for residential, and 100 for occupational
Chronic Dermal & Inhalation	Dog Chronic Toxicity (MRID 401667-01 and 420228-01)	3.1 mg/kg/day (LOAEL)	Decreases in brain cholinesterase (ChE) in females	300 for residential, and 300 for occupational
Dermal Absorption	Rat Dermal Absorption Study	12.7 percent		
Inhalation Absorption	100% inhalation absorption value - no study available			
Q_1*	0.000875		Based on increased incidence of hemangiomas/hemangiosarcomas in male mice	

A series of acute toxicity tests were also conducted using carbaryl (i.e., outside of the rat study which is discussed above). The results indicate that carbaryl is a category III toxicant via the oral and dermal routes and a category IV toxicant via inhalation. It is also a category IV eye and skin irritant. Results were negative for dermal sensitization and delayed acute neurotoxicity in hens.

1.4 Incident Reports

An incidence report has been completed by the Agency. It is considered with the information included in this document in the overall human health risk assessment for carbaryl. The identifying information for the incident report (i.e., date and author, etc.) is included in the overall human health risk assessment.

1.5 Summary of Use Patterns and Formulations

Carbaryl products are described in this section. Additionally, available information that describes the manner in which registered carbaryl end-use products are used is provided in this section (*e.g.* use categories/sites, application methods and application rates). For more detailed information, please refer to Appendix A of this document. Appendix A contains the *Quantitative Usage Analysis For Carbaryl* produced in 2002 by the Biological and Economic Analysis Division and the *Use Profile Report For Carbaryl* also produced in 2002 by the Biological and Economic Analysis Division. [Note: The previous carbaryl occupational and residential exposure/risk assessment chapters (e.g., phase 3 of 5/29/02, D281418) were based on the 1998 versions of these BEAD reports. There are no significant changes for the inputs used in the occupational or residential assessments as a result of the 2002 changes in the QUA. There were no changes in the updated *Use Profile Report*.] Additionally, it should be noted that Bayer submitted use information at a SMART meeting, from the *Sevin User Survey*, and an analysis of the *Residential Exposure Joint Venture* pesticide user survey. Each has been reviewed and used as appropriate in this document.

1.5.1 End-Use Products

Carbaryl (1-naphthyl N-methyl-carbamate) is a broad-spectrum carbamate insecticide marketed in a variety of end-use products for both occupational and homeowner use. End-use product names include Adios, Bugmaster, Carbamec, Carbamine, Crunch, Denapon, Dicarbam, Hexavin, Karbaspray, Nac, Rayvon, Septene, Sevin, Tercyl, Tornado, Thinsec, and Tricarnam. Use sites include but are not limited to: fruit and nut trees; vegetable crops; field and forage crops; grapes; forestry; lawns and other turf such as golf courses; ornamental trees, shrubbery, annuals, and perennials; wide area treatment targets such as residential mosquito adulticide uses; poultry production facilities; and companion animals (e.g., dogs and cats).

Table 2 summarizes the technical and manufacturing products with their respective EPA registration numbers.

Table 2: Technical and Manufacturing Carbaryl Products

Formulation	EPA Reg. No. (% active ingredient)
Technical	**34704**-707 (99%); **264**-324 (99%),-325 (97.5%); **19713**-75 (99%)

Table 2: Technical and Manufacturing Carbaryl Products	
Formulation	**EPA Reg. No. (% active ingredient)**
Manufacturing Product	**264**-328 (80%); **769**-971 (80%); **19713**-369 (50 %); **4816**-270 (97.5%),-407 (1%)

Based on a review (2/27/01) of the *Office of Pesticide Programs – Reference Files System (REFS)*, there are 307 active product labels. Carbaryl formulations include dusts, emulsifiable concentrates, soluble concentrates; water dispersable granulars; flowable concentrates; wettable powders; granulars; baits; pet dips and pet shampoos; aerosol sprays; ready-to-use pump sprayers; and pet collars (i.e., treated articles). Table 3 outlines the formulations and EPA registration numbers for labels of carbaryl end-use products according to REFs. Many of the products described in Table 3 can be used in a variety of settings ranging from agriculture and commercial facilities to residential areas. Some products are marketed in a single marketplace while others are sold for use in each setting. From sales information provided by the Bayer Corporation at the SMART meeting with EPA on September 24, 1998 approximately 34 percent of carbaryl end-use products are used in the homeowner/residential setting while 59 percent is used in agriculture. The remaining 7 percent is used in nursery, landscape and golf course industries. [Note: No comments have been received throughout the RED process which would indicate a significant change in these values since 1998.]

Table 3: End-Use Product Formulations and EPA Reg. Number.	
Formulation Type	**EPA Registration Number (Percent Active Ingredient)**
Emulsifiable Concentrates & Flowable Concentrates	**7401**-83,-210 (25%),-208(13%); **19713**-49(43.4%),-89 (22.5%), -131(49%); **51036**-66(43.3%),-123(22.5%); **10163**-60 (43.7%),-134(80%); **10107**-42 (43.4%),-44 (23.4%); **11715**-207,-209,-229 (42.6%); **33955**-533 (23.4%); **67517**-31(5%); **9779**-260 (43.4%); **8660**--133 (11.7%); **264**-321 (40%), -333 (44.1%), -334(22.5%), -335, -349 (43%), -422 (48%) ; **2217**-366 (50%), 600 (23.4%); **4**-59(0.5%),-122 (0.3%);-237 (22.5%); **192**-174 (21.3%); **239**-2628(21.3%); **270**-286 (23%); **407**-383 (24%); **5905**-251 (40.38%); **5887**-102,-162 (0.3%)0; **769**-493(42.85%),-573 (23%), -648,-865,-883 (21.3%); **28293**-222(21.3%); **59144**-6 (21.3%); **46515**-35 (11.7%); **16**-76 (21.3%);**34704**-447(43%); **8660**-70 (24.4%); **909**-103(21.3%); **46515**-36(21.3%); **7401**-38, -62 (5%),386 (13.5); **802**-585 (21.3%); **50383**-10 (22.5%); **54705**-4 (41.2%); **16**-76
	SLNs: CO8800-1300, FL8900-3700, HI9700-0300, NC9600-0300, OH9600-0300,OR9500-0600,PA9600-0200, VA9500-0100, WA9700-2200
Wettable Powders & Soluble Granules	**33955**-450 (50%); **51036**-151(80%);**19713** -50 (80%),-52(50%), -363 (85%), -84 (95%); **10163**-133 (80%); **9779**-294(90%); **8660**-60 (50%); **5905**-517 (80%); **264**-314 (50%), -315 (85%),- 316 (80%), -427 (39.7%), -526 (80%); **5481**-65 (50%), 242 (0.5%), 271 (50%); **5887**-86 (50%); **2217**-389 (50%); **4**-157 (13.5%), 387 (50%); **769**-574 (80%),-868 (50%),-919 (21.3),-920, -834,-972 (50%); **70**-285 (50%); **1386**-445; **34704**-350(50%),-619 (80%); **1386**-455; **16**-99(50%); **407**-287(50%); **228**-249(5%)
	SLNs: CA7802-070, CA8100-5900, CA8300-0700, CA8300-0701, CA8300-0702, FL8900-3600, HI9600-0900, NC8200-0700, NC8700-0702, WA9000-1300

Table 3: End-Use Product Formulations and EPA Reg. Number.	
Formulation Type	**EPA Registration Number (Percent Active Ingredient)**
Dusts	**67517**-32 (10%); **9198**-141 (2.37%),-147(5%),-148(10%); **4**-29 (1.25%),-143 (5%),-413, -415; **16**-12 (2%),-98 (10%),-121(5%),-127(2%); **239**-1349,-1513 (10%), -2181 (5%); **270**-272 (5%); **70**-165 (10%),-166(5%); **16**-27 (5%); **67572**-16 (5%),-36 (10%); **59144**-3 (5%),-5 (10%); **50383**-16 (5%); **49585**-4,-24 (5%),-26(10%); **43576**-3(5%); **34911**-6 (5%); **28293**-6,-10, -301,-302(5%),-14(12.5%),-18,-102,-301 (10%),-237(5%); **19713**-53,-212(10%),-213(5%),-244(80%); **829**-128 (5%),-131(1.75%),-142(50%),-200(10%); **2217**-383,-572 (5%); **2724**-75 (5%); **2781**-25(5%); **769**-559,-611,-613,-642,-647,-906 (5%),-835(1.75%),-229,-612,-665(10%),-614(12.5%); **655**-788(5%),-789 (10%); **11715**-250(12.5%),-255, -294(5%),-292(10%); **9779**-74 (5%);**8660**-72,-234(5%),-241(10%); **7401**-69,-310(5%),-291(1.75),-334(2%),-81,-166,-154(10%); **5887**-43(5%); **5481**-275,-282,-321(2%),-58,-98,-253,-283,- 316,-451 (5%),-312,-323(7.5%),-108,-277,-294(10%),-190(46%); **4758**-7,-32,-34(5%); **4306**-10(5%); **3342**-100(5%); **5887**-77(0.3%); **2935**-193 (5%),-320(10%); **3342**-51(5%),-53(2%),-56(1.75%),-69(10%); **2393**-375(5%); **1386**-451,-630(5%)-633(10%); **869**-118(5%).-180(10%); **802**-442(5%); **572**-107(5%); **192**-70(5%); **228**-251,-252(5%); **51036**-13(10%),-48(5%); **33955**-462(5%); **10163**-124(10%); **10159**-2(5%); **10107**-43(10%),-45(5%); **9779**-81(10%),-61(50%);**36272**-14(5%);**37425**-13(12.5%); **49784**-3(12.5%);**71949**-11(10%),-10(5%)
Granular	**28293**-233 (6.3%); **9198**-142 (3.5%); **5887**-94,-170 (5%); **769**-728 (5%), -970*(3.5%),-976(2%); 59144-26*(1%), 27* (2%); **34704**-289(10%),-373* (5%); **32802**-58(3.9%),-59* (1.43); **10404**-61*(6.3%), 62*(4%); **8378**-31*(4.3%),-36*(1.43%); **5481**-89(10%),-90,-97*(5%),-95*(4%), - 100*(5%); **264**-430*(7%); **909**-83*(5%); **869**-228*(2%); **9779**-156*(5%); **8660**-28* (1%); **7401**-43(3.34%),-51(1.8%); **192**-199 (2%); **4**-142(4.6%); **572**-204(8%); **802**-351(5%); **264**-429(7%); **5905**-169(10%),180(180%); **9198**-106(6.2%),-139(4.6%),-143(4%),-144(4.55%),-145(6.3%),-146(8%); **19713**-334(10%); **51036**-225(5%);**67572**-81(1%)
Bait	**67650**-2 (2%);; **61282**-4,-21(10.04%),-16,-22 (5%); **42057**-39 (4%); **32802**-51 (5%); **10370**-152 (5%); **8278**-3 (5%); **769**-729,-730 (5%); **802**-493 (5%); **31282**-22* (5%); **4**-333* (5%); **1386**-655*(5%); **10107**-143* (5%); **869**-119(5%); **7401**-72*(4%),-148 (2%),-265(4%); **8119**-5 (5%); **239**--2514 (5%); **70**-244(5%); **829**-182(4.25%),-285 (5%); **961**-290(7.15%),-355(5.93%); **264**-312 (10%),-320(5%); **2393**-209(5%); **6973**-10(4%); **7729**-7(5%); **8660**-111(5%),-188(4.55%); **10163**-32(5%);**11656**-20(4%),-21(5%); **28293**-235(5%); **34704**-23,-483(5%); **49399**-1(2%),-2(5%); **51036**-61(5%),,-185,-210(13%),-204,-227(1.3%),-286(10%); **59639**-52,-60(5%); **2935**-366(5%);**19713**-494(5%);**34911**-8(4%);**67572**-56(4%);**71949**-12(5%)
	SLNs: FL9200-0800
Dips, Shampoos	**28293**-8(60%); **2097**-8 (0.5%)
Pet collars (treated articles)	**2724**-272 (8.5%), 273 (16%)
Ready to Use Pump Sprayers & Aerosol Cans	**1910**-2 (1%); **67572**-75 (0.126%); **9444**-98,-190 (0.5%); **769**-977(0.126%); **8119**-3 (5%); **28293**-97 (0.5%)

1.5.2 Mode of Action and Targets Controlled

Carbaryl (1-naphthyl methylcarbamate) belongs to the carbamate class of pesticides. Like the other carbamates, carbaryl antagonizes acetylcholine and competes for binding sites on the enzyme cholinesterase. In agriculture and residential/recreational areas, carbaryl is used as a contact insecticide recommended for use against pests in a variety of settings. These pests include (i.e., based on information provided on labels and in the *Use Profile Report* included as Appendix A of this document):

- **On Fruit Trees and Nut Trees**: apple aphid, apple maggot, apple mealybug, apple rust mite, apple sucker, bagworms, California pearlslug, codling moth, eastern tent caterpillar, European apple sawfly, eyespotted bud moth, fruittree leafroller, green fruitworm, Japanese beetle, lesser appleworm, lygusbugs, orange tortrix, pear leaf blister mite, pear psylla, pear rust mite, periodical cicada, plum curculio, redbanded leafroller, scale insects, tarnished plant bug, tentiform leafminers. White apple leafhopper, wooly apple aphid, navel orangeworm, peach twig borer, san Jose scale, European raspberry aphid, omnivorous leafroller, raspberry sawfly, rose chafer, snowy rose tree cricket, blueberry maggot, sherry fruitworm, cranberry fruitworm, European fruit lecanium, chestnut weevil, avocado leafroller, california orangedog, citrus cutworm citrus root weevil, fullers rose beetle, orange tortrix, western tussock moth, west Indian sugarcane borer, filbert aphid, filbert leafroller, filbertworm, eight spotted forester, grape berry moth, grape leaffolder, grape leafhopper, June beetles, saltmarsh caterpillar, western grapeleaf skeletonizer, western yello-striped armyworm, olive scale, apple pendemis, cucumber beetles, European earwig, lesser peach tree borer, oriental fruit moth, peach twig borer, tarnished plant bug, tussock moth, black margined aphid, fall webworm, pecan leaf phylloxera, pecan nut casebearer, pecan spittlebug, pecan stem phylloxera, pecan weevil, twig girdler, walnut caterpillar, calico scale.

- **On Terrestrial Food and Feed Crops:** blister beetles, Mexican bean beetles alfalfa caterpillar, beanleaf beetle, cucumber beetle, grasshoppers, green cloverworm, japanese beetle, leafhoppers, three cornered alfalfa hopper, thrips, velvetbean caterpillar, alfalfa weevil larvae, armyworm, cloverhead weevil, cotton fleahopper, cotton leafworm, flea beetle, striped blister beetle, boll weevil, bollworms, cotton leafperforator, plant bugs, saltmarsh caterpillar, corn earworm, corn rootworm adults, southwestern corn borer, japanese beetle, European corn borer, cutworms, Egyptian alfalfa weevil larvae, Essex skipper, European alfalfa beetle, fall armyworm, lygus bugs, webworms, yellowstriped armyworm, asparagus beetle, apache cicada, stinkbugs, tarnished plant bug, webworm, cowpea curculio, aster leafhoppers, harlequin bug, imported cabbageworm, melonworm, pickleworm, squash bugs, pink bollworm, range caterpillars, thrips, white grubs, white fringed beetle adult, Colorado potato beetle, pea leaf weevil, tomato fruitworm, tomato hornworm, grape colaspis, sweet potatoweevil;, tortoise beetles, green June beetle grubs, budworms, cereal leaf beetle (except in CA).

- **On Ornamentals**: blister beetle, flea beetle, boxelder bug, japanese beetle, June beetle, lace bug, leafhopper, leafroller, mealybug, plant bug, psyllids, rose aphid thrips, apple aphid, bagworm, birch leafminer, cankerworm, eastern spruce gall aphid, elm leaf aphid, elm leaf beetle, gypsy moth, mimosa webworm, oak leafminer, orange tortrix, periodical cicada, puss caterpillar, rose aphid, rose slug, sawfly, scale, tent caterpillar, thrips, willow leaf beetle.

- **On Lawns/Turf**: ants, bluegrass billbug, chinch bug, cut worm, crane fly, earwig, European chafer, fall armyworm, fleas, green June beetle, leafhopper, millipedes, mosquitoes, sod webworms (lawn moths), *ixoides spp.*(deer tick, bear tick, black legged tick), *amblyomma spp.*(lone star tick).

- **Poultry**: northern fowl mite, chicken mite, lice, fleas, bedbugs, fowl ticks.

- **In and Around Buildings:** indoors: ants, crickets, firebrats, silverfish, bees, wasps, brown dog ticks, fleas, carpenter ants, scorpions, centipedes, earwigs, millipedes, cockroaches, spiders.

- **Outdoors**: ants, bees, wasps, brown dog ticks, carpenter ants, centipedes, cockroaches, crickets, earwigs, firebrats, fire ants (mound treatment), silverfish, fleas millipedes, scorpions and spiders.

- **Public Health/Wide Area**: mosquitoes.

- **Dogs and cats**: fleas and ticks, on animal and in bedding/housing.

1.5.3 Registered Use Categories and Sites

An analysis of the current labeling and available use information was completed using the *Office of Pesticide Programs–Label Use Information System* (LUIS) in addition to REFs. Carbaryl is registered for use in a variety of occupational and homeowner/residential scenarios. For reasons of clarity in the risk assessment process, the use patterns have been described in a manner that delineates occupational from homeowner/residential uses.

Occupational Use Sites

Occupational populations are potentially exposed while making carbaryl applications to the following targets or after contact with the treated targets after previous carbaryl applications. The following list is a summary of occupational use sites as described in the *Carbaryl Use Profile* prepared by Don Atwood of the Biological and Economic Analysis Division in November of 1998 (see Appendix A). [Note: Modifications to the Use Profile have been made based on label deletions and modifications since November of 1998.]

Terrestrial Food Crop

Cucurbits - cucumber, melons, Chinese okra, pumpkin, and squash
Flavoring and Spice Crops - dill
Fruiting Vegetables - tomato, eggplant and pepper
Grain Crops - prosso millet
Leafy and Stem Vegetables - beets, broccoli, brussels sprouts, cabbage, chinese cabbage, cauliflower, celery, Swiss chard, collards, dandelion, endive (escarole), hanover salad, kale, kohlrabi, lettuce (head, crisphead types, leaf types), mustard, parsley, rhubarb, and spinach
Miscellaneous Fruits - olive
Miscellaneous Vegetables - asparagus
Nut Crops - almond, chestnut, filbert (hazelnut), pecan, pistachio, and walnut (english/black)
Pome Fruits - crabapple, pear, and quince
Root Crop Vegetables - beets, carrot (including tops), horseradish, radish, rutabaga, salsify, and sweet potato

Small Fruits - blackberry, blueberry, boysenberry, caneberries, cranberry, dewberry, loganberry, raspberry (black, red), and strawberry
Specialized Field Crops - okra
Stone Fruits - apricot, cherry, nectarine, peach, plum, and prune

Terrestrial Food+Feed Crop

Citrus Fruits -grapefruit, lemon, lime, orange, tangerine
Crops Grown for Oil - field corn, flax, and sunflower
Miscellaneous Fruits - longan and mango
Fiber Crops - flax
Fruiting Vegetables - tomato
Grain Crops - field corn, rice, sorghum and wheat
Groups of Agricultural Crops Which Cross Established Crop Groupings - cotton, peanuts, peas, sorghum, soybeans, and vegetables
Leafy and Stem Vegetables - mustard and turnip
Nut Crops - almond, chesnuts, filberts, pecans, pistachios and walnuts
Pome Fruits - apple, pears, loquats, crabapples and oriental pears
Root Crop Vegetables - parsnip, white/irish potato, salsify, and turnip
Seed and Pod Vegetables - beans (dried type), succulent beans (lima and snap), cowpea/blackeyed pea, cowpea/sitao, lentils, peanuts, peas (dried type), field peas, southern peas, succulent peas, and soybeans (edible)
Small Fruits - grapes, caneberries, blueberries, cranberries and strawberries
Specialized Field Crops - popcorn, sweet corn, and sunflower
Sugar Crops - sugar beet

Terrestrial Feed Crop

Forage Grasses - corn, grass forage/fodder/hay, millet (proso), pastures, rangeland, rice, sorghum, and wheat
Forage Legumes and Other Nongrass Forage Crops - alfalfa, clover, cotton, and trefoil
Grain Crops - proso millet
Groups of Agricultural Crops Which Cross Established Crop Groupings - grasses grown for seed

Terrestrial non-food crop

Agricultural Uncultivated Areas - Agricultural fallow/idleland and Agricultural rights-of way/fencerows/hedgerows
Commercial/Industrial/Institutional Premises and Equipment
Commercial/Institutional/Industrial premises/Equipment (Outdoor)
Fiber Crops
Forest Trees - Christmas tree plantations

Groups of Agricultural Crops Which Cross Established Crop Groupings - Fruits (unspecified)
Nonagricultural Uncultivated Areas - Outdoor buildings/structures, rights-of-way/fencerows/hedgerows, uncultivated areas/soils, and recreational areas
Ornamental Lawns and Turf - commercial/industrial lawns, golf course turf,
Ornamental sod farm (turf), and recreational area lawns
Specialized Field Crops - tobacco
Wide Area/General Outdoor Treatments - fencerows/hedgerows, urban areas, and wide area/general outdoor treatment (public health use)

Terrestrial non-food+outdoor residential

Nonagricultural Uncultivated Areas - rights-of-way/fencerows/hedgerows

Ornamental Herbaceous Plants

Ornamental Lawns and Turf
Ornamental Nonflowering Plants
Ornamental Woody Shrubs and Vines
Ornamental and/or Shade Trees
Wide Area/General Outdoor Treatments - fencerows/hedgerows

Terrestrial+Greenhouse non-food crop

Ornamental Herbaceous Plants
Ornamental Woody Shrubs and Vines
Ornamental and/or Shade Trees

Animal Uses

Poultry (chickens, ducks, geese, game birds, turkeys)
Livestock (cattle, sheep, horses, etc.)
Pets (cats and dogs)

Aquatic food crop

Aquatic Sites - commercial fishery water systems
Grain Crops - rice
Small Fruits - cranberry
Fish & Shellfish Uses - oyster beds

Aquatic non-food industrial

Aquatic Sites - Drainage systems

Forestry

Forest Trees - forest plantings (reforestation programs, tree farms, tree plantations, etc), forest trees (all or unspecified), maple (forest), and shelterbelt plantings

Homeowner/Residential Use Sites

Residential and non-occupational use sites include those labeled for outdoor applications such as on lawns, gardens, and ornamentals as well as for use on companion animals such as dogs or cats. There are no labels that allow indoor premise treatments (e.g., crack and crevice or broadcast). Carbaryl can be purchased and used by homeowners in residential settings. It can also be used by professionals such as LCOs (Lawn Care Operators) in residential settings. Exposures can also occur as a result of uses in other areas frequented by the general population such as parks and recreational areas, treated Christmas tree plantations, and forests. Veterinary clinic uses can also result in exposures due to contact with treated animals. The following is a list of use sites in the residential environment.

- **Trees:** fruits, nuts, and shade/ornamental;
- **Lawns and Ornamentals:** lawns, house perimeter, shrubs and flowers;
- **Vegetables**: beans, berries, broccoli, brussels sprouts, cabbage, carrots, cauliflower, corn, cowpeas, cucumbers, eggplant, herbs, lettuce, melon, okra, onions, peas, peppers, potatoes, summer squash, tomatoes;
- **Pets:** dogs, cats, and housing/bedding; and
- **Fire Ant Mounds**

1.5.4 Application Parameters

Application parameters are generally defined by the physical nature of the use site, the physical nature of the formulation (e.g., formula and packaging), by the equipment required to deliver the chemical to the use site, and by the application rate required to achieve an efficacious dose. As such, the application parameters for major crop groups or application targets have been summarized by identifying the maximum application rates for each group and the equipment that can be used to make applications. All of the information presented below are summarized from the Agency's QUA and Use Profile documents included as Appendix A, from the SMART meeting information provided to the Agency on September 24, 1998 by the Bayer Corporation, from current carbaryl labels, and from the use summary used in the dietary exposure aspect of the risk assessment. [Note: The previous carbaryl occupational and residential exposure/risk assessment chapters (e.g., phase 3 of 5/29/02, D281418) were based on the 1998 versions of these BEAD reports. There are no significant changes for the inputs used in the occupational or residential assessments as a result of the 2002 changes in the QUA. There were no changes in the updated *Use Profile Report*.]

Selected crop groupings and application targets along with corresponding typical (if available) and maximum application rates that are used in the risk assessment are presented in Table 4 below. Additionally, the equipment that can be used to make applications are also discussed below for each crop group considered. The Agency could not quantitatively address the use of carbaryl in every specific crop or setting in its risk assessment because of the associated level of complexity that would be added to the risk assessment process. Instead, representative crops or targets were selected that were used as the basis for the assessment. A broad range of rates were used to ensure that use scenarios would be addressed in the range of values selected.

Table 4: Representative Application Rates Considered in Risk Assessment

Crop or Target	Occupational Products				Residential Products lb ai/1000 ft^2 (units may vary)
	lb ai/A/acre (units may vary)	max. apps/season	lb ai/season	Average Rates	
Alfalfa, clover, trefoil	1.5	1/cutting	1.5/cutting	1.1	-
Asparagus	2 4 - postharvest	3 - broadcast 2 - postharvest	6 - broadcast 10 - postharvest	0.9	0.023 -0.094
Beans (fresh & dried), cowpeas, peas	1.5	4	6	0.9	0.012-0.047
Beets, carrot, horseradish, radish, parsnip	2 - foliar 2.2 - soil broadcast	6 - foliar 4 - soil	6	0.8	0.012-0.047
Blueberries	2 - foliar 0.5 lb/1000 ft^2 - soil	5	10	1.7	0.012-0.047
Cole Crops (broccoli, brussel sprouts, cabbage, cauliflower, chinese cabbage, collards, kale, kohlrabi, mustard greens)	2 - foliar 2.2 - soil broadcast	4	6	0.8	0.012-0.047
Caneberries	2 - foliar 2.2 - soil broadcast	5 4	10 Not specified	1.7	0.012-0.047
Celery, Dandelion	2 - foliar 2.2 - soil broadcast	4	6	1.0	0.012-0.047
Citrus	16 (foliar in CA only) 10 (foliar in FL only) 7.5 - foliar 1 lb/100 gal.	1 Not specified 8 Not specified	20 Not specified 20 Not specified	2.7 to 3.4 (lemons & oranges)	0.023-0.176
Corn (field and pop)	2	4	8	1.0	0.012-0.047
Corn (sweet)	2 - foliar 2.2 - soil broadcast	8 4	16 Not specified	1.3	0.012-0.047
Cranberry	2	5	10	2.0	0.012-0.047
Cucurbits (cucumber, melon, pumpkin, squash)	1	6	6	1.1	0.012-0.047
Fruiting Vegetable (tomato, eggplant, pepper)	2	7	8	1.0	0.012-0.047
Grapes	2	5	10	1.4	0.012-0.047
Grasses Grown For Seed	1.5	2	3	0.8 (based on hay)	-
Leafy Vegetable (head and leaf lettuce, endive, mustard green)	2 - foliar 2.2 - soil broadcast	5 4	6 Not specified	1.1	0.012-0.047
Nuts (almond, chestnut, pecan, pistachio, walnut, etc.), foliar or dormant/delayed	5	4	15	2.5 (pecans)	0.047-0.12
Nuts (almond, chestnut, pecan, walnut), foliar in CA	1 lb ai/100 gal	Not specified	Not specified	Not specified	0.047-0.12
Ornamental	2.2 or 2% solution	-	-	1.5	0.023
Oyster beds (SLN only)	10	Not specified	Not specified	-	-
Peanut	2	5	8	0.8	0.012-0.047

Table 4: Representative Application Rates Considered in Risk Assessment					
Crop or Target	Occupational Products				Residential Products lb ai/1000 ft^2 (units may vary)
	lb ai/A/acre (units may vary)	max. apps/season	lb ai/season	Average Rates	
Pome fruit	3	8	15	1.2 (based on apples)	0.012-0.07
Poultry	1/1000 ft^2 broiler 0.64-0.76/100 layers	-	-	-	-
Potatoes & Tubers (turnips)	2	6	6	0.8	-
Rangeland/pastures	1	1	1	0.9	-
Rice	1.5	2	4	1.1	-
Right of Way	1.5		3	0.4	-
Sorghum	2	4	6	1.1	-
Stone fruit (apricot, cherry, nectarine, peach, plum/prune), foliar or dormant/delayed	3 4 - CA only	3 foliar & 1 dormant/delayed	14	1.1	0.047-0.12
Stone fruit (apricot, cherry, nectarine, peach, plum/prune), foliar	1 lb ai/100 gal	Not specified	Not specified	Not specified	0.047-0.12
Strawberries	2	5	10	1.4	0.012-0.047
Sugar beets	1.5 to 2	2 to 4	4	1.3	0.012-0.047
Sweet Potatoes	2 foliar 8 lb/100 gal drip	8 foliar Not specified	8 foliar 1.2	1.6 foliar Not specified	0.012-0.047
Sunflower	1.5	2	3	0.7	0.012-0.047
Tobacco	2	4	8	1.1	-
Tree farm	1	-	2	0.7	-
Turf/golf	8 - liquids 9 - granulars	-	0.8/1000sf	2 to 4	0.047 to 0.25 (lawns) [max levels for different products]
Wheat, flax	1.5	2	3	0.8	-
Ants	2%sol	-	-	-	2%sol
Mosquito Control	2	-	-	-	-
Outdoor Banding	2%sol	-	-	-	2%sol
Domestic Animals (e.g., cats/dogs)	Dust 0.2 lb ai/dog Sha. 0.01 lb ai/dog	-	-	-	Dust 0.2 lb ai/dog Sha. 0.01 lb ai/dog
Domestic Animals (e.g., cats/dogs)	1.3 oz/dog collar	-	-	-	1.3 oz/dog collar

- **Tree Crops:** The application rate for commercial crops is between 2 to 6 lb ai per acre for most crops. Citrus rates are higher at 16 lb ai per acre (CA only). Equipment for commercial use is airblast, aerial and chemigation.

- **Grapes**: The application rate for commercial crops is 2 lb ai per acre. Equipment for commercial use is airblast, over the row groundboom, power duster, aerial and chemigation.

- **Field, forage, fiber, small fruit (i.e., berries) and vegetable crops**: The application rate for commercial crops is 1 to 2 lb ai per acre. Equipment for commercial use is groundboom, aerial and chemigation.

- **Non crop areas**: The application rate for commercial area is 1 lb ai per acre. Equipment is groundboom, aerial and right of way sprayer.

- **Ornamentals**: The application rate for commercial area is 2.2 lb ai per acre. Equipment for commercial use is low-pressure handwand, backpack, high-pressure handwand and airblast/mist blower.

- **Lawn Care** (professional certified operator (pco)): The application rate for pco applicators is up to 8 lb ai per acre. The application equipment is hand-held power sprayers and granular spreaders.

- **Evergreens in large stands**: the application rate for commercial crops is 1 lb per acre or 1.8 lb ai per 1000 square feet to the seed, mound or trunk. Equipment used for commercial areas is airblast, aerial, and high-pressure handwand.

- **Poultry**: The application rates for commercial poultry production vary from 0.0048 lb ai per bird, to 0.08 lb ai per 1000 square feet and are also reported as 1 lb ai per 3.1 gallons. Application equipment for commercial production includes, compressed air sprayer, fogger, backpack sprayer and mist blower and power sprayers.

- **Homeowner fruits and nuts**: 0.0039 lb ai per gallon or up to 0.8 lb ai per 5 trees. Application equipment includes, hose-end sprayer and hand held pump sprayer.

- **Homeowner vegetables:** The application rate for homeowner vegetable gardens is 0.0026 lb ai per 20 foot row. The application equipment includes, hose-end sprayer, hand held pump sprayer, hand held dusters and shaker cans.

- **Homeowner lawn care**: Maximum application rates range from 2 lb ai/acre (0.047 lb ai/1000 ft2) up to almost 11 lb ai per acre (0.25 lb ai/1000 ft2) depending upon the product/packaging and the pest. For the vast majority of products (e.g., professional application to residential lawns that could result in postapplication exposures and open packaging for homeowners) the maximum application rates are 8 lb ai/acre for liquids and 9 lb ai/acre for granules. Equipment for homeowner use is hose-end sprayer, granular spreader, and belly grinder.

- **Homeowner ornamentals:** The application rate for homeowner ornamentals is 0.02 lb ai per gallon of water or 0.5 lb ai per 50 shrubs. Equipment for homeowner is hose-end or hand held pump sprayers.

- **Pets:** Pet care products are applied via containers (i.e., powders and dusts by shake can, ready to use and pressurized containers) and rubbed in by hand. Application rate is made by the handler. Shampoos also are applied in the same manner. Pet collar application rate is 1 collar per animal and each collar contains 16 percent ai. Application equipment is a pet collar.

- **Pet bedding**: Applications are made to cover bedding by dusters or spray formulas including pressurized sprays.

2.0 Occupational Exposures and Risks

It has been determined there is a potential for exposure in both occupational and residential/homeowner scenarios from handling carbaryl products during the application process (i.e., mixer/loaders, applicators, flaggers and mixer/loader/applicators) and from entering areas previously treated with carbaryl (e.g., postapplication worker exposure). As a result, risk assessments have been completed for both occupational handler and postapplication scenarios as well as residential handler and postapplication scenarios. This section includes the occupational aspects of the risk assessment. Occupational handler exposures and risks are addressed in *Section 2.1: Occupational Handler Exposures and Risks* while occupational post-application worker risks are presented and summarized in *Section 2.2: Occupational Post-Application Exposures and Risks*. The calculated risks are characterized in *Section 2.3: Occupational Risk Characterization.*

2.1 Occupational Handler Exposures and Risks

The Agency uses the term "Handlers" to describe those individuals who are involved in the pesticide application process. The agency believes that there are distinct job functions or tasks related to applications and that exposures can vary depending on the specifics of each task. Job requirements (e.g., amount of chemical to be used in an application), the kinds of equipment used, the crop or target being treated, and the circumstances of the user (e.g., the level of protection used by an applicator) can cause exposure levels to differ in a manner specific to each application event. The scenarios that serve as the basis for the risk assessment are presented in *Section 2.1.1: Handler Exposure Scenarios*. The exposure data and assumptions that have been used for the calculations are presented in *Section 2.1.2: Data and Assumptions For Handler Exposure Scenarios*. The calculations and the algorithms that have been used for the noncancer elements of the risk assessment as well as the risk values are presented in *Section 2.1.3: Handler Exposure and Non-Cancer Risk Estimates* while the analogous information using the Q_1* for cancer estimates are presented in *Section 2.1.4: Handler Exposure and Risk Estimates For Cancer*. *Section 2.1.5: Summary of Risk Concerns and Data Gaps For Handlers* presents the overall risk picture for carbaryl. Finally, recommendations are presented in *Section 2.1.6: Recommendations For Refining Occupational Handler Risk Assessment.*

2.1.1 Handler Exposure Scenarios

Exposure scenarios can be thought of as ways of categorizing the kinds of exposures that occur related to the use of a chemical. The use of scenarios as a basis for exposure assessment is very common as described in the *U.S. EPA Guidelines For Exposure Assessment* (U.S. EPA; Federal Register Volume 57, Number 104; May 29, 1992). The purpose of this section is to describe the exposure scenarios that were used by the Agency in the assessment for carbaryl handlers and to explain how the scenarios were defined. Information from the current labels; use and usage information; toxicology data; and exposure data were all key components in the developing the exposure scenarios.

The first step in the handler risk assessment process is to identify the kinds of individuals that are likely to be exposed to carbaryl during the application process. In order to do this in a consistent manner, the Agency has developed a series of general descriptions for tasks that are associated with pesticide applications. Common tasks (as an example) can include: preparation of dilute, water-based spray solutions for application; transferring or loading dilute spray solutions into sprayers for application; and making applications with specific types of equipment such as a groundboom or airblast sprayer. Tasks associated with occupational pesticide use (i.e., for "handlers") can generally be categorized using one of the following terms:

- **Occupational Mixer/loaders:** these individuals perform tasks in preparation for an application. For example, they would prepare dilute spray solutions and/or load/transfer solid materials (e.g., granulars) or dilute spray solutions into application equipment such as a groundboom tractor or planter prior to application.

- **Occupational Applicators:** these individuals operate application equipment during the release of a pesticide product into the environment. These individuals can make applications using equipment such as groundboom sprayers or tractor-drawn spreaders for granular materials.

- **Occupational Mixer/loader/applicators:** these individuals are involved in the entire pesticide application process (i.e., they do all job functions related to a pesticide application event). These individuals would prepare a dilute spray solution and then also apply the solution. The Agency always considers some exposures to be mixer/loader/applicator exposures because of the equipment used and the logistics associated with such applications. For example, if one uses a small handheld device such as a 1 gallon low pressure handwand sprayer it is anticipated that one individual will mix a spray solution and then apply the solution because of labor and logistical considerations.

- **Occupational Flaggers:** these individuals guide aerial applicators during the release of a pesticide product onto an intended target.

Next, assessors must understand how exposures to carbaryl occur (i.e., frequency and duration) and how the patterns of these occurrences can cause the effects of the chemical to differ (referred to as dose response). Wherever possible, use and usage data determine the appropriateness of certain types of risk assessments (e.g., a chronic risk assessment is not warranted for a vast majority of carbaryl uses because chronic duration exposure patterns do not occur). Other parameters are also defined from use and usage data such as application rates and application frequency. The Agency always completes risk assessments using maximum application rates for each scenario because what is possible under the label (the legal means of controlling pesticide use) must be evaluated, for complete stewardship, in order to ensure there are no concerns for each specific use. Additionally, whenever the Agency has additional information such as typical application rates for some crops, as in this case, it uses the information to further evaluate the overall risks associated with the use of the chemical in order to allow for a more informed risk management decision. In this case, average application rates (considered to be the same as typical rates for the purposes of this assessment) defined in the recent *Quantitative Usage Analysis* were available for some crops and integrated into the assessment.

A chemical can produce different effects based on how long a person is exposed, how frequently exposures occur, and the level of exposure. It is likely that carbaryl exposures can occur in a variety of patterns. The Agency believes that occupational carbaryl exposures can occur over a single day or up to weeks at a time even though each crop or application target is generally treated only a few times per season. Intermittent exposures over several weeks are also anticipated. Some applicators may apply carbaryl over a period of weeks because they need to cover large acreages, they may be custom or professional applicators that are completing a number of applications within a region, or they may be applying carbaryl over a period of several days (e.g., a veterinary assistant who dips dogs periodically over a period of several weeks). The Agency classifies exposures up to 30 days as short-term and exposures greater than 30 days up to several months as intermediate-term. The Agency completes both short- and intermediate-term assessments for occupational scenarios in essentially all cases because these kinds of exposures are likely and acceptable use and usage data are not available to justify deleting intermediate-term scenarios. For carbaryl, the agency has completed both short-term assessment and intermediate-term assessments because of likely extended periods of exposure in segments of the user population. [Note: The dermal toxicity study NOAEL has been applied to both durations and the NOAELs from the studies used to evaluate inhalation exposures are the same number so the results for both short-term and intermediate-term risks are numerically identical.] Long-term or chronic exposures (essentially every working day over a year) can also occur for some chemicals including an anticipated small number of carbaryl users, particularly in the greenhouse and floriculture industry. These have been addressed as appropriate. Finally, cancer risks have also been calculated using a amortized lifetime average daily dose (LADD) and linear, low dose extrapolation (i.e., the Q_1*).

The toxicity of chemicals can also vary based on the route of exposure or how a chemical enters the body. For example, exposures to the skin can result in a different toxic effect and/or severity of reaction than exposures via inhalation. The effects of a chemical can also vary for different durations of exposure. The toxicology database for carbaryl indicates that the Agency consider exposures to the skin combined with exposures via inhalation because the effects and the dose levels at which effects occur are the same regardless of whether it is deposited on the skin or it is inhaled (e.g., cholinesterase inhibition was the effect noted for the inhalation endpoint defined in the acute neurotoxicity study and for the dermal endpoint defined in the 21 day dermal toxicity study used for the short-term risk assessment). This is also true for all different durations of exposure as similar effects were observed in all toxicity studies selected as the source of the endpoints used for risk assessment purposes. [Note: For further information regarding the toxicity endpoints, see *Section 1.3: Summary of Toxicity Concerns Relating To Occupational/Residential Exposures*.]

Occupational handler exposure assessments are completed by the Agency using different levels of personal protection. The Agency typically evaluates all exposures with a tiered approach. The lowest tier is represented by the baseline exposure scenario followed by increasing the levels of personal protection represented by personal protective equipment or PPE (e.g., gloves, extra clothing, and respirators) and engineering controls (e.g., closed cabs and closed loading systems). This approach is always used by the Agency in order to be able to define label language using a risk-based approach and not based on generic requirements for label language. [Note: Current labels mostly require single layer clothing, chemical-resistant gloves, and no respirator.] In addition, the minimal level of adequate protection for a chemical is generally considered by the Agency to be the most practical option for risk reduction (i.e., over-burdensome risk mitigation measures are not considered a practical alternative). The levels of protection that formed the basis for the calculations in this assessment include (which were combined to obtain 8 different scenarios):

- **Baseline:** Represents typical work clothing or a long-sleeved shirt and long pants with no respiratory protection. No chemical-resistant gloves are included in this scenario.

- **Minimum Personal Protective Equipment (PPE):** Represents the baseline scenario with the use of chemical-resistant gloves and a dust/mist respirator with a protection factor of 5.

- **Maximum Personal Protective Equipment (PPE):** Represents the baseline scenario with the use of an additional layer of clothing (e.g., a pair of coveralls), chemical-resistant gloves, and an air purifying respirator with a protection factor of 10. [Note: See specific change in comments below pertaining to open cab airblast applicators.]

- **Engineering Controls:** Represents the use of an appropriate engineering control such as a closed tractor cab or closed loading system for granulars or liquids. Engineering controls are not applicable to handheld application methods which have no known devices that can be used to routinely lower the exposures for these methods.

It has been determined that exposure to pesticide handlers is likely during the occupational use of carbaryl in a variety of environments including agriculture, commercial/industrial premises, and in residential environments. The anticipated use patterns and current labeling indicate 28 major occupational exposure scenarios based on the types of equipment and techniques that can potentially be used to make carbaryl applications. The quantitative exposure/risk assessment developed for occupational handlers is based on these scenarios. [Note: The scenario numbers correspond to the tables of risk calculations included in the occupational risk calculation aspects of the appendices.]

Mixing/Loading
(1a) Dry Flowable for Aerial/Chemigation in Agriculture;
(1b) Dry Flowable for Airblast;
(1c) Dry Flowable for Groundboom;
(1d) Dry Flowable for High Pressure Handwand and Right of Way Sprayers;
(1e) Dry Flowable for LCO Applications;
(1f) Dry Flowable for Aerial Wide Area Uses;
(2a) Granular for Aerial;
(2b) Granular for Broadcast Spreader;
(3a) Liquids for Aerial/Chemigation;
(3b) Liquids for Airblast;
(3c) Liquids for Groundboom;
(3d) Liquids for High Pressure Handwand and Right of Way Sprayers;
(3e) Liquids for LCO Applications;
(3f) Liquids for Aerial Wide Area Uses;
(3g) Liquids for Ground Wide Area Uses;
(4a) Wettable Powder for Aerial/Chemigation;
(4b) Wettable Powder for Airblast;
(4c) Wettable Powder for Groundboom;
(4d) Wettable Powder for High Pressure Handwand and Right of Way Sprayers;
(4e) Wettable Powder for LCO Applications;
(4f) Wettable Powder for Aerial Wide Area Uses;

Applicator:
(5a) Aerial/Liquid Application;
(5b) Aerial/Liquid Wide Area Application;
(5c) Aerial/Granular Application;
(6a) Airblast Application;
(6b) Wide Area Ground Fogger (Airblast as surrogate);
(7) Groundboom Application;
(8) Solid Broadcast Spreader Application;
(9) Aerosol Can Application;
(10) Trigger Sprayer (RTU) Application;
(11) Right-of-Way Sprayer Application;
(12) High Pressure Handwand Application;
(13) Veterinary Technician/Animal Groomer Liquid Application;
(14) Veterinary Technician/Animal Groomer Dust Application;
(15) Granulars/Bait and Pellets Dispersed by Hand;
(16) Granulars/Bait and Pellets Dispersed with Spoon;

Mixer/Loader/Applicator:
(17) Low Pressure/High Volume Turfgun Application;
(18a) Wettable powder, Low pressure handwand;
(18b) Liquid: Low Pressure Handwand;

(19) Backpack;
(20) Granular Belly Grinder;
(21) Push-type Granular Spreader;
(22) Handheld Fogger;
(23) Powered Backpack;
(24) Granular Backpack;
(25) Tree Injection;
(26) Drenching/Dipping Seedlings For Propagation;
(27) Sprinkler Can;

Flaggers:
(28a) Flagging For Liquid Sprays; and
(28b) Flagging For Granular Applications.

2.1.2 Data and Assumptions For Handler Exposure Scenarios

A series of assumptions and exposure factors served as the basis for completing the occupational handler risk assessments. Each assumption and factor is detailed below on an individual basis. In addition to these values, exposure values were used to calculate risk estimates. Mostly, these values were taken from the Pesticide Handlers Exposure Database (PHED). In other cases, chemical-specific data were submitted to support the reregistration of carbaryl. Both PHED and the individual studies are presented below.

The assumptions and factors used in the risk calculations include:

- Carbaryl is one of the most widely used pesticide chemicals. It has an extraordinary number of use patterns that are impossible to completely capture in this document. As such, the Agency has patterned this risk assessment on a series of likely representative scenarios that are believed by the Agency to represent the vast majority of carbaryl uses. Refinements to the assessment will be made as more detailed information about carbaryl use patterns become available.

- The carbaryl 80 S label EPA Reg 264-316 has a 24(c) label (SLN WA-900013) that allows application to oyster beds to control ghost and mud shrimp. The application rate is 8 lb ai/acre based on information from Bob Merkel of the Washington State Department of Agriculture (WSDA) [contained in email from CRM Anthony Britten of 1/3/02]. WSDA information also indicates that applications are completed with helicopters over a 3 day period in July and that approximately 800 acres are treated usually with 3 aircraft. Beds are treated with 10 gallons of spray solution per acre at a concentration of 0.8 lb ai/gallon. With this information, the Agency calculated that approximately 89 acres would be treated per day by each helicopter and that 711 lb ai would also be used. The Agency did not calculate risks specifically for this scenario. However, the Agency considered a wide range of aerial application scenarios in this assessment. For all formulations and for pilots, the vegetable scenario based on 2 lb ai/acre and 350 acres treated per day (i.e., 700 lb ai applied per day) yields essentially the same risk numbers that would be associated with treating oyster beds. As a result, please refer to the aerial vegetable scenarios to obtain risk estimates for treating oyster beds.

- Carbaryl labels allow for its use to treat wide areas and rangeland for the control of many insect pests. USDA/APHIS is responsible, under Federal mandate, for operating a grasshopper control program which uses carbaryl as a chemical agent. As such, the Agency addressed the risks associated with this program in this assessment based on information obtained in a conference call between USDA/APHIS and EPA on January 28, 2003. The representatives from APHIS were directly involved with the grasshopper control program. The information received indicates that common ag aircraft are generally used in the applications (e.g., Turbo Thrush) and that two general types of applications are made involving ultra-low-volume liquid sprays (ULV) or granular baits. ULV applications can range up to 5000 to 6000 acres per day depending on the equipment used while the rates range from 0.125 lb ai/a (RAAT approach) up to 0.375 lb ai/a for a complete treatment. The maximum rate for this application is 0.5 lb ai/acre. The maximum bait application rate is 0.03 lb ai/a and the daily number of acres would be less because of logistical issues.

- Average body weight of an adult handler is 70 kg because the toxicity endpoint values used for the assessments are appropriate for average adult body weight representing the general population. This is the case because none of the effects identified in the selected toxicity studies were sex specific (i.e., NOAELs selected by HIARC were the same for males and females).

- All analyses were completed using chemical-specific exposure data or data that were deemed to be a source of acceptable surrogate exposure data for the scenario in question. Several handler assessments were completed using "low quality" PHED data due to the lack of a more acceptable dataset. Additionally, in some cases, no empirical data were available for the scenario but an exposure assessment approach was developed based on an approach outlined in the *SOPs For Residential Exposure Assessment*. In these cases, the assumptions and approached included in the SOPs served as the basis for the assessment (e.g., some pet uses). The PHED unit exposure values range between the geometric mean and the median of the available exposure data. Factors derived from the *SOPs For Residential Exposure Assessment* are generally considered to be conservative. When data from other studies were used, the appropriate statistical measure of central tendency was used (see each study summary below for data descriptor).

- Several generic protection factors were used to calculate handler exposures. The protection factors used for clothing layers (i.e., 50%) and gloves (90%) have not been completely evaluated by the Agency. Additionally, the Agency uses a 98% reduction factor to estimate exposures that involve the use of engineering controls. There is an ongoing project through NAFTA to address the issue of protection factors (a draft document assessing protection factors using PHED has been completed). The results of this effort show that the protection factors being currently used by the Agency are within those predicted in the analysis. The values used for respiratory protection (i.e., PF 5 or PF 10) are based on the *NIOSH Respirator Decision Logic.*

- Comments received from Bayer Corporation during Phase 4 of the reregistration process indicate that a label requirement for the use of protective headgear for open cab airblast applicators on tree fruit crops would be acceptable if the use of such equipment was considered in the assessment process. Comments were also received from various commodity organizations indicating that closed cab tractors would be difficult to use in some tree crops because of canopy shape/size compared to closed tractor cabs (i.e., the size of the tractor cabs would preclude entry into smaller height crops with tight canopy spacing between rows). [Note: No information other than anecdotal evidence was provided to substantiate this claim by the commodity organizations.] The Agency only adjusted the unit exposure value for the maximum PPE scenario using a 50 percent protection factor and applying it to exposures on the head and back of the neck which also are the major contributors to open cab airblast applicator exposures (i.e., dermal unit exposure was reduced from 0.22 mg/lb ai applied to 0.13 mg/lb ai applied).

- Exposure factors used to calculate daily exposures to handlers are based on applicable data if available. For lack of appropriate data, values from a scenario deemed similar enough by the assessor might be used. As a example, mixer/loader/applicator data for hose-end sprayers were used to assess sprinkler can applications. The nature of these application methods are believed to be similar enough to bridge the data. There are other instances where the Agency has bridged specific data to represent other scenarios.

- Separate short-term, intermediate-term, and chronic risk assessments were completed for the noncancer endpoints based on the toxicity endpoints that were identified. The Agency believes that there are exposure scenarios that fit each of these categories. All noncancer scenarios are expected to be short- or intermediate-term in nature. The Agency only anticipates a limited number of scenarios that are chronic in nature which are included in the greenhouse and ornamental industry. The Agency also calculated cancer risks for private growers (i.e., those growers who would treat their own fields) and for more frequent carbaryl users such as a commercial applicator. The range in the cancer risk assessments is intended to address the large population of growers who likely complete their own applications but also to address likely smaller, more highly exposed commercial applications. The Agency has used a value of 30 application events per year for all commercial applicator scenarios and 10 days per year to account for private growers (i.e., 1/3rd of the analogous professional job function, this is also used for the postapplication risk assessment). These values are supported by the data included in the University of California studies of seasonal labor in California and the recent Department of Labor National Agricultural Worker Survey (NAWS).

- The exposure duration (i.e., years per lifetime) values used by the Agency in the cancer risk assessment are consistent with those used for other chemicals (i.e., 35 working years and 70 year lifetime).

- In many scenarios it is likely that a grower would mix, load, and apply chemicals all in one day because of limited labor, efficiency, or many other reasons. In most cases, however, the Agency considers mixing/loading, and application as separate job functions. This is done primarily due to a lack of data that allows additivity between tasks to be appropriately assessed. Also, this approach allows for more flexibility in the risk management process. For example, if a closed loading system might be required for mixer/loaders but engineering controls might not be required to reduce applicator exposures. If combined exposure estimates were considered, engineering controls might have been required for both tasks.

- The Agency has evaluated scenarios that may be limited in nature such as flagging during aerial applications because engineering controls (i.e., Global Positioning Satellite technology) are now predominantly used as indicated by the 1998 National Agricultural Aviation Association (NAAA) survey of their membership. It appears, however, flaggers are still used in approximately 10 to 15 percent of aerial application operations. In cases like these, the Agency strongly encourages the use of the engineering control system but will continue to evaluate risks for flaggers and any other population where a clear exposure pathway exists until the potential for exposure is eliminated. The Agency is aware that NAAA is conducting another survey of its membership on exposure issues and will consider those results as is timely and appropriate.

- The Agency always considers the maximum application rates allowed by labels in its risk assessments in order to be able to consider what is legally possible based on the label. If additional information such as average or typical rates are available, these values are used as well in order to allow risk managers to make a more informed risk management decision. Average application rates were available from the SMART meeting and BEAD’s QUA. These data indicate that in most cases, average application rates differ from maximum application rates on average by a factor of two. For example, when interpreting the results of the cancer assessment, the small differences generally seen in the available rates should be considered along with the overall magnitude of the cancer risk results. However, it should be noted that because there appears to be little difference between the typical and maximum application rates, overall risk results are not expected to be sensitive to changes in this parameter.

- The average occupational workday is assumed to be 8 hours. The daily areas to be treated were defined for each handler scenario (in appropriate units) by determining the amount that can be reasonably treated in a single day (e.g. acres, animals). The factors used for the carbaryl assessment are the same as those detailed in the Health Effects Division Science Advisory Committee on Exposure *Policy 9: Standard Values for Daily Acres Treated in Agriculture* which was completed on July 5, 2000. The following daily volumes handled and acres, excerpted from the policy, to be treated in each occupational scenario include:
    - Aerial applications:1200 acres for large field crops and forest treatments, 350 acres for other field crops, and 7500 acres for mosquito control adulticide applications;
    - Groundboom: 200 acres for large field crops (e.g., wheat and corn), 80 acres treated for other field crop groundboom applications, and 40 acres on golf course turf;
    - Airblast: 40 acres treated for agricultural applications;
    - Ground fogger: 3000 acres for mosquito control (airblast as surrogate);
    - 8 pet animals treated per day for veterinary and professional groomer uses;
    - 1000 gallons of spray solution prepared when mixing/loading liquids for high pressure handwand application or making the application;
    - 40 gallons when mixing/loading/applying liquids with a backpack sprayer or a low pressure handwand sprayer;
    - 10 mounds per day treated for fire ant applications.

  [Note: The veterinary and fireant treatments are not included in the policy but represent values that have been used by the Agency in previous assessments. Some carbaryl use patterns may not be summarized above, refer to Policy 9 for further information.]

- A comment by Bayer Corporation was made concerning the validity of extrapolating unit exposure estimates from PHED to large acreages such as 200 acres/day for groundboom and 1200 acres/day for aerial applications. A biological monitoring study conducted using ethoprop during large acreage potato applications (MRID 45621501) was referenced as the basis for questioning the approach. Bayer also indicated that this phenomena would also be explored in more detail through the auspices of the *Agricultural Handlers Exposure Taskforce* (AHETF) of which Bayer is a member. The Agency evaluated the ethoprop data and determined that the results were inconclusive at this point. As such, no direct changes were made to the assessment based on this comment.

- For direct pet animal treatments, Agency policy outlined in the Residential SOPs, was used to define the amount of chemical applied in animal treatments. For pet treatments, the SOPs prescribe that ½ of a container is used to treat each animal. Dusts and liquid shampoos for carbaryl are available in a 6 ounce bottle (0.5% solution) and a 4 lb container (10% dust).

- Currently the Agency has no exposure monitoring data on dust applications to crops in agriculture. There are other data gaps that have been identified for carbaryl applications. Each is identified in the calculation tables and is also noted in the summary of risk calculations.

- Ultra-low volume applications for uses such as mosquito control adulticides were considered using a large acreage estimate to aerial applicators. The mosquito adulticide uses that were evaluated in the same manner as other chemicals used for that purpose (e.g., the same acreage estimates were used as for other chemicals like fenthion and naled).

- The impact of using large area (i.e., acreage) estimates should be considered when interpreting the results such as with the scenarios intended to address wide area treatments. For wide area treatments, the Agency considered large acreage aerial and ground fogger applications related to mosquito control operations and for the APHIS grasshopper control program. This is particularly true when considering the groundfogger mosquito control applications since agricultural airblast data were used as a surrogate and groundfoggers treat much larger acreages on a daily basis and the type/amount of spray put out by them is somewhat different from airblast equipment.

The Agency uses a concept known as *unit exposure* as the basis for the scenarios used to assess handler exposures to pesticides. *Unit exposures* numerically represent the exposures one would receive related to an application. They are generally presented as (mg active ingredient exposure/pounds of active ingredient handled). The Agency has developed a series of unit exposures that are unique for each scenario typically considered in our assessments (i.e., there are different unit exposures for different types of application equipment; job functions; and levels of protection). The *unit exposure* concept has been established in the scientific literature and also through various exposure monitoring guidelines published by the U.S. EPA and international organizations such as Health Canada and OECD (Organization For Economic Cooperation and Development). The concept of unit exposures can be illustrated by the following example. If an individual makes an application using a groundboom sprayer with either 10 pounds of chemical A or 10 pounds of chemical B using the same application equipment and protective measures, the exposures to chemicals A and B would be similar. The unit exposure in both cases would be 1/10th of the total exposure (measured in milligrams) received during the application of either chemical A or chemical B (i.e., milligrams on the skin after applying 10 pounds of active ingredient divided by 10 pounds of active ingredient applied).

The unit exposure values that were used in this assessment were based on one carbaryl-specific occupational handler exposure monitoring study during professional dog grooming, three other studies which were used as sources of surrogate exposure information that are not currently included in the Pesticide Handler Exposure Database (PHED) Version 1.1 August 1998, and PHED itself. A brief summary of these studies is provided below in this section. Along with these data, unit exposures from PHED were used to complete remaining aspects of this risk assessment. Each is discussed and summarized below.

Occupational Handler Exposure Studies: A total of five studies are described in this section. One study monitored carbaryl use during professional dog grooming activities. The other studies were not completed with carbaryl but were completed with other active ingredients and used as a source of surrogate exposure information for various carbaryl use patterns. Each study can be identified with the following information. A summary of each is also provided below.

- "**Dermal Exposure and Inhalation Exposure to Carbaryl by Commercial Pet Groomers During Applications of Adams ™ Carbaryl Shampoo.**" EPA MRID 446584-01, September 1998 Report dated August 10, 1998; Author; Thomas C. Mester, Ph.D. Sponsor: Pfizer Animal Health.

- "**Worker Exposure Study During Application In Banana Plantation With Temik 10G, RP Study SA 98337, EPA MRID 451672-01, Vol. 3 of 4**" EPA MRID 451672-01; November 1999 Report; Author: Michel Urtizberea; Sponsor: Bayer Crop Protection; EPA DER Completed on 10/17/00 (DP Barcode D267546).

- "**Worker Exposure Study During Application Of Regent 20GR In Banana Plantation, (RP Study 94/136 - Amended, EPA MRID 452507-01, Vol. 4 of 4, Analytical Lab. CP/Man/ENH/338/95/0072)**" EPA MRID 452507-02; June 1996 Report; Author: P.G. Pontal; Sponsor: Bayer Crop Protection; EPA DER Completed on 1/05/01 (DP Barcode 270065).

- "**Exposure of Applicators to Propoxur During Trigger-Pump Spray Applications of a Liquid Product** " EPA MRID 410547-01; November 1, 1988; Author: R.D. Knarr, Ph.D., CIH; Sponsor: Bayer Corporation; EPA review (9/29/89) by Versar, Inc. for PHED purposes under Contract 68-02-4254, Task 220.

- "**Integrated Report For Evaluation of Potential Exposures To Homeowners and Professional Lawncare Operators Mixing, Loading, and Applying Granular And Liquid Pesticides To Residential Lawns** " EPA MRID 449722-01; October 10, 1999; Author: Dennis R. Klonne, Ph.D.; Sponsor: Outdoor Residential Exposure Task Force; EPA Review by Gary Bangs (April 30, 2001).

[**Note to Chemical Review Manager:** There are no data compensation issues associated with the use of non-ORETF data included in MRIDs 451672-01 and 452507-01 as these studies were sponsored and submitted by the Bayer Corporation and the propoxur trigger sprayer study has a signed PHED data waiver but just has not been included into PHED at this time. Appendix B contains the data excerpted from MRID 446585-01 in various tables which is a carbaryl-specific study recently completed by the Bayer Corporation. Data from the other referenced studies are not included in Appendix B because separate reviews exist for each which can be independently referenced. Some of the handler exposure data used in this assessment are from the Outdoor Residential Exposure Task Force (ORETF). There is also no data compensation issue associated with the use of the ORETF data in the carbaryl risk assessment because the Bayer Corporation, the registrant for carbaryl, is a member of the ORETF. The task force recently submitted proprietary data to the Agency on hose-end sprayers, push-type granular spreaders, and handgun sprayers (MRID # 44972201). The ORETF data were used in this assessment in place of PHED data. The

ORETF data were designed to replace the present PHED data with higher-confidence, higher quality data that contains more replicates than the PHED data for those scenarios. Finally, the Agency identified several occupational exposure studies from the literature by investigators such as Popendorf and Wolfe. These data have not been used by the Agency quantitatively in this assessment because of several issues but were qualitatively considered and also used to confirm the currently used exposure data.]

MRID 446584-01 (carbaryl-specific dog groomer data): The data collected reflect the dermal and respiratory exposure of commercial pet groomers applying the end use product, Adams® Carbaryl Flea and Tick Shampoo containing 0.50 percent carbaryl. These data meet most of the criteria specified in Series 875 Occupational and Residential Exposure Test Guidelines. The data are of sufficient scientific quality to be used in the reregistration of carbaryl. The protocol was reviewed by the then Occupational and Residential Exposure Branch of the Health Effects Division. The protocol was accepted as written with the stipulation that protective latex gloves not be worn by groomers because "this protocol was required as a worst case estimate of exposure. Therefore, the use of gloves in this study needs to be deleted" (From George Tompkins to Michael Metzger, dated November 26, 1996). In this study, applications of Adams® Carbaryl Flea and Tick Shampoo were made by professional pet groomers to 8 dogs at 2 sites in Georgia. A total of 16 replicates were monitored for dermal and inhalation exposure. Eight dogs of various sizes and hair lengths were shampooed during each replicate. Dermal exposure was monitored with face and neck swabs, 100 percent cotton union suit dosimeter worn underneath a short-sleeved t-shirt, long pants and a 65/35 polyester cotton long-sleeved smock (i.e., represents a short-sleeved shirt under a long-sleeved coat/smock). Hand exposure was quantified using handwash rinses (no protective gloves were worn). Inhalation exposure was monitored using personal air pumps with XAD2 resin tubes.

Between 373.3 to 3719.95 mg carbaryl (average use was 1360 mg ai) was used to shampoo 8 dogs. According to label directions, the application rate is a subjective determination by the individual groomers based on amount needed to create the desired lather. The dogs were wetted, shampooed to a lather (lather remained on dogs for 5 minutes) and rinsed. It is not clear how many or which of the dogs got further post-shampoo attention such as grooming or drying.

After completing 8 dog shampoos the dosimeters were collected. Face/neck swabs and 2 hand rinses were performed along with collection of the 100 percent cotton union suit. Only whole-body dosimeter values were adjusted for field recovery (87 percent). No other samples were corrected for recovery as the field and laboratory recoveries generally were >90 percent. Dermal exposures ranged between 0.88 mg and 17 mg ai and inhalation exposures range between 0.05 µg (non-detect) and 1.96 µg ai. The limit of detection (LOD) was 0.010 µg/ml. The limit of quantitation (LOQ) was 1 µg per whole body dosimeter, 0.10 µg/ml for 50 ml hand wash aliquot, 0.10 µg per facial wipe, 0.10 µg per resin tube, and 0.10 µg for glass fiber filter/support pad. Table 5 contains the results which have been normalized based on each of the following factors:

- mg ai exposed per lb ai handled;
- ai exposed per hour, and
- mg ai per lb dog shampooed.

The geometric mean of the normalized numbers was used in reregistration calculations because it is a measure of central tendency.

Even though the study protocol was approved prior to completion of the field work, the following factors should be considered when interpreting these results. In this task, direct contact of the dipping solution with the hands represents a major potential source of exposure. Therefore, obtaining accurate hand exposure estimates is critical in defining the risks for this use. The study measured the amount of carbaryl left on the hands after 8 shampoos and rinses using an aqueous handwash method. Shampoo was applied, a lather was created and rinsed off with a large degree of hand contact with the shampoo and water stream. Carbaryl repeatedly contacted the hand for the duration of the grooming and some was removed during the rinsing of each dog. Because of this potential flux of residues off and on the groomer's hands and the presence of surfactants which may impact dermal absorption levels, the handwash method may underestimate exposures. This study should not be used for residential exposure assessments because protective clothing (i.e., smock and long pants) were worn over the whole-body dosimeters and adjusting the data using negative protection factors which is generally not considered appropriate.

Table 5: Unit Exposure Values Obtained From Professional Dog Groomer Study (MRID 446584-01)

Dermal				Inhalation			
Unit	Arithmetic Mean	Geometric Mean	Median	Unit	Arithmetic Mean	Geometric Mean	Median
mg ai / lb ai handled	1900	1800	1800	µg ai / lb ai handled	24	12	19
mg ai / hour application	1.6	1.1	1.1	µg ai / hour application	0.20	0.96	0.21
mg ai / lb of dog treated	0.18	0.13	0.14	µg ai / lb of dog treated	0.020	0.011	0.020
Appendix B contains the data excerpted from MRID 446585-01. Data from none of the other studies are included in Appendix B because separate reviews exist for each of the other studies which can be independently referenced.							

EPA MRID 45167201 (Temik granular backpack study): A total of 12 mixer/loader/applicator events during granular backpack (i.e., a specialized device manufactured by Swissmex Rapid) application to bananas were monitored during August of 1998 on the island of Martinique which is in the French West Indies. Weather was typical of the application season in that it was hot, humid, and rainy at points. Monitoring was completed using whole body dosimeters, handwashes, facial wipes, and personal sampling pumps equipped with XAD resin/filter combination samplers. Temik 10G was supplied in 22 pound boxes which was loaded directly into the backpack devices (i.e., 4 to 8 boxes were used per replicate). The application rate for aldicarb used in this study is 20 grams of Temik 10G (i.e., 2 grams ai/plant) which is equivalent to about 3.56 lb ai/acre at approximately 2000 plants per acre. The numbers of acres treated ranged from approximately 2.5 to 5 acres. The pounds of active ingredient handled ranged from 8.8 up to 17.6 per replicate. Each applicator wore the whole body dosimeters covered by a cotton coverall, Tyvek gloves supplied with the Temik 10G formulation, and an apron on their backs between their backs and the backpack applicator. The Tyvek gloves were changed with each box of Temik 10G used. In many instances, the gloves were compromised because they were ripped. In one case, the gloves filled with rainwater. In many other cases, when the whole body dosimeters were removed, they were found to be wet and muddy.

Analysis of aldicarb and its sulfoxide and sulfone degradates was completed. The residue levels were added together to obtain total exposure levels. The limits of quantification (LOQ) were 1.0 µg per sample for the whole-body dosimeters and handwashes (600 mL volume). The LOQ for the facial wipes was 0.10 µg per sample and 0.050 0.10 µg per sample for the air filters.

Field and laboratory recovery data were generated for all media for all residues measured (i.e., parent and metabolites). Field recovery data were generated in a manner that addressed field sampling, field storage, transport, laboratory storage, and analysis. Residues were corrected for the overall average field recovery for each residue/matrix combination. Generally, recovery was adequate for all media/residue combinations. If the PHED grading criteria are applied, all residue/matrix combinations (except facial wipes with sulfone residues) have at least grade “B” data and in many cases the data meet the grade “A” criteria. The grade “B” criteria require laboratory recovery data with an average of at least 80 percent and a coefficient of variation of 25 or less accompanied with field recoveries that are at least 50 percent but not exceeding 120 percent. The grade “A” criteria require laboratory recovery data with an average of at least 90 percent and a coefficient of variation of 15 or less accompanied with field recoveries that are at least 70 percent but not exceeding 120 percent.

Unit exposure values were calculated using the data from the study and a commercial spreadsheet program (Table 6). The exposures that were calculated were normalized by the amount of chemical used, the duration of the application interval, and by the body weight of the individual applicators. For each calculation, the arithmetic mean, geometric mean, and various percentiles were calculated. No analyses were completed with these data to ascertain the exact type of distribution. The Agency typically uses the best fit values from the Pesticide Handlers Exposure Database which are representations of the central tendency. Considering the standard practice, the Agency will use the geometric mean for risk assessment purposes. The other values are presented for comparative purposes.

Table 6: Unit Exposure Values Obtained From Granular Backpack Application Study (MRID 451672-01)

Type	(mg exp./lb ai handled)		(mg exp./hour)		(mg exp./kg body weight/day)	
	Dermal	Inhalation	Dermal	Inhalation	Dermal	Inhalation
Arith. Mean	0.1391	0.0046	0.5473	0.0179	0.0585	0.0018
Geo. Mean	0.0995	0.0042	0.3979	0.0169	0.0409	0.0017
25th %tile	0.0474	0.0031	0.2511	0.0134	0.0220	0.0015
75th %tile	0.1691	0.0062	0.7436	0.0229	0.0765	0.0023

Table 6: Unit Exposure Values Obtained From Granular Backpack Application Study (MRID 451672-01)						
Type	(mg exp./lb ai handled)		(mg exp./hour)		(mg exp./kg body weight/day)	
	Dermal	Inhalation	Dermal	Inhalation	Dermal	Inhalation
90th %tile	0.2217	0.0068	0.8489	0.0264	0.0947	0.0027
95th %tile	0.3510	0.0076	1.2119	0.0282	0.1390	0.0028
99th %tile	0.4722	0.0083	1.5594	0.0298	0.1805	0.0030

EPA MRID 452507-01 (Fipronil Spoon Application Study): A total of 18 mixer/loader/applicator events during granular backpack (i.e., a specialized device manufactured by Horstine Farmery) or spoon application to bananas were monitored during applications on three different days in June, 1994 on the same banana plantation in Cameroon. [Note: Only the spoon application data included in this study are used in the carbaryl risk assessment as backpack granular applications have been assessed using the data presented above.] The 18 replicates were distributed over the 3 sampling days as follows: 6 spoon/hand applications on day 1; 4 spoon/hand applications on day 2; and 8 backpack events on day 3. Weather was typical of the application season in that it was hot and humid. Monitoring was completed using whole body dosimeters, cotton gloves, cotton caps, and personal sampling pumps equipped with filters. Regent 20GR was supplied in 22 pound boxes which was loaded directly into the backpack devices or buckets for the spoon applicators. The application rate for fipronil used in this study is 7.5 grams of Regent 20GR (i.e., 0.15 grams ai/plant) which is equivalent to about 0.26 lb ai/acre (0.00033 lb ai/plant) at approximately 800 plants per acre. The numbers of acres treated ranged from approximately 0.75 to 1 acre. The pounds of active ingredient handled ranged from about a quarter to half a pound per replicate. Each applicator wore whole body dosimeters that also served as the normal work clothing. PVC gloves were also worn over cotton gloves which served as the dosimeters. A protection factor of 50 percent was used by the Agency to calculate exposure levels under a layer of normal work clothing. Dosimeter samples were segmented into arms, legs, and torso for analysis.

Analysis of fipronil residues was completed with gas chromatography and electron capture detection. The limits of quantification (LOQ) were 9.7 µg per sample for all media used. The limit of detection (LOD) varied for each media. The LOD for the cotton gloves was 0.5 µg per sample, 0.10 µg per sample for the air filters, and 2.0 to 4.0 µg per sample for the whole body dosimeters depending upon the sample analyzed. Field and laboratory recovery data were generated for all media. Field recovery data were generated in a manner that addressed field sampling, field storage, transport, laboratory storage, and analysis. However, the laboratory recovery data were indeterminate because the sample media could not be identified for each reported result. The overall recovery values do appear to be quantitative. Residues were corrected for the overall average field recovery for each residue/matrix combination. Generally, recovery was adequate for all media/residue combinations (i.e., all correction factors were greater than 85 percent). If the PHED grading criteria are applied and the overall laboratory recovery averages are used all residue/matrix combinations are considered grade “A” data. The grade “A” criteria require laboratory recovery data with an average of at least 90 percent and a coefficient of variation of 15 or less accompanied with field recoveries that are at least 70 percent but not exceeding 120 percent.

Unit exposure values were calculated using the data from the study and a commercial spreadsheet program. The exposures that were calculated were normalized by the amount of chemical used, the duration of the application interval, and by the body weight of the individual applicators (see table below). The values are based on a 50 percent clothing penetration factor and are separated for each equipment type monitored in this study. For each normalization factor, the arithmetic mean, geometric mean, and various percentiles were calculated. No analyses were completed with these data to ascertain the exact type of distribution. The Agency typically uses the best fit values from the Pesticide Handlers Exposure Database which are representations of the central tendency. Considering the standard practice, the Agency will use the geometric mean for risk assessment purposes. The other values are presented for comparative purposes.

Table 7: Unit Exposure Values Obtained From Granular Spoon Application Study (MRID 452507-01)

Type	(mg exp./lb ai handled)		(mg exp./hour)		(mg exp./kg body weight/day)	
	Dermal	Inhalation	Dermal	Inhalation	Dermal	Inhalation
Applications with a Spoon						
Arith. Mean	2.875	0.106	0.433	0.016	0.025	0.001
Geo. Mean	1.978	0.045	0.246	0.006	0.014	0.0003
Median	1.889	0.039	0.221	0.005	0.011	0.0003
25th %tile	0.990	0.024	0.104	0.003	0.006	0.0001
75th %tile	4.140	0.066	0.677	0.007	0.035	0.0004
90th %tile	6.113	0.316	0.999	0.052	0.059	0.003
95th %tile	7.276	0.402	1.190	0.066	0.072	0.004
99th %tile	8.207	0.471	1.342	0.077	0.082	0.005

EPA MRID 410547-01 (Propoxur trigger sprayer study): A total of 15 applicator events during residential applications using a hand-operated trigger pump sprayer, attached with an 18 inch hose to half gallon cans containing 0.95 percent propoxur, were completed in this study. The study was completed between October 26 and November 1, 1988 in the Kansas City Missouri metro area. Each person monitored in the study was a Bayer (the sponsor corporation) employee. Three employees were used to complete all replicates. In each replicate, "each applicator used a separate one-half gallon can of Raid for each house. The cap was removed from the top of the can and the hose sprayer was attached by inserting the dip tube into the can and tightening the screw cap. The sprayer was primed by pumping the trigger. The applicator treated the outside of the home in areas where pests were likely to be found, such as screens, door and window frames, foundation walls, patios, porches, stoops, and decks. When the application was completed, the hose sprayer was secured under the handle of the can." The data included in the study indicate that exposure durations ranged from 9 to 21 minutes per replicate and the amount of active ingredient handled ranged from 0.16 to 0.4 oz (i.e., 0.01 to 0.025 lb ai). Dermal (nonhand) exposure monitoring during each replicate was completed using gauze sponges held in "aluminized paper holders" with an open sampling surface area of 24.6 cm^2 while hand exposures were quantified with the handwash technique (2 - 200 mL aliquots of ethanol per hand for a total volume of 800 mL per person). Inhalation exposures were monitored using standard personal sampling pumps operating a 1 liter per minute with quartz microfiber filters. Samples were collected in this study to represent exposures when a person was wearing normal work clothing (i.e., long pants and long-sleeved shirts) and chemical-resistant gloves.

Analysis of propoxur residues was completed with high performance liquid chromatography, post-column derivatization, and fluorescence detection. The limits of quantification (LOQ) were 10 µg per sample for the handwash solutions, 0.1 µg/sample for the inhalation filters, and 0.03 $\mu g/cm^2$ for the dermal patch samples. Field and laboratory recovery data were generated for all media. This study was reviewed in September 1989 under EPA contract 68-02-4254 by Versar. The values used for regulatory purposes have been excerpted from that review (including recovery results). Average laboratory recovery for all media ranged from 99.2 to 109 percent while the coefficients of variation for each media were generally less than 5 (i.e., for the patches, the CV = 16.5). Patches and filters were fortified at 1 µg/sample while hand rinses were fortified at either 200 or 1000 µg/sample. Average field recovery results ranged from 90.3 to 102.2 percent while coefficients of variation also were generally less than 5 (i.e., inside patch CV= 6.9). Patches were fortified at levels from 1 to 50 µg/sample, hand rinses were fortified at 200 µg/sample, and filters were fortified at 0.2 µg/sample.

Unit exposure values were calculated using the data from the study and a commercial spreadsheet program. The exposures that were calculated were normalized by the amount of chemical used by individual applicators (Table 8).

Table 8: Unit Exposure Values Obtained From Propoxur Trigger Pump Sprayer Study (MRID 410547-01)

Type	(mg exp./lb ai handled)	
	Dermal	Inhalation
Geometric Mean	13.5	0.123
Unit exposure values excerpted from Versar PHED Data review under Contract 68-02-4254 (9/29/89).		

EPA MRID 449722-01 (ORETF Handler Studies): A report was submitted by the ORETF (Outdoor Residential Exposure Task Force) that presented data in which the application of various products used on turf by homeowners and lawncare operators (LCOs) was monitored. All of the data submitted in this report were completed in a series of studies. The two studies that monitored LCO exposure scenarios used a granular spreader (ORETF Study OMA001) and a low pressure, high volume turf handgun (ORETF Study OMA002) are summarized below.

> **OMA001:** A loader/applicator study was performed by the Outdoor Residential Exposure Task Force (ORETF) using Dacthal (active ingredient DCPA, dimethyl tetrachloroterephthalate) as a surrogate compound to determine "generic" exposures of lawn care operators (LCOs) applying a granular pesticide formulation to residential lawns. Surrogate chemicals were chosen by the Task Force for their representativeness based on physical chemical properties and other factors. Dacthal, which was the surrogate chemical used for the granular spreader and low-pressure hand gun sprayer studies, has a molecular weight of 331.97 and a vapor pressure of 1.6×10^{-6}, and is believed to be an appropriate surrogate for many relatively nonvolatile pesticides. The study was designed to simulate a typical work day for a LCO applying granular pesticide formulation to home lawns. Each LCO replicate involved loading and applying approximately 3.3 lb ai (360 lb formulated product) over a period of about 4 hours to 15 simulated residential lawns (6480 ft^2 each) with a rotary type spreader. The average industry application rate of 2 lb ai/acre was simulated (actual rate achieved was about 1.9 lb ai/acre). The monitoring period included driving,

placing the spreader onto and off of the truck, carrying and loading the formulation in the spreader, and the actual application. Incidental activities such as repairs, cleaning up spills, and disposing of empty bags were monitored. A total of 40 replicates (individual application events) were monitored using passive dosimetry (inner and outer whole body dosimeters, hand washes, face/neck wipes, and personal inhalation monitors with OVS tubes). The inner samples represent a single layer of clothing. Inhalation exposure was calculated using an assumed respiratory rate of 17 Lpm for light work (NAFTA,1999), the actual sampling time for each individual, and the pump flow rate. In 20 of the replicates, the subjects wore chemical-resistant gloves while in the remaining replicates, no gloves were worn. No gloves were worn in any replicate while driving. All results were normalized for the amount of active ingredient handled. Nearly all samples (for every body part and for inhalation) were above the level of quantitation (LOQ) for dacthal. Where results were less than the reported LOQ, ½ LOQ value was used for calculations, and no recovery corrections were applied. The overall laboratory recoveries (83-101%) and field recoveries (73-98%). The unit exposure values are presented in Table 9 below. [Note the inhalation exposure value is a median because the data were found to be neither normally nor lognormally distributed. All dermal values are geometric means as the data were lognormally distributed.]

OMA002: A mixer/loader/applicator study was performed by the Outdoor Residential Exposure Task Force (ORETF) using Dacthal as a surrogate compound to determine "generic" exposures to individuals applying a pesticide to turf with a low-pressure "nozzle gun" or "hand gun" sprayer. Dermal and inhalation exposures were estimated using whole-body passive dosimeters and breathing-zone air samples on OVS tubes. Inhalation exposure was calculated using an assumed respiratory rate of 17 Lpm for light work (NAFTA,1999), the actual sampling time for each individual, and the pump flow rate. All results were normalized for lb ai handled. A total of 90 replicates were monitored using 17 different subjects. Four different formulations of dacthal [75% wettable powder (packaged in 4lb and 24 lb bags), 75% wettable powder in water soluble bags (3 lb bag), 75% water dispersable granules (2 lb bag) and 55% liquid flowable (2.5 Gal container)] were applied by five different LCOs to actual residential lawns at each site in three different locations (Ohio, Maryland, and Georgia) for a total of fifteen replicates per formulation. An additional ten replicates at each site were monitored while they performed spray application only using the 75 percent wettable powder formulation. A target application rate of 2 lb ai/acre was used for all replicates (actual rate achieved was about 2.2 lb ai/acre). Each replicate treated a varying number of actual client lawns to attain a representative target of 2.5 acres (1 hectare) of turf. The exposure periods averaged five hours twenty-one minutes, five hours thirty-nine minutes, and six hours twenty-four minutes, in Ohio, Maryland and Georgia, respectively. Average time spent spraying at all sites was about two hours. All mixing, loading, application, adjusting, calibrating, and spill clean up procedures were monitored, except for typical end-of-day clean-up activities, e.g. rinsing of spray tank, etc. Dermal exposure was measured using inner and outer whole body dosimeters, hand washes, face/neck washes, and personal air monitoring devices. All test subjects wore one-piece, 100 percent cotton inner dosimeters beneath 100 percent cotton long-sleeved shirt and long pants, rubber boots and nitrile gloves. Gloves are typically worn by most LCOs, and required by many pesticide labels for mixing and loading. Overall, residues were highest on the upper and lower leg portions of the dosimeters In general, concurrent lab spikes produced mean recoveries in the range of 78-120 percent, with the exception of OVS sorbent tube sections which produced mean recoveries as low as 65.8 percent. Adjustment for recoveries from field fortifications were performed on each dosimeter section or sample matrix for each study participant, using the mean recovery for the closest field spike level for each matrix and correcting the value to 100 percent. The unit exposure values are presented in Table 9 below. [Note the data were found to be lognormally distributed. As a result, all exposure values are geometric means.]

Table 9: Unit Exposure Values Obtained From ORETF LCO Studies (MRID 449722-01)

Type	(mg exp./lb ai handled)			
	Dermal			Inhalation
	Single Layer, No Gloves	Single Layer, Gloves	Double Layer, Gloves	
LCO Push Granular Spreader	0.35	0.22	0.11	0.0071
LCO Turfgun (WP Formulation)	No Data	0.65	0.36	0.0066

All unit exposure values are geometric means except inhalation value for granular spreader. Double layer value calculated using a 50% protection factor. Turfgun, no glove data were not back calculated using a 90 percent protection factor as it is deemed unreliable. WP formulation in WSP packaging used for turfgun assessment as the unit exposures for this scenario were slightly higher than for the other scenarios and deemed representative of current products/packaging.

Pesticide Handler Exposure Database (PHED) Version 1.1 (August 1998): Chemical-specific data for assessing human exposures during pesticide handling activities were submitted to the Agency in support of one occupational exposure scenario for the reregistration of carbaryl. It is the policy of HED to combine submitted chemical-specific data with that from the Pesticide Handlers Exposure Database (PHED) Version 1.1 when appropriate to assess handler exposures for regulatory actions[4]. The scenario/chemical-specific study submitted has no corresponding scenario in PHED, therefore, unit exposure values from the study are used to calculate exposure and risk for the use pattern. For all other remaining scenarios, data from PHED were used to complete the assessment.

PHED was designed by a task force of representatives from the U.S. EPA, Health Canada, the California Department of Pesticide regulation, and member companies of the American Crop Protection Association. PHED is a software system consisting of two parts -- a database of measured exposure values for workers involved in the handling of pesticides under actual field conditions and a set of computer algorithms used to subset and statistically summarize the selected data. Currently, the database contains values for over 1,700 monitored individuals (i.e., replicates)

Users select criteria to subset the PHED database to reflect the exposure scenario being evaluated. The subsetting algorithms in PHED are based on the central assumption that the magnitude of handler exposures to pesticides are primarily a function of activity (e.g., mixing/loading, applying), formulation type (e.g., wettable powders, granulars), application method (e.g., aerial, groundboom), and clothing scenarios (e.g., gloves, double layer clothing).

Once the data for a given exposure scenario have been selected, the data are normalized (i.e., divided by) by the amount of pesticide handled resulting in standard unit exposures (milligrams of exposure per pound of active ingredient handled). Following normalization, the data are statistically summarized. The distribution of exposure values for each body part (e.g., chest upper arm) is categorized as normal, lognormal, or "other" (i.e., neither normal nor lognormal). A central tendency value is then selected from the distribution of the exposure values for each body part. These values are the arithmetic mean for normal distributions, the geometric mean for lognormal distributions, and the median for all "other" distributions. Once selected, the central tendency values for each body part are composited into a "best fit" exposure value representing the entire body.

The unit exposure values calculated by PHED generally range from the geometric mean to the median of the selected data set. To add consistency and quality control to the values produced from this system, the PHED Task Force has evaluated all data within the system and has developed a set of grading criteria to characterize the quality of the original study data. The assessment of data quality is based on the number of observations and the available quality control data. These evaluation criteria and the caveats specific to each exposure scenario are summarized in Appendix C, Table C1. While data from PHED provide the best available information on handler exposures, it should be noted that some aspects of the included studies (e.g., duration, acres treated, pounds of active ingredient handled) may not accurately represent labeled uses in all cases. HED has developed a series of tables of standard unit exposure values for many occupational scenarios that can be utilized to ensure consistency in exposure assessments. Unit exposures are used which represent different levels of personal protection as described above. Protection factors were used to calculate unit exposure values for varying levels of personal protection if data were not available.

2.1.3 Occupational Handler Exposure and Non-Cancer Risk Estimates

The occupational handler exposure and non-cancer risk calculations are presented in this section. Noncancer risks were calculated using the Margin of Exposure (MOE) which is a ratio of the body burden to the toxicological endpoint of concern. Body burden values are calculated by first calculating exposures by considering application parameters (i.e., rate and area treated) along with unit exposure levels. Exposures were then normalized by body weight and adjusted for absorption factors as appropriate to calculate dose levels (i.e., body burdens). MOEs were then calculated.

Daily Exposure: The daily exposure, daily dose and hence the risks, to handlers were calculated as described below. The first step was to calculate daily exposure (dermal or inhalation) using the following formula:

Daily Exposure (mg ai/day) =

Unit Exposure (mg ai/lb ai) x Application Rate (lb ai/A) x Daily Acres Treated (A/day)

Where:

Daily Exposure	=	Amount deposited on the surface of the skin that is available for dermal absorption or amount that is inhaled, also referred to as potential dose (mg ai/day);
Unit Exposure	=	Normalized exposure value derived from August 1998 PHED Surrogate Exposure Table and various referenced exposure studies noted above (mg ai/lb ai);
Application Rate	=	Normalized application rate based on a logical unit treatment such as acres or gallons, maximum and typical values are generally used (lb ai/A); and
Daily Acres Treated	=	Normalized application area based on a logical unit treatment such as acres (A/day) or gallons per day can be substituted (gal/day).

Inhalation exposure values were calculated in a similar manner. The only difference is that unit exposure values representing the inhalation route were used that were calculated using PHED and standard human breathing rates (29 liters/minute and an 8 hour exposure). [Note: In some cases, the above equation has been substituted by an algorithm excerpted from the Agency's *SOPs For Residential Exposure Assessment* (chapter 9) that calculates exposures based on the percent of active ingredient applied (e.g., pet treatment calculations). It should also be noted that HED has agreed to use the NAFTA recommended values for breathing rate rather than the existing rate in Series 875 Group A (i.e., previously known as Subdivision U). Series 875 Group A recommends an inhalation rate of 29 L/min. The new NAFTA recommended inhalation rates are 8.3, 16.7, and 26.7 L/min for sedentary activities (e.g., driving a tractor), light activities (e.g., flaggers and mixer/loaders < 50 lb containers), and moderate activities (e.g., loading > 50 lb containers, handheld equipment in hilly conditions), respectively. These inhalation reduction factors are 3.5 for tractor drivers, 1.7 for mixer/loaders and flaggers, and 1.1 for handheld equipment. These changes in exposure factors will be programmed into the next version of the handler exposure data base and are characterized in this document for regulatory risk management decisions.]

Daily Dose: Daily dose (inhalation or dermal) was then calculated by normalizing the daily dermal exposure value by body weight and accounting for dermal absorption (i.e., a biologically available dose resulting from dermal exposure was then calculated). For adult handlers using carbaryl, an average adult body weight of 70 kg was used for all exposure scenarios because all scenarios were occupational and the toxic effect was seen in males and females. Additionally, a dermal absorption factor of 12.7 percent was used for all chronic duration dermal calculations based on an absorption study in rats. A 21-day dermal administration toxicity study in rats was used to calculate risks for short- and intermediate-term dermal exposure. In cases such as this, a default value of 100 percent is used in the calculation. It should also be noted that there is no specific inhalation absorption factor that is available for carbaryl. Therefore, a factor of 100 percent has been used for all calculations. Daily dose was calculated using the following formula:

$$Average\ Daily\ Dose\left(\frac{mg\ ai}{kg/day}\right) = Daily\ Exposure\left(\frac{mg\ ai}{day}\right)\ x\ \left(\frac{AbsorptionFactor(\%/100)}{Body\ Weight\ (kg)}\right)$$

Where:

Average Daily Dose	=	The amount as absorbed dose received from exposure to a pesticide in a given scenario (mg pesticide active ingredient/kg body weight/day, also referred to as ADD);
Daily Exposure	=	Amount deposited on the surface of the skin that is available for dermal absorption or amount that is inhaled, also referred to as potential dose (mg ai/day);
Absorption Factor	=	A measure of the flux or amount of chemical that crosses a biological boundary such as the skin (% of the total available absorbed); and
Body Weight	=	Body weight determined to represent the population of interest in a risk assessment (kg).

The handler exposure assessment does not include any dietary or drinking water inputs.

Margins of Exposure: Finally, the calculations of daily dermal dose and daily inhalation dose received by handlers were then compared to the appropriate endpoint (i.e., NOAEL or LOAEL) to assess the total risk to handlers for each exposure route within the scenarios. Short- and intermediate-term dermal MOEs were calculated using a NOAEL of 20.0 mg/kg/day defined in the rat 21 day dermal toxicity study (Table 1). Short-term inhalation MOEs were calculated using a NOAEL of 1.0 mg/kg/day defined in the rat developmental neurotoxicity and rat acute neurotoxicity studies (Table 1). Intermediate-term inhalation MOEs were calculated using a NOAEL of 1.0 mg/kg/day defined in a subchronic neurotoxicity study in rats. Additionally, when required for a limited number of scenarios, chronic dermal and inhalation MOEs were calculated using a LOAEL of 3.1 mg/kg/day that was defined in a 1 year dog feeding study. All MOE values were calculated separately for dermal and inhalation exposure levels using the formula below:

$$MOE = \frac{NOAELorLOAEL\left(\frac{mg\ ai}{kg/day}\right)}{Average\ \ Daily\ \ Dose\left(\frac{mg\ ai}{kg/day}\right)}$$

Where:

MOE	=	Margin of exposure, value used by the Agency to represent risk or how close a chemical exposure is to being a concern (unitless);
ADD	=	(Average Daily Dose) or the amount as absorbed dose received from exposure to a pesticide in a given scenario (mg pesticide active ingredient/kg body weight/day); and
NOAEL or LOAEL	=	Dose level in a toxicity study, where no observed adverse effects occurred (NOAEL) in the study or the lowest dose level where an adverse effect occurred (LOAEL) in the study (mg pesticide active ingredient/kg body weight/day).

It is important to present risk values for each route of exposure (i.e., dermal or inhalation) in each scenario because it makes determining appropriate risk mitigation measures easier. For example, if overall risks are driven by dermal exposures and not inhalation, it would not advisable to require respirators as they may marginally reduce overall risks. It is also important to present overall risk estimates for each scenario considered by calculating total MOEs. A total MOE was calculated because common toxicity endpoints were used to calculate dermal and inhalation risks for each exposure duration. The following formula is used to calculate total MOE values by combining the route-specific MOEs:

$$MOE_{total} = 1/((1/MOE_a) + (1/MOE_b) +.... (1/MOE_n))$$

Where:

MOE_a, MOE_b, and MOE_n represent MOEs for each exposure route of concern

A margin of exposure (MOE) uncertainty factor of 100 is considered an appropriate risk level for the short- and intermediate-term risk assessments because a NOAEL was used as the basis for the assessment. A margin of exposure (MOE) uncertainty factor of 300 is considered an appropriate risk level for the chronic risk assessment because a LOAEL was selected from the1 year dog feeding study as the basis for the assessment.

Noncancer Risk Summary: All of the noncancer risk calculations for occupational carbaryl handlers completed in this assessment are included in Appendix C (Tables 1 - 9). The specifics of each of table included in Appendix C are described below. A summary of the results for each exposure scenario is also provided below (please refer to Appendix C for more details).

- **Appendix C/Table 1: Sources of Exposure Data Used in the Occupational Carbaryl Handler Exposure and Risk Calculations** Describes the sources and quality of the exposure data used in all of the occupational handler calculations.

- **Appendix C/Table 2: Input Parameters For Carbaryl Occupational Handler Exposure and Risk Calculations** Presents the numerical unit exposure values and other factors used in the occupational handler risk assessments.

- **Appendix C/Table 3: Margins of Exposure For Carbaryl Occupational Handler Risk Assessment At The Baseline Level of Personal Protection** Risk values are presented for each exposure duration considered in the assessment (i.e., short-, intermediate-, and chronic duration exposures). Represents typical work clothing or a long-sleeved shirt and long pants with no respiratory protection. No chemical-resistant gloves are included in this scenario. Note that some scenarios have no baseline dermal exposure values (see notes on Tables 1 and 2). [Note: The calculations from this table have been used to develop the summary in Tables 7, 8, and 9.]

- **AppendixC/Table 4: Margins of Exposure For Carbaryl Occupational Handler Risk Assessment At The Minimum Level of Personal Protection** Risk values are presented for each exposure duration considered in the assessment (i.e., short-, intermediate-, and chronic duration exposures). Represents the baseline scenario with the use of chemical-resistant gloves and PF 5 respirators. [Note: The calculations from this table have been used to develop the summary in Tables 7, 8, and 9.]

- **Appendix C/Table 5: Margins of Exposure For Carbaryl Occupational Handler Risk Assessment At The Maximum Level of Personal Protection** Risk values are presented for each exposure duration considered in the assessment (i.e., short-, intermediate-, and chronic duration exposures). Represents the baseline scenario with the use of an additional layer of clothing (e.g., a pair of coveralls), chemical-resistant gloves, and a PF 10 respirator. [Note: The calculations from this table have been used to develop the summary in Tables 7, 8, and 9.]

- **Appendix C/Table 6: Margins of Exposure For Carbaryl Occupational Handler Risk Assessment Using Engineering Controls** Risk values are presented for each exposure duration considered in the assessment (i.e., short-, intermediate-, and chronic duration exposures). Represents the use of an appropriate engineering control such as a closed tractor cab or closed loading system for granulars or liquids. Engineering controls are not applicable to handheld application methods there are no known devices that can be used to routinely lower the exposures for these methods. [Note: The calculations from this table have been used to develop the summary in Tables 7, 8, and 9.]

- **Appendix C/Table 7: Combined Short-Term Margins Of Exposure For Carbaryl Occupational Handler Risk Assessment** Presents combined dermal and inhalation MOEs with each possible combination of dermal and respiratory protection considered in this assessment. Results for exposure durations $\leq$ 30 days are only included in this table based on the use of the developmental neurotoxicity and acute neurotoxicity studies in rats to define the NOAEL for this duration. [Note: See tables 3 through 6 for calculations of specific MOE values.]

- **Appendix C/Table 8: Combined Intermediate-Term Margins Of Exposure For Carbaryl Occupational Handler Risk Assessment** Presents combined dermal and inhalation MOEs with each possible combination of dermal and respiratory protection considered in this assessment. Results for exposure durations >30 days up to several months are only included in this table based on the use of a subchronic neurotoxicity study in rats to define the NOAEL for this duration. [Note: See tables 3 through 6 for calculations of specific MOE values.]

- **Appendix C/Table 9: Combined Chronic Margins Of Exposure For Carbaryl Occupational Handler Risk Assessment** Presents combined dermal and inhalation MOEs with each possible combination of dermal and respiratory protection considered in this assessment. Results for exposures that occur essentially each working are only included in this table based on the use of a chronic dog feeding study to define the LOAEL for this duration. [Note: See tables 3 through 6 for calculations of specific MOE values.]

Tables 1 through 6 of Appendix C provide the inputs and illustrate how the calculations were performed to define the noncancer risks (i.e., Margins of Exposure or MOEs) for carbaryl handlers. The exposure data and other factors which were used represent the best sources of data currently available to the Agency for completing these kinds of assessments. For example, maximum application rates were derived directly from carbaryl labels. The recent use and usage report was also reviewed to define average application rates for each crop or group of crops considered. Exposure factors (e.g., body weight, amount treated per day, protection factors, etc.) are all standard values that have been used by the Agency over several years and are derived from peer reviewed sources whenever possible (e.g., Exposure Factors Handbook). The unit exposure values are the best available estimates of exposure. Some unit exposure values are high quality while others represent low quality, but the best available, data. Data quality should be considered in the interpretation of the uncertainties associated with each risk value presented. Please identify these scenarios based on information provided in Appendix C/Table 1. Additionally, it should be noted that the animal grooming scenario with dusts calculations were based on the SOPs For Residential Exposure Assessment (i.e., 10% of applied is considered equivalent to the dermal exposure). This calculation should be considered only as a rangefinder.

Tables 7, 8, and 9 in Appendix C provide the overall results of the risk assessment for each distinct exposure duration considered because they contain the combined risk values for each scenario using several combinations of personal protection (e.g., short-term combined MOEs are presented in Table 7). When protective measures are used to reduce risks it is appropriate to consider how each method will reduce the associated risks and the burden associated with the use of that method (e.g., gloves are thought to routinely reduce risks from dermal exposures by 90 percent based on the Agency protection factor for gloves). It should be noted that there were several scenarios which were identified for which no appropriate exposure data are known to exist. These include:

- Animal Grooming Dust Application;
- Dust applications in agriculture (not included on handler tables in Appendix C but considered a major data gap);
- Handheld Fogging For Mosquito and Other Pest Treatments;
- Power Backpack Application;
- Tree Injection; and
- Drenching/dipping seedlings [Note: The mixing/loading component only of this scenario has been addressed quantitatively.]

<u>Short-term and Intermediate-term Risk Summary:</u> Short-term and intermediate-term risks were calculated for different exposure scenarios at different levels of personal protection as illustrated in Tables 7 and 8 of Appendix C, respectively. The results and trends for both the short-term and intermediate-term calculations are identical because all exposure inputs were similar and the NOAEL values of 20 mg/kg/day for dermal exposures and 1 mg/kg/day for inhalation exposures are the same for both durations. The only difference is the source of the NOAELs selected for the inhalation risk assessment. The short-term values were determined based on rat developmental neurotoxicity and acute neurotoxicity studies while the intermediate-term NOAEL was defined using a subchronic neurotoxicity study in rats. Therefore, for economy, the results for both short- and intermediate-term occupational handlers have been summarized together in this section. [Note: If risk estimates were altered because of additional data or other reason, then separate sections would be presented as appropriate.]

In most scenarios, MOEs meet or exceed the required uncertainty factor of 100 at some level of personal protection. For the most part, current label requirements for personal protection (single layer clothing, gloves, and no respirator) appear to be generally inadequate for most scenarios except for operations where exposures and/or the amount of chemical used is low. Table 10 summarizes the results for short-term and intermediate-term occupational handlers. [Note: Scenarios where MOEs are still of concern (i.e., <100) for any personal protection considered are highlighted and the minimum required PPE is also highlighted if it exceeds current label requirements.]

Table 10: Summary of Short-/Intermediate-Term Occupational Handler Noncancer Risks

Scenario	Rate (lb ai/acre) [unless noted]	Area Treated (acres/day) [unless noted]	Risk Summary	
			MOEs	Min. Req. PPE
Mixer/Loaders				
1a Dry Flowable: Aerial/Chemigation	1-2 (wheat/corn) 2-5 (veg., stone fruit, 24C on oysters)	1200 350	363-726 498-1244	**EC** **EC**
1b Dry Flowable: Airblast	7.5-16 (various fruit & nut trees) 5 (nuts) 1.1-3 (pome & stone fruit, grapes)	40 40 40	1360-2902 101 143-391	**EC** **SL/GL/PF5** Baseline
1c Dry Flowable: Groundboom	1.5-2 (wheat/corn) 2 (strawberry/veg) 8 (turf/golf courses) 4 (turf/golf courses)	200 80 40 40	2177-2902 107 2721 108	**EC** Baseline **EC** Baseline
1d Dry Flowable: High Press HW/ROW Sprayer	4 lb ai/100 gal (poultry)	1000 gal	430	Baseline
1e Dry Flowable: Low press./High Vol. Turfgun	4 -8 (LCO on turf)	5	430-860	Baseline
1f Dry Flowable: Wide area aerial	2 (rangeland/forestry)	7500	**58**	**MOE < 100**
2a Granular: Aerial Application	2 (corn) 2 (corn) 0.03 (APHIS grasshopper)	1200 350 1000-6000	688 146 183-1100	**EC** **SL/GL/PF5** Baseline

Table 10: Summary of Short-/Intermediate-Term Occupational Handler Noncancer Risks				
Scenario	Rate (lb ai/acre) [unless noted]	Area Treated (acres/day) [unless noted]	Risk Summary	
			MOEs	Min. Req. PPE
2b Granular: Solid broadcast spreader	1.5 (wheat/corn) 2 (wheat/corn) 2 (vegetables) 6 (turf/golf courses) 9 (turf/golf courses)	200 200 80 40 40	110 256 206 138 284	Baseline **SL/GL/PF5** Baseline Baseline **SL/GL/PF5**
3a Liquid: Aerial/Chemigation	1.5-2 (wheat, max corn) 1 (avg. corn) 5 (stone fruit) 2 (vegetables)	1200 1200 350 350	**57-76** 114 **78** 103	**All MOEs < 100** **EC** **MOE<100** **DL/GL/PF10**
3b Liquid: Airblast Application	16 (Citrus-24C in California) 7.5 (Citrus) 5 (Nuts) 1.1-3 (Grapes, pome & stone fruit)	40 40 40 40	100 168 149 248-677	**DL/GL/PF10** **SL/GL/PF5** SL/GL/NR SL/GL/NR
3c Liquid: Groundboom	1.5 (wheat) 2 (corn) 2 (strawberries) 8 (turf/golf courses) 4 (turf/golf courses)	200 200 80 40 40	168 126 186 157 186	**SL/GL/PF5** **SL/GL/PF5** SL/GL/NR **SL/GL/PF5** SL/GL/NR
3d Liquid: High Press HW/ROW Sprayer	4 lb ai/100 gal (poultry)	1000 gal	745	SL/GL/NR
3e Liquid: Low press./High Vol. Turfgun	4 -8 (LCO on turf)	5	745-1489	SL/GL/NR
3f Liquid: Wide area aerial	2 (Range/Forestry) 0.016 (Mosquito adulticide) 0.15 (Mosquito adulticide) 1 (Mosquito adulticide) 0.375-0.5 (APHIS grasshopper) 0.125 (APHIS grasshopper)	7500 7500 7500 7500 6000 6000	**9** 248 121 **18** **46-61** 182	**MOE < 100** SL/GL/NR **EC** **MOE < 100** **MOE<100** **EC**
3g Liquid: Wide area ground	0.016 (Mosquito adulticide) 0.15 (Mosquito adulticide) 1 (Mosquito adulticide)	3000 3000 3000	621 112 **45**	SL/GL/NR **SL/GL/PF5** **MOE < 100**
4a Wettable Powders: Aerial	1-2 (Wheat/corn) 5 (stone fruit) 2 (vegetables)	1200 350 350	**40-80** **55** 137	**All MOEs < 100** **MOE < 100** **EC**
4b Wettable Powders: Airblast	16 (Citrus-24C in California) 1.1-7.5 (Citrus, nuts, grapes, pome & stone fruit)	40 40	150 320-2180	**EC** **EC**
4c Wettable Powders: Groundboom	1.5-2 (wheat/corn) 2 (strawberries) 4-8 (turf/golf courses)	200 80 40	240-320 599 299-599	**EC** **EC** **EC**
4d Wettable Powders: High Press HW/ROW Sprayer	4 lb ai/100 gal (poultry)	1000 gal	102	**SL/GL/PF5**
4e Wettable Powders: Low press./High Vol. Turfgun	4 (LCO on turf) 8 (LCO on turf)	5 5	102 205	**SL/GL/PF5** **SL/GL/PF5**

Table 10: Summary of Short-/Intermediate-Term Occupational Handler Noncancer Risks				
Scenario	Rate (lb ai/acre) [unless noted]	Area Treated (acres/day) [unless noted]	Risk Summary	
			MOEs	Min. Req. PPE
4f Wettable Powders: Wide area aerial	2 (Range/Forestry)	7500	**6**	**MOE<100**
Applicators				
5a Aerial: Agricultural uses, liquid sprays	1-1.5 (wheat/avg. corn) 2 (max corn) 5 (stone fruit) 2 (vegetables, 24C on oysters)	1200 1200 350 350	113-170 **85** 116 292	**EC** **MOE<100** **EC** **EC**
5b Aerial: Wide area uses, liquid sprays	2 (Range/Forestry) 0.016-0.15 (Mosquito adulticide) 1 (Mosquito adulticide) 0.375-0.5 (APHIS grasshopper) 0.125 (APHIS grasshopper)	7500 7500 7500 6000 6000	**14** 181-1700 **27** **68-91** 272	**MOE<100** **EC** **MOE<100** **MOE<100** **EC**
5c Aerial: Agricultural uses, granular applications	2 (corn) 2 (corn) 0.03 (APHIS grasshopper)	1200 350 1000-6000	**21** **72** 281-1685	**MOE<100** **MOE<100** **EC**
6a Airblast: Agricultural uses	16 (Citrus 24C in California) 3-7.5 (Citrus, nuts, max pome/stone fruit) 2 (grapes) 1.1 (avg. stone fruit)	40 40 40 40	105 224-561 118 123	**EC** **EC** **DL/HEAD/GL/PF5** **SL/GL/PF5**
6b Airblast: Wide area uses, liquid sprays	0.016 (Mosquito adulticide) 0.15 (Mosquito adulticide) 1 (Mosquito adulticide)	3000 3000 3000	113 150 **22**	**SL/GL/PF5** **EC** **MOE<100**
7 Groundboom	1.5-2 (Wheat, corn) 2 (Strawberries) 4-8 (Turf/golf course)	200 80 40	122-162 304 152-304	Baseline Baseline Baseline
8 Solid broadcast spreader (granular)	1.5-2 (Wheat, corn) 2 (Strawberries) 4-8 (Turf/golf course)	200 80 40	103-138 258 115-172	Baseline Baseline Baseline
9 Aerosol Can	0.01 lb ai/can	2 cans	324	Baseline
10 Trigger pump sprayer	0.01 lb ai/can	1 can	8772	SL/GL/NR
11 Right of way sprayer	1.5 lb ai/100 gallons	1000 gallons	199	SL/GL/NR
12 High pressure handwand	4 lb ai/100 gallons	1000 gallons	**66**	**MOE<100**
13 Animal groomer, liquid application	0.01 lb ai/dog	8 dogs	**9.7**	**MOE<100**
14 Animal groomer, dust application (see App C/Table 3)	0.2 lb ai/dog	8 dogs	8750	Baseline (dermal exp only)
15 Granulars & baits applied by hand	9 (Ornamentals & gardens)	1	**3.8**	**MOE<100**
16 Granulars & baits applied by spoon	9 (Ornamentals & gardens)	1	**75.1**	**MOE<100**
Mixer/Loader/Applicators				

Table 10: Summary of Short-/Intermediate-Term Occupational Handler Noncancer Risks				
Scenario	Rate (lb ai/acre) [unless noted]	Area Treated (acres/day) [unless noted]	Risk Summary	
			MOEs	Min. Req. PPE
17 Low pressure, high volume turfgun (ORETF Data)	8 (LCO Use on turf) 4 (LCO Use on turf)	5 5	**94** 104	**MOE<100** **SL/GL/PF5**
18a Wettable powder, low pressure handwand	1 lb ai/1000 ft^2 (poultry house) 2% solution (ornamentals)	20,000 ft^2 40 gallons	**8.3** 135	**MOE<100** **SL/GL/PF5**
18b Liquids, low pressure handwand	1 lb ai/1000 ft^2 (poultry house) 2% solution (ornamentals)	20,000 ft^2 40 gallons	127 1699	**SL/GL/PF5** SL/GL/NR
19 Backpack sprayer	1 lb ai/1000 ft^2 (poultry house) 2% solution (ornamentals)	20,000 ft^2 40 gallons	**42** 565	**MOE<100** Baseline
20 Granular, bellygrinder	9 (Turf)	1	**27**	**MOE<100**
21 Granular, push-type spreader	9 (Turf)	5	124	**SL/GL/PF5**
22 Handheld fogger	No data	No data	No data	No data
23 Power backpack	No data	No data	No data	No data
24 Granular, backpack	9 (Ornamentals)	1	1562	**DL/GL/NR**
25 Tree injection	No data	No data	No data	No data
26 Drench/dipping forestry/ornamentals	1.5 lb ai/100 gallons (Ornamental/seedling dip)	100 gallons	199	SL/GL/NR
27 Sprinkler can	2% solution (Ornamentals)	10 gallons	226	Baseline
Flaggers				
28a Flagger: liquid sprays	2 (Corn) 2 (Vegetables)	1200 350	249 111	**EC** Baseline
28b Flagger: granular applications	2 (Corn) 2 (Vegetables)	1200 350	101 345	Baseline Baseline

Baseline = Long pants, long-sleeved shirts, no gloves
SL = Single layer clothing with or without gloves (GL or NG)
DL = Double layer clothing (i.e., coveralls over SL) with or without gloves (GL or NG)
EC = Engineering controls
NR = No respirator
PF5 = Protection factor 5 respirator
PF10 = Protection factor 10 respirator
Current label = SL/GL/NR
Min. Req. PPE = level of PPE where MOEs > 100, where current label is exceeded or no adequate PPE is found, results are bold. MOEs which never exceed 100 are for highest feasible type of mitigation (e.g., engineering control in most cases).

Chronic Risk Summary: MOEs were calculated for only a limited number of exposure ornamental use scenarios where the Agency believes that this kind of exposure pattern may exist. These calculations were also completed at different levels of personal protection as illustrated in Table 11 (Table 9 of Appendix C summarized below). For most scenarios (3 of 5), MOEs meet or exceed the required uncertainty factor of 300 at some level of personal protection. The granular hand application scenarios are problematic. The uncertainty factor of 300 is required for the chronic exposure scenarios because a LOAEL and not a NOAEL was used for risk assessment purpose as defined in a chronic dog feeding study using carbaryl. It is Agency policy to apply an additional factor of 3 to the overall uncertainty factor when using a LOAEL for risk assessment purposes.

Table 11: Summary of Chronic Occupational Handler Noncancer Risks

Scenario	Rate (lb ai/acre) [unless noted]	Area Treated (acres/day) [unless noted]	Risk Summary	
			MOEs	Min. Req. PPE
Applicators				
15 Granulars & baits applied by hand	9 (Ornamentals & gardens)	1	**4.7**	**MOE<300**
16 Granulars & baits applied by spoon	9 (Ornamentals & gardens)	1	**92.6**	**MOE<300**
Mixer/Loader/Applicators				
18a Wettable powder, low pressure handwand	2% solution (ornamentals)	40 gallons	302	**DL/GL/PF10**
18b Liquids, low pressure handwand	2% solution (ornamentals)	40 gallons	3206	SL/GL/NR
19 Backpack sprayer	2% solution (ornamentals)	40 gallons	781	Baseline

Baseline = Long pants, long-sleeved shirts, no gloves
SL = Single layer clothing with or without gloves (GL or NG)
DL = Double layer clothing (i.e., coveralls over SL) with or without gloves (GL or NG)
EC = Engineering controls
NR = No respirator
PF5 = Protection factor 5 respirator
PF10 = Protection factor 10 respirator
Current label = SL/GL/NR
Min. Req. PPE = level of PPE where MOEs > 300, where current label is exceeded or no adequate PPE is found, results are bold. MOEs which never exceed 300 are for highest feasible type of mitigation (e.g., PPE in most cases).

2.1.4 Occupational Handler Exposure and Risk Estimates for Cancer.

The occupational handler exposure and cancer risk calculations are presented in this section. Cancer risks were calculated using a linear low-dose extrapolation approach in which a *Lifetime Average Daily Dose* (LADD) is first calculated and then compared with a Q_1^* that has been calculated for carbaryl based on dose response data in the appropriate toxicology study ($Q_1^* = 8.75 \times 10^{-4}$ (mg/kg/day)$^{-1}$). Absorbed average daily dose (ADD) levels were used as the basis for calculating the LADD values. Section 2.1.3 above describes how the ADD values were first calculated for the noncancer MOE calculations. These values also serve as the basis for the cancer risk estimates. Dermal and inhalation ADD values were first added together to obtain combined ADD values. LADD values were then calculated and compared to the Q_1* to obtain cancer risk estimates.

Lifetime Average Daily Dose: After the development of the ADD values, the next step required to calculate the carcinogenic risk is to amortize these values over the working lifetime of occupational handlers based on use patterns, this results in the LADD for that use. Product labels limit use to every 7 to 10 days or a seasonal "lb ai per acre" limit. Also, according to available use/usage data, on average, carbaryl is applied more than once per year for most crops. Based on this information and due to the number and variety of target insects and crops registered for carbaryl applications, the Agency considered two distinct populations in the cancer risk assessment including private growers at 10 use events per year and commercial applicators that would have a more frequent use pattern of 30 days per year. Finally, a 35 year career and a 70 year lifespan was used to complete the calculations. LADD values were calculated using the following equation:

$$LADD = ADD \times \frac{TreatmentFrequency}{365 Days / year} \times \frac{WorkingDuration}{Lifetime}$$

Where:

Lifetime Average Daily Dose	=	The amount as absorbed dose received from exposure to a pesticide in a given scenario over a lifetime (mg pesticide active ingredient/kg body weight/day, also referred to as LADD);
Average Daily Dose	=	The amount as absorbed dose received from exposure to a pesticide in a given scenario on a daily basis (mg pesticide active ingredient/kg body weight/day, also referred to as ADD);
Treatment Frequency	=	The annual frequency of an application by an individual (days/year);
Working Duration	=	The amount of a lifetime that an individual spends engaged in a career involving pesticide exposure (35 years);
Lifetime	=	The average life expectancy of an individual (70 years).

Cancer Risks : Finally, cancer risk calculations were completed by comparing the LADD values calculated above to the Q1* for carbaryl (Q_1* = 8.75 x 10^{-4} $(mg/kg/day)^{-1}$, see Table 1 for further information). The Agency considered more typical users in these calculations (i.e., private growers at 10 events per year) as well as more frequent users that might represent commercial applicators (i.e., 30 events per year). Cancer risk values were calculated using the following equation:

$$Risk = LADD \times Q_1*$$

Where:

Risk	=	Probability of excess cancer cases over a lifetime (unitless);
Lifetime Average Daily Dose	=	The amount as absorbed dose received from exposure to a pesticide in a given scenario over a lifetime (mg pesticide active ingredient/kg body weight/day, also referred to as LADD); and
Q_1*	=	Quantitative dose response factor used for linear, low-dose response cancer risk calculations $(mg/kg/day)^{-1}$.

The Agency has defined a range of acceptable cancer risks based on a policy memorandum issued in 1996 by then office director, Mr. Dan Barolo. This memo refers to a predetermined quantified "level of concern" for occupational carcinogenic risk. In summary, this policy memo indicates occupational carcinogenic risks that are 1×10^{-6} or lower require no risk management action. For those chemicals subject to reregistration, the Agency is to carefully examine uses with estimated risks in the 10^{-6} to 10^{-4} range to seek ways of cost-effectively reducing risks. If carcinogenic risks are in this range for occupational handlers, increased levels of personal protection would be warranted as is commonly applied with noncancer risk estimates (e.g., additional PPE or engineering controls). Carcinogenic risks that remain above 1.0×10^{-4} at the highest level of mitigation appropriate for that scenario remain a concern.

Cancer Risk Summary All of the cancer risk calculations for occupational carbaryl handlers completed in this assessment are included in Appendix C (Tables 10 and 11). The specifics of each of table included in Appendix C are described below. A brief summary of the results for each exposure scenario is also provided below.

- **Appendix C/Table 10: Carbaryl Occupational Handler Risks For Private Growers** Presents cancer risks for combined dermal and inhalation for private growers (i.e., 10 applications per year) with each possible combination of dermal and respiratory protection considered in this assessment.

- **Appendix C/Table 11: Carbaryl Occupational Handler Risks For Commercial Applicators** Presents cancer risks for combined dermal and inhalation for commercial applicators (i.e., 30 applications per year) with each possible combination of dermal and respiratory protection considered in this assessment.

Tables 1 through 6 of Appendix C should also be considered as they illustrate how the route-specific ADD values were calculated which are the basis for the cancer risk values. These route-specific ADD values were added and applied to the Q_1* value to calculate the cancer risks as described above.

Cancer risks for private growers (i.e., 10 applications per year) were calculated for different exposure scenarios at different levels of personal protection (Table10 of Appendix C). All scenarios for private growers have risks that are <1x10^{-4} at some level of personal protection specified in the Barolo memo. In fact, for all but one scenario (Scen 4f: Mixing/loading Wettable Powders for wide area aerial applications) cancer risks are <1x10^{-4} at current label requirements for personal protection. If a 1x10^{-6} risk level is specified as a concern, results are similar in that risks for a majority of scenarios are <1x10^{-6} at current label requirements. In fact, only 8 of the 128 scenarios considered for private applicators have cancer risks >1x10^{-6} (and less than 1x10^{-4}) even when the most protective ensembles of either protective clothing or engineering controls are considered. As with the risks calculated for private growers, cancer risks for commercial applicators (i.e., 30 applications per year) were calculated for different exposure scenarios at different levels of personal protection (Table 11 of Appendix C). Again, risks for all but one scenario (Scen 4f: Mixing/loading Wettable Powders for wide area aerial applications) are less than the 1x10^{-4} level specified in the Barolo memo at current label requirements for personal protection (i.e., risks for this scenario are < 1x10^{-4} if additional protective clothing or equipment is used). If a 1x10^{-6} risk level is specified as a concern for commercial applicators, results indicate that risks for about half of the scenarios considered are <1x10^{-6} at current label requirements and that only 21 of the 128 scenarios considered have cancer risks >1x10^{-6} (and less than 1x10^{-4}) even when the most protective ensembles of either protective clothing or engineering controls are considered. In general, the cancer risk estimates would lead to less restrictive measures when compared to the noncancer results. Table 12 below provides a summary of the cancer risks that have been calculated for private growers and commercial applicators.

Table 12: Summary of Occupational Handler Cancer Risks For Private Growers and Commercial Applicators

Scenario	Rate (lb ai/acre) [unless noted]	Area Treated (acres/day) [unless noted]	Risk Summary			
			Private Growers		Commercial Applicators	
			Risk	Min. Req. PPE	Risk	Min. Req. PPE
Mixer/Loaders						
1a Dry Flowable: Aerial/Chemigation	1-2 (wheat/corn) 5 (stone fruit) 2 (vegetables, 24C on oysters)	1200 350 350	3.7 to 7.4x10^{-8} 5.4x10^{-8} 1.0x10^{-6}	**EC** **EC** **SL/GL/PF10**	1.1 to 2.2x10^{-7} 1.6x10^{-7} 6.5x10^{-8}	**EC** **EC** **EC**
1b Dry Flowable: Airblast	16 (Citrus, 24C in CA) 1.1-7.5 (grapes, various fruit & nut trees)	40 40	1.0x10-6 6.9x10^{-8} to 4.7x10^{-7}	Baseline Baseline	5.9x10^{-8} 1.4 to 9.3x10^{-7}	**EC** **DL/GL/PF10**
1c Dry Flowable: Groundboom	2 (corn) 1.5 (wheat) 2 (strawberry/veg) 8 (turf/golf courses) 4 (turf/golf courses)	200 200 80 40 40	4.7x10^{-7} 6.3x10^{-7} 2.5x10^{-7} 5.0x10^{-7} 2.5x10^{-7}	Baseline Baseline Baseline Baseline Baseline	1.0x10^{-6} 3.7x10^{-8} 7.5x10^{-7} 1.0x10^{-6} 7.5x10^{-7}	**DL/GL/NR** **EC** Baseline **DL/GL/PF5** Baseline
1d Dry Flowable: High Press HW/ROW Sprayer	4 lb ai/100 gal (poultry)	1000 gal	6.3x10^{-8}	Baseline	1.9x10^{-7}	Baseline
1e Dry Flowable: Low press./High Vol. Turfgun	4 -8 (LCO on turf)	5	3.1 to 6.3x10^{-8}	Baseline	9.4x10^{-8} to 1.9x10^{-7}	Baseline

Table 12: Summary of Occupational Handler Cancer Risks For Private Growers and Commercial Applicators

Scenario	Rate (lb ai/acre) [unless noted]	Area Treated (acres/day) [unless noted]	Risk Summary			
			Private Growers		Commercial Applicators	
			Risk	Min. Req. PPE	Risk	Min. Req. PPE
1f Dry Flowable: Wide area aerial	2 (rangeland/forestry)	7500	4.6x10^{-7}	**EC**	**1.4x10^{-6}**	**All < 1x10^{-6}**
2a Granular: Aerial Application	2 (corn) 2 (corn) 0.03 (APHIS grasshopper)	1200 350 1000-6000	5.0x10^{-7} 3.3x10^{-7} 1.4 to 8.5x10^{-8}	**SL/GL/PF5** Baseline Baseline	9.5x10^{-7} 9.9x10^{-7} 4.3x10^{-8} to 1.3x10^{-7}	**DL/GL/PF5** Baseline Baseline
2b Granular: Solid broadcast spreader	1.5-2 (wheat/corn) 2 (vegetables) 6-9 (turf/golf courses)	200 80 40	1.4 to 1.9x10^{-7} 7.6x10^{-8} 1.1 to 1.7x10^{-7}	Baseline Baseline Baseline	4.3 to 5.7x10^{-7} 2.3x10^{-7} 3.4 to 5.1x10^{-7}	Baseline Baseline Baseline
3a Liquid: Aerial/Chemigation	1 (avg. corn) 1.5 (wheat) 2 (corn) 5 (stone fruit) 2 (vegetables)	1200 1200 1200 350 350	9.7x10^{-7} 9.9x10^{-7} 8.5x10^{-7} 9.5x10^{-7} 4.9x10^{-7}	**SL/GL/PF5** **DL/GL/PF5** SL/GL/NR **SL/GL/PF5** SL/GL/NR	**1.1x10^{-6}** **1.4x10^{-6}** 7.2x10^{-7} **1.1x10^{-6}** 8.6x10^{-7}	**All < 1x10^{-6}** **All < 1x10^{-6}** EC **All < 1x10^{-6}** **DL/GL/PF5**
3b Liquid: Airblast Application	16 (citrus, 24C in CA) 1.1-7.5 (grapes, various fruit & nut trees)	40 40	4.5x10^{-7} 3.1x10^{-8} to 2.1x10^{-7}	SL/GL/NR SL/GL/NR	1.0x10-6 9.3x10^{-8} to 6.4x10^{-7}	**SL/GL/PF5** SL/GL/NR
3c Liquid: Groundboom	1.5-2 (wheat/corn) 2 (strawberries) 4-8 (turf/golf courses)	200 80 40	2.1 to 2.8x10^{-7} 1.1x10^{-7} 1.1 to 2.3x10^{-7}	SL/GL/NR SL/GL/NR SL/GL/NR	6.4 to 8.5x10^{-7} 3.4x10^{-7} 3.4 to 6.8x10^{-7}	SL/GL/NR SL/GL/NR SL/GL/NR
3d Liquid: High Press HW/ROW Sprayer	4 lb ai/100 gal (poultry)	1000 gal	2.8x10^{-8}	SL/GL/NR	8.5x10^{-8}	SL/GL/NR
3e Liquid: Low press./High Vol. Turfgun	4 -8 (LCO on turf)	5	1.4 to 2.8x10^{-8}	SL/GL/NR	4.2 to 8.5x10^{-8}	SL/GL/NR
3f Liquid: Wide area aerial	2 (Range/Forestry) 0.016 (Mosquito adulticide) 0.15 (Mosquito adulticide) 1 (Mosquito adulticide) 0.125 (APHIS grasshopper) 0.375 (APHIS grasshopper) 0.50 (APHIS grasshopper)	7500 7500 7500 7500 6000 6000 6000	**3.0x10^{-6}** 8.5x10^{-8} 7.9x10^{-7} **1.5x10^{-6}** 5.3x10^{-7} 9.2x10^{-7} 6.0x10^{-7}	**All > 1x10^{-6}** SL/GL/NR SL/GL/NR **All > 1x10^{-6}** SL/GL/NR **DL/GL/PF5** **EC**	**9.1x10^{-6}** 2.5x10^{-7} 6.8x10^{-7} **4.5x10^{-6}** 9.2x10^{-7} **1.4x10^{-6}** **1.8x10^{-6}**	**All > 1x10^{-6}** SL/GL/NR **EC** **All > 1x10^{-6}** **DL/GL/PF5** **All > 1x10^{-6}** **All > 1x10^{-6}**
3g Liquid: Wide area ground	0.016 (Mosquito Adulticide) 0.15 (Mosquito adulticide) 1 (Mosquito adulticide)	3000 3000 3000	3.4x10^{-8} 3.2x10^{-7} 6.0x10^{-7}	SL/GL/NR SL/GL/NR **EC**	1.0x10^{-7} 9.5x10^{-7} **1.8x10^{-6}**	SL/GL/NR SL/GL/NR **All > 1x10^{-6}**
4a Wettable Powders: Aerial	1.5 (Wheat) 2 (Corn - max) 1 (Corn - typ) 5 (stone fruit) 2 (vegetables)	1200 1200 1200 350 350	4.6x10^{-7} 6.1x10^{-7} 3.1x10^{-7} 4.4x10^{-7} 1.8x10^{-7}	**EC** **EC** **EC** **EC** **EC**	**1.4x10^{-6}** **1.8x10^{-6}** 9.2x10^{-7} **1.3x10^{-6}** 5.3x10^{-7}	**All > 1x10^{-6}** **All > 1x10^{-6}** **EC** **All > 1x10^{-6}** **EC**
4b Wettable Powders: Airblast	16 (Citrus-24C in California) 7.5 (Citrus) 5 (Nuts) 3 (Pome & stone fruit) 2 (Grapes) 1.1(Avg. stone fruit)	40 40 40 40 40 40	1.6x10^{-7} 7.6x10^{-8} 1.0x10^{-6} 6.2x10^{-7} 8.8x10^{-7} 4.9x10^{-7}	**EC** **EC** **SL/GL/PF5** **SL/GL/PF5** SL/GL/NR SL/GL/NR	4.9x10^{-7} 2.3x10^{-7} 1.5x10^{-7} 9.2x10^{-8} 1.0x10^{-6} 5.7x10^{-7}	**EC** **EC** **EC** **EC** **DL/GL/PF5** **DL/GL/PF5**
4c Wettable Powders: Groundboom	1.5 (wheat) 2 (corn) 2 (strawberries) 8 (turf/golf courses) 4 (turf/golf courses)	200 200 80 40 40	7.6x10^{-8} 1.0x10^{-7} 8.3x10^{-7} 8.1x10^{-8} 8.3x10^{-7}	**EC** **EC** **SL/GL/PF5** **EC** **SL/GL/PF5**	2.3x10^{-7} 3.1x10^{-7} 1.2x10^{-7} 2.4x10^{-7} 1.2x10^{-7}	**EC** **EC** **EC** **EC** **EC**

Table 12: Summary of Occupational Handler Cancer Risks For Private Growers and Commercial Applicators						
Scenario	Rate (lb ai/acre) [unless noted]	Area Treated (acres/day) [unless noted]	Risk Summary			
			Private Growers		Commercial Applicators	
			Risk	Min. Req. PPE	Risk	Min. Req. PPE
4d Wettable Powders: High Press HW/ROW Sprayer	4 lb ai/100 gal (poultry)	1000 gal	$4.4x10^{-7}$	SL/GL/NR	$5.2x10^{-7}$	**DL/GL/PF5**
4e Wettable Powders: Low press./High Vol. Turfgun	4 (LCO on turf) 8 (LCO on turf)	5 5	$2.2x10^{-7}$ $4.4x10^{-7}$	SL/GL/NR SL/GL/NR	$6.6x10^{-7}$ $6.2x10^{-7}$	SL/GL/NR **SL/GL/PF5**
4f Wettable Powders: Wide area aerial	2 (Range/Forestry)	7500	**$3.8x10^{-6}$**	**All > $1x10^{-6}$**	**$1.1x10^{-5}$**	**All > $1x10^{-6}$**
Applicators						
5a Aerial: Agricultural uses, liquid sprays	1-2 (wheat/corn) 5 (stone fruit) 2 (vegetables, 24C on oysters)	1200 350 350	1.6 to $3.2x10^{-7}$ $2.3x10^{-7}$ $9.2x10^{-8}$	**EC** **EC** **EC**	4.7 to $9.5x10^{-7}$ $6.9x10^{-7}$ $2.8x10^{-7}$	**EC** **EC** **EC**
5b Aerial: Wide area uses, liquid sprays	2 (Range/Forestry) 0.016 (Mosquito adulticide) 0.15 (Mosquito adulticide) 1 (Mosquito adulticide) 0.125 (APHIS grasshopper) 0.375 (APHIS grasshopper) 0.50 (APHIS grasshopper)	7500 7500 7500 7500 6000 6000 6000	**$2.0x10^{-6}$** $1.6x10^{-8}$ $1.5x10^{-7}$ $9.8x10^{-7}$ $9.8x10^{-8}$ $3.0x10^{-7}$ $3.9x10^{-7}$	**All > $1x10^{-6}$** **EC** **EC** **EC** **EC** **EC** **EC**	**$5.9x10^{-6}$** $4.7x10^{-8}$ $4.4x10^{-7}$ **$3.0x10^{-6}$** $3.0x10^{-7}$ $8.9x10^{-7}$ **$1.2x10^{-6}$**	**All > $1x10^{-6}$** **EC** **EC** **All > $1x10^{-6}$** **EC** **EC** **All > $1x10^{-6}$**
5c Aerial: Agricultural uses, granular applications	2 (corn) 2 (corn) 0.03 (APHIS grasshopper)	1200 350 1000-6000	$6.2x10^{-7}$ $1.8x10^{-7}$ $7.8x10^{-9}$ to $4.7x10^{-8}$	**EC** **EC** **EC**	**$1.9x10^{-6}$** $5.5x10^{-7}$ $2.3x10^{-8}$ to $1.4x10^{-7}$	**All > $1x10^{-6}$** **EC** **EC**
6a Airblast: Agricultural uses	16 (Citrus 24C in California) 7.5 (Citrus) 5 (Nuts) 3 (Pome & stone fruit) 2 (Grapes) 1.1 (Avg pome & stone fruit)	40 40 40 40 40 40	$2.7x10^{-7}$ $8.9x10^{-7}$ $7.2x10^{-7}$ $1.0x10^{-6}$ $6.9x10^{-7}$ $3.8x10^{-7}$	**EC** **DLHD/GL/PF5** **DLHD/GL/NR** Baseline Baseline Baseline	$8.2x10^{-7}$ $3.9x10^{-7}$ $2.6x10^{-7}$ $1.0x10^{-6}$ $1.0x10^{-7}$ $7.9x10^{-7}$	**EC** **EC** **EC** **DLHD/GL/PF10** **DLHD/GL/NR** SL/GL/NR
6b Airblast: Wide area fogger	0.016 (Mosquito adulticide) 0.15 (Mosquito adulticide) 1 (Mosquito adulticide)	3000 3000 3000	$4.1x10^{-7}$ $1.9x10^{-7}$ **$1.3x10^{-6}$**	Baseline **EC** **All > $1x10^{-6}$**	$8.6x10^{-7}$ $5.8x10^{-7}$ **$3.9x10^{-6}$**	SL/GL/NR **EC** **All > $1x10^{-6}$**
7 Groundboom	1.5-2 (Wheat/corn) 2 (Strawberries) 8 (Turf/golf course) 4 (Turf/golf course)	200 80 40 40	1.3 to $1.7x10^{-7}$ $6.9x10^{-8}$ $1.4x10^{-7}$ $6.9x10^{-8}$	Baseline Baseline Baseline Baseline	3.9 to $5.2x10^{-7}$ $2.1x10^{-7}$ $4.1x10^{-7}$ $2.1x10^{-7}$	Baseline Baseline Baseline Baseline
8 Solid broadcast spreader (granular)	1.5-2 (Wheat/corn) 2 (Strawberries) 4-8 (Turf/golf course)	200 80 40	1.3 to $1.7x10^{-7}$ $6.7x10^{-8}$ 1.0 to $1.5x10^{-7}$	Baseline Baseline Baseline	3.8 to $5.0x10^{-7}$ $2.0x10^{-7}$ 3.0 to $4.5x10^{-7}$	Baseline Baseline Baseline
9 Aerosol Can	0.01 lb ai/can	2 cans	$8.7x10^{-8}$	Baseline	$2.6x10^{-7}$	Baseline
10 Trigger pump sprayer	0.01 lb ai/can	1 can	$3.1x10^{-9}$	SL/GL/NR	$9.4x10^{-9}$	SL/GL/NR
11 Right of way sprayer	1.5 lb ai/100 gallons	1000 gallons	$4.3x10^{-7}$	Baseline	$4.1x10^{-7}$	SL/GL/NR
12 High pressure handwand	4 lb ai/100 gallons	1000 gallons	$6.6x10^{-7}$	**SL/GL/PF5**	$1.1x10^{-6}$	**All > $1x10^{-6}$**
13 Animal groomer, liquid application	0.01 lb ai/dog	8 dogs	**$3.1x10^{-6}$**	**All > $1x10^{-6}$**	**$9.4x10^{-6}$**	**All > $1x10^{-6}$**

Table 12: Summary of Occupational Handler Cancer Risks For Private Growers and Commercial Applicators						
Scenario	Rate (lb ai/acre) [unless noted]	Area Treated (acres/day) [unless noted]	Risk Summary			
			Private Growers		Commercial Applicators	
			Risk	Min. Req. PPE	Risk	Min. Req. PPE
14 Animal groomer, dust application	0.2 lb ai/dog	8 dogs	$3.5x10^{-9}$	Baseline	$1.0x10^{-8}$	Baseline
15 Granulars & baits applied by hand	9 (Ornamentals & gardens)	1	**$8.0x10^{-6}$**	**All > $1x10^{-6}$**	**$2.4x10^{-5}$**	**All > $1x10^{-6}$**
16 Granulars & baits applied by spoon	9 (Ornamentals & gardens)	1	$4.6x10^{-7}$	SL/GL/NR	**$1.2x10^{-6}$**	**All > $1x10^{-6}$**
Mixer/Loader/Applicators						
17 Low pressure, high volume turfgun (ORETF Data)	8 (LCO Use on turf) 4 (LCO Use on turf)	5 5	$3.1x10^{-7}$ $6.1x10^{-7}$	SL/GL/NR SL/GL/NR	$9.7x10^{-7}$ $9.2x10^{-7}$	**DL/GL/PF5** SL/GL/NR
18a Wettable powder, low pressure handwand	1 lb ai/1000 ft^2 (poultry house) 2% solution (ornamentals)	20,000 ft^2 40 gallons	**$3.1x10^{-6}$** $3.0x10^{-7}$	**All > $1x10^{-6}$** SL/GL/NR	**$9.2x10^{-6}$** $9.0x10^{-7}$	**All > $1x10^{-6}$** SL/GL/NR
18b Liquids, low pressure handwand	1 lb ai/1000 ft^2 (poultry house) 2% solution (ornamentals)	20,000 ft^2 40 gallons	$2.1x10^{-7}$ $1.2x10^{-8}$	**SL/GL/PF5** SL/GL/NR	$6.2x10^{-7}$ $3.5x10^{-8}$	**SL/GL/PF5** SL/GL/NR
19 Backpack sprayer	1 lb ai/1000 ft^2 (poultry house) 2% solution (ornamentals)	20,000 ft^2 40 gallons	$7.0x10^{-7}$ $4.8x10^{-8}$	**DL/GL/PF5** Baseline	**$2.2x10^{-6}$** $1.4x10^{-7}$	**All > $1x10^{-6}$** Baseline
20 Granular, bellygrinder	9 (Turf)	1	**$1.1x10^{-6}$**	**All > $1x10^{-6}$**	**$3.4x10^{-6}$**	**All > $1x10^{-6}$**
21 Granular, push-type spreader	9 (Turf)	5	$4.0x10^{-7}$	Baseline	$8.2x10^{-7}$	SL/GL/NR
22 Handheld fogger	No data	No data	No data	No data	No data	No data
23 Power backpack	No data	No data	No data	No data	No data	No data
24 Granular, backpack	9 (Ornamentals)	1	$1.9x10^{-8}$	**DL/GL/NR**	$5.8x10^{-8}$	**DL/GL/NR**
25 Tree injection	No data	No data	No data	No data	No data	No data
26 Drench/dipping forestry/ornamentals	1.5 lb ai/100 gallons (Ornamental/seedling dip)	100 gallons	$1.1x10^{-7}$	SL/GL/NR	$3.2x10^{-7}$	SL/GL/NR
27 Sprinkler can	2% solution (Ornamentals)	10 gallons	$1.3x10^{-7}$	Baseline	$4.0x10^{-7}$	Baseline

Table 12: Summary of Occupational Handler Cancer Risks For Private Growers and Commercial Applicators						
Scenario	Rate (lb ai/acre) [unless noted]	Area Treated (acres/day) [unless noted]	Risk Summary			
			Private Growers		Commercial Applicators	
			Risk	Min. Req. PPE	Risk	Min. Req. PPE
Flaggers						
28a Flagger: liquid sprays	2 (Corn) 2 (Vegetables)	1200 350	$7.2x10^{-7}$ $2.1x10^{-7}$	Baseline Baseline	$3.5x10^{-7}$ $6.3x10^{-7}$	**EC** Baseline
28b Flagger: granular applications	2 (Corn) 2 (Vegetables)	1200 350	$2.1x10^{-7}$ $6.1x10^{-8}$	Baseline Baseline	$6.2x10^{-7}$ $1.8x10^{-7}$	Baseline Baseline

Baseline = Long pants, long-sleeved shirts, no gloves
SL = Single layer clothing with or without gloves (GL or NG)
DL = Double layer clothing (i.e., coveralls over SL) with or without gloves (GL or NG)
EC = Engineering controls
NR = No respirator
PF5 = Protection factor 5 respirator
PF10 = Protection factor 10 respirator
Current label = SL/GL/NR
Min. Req. PPE = level of PPE where cancer risks > $1x10^{-6}$, where current label is exceeded or no adequate PPE is found, results are bold. Risks which never exceed $1x10^{-6}$ are for highest feasible type of mitigation (e.g., engineering control in most cases).

2.1.5 Summary of Risk Concerns and Data Gaps for Handlers

Generally, most scenarios have risks associated with them that meet or exceed the Agency's uncertainty factors for noncancer risk assessments (i.e., 100 for short-term and intermediate-term and 300 for chronic) and requirements for cancer risk results (i.e., range of $1x10^{-6}$ to $1x10^{-4}$ as defined by Office Director Barolo in 1996) at some level of personal protection. Current carbaryl labels typically require that handlers wear long pants, long-sleeved shirts, and gloves. Respirators are generally not required. For most scenarios, the noncancer risks for this personal protection ensemble do not meet Agency risk requirements and additional levels of personal protection are required to achieve Agency risk targets. In fact, in many cases engineering controls such as closed loading systems or closed cab tractors are needed. The Agency does have risk concerns over the use of carbaryl in some agricultural and other occupational settings (i.e., MOEs at any level of personal protection are <100 or <300, depending on the duration). As would be expected, these scenarios with the highest associated risk also have high daily chemical use amounts based on application rates or high acreages treated or the exposures for the scenarios in question are relatively high. Generally, the areas that appear to be problematic include: large acreage aerial and chemigation applications in agriculture or for wide area treatments such as mosquito control; airblast applications at higher rates; pet grooming; and the use of certain handheld equipment for applications to turf or gardens (e.g., bellygrinder). This general trend was essentially the same regardless of the noncancer toxicity endpoints which were considered (e.g., short-term, intermediate-term). Risks for corresponding scenarios based on cancer concerns were generally less than noncancer results across all scenarios. In fact, in all but one scenario, cancer risks were $<1x10^{-4}$ at current carbaryl label requirements of single layer clothing, gloves, and no respirator. Several data gaps were also identified in many different use areas that include: dust use for animal grooming and in agriculture; various specialized hand equipment application methods (e.g., powered backpack, power hand fogger, and tree injection); and nursery operations such as seedling dips.

2.1.6 Recommendations For Refining Occupational Handler Risk Assessment

In order to refine this occupational risk assessment, data on actual use patterns including rates, timing, and acreages treated would better characterize carbaryl risks. Exposure studies for many equipment types that lack data or that are not well represented in PHED (e.g., because of low replicate numbers or data quality) should also be considered based on the data gaps identified above and based on a review of the quality of the data used in this assessment. Risk managers should consider that the risks associated with current label requirements for personal protection generally do not meet Agency risk targets.

2.2 Occupational Postapplication Exposures and Risks

The Agency uses the term “postapplication” to describe exposures to individuals that occur as a result of working in an environment that has been previously treated with a pesticide (also referred to as reentry exposure). The agency believes that there are distinct job functions or tasks related to the kinds of activities that occur in previously treated areas such as harvesting vegetables in a treated field. Job requirements (e.g., the kinds of jobs to cultivate a crop), the nature of the crop or target that was treated, and the how chemical residues degrade in the environment can cause exposure levels to differ over time. Each factor has been considered in this assessment. The scenarios that serve as the basis for the risk assessment are presented in *Section 2.2.1: Occupational Postapplication Exposure Scenarios*. The exposure data and assumptions that have been used for the calculations are presented in *Section 2.2.2: Data and Assumptions For Occupational Postapplication Exposure Scenarios*. The calculations and the algorithms that have been used for the noncancer elements of the risk assessment as well as the calculated risk values are presented in *Section 2.2.3: Occupational Postapplication Exposure and Noncancer Risk Estimates* while the analogous information using the Q_1* for cancer estimates are presented in *Section 2.2.4: Occupational Postapplication Exposure and Risk Estimates For Cancer*. *Section 2.2.5: Summary of Occupational Postapplication Risk Concerns and, Data Gaps* presents the overall risk picture for carbaryl. Finally, recommendations are presented in *Section 2.2.6: Recommendations For Refining Occupational Postapplication Risk Assessment*.

2.2.1 Occupational Postapplication Exposure Scenarios

Carbaryl uses are extremely varied as it can be used in agriculture, on ornamentals, on turf (golf courses and lawns) and on companion animals (e.g., on dogs and cats). As a result, a wide array of individuals can potentially be exposed by working in areas that have been previously treated. The Agency is concerned about these kinds of exposures one could receive in the workplace. The purpose of this section is to explain how postapplication exposure scenarios were developed for each occupational setting where carbaryl can be used. Exposure scenarios can be thought of as ways of categorizing the kinds of exposures that occur related to the use of a chemical. The use of scenarios as a basis for exposure assessment is very common as described in the *U.S. EPA Guidelines For Exposure Assessment* (U.S. EPA; Federal Register Volume 57, Number 104; May 29, 1992).

The agency uses a concept known as the *transfer coefficient* to numerically represent the post-application exposures one would receive (i.e., generally presented as cm^2/hour). The transfer coefficient concept has been established in the scientific literature and through various exposure monitoring guidelines published by the U.S. EPA and international organizations such as Health Canada and OECD (Organization For Economic Cooperation and Development). The establishment of transfer coefficients also forms the basis of the work of the Agricultural Reentry Task Force, of which, Bayer is a member. The transfer coefficient is essentially a measure of the contact with a treated surface one would have while doing a task or activity. These values are defined by calculating the ratio of an exposure for a given task or activity to the amount of pesticide on leaves (or other surfaces) that can rub off on the skin resulting in an exposure. For postapplication exposures, the amounts that can rub off on the skin are measured using techniques that specifically determine the amount of residues on treated leaves or other surfaces (referred to as transferable residues) rather than the total residues contained both on the surface and absorbed into treated leaves. Transfer coefficients can be illustrated by the following example. Consider two vegetable fields where the amount of chemical on treated leaf surfaces that can rub off on the skin is the same. One field has been treated with chemical A while the other field has been treated in a similar manner with chemical B. If an individual harvests the same vegetables for a day in each field, the exposures the individual would receive would be similar. The transfer coefficient would also be similar for each field and chemical because the ratio of exposure to residue would be the same. If the same individual would do another activity in those fields such as scout the vegetables for pests or tie the vegetables, the exposures would be different as would the resulting transfer coefficients because the activity that resulted in the exposures is different. In this example, three distinct transfer coefficients could be determined for vegetable crops: harvesting; scouting; and tying. The Agency has developed a series of standard *transfer coefficients* that are unique for variety of job tasks or activities that are used in lieu of chemical- and scenario-specific data.

As with the handler risk assessment process, the first step in the post-application risk assessment process is to identify the kinds of individuals that are likely to be exposed to carbaryl after application. In order to do this in a consistent manner, the Agency has developed a series of general descriptions for tasks that are associated with post-application exposures. The Agency also considers whether or not individuals are exposed to pesticides as part of their employment (referred to as occupational risk assessments). Common examples include: agricultural harvesters, scouting activities in agriculture, crop maintenance tasks (e.g., irrigating, hoeing and weeding), and turf maintenance (golf course mowing and sod harvesting).

The next step in the risk assessment process is to define how and when chemicals are applied in order to determine the level of transferable residues to which individuals could be exposed over time. Wherever available, use and usage data are included in this process to define values such as application rates and application frequency. The Agency always completes risk assessments using maximum application rates for each scenario because what is possible under the label (the legal means of controlling pesticide use) must be evaluated, for complete stewardship, in order to ensure the Agency has no concern for the specific use. Additionally, whenever the Agency has additional information, such as typical or average application rates or frequency data, it uses the information to further evaluate the overall risks associated with the use of the chemical. In order to define the amount of transferable residues to which individuals can be exposed, the Agency relies on chemical- and crop-specific studies as described in the Agency guidelines for exposure data collection (*Series 875, Occupational and Residential Exposure Test Guidelines: Group B - Postapplication Exposure Monitoring Test Guidelines*). The Agency has also developed a standard modeling approach that can also be used to predict transferable residues over time in lieu of chemical- and scenario-specific data (best described in the Agency's *SOPs For Residential Exposure Assessment*). All scenarios were evaluated using carbaryl-specific DFR dissipation data.

Next, assessors must understand how exposures to carbaryl occur (i.e., frequency and duration) and how the patterns of these occurrences can alter the effects of the chemical in the population after being exposed (referred to as dose response). The Agency believes that carbaryl exposures can occur from over a single day up to every working day depending on the crop and industry being considered. This is supported by the fact that several areas within a work environment may be treated at different times. For example, parts of agricultural fields in a localized area might be treated over several weeks because of an infestation with a concurrent need for hand labor activities. Therefore, individuals working in those fields might be exposed from contact with treated foliage over an extended period of time that could be categorized as an intermediate-term exposure as they work on different sections of fields. Three different types of noncancer risk calculations were required for each exposure duration considered. The durations of exposure that were considered for noncancer toxicity were short-term ($\leq$30 days), intermediate-term (30 days up to several months), and chronic (every working day). A complete array of calculations was completed for all identified exposure scenarios using the short- and intermediate-term endpoints because the Agency believes that carbaryl uses fit the criteria for both of these durations. The only calculations that were completed using the chronic endpoint were limited and those associated with the greenhouse and floriculture industries where these kinds of exposures may occur. Cancer risks were also calculated using a linear, low-dose extrapolation model (i.e., Q_1*) for both private growers (i.e., 10 days per year) and for those who may more actively use carbaryl such as a professional farmworker (i.e., 30 days per year). Inhalation exposures are thought to be negligible in outdoor postapplication scenarios because of the low vapor pressure and due to the infinite dilution expected outdoors. As such, inhalation postapplication exposures are not considered in this assessment.

The use of personal protective equipment or other types of equipment to reduce exposures for post-application workers is not considered a viable alternative for the regulatory process except in specialized situations (e.g., a rice scout will wear rubber boots in flooded paddies). This is described in some detail in the Agency's Worker Protection Standard (40CFR170). As such, an administrative approach is used by the Agency to reduce the risks and is referred to as the *Restricted Entry Interval* or REI. The REI is a measure of the amount of time required to pass after application of a pesticide before engaging in a task or activity in a treated field. Postapplication risk levels are generally calculated in the risk assessment process on a chemical-, crop-, and activity-specific basis. To establish REIs, the Agency considers postapplication risks on varying days after application. [Note: Current labels specify REIs of 12 hours after application for all crop/cultural practice combinations while Pre-Harvest Intervals (PHIs) are less than 7 days for most crops with some as long as 28 days.]

The Agency has used the basic approach described above since the mid 1980s for calculating postapplication risks to pesticides. From that time to the present, several revisions and modifications were made to Agency policies as data which warranted such changes became available. In 1995, the Agency issued a Data Call-In for postapplication agricultural data that prompted the formation of the Agricultural Reentry Task Force (ARTF), of which Bayer is a member. This task force has generated a number of exposure studies and associated documents that are currently under review by the Agency. The work of the ARTF is not yet complete, however, sufficient data were available from the group that warranted a significant interim change in Agency policy related to the data which were already available as the efforts of the ARTF paralleled the Agency push for tolerance reassessment stipulated by the timelines established by FQPA. As a result of the need for the revision and using the latest data, the Agency developed a revised policy on August 7, 2000 entitled *Policy 003.1 Science Advisory Council For Exposure Policy Regarding Agricultural Transfer Coefficients*. The revision to this policy entailed linking worker activities to more specific crop/agronomic groupings and making better use of the available occupational post-application exposure data. In the new policy, transfer coefficients were selected to represent the activities associated with 18 distinct crop/agronomic groupings based on different types of vegetables, trees, berries, vine/trellis crops, turf, field crops, and bunch/bundle crops (e.g., tobacco). In this new scheme which the Agency uses to develop scenarios for occupational postapplication exposures, carbaryl uses were identified in all of the crop groupings in the policy. These crop groups include:

- Low Berry (e.g., lowbush blueberries, cranberries, strawberries);
- Bunch/bundle (e.g., bananas, hops, tobacco);
- Field/row crops, low/medium (e.g., alfalfa, barley, beans, cotton, peanuts, peas);
- Field/row crops, tall (e.g., corn, sorghum, sunflowers);
- Cut flowers (e.g., floriculture crops);
- Sugarcane;
- Trees/fruit, deciduous (e.g., apples, apricots, cherry, peaches, pears);
- Trees/fruit, evergreen (e.g., avocados, Christmas trees, citrus);
- Trees/nut (e.g., almonds, hazelnuts, macadamia, pecans, walnuts);
- Turf/sod (e.g., golf courses, sod farms);
- Vegetable/root (e.g., beets, carrots, onions, potatoes, turnips);
- Vegetable/cucurbit (e.g., cantelope, cucumber, squash, watermelon);
- Vegetable/fruiting (e.g., eggplant, pepper, tomato, okra);
- Vegetable/head and stem brassica (e.g., brocolli, cauliflower, brussel sprouts, cauliflower);
- Vegetables/leafy (e.g., collards, greens, lettuce, parsley, spinach, napa);

- Vegetables/stem and stalk (e.g., artichoke, asparagus, pineapple);
- Vine/trellis (e.g., blackberries, blueberries, grapes, kiwi, raspberries); and
- Nursery crops (e.g., container and B&B ornamentals).

Within each agronomic group, a variety of cultural practices are required to maintain the included crops. These practices are varied and typically involve light to heavy contact with immature plants as well as with more mature plants. The Agency selected transfer coefficient values in its revision of Policy 003 to represent this range of exposures within each agronomic group. In the policy, transfer coefficients were placed in 1 of 5 generic categories based on the exposures relative to that group. These 5 categories include: very low exposure, low exposure, medium exposure, high exposure, and very high exposure. Numerical values were not necessarily assigned to each category for each crop group. Selections depended upon the actual agronomic practices that were identified by the Agency for each group (i.e., some groups had 2 assigned transfer coefficients while others had 5). Carbaryl can be used in each of the agronomic crop groupings described above. As such, all agronomic crop group/transfer coefficients were used to calculate postapplication risks for carbaryl. [Note: Specific transfer coefficient values are included in Appendix E of this document which contains all of the calculations. The transfer coefficient values which have been used are excerpted directly from Agency policy 003. The nursery crop group data have not yet been formally included in EPA Policy 3. However, the studies in this area submitted by ARTF have been reviewed and used since they will be integrated into Policy 3 in a short timeframe.]

The revised policy on transfer coefficients has been significantly expanded to more closely link job practices to one of 18 crop/agronomic groups as indicated above. It has also more clearly defined the scope of the policy as the types of tasks/job functions that should be addressed using transfer coefficients are more clearly defined and described. The policy also describes which kinds of jobs result in exposures that cannot be addressed with transfer coefficients such as hand harvesting asparagus (i.e., because there is no foliar contact) or those that are of special concern such as vacuuming while harvesting tree nuts. The revised policy also describes in more detail those exposures that are considered to be negligible as outlined in HED Exposure SAC Policy 11: *Mechanized Agricultural Practices and Post-Application Exposure Assessments* (e.g., mechanical harvesting). It should be noted that mechanical harvesting and other similar low/no exposure activities should be addressed by the guidance contained in Policy 11 which is based on the Worker Protection Standard guidance for such activities (40CFR 170). If there are exposures that are of special concern, then additional data or characterization in the risk mitigation phase of the reregistration process should be considered. Exposures that are thought to be out of the scope of Policy 003 for carbaryl are presented below. A discussion of associated mechanized practices is also provided.

2.2.2 Data and Assumptions for Occupational Postapplication Exposure Scenarios

A series of assumptions and exposure factors served as the basis for completing the occupational postapplication worker risk assessments. Each assumption and factor is detailed below on an individual basis. In addition to these values, transfer coefficient values were used to calculate risk estimates. Several chemical-specific residue dissipation studies were also submitted which were used in the development of the risk values . The transfer coefficients were taken from the Agency's revised policy entitled *Policy 003.1 Science Advisory Council For Exposure Policy Regarding Agricultural Transfer Coefficients* (August 7, 2000). Each of these factors are presented below.

The assumptions and factors used in the risk calculations include:

- There are many factors that are common to handler and postapplication risk assessments such as body weights, duration, and ranges of application rates. Please refer to the assumptions and factors in Section 2.1.2 for further information concerning these values which are common to both handler and postapplication risk assessments. In the postapplication risk assessment, generally only maximum application rates were considered because of the complexity of the calculations (i.e., short-term, intermediate-term, chronic, and cancer endpoints for each of the agronomic groups contained in Policy 003).

- The transfer coefficient in Policy 003 for tree fruit thinning has been reduced since the issuance of the policy from 8000 cm^2/hour to 3000 cm^2/hour based on a re-evaluation of the data from the cited study (i.e., the change is based on an altered analytical recovery correction factor that was erroneously used by Bayer in the initial study report). This modification has been made in the tree fruit group and any other scenarios which have used this value. Additionally, preliminary data from a biomonitoring study of tree fruit thinning presented at the International Society of Exposure Analysis meeting in August 2002, sponsored by Bayer and conducted by Krieger et al from the University of California Riverside, also supports use of a transfer coefficient of 3000 cm^2/hr for tree fruit thinners.

- The tree fruit harvester transfer coefficient used in this assessment of 1500 cm^2/hr was reduced in this assessment from a value of 3000 cm^2/hr. This modification was discussed at the Agency's Science Advisory Council For Exposure (i.e., EXPOSAC) and has been permanently incorporated into its Policy 003 for agricultural transfer coefficients. This modification was made by considering the results of six different tree harvester studies conducted/owned by the Agricultural Reentry Task Force, two of which evaluated exposure to carbaryl. A range of crops was represented in these data including pome fruit (apples), stone fruit (peaches), and citrus. Other chemistries which were considered include: an organophosphate insecticide, a pyrethroid insecticide, and a fungicide.

- The available dislodgeable foliar residue and turf transferable residue data for were used to complete all postapplication risk assessments. The chemical-specific residue data are described in detail below and summarized in Appendix D. These data indicate that the percent of transferability averages approximately 16 percent of the application rate for the agricultural crops using the Iwata aqueous solution/leaf punch method and approximately 1.1 percent for the turf measurements taken using the new ORETF roller method. Given these values, the Agency has used them for all postapplication crops and scenarios as the transferability is in the appropriate range for use in risk assessments.

- The use of common engineering controls as well as personal protective equipment or clothing is not considered a practical solution for mitigating postapplication worker risks as described in the Agency's Worker Protection Standard (40CFR170). Of course, when well recognized mechanized options are available such as for harvesting the Agency considers them in the overall risk picture for each applicable crop/chemical/cultural practice combination (i.e., mechanized operations are also discussed in 40CFR170 and in the Agency's recently revised transfer coefficient policy 003). In lieu of PPE or engineering controls to mitigate risks, the Agency uses an administrative approach by establishing Restricted-Entry Intervals which are essentially the time it takes for chemical residues to dissipate to levels where jobs can be done at exposure levels that are not a concern.

- Exposures were calculated to reflect chemical-specific residue dissipation rates over time coupled with surrogate transfer coefficients as outlined in the Agency's revised policy. Carbaryl is used in virtually every aspect of agriculture but only 4 dislodgeable foliar residue studies were submitted that meet current Agency guidelines for sampling techniques and data quality. Studies identified in the literature such as those completed by Zweig on strawberries in 1984 ($t_{1/2}$ = 4.1 days) and Iwata in 1979 on lemons and oranges at 11.5 lb ai/acre ($t_{1/2}$ = 14 days and $t_{1/2}$ = 22 days, respectively) were considered qualitatively by the Agency to confirm the more current data. [Note: The Iwata data indicate a longer ½ life than seen in the current data. This is probably due to the high application rate compared to the current carbaryl labels.] The chemical-specific dissipation data used in this current assessment were generated in studies completed by the ARTF as part of their data generation effort. These studies were conducted using Iwata's DFR sampling method on tobacco, olives, sunflowers, and cabbage. A turf transferable residue (TTR) study was also completed by the ORETF using the new roller method. The Agency uses transfer coefficients in different agronomic groups as described above to complete risk assessments. The 5 DFR and TTR studies were used as the transferable residue source term for each of these groups. These data were extrapolated to other groups based on the nature of the crop and application method. For example, the olive data were used to calculate risks for all tree crops because airblast (which was used in the olive study) would be the application method of choice for tree crops, the rates are similar, and the plant canopies are similar (i.e., can impact light and precipitation levels which in turn impact DFRs). A more complete description of how the data have been used is provided below.

- As described in the handler section and throughout the document, short-term noncancer risks were calculated by comparing single day exposures. This same approach was used in the postapplication assessment where single day exposures based on the dissipation of carbaryl residues were calculated to complete the short-term risk assessment (i.e., single day risks were calculated based on daily DFR dissipation values over time). The intermediate and chronic postapplication risk calculations, however, differ from the handler calculations for these extended periods. In a handler assessment, the exposures are the same from day to day because there is no residue dissipation involved (i.e., if one sprays whether it is the 1st or the 50th day in a row using the same equipment, the exposures would be similar because the source of exposure is similar). In postapplication assessments, the source term is expected to diminish because of residue dissipation. Hence, for the intermediate-term and chronic postapplication risk assessments, averages based on DFR dissipation and an appropriate duration for the endpoint were used to calculate postapplication risks. In the intermediate-term assessment, a 30 day average was used to calculate risks because the HIARC identified exposures longer than 30 days as intermediate-term in nature. In the chronic assessment, a 30 day average was used based on the likelihood that carbaryl could be sprayed at least once a month in the ornamental industry (which are the only scenarios identified as chronic by the Agency). There are many approaches that can be used in the calculation of intermediate-term postapplication risks including using single day dose levels like in the short-term assessment and just comparing them to the intermediate-term endpoint. This is effective as a screening approach but is unlikely to actually occur based on simple probability (e.g., finding a freshly treated field 30 days in a row would be less likely than working in a field where residues are dissipating over time).

- Risks were calculated using the generic transfer coefficients that represent many different types of cultural practices. Transfer coefficients are thought to be generic (i.e., specific to a crop/activity combination but independent of the chemical used to generate them). Several values, however, included in the Agency's revised policy were developed using carbaryl data. Because carbaryl can be used so widely, every crop/cultural practice combination represented by different transfer coefficients included in the Agency policy was completed.

- A pseudo-first order kinetics analysis was used to analyze carbaryl residue dissipation over time as outlined in the Agency's draft *Series 875 Postapplication Exposure Monitoring Guidelines*. A more sophisticated curve-fitting approach was not warranted because the correlation coefficients in the analysis were appropriate and the data have been used generically to extrapolate to a variety of other crops where decay rates and mechanisms may differ (i.e., any sophistication gained with a curve fitting technique would be lost in an extrapolation to another crop).

- When the Agency extrapolated the available DFR data to other crops, it adjusted the data for differences in application rate using a simple proportional approach. This approach seems to be the most appropriate given the data which are available. This approach is commonly used in Agency postapplication risk assessments.

- The exposure frequency values for the postapplication cancer risk assessment are intended to consider the exposures of professional farmworkers and those growers/users who do their own hand labor (e.g., harvesting as well as other cultural activities) concurrently with carbaryl applications. As a result, cancer risks for all postapplication scenarios have been assessed using 30 days per year for professional farmworkers and 1/3rd of that for private growers analogous to the handler assessment completed above.

- In postapplication cancer risk assessments, the Agency uses a tiered approach. In this case LADD (Lifetime Average Daily Dose) levels were calculated by amortizing single day exposures which are the same values used in the short-term assessment over a lifetime using the 10 and 30 days per year frequency values. This may introduce a level of conservatism into the assessment. However, it does not appear that cancer risks would drive decisions for postapplication exposure scenarios because of the concerns for reentry workers from noncancer risks. Therefore, the analysis was not refined further. Potential refinements may have included the use of an average exposure to amortize over a lifetime or the area under the appropriate DFR curve could be integrated and amortized.

Postapplication Studies: A total of five studies are described in this section.. One study, conducted by the Bayer Corporation, quantifies carbaryl-specific turf transferable residues in 3 different states. The other studies were all conducted by the ARTF for use in defining generic transfer coefficients. Carbaryl is one of the compounds that was selected by the ARTF as a surrogate chemical for their efforts. These studies quantified residue dissipation and exposure during tobacco harvesting, during scouting in sunflowers, while weeding cabbage, and while pruning olive trees. The DFR component of those studies has been extracted for chemical-specific use in this risk assessment. The transfer coefficients used in this assessment are from Agency's interim transfer coefficient policy developed by HED's Science Advisory Council for Exposure using proprietary data from the Agricultural Re-entry Task Force (ARTF) database (policy # 3.1). Each study can be identified with the following information. Detailed information is provided in Tables 1 through 8 of Appendix D. Tables 1 through 7 contain results from individual studies while Table 8 contains a summary of the critical data and statistical results. The studies which have been used in this assessment are identified below followed by a brief summary of each:

- **"Determination of Dermal and Inhalation Exposure To Reentry Workers During Harvesting In Tobacco, Study Number: ARF024"** EPA MRID 450059-11; Report dated July 20, 1999; Authors; Dennis R. Klonne, Susan C. Artz, Cassie Prochaska, Aaron Rotondaro; Sponsor: Agricultural Reentry Task Force; Performing Laboratories: Field - Grayson Research LLC and Analytical - Morse Laboratories.

- **"Determination of Dermal and Inhalation Exposure To Reentry Workers During Pruning of Olive Trees, Study Number: ARF033"** EPA MRID 451751-02; Report dated February 8, 2000; Authors; Dennis R. Klonne, Randy Fuller, Richard Honeycutt; Sponsor: Agricultural Reentry Task Force; Performing Laboratories: Field - HERAC, Inc. and Analytical - Morse Laboratories.

- **"Determination of Dermal and Inhalation Exposure To Reentry Workers During Scouting in Sunflower, Study Number: ARF022"** EPA MRID 450059-09; Report dated

September 28, 1999; Authors; Dennis R. Klonne, Eric Bruce, Susan Artz, Casey Howell; Sponsor: Agricultural Reentry Task Force; Performing Laboratories: Field - ABC Laboratories and Analytical - Maxim Technologies.

- **"Determination of Dermal and Inhalation Exposure To Reentry Workers During Weeding In Cabbage, Study Number: ARF037"** EPA MRID 451917-01; Report dated May 30, 2000; Authors; Dennis R. Klonne, Randy Fuller, Tami Belcher; Sponsor: Agricultural Reentry Task Force; Performing Laboratories: Field - Excel Research Services and Analytical - Maxim Technologies.

- **"Carbaryl: Determination of Transferable Residues From Turf Treated With Dragon® Sevin® Liquid"** EPA MRID 451143-01; Report dated November 4, 1999; Author; Thomas C. Mester; Sponsor: Bayer Corporation; Performing Laboratory: ABC Laboratories.

[**Note to Risk Managers:** There are no data compensation issue associated with the use of the ARTF data in the carbaryl risk assessment because the Bayer Corporation, the registrant for carbaryl, is a member of the ARTF. The task force has submitted proprietary data that were generated using carbaryl. It is the intention of HED's Science Advisory Council for Exposure that the transfer coefficient policy will be periodically updated to incorporate additional information about agricultural practices in crops and new data on transfer coefficients. Much of this information will originate from exposure studies currently being conducted by the ARTF, from further analysis of studies already submitted to the Agency, and from studies in the published scientific literature.]

MRID 450059-11 (tobacco DFR data): This study contained a human exposure element which was reviewed separately by the Agency during the development of the revised policy 003 on transfer coefficients. The DFR component of the data only has been summarized below for use in the carbaryl risk assessment. The field phase of this study was conducted at a single site near Zebulon, North Carolina which is in a major growing region for flue-cured tobacco. The field phase of the study was conducted during the period from July 1 to August 13, 1998. Sample analyses were completed by October, 1998. A tractor mounted groundboom sprayer was used to make 2 applications of Sevin XLR Plus, a liquid flowable formulation, 8 days apart at an application rate of 2 lb ai/acre. Spray volume was 20 gallons of water per acre. The tobacco plants were approximately 4.5 feet tall and were spaced approximately 2 feet within each row while the rows were spaced 4 feet apart (i.e., ~5400 plants/acre). No significant precipitation was observed in this study until at least 7 days after application.

Triplicate DFR samples were collected out to 35 days after the last application using the Iwata method (i.e., a total surface area sampled of 400 cm2/sample collected with a 1 inch diameter Birkestrand leaf punch and dislodged with a 0.01 percent Aerosol solution). The *Limit of Quantitation (LOQ)* in this study was 1 µg/sample or 0.0025 µg/cm^2. There were still measurable residues 35 days after application. The percent transferability of the 0 day sample was 19 percent of the application rate. Average field recovery over all fortification levels was 114 percent with a coefficient of variation of 6.1. The results of the study are presented in detail in Table 1 of

Appendix D. The results of the pseudo-first order statistical analysis of the data presented in Appendix D are summarized below in Table 13.

Table 13: Tobacco DFR Dissipation Data (MRID 450059-11)							
Location	App. Rate (lb ai/acre)	App. Method	Corr. Coeff.	Slope (Ln TTR vs. t)	$[T_0]$ ($\mu g/cm^2$)	$T_{1/2}$ (days)	Day 0 (% trans.)
NC	2	Groundboom	0.957	-0.205	4.26	3.4	19.0

MRID 451751-02 (olive DFR data): This study contained a human exposure element which was reviewed separately by the Agency during the development of the revised policy 003 on transfer coefficients. The DFR component of the data only has been summarized below for use in the carbaryl risk assessment. The field phase of this study was conducted at a single site near Terra Bella, California which is in a major growing region for olives. The field phase of the study was conducted during the period from November 2 to November 17, 1998. Sample analyses were completed by January, 1999. A typical airblast sprayer was used to make a single application of Sevin XLR Plus, a liquid flowable formulation, at an application rate of 7.65 lb ai/acre. Spray volume was 758 gallons of water per acre. The olive trees were approximately 20 feet tall and were spaced approximately 28 feet within each row while the rows were spaced 28 feet apart (i.e., ~56 trees/acre). No significant precipitation was observed in this study until at least 7 days after application.

Triplicate DFR samples were collected out to 14 days after application using the Iwata method (i.e., a total surface area sampled of 400 cm2/sample collected with a 1 inch diameter Birkestrand leaf punch and dislodged with a 0.01 percent Aerosol solution). The *Limit of Quantitation (LOQ)* in this study was 1 µg/sample or 0.0025 $\mu g/cm^2$. There were still measurable residues 14 days after application. The percent transferability of the 0 day sample was 3.6 percent of the application rate. Average field recovery over all fortification levels was 109.7 percent with a coefficient of variation of 4.8. The results of the study are presented in detail in Table 2 of Appendix D. The results of the pseudo-first order statistical analysis of the data presented in Appendix D are summarized below in Table 14.

Table 14: Olive DFR Dissipation Data (MRID 451751-02)							
Location	App. Rate (lb ai/acre)	App. Method	Corr. Coeff.	Slope (Ln TTR vs. t)	$[T_0]$ ($\mu g/cm^2$)	$T_{1/2}$ (days)	Day 0 (% trans.)
CA	7.65	Airblast	0.913	-0.0988	3.067	7	3.6

MRID 450059-09 (sunflower DFR data): This study contained a human exposure element which was reviewed separately by the Agency during the development of the revised policy 003 on transfer coefficients. The DFR component of the data only has been summarized below for use in the carbaryl risk assessment. The field phase of this study was conducted at a single site near Northwood, North Dakota which is in a major growing region for sunflowers. The field phase of the study was conducted during the period from July 20 to August 25, 1998. Sample analyses were completed by December, 1998. A fixed-wing aircraft was used to make 2 applications of Sevin XLR Plus, a liquid flowable formulation, 7 days apart at an application rate of 1.5 lb ai/acre. Spray volume was 3 gallons of water per acre. The sunflower plants were approximately 4 feet tall and were spaced approximately 0.5 feet within each row while the rows were spaced 2.5 feet apart (i.e., ~35000 plants/acre). No significant precipitation was observed in this study until at least 14 days after application.

DFR samples were collected out to 28 days after the last application using the Iwata method (i.e., a total surface area sampled of 400 cm2/sample collected with a 1 inch diameter Birkestrand leaf punch and dislodged with a 0.01 percent Aerosol solution). The *Limit of Quantitation (LOQ)* in this study was 1 µg/sample or 0.0025 µg/cm^2. There were still measurable residues 28 days after application. The percent transferability of the 0 day sample was 32 percent of the application rate. Average field recovery over all fortification levels was 93.1 percent with a coefficient of variation of 9.1. The results of the study for each site are presented in detail in Table 3 of Appendix D. The results of the pseudo-first order statistical analysis of the data presented in Appendix D are summarized below in Table 15.

Table 15: Sunflower DFR Dissipation Data (MRID 450059-09)

Location	App. Rate (lb ai/acre)	App. Method	Corr. Coeff.	Slope (Ln TTR vs. t)	$[T_0]$ (µg/cm^2)	$T_{1/2}$ (days)	Day 0 (% trans.)
AND	1.5	FW Aerial	0.986	-0.134	5.35	5.2	31.8

MRID 451917-01 (cabbage DFR data): This study contained a human exposure element which was reviewed separately by the Agency during the development of the revised policy 003 on transfer coefficients. The DFR component of the data only has been summarized below for use in the carbaryl risk assessment. The field phase of this study was conducted at a single site near Fresno, California which is in a major growing region for cabbage. The field phase of the study was conducted during the period from September 29 to November 10, 1999. Sample analyses were completed by May, 2000. A tractor drawn groundboom sprayer was used to make 2 applications of Sevin XLR Plus, a liquid flowable formulation, 7 days apart at an application rate of 2.07 lb ai/acre. Spray volume was 31.1 gallons of water per acre. The cabbage plants were approximately 8 to 10 inches tall and were spaced approximately 1 feet within each row while the rows were spaced 3 feet apart (i.e., ~15000 plants/acre). No significant precipitation was observed in this study. All irrigation was in-furrow which is not believed to impact DFR levels.

Triplicate DFR samples were collected out to 35 days after the last application using the Iwata method (i.e., a total surface area sampled of 400 cm2/sample collected with a 1 inch diameter Birkestrand leaf punch and dislodged with a 0.01 percent Aerosol solution). The *Limit of Quantitation (LOQ)* in this study was 1 µg/sample or 0.0025 µg/cm^2. There were still measurable residues 35 days after application in 1 of the 3 samples collected while all samples on day 28 contained detectable residues. The percent transferability of the 0 day sample was 10.9 percent of the application rate. Average field recovery over all fortification levels was 97.2 percent with a coefficient of variation of 8.3. The results of the study for each site are presented in detail in Table 4 of Appendix D. The results of the pseudo-first order statistical analysis of the data presented in Appendix D are summarized below in Table 16.

Table 16: Cabbage DFR Dissipation Data (MRID 451917-01)

Location	App. Rate (lb ai/acre)	App. Method	Corr. Coeff.	Slope (Ln TTR vs. t)	$[T_0]$ (µg/cm^2)	$T_{1/2}$ (days)	Day 0 (% trans.)
CA	2.07	Groundboom	0.956	-0.190	2.46	3.6	10.6

Table 16: Cabbage DFR Dissipation Data (MRID 451917-01)							

MRID 451143-01 (turf transferable residue data): A TTR study was conducted at individual sites in three states using the ORETF roller sampling method. The locations were in California, Georgia, and Pennsylvania. Tall fescue was the variety in California and Pennsylvania. Bermudagrass was the variety in Georgia. Field work took place over three week intervals at each site. Applications were made and samples were collected essentially in October of 1998 in California and Georgia while the Pennsylvania study was completed essentially in May 1999. Two applications were made 7 days apart at each site. All applications in this study were completed at a rate of 8.17 lb ai/acre. In California and Georgia, applications were made with typical groundboom sprayers using approximately 55 and 31 gallons of water per acre, respectively. In Pennsylvania, the applications were made with a CO_2 powered sprayer in approximately 45 gallons of water per acre. All applications were made using Dragon Sevin Liquid which is a flowable concentrate formulation that contains carbaryl at a nominal concentration of 21 percent by weight or 2 lb ai/gallon.

There was approximately from 1 inch up to 2.7 inches of irrigation water on the day of the final application at each site. Additionally, on the day of the final application, rain was noted that ranged in accumulations from 0.2 to 1.23 inches. California and Pennsylvania also received additional rain in the week after the last application (i.e., both events < 1 inch). It could not be determined, based on the study data, if the rain and irrigation events on the day of the last application at each site occurred prior to or after the application. Mowing events were also noted in the data except in Georgia where no mowing was done. The other sites were mowed prior to the last application and at some point at least 6 days after the last application.

Triplicate TTR samples were collected using the ORETF roller method at 8 intervals out to 14 days after the last application. All but two samples at each site were collected during the 1^{st} week of the study. The *Limit of Quantitation (LOQ)* for carbaryl residues was 2 µg/sample which is equivalent to 0.00035 $\mu g/cm^2$ based on a sample surface area of 5690 cm^2. Average field recovery values across levels from all sites was greater than 90 percent. Additionally, the variability in the field recovery data as defined using the coefficient of variation was also low (<10) except for the Georgia site where the CV was 28. However, at the Georgia and Pennsylvania sites, the dose-specific recovery value that closest approximated the field sample levels warranted that the results be corrected by the investigators (i.e., 119 % in Georgia and 89% in Pennsylvania, respectively). Residue levels were not corrected for recovery at the California site. In all cases, residue levels exceeded the LOQ even at 14 days after application. The results of the study for the California, Georgia, and Pennsylvania sites, respectively, are presented in Tables 5, 6, and 7 of Appendix D. The data and the results of the pseudo-first order statistical analysis of the data presented in Appendix D are summarized below in Table 17.

Table 17: TTR Dissipation Data Measured Using ORETF Roller In 3 States (MRID 451143-01)							
Location	App. Rate (lb ai/acre)	App. Method	Corr. Coeff.	Slope (Ln TTR vs. t)	$[T_0]$ ($\mu g/cm^2$)	$T_{1/2}$ (days)	Day 0 (% trans.)
CA	8.17	Groundboom	0.971	-0.543	0.927	1.3	1.0
GA	8.17	Groundboom	0.887	-0.168	1.12	4.1	1.2
PA	8.17	CO_2	0.984	-0.248	1.12	2.8	1.2
The Georgia data were used to calculate short-term and intermediate-term risks because of the added persistence (i.e. to consider a 30 day average residue). Note that intermediate-term risks could not even be calculated for PA and CA data because of the shorter decay time. The California data were used to calculate cancer risks because of the quicker dissipation which may represent more typical uses.							

2.2.3 Occupational Postapplication Exposure and Noncancer Risk Estimates

The occupational postapplication exposure and non-cancer risk calculations are presented in this section. Noncancer risks were calculated using the Margin of Exposure (MOE) which is a ratio of the body burden to the toxicological endpoint of concern. Body burden values were determined by first calculating exposures by considering transferable residue levels in areas where people work (i.e., the potential sources of exposure) and the kinds of jobs or tasks required to produce agricultural commodities or to maintain other areas such as golf courses. These factors are represented by DFR or TTR concentrations and transfer coefficients. Exposures were calculated by multiplying these factors by an 8 hour work day. Exposures are then normalized by body weight and adjusted for dermal absorption to calculate absorbed dose (i.e., body burdens). MOEs were then calculated. Postapplication risks diminish over time because carbaryl residues eventually dissipate in the environment. As a result risk values were calculated over time based on changing residue levels.

Dissipation Kinetics: The first step in the postapplication risk assessment was to complete an analysis of the available dislodgeable foliar and turf transferable residue (DFR) data. All residue data generated in the referenced studies are summarized in Appendix D as well as in Tables 13 through 17 above. As discussed in Section 2.2.2 above, data from the 4 DFR studies were used to calculate risks for all agronomic crop groups. Best fit DFR levels were calculated based on empirical data using the equation D2-16 from *Series 875-Occupational and Residential Test Guidelines: Group B-Postapplication Exposure Monitoring Test Guidelines*. The summary of the available chemical-specific DFR data, presented in tables 13 through 17 above, were developed based on a semilog regression of the empirical dissipation data using a commercial spreadsheet linear regression function. Half-lives were calculated using the algorithm ($T_{1/2}$ = -Ln 2/slope). The results of those statistical analyses were used to calculate best fit concentrations over time using the following pseudo-first order equation:

$$C_{envir(t)} = C_{envir(0)} e^{PAI_{(t)} * M}$$

Where:

> $C_{envir(t)}$ = dislodgeable foliar or turf transferable residue concentration ($\mu g/cm^2$) that represents the amount of residue on the surface of a contacted leaf surface that is available for dermal exposure at time (t);
> $C_{envir(0)}$ **=** dislodgeable foliar or turf transferable residue concentration ($\mu g/cm^2$) that represents the amount of residue on the surface of a contacted leaf surface that is available for dermal exposure at time (0);
> **e =**natural logarithms base function;
> PAI_t **=** postapplication interval or dissipation time (e.g., days after treatment or DAT); and
> **M =** slope of line generated during linear regression of data [ln(C_{envir}) versus postapplication interval (PAI)].

In cases where no chemical-specific residue dissipation data are available, the Agency typically uses a generic dissipation model to complete risk calculations. In this case, the Agency determined that it is more appropriate, however, to extrapolate using carbaryl-specific dissipation data in the risk assessment for other currently labelled crops than it is to use the generic dissipation model. This approach is consistent with current Agency policies for generating transferable/dislodgeable residue data. The existing residue data were extrapolated to the currently labelled crops as follows:

- **Tobacco DFR Data:** These data have been used to complete all assessments for the crop/activity combinations included in the bunch/bundle, sugarcane, and vine/trellis agronomic crop groups defined in the Agency's revised transfer coefficient policy 003. This extrapolation was completed because of similarities in application methods between the study and selected crop groups, the crop canopy, and application rates (i.e., between the study and current labels).

- **Olive DFR Data:** These data have been used to complete all assessments for the crop/activity combinations included in all of the tree fruit and nut crop groups defined in the Agency's revised transfer coefficient policy 003. This extrapolation was completed because of similarities in application methods between the study and selected crop groups, the crop canopy, and application rates (i.e., between the study and current labels).

- **Sunflower DFR Data:** These data have been used to complete all assessments for the crop/activity combinations in the tall field/row crop group defined in the Agency's revised transfer coefficient policy 003. No extrapolation was required in this assessment. An additional consideration was that the cabbage study was based on groundboom application and not aerial application. Groundboom applications are thought to be much more prevalent in the overall use pattern for carbaryl.

- **Cabbage DFR Data:** These data have been used to complete all assessments for the crop/activity combinations included in the berry, cut flower, low/medium field and row, and all vegetable (i.e., stem/stalk, brassica, leafy, fruiting, cucurbits, root) agronomic crop groups defined in the Agency's revised transfer coefficient policy 003. This extrapolation was completed because of similarities in application methods between the study and selected crop groups, the crop canopy, and application rates (i.e., between the study and current labels).

- **Turf TTR Data:** These data have been used to complete all assessments for the crop/activity combinations for the turf agronomic crop group defined in the Agency's revised transfer coefficient policy 003. No extrapolation was required in this assessment.

Daily Exposure: The next step in the risk assessment process was to calculate dermal exposure values (remembering that inhalation exposures are not assessed for these scenarios) on each post-application day after application using the following equation (see equation D2-20 from *Series 875-Occupational and Residential Test Guidelines: Group B-Postapplication Exposure Monitoring Test Guidelines* and *Residential SOP 3.2: Postapplication Dermal Potential Doses From Pesticide Residues On Gardens*):

$$DE_{(t)}\ (\text{mg/day}) = (TR_{(t)}\ (\mu g/cm^2) \times TC\ (cm^2/hr) \times Hr/Day)/1000\ (\mu g/mg)$$

Where:

DE(t)	=	Daily exposure or amount deposited on the surface of the skin at time (t) attributable for activity in a previously treated area, also referred to as potential dose (mg ai/day);
TR(t)	=	Transferable residues that can either be dislodgeable foliar or turf transferable residue at time (t) where the longest duration is dictated by the decay time observed in the studies ($\mu g/cm^2$);
TC	=	Transfer Coefficient (cm^2/hour); and
Hr/day	=	Exposure duration meant to represent a typical workday (hours).

Note that the ($TR_{(t)}$) input may represent levels on a single day after application in the case of short-term risk calculations. For intermediate-term calculations, rolling 7 day average concentrations were calculated based on the applicability of the toxicology data (i.e., intermediate-term endpoint is applied to exposures >30 days). In the limited number of chronic calculations, a 30 day average was also used based on a likely frequency between applications.

Daily Dose and Margins of Exposure: The use of dissipation data and the manner in which daily postapplication dermal exposure values were calculated are inherently different than with handler exposures. Once daily exposure values are calculated, the calculation of daily absorbed dose and the resulting Margin of Exposure values use the same algorithms that are described above for the handler exposures (See Section 2.1.3). These calculations are completed for each day or appropriate block of time after application.

Noncancer Risk Summary: All of the noncancer risk calculations for occupational carbaryl handlers completed in this assessment are included in Appendix E. The specifics of each of table included in Appendix E are described below. A summary of the results for each crop/activity combination considered for each timeframe is also provided below.

- **Appendix E/Table 1: Inputs For Carbaryl Occupational Postapplication Risk Assessment** Presents the numerical unit exposure values and other factors used in the occupational handler risk assessments.

- **Appendix E/Table 2: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Low Berry Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 4: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Bunch/Bundle Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 6: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Short/Medium Field Row Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 8: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Tall Field Row Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 10: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Cut Flower Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively). [Note: Table 10 also contains chronic risk values.]

- **Appendix E/Table 12: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Sugarcane Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 14: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Deciduous Tree Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 16: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Evergreen Tree Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 18: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Tree Nut Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 20: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Turf** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 22: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Root Vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 24: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Cucurbit Vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 26: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Fruiting Vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 28: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Brassica Vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 30: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Leafy Vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 32: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Root Vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 34: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Vine Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 36: Carbaryl Occupational Postapplication Noncancer Risk Assessment For Nursery Stock Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively). [Note: Table 36 also contains chronic risk values.]

It should be noted that there were several scenarios for which no appropriate exposure data are known to exist or ongoing transfer coefficient studies have not yet been submitted (e.g., ARTF nursery and ornamental data). The scope of the Agency's revised policy 003 for transfer coefficients should also be considered as it only quantitatively addresses risks where the transfer coefficient model is appropriate (i.e., where foliar contact is known to exist). There are many kinds of potential exposure pathways that do not involve foliar contact that have not been addressed in this risk assessment (as defined in policy 003, refer to that document for a complete list). The scenarios include:

- Transplanting many crops including in the ornamental and forestry industry;
- Thinning some crops such as hops;
- Some partially mechanized operations that also involve human contact (e.g., cotton harvesting where module builders and trampers are used, see below);
- Hand weeding some crops such as wheat;
- Various operations with Christmas trees such as pruning or baling; and
- Various operations with nut production such as sweeping for harvest.

[Note: Additional DFR data on different crops could refine exposure and risk estimates.]

Mechanized practices can be divided into fully mechanized activities that meet the definition of "No contact" in the Agency's Worker Protection Standard (WPS) and mechanically assisted practices with potential for exposure. In the case of fully mechanized activities, the Agency does not complete a quantitative exposure assessment but addresses these types of potential exposures qualitatively by allowing early entry as described in the WPS.

> "A worker may enter a treated area during a restricted-entry interval if the agricultural employer assures that both of the following are met: (1) The worker will have no contact with anything that has been treated with the pesticide to which the restricted-entry interval applies including, but not limited to, soil, water, air, or surfaces of plants; and (2) no such entry is allowed until any inhalation exposure level listed in the labeling has been reached or any ventilation criteria established by § 170.110 (c)(3) or in the labeling have been met."

In cases of partially mechanized activities where the potential for exposure exists, the Agency assesses the resulting exposures similarly to those resulting from hand labor activities for "high exposure potential" activities (i.e., transfer coefficients are used to represent exposures associated with the activity). Partially mechanized activities with "low exposure potential"are assessed qualitatively. Available use and usage information have been used to characterize the predominance of these activities that meet the fully mechanized ("No contact") and the mechanically assisted definitions in the risk assessment to allow risk managers flexibility in their decisions with regard to various segments of the exposed population for carbaryl. The Agency also acknowledges that there is some potential for exposure because individuals engaged in fully mechanized activities have short-term excursions from the protected area for various reasons (e.g., unclogging machinery or equipment inspection for breakage). In these cases, the WPS § 170.112(c) *Exception for short-term activities* applies.

The level of concern for all assessments is established by the uncertainty factor that is associated with a specific duration of exposure. Uncertainty factors are defined for occupational exposures under FIFRA and account for intra-species sensitivity and inter-species extrapolation. In other cases, like carbaryl, additional factors can also be required (i.e., 3x) because a *Lowest Observed Adverse Effect Level* (i.e., LOAEL) has been selected as the dose level upon which the risk assessment is based and not on the *No Observed Adverse Effect Level* (i.e., NOAEL). In this case, three distinct durations of exposure were considered for postapplication workers including: short-term ($\leq$30 days), intermediate-term (>30 days to several months), and chronic (essentially every working day). The toxicological endpoints and uncertainty factors which have been applied to each exposure duration are those described in Section 1.3/Table 1. The results for each exposure duration are presented separately below.

Noncancer short-term, intermediate-term, and chronic risks were calculated for different crop groups as described above. Table 18 below provides a summary of these risks for each crop/activity combination considered. For each crop group/activity combination, the short-term MOE value at the current REI of 12 hours is presented (i.e., the Day 0 MOE) as well as the number of days required for short-term MOEs to reach the Agency's uncertainty factor of 100. Additionally, the intermediate-term and chronic MOEs which have been calculated using 30 day average exposures based on the dissipation of carbaryl residues are also included. The uncertainty factor for intermediate-term exposures is 100 and for chronic exposures is 300.

Current label requirements specify 12 hour REIs. For all but the lowest exposure scenarios in some crops, short-term MOEs are of concern (i.e., less than the required uncertainty factor of 100) at the current REI. Generally, short-term MOEs meet or exceed the Agency uncertainty factor in the range of 3 to 5 days for lower to medium exposure activities and from 8 to 12 days after application in most higher exposure scenarios. Intermediate-term MOEs are not of concern generally for low to medium level exposures but are of concern for higher level exposures such as harvesting in some crops. Chronic exposures are of concern for the cut flower industry but not for general greenhouse and nursery production activities.

Table 18: Summary of Carbaryl Noncancer Postapplication Worker Risks						
Crop Group	Result Type	Exposure Descriptor (See Appendix E)				
		Very Low	Low	Medium	High	Very High
Low Berry	ST MOE Day 0	NA	184	NA	49	NA
	Days For ST MOE > UF	NA	0	NA	4	NA
	IT 30 Day Avg MOE	NA	991	NA	264	NA
Bunch/Bundle	ST MOE Day 0	NA	411	32	21	NA
	Days For ST MOE > UF	NA	0	6	8	NA
	IT 30 Day Avg MOE	NA	2365	182	118	NA
Low /Med. Field/Row Crops	ST MOE Day 0	NA	982	65	39	NA
	Days For ST MOE > UF	NA	0	3	5	NA
	IT 30 Day Avg MOE	NA	5286	352	211	NA
Tall Field/Row Crops	ST MOE Day 0	NA	245	61	25	<1
	Days For ST MOE > UF	NA	0	4	11	+30
	IT 30 Day Avg MOE	NA	970	242	97	6
Cut Flowers	ST MOE Day 0	NA	30	18	11	NA
	Days For ST MOE > UF	NA	7	9	12	NA
	IT 30 Day Avg MOE	NA	159	99	57	NA
	Chronic MOE	NA	194	121	69	NA
Sugarcane	ST MOE Day 0	NA	NA	55	27	NA
	Days For ST MOE > UF	NA	NA	3	7	NA
	IT 30 Day Avg MOE	NA	NA	315	158	NA
Decid. Fruit Trees	ST MOE Day 0	1455	146	NA	97	49
	Days For ST MOE > UF	0	0	NA	1	8
	IT 30 Day Avg MOE	4450	445	NA	297	148
Evergreen Fruit Trees	ST MOE Day 0	582	58	39	19	NA
	Days For ST MOE > UF	0	6	10	17	NA
	IT 30 Day Avg MOE	1780	178	119	59	NA
Nut Trees	ST MOE Day 0	NA	175	NA	35	NA
	Days For ST MOE > UF	NA	0	NA	11	NA
	IT 30 Day Avg MOE	NA	534	NA	107	NA

Table 18: Summary of Carbaryl Noncancer Postapplication Worker Risks						
Crop Group	Result Type	Exposure Descriptor (See Appendix E)				
		Very Low	Low	Medium	High	Very High
Turf/Sod	ST MOE Day 0	NA	312	NA	10	NA
	Days For ST MOE > UF	NA	0	NA	14	NA
	IT 30 Day Avg MOE	NA	1505	NA	46	NA
Root Veg.	ST MOE Day 0	NA	245	49	29	NA
	Days For ST MOE > UF	NA	0	4	7	NA
	IT 30 Day Avg MOE	NA	1322	264	159	NA
Cucurbit Veg.	ST MOE Day 0	NA	147	49	29	NA
	Days For ST MOE > UF	NA	0	4	7	NA
	IT 30 Day Avg MOE	NA	793	264	159	NA
Fruiting Veg.	ST MOE Day 0	NA	147	105	74	NA
	Days For ST MOE > UF	NA	0	0	2	NA
	IT 30 Day Avg MOE	NA	793	566	396	NA
Brassica	ST MOE Day 0	NA	37	18	15	NA
	Days For ST MOE > UF	NA	6	9	11	NA
	IT 30 Day Avg MOE	NA	198	99	79	NA
Leafy Veg.	ST MOE Day 0	NA	147	49	29	NA
	Days For ST MOE > UF	NA	0	4	7	NA
	IT 30 Day Avg MOE	NA	793	264	159	NA
Stem/stalk Veg.	ST MOE Day 0	NA	137	82	41	NA
	Days For ST MOE > UF	NA	0	1	5	NA
	IT 30 Day Avg MOE	NA	788	473	236	NA
Vine/trellis	ST MOE Day 0	NA	147	74	15	7
	Days For ST MOE > UF	NA	0	2	11	14
	IT 30 Day Avg MOE	NA	793	396	79	40

Table 18: Summary of Carbaryl Noncancer Postapplication Worker Risks						
Crop Group	Result Type	Exposure Descriptor (See Appendix E)				
		Very Low	Low	Medium	High	Very High
Nursery/ Ornamentals	ST MOE Day 0	NA	669	421	184	NA
	Days For ST MOE > UF	NA	0	0	0	NA
	IT 30 Day Avg MOE	NA	3604	2266	991	NA
	Chronic MOE	NA	4399	2765	1210	NA
ST = Short-term, IT = Intermediate-term, 30 Day Avg.= Average exposure level over 30 day interval. NA = Exposure descriptor not applicable for that crop group. UF = uncertainty factor or target MOE of 100.						

2.2.4 Occupational Postapplication Exposure and Risk Estimates for Cancer

The occupational exposure and cancer risk calculations for postapplication workers are presented in this section. Cancer risks were calculated using a linear low-dose extrapolation approach in which a *Lifetime Average Daily Dose* (LADD) is first calculated and then compared with a Q_1* that has been calculated for carbaryl based on dose response data in the appropriate toxicology study ($Q_1^* = 8.75 \times 10^{-4}$ $(mg/kg/day)^{-1}$). Absorbed average daily dose (ADD) levels were used as the basis for calculating the LADD values. Section 2.1.3 above describes how the ADD values were first calculated for the noncancer MOE calculations. These values also serve as the basis for the cancer risk estimates. Dermal and inhalation ADD values were first added together to obtain combined ADD values. LADD values were then calculated and compared the Q_1^* to obtain cancer risk estimates.

LADD and Cancer Risk Calculations: The use of dissipation data and the manner in which daily postapplication dermal exposure values were calculated are inherently different than with handler exposures. Once daily exposure values are calculated, the calculation of LADD (Lifetime Average Daily Dose) and the resulting cancer risks use the same algorithms that are described above for the handler exposures (See Section 2.1.4).

To reiterate, occupational carcinogenic risks that are 1×10^{-6} or lower require no risk management action based on the 1996 Barolo memo. For those chemicals subject to reregistration, the Agency is to carefully examine uses with estimated risks in the 10^{-6} to 10^{-4} range to seek ways of cost-effectively reducing risks. If carcinogenic risks are in this range for postapplication workers, an increase in time after application prior to allowing a reentry activity would be warranted as is commonly applied to noncancer risk estimates.

Cancer Risk Summary All of the cancer risk calculations for carbaryl postapplication workers are included in Appendix E (various tables). The specifics of each of table included in Appendix E are summarized below.

- **Appendix E/Table 1: Inputs For Carbaryl Occupational Postapplication Risk Assessment** Presents the numerical unit exposure values and other factors used in the occupational handler risk assessments.

- **Appendix E/Table 3: Carbaryl Occupational Postapplication Cancer Risk Assessment For Low Berry Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 5: Carbaryl Occupational Postapplication Cancer Risk Assessment For Bunch/Bundle Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 7: Carbaryl Occupational Postapplication Cancer Risk Assessment For Short/Medium Field Row Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 9: Carbaryl Occupational Postapplication Cancer Risk Assessment For Tall Field Row Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 11: Carbaryl Occupational Postapplication Cancer Risk Assessment For Cut Flower Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 13: Carbaryl Occupational Postapplication Cancer Risk Assessment For Sugarcane Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 15: Carbaryl Occupational Postapplication Risk Assessment For Deciduous Tree Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 17: Carbaryl Occupational Postapplication Cancer Risk Assessment**

For Evergreen Tree Crop Group Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 19: Carbaryl Occupational Postapplication Cancer Risk Assessment For Tree Nut Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 21: Carbaryl Occupational Postapplication Cancer Risk Assessment For Turf** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 23: Carbaryl Occupational Postapplication Cancer Risk Assessment For Root Vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 25: Carbaryl Occupational Postapplication Cancer Risk Assessment For Cucurbit Vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 27: Carbaryl Occupational Postapplication Cancer Risk Assessment For Fruiting Vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 29: Carbaryl Occupational Postapplication Cancer Risk Assessment For Brassica Vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 31: Carbaryl Occupational Postapplication Cancer Risk Assessment For Leafy Vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 33: Carbaryl Occupational Postapplication Cancer Risk Assessment For Root Vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 35: Carbaryl Occupational Postapplication Cancer Risk Assessment**

For Vine Crop Group Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix E/Table 37: Carbaryl Occupational Postapplication Cancer Risk Assessment For Nursery Stock Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

Cancer risks for private growers (i.e., 10 exposures/year) and commercial farmworkers (i.e., 30 exposures/year) were calculated for different crop groups as described above and summarized in Table 19 below. Within each crop group, differing transfer coefficients were used to represent various types of cultural practices. Current label requirements specify 12 hour REIs. For all scenarios, cancer risks are $<1x10^{-4}$ on the day of application (i.e., at the current REI). Likewise, cancer risks are $<1x10^{-6}$ on the day of application for most crop/activity scenarios with private growers and also for low to medium exposures for commercial farmworkers. In fact, risks for all scenarios were in the 10^{-6} range in all but three scenarios for commercial farmworkers participating in very high exposure activities (e.g., sweetcorn handharvesting) on the day of application. In these three cases, risks were in the 10^{-5} range on the day of application. For private growers, it takes up to approximately 5 days for risks to decline to $<1x10^{-6}$ for crop/activity combinations that exceed $1x10^{-6}$ on the day of application. For commercial farmworkers, it takes up to approximately 8 days for risks to reach the target level of concern of $<1x10^{-6}$. The 1996 Barolo memo which focused on cancer risk management should be considered in the interpretation of these results. Current label requirements appear to be adequate for all postapplication cancer risks if the 10^{-4} range is used for risk management. If the 10^{-6} risk range is considered, it also appears that the current REI appears adequate to address cancer risks for many crop/activity combinations. However, for higher exposure situations, longer duration REIs are predicted. In all cases, REIs predicted based on cancer risks are less restrictive or similar (i.e., within a day or two for commercial farmworkers) than those predicted based on the noncancer effects of carbaryl. In no cases do cancer risks indicate more restrictive REIs than for noncancer risks calculated for the corresponding crop/activity exposure scenario.

Table 19: Summary of Carbaryl Cancer Postapplication Worker Risks

Crop Group	Result Type	Exposure Descriptor (From Policy 003/See Appendix E)				
		Very Low	Low	Medium	High	Very High
Low Berry	Private Grower Day 0 Risk	NA	1.7×10^{-7}	NA	6.2×10^{-7}	NA
	Private Grower Days $< 1x10^{-6}$	NA	0	NA	0	NA
	Com.. Farmworker Day 0 Risk	NA	5.0×10^{-7}	NA	1.9×10^{-6}	NA
	Com.. Farmworker Days $< 1x10^{-6}$	NA	0	NA	4	NA
Bunch/Bundle	Private Grower Day 0 Risk	NA	7.4×10^{-8}	9.6×10^{-7}	1.5×10^{-6}	NA
	Private Grower Days $< 1x10^{-6}$	NA	0	0	2	NA
	Com.. Farmworker Day 0 Risk	NA	2.2×10^{-7}	2.9×10^{-6}	4.4×10^{-6}	NA

Table 19: Summary of Carbaryl Cancer Postapplication Worker Risks						
Crop Group	Result Type	Exposure Descriptor (From Policy 003/See Appendix E)				
		Very Low	Low	Medium	High	Very High
	Com.. Farmworker Days < $1x10^{-6}$	NA	0	5	8	NA
Low /Med. Field/Row Crops	Private Grower Day 0 Risk	NA	$3.1x 10^{-8}$	$4.7x 10^{-7}$	$7.8x 10^{-7}$	NA
	Private Grower Days < $1x10^{-6}$	NA	0	0	0	NA
	Com.. Farmworker Day 0 Risk	NA	$9.3x 10^{-8}$	$1.4x 10^{-6}$	$2.3x 10^{-6}$	NA
	Com.. Farmworker Days < $1x10^{-6}$	NA	0	2	5	NA
Tall Field/Row Crops	Private Grower Day 0 Risk	NA	1.2×10^{-7}	5.0×10^{-7}	1.2×10^{-6}	2.1×10^{-5}
	Private Grower Days < $1x10^{-6}$	NA	0	0	2	23
	Com.. Farmworker Day 0 Risk	NA	3.7×10^{-7}	1.5×10^{-6}	3.7×10^{-6}	8.5×10^{-5}
	Com.. Farmworker Days < $1x10^{-6}$	NA	0	3	10	31
Cut Flowers	Private Grower Day 0 Risk	NA	1.0×10^{-6}	1.7×10^{-6}	2.9×10^{-6}	NA
	Private Grower Days < $1x10^{-6}$	NA	0	3	6	NA
	Com.. Farmworker Day 0 Risk	NA	3.1×10^{-6}	5.0×10^{-6}	8.7×10^{-6}	NA
	Com.. Farmworker Days < $1x10^{-6}$	NA	6	9	12	NA
Sugarcane	Private Grower Day 0 Risk	NA	NA	5.6×10^{-7}	1.1×10^{-6}	NA
	Private Grower Days < $1x10^{-6}$	NA	NA	0	1	NA
	Com.. Farmworker Day 0 Risk	NA	NA	1.7×10^{-6}	3.3×10^{-6}	NA
	Com.. Farmworker Days < $1x10^{-6}$	NA	NA	3	6	NA
Decid. Fruit Trees	Private Grower Day 0 Risk	2.1×10^{-8}	2.1×10^{-7}	NA	3.1×10^{-7}	6.3×10^{-7}
	Private Grower Days < $1x10^{-6}$	0	0	NA	0	0
	Com.. Farmworker Day 0 Risk	6.3×10^{-8}	6.3×10^{-7}	NA	9.4×10^{-7}	1.9×10^{-6}
	Com.. Farmworker Days < $1x10^{-6}$	0	0	NA	0	6
Evergreen Fruit Trees	Private Grower Day 0 Risk	5.2×10^{-8}	5.2×10^{-7}	7.8×10^{-7}	1.6×10^{-6}	NA
	Private Grower Days < $1x10^{-6}$	0	0	0	5	NA
	Com.. Farmworker Day 0 Risk	1.6×10^{-7}	1.6×10^{-6}	2.4×10^{-6}	4.7×10^{-6}	NA
	Com.. Farmworker Days < $1x10^{-6}$	0	5	9	16	NA
Nut Trees	Private Grower Day 0 Risk	NA	1.7×10^{-7}	NA	8.7×10^{-7}	NA
	Private Grower Days < $1x10^{-6}$	NA	0	NA	0	NA
	Com.. Farmworker Day 0 Risk	NA	5.7×10^{-7}	NA	2.6×10^{-6}	NA
	Com.. Farmworker Days < $1x10^{-6}$	NA	0	NA	10	NA

Table 19: Summary of Carbaryl Cancer Postapplication Worker Risks						
Crop Group	Result Type	Exposure Descriptor (From Policy 003/See Appendix E)				
		Very Low	Low	Medium	High	Very High
Turf/Sod	Private Grower Day 0 Risk	NA	8.1×10^{-8}	NA	2.7×10^{-6}	NA
	Private Grower Days < $1x10^{-6}$	NA	0	NA	2	NA
	Com.. Farmworker Day 0 Risk	NA	2.4×10^{-7}	NA	8.0×10^{-6}	NA
	Com.. Farmworker Days < $1x10^{-6}$	NA	0	NA	4	NA
Root Veg.	Private Grower Day 0 Risk	NA	1.2×10^{-7}	6.2×10^{-7}	1.0×10^{-6}	NA
	Private Grower Days < $1x10^{-6}$	NA	0	0	0	NA
	Com.. Farmworker Day 0 Risk	NA	3.7×10^{-7}	1.9×10^{-6}	3.1×10^{-6}	NA
	Com.. Farmworker Days < $1x10^{-6}$	NA	0	4	6	NA
Cucurbit Veg.	Private Grower Day 0 Risk	NA	2.1×10^{-7}	6.2×10^{-7}	1.0×10^{-6}	NA
	Private Grower Days < $1x10^{-6}$	NA	0	0	0	NA
	Com.. Farmworker Day 0 Risk	NA	6.2×10^{-7}	1.9×10^{-6}	3.1×10^{-6}	NA
	Com.. Farmworker Days < $1x10^{-6}$	NA	0	4	6	NA
Fruiting Veg.	Private Grower Day 0 Risk	NA	2.1×10^{-7}	2.9×10^{-7}	4.1×10^{-7}	NA
	Private Grower Days < $1x10^{-6}$	NA	0	0	0	NA
	Com.. Farmworker Day 0 Risk	NA	6.2×10^{-7}	8.7×10^{-7}	1.2×10^{-6}	NA
	Com.. Farmworker Days < $1x10^{-6}$	NA	0	0	1	NA
Brassica	Private Grower Day 0 Risk	NA	8.3×10^{-7}	1.7×10^{-6}	2.1×10^{-6}	NA
	Private Grower Days < $1x10^{-6}$	NA	0	3	4	NA
	Com.. Farmworker Day 0 Risk	NA	2.5×10^{-6}	5.0×10^{-6}	6.2×10^{-6}	NA
	Com.. Farmworker Days < $1x10^{-6}$	NA	5	9	10	NA
Leafy Veg.	Private Grower Day 0 Risk	NA	2.1×10^{-7}	6.2×10^{-7}	1.0×10^{-6}	NA
	Private Grower Days < $1x10^{-6}$	NA	0	0	0	NA
	Com.. Farmworker Day 0 Risk	NA	6.2×10^{-7}	1.9×10^{-6}	3.1×10^{-6}	NA
	Com.. Farmworker Days < $1x10^{-6}$	NA	0	4	6	NA
Stem/stalk Veg.	Private Grower Day 0 Risk	NA	2.2×10^{-7}	3.7×10^{-7}	7.4×10^{-7}	NA
	Private Grower Days < $1x10^{-6}$	NA	0	0	0	NA
	Com.. Farmworker Day 0 Risk	NA	6.7×10^{-7}	1.1×10^{-6}	2.2×10^{-6}	NA
	Com.. Farmworker Days < $1x10^{-6}$	NA	0	1	4	NA
Vine/trellis	Private Grower Day 0 Risk	NA	2.1×10^{-7}	4.1×10^{-7}	2.1×10^{-6}	4.1×10^{-6}

Table 19: Summary of Carbaryl Cancer Postapplication Worker Risks						
Crop Group	Result Type	Exposure Descriptor (From Policy 003/See Appendix E)				
		Very Low	Low	Medium	High	Very High
	Private Grower Days < $1x10^{-6}$	NA	0	0	4	8
	Com.. Farmworker Day 0 Risk	NA	6.2×10^{-7}	1.2×10^{-6}	6.2×10^{-6}	1.2×10^{-5}
	Com.. Farmworker Days < $1x10^{-6}$	NA	0	1	10	13
Nursery/ Ornamentals	Private Grower Day 0 Risk	NA	4.5×10^{-8}	7.2×10^{-8}	1.7×10^{-7}	NA
	Private Grower Days < $1x10^{-6}$	NA	0	0	0	NA
	Com.. Farmworker Day 0 Risk	NA	1.4×10^{-7}	2.2×10^{-7}	5.0×10^{-7}	NA
	Com.. Farmworker Days < $1x10^{-6}$	NA	0	0	0	NA
NA = Exposure descriptor not applicable for that crop group.						

2.2.5 Summary of Occupational Postapplication Risk Concerns and Data Gaps

Current label requirements specify 12 hour REIs. For all but the lowest exposure scenarios in some crops, MOEs do not meet or exceed required uncertainty factors until several days after application. If short-term risks are considered, MOEs meet or exceed the Agency uncertainty factor generally in the range of 3 to 5 days after application for lower to medium exposure activities and from 8 to 12 days after application in most higher exposure scenarios. If intermediate-term risks are considered, MOEs are not of concern based on a 30 day average exposures except for higher level exposures such as harvesting in some crops. Chronic exposures are of concern for the cut flower industry but not for other general greenhouse and nursery production activities based on the most recent ARTF data.

Cancer risks were calculated for private growers and professional farmworkers with the only difference being the annual frequency of exposure days. Cancer risks for private growers and commercial farmworkers are generally in the 10^{-8} to 10^{-6} range on the day of application. If a $1x10^{-4}$ cancer risk is the target, the current REI would be adequate for all scenarios considered in the assessment. If a $1x10^{-6}$ cancer risk is used, then durations longer than the current REI should be considered for some cases which are not considered low to medium exposures. It should be noted that the cancer risk calculations are less restrictive than noncancer risk estimates for the same scenarios in all cases.

The Agency has used the latest information to complete this postapplication risk assessment for carbaryl. Several data gaps exist such as a lack of exposure data on mechanized or partially mechanized cultural practices where there is a potential for exposure. Additionally, because of the number and breadth of carbaryl uses, there may be many exposure pathways where the transfer coefficient approach is not an appropriate model (e.g., hand transplanting where no foliar contact occurs) that have not been quantitatively addressed due to a lack of data.

2.2.6 Recommendations For Refining Occupational Postapplication Risk Assessment

To refine this occupational risk assessment, data on actual use patterns including rates, timing, and the kinds of tasks that are required to produce agricultural commodities and other products would better characterize carbaryl risks. Exposure studies for many cultural practices that lack data or that are not well represented in the revised transfer coefficient policy should also be considered based on the data gaps identified above. Risk managers should consider that the risks associated with the current label REI generally do not meet Agency risk targets.

2.3 Occupational Risk Characterization

2.3.1 Handler Characterization

The occupational handler assessment for carbaryl is complex in that three different types of noncancer risk calculations were required based on the recently selected endpoints. The durations of exposure that were considered for noncancer toxicity were short-term ($\leq$30 days), intermediate-term (30 days up to several months), and chronic (every working day). A complete array of calculations was completed for all identified exposure scenarios using the short- and intermediate-term endpoints because the Agency believes that carbaryl uses fit the criteria for both of these durations. The only calculations that were completed using the chronic endpoint were limited and those associated with the greenhouse and floriculture industries where these kinds of exposures may occur. Cancer risks were also calculated using a linear, low-dose extrapolation model (i.e., Q_1*) for both private growers (i.e., 10 application days per year) and for those who may more actively use carbaryl such as a commercial applicator (i.e., 30 application days per year). Cancer calculations were completed as well for every scenario that has been identified for both private growers and commercial applicators. For all of the different types of endpoints selected (except chronic where a limited number of calculations were completed), the Agency identified exposures that fit into 28 different scenarios which are defined based on the equipment used to make applications or the type of formulation used. Within each of these categories, different application rates and acres treated values were considered to evaluate the broad range of applications that may occur with each kind of equipment (e.g., a groundboom may be used for turf or agriculture). All totaled, 140 different crop/rate/acres combinations were considered within the 28 scenarios for the short- and intermediate-term toxicity categories plus 4 chronic crop/rate/acre combinations. The overall result is that 4 sets of 140 calculations each (564 total calculations) were completed for occupational carbaryl handlers. Finally, it should be noted that each calculation was completed at different levels of personal protection to allow for a more informed risk management decision. Even given the scope of the calculations that have already been completed, it is likely that there are some uses of carbaryl that have not been quantitatively addressed in this document either through lack of exposure data or other information and because carbaryl is such a widely used chemical. These scenarios will be addressed by the Agency when they are identified as carbaryl progresses through the reregistration process. Readers are also encouraged to evaluate novel scenarios by considering the range of estimates already completed as it is likely that many uses could be quantitatively assessed by reviewing those calculations as a wide array of chemical use combinations and equipment types have already been considered.

The data that were used in the carbaryl occupational handler risk assessment represent the best data and approaches that are currently available. While some of the data which have been used may not be of optimal quality, they represent the best available data for the scenario in question. In many cases, the Pesticide Handlers Exposure Database (PHED) was used to develop the unit exposure values. The quality of the data included in PHED vary widely from scenarios that meet guideline requirements for studies to others where a limited number of poor quality datapoints are available. The results for each scenario should be reviewed in the context of the quality of these data. In addition to PHED, the Agency used a number of studies to define unit exposure values. Generally, the quality of these studies is excellent. Most, except for the trigger sprayer data, are very recent and based on the newest analytical requirements and monitoring techniques. PHED unit exposure values represent a central tendency of the data (i.e., geometric mean, median or arithmetic mean depending upon the distribution of the data). As such, the values based on the recent studies also are measures of central tendency (e.g., the geometric means were selected from each study for assessment purposes in most cases). Along with the unit exposure values used in the assessment, other inputs include application rates and daily acres treated values. Selected application rates represent a range for each major market in which carbaryl is used including agriculture, turf (lawncare, golf courses, etc.), ornamentals, and for wide area applications such as mosquito control. Many application rates also represent maximum amounts that are allowed by the label for certain settings. Where available, average use rates were also used to provide for a more informed risk management decision. The application rates that were selected for use in the risk assessment were defined based on labels, information provided by the Bayer Corporation at the September 24, 1998 SMART Meeting for carbaryl, and based on various analyses of carbaryl use patterns completed by the Agency's Biological and Economic Analysis Division. The other key input for completing handler risk assessments used for defining how much chemical can be used in a day is how much can be treated in a day which is generally expressed as the number of acres treated per day. The values that were used for this parameter represent the latest Agency thinking on this issue. In fact, the *Science Advisory Council For Exposure* recently updated the policy for these inputs (July 2000 Exposure SAC Policy 9: *Standard Values for Daily Acres Treated in Agriculture*). These most recent values have been used for the calculations.

In addition to the key sources of information considered above, there are many underlying factors that may impact the overall results of a risk assessment. For example, the protection factors used for adding additional levels of dermal and respiratory protection may impact the overall risk picture. The factors used in this assessment by the Agency are the ones that have been used for several years. Other such factors may include the fact that average application rates have been generally used to represent typical application rates to calculate ranges of risks when it is clear that the two values could differ greatly. The Agency has taken this approach because the data required to define typical application rates within each crop are generally unavailable. There are also exposure monitoring issues that should be considered. For example, in many cases the data included in PHED are based on the use of cotton gloves for hand exposure monitoring which are thought by many to overestimate exposure because they potentially retain residues more than human skin would over time (i.e., they may act like a sponge compared to the actual hand). A similar issue was noted with the carbaryl-specific dog grooming study that used the handwash approach to monitor exposure after shampooing several dogs. These intangible elements of the risk assessment reflect many of the hidden uncertainties associated with exposure data. The overall impacts of these uncertainties is hard to quantify. The factor to again consider is that the Agency used the best available data to complete the risk assessment for carbaryl. It should also be noted that the Agency
carefully considered comments received on the previous assessment and has incorporated responses as appropriate. Two key changes in the assessment made as a result of the comments were the consideration of protective headgear for open cab airblast applicators and consideration of high acreage extrapolation based on a biomonitoring study using ethoprop which was inconclusive (i.e., no changes to the high acreage assessments were completed based on this comment).

In summary, the Agency believes that the risk values presented in this occupational assessment represent the highest quality results that could be produced given the exposure, use, and toxicology data that are available. Certainly risk managers and other interested parties should consider the quality of individual inputs when interpreting the results and make decisions accordingly. It is difficult to ascertain where on a distribution the values which have been calculated fall because the distributional data for exposure, application rates, acres treated and many other parameters are unrefined. The Agency does believe, however, that the risks represent conservative estimates of exposure because maximum application rates are coupled with large acreage estimates to define risk estimates that likely fall in the upper percentiles of the actual exposure distributions. Additionally, risk estimates are thought to be conservative even when measures of central tendency are combined because values that would be considered to be in the lower percentile aspect of any input parameter have not been used in the calculations.

2.3.2 Postapplication Characterization

Like the occupational handler risk assessment discussed above, the postapplication worker risk assessment for carbaryl is also complex in that three different types of noncancer risk calculations were required based on the recently selected endpoints along with cancer risk calculations using a linear, low-dose extrapolation model. For all of the different types of endpoints selected (except chronic where a limited number of calculations were completed), the Agency identified exposures that fit into 18 different crop groups which are defined essentially based on the nature of the crop where a work activity would take place. Within each of these crop groups, ranges of transfer coefficients were considered to reflect differences in exposures that would be associated with the variety of cultural practices that are required to produce the crop/product. All totaled, 54 different cultural practices were considered within the 18 crop groups for each toxicity category. The overall result is that 4 sets of 56 calculations each (224 plus a few chronic values) were completed for postapplication workers. Finally, it should be noted that each calculation was completed at different days after application to reflect residue dissipation over time in the environment and to allow for a more informed risk management decision. Even given the scope of the calculations that have already been completed, it is likely that there are some uses of carbaryl that have not been quantitatively addressed in this document either through lack of exposure data or other information and because carbaryl is such a widely used chemical. These scenarios will be addressed by the Agency when they are identified as carbaryl progresses through the reregistration process. Readers are also encouraged to evaluate novel scenarios by considering the range of estimates already completed as it is likely that many uses could be quantitatively assessed by reviewing existing calculations as a wide array of crop/activity combinations have already been considered.

The data that were used in the carbaryl postaapplication worker risk assessment represent the best data and approaches that are currently available. The latest Agency transfer coefficient values have been used to complete this assessment including the recently submitted ARTF studies on greenhouse workers. Most of the values in the current Agency policy are based on the work of the Agricultural Reentry Task Force (ARTF) of which, Bayer is a member. The current Agency policy is interim in nature but represents all of the data that have been submitted by the ARTF and evaluated by the Agency. The work of the ARTF is still ongoing so additional data may become available to refine the exposure estimates as more data are submitted to the Agency. Also, it is possible that there are exposure scenarios that have not been addressed by the Agency because the transfer coefficient model is not appropriate as there is little or no foliar contact associated with the activity. There are also potentially, partially mechanized activities that could lead to exposure where the Agency has no information. These will need to be carefully considered in the reregistration process. In addition to the exposure inputs for specific activities (i.e., transfer coefficients), the Agency used 4 carbaryl-specific DFR (Dislodgeable Foliar Residue) dissipation studies and a single TTR (Turf Transferable Residue) study to calculate risks for all postapplication workers in every region in the country. It is standard practice for the Agency to use these kinds of studies in this manner but it is likely that additional crop- and region-specific data could be used to further refine the risk assessment. Several other key pieces of data and information were considered in the development of the postapplication risk values including use and usage information and exposure frequency in the cancer risk assessment. For many agricultural crops, the maximum application rate is low (e.g., 1.5 to 2 lb ai/acre) in many crops. As a result, postapplication risks were generally calculated at maximum rate levels because of the already inherent complexity of the assessment and because it is likely that results may not be extremely sensitive to changes in this value.

In addition to the key sources of information considered above, there are many underlying factors that may impact the overall results of a risk assessment. For example, subtle differences between activities in similar crops within each of the 18 agronomic groups considered in the assessment may not be accurately reflected in the current transfer coefficient values. The use of 4 DFR studies to represent all crops and all regions within the country could lead to results that do not reflect actual use practices and conditions in some parts of the country. Additionally, the exposure frequency values that were used for private growers and professional farmworkers tend to be supported by available data but could be refined if data on work patterns and regional carbaryl use becomes available. As with the handler assessment above, the intangible elements reflect many of the hidden uncertainties associated with exposure data. The overall impacts of these uncertainties is hard to quantify. The factor to again consider is that the Agency used the best available data to complete the risk assessment for carbaryl.

In summary, the Agency believes that the risk values presented in this postapplication assessment represent the highest quality results that could be produced given the exposure, use, and toxicology data that are available. Certainly risk managers and other interested parties should consider the quality of individual inputs when interpreting the results and make decisions accordingly. It is difficult to ascertain where on a distribution the values which have been calculated fall because the distributional data for exposure, residue dissipation and many other parameters are unrefined. The Agency does believe, however, that the risks represent conservative estimates of exposure because maximum application rates are used to define residue levels upon which the risk calculations are based. Additionally, risk estimates are thought to be conservative even when measures of central tendency (e.g., most transfer coefficients are thought to be central tendency) are used because values that would be considered to be in the lower percentile aspect of any input parameter have not been used in the calculations.

3.0 Residential and Other Non-Occupational Exposures and Risks

It has been determined there is a potential for exposure in residential settings during the application process for homeowners who purchase and use products containing carbaryl. There is also a potential for exposure from entering areas previously treated with carbaryl such as lawns where children might play or golf courses and homegardens that could lead to exposures for adults. Carbaryl is also labeled for mosquito adulticide use which has been considered in this assessment. As a result, risk assessments have been completed for both residential handler and postapplication scenarios. Residential handler exposures and risks calculated using passive dosimetry approaches are addressed in *Section 3.1: Residential Handler Exposures and Risks* while residential post-application risks for adults and children calculated using passive dosimetry approaches are presented and summarized in *Section 3.2: Residential Post-Application Exposures and Risks*. The design and results of a suburban resident biomonitoring study completed as a refinement to the residential assessment by Bayer Corporation along with supporting information and associated risks are presented and summarized in *Section 3.3: Carbaryl Suburban Resident Biomonitoring Study, Associated Data & Risks.* This assessment is based on a deterministic approach which should also be considered in context with the companion probabilistic assessments that have been (or will be) submitted/generated by Bayer Crop Sciences and the Chemistry and Exposure Branch of the Health Effects Division of OPP (see *Section 3.4: Companion Probabilistic Assessments* below for further information).The calculated risks are characterized in *Section 3.5: Residential Risk Characterization.*

3.1 Residential Handler Exposures and Risks Calculated Using Passive Dosimetry

The Agency uses the term "Handlers" to describe those individuals who are involved in the pesticide application process. The agency believes that there are distinct tasks related to applications and that exposures can vary depending on the specifics of each task as was described above for occupational handlers. Residential handlers are addressed somewhat differently by the Agency as homeowners are assumed to complete all elements of an application with little use of any protective equipment. The scenarios that serve as the basis for the risk assessment are presented in *Section 3.1.1: Handler Exposure Scenarios*. The exposure data and assumptions that have been used for the calculations are presented in *Section 3.1.2: Data and Assumptions For Handler Exposure Scenarios*. The calculations and the algorithms that have been used for the noncancer elements of the risk assessment as well as the risk values are presented in *Section 3.1.3: Handler Exposure and Non-Cancer Risk Estimates* while the analogous information using the Q_1* for cancer estimates are presented in *Section 3.1.4: Handler Exposure and Risk Estimates For Cancer*. *Section 3.1.5: Summary of Risk Concerns and Data Gaps For Handlers* presents the overall risk picture for carbaryl. Finally, recommendations are presented in *Section 3.1.6: Recommendations For Refining Residential Handler Risk Assessment*. It should be noted that the results of this assessment should be considered in context with the information presented in *Section 3.3: Carbaryl Suburban Resident Biomonitoring Study, Associated Data & Risks* where risks based on the suburban resident biological monitoring study have been presented. This assessment is based on a deterministic approach which should also be considered in context with the companion probabilistic assessments that have been (or will be) submitted/generated by Bayer Crop Sciences and the Chemistry and Exposure Branch of the Health Effects Division of OPP (see Section 3.4 below for further information). A large percentage of those monitored were residential carbaryl applicators which allows for direct comparison to the passive dosimetry based assessment presented in this section.

3.1.1 Handler Exposure Scenarios

Scenarios are again used, as with the occupational handler risk assessment above, to define risks based on the *U.S. EPA Guidelines For Exposure Assessment* (U.S. EPA; Federal Register Volume 57, Number 104; May 29, 1992). The purpose of this section is to describe how the exposure scenarios were defined. Much of the process for residential uses is identical to that considered for the occupational assessment with a few notable exceptions that include:

- Residential handler exposure scenarios are only considered to be short-term in nature due to the episodic uses associated with homeowner products, as a result, no intermediate-term or chronic assessments were completed for handlers;

- A tiered approach for personal protection using increasing levels of PPE is not used in residential handler risk assessments, rather than using PPE, homeowner handler assessments are completed based on individuals using shorts and short-sleeved shirts;

- Homeowner handlers are expected to complete all tasks associated with the use of a pesticide product including mixing/loading if needed as well as the application;

- Label use rates and use information specific to residential products serve as the basis for the risk calculations as opposed to the rates used in the occupational assessment; and

- Area/volumes of spray or chemical used in the risk assessment are based on Agency guidance specific to residential use patterns.

It has been determined that exposure to pesticide handlers is likely during the residential use of carbaryl in a variety of environments including on lawns, gardens and ornamentals, and pets. The anticipated use patterns and current labeling indicate 17 major residential exposure scenarios based on the types of equipment and techniques that can potentially be used to make carbaryl applications. The quantitative exposure/risk assessment developed for residential handlers is based on these scenarios. [Note: The scenario numbers correspond to the tables of risk calculations included in the occupational risk calculation aspects of the appendices.]

(1) Garden Uses: Ready-to-use Trigger Sprayer;
(2) Garden Uses: Ornamental Duster;
(3) Garden Uses: Hose-end Sprayer;
(4) Garden Uses: Low Pressure Handwand;
(5) Tree/ornamental Uses: Low Pressure Handwand;
(6) Tree/ornamental Uses: Hose-end Sprayer;
(7) Garden Uses: Backpack Sprayer;
(8) Lawncare Liquid Uses: Hose-end Sprayer;
(9) Pet (Dog and Cat) Uses: Dusting;
(10) Pet (Dog and Cat) Uses: Liquid Application;
(11) Lawncare Granular and Bait Uses: Belly Grinder;
(12) Lawncare Granular and Bait Uses: Push-type Spreader;
(13) Ornamental and Garden Uses: Granulars and Baits By Hand;
(14) Various Pest Uses: Aerosol Cans;
(15) Pet (Dog and Cat) Uses: Collars;
(16) Garden and Ornamental Uses: Sprinkler Can; and
(17) Garden and Ornamental Uses: Paint-on.

3.1.2 Data and Assumptions For Handler Exposure Scenarios

A series of assumptions and exposure factors served as the basis for completing the residential handler risk assessments. Each assumption and factor is detailed below. In addition to these factors, unit exposure values were used to calculate risk estimates. Mostly, these unit exposure values were taken from the Pesticide Handlers Exposure Database (PHED). In other cases, chemical-specific exposure data were submitted to support the reregistration of carbaryl. Both PHED and the individual studies are presented below. [Note: Several of the assumptions and factors used for the assessment are similar to those used in the occupational assessment presented above. As such, only factors that are unique to the residential scenarios are presented below.]

Assumptions and Factors: The assumptions and factors used in the risk calculations include:

- Carbaryl is one of the most widely used pesticide chemicals. It has an extraordinary number of use patterns that are impossible to completely capture in this document. As such, the Agency has patterned this risk assessment on a series of likely representative scenarios that are believed to represent the vast majority of carbaryl uses. Refinements to the assessment will be made as more detailed information about carbaryl use patterns become available.

- Exposure factors used to calculate daily exposures to handlers were based on applicable data if available. For lack of appropriate data, values from a scenario deemed similar enough by the assessor might be used. As an example, mixer/loader/applicator data for hose-end sprayers were used to assess sprinkler can applications. The nature of these application methods are believed to be similar enough to bridge the data. There were other instances where the Agency bridged specific data to represent other scenarios. See Appendix G/Table 1 for more details.

- The exposure duration (i.e., years per lifetime) values used by the Agency in the cancer risk assessment were consistent with those used for other chemicals (i.e., 50 years with home-use chemicals and 70 year lifetime).

- The Agency always considers the maximum application rates allowed by labels in its risk assessments to consider what is legally possible based on the label. If additional information such as average or typical rates are available, these values are also used to allow risk managers to make a more informed risk management decision. Average application rates were available from the SMART meeting and BEAD's QUA. These data indicated that in most cases, average application rates differed from maximum application rates on average by a factor of two. In some other cases, the average application rates identified from the studies conducted by Bayer were also used to define "average study use rate values" which were included in the calculations to provide for a more informed risk management decision.

- Residential risk assessments were not based on what could be applied in a typical workday like with the occupational risk assessments presented above. Instead, the Agency based calculations on what would reasonably be treated by homeowners such as the size of a lawn, or the size of a garden. This information was used by the Agency to define chemical throughput values for handlers which in turn were coupled with unit exposure values to calculate risks. The factors used for the carbaryl assessment were those dictated in the Health Effects Division Science Advisory Committee *Policy 12: Recommended Revisions To The Standard Operating Procedures For Residential Exposure Assessment* which was completed on February 22, 2001. [Note: Information presented at SMART meeting did not include event-specific information that would cause the Agency to use different values than those presented below.] The following daily volumes handled and area treated, excerpted from the policy and used in each residential scenario, include:

  - 1 container of each ready-to-use non-pet product including garden dusts, trigger sprayers and aerosol cans (scenarios for 25 and 50 % used of the total product volume were also presented for the trigger sprayer and garden dust scenarios to allow for a more informed risk management decision);
  - ½ container of each ready-to-use pet products including dusts and liquid shampoos;
  - 1 pet collar;
  - 100 gallons of finished spray output for hose-end sprayers;
  - 5 gallons when mixing/loading/applying liquids with a backpack sprayer or a low pressure handwand sprayer, value was also used for sprinkler can applications;
  - 1 gallon of paint-on solution for ornamental/garden uses;
  - 20,000 square feet is used to represent the surface area treated for broadcast applications to lawns;
  - 1000 square feet is used as the treatment area for many spot applications in lawns, gardens, and ornamentals (this value used as appropriate when application rates were based on a square foot basis for spot-type treatments); and
  - 5 mounds per day treated for fire ant applications.

- At the September 24, 1998 SMART Meeting with the Agency, the Bayer Corporation supplied data focused on the use patterns for carbaryl. The information presented at that meeting supports the inputs used by the Agency in this risk assessment. Several key factors have been summarized below for residential users of carbaryl:

  - Carbaryl accounted for approximately 9 percent of the residential insecticide market and was ranked 4th on the list behind the pyrethroids, chlorpyrifos, and diazinon [Note: This may be different in 2001 because of registration changes for other chemicals];
  - The maximum turf application rate noted was 8 lb ai/acre by lawns/landscape services on residential turf;
  - Insect control on vegetables (~58% of users), annuals (~50% of users), lawns (~35% of users), trees/shrubs (~34% of users) account for the majority of uses for carbaryl;
  - Pet uses account for ~13 percent of users;
  - The annual frequency for use was reported to be 1 (34th %tile) to 2 times per year

  (60th %tile) and 5 times per year (84th %tile);
  - Aphids, ants, fire ants, fleas, and slugs/snails are the most predominantly controlled pests by residential carbaryl users (~30% down to 15% of uses, respectively);
  - Most (75%) of vegetable gardens treated with carbaryl are <800 ft^2 but ~8 percent are between 800 and 1500 ft^2, ~9 percent are between 1500 and 5000 ft^2, and ~6 percent are greater than 5000 ft^2;
  - Tomatoes, peppers, cucumbers, beans, and fruit trees represent the most treated garden plants;
  - Most (82%) of flower gardens treated with carbaryl are <500 ft^2 but ~10 percent are between 500 and 1200 ft^2, and ~8 percent are greater than 1200 ft^2;
  - Roses, shrubs, and certain annuals represent the most treated flowering/ornamental plants; and
  - Dusts (65%) and liquid concentrate (25%) account for most carbaryl sales in the residential annual market of ~2.2M pounds active ingredient per year.

- The Bayer Corporation provided data for frequency of annual use among residential applicators that had been used to calculate cancer risks for adults in the general population. These data show that the 60th percentile is between 1 and 2 uses per year so all cancer risks have been calculated based on a single use event per year. Risk managers should consider this element in their interpretation of the overall results. For example, there might be a smaller population of more frequent users (e.g., 84th %tile = 5 times per year) that maintain high frequencies of use over their lifetimes which is critical for consideration in cancer risk assessment. Longitudinal data, however, were not available to establish that such populations definitively exist. Additionally, the Agency calculated the number of days exposure per year that would be required to exceed a risk level of 1.0×10^{-6} to illustrate an exposure limit in order to allow for a more informed risk management decision.

- For pet collar uses, Agency policy outlined in the Residential SOPs, was used to define the exposure level associated with putting the collar on an animal. The SOPs specify 1 percent of the total active ingredient in the collar is considered equal to the exposure.

- For turf, the maximum application rate that was indicated at the SMART meeting was 8 lb ai/acre even though current labels allow for applications by homeowners at up to 11 lb ai/acre for Lock-n-load type packages and 9 lb ai/acre for granulars.

- Bayer Corporation submitted information from the Residential Exposure Joint Venture (a group convened under the auspices of CSPA-Chemical Specialty Manufacturers Association) survey of residential pesticide users. The results of this survey do not appear at this time to contradict the use information that was considered in the current assessment (i.e., see review of submission described in Section 3.3 below, Author: Steve Nako, D284657, Date: 2/5/03). [Note: The review of the REJV data are presented in Section 3.3 below because they are critical to the overall interpretation of the biomonitoring study but appear to have little impact on the passive-dosimetry based risk assessment for handlers as the information does not contradict that used in this assessment.]

Residential Handler Exposure Studies: The unit exposure values that were used in this assessment were based on three carbaryl-specific residential handler studies which quantified exposures during pet treatments with a dust; applications to gardens using a ready-to-use trigger sprayer, a dust, a hose-end sprayer, and a low-pressure handwand; and during applications to trees using a low-pressure handwand and a hose-end sprayer. Two other studies completed by the Outdoor Residential Exposure Task Force and the Pesticide Handler Exposure Database (PHED, Version 1.1 August 1998) were also used as sources of surrogate information. For pet collars only, a scenario from the *SOPs For Residential Exposure Assessment* not based on monitoring data was used to calculate exposures. [Note: There has also been a suburban resident biological monitoring study which was submitted by Bayer that is presented in *Section 3.3: Carbaryl Suburban Resident Biomonitoring Study, Associated Data & Risks* where the results and risks based on this study are presented. Please refer to that section for further details. This assessment is based on a deterministic approach which should also be considered in context with the companion probabilistic assessments that have been (or will be) submitted/generated by Bayer Crop Sciences and the Chemistry and Exposure Branch of the Health Effects Division of OPP (see Section 3.4 below for further information).] A citation for each study as well as a brief summary is provided below. [Note: PHED is described above in Section 2.1.2, refer to that section for further information.]

- **Carbaryl Applicator Exposure Study During Application of Sevin® 5 Dust to Dogs By the Non-Professional.** Agrisearch Study No. 1517. EPA MRID 444399-01. Report date August 22, 1997; Authors: D. Larry Merricks, Ph.D., Sponsor: Rhone Poulenc Ag Company.

- **Carbaryl Mixer/Loader/Applicator Exposure Study during Application of RP-2 Liquid (21%) Sevin® Ready to Use Insect Spray or Sevin® 10 Dust to Home Garden Vegetables.** Agrisearch Study No. 1519. EPA MRID 444598-01. Report dated August 22, 1998, Author; Thomas C. Mester, Ph.D., Sponsor: Rhone Poulenc Ag Company.

- **Carbaryl Mixer/Loader/Applicator Exposure Study during Application of RP-2 Liquid (21%) to Fruit Trees and Ornamental Plants.** Agrisearch Study No. 1518. MRID 445185-01. Report dated January 23, 1998. Author D. Larry Merricks, Ph.D., Sponsor: Rhone Poulenc Ag Company.

- "**Integrated Report For Evaluation of Potential Exposures To Homeowners and Professional Lawncare Operators Mixing, Loading, and Applying Granular And Liquid Pesticides To Residential Lawns** " EPA MRID 449722-01; October 10, 1999; Author: Dennis R. Klonne, Ph.D.; Sponsor: Outdoor Residential Exposure Task Force; EPA Review by Gary Bangs (April 30, 2001).

[**Note to Chemical Review Manager:** Appendix F contains the data excerpted from each of the carbaryl-specific studies which were recently completed by the Bayer Corporation. Some of the handler exposure data used in this assessment are from the Outdoor Residential Exposure Task Force (ORETF). There is no data compensation issue associated with the use of the ORETF data in the carbaryl risk assessment because the Bayer Corporation, the registrant for carbaryl, is a member of the ORETF. The task force recently submitted proprietary data to the Agency on hose-end sprayers and push-type granular spreaders for residential handlers (MRID # 44972201). The ORETF data were used in this assessment in place of PHED data. The ORETF data were designed to replace the present PHED data with higher-confidence, higher quality data that contains more replicates than the PHED data for those scenarios. Finally, the Agency identified several occupational exposure studies from the literature by investigators such as Kurtz and Bode. These data have not been used by the Agency quantitatively in this assessment because of several issues but were qualitatively considered and also used to confirm the currently used exposure data.]

MRID 44439901 (Carbaryl homeowner dog dusting study): The objective of the study was to measure homeowner dermal and respiratory exposure to carbaryl while dusting 3 dogs for fleas using Sevin® 5 Dust. The dogs were from a local facility and varied in size and fur length. The product was supplied to the handlers in 1 lb. Ortho Sevin® 5 Dust canisters. The handlers opened the can, shook the product onto the dogs coat and rubbed the dust into the fur. The first replicate consisted of each applicator applying dust to 3 dogs of varying size with chemical resistant gloves. The first set of monitoring devices, handwashes and face/neck wipes and air monitors were taken and replaced with a clean set of dosimeters on the same person for the second set of replicates. The second replicate was the same handler applying Ortho®Sevin® 5 Dust without gloves on 3 dogs. A total of 40 replicates were collected, 20 replicates with gloves and 20 replicates without gloves.

Each replicate wore inner and outer dosimeters to simulate skin and clothing respectively. The inner dosimeter layer consisted of 100 percent cotton long leg and long sleeved underwear worn beneath the outer dosimeter of long leg and long sleeved 100 percent cotton work clothes. Each dosimeter was cut into six separate dermal body part samples (i.e., lower and upper arms, lower and upper legs, front and back torso) for a total of 480 dermal samples for handlers with gloves and without gloves. The cloth dosimeter parts (inner and outer), handwashes, face/neck wipes and air monitoring devices frozen, sent to a laboratory and analyzed for carbaryl. The amount of product used to dust 3 dogs averaged 65.3 grams or 3.51 grams ai. On average to dust 3 dogs required 7 minutes.

Field fortification recoveries for passive dosimeters averaged >90 percent for inner and outer dosimeters. Face and neck wipe fortifications average 87.6 percent. Inhalation OVS tube field fortification averaged 100 percent, however one sample of 30 was damaged in shipping and one day does not have field fortification data. Dosimeter field fortification results that were >90 percent were not adjusted, therefore only the face and neck wipe were adjusted for field recovery. Laboratory method validation for each matrix fell within the acceptable range of 70 to 120 percent. Storage stability tests were done and acceptable.

Unit exposure values were calculated using the data from the study and a commercial spreadsheet program. The study reported the total exposure to carbaryl as only the inner dosimeter. Since this is a residential product, inner dosimeter upper arm and upper legs, front and back torso were combined with the outer dosimeter lower arms and lower legs to account for the handler wearing, a short-sleeved shirt, short pants and no gloves. The exposures that were calculated were normalized by the amount of chemical used and by the body weight of the dogs treated by the individual applicators. For each calculation, the arithmetic mean, geometric mean, and median of the data are presented in Table 20 below. No analyses were completed with these data to ascertain the exact type of distribution. The Agency typically uses the best fit values from the Pesticide Handlers Exposure Database which are representations of the central tendency. Considering the standard practice, the Agency will use the geometric mean for risk assessment purposes. The other values are presented for comparative purposes.

Table 20: Unit Exposure Values Obtained From Carbaryl Homeowner Dog Dusting Study (MRID 444399-01)

Type	(mg exp./lb ai handled)		(mg exp./lb treated dog)	
	Dermal	Inhalation	Dermal	Inhalation
Applications with a dust to dogs				
Arith. Mean	3800	33	0.0080	5.0×10^{-12}
Geo. Mean	3300	25	0.0052	3.8×10^{-12}
Median	3300	27	0.0057	3.9×10^{-12}

MRID 44459801 (Carbaryl application to vegetables study): The data collected reflect the dermal and respiratory exposure of homeowners mixing, loading and applying RP-2 Liquid (21%), a carbaryl end-use product. Applications were made by volunteers to two 18 foot rows of tomatoes and one 18 foot row of cucumber. The only test field was located in Florida. For this study, RP-2 Liquid (21%) exposures were monitored using hose-end sprayers and low-pressure handwand sprayers. Exposures to Sevin® 10 Dust, using a separate duster device that required transfer from the package and Sevin® Ready To Use Insect Spray (RTU) in a trigger sprayer package were also monitored. Exposure for each spray method/product combination was monitored using 40 handlers (replicates). Of the 40 replicates per spray method/product combination, 20 wore household latex gloves and 20 performed tasks without gloves. The 20 dust product replicates loaded the dusters and applied without gloves only.

Each replicate opened the end-use product, added it to the application implement (except the RTU product), adjusted the setting and applied it to the vegetable rows. After application to the vegetable rows, dosimeters were collected. Inhalation exposure was monitored with personal air sampling pumps with OVS tubes attached to the shirt collar in the breathing zone. Dermal exposure was assessed by extraction of carbaryl from inner and outer 100 percent cotton dosimeters, face/neck wipes, and glove and hand washes. The inner and outer dosimeters were segmented into: lower and upper arms, lower and upper legs, front and back torso.

Field fortification recoveries for passive dosimeters averaged 84.3 percent for inner and 77.7 percent for outer dosimeters. Face and neck wipe fortifications average 84.8 percent. Handwash and Inhalation OVS tube field fortification averaged >90 percent. Inner and outer dosimeter and face and neck wipe residues were adjusted for field fortification results. Handwash and inhalation residues were not adjusted.

Laboratory method validation for each matrix fell within the acceptable range of 70 to 120 percent. The limit of quantitation (LOQ) was 1.0 µg/sample for all media except the inhalation monitors where the LOQ was 0.01 µg/sample. The limit of detection (LOD) was 0.5 µg/sample for all media except the inhalation monitors where the LOQ was 0.005 µg/sample.

Dermal exposure was determined by adding the values from the bare hand rinses, face/neck wipes to the outer dosimeter lower legs and lower arms plus the inner dosimeter front and rear torso, upper legs, lower legs, lower arms, and upper arms. This accounts for the residential handlers with barehands wearing short-sleeved shirt and short pants. Unit exposures for this scenario in each application method are presented below in Table 21. [Note: The geometric mean values were used for risk assessment purposes.]

Table 21: Unit Exposure Values Obtained From Carbaryl Homeowner Vegetable Treatment Study (MRID 444598-01)

Scenario Monitored	Dermal Unit Exposure (mg ai/lb handled)		Inhalation Unit Exposure (µg ai /lb handled)	
	Geometric Mean	Median	Geometric Mean	Median
Hand Held Pump-Spray	38	35	9	11
Hose-End Sprayer	34	31	2	2.3
Ready-to-Use Spray	54	53	67	34
Duster	148	140	870	1200

MRID 44518501 (Carbaryl application to trees and shrubs study): Applications of Sevin Liquid® Carbaryl insecticide [RP-2 liquid (21%)] were made by volunteers to two young citrus trees and two shrubs in each replicate that was monitored in the study. The test field was located only in Florida. Twenty (20) replicates were monitored using hose-end sprayer (Ortho® DIAL or Spray® hose end sprayer), and 20 replicates were monitored using hand held pump sprayers (low pressure handwands).

Each replicate opened the end-use product, added it to the hose-end sprayer or hand held pump and then applied it to the trees and shrubs. After application to two trees and two shrubs dosimeters were collected. Inhalation exposure was monitored with personal air sampling pumps with OVS tubes attached to the shirt collar in the breathing zone. Dermal exposure was assessed by extraction of carbaryl from inner and outer 100 percent cotton dosimeters. The inner and outer dosimeters were segmented into: lower and upper arms, lower and upper legs, front and back torso. No gloves were worn therefore hand exposure was assessed with 400 ml handwash with 0.01 percent Aerosol OT-75 sodium dioctyl sulfosuccinate (OTS). One hundred (100) percent cotton handkerchiefs wetted with 25 ml OTS were used to wipe face and neck to determine exposure.

Field fortification recoveries for passive dosimeters averaged 88.3 percent for inner and 76.2 percent for outer dosimeters. Face and neck wipe fortifications average 82.5 percent. Handwash and inhalation OVS tube field fortification averaged >90 percent. Inner and outer dosimeter and face and neck wipe residues were adjusted for field fortification results. Handwash and inhalation residues were not adjusted.

Laboratory method validation for each matrix fell within the acceptable range of 70 to 120 percent.   The limit of quantitation (LOQ) was 1.0 µg/sample for all media except the inhalation monitors where the LOQ was 0.01 µg/sample. The limit of detection (LOD) was 0.5 µg/sample for all media except the inhalation monitors where the LOQ was 0.005 µg/sample.

For use in reregistration documents, the dermal exposure was calculated by adding the values from the hand rinses, face/neck wipes to the outer dosimeter lower legs and lower arms plus the inner dosimeter front and rear torso, upper legs, lower legs, lower arms, and upper arms. This accounts for the residential handlers with barehands wearing short-sleeved shirt and short pants. The results are summarized in Table 22 below. [Note: The geometric mean values were used for risk assessment purposes.]

Table 22: Unit Exposure Values Obtained From Carbaryl Homeowner Ornamental Treatment Study (MRID 44518501)

Scenario Monitored	Hose End			Pump Sprayer		
	Applied (lb ai)	Dermal Exposure (mg ai/lb handled)	Inhalation (ug ai/lb handled)	Applied (lb ai)	Dermal Exposure (mg ai/lb handled)	Inhalation (ug ai/lb handled)
Geo. Mean	0.033	39	2.5	0.017	56	6.5
Median	0.026	44	3.6	0.018	49	4.3

EPA MRID 449722-01 (ORETF Handler Studies): A report was submitted by the ORETF (Outdoor Residential Exposure Task Force) that presented data in which the application of various products used on turf by homeowners and lawncare operators (LCOs) was monitored. All of the data submitted in this report were completed in a series of studies. The two studies that monitored homeowner exposure scenarios used a granular spreader (ORETF Study OMA003) and a hose-end sprayer (ORETF Study OMA004) are summarized below.

OMA003: A total of 30 volunteer test subjects were monitored using passive dosimetry (inner and outer whole body dosimeters, hand washes, face/neck wipes, and personal inhalation monitors). Each test subject carried, loaded, and applied two 25-lb bags of fertilizer (0.89% active ingredient) with a rotary type spreader to a lawn (a turf farm in North Carolina) covering 10,000 ft^2 (one bag to each of the two 5000 ft^2 test plots). Application to each subplot continued until the hopper was empty. Each participant also disposed of the empty bags at the end of the replicate. The target application rate was 2 lb ai/acre (actual rate achieved was about 1.9 lb ai/acre). The average application time was 22 minutes, including loading the rotary push spreader and disposing of the empty bags. Approximately 0.45 lb ai was handled in each replicate. Dermal exposure was measured using inner and outer whole body dosimeters, hand washes, face/neck washes, and personal air monitoring devices with OVS tubes. Overall, residues were highest on the upper and lower leg portions of the dosimeters. Inhalation exposure was calculated using an assumed respiratory rate of 17 Lpm for light work (NAFTA,1999), the actual sampling time for each individual, and the pump flow rate. All results were normalized for lb a.i. handled.

All fortified samples and field samples collected on the same study day were stored frozen and analyzed together, eliminating the need for storage stability determination. Seventy-seven percent (77%) of the face and neck washes were below the level of quantitation (LOQ) for dacthal, and ten percent (10%) of the air samples were also at or below the LOQ. Where results were less than the reported LOQ, ½ LOQ value was used for calculations, and no recovery corrections were applied. Lab spike recoveries for all matrices were in the range of 83-99 percent. Mean field fortification recoveries over the four study days for each fortification level ranged from 83 to 97 percent.

OMA004: Dermal and inhalation exposures were estimated using passive dosimetry techniques (biological monitoring data were not collected). A total of 60 replicates were monitored using 30 test subjects (two replicates each) during applications to residential lawns in Frederick, Maryland. Thirty applicator replicates were monitored using a ready-to-use (RTU) product (Bug-B-Gon) packaged in a 32 fl. oz. screw-on container. These containers were attached to garden hose-ends. An additional 30 mixer/loader/applicator replicates were monitored using Diazinon Plus also packaged in 32 fl. oz. plastic bottles. This product required the test subjects to pour the product into dial-type sprayers (DTS) that were attached to garden hose-ends.

A nominal application rate of 4 lb ai/acre was used for all replicates. Each replicate monitored the test subject treating 5,000 ft^2 of turf and handling a total of 0.5 lb ai/replicate. The average time per replicate was 75 minutes. Dermal and inhalation exposure were measured using inner and outer whole body dosimeters (long pants and long sleeved shirt over long underwear), hand washes, face/neck washes, and personal air monitoring devices. Lab-fortified dosimeters had recoveries of 87-103 percent; field-fortified dosimeters had a mean range of 79-104 percent recovery, with very little variance. The study results are corrected for field recoveries using the correction factor for the level of fortification closest to the field result.

The route-specific exposure data (dermal and inhalation) from both studies were lognormally distributed. Therefore, the geometric mean of the dermal and inhalation data should be used for exposure assessments. The exposures account for residential handlers with barehands wearing short-sleeved shirt and short pants. The unit exposure values are presented in Table 23 below.

Table 23: Unit Exposure Values Obtained From ORETF Homeowner Studies (MRID 449722-01)

Scenario	(mg exp./lb ai handled)	
	Dermal	Inhalation
Homeowner Push Granular Spreader	0.68	0.00091
Homeowner Hose-End - Open Mix	11.0	0.016
Homeowner Hose-End - Ready-to-Use	2.6	0.011

All unit exposure values are geometric means. Exposure values represent individuals wearing shorts and short-sleeved shirts. Hose-end sprayer data for mix your own (not the Ready-to-use/no contact package) was used for risk assessment purposes, the values for ready-to-use packaging are presented for comparative purposes (i.e., 76 % dermal exposure reduction).

3.1.3 Residential Handler Exposure and Non-Cancer Risk Estimates

The residential handler exposure and non-cancer risk calculations are presented in this section. Noncancer risks were calculated using the Margin of Exposure (MOE) as described in Section 2.1.3. Much of the process for residential uses is identical to that considered for the occupational assessment with a few notable exceptions as described above in Section 3.1.1 (e.g., all are short-term exposures and people wear shorts and short-sleeved shirts with no gloves and use packaging that requires open mixing). The other major difference with residential risk assessments is that the uncertainty factor which defines the level of risk concern also has the additional FQPA safety factor applied. In the case of carbaryl, in January and February 2002 meetings of the FQPA Safety Factor Committee, it was decided that the factor should be reduced to 1 based on the recently revised FQPA SFC standard operating procedures. Therefore, the overall uncertainty factor applied to carbaryl for residential handler risk assessments is 100 which is based on the FQPA safety factor of 1 along with the 100 applied for inter-species extrapolation, intra-species sensitivity, and the use of a NOAEL for risk assessment.

Noncancer Risk Summary: All of the noncancer risk calculations for occupational carbaryl handlers completed in this assessment are included in Appendix G (Tables 1 - 3). The specifics of each of table included in Appendix G are described below. A brief summary of the results for each exposure scenario is also provided below.

- **Appendix G/Table 1: Sources of Exposure Data Used In The Carbaryl Homeowner Handler Exposure and Risk Calculations** Describes the sources and quality of the exposure data used in all of the residential handler calculations.

- **Appendix G/Table 2: Input Parameters For Carbaryl Homeowner Handler Exposure and Risk Calculations** Presents the numerical unit exposure values and other factors used in the residential handler risk assessments.

- **Appendix G/Table 3: Carbaryl MOEs Attributable To Combined Homeowner Handler Dermal and Inhalation Exposures** Risk values are presented for each exposure scenario considered in the assessment. Exposures represent individuals wearing short-sleeved shirts and short pants.

The data submitted by the Bayer Corporation accompanied by the other data used by the Agency have provided a basic broad overview of the uses of carbaryl around a residential environment (i.e., the database is fairly complete). As indicated above, however, it is likely that carbaryl can be used in a myriad of ways that have not been identified in this assessment because of different pests or types of application equipment. The Agency will consider risks from these additional scenarios as data become available. It should also be noted that there were many other scenarios where medium to low PHED quality data were used to complete the assessment. Data quality should be considered in the interpretation of the uncertainties associated with each risk value presented. The results of the suburban resident biomonitoring study should also be considered in the context of this assessment (see *Section 3.3: Carbaryl Suburban Resident Biomonitoring Study, Associated Data & Risks*). This assessment is based on a deterministic approach which should also be considered in context with the companion probabilistic assessments that have been (or will be) submitted/generated by Bayer Crop Sciences and the Chemistry and Exposure Branch of the Health Effects Division of OPP (see Section 3.4 below for further information).

Short-term risks for residential handlers (intermediate-term scenarios are not thought to exist because of the sporadic nature of applications by homeowners) are presented in Table 24 (Appendix G/Table 3 summarized below for the convenience of the reader). For most scenarios (40 out of 52), risks are not of concern because MOEs exceed the required uncertainty factor of 100. As expected, the scenarios for which MOEs do not meet or exceed 100 have a relatively high unit exposure associated with them or the amount of chemical used over a day is relatively high (based on high application rates and/or high amounts of area treated). The use of dusts in gardens and for pet grooming along with some liquid sprays on ornamentals appear to be the most problematic scenarios. Unlike the occupational handler scenarios, the use of different levels of personal protective clothing and equipment is not considered for residential handlers because of a lack of availability, training, and maintenance. [Note: Scenarios where MOEs are still of concern (i.e., <100) for are highlighted in the table.]

TABLE 24 CARBARYL MOEs ATTRIBUTABLE TO COMBINED SHORT-TERM HOMEOWNER HANDLER DERMAL AND INHALATION EXPOSURES									
SCEN.	SCEN. DESCRIPTOR	CROP TYPE OR TARGET	EXPOSURE FACTORS				DERMAL MOEs	INHALATION MOEs	COMBINED MOEs
			APPL. RATE (lb ai/unit)	BASIS FOR RATE (defines unit treated)	TREATED UNITS	ACTIVE USED (lb ai/event)			
1	Garden: Ready-to-Use Trigger Sprayer (MRID 444598-01)	Vegetables/ Ornamentals	0.003	32 oz bottle 0.126 % (769-977)	0.25	0.00075	34567.9	1393034.8	33730.9
		Vegetables/ Ornamentals	0.003	32 oz bottle 0.126 % (769-977)	0.5	0.0015	17284.0	696517.4	16865.4
		Vegetables/ Ornamentals	0.003	32 oz bottle 0.126 % (769-977)	1	0.003	8642.0	348258.7	8432.7
		Average Study Use Rate	0.012	(lb ai/1000 ft2)	1	0.012	2160.5	87064.7	2108.2
2	Garden/Ornamental Dust (MRID 444598-01)	Vegetables/ Ornamentals	0.4	4 lb bottle 10% (239-1513)	0.25	0.1	**94.6**	804.6	**84.6**
		Vegetables/ Ornamentals	0.4	4 lb bottle 10% (239-1513)	0.5	0.2	**47.3**	402.3	**42.3**
		Vegetables/ Ornamentals	0.4	4 lb bottle 10% (239-1513)	1	0.4	**23.6**	201.1	**21.2**
		Average Study Use Rate	0.079	(lb ai/1000 ft2)	1	0.079	119.7	1018.5	107.1
3	Garden: Hose-End (MRID 444598-01)	General Use (2% soln)	0.02	(lb ai/gal spray applied)	100	2	**20.6**	17500.0	**20.6**
		Perimeter Nuisance Pest	0.19	(lb ai/1000 ft2)	1	0.19	216.7	184210.5	216.5
		Vegetables	0.012	(lb ai/1000 ft2)	1	0.012	3431.4	2916666.7	3427.3
		Vegetables/ Ornamentals	0.023	(lb ai/1000 ft2)	1	0.023	1790.3	1521739.1	1788.2
		Vegetables	0.047	(lb ai/1000 ft2)	1	0.047	876.1	744680.9	875.1
		Average Study Use Rate	0.26	(lb ai/1000 ft2)	1	0.26	158.4	134615.4	158.2
		Fire Ant	0.0075	(lb ai/gal spray)	100	0.75	**54.9**	46666.7	**54.8**
4	Garden: Low Pressure Handwand (MRID 444598-01)	General Use (2% soln)	0.02	(lb ai/gal spray applied)	5	0.1	368.4	77777.8	366.7
		Perimeter Nuisance Pest	0.19	(lb ai/1000 ft2)	1	0.19	193.9	40935.7	193.0
		Vegetables	0.012	(lb ai/1000 ft2)	1	0.012	3070.2	648148.1	3055.7
		Vegetables/ Ornamentals	0.023	(lb ai/1000 ft2)	1	0.023	1601.8	338164.3	1594.3
		Vegetables	0.047	(lb ai/1000 ft2)	1	0.047	783.9	165484.6	780.2
		Average Study Use Rate	0.083	(lb ai/1000 ft2)	1	0.083	443.9	93708.2	441.8
		Fire Ant	0.0075	(lb ai/gal spray)	5	0.0375	982.5	207407.4	977.8

TABLE 24 CARBARYL MOEs ATTRIBUTABLE TO COMBINED SHORT-TERM HOMEOWNER HANDLER DERMAL AND INHALATION EXPOSURES

SCEN.	SCEN. DESCRIPTOR	CROP TYPE OR TARGET	EXPOSURE FACTORS				DERMAL MOEs	INHALATION MOEs	COMBINED MOEs
			APPL. RATE (lb ai/unit)	BASIS FOR RATE (defines unit treated)	TREATED UNITS	ACTIVE USED (lb ai/event)			
5	Trees/Ornamentals: Low Pressure Handwand (MRID 445185-01)	Ornamental	0.023	(lb ai/1000 ft2)	1	0.176	1087.0	468227.4	1084.4
		Pome Fruit	0.07	(lb ai/1000 ft2)	1	0.07	357.1	153846.2	356.3
		Nuts/Stone Fruit	0.12	(lb ai/1000 ft2)	1	0.12	208.3	89743.6	207.9
		Citrus	0.176	(lb ai/1000 ft2)	1	0.023	142.0	61188.8	141.7
		Average Study Use Rate	0.0047	(lb ai/gal, 17g ai/4 min at 2GPM)	5	0.024	1063.8	458265.1	1061.4
6	Trees/Ornamentals: Hose End Sprayer (MRID 445185-01)	Ornamental	0.023	(lb ai/1000 ft2)	1	0.176	1560.8	1217391.3	1558.8
		Pome Fruit	0.07	(lb ai/1000 ft2)	1	0.07	512.8	400000.0	512.2
		Nuts/Stone Fruit	0.12	(lb ai/1000 ft2)	1	0.12	299.1	233333.3	298.8
		Citrus	0.176	(lb ai/1000 ft2)	1	0.023	204.0	159090.9	203.7
		Average Study Use Rate	0.005	(lb ai/gal spray)	100	0.5	**71.8**	56000.0	**71.7**
7	Garden: Backpack Sprayer (PHED)	General Use (2% soln)	0.02	(lb ai/gal spray applied)	5	0.1	2745.1	23333.3	2456.1
		Perimeter Nuisance Pest	0.19	(lb ai/1000 ft2)	1	0.19	1444.8	12280.7	1292.7
		Vegetables	0.012	(lb ai/1000 ft2)	1	0.012	22875.8	194444.4	20467.8
		Vegetables/ Ornamentals	0.023	(lb ai/1000 ft2)	1	0.023	11935.2	101449.3	10678.9
		Vegetables	0.047	(lb ai/1000 ft2)	1	0.047	5840.6	49645.4	5225.8
		Average Study Use Rate	0.083	(lb ai/1000 ft2)	1	0.083	3307.3	28112.5	2959.2
		Fire Ant	0.0075	(lb ai/gal spray)	5	0.0375	7320.3	62222.2	6549.7
8	Lawn Care: Hose End Sprayer (MRID 449722-01/ORETF OMA 004)	Lawn (broadcast)	0.25	(lb ai/1000 ft2)	20	5	**25.5**	875.0	**24.7**
		Lawn (spot)	0.25	(lb ai/1000 ft2)	1	0.25	509.1	17500.0	494.7
9	Dusting Dog (MRID 444399-01)	Average Study Use Rate	0.0026	(lb ai/dog)	1	0.0026	163.2	1076.9	141.7
		Dog (10% & ½ of 2 lb)	0.1	(lb ai/dog)	1	0.1	**4.2**	28.0	**3.7**
		Dog (5% & ½ of 2 lb)	0.05	(lb ai/dog)	1	0.05	**8.5**	56.0	**7.4**
10	Dogs: Liquid Application	Dog (0.5% & ½ of 6 oz)	0.001	(lb ai/dog)	1	0.001	14000000.0	No Data	No Data
11	Granular & Baits Lawn Care: Belly Grinder	Lawn (spot)	0.21	(lb ai/1000 ft2)	1	0.21	**60.6**	5376.3	**59.9**
		Lawn (spot)	0.1	(lb ai/1000 ft2)	1	0.1	127.3	11290.3	125.9
12	Granular & Baits Lawn Care: Push-Type Spreader (MRID 449722-01/ORETF OMA 003)	Lawn (broadcast)	0.21	(lb ai/1000 ft2)	20	4.2	490.2	18315.0	477.4
		Lawn (broadcast)	0.1	(lb ai/1000 ft2)	20	2	1029.4	38461.5	1002.6
13	Granulars & Baits By Hand	Ornamentals and Gardens	0.21	(lb ai/1000 ft2)	1	0.21	**15.5**	713.8	**15.2**
14	Aerosol	Various	0.005	(0.5 % ai in soln./1 pt can)	16	0.08	**79.5**	364.6	**65.3**
15	Collar	Dog	0.013	(16 % ai per 1.3 oz collar)	1	0.013	10769230.8	No Data	No Data
16	Sprinkler Can (Source: Scenario 6)	Ornamentals (2% Soln)	0.02	(2% soln used ad libitum)	5	0.1	359.0	280000.0	358.5

TABLE 24 CARBARYL MOEs ATTRIBUTABLE TO COMBINED SHORT-TERM HOMEOWNER HANDLER DERMAL AND INHALATION EXPOSURES									
SCEN.	SCEN. DESCRIPTOR	CROP TYPE OR TARGET	EXPOSURE FACTORS				DERMAL MOEs	INHALATION MOEs	COMBINED MOEs
			APPL. RATE (lb ai/unit)	BASIS FOR RATE (defines unit treated)	TREATED UNITS	ACTIVE USED (lb ai/event)			
17	Ornamental Paint On	Ornamentals (2% Soln)	0.02	(2% soln used ad libitum)	1	0.02	304.3	12323.9	297.0

3.1.4 Residential Handler Exposure and Risk Estimates for Cancer

The residential handler exposure and cancer risk calculations are presented in this section. Cancer risks were calculated using a linear, low-dose extrapolation approach (Q_1*) using the same formula as described above in Section 2.1.4. In addition to the cancer risk estimates for an annual frequency of 1 time per year, the number of days of exposure per year required to get a $1x10^{-6}$ cancer risk have been calculated. In this calculation, the $1x10^{-6}$ cancer risk limit was divided by the calculated cancer risk for each scenario for a single day of exposure. Much of the process for residential uses is identical to that considered for the occupational assessment with a few notable exceptions as described above in Section 3.1.1 (e.g., all are short-term exposures and people wear shorts and short-sleeved shirts). The other major difference with residential risk assessments is that the annual frequency of use is lower for homeowners (i.e., 1 day use per year has been used to complete the calculations).

Cancer Risk Summary All of the cancer risk calculations for residential carbaryl handlers completed in this assessment are included in Appendix G (Table 4). The specifics of this table as well as a brief summary of the results for each exposure scenario is also provided below.

- **Appendix G/Table 4: Carbaryl Cancer Risks Attributable To Combined Homeowner Handler Dermal and Inhalation Exposures** Presents cancer risks for combined dermal and inhalation exposures considered in the assessment (i.e., 1 time/year). Additionally, the number of days of exposure that are allowed per year (i.e., up to a $1x10^{-6}$ cancer risk limit) are also presented.

Table 25 presents the quantitative risks associated with each scenario considered in the assessment. For all but one scenario (i.e., treating dogs with ½ bottle of 10 percent dust), cancer risks are less than $1x10^{-6}$ (most are in the 10^{-8} or 10^{-10} range) when a single application per year is evaluated. This table also includes the allowable number of days exposure per year. There are 5 scenarios where 5 days or less of exposure per year is allowable. These results should be considered in conjunction with the use and usage information supplied by the Bayer Corporation that indicates the 60^{th} percentile annual frequency of use is between 1 and 2 uses per year and that 5 uses per year is at the 84th percentile (see *Section 3.1.2: Data and Assumptions For Handler Exposure Scenarios* above). As with the noncancer risks, the use of dusts in gardens and for pet grooming along with some liquid sprays on ornamentals appear to be the most problematic scenarios. [Note: Scenarios where risks are still of concern (i.e., <1x10^{-6}) for are highlighted in the table.]

TABLE 25: CARBARYL CANCER RISKS ATTRIBUTABLE TO COMBINED HOMEOWNER HANDLER DERMAL AND INHALATION EXPOSURES								
SCEN.	SCEN. DESCRIPTOR	CROP TYPE OR TARGET	EXPOSURE FACTORS				CANCER RISK	ALLOWED DAYS/YR
			APPL. RATE (lb ai/unit)	BASIS FOR RATE (defines unit treated)	TREATED UNITS	ACTIVE USED (lb ai/event)		
1	Garden: Ready-to-Use Trigger Sprayer (MRID 444598-01)	Vegetables/ Ornamentals	0.003	32 oz bottle 0.126 % (769-977)	0.25	0.00075	1.27e-10	>365
		Vegetables/ Ornamentals	0.003	32 oz bottle 0.126 % (769-977)	0.5	0.0015	2.54e-10	>365
		Vegetables/ Ornamentals	0.003	32 oz bottle 0.126 % (769-977)	1	0.003	5.08e-10	>365
		Average Study Use Rate	0.012	(lb ai/1000 ft2)	1	0.012	2.03e-09	>365
2	Garden/Ornamental Dust (MRID 444598-01)	Vegetables/ Ornamentals	0.4	4 lb bottle 10% (239-1513)	0.25	0.1	4.81e-08	21
		Vegetables/ Ornamentals	0.4	4 lb bottle 10% (239-1513)	0.5	0.2	9.62e-08	10
		Vegetables/ Ornamentals	0.4	4 lb bottle 10% (239-1513)	1	0.4	1.92e-07	5
		Average Study Use Rate	0.079	(lb ai/1000 ft2)	1	0.079	3.80e-08	26
3	Garden: Hose-End (MRID 444598-01)	General Use (2% soln)	0.02	(lb ai/gal spray applied)	100	2	2.11e-07	5
		Perimeter Nuisance Pest	0.19	(lb ai/1000 ft2)	1	0.19	2.01e-08	50
		Vegetables	0.012	(lb ai/1000 ft2)	1	0.012	1.27e-09	>365
		Vegetables/ Ornamentals	0.023	(lb ai/1000 ft2)	1	0.023	2.43e-09	>365
		Vegetables	0.047	(lb ai/1000 ft2)	1	0.047	4.97e-09	201
		Average Study Use Rate	0.26	(lb ai/1000 ft2)	1	0.26	2.75e-08	36
		Fire Ant	0.0075	(lb ai/gal spray)	100	0.75	7.93e-08	13
4	Garden: Low Pressure Handwand (MRID 444598-01)	General Use (2% soln)	0.02	(lb ai/gal spray applied)	5	0.1	1.18e-08	85
		Perimeter Nuisance Pest	0.19	(lb ai/1000 ft2)	1	0.19	2.25e-08	45
		Vegetables	0.012	(lb ai/1000 ft2)	1	0.012	1.42e-09	>365
		Vegetables/ Ornamentals	0.023	(lb ai/1000 ft2)	1	0.023	2.72e-09	>365
		Vegetables	0.047	(lb ai/1000 ft2)	1	0.047	5.56e-09	180
		Average Study Use Rate	0.083	(lb ai/1000 ft2)	1	0.083	9.82e-09	102
		Fire Ant	0.0075	(lb ai/gal spray)	5	0.0375	4.44e-09	225

TABLE 25: CARBARYL CANCER RISKS ATTRIBUTABLE TO COMBINED HOMEOWNER HANDLER DERMAL AND INHALATION EXPOSURES								
SCEN.	SCEN. DESCRIPTOR	CROP TYPE OR TARGET	EXPOSURE FACTORS				CANCER RISK	ALLOWED DAYS/YR
			APPL. RATE (lb ai/unit)	BASIS FOR RATE (defines unit treated)	TREATED UNITS	ACTIVE USED (lb ai/event)		
5	Trees/Ornamentals: Low Pressure Handwand (MRID 445185-01)	Ornamental	0.023	(lb ai/1000 ft2)	1	0.176	4.01e-09	250
		Pome Fruit	0.07	(lb ai/1000 ft2)	1	0.07	1.22e-08	82
		Nuts/Stone Fruit	0.12	(lb ai/1000 ft2)	1	0.12	2.09e-08	48
		Citrus	0.176	(lb ai/1000 ft2)	1	0.023	3.06e-08	33
		Average Study Use Rate	0.0047	(lb ai/gal, 17g ai/4 min at 2GPM)	5	0.47	4.09e-09	244
6	Trees/Ornamentals: Hose End Sprayer (MRID 445185-01)	Ornamental	0.023	(lb ai/1000 ft2)	1	0.176	2.79e-09	359
		Pome Fruit	0.07	(lb ai/1000 ft2)	1	0.07	8.49e-09	118
		Nuts/Stone Fruit	0.12	(lb ai/1000 ft2)	1	0.12	1.45e-08	69
		Citrus	0.176	(lb ai/1000 ft2)	1	0.023	2.13e-08	47
		Average Study Use Rate	0.005	(lb ai/gal spray)	100	0.025	6.06e-08	16
7	Garden: Backpack Sprayer (PHED)	General Use (2% soln)	0.02	(lb ai/gal spray applied)	5	0.1	1.66e-09	>365
		Perimeter Nuisance Pest	0.19	(lb ai/1000 ft2)	1	0.19	3.15e-09	317
		Vegetables	0.012	(lb ai/1000 ft2)	1	0.012	1.99e-10	>365
		Vegetables/ Ornamentals	0.023	(lb ai/1000 ft2)	1	0.023	3.81e-10	>365
		Vegetables	0.047	(lb ai/1000 ft2)	1	0.047	7.79e-10	>365
		Average Study Use Rate	0.083	(lb ai/1000 ft2)	1	0.083	1.38e-09	>365
		Fire Ant	0.0075	(lb ai/gal spray)	5	0.0375	6.22e-10	>365
8	Lawn Care: Hose End Sprayer (MRID 449722-01/ORETF OMA 004)	Lawn (broadcast)	0.25	(lb ai/1000 ft2)	20	5	1.73e-07	6
		Lawn (spot)	0.25	(lb ai/1000 ft2)	1	0.25	8.64e-09	116
9	Dusting Dog (MRID 444399-01)	Average Study Use Rate	0.0026	(lb ai/dog)	1	0.0026	2.82e-08	35
		Dog (10% & ½ of 2 lb)	0.1	(lb ai/dog)	1	0.1	**1.09e-06**	**1**
		Dog (5% & ½ of 2 lb)	0.05	(lb ai/dog)	1	0.05	5.43e-07	2
10	Dogs: Liquid Application	Dog (0.5% & ½ of 6 oz)	0.001	(lb ai/dog)	1	0.001	3.11e-13	>365
11	Granular & Baits Lawn Care: Belly Grinder	Lawn (spot)	0.21	(lb ai/1000 ft2)	1	0.21	7.21e-08	14
		Lawn (spot)	0.1	(lb ai/1000 ft2)	1	0.1	3.43e-08	29
12	Granular & Baits Lawn Care: Push-Type Spreader (MRID 449722-01/ORETF OMA 003)	Lawn (broadcast)	0.21	(lb ai/1000 ft2)	20	4.2	8.97e-09	112
		Lawn (broadcast)	0.1	(lb ai/1000 ft2)	20	2	4.27e-09	234
13	Granulars & Baits By Hand	Ornamentals and Gardens	0.21	(lb ai/1000 ft2)	1	0.21	2.83e-07	4
14	Aerosol	Various	0.005	(0.5 % ai in soln./1 pt can)	16	0.08	5.94e-08	17

TABLE 25: CARBARYL CANCER RISKS ATTRIBUTABLE TO COMBINED HOMEOWNER HANDLER DERMAL AND INHALATION EXPOSURES								
SCEN.	SCEN. DESCRIPTOR	CROP TYPE OR TARGET	EXPOSURE FACTORS				CANCER RISK	ALLOWED DAYS/YR
			APPL. RATE (lb ai/unit)	BASIS FOR RATE (defines unit treated)	TREATED UNITS	ACTIVE USED (lb ai/event)		
15	Collar	Dog	0.013	(16 % ai per 1.3 oz collar)	1	0.013	4.04e-13	>365
16	Sprinkler Can (Source: Scenario 6)	Ornamentals (2% Soln)	0.02	(2% soln used ad libitum)	5	0.1	1.21e-08	82
17	Ornamental Paint On	Ornamentals (2% Soln)	0.02	(2% soln used ad libitum)	1	0.02	1.44e-08	69

3.1.5 Summary of Risk Concerns and Data Gaps for Handlers

Generally, MOEs associated with most scenarios (40 of 52 considered) are not of concern because they exceed the Agency's uncertainty factors for noncancer risk assessments (i.e., 100 uncertainty factor). The scenarios of concern involve the use of dusts in gardens and on pets and some liquid sprays on gardens. Cancer risks for most scenarios are in the 10^{-8} to 10^{-10} range although there is one scenario where the risks slightly exceed $1x10^{-6}$ (dusting dogs $1.09x10^{-6}$). It should be noted that there are 5 scenarios where the allowable days per year of exposure is less than or equal to 5 which should be considered in conjunction with the use/usage data from Bayer that indicates 5 uses per year is the 84th percentile. The database for carbaryl is fairly complete compared to many other chemicals. Recent, high quality data generated by the Bayer Corporation and the ORETF, of which Bayer is a member, have been used to address the key residential uses of carbaryl on lawns, flower and vegetable gardens, and pets. Use and usage inputs also appear to be essentially consistent with the information provided by the Bayer Corporation at the 1998 SMART meeting. No key data gaps have been identified by the Agency at this time for residential handlers. However, it is likely that there are scenarios that remain unaddressed by the Agency at this time due to a lack of data or other meta information. The Agency will address other appropriate scenarios as they are identified. It should also be noted that information from the Residential Exposure Joint Venture survey of pesticide users does not contradict or supercede use of the information considered in this assessment.

In summary, the deterministic assessment for residential exposure presented in this section concludes that there are a significant number of risk concerns for carbaryl as it is currently used in a residential environment. However, as noted above, Bayer Crop Science has completed an a suburban resident biological monitoring study that should also be considered in context with these results as well as the probabilistic assessments which have been completed.

3.1.6 Recommendations For Refining Residential Handler Risk Assessment

In order to refine this residential risk assessment, more data on actual use patterns including rates, timing, and areas treated would better characterize carbaryl risks. Exposure studies for many equipment types that lack data or that are not well represented in PHED (e.g., because of low replicate numbers or data quality) should also be considered based on the data gaps identified above and based on a review of the quality of the data used in this assessment.

The Bayer Corporation has attempted to respond to many of the issues raised above by conducting the suburban resident biomonitoring study and providing supporting information on use patterns (e.g., REJV survey results) and pharmacokinetics. As such, the results of this assessment will be considered in context with the information presented in *Section 3.3: Carbaryl Suburban Resident Biomonitoring Study, Associated Data & Risks* where risks based on the suburban resident biological monitoring study have been presented. This assessment is based on a deterministic approach which should also be considered in context with the companion probabilistic assessments that have been (or will be) submitted/generated by Bayer Crop Sciences and the Chemistry and Exposure Branch of the Health Effects Division of OPP (see Section 3.4 below for further information). A large percentage of those monitored were residential carbaryl applicators which allows for direct comparison to the passive dosimetry based assessment presented in this section.

3.2 Residential Postapplication Exposures and Risks Calculated Using Passive Dosimetry

The Agency uses the term “postapplication” to describe exposures to individuals that occur as a result of being in an environment that has been previously treated with a pesticide. Carbaryl can be used in many areas that can be frequented by the general population including residential areas (e.g., home lawns and gardens), parks, athletic fields, and golf courses. As a result, individuals can be exposed by entering these areas if they have been previously treated. Carbaryl can also be used on companion animals which can lead to exposures by contact with the treated animal. Finally, carbaryl can also be used as a mosquito adulticide which can result in exposures to the general population because it involves wide area, ultra-low volume spraying in residential areas. The Agency generically refers to these exposures as “residential” in nature. Another definition could be any exposures that do not occur as a result of employment or exposures to the general population. The scenarios that serve as the basis for the risk assessment are presented in *Section 3.2.1: Residential Postapplication Exposure Scenarios*. The exposure data and assumptions that have been used for the calculations are presented in *Section 3.2.2: Data and Assumptions For Residential Postapplication Exposure Scenarios*. The calculations and the algorithms that have been used for the noncancer elements of the risk assessment as well as the calculated risk values are presented in *Section 3.2.3: Residential Postapplication Exposure and Noncancer Risk Estimates* while the analogous information using the Q_1* for cancer estimates are presented in *Section 3.2.4: Residential Postapplication Exposure and Risk Estimates For Cancer*. *Section 3.2.5: Summary of Residential Postapplication Risk Concerns and, Data Gaps* presents the overall risk picture for carbaryl. Finally, recommendations are presented in *Section 3.2.6: Recommendations For Refining Residential Postapplication Risk Assessment*. It should be noted that the results of this postapplication assessment should be considered in context with the information presented in

Section 3.3: Carbaryl Suburban Resident Biomonitoring Study, Associated Data & Risks where risks based on the suburban resident biological monitoring study have been presented. This assessment is based on a deterministic approach which should also be considered in context with the companion probabilistic assessments that have been (or will be) submitted/generated by Bayer Crop
Sciences and the Chemistry and Exposure Branch of the Health Effects Division of OPP (see Section 3.4 below for further information). A large percentage of those monitored were adults (not involved in the application) and children who lived in the treated residences which allows for direct comparison to the passive dosimetry based assessment presented in this section.

3.2.1 Residential Postapplication Exposure Scenarios

Carbaryl uses are extremely varied and include home gardens, ornamentals, turf (golf courses and lawns) and companion animals (e.g., on dogs and cats). Carbaryl also has more limited uses that were considered including as a mosquito adulticide in residential areas and for Ghost/Mud shrimp control in Washington. As a result, a wide array of individuals of varying ages can potentially be exposed when they do activities in areas that have been previously treated or have contact with treated companion animals. The Agency is concerned about these kinds of exposures. The purpose of this section is to explain how postapplication exposure scenarios were developed for each residential setting where carbaryl can be used. Exposure scenarios can be thought of as ways of categorizing the kinds of exposures that occur related to the use of a chemical. The use of scenarios as a basis for exposure assessment is very common as described in the *U.S. EPA Guidelines For Exposure Assessment* (U.S. EPA; Federal Register Volume 57, Number 104; May 29, 1992).

The processes that were used by the Agency in the development of scenarios for occupational exposure assessment (Section 2.2.1 above) are essentially the same as those used for residential exposure patterns. There are key differences, however, in the residential exposure assessment that include exposures were calculated for children of differing ages as well as adults; non-dietary ingestion exposures were calculated (i.e., soil ingestion, hand-/object-to-mouth); a dermal "hug" approach has been used instead of transfer coefficients to calculate exposures to companion animals; exposures to swimmers, oyster harvesters, and children playing on a beach were calculated; and cancer risks were not calculated for children per Agency policy.

The Agency relies on a standardized approach for completing residential risk assessments that is based on current carbaryl labels and guidance contained in the following five documents:

- ***Series 875, Residential and Residential Exposure Test Guidelines: Group B - Postapplication Exposure Monitoring Test Guidelines (V 5.4, Feb. 1998)*** This document provides general risk assessment guidance and criteria for analysis of residue dissipation data.

- ***Standard Operating Procedures For Residential Exposure Assessment (Dec. 1997)*** This document provides the overarching guidance for developing residential risk assessments including scenario development, algorithms, and values for inputs.

- ***Science Advisory Council For Exposure Policy 003.1 (Aug. 2000): Agricultural Transfer Coefficients*** This document provides transfer coefficients which have been used to assess exposures in home gardens.

- ***Science Advisory Council For Exposure Policy 12 (Feb. 2001): Recommended Revisions To The Standard Operating Procedures (SOPs) For Residential Exposure Assessment*** This document provides additional, revised guidance for completing residential exposure assessments.

- ***Overview of Issues Related To The Standard Operating Procedures For Residential Exposure Assessment (August 1999 Presentation To The FIFRA SAP)*** This document provides rationale for Agency changes in SOPs. Companion animal approach included in document used for risk assessment.

The Agency also completed a specific, screening level risk assessment for Mud and Ghost shrimp control in Washington State. The assessment considering swimming in areas that have been treated as well as oyster harvesting for adults and playing on a beach for toddlers. The calculations for these scenarios were based on the Agency's SOPs described above, the Agency's program, and data generated by the Washington Department of Ecology. The specific documents that were consulted include:

- ***RAGS, Part A - Risk Assessment Guidance For Superfund, Volume 1: Human Health Evaluation Manual (Part A), Interim Final (EPA/540/1-89/002, December 1989)*** This document was consulted for overall guidance on how to address risks from exposure to contaminated sediments.

- ***RAGS, Part E - Risk Assessment Guidance For Superfund, Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidelines For Dermal Risk Assessment), Interim Review Draft For Public Comment (EPA/540/R/99/005, September 2001)*** This document was consulted for overall guidance on how to address risks from exposure to contaminated sediments. Specific soil adherence values were also obtained from Exhibit 3-3, page 3-18.

- ***Carbaryl Concentrations In Willapa Bay and Recommendations For Water Quality Guidelines (March 2001, Pub No. 01-03-005, Author: Art Johnson)*** Water concentration data were obtained from this document. It presented monitoring data collected by the Washington Department of Ecology as well as data collected by the Shoalwater Bay Tribe.

- ***Screening Survey of Carbaryl (Sevin) and 1-napthol Concentrations in Willapa Bay Sediments (May 1999, Pub No. 99-323, Author: Cynthia Stonick)*** Sediment and water concentration data were obtained from this document.

When the guidance in current labels and these documents is considered, it is clear that the Agency should consider children of differing ages as well as adults in its assessments. It is also clear that different age groups should be considered in different situations. The populations that were considered in the assessment include:

- **Residential (homeowner) Adults:** these individuals are members of the general population that are exposed to chemicals by engaging in activities at their residences (e.g., in their lawns or gardens) and also in areas not limited to their residence (e.g., golf courses or parks) previously treated with a pesticide. These kinds of exposures are attributable to a variety of activities and usually addressed by the Agency in risk assessments by considering a representative activity as the basis for the exposure calculation.

- **Residential Children:** children are members of the general population that can also be exposed in their residences (e.g., on lawns, in gardens, or from contact with treated pets) as well as other areas previously treated with a pesticide (e.g., parks). These kinds of exposures are attributable to a variety of activities such as playing outside, home gardening, or playing with a companion animal. Toddlers have been selected as a sentinel (or representative) population for turf and companion animal assessments. Youth-aged children (ages 10 to 12) are considered the sentinel population for a fruit harvesting assessment because it is likely that children of this age would help with garden maintenance. They are usually addressed by the Agency in risk assessments by considering a representative activities for each age group in an exposure calculation.

The *SOPs For Residential Exposure Assessment* define several scenarios that apply to uses specified in current labels. These scenarios served as the basis for the residential postapplication assessment along with the modifications to them and the additional data/approaches described above. The Agency used this guidance to define the exposure scenarios that essentially include child exposure on treated lawns (dermal and nondietary ingestion considered), child exposure in treated gardens, exposure to children from treated companion animals, and the exposure of adults while doing gardening, lawncare, or golfing. The SOPs and the associated scenarios are presented below:

- ***Dose from dermal exposure on treated turf calculated using SOP 2.2:*** Postapplication dermal dose among toddlers from playing on treated turf;

- ***Dose from ingestion of carbaryl granules from treated turf calculated using SOP 2.3.1:*** Postapplication dose among toddlers from episodic nondietary ingestion of pesticide granules picked up from treated turf (i.e., those residues that end up in the mouth from a child touching turf and then putting their hands in their mouth);
- ***Dose from hand-to-mouth activity from treated turf calculated using SOP 2.3.2:*** Postapplication dose among toddlers from incidental nondietary ingestion of pesticide

residues on treated turf from hand-to-mouth transfer (i.e., those residues that end up in the mouth from a child touching turf and then putting their hands in their mouth);

- ***Dose from object-to-mouth activity from treated turf calculated using SOP 2.3.3:*** Postapplication dose among toddlers from incidental nondietary ingestion of pesticide residues on treated turf from object-to-mouth transfer (i.e., those residues that end up in the mouth from a child mouthing a handful of treated turf);

- ***Dose from soil ingestion activity from treated turf calculated using SOP 2.3.4:*** Postapplication dose among toddlers from incidental nondietary ingestion of pesticide residues from ingesting soil in a treated turf area (i.e., those soil residues that end up in the mouth from a child touching treated soil and turf then putting their hands in their mouth);

- ***Dose from dermal exposure while working in treated gardens or with various trees (nut, fruit, and ornamentals) calculated using SOPs 3.2 & 4.2:*** Postapplication dermal dose among adults and youth-aged children (ages 10 to 12) while gardening [Note: These series of SOPs also call for addressing nondietary ingestion, these types of exposures have been included in the turf/toddler calculations. The transfer coefficients used are from updated Agency.];

- ***Postapplication Potential Dose From Incidental Nondietary Ingestion if Pesticide Residues While Swimming calculated using SOP 5.2.1:*** Postapplication potential dose among adults while swimming - the general guidance applies, updates to this SOP have been completed in the form of the SWIMODEL (V2.0) which was used for this assessment;

- ***Dose from dermal contact with treated pets calculated using SOP 9.2.1:*** Postapplication potential dose among toddlers from the dermal contact with a treated pet and absorption through the skin (i.e., residues that end up as body burden after deposition on and absorption through the skin); and

- ***Dose from hand-to-mouth activity calculated using SOP 9.2.2:*** Postapplication potential dose among toddlers from nondietary ingestion of pesticide residues on treated pets from hand-to-mouth transfer (i.e., those residues that end up in the mouth from a child touching a pet and then putting their hands in their mouth).

The detailed residential postapplication calculations are presented in Appendices H through M of this document. Please refer to them to review the specifics of the risk assessment. Appendix H contains the turf risk assessment for adults and children. Appendix I contains the risk assessment for uses in gardens and fruit trees that addresses such activities as harvesting for adults and youth-aged children. Appendix J presents the risks associated with uses on pets. Appendix K provides the background information on how deposition patterns for wide area applications such as mosquito adulticides were calculated. Appendix L presents the risks that result from the use of carbaryl as a mosquito adulticide. This assessment is essentially the same as that done for turf with the addition of a factor to account for the limited amount of residues that are deposited on turf because of how mosquito adulticides are applied. Appendix M presents the data and risk calculations used to address carbaryl use for Ghost and Mud Shrimp control in Washington State.

3.2.2 Data and Assumptions for Residential Postapplication Exposure Scenarios

A series of assumptions and exposure factors served as the basis for completing the residential postapplication risk assessments. Each assumption and factor are detailed below. In addition to these values, a study was also submitted by the Bayer Corporation which was not used by the Agency in this assessment. The study, however, is identified below for recordkeeping purposes along with the rationale for not using it in the assessment.

The assumptions and factors used in the risk calculations are consistent with current Agency policy for completing residential exposure assessments (i.e., *SOPs For Residential Exposure Assessment*). [Note: More detail about the origin of each factor can be obtained in the SOP document and associated documents such as the Agency's 1999 Overview document presented to the FIFRA SAP.] The values used in this assessment include:

- There are many factors that are common to the occupational and residential postapplication risk assessments such as body weights for adults, analysis of residue dissipation data, and transfer coefficients used for the garden exposure scenarios. Please refer to the assumptions and factors in Section 2.1.2 for further information concerning these common values. [Note: The transfer coefficients have not been adjusted for the clothing that someone working in their home garden might be anticipated to wear such as shorts and short-sleeved shirt.]

- Carbaryl labels allow for wide area applications in mosquito control (for adulticides) and for the control of other pest species such as black fly. When the Agency considers these use patterns in risk assessments, the amount deposited on the turf is determined by the using the AgDrift model for aerial applications (9.5 percent deposits on turf) and published data from the scientific literature for ground fogger applications (5 percent deposits on turf) as described in Appendix K. All other components are similar to a residential turf risk assessment. The Sevin XLR label for mosquito and fly control was key in defining the input parameters for the AgDrift calculations. This label specified a range of application rates from 0.016 to 1 lb ai/acre. The label also indicated that the optimal droplet size range is from 8 to 30 µm. However, the label also had specific requirements for aerial applications for droplets "with a calculated VMD of less than 50 µm" and an allowance that "no more than 5 percent of the droplets should be larger than 80 µm." Once the deposition patterns have been defined, a turf-type risk assessment was completed accounting for different deposition patterns, compared to a typical turf risk assessment. Different deposition patterns were accounted for in the calculation of the turf transferable residues to which adults and children are exposed. The calculations are presented in Appendix L.

- Exposure frequency values used in cancer risk assessments for adults are the same as those used for residential handlers (1 time per year). However, the Agency does believe that there are higher frequency golfers (i.e., average golfers over all ages play 18 rounds year) based on a 1992 report *(Golf Course Operations, Cost of Doing Business/Profitability* by the Center For Golf Course Management). The Agency also believes that individuals may reenter treated home gardens more than one time per year. However, exact information linking the timing of applications and the frequency of reentry is not available. It should be noted that this issue is being addressed by the Agency in the development of calendar-based, residential modeling programs such as *Lifeline*. Therefore, until calendar-based approaches are implemented, only single reentry events have been considered in the cancer risk assessment. Risk managers should consider the likelihood of additional reentry events when interpreting the results of the cancer risk assessment. To refine these results, the Agency has also calculated the number of exposure days allowed per year to achieve a $1x10^{-6}$ cancer risk ceiling just as with the residential handler assessment above. Risk managers should also consider the likelihood of intermediate-term exposures occurring for adults. The Agency calculated intermediate-term postapplication risks for adults yet, in reality, the population where these exposures would be expected is likely very small except for maybe home gardeners. The Agency also calculated intermediate-term exposures for youth-aged children and toddlers where the behaviors used as the basis for the risk assessment are thought to more likely occur on a routine basis (i.e., the population would be expected to be larger).

- The Agency combines or aggregates risks resulting from exposures to individual chemicals when it is likely they can occur simultaneously based on the use pattern and the behavior associated with the exposed population. Within a residential assessment, this can take two forms. The first is to add together risks for individual exposure scenarios from all likely sources of exposure such as after an application to turf or use on a pet. For carbaryl, the Agency has added together risk values (i.e., MOEs) for different kinds of exposures within the turf (dermal, hand-to-mouth, object-to-mouth, and soil ingestion) and pet scenarios (dermal and hand-to-mouth). These represent the standard set of exposures that are typically added together when chemicals are used on turf or on pets because it is logical they can co-occur. The second is to add exposures from different residential exposure scenarios that can possibly co-occur such as when a homeowner makes an application and then checks their garden for bugs a few hours later on the same day. Typically, the Agency only adds exposures from different exposure scenarios together (e.g., spraying and gardening) when risks from both are not already a concern. For carbaryl, however, there are risk concerns for many residential handler scenarios so the Agency did not add risk values from any postapplication exposure together with applicator risks.

- The frequency of retreatment could not be determined based on information provided by the Bayer Corporation at the SMART meeting or other associated information. Labels generally specify a minimum interval of 1 week between applications. The risk assessments are based on five different residue (DFR or TTR) studies. In all studies except on olives, multiple applications were completed at 1 week intervals so any additivity between applications would also be accounted for in the empirical data used for risk assessment.

- Exposures to children playing on treated turf as well as adults on turf (lawncare and golfing) have been addressed using the latest Agency approaches for this scenario including:
  - 5 percent of the application rate has been used to calculate the 0-day residue levels used for defining risks from hand-to-mouth behaviors, measured TTR values are not used because of differences in transferability versus what would be expected during hand-to-mouth behaviors;
  - 20 percent of the application rate has been used to calculate the 0-day residue levels used for defining risks from object-to-mouth behaviors, measured TTR values are not used because of differences in transferability versus what would be expected during hand-to-mouth behaviors, a higher percent transfer has been used for object-to-mouth behaviors because it involves a teething action believed to be more analogous to DFR/leaf wash sample collection where 20 percent is also used;
  - the measured TTR levels quantified in MRID 451143-01 have been used to complete the dermal exposure calculations as the 0-day transferability was > 1 percent of the application rate for the short- and intermediate-term data sources, studies where transferability is less than 1 percent are not used for risk assessment purposes because the transfer coefficients used by the Agency for defining exposures are based on Jazzercize studies in which TTR values were measured by techniques where transferability is generally in the 1 to 5 percent range other than the ORETF roller method where transferability tends to be lower;
  - short- and intermediate-term exposures have been calculated because play and mouthing behaviors are assumed to routinely occur daily and for extended periods such as over 30 days, carbaryl residues are also expected to be present based on residue dissipation data (i.e., slow dissipation rate);
  - in cases where 0 day residues have been calculated based on application rates (i.e., hand-/object-to-mouth residues and for soil dissipation), dissipation over time measured in the TTR study (i.e., slope of decay curve) has been used to predict TTR and soil levels over time, carbaryl residues were detectable even at 14 days after application (i.e., final sampling interval) at all sites in the TTR studies used in this assessment, at 14 days average residues at the Georgia and Pennsylvania study sites were still orders of magnitude above the quantitation limit, this indicates that predicted residue levels for extended durations should be considered appropriate based on the empirical data (e.g., critical for consideration of intermediate-term exposures);

- the transfer coefficients used, except golfing, are those presented at the 1999 Agency presentation before the FIFRA Science Advisory Panel that have been adopted in routine practice by the Agency;
- transfer coefficients have been adjusted for differences between short- and intermediate-term exposures;
- adult golfers have been assessed using a transfer coefficient of 500 cm^2/hour [Note: The Agency is currently developing a policy on golfer exposures and has used this value in other assessments];
- 3 year old toddlers are expected to weigh 15 kg;
- hand-to-mouth exposures are based on a frequency of 20 events/hour and a surface area per event of 20 cm^2 representing the palmar surfaces of three fingers;
- saliva extraction efficiency is 50 percent meaning that every time the hand goes in the mouth approximately ½ of the residues on the hand are removed;
- object-to-mouth exposures are based on a 25 cm^2 surface area;
- exposure durations are expected to be 2 hours based on information in the Agency's *Exposure Factors Handbook* except for golfers where the exposure duration for an 18 hole round of golf is 4 hours based on a 1992 report *(Golf Course Operations, Cost of Doing Business/Profitability* by the Center For Golf Course Management);
- soil residues are contained in the top centimeter and soil density is 0.67 mL/gram;
- dermal, hand- and object-to-mouth, and soil ingestion are added together to represent an overall risk from exposure to turf while granular ingestion is considered to be a much more episodic behavior and is considered separately by the Agency;
- children of various ages down to the very young (e.g., 4 or 5 years old) are currently playing golf, the Agency recognizes that age may impact exposures because of changes in behavior and skin surface area to body weight ratios but has not yet developed a quantitative approach for calculating their risks; and
- comments were received on the previous version of the assessment (D281418, 5/29/02) that indicated a concern because the Agency did not consider "feral" food intake, the Agency position is that the hand-to-mouth and object-to-mouth assessments included for children playing on turf would address this issue particularly since the object-to-mouth scenario is based on a child mouthing treated turf.

- Exposures to children and adults working in home gardens have been addressed using the latest Agency approaches for this scenario including:
  - youth-aged children are considered along with adults;
  - 12 year old youth are expected to weigh 39.1 kg;
  - exposure durations are expected to be 40 minutes;
  - Pre-Harvest Intervals (PHIs) are less than 7 days for most crops with some as long as 28 days;
  - transfer coefficients for youth were calculated by adjusting the appropriate adult transfer coefficients by a 50% factor as has been done by the Agency since the inception of the *SOPs For Residential Exposure Assessment*;
  - the updated transfer coefficients specified in Agency policy 003 (along with recent changes to tree fruit harvester and thinner TCs) described above in the occupational

risk assessment have been used rather than those currently specified in the SOPs because they represent more refined estimates of exposure for the fruiting vegetable and deciduous tree crop groups, these crop groups have been used in the SOPs to represent home garden exposures;
    - the combination of adjusting transfer coefficients for youth-aged children and using appropriate body weights for the age group results in dose levels that are slightly lower than that of adults in the same activity (the TC reduction and body weight reduction is essentially a 1:1 ratio); and
    - the DFR data used for the assessments are the same as those used in the occupational risk assessment for the selected crop groups.

- Exposures to children after contact with treated pets have been addressed using the latest Agency approaches for this scenario including:
    - only toddlers are considered because their exposures are thought to be highest exposed population (i.e., they are considered the sentinel population by the Agency);
    - a equilibrium approach based on a single child "hug" of the treated animal is used to assess dermal exposure as described in the 1999 Agency SAP Overview document (i.e., the skin loads after a single contact with the treated animal and additional contacts don't proportionally add exposures), the surface area of the dermal hug is based on a toddler skin surface area and typical clothing;
    - residue dissipation is 5 percent per day for the shampoo and dust products (based on data from J. Chambers at Mississippi State University on other pet use products);
    - the Agency default for transferability of residues from fur is 20 percent, however, a pet collar transferable residue study (MRID 45792201) was submitted and used in the assessment for comparative purposes with the Agency's standard approach, the data from this study were used to develop an alternative transferability factor of 2.6 percent for dusts and liquid applications (even though the physical forms are very different which should be considered);
    - the active lifetime of a collar is expected to be 120 days based on label statements which was used by the Agency, a daily emission term from the collar of 0.000290 mg/cm^2/gram ai/day is also based on measured data from Mississippi State University for a pet collar, additionally data from a pet collar transferable residue study (MRID 45792201) was submitted and used in the assessment for comparative purposes with the Agency's standard approach the data from this study were used to complete risk calculations using direct measurements of transferable residue concentration on dogs;
    - risks are based on an even loading of residues across the entire surface of a 30 lb dog which has been chosen as a representative animal, the animal surface area was calculated using (12.3 * Body Weight (g) $^{0.65}$) from the Agency's 1993 Wildlife Exposure Factors Handbook (i.e., dog surface area of 5986 cm^2);

- the approach used to address the hand-to-mouth exposure pathway has been modified since the previous risk assessment, in previous assessment contact with dogs was based on 40 events per day, in each event, the palmar surface of the hands (i.e., 20cm^2/event) is placed in the mouth of the child contributing to nondietary ingestion exposure, in the revised approach the frequency term has been modified to an equilibrium approach analogous to the dermal exposure component (i.e., the frequency = 1) because the data on which the transferable residue concentrations are based rely on a 5 minute heavy rubbing/petting technique that would lead to concentrations on the hands that would be expected to be significantly higher than would result from a single contact.

- For turf, the maximum application rate indicated at the SMART meeting was 8 lb ai/acre even though current labels allow for applications by homeowners at up to 11 lb ai/acre for Lock-n-load type packages and 9 lb ai/acre for granulars. The TTR study was conducted also, it should be noted, at 8 lb ai/acre (see below for more details). Based on the design of the TTR study and what was indicated at the SMART meeting, the Agency completed the postapplication assessment using the data directly from the TTR study without any adjustment for application rate. Risks at higher application rates would be worse than those presented at the 8 lb ai/A application rate (see below).

- Postapplication residential risks are based generally on maximum application rates or values specified in the *SOPs For Residential Exposure Assessment.*

- The Jazzercise approach is the basis for the dermal transfer coefficients as described in the Agency's Series 875 guidelines, *SOPs For Residential Exposure Assessment*, and the 1999 FIFRA SAP Overview document

- In Washington state, carbaryl is used under a 24C label (WA-900013) to control Ghost and Mud shrimp in Willapa Bay. The Agency considered contact with sediments (e.g., oyster digging for adults and playing on beach for toddlers) and water (adult swimming) that could contain carbaryl residues using commonly accepted risk assessment methods (i.e., RAGS - Superfund Guidance and SWIMODEL (V2.0)), water monitoring data, and sediment data. In these assessments, conservative inputs for sediment and water concentrations were used and also conservative exposure factors were used to ensure the screening level nature of the calculations. Such inputs included selection of the highest water concentration estimate from all available data sources for swimmers and highest sediment concentrations for oyster digging or children playing. Other conservative inputs included the permeation coefficient from the SWIMODEL, the use of a 90th percentile value for the duration of swimming for a noncompetitive swimmer of 3 hours (which would be expected to be conservative in the areas where this use occurs), and the entire surface area of a toddler used for playing on a beach. [Note: The water and sediment concentration data have been reviewed by the Agency's Environmental Fate and Effects Division (D279109, Thomas Steeger - author).]

Postapplication Studies: Two studies were submitted in support of the Reregistration of carbaryl that focused on passive dosimetry approaches in a residential environment. [Note: There has also been a suburban resident biological monitoring study which was submitted by Bayer that is presented in *Section 3.3: Carbaryl Suburban Resident Biomonitoring Study, Associated Data & Risks* where the results and risks based on this study are presented. Please refer to that section for further details. This assessment is based on a deterministic approach which should also be considered in context with the companion probabilistic assessments that have been (or will be) submitted/generated by Bayer Crop Sciences and the Chemistry and Exposure Branch of the Health Effects Division of OPP (see Section 3.4 below for further information).] The first study, conducted by the Bayer Corporation, which measured concurrent dermal exposure using Jazzercize and turf transferable residues of Ronstar 50WP (oxadiazon) was submitted for use in the risk assessment. The use of this study was not accepted because it is very specific to the use of oxadiazon on turf. In particular, the study was conducted on a dormant grass and the transfer coefficients differ from those currently used in standard Agency risk assessments. In fact, the ORETF, of which Bayer is a member, considered this study for purchase and use in its generic approach to dermal exposures on turf. Based on essentially the same reasons as the Agency has used, the study was not purchased. The second study monitored the amount of transferable residues that were released from 10 dogs treated with 16 percent carbaryl collars up to 1 week after application. A citation for each study as well as a brief summary is provided below:

- **Evaluation of Turf Reentry Exposure To a Broadcast Application of Ronstar 50WP** EPA MRID 447425-01; Report dated January 18, 1995; Authors: Leah Rosenheck and Shirley Sanchez; Sponsor: Bayer Corporation (formerly Rhone Poulenc).

- **Determination of the Quantity of Carbaryl Removed by Petting Dogs Wearing 16% Carbaryl Dog Collars** EPA MRID 457922-01; Report dated October 24, 1977; Authors: Don Emlay and Robin Rudolph; Sponsor: Zoecon Laboratories.

Note to Chemical Review Manager: There are no data compensation issues associated with either of these studies since they were both conducted by carbaryl registrants.

MRID 457922-01 (Transferable residues from dogs treated with 16% carbaryl collar): This study evaluated the quantity of carbaryl removed from dogs of various sizes and hair lengths for a period of up to 7 days after placement of the collars. A 16 percent carbaryl collar was placed on the dogs and the dogs were petted for 2 ten minute periods on each sampling day by a person wearing a pair of white cotton gloves which were collected for analysis. A separate set of gloves was used for each 10 minute interval but they were combined for analysis so each daily residue measurement per animal represents that removed by 20 minutes of petting. Samples were taken 24 hours, 96 hours, and 1 week after the collars were put on the dogs. According to the report "all dogs were petted in such a manner that contact with all portions of their bodies resulted. This allowed for maximum contact with carbaryl present on the dogs and frequent collar contact." Samples were extracted with a 10 percent methanol in chloroform solution by shaking then an aliquot was solvent exchanged with diethyl ether. This solution was then analyzed by HPLC. No recovery data of any kind were presented in the study report. The report also mentioned a "total average quantity of carbaryl released from a collar and available to the dog on a day to day basis" value. This value was treated as a source term by the Agency to estimate the percent transferability on each day.

The average amounts of total carbaryl residues that were removed on each sampling day were calculated as were transferable residue concentrations. Transferable residue concentrations were calculated using the dog surface area algorithm described above and the weights of the individual animals. The results of this study are presented in Table 26 below. It should be noted that the petting regimen in this study covered the entire dog but other data by Boone and Chambers et al suggest that residues from collars are more localized around the head and neck (i.e., 1/3rd) of the dog. As such, the Agency has calculated transferable residue concentrations using both approaches for comparative purposes. Overall, the data contained in this study are considered by the Agency to be for rangefinder purposes only due to the lack of quality control procedures. However, the results from this study are chemical-specific and significantly different from Agency standard values so they have been used for comparative purposes in the assessment.

Table 26: Carbaryl Transferable Residues From Dogs With 16% Collars (MRID 45792201)

Sample Interval	Avg. Total Residue Removed (mg)	Total Residues Available (mg)	Transferability (%)	Calculated [TR] (mg/cm^2)	
				Whole Dog	1/3 rd of Dog
24 hr	2.08	75	2.8	0.0004178	0.0012535
96 hr	1.86	75	2.5	0.0004089	0.0012267
1 week	1.74	69	2.5	0.0003978	0.0011934

An average transferability of 2.6% was used for risk assessment purposes. The value was used for comparative purposes in the dust and liquid assessments. The calculated [TR] values were used for comparative risk assessment purposes for the collars (see below for further information).

3.2.3 Residential Postapplication Exposure and Noncancer Risk Estimates

The residential postapplication exposure and non-cancer risk calculations are presented in this section. Noncancer risks were calculated using the Margin of Exposure (MOE) which is a ratio of the body burden to the toxicological endpoint of concern. Exposures were calculated by considering the potential sources of exposure (i.e., DFRs on garden plants, TTRs on lawns, and transferable residues on treated pets) then calculating dermal and nondietary ingestion exposures. The major difference with residential risk assessments is that the uncertainty factor which defines the level of risk concern also has to consider application of the additional FQPA safety factor specified by the legislation. In the case of carbaryl, in January and February 2002 meetings of the FQPA Safety Factor Committee, it was decided that the FQPA factor should be reduced to 1.

Therefore, the overall uncertainty factor applied to carbaryl for residential postapplication risk assessments is 100 which is based on the FQPA safety factor of 1 along with the 100 applied for inter-species extrapolation, intra-species sensitivity, and the use of a NOAEL for risk assessment.

Dermal exposures and risks from lawn and garden uses were calculated in the same manner as described above in Section 2.2.3. Dermal exposures from treated pets were calculated using a slightly different approach where a "hug" contact is expected to lead to an equilibrium concentration on the skin of the affected individual. Exposures to sediment and water while swimming were calculated using a soil adherence approach analogous to that used in Superfund risk assessments and swimmer exposures were calculated using the SWIMODEL which has been validated and also brought before the FIFRA SAP. Along with calculating these dermal exposures, other aspects of the turf, treated pet, and sediment exposure scenarios involved calculating dose from non-dietary ingestion. The algorithms used for each type of calculation are presented below which have not been previously addressed in Section 2.2.3.

Nondietary Ingestion Exposure From Treated Turf: Nondietary ingestion exposure levels from turf were calculated using the following equations. These values were then used to calculate MOEs as illustrated above. The following illustrates the approach used to calculate the nondietary ingestion exposures that are attributable to hand-to-mouth behavior on treated turf (SOP 2.3.2):

$$D = (TTR * (SE/100) * SA * Freq * Hr * (1mg/1000\mu g))$$

where:

D	=	dose from hand-to-mouth activity (mg/day);
TTR	=	Turf Transferable Residue where dissipation is based on TTR study and the 0-day value is based on the 5% initial transferability factor unless acceptable data are available ($\mu g/cm^2$);
SE	=	saliva extraction factor (%);
SA	=	surface area of the hands (cm^2);
Freq	=	frequency of hand-to-mouth events (events/hour); and
Hr	=	exposure duration (hours).

The following illustrates the approach used to calculate exposures that are attributable to object-to-mouth behavior on treated turf that is represented by a child mouthing on a handful of turf (SOP 2.3.3):

$$D = (TTR * IgR * (1mg/1000\mu g))$$

where:

D	=	dose from mouthing activity (mg/day);
TTR	=	Turf Transferable Residue where dissipation is based on TTR study and the 0-day value is based on the 20% initial transferability factor (µg/cm^2); and
IgR	=	ingestion rate for mouthing of grass per day (cm^2/day).

The following illustrates the basics of the approach, used to calculate exposures that are attributable to soil ingestion (SOP 2.3.4):

$$D = (SR * IgR * (1E-6\ g/1\ \mu g))$$

where:

D	=	dose from soil ingestion activity (mg/day);
SR	=	Soil Residue where dissipation is based on TTR study and the 0-day value is based on the application rate, 1 cm depth of surface soil, and the density of soil (µg/cm^3); and
IgR	=	ingestion rate for daily soil ingestion (mg/day).

Dermal Exposure From Treated Pets: Dermal exposure from treated pets was calculated using the following equation. These values were then used to calculate MOEs as illustrated above. This approach is based on the Agency presentation at the 1999 FIFRA Science Advisory Panel and is detailed in the accompanying overview document.

$$D = (((AR * F_{AR})/SA_{pet}) * (1-DR)^{t} * SA_{hug} * (1mg/1000\mu g))$$

where:

D	=	dose from dermal pet contact (mg/day);
AR	=	application rate or amount applied to animal in a single treatment (mg ai/animal);
F_{AR}	=	fraction of the application rate available for dermal contact as transferable residue (%/100);
SA_{pet}	=	surface area of a treated dog (cm^2/animal);
t	=	time after application (days);
DR	=	fractional dissipation rate per day (% per day/100); and
SA_{hug}	=	surface area of a child hug (cm^2 contact/hug).

[Note: For collars, the ((AR/F_{AR})/SA_{pet}) term is replaced with a measured emission term of 0.00029 mg/cm^2/gram ai in collar/day which is then multiplied by the amount of active ingredient in the collar to calculate risks. Additionally, directly measured transferable residues from collars were also used in this case to replace this term.]

Nondietary Exposure From Treated Pets: Nondietary exposure from treated pets was calculated using the following equation (SOP 9.2.2). This exposure pathway occurs when children touch animals then put their hands in their mouths. These values were then used to calculate MOEs as illustrated above.

$$D = (((AR * F_{AR})/SA_{pet}) * (1 - D)^{t} * (SAL/100) * SA_{hands} * Freq)$$

where:

D	=	nondietary ingestion dose from with treated pets (mg/day);
AR	=	application rate or amount applied to animal in a single treatment (mg ai/animal);
F_{AR}	=	fraction of the application rate available for dermal contact as transferable residue (%/100);
SA_{pet}	=	surface area of a treated dog (cm^2/animal);
t	=	time after application (days);
DR	=	fractional dissipation rate per day (% per day/100);
SAL	=	saliva extraction factor (% extractability);
SA_{hands}	=	surface area of the hands (cm^2);
Freq	=	hand-to-mouth events (1 event/day).

[Note: Collar emissions are defined as described above for dermal exposures.]

Mosquito Control Applications: Mosquito control and other uses (e.g., black fly treatments) have been addressed using a methodology that involves defining how much material is deposited on the ground in impacted areas then using the same methodology that is used for a turf risk assessment. The calculations for defining how much deposited on the ground after such applications involved published literature for ground-based techniques and the AgDrift model for aerial application methods (see Appendix K for further information). See above for turf risk assessment calculations. Along with the calculations that involved children playing on treated turf, the air concentration of carbaryl on the day of application close to the ground was used to calculate MOEs on that day only which were combined with the dermal and mouthing behaviors for that day. The air concentration value is a direct output of the model used to calculate deposition concentrations.

Ghost and Mud Shrimp 24C Applications: Applications to Willapa Bay in Washington state have been addressed using the SWIMODEL and guidance from RAGS. The SWIMODEL provides exposure rates (mg/day) from several routes of exposure. Dermal exposures were separated out to apply the NOAEL from the 21 day dermal rat study (i.e., 20 mg/kg/day) using a simple proportion. All other calculations were similar to other scenarios for MOEs and dose.

Sediment exposures included a dermal component for adults and toddlers and a hand-to-mouth component for toddlers. Dermal exposures to sediments were calculated using the following:

$$D = ((Sed * Adh * SA)/((1000\mu g/1mg) * (1000g/1kg) * (1000mg/1g) * BW))$$

where:

D	=	potential dose from dermal sediment contact (mg/kg/day);
Sed	=	concentration of carbaryl in sediment (µg/kg or ppb), varies over time with concentration data obtained from WA state reports and linear extrapolation between Day 2 and Day 30 data;
Adh	=	soil adherence factor (mg/cm^2);
SA	=	surface area of the body parts contacted (cm^2); and
BW	=	body weight (kg).

Nondietary ingestion exposures that are attributable to hand-to-mouth behavior for toddlers on beaches were calculated as follows:

$$D = ((Sed * (SE/100) * SA * Freq * Adh)/((1000\mu g/mg) * (1000mg/g) * (1000g/kg) * BW))$$

where:

D	=	dose from hand-to-mouth activity (mg/kg/day);
Sed	=	concentration of carbaryl in sediment (µg/kg or ppb), varies over time with concentration data obtained from WA state reports and linear extrapolation between Day 2 and Day 30 data;
SE	=	saliva extraction factor (%);
SA	=	surface area of the hands (cm^2);
Adh	=	soil adherence factor (mg/cm^2); and
BW	=	body weight (kg).

Noncancer Risk Summary: All of the noncancer risk calculations for the various residential carbaryl assessments are included in Appendices H, I, J, K, L and M for the turf, home garden, pet, mosquito control and oyster bed scenarios, respectively. [Note: Both Appendices K and L pertain to mosquito control.] The specifics of each of table included in these Appendices are described below. A summary of the results for each scenario considered for each timeframe is also provided below.

- **Appendix H/Table 1 : Carbaryl Postapplication Residential Turf Risk Assessment Inputs** Contains each numerical input utilized in the calculation of the residential postapplication risk values.

- **Appendix H/Table 2 : Residue Levels Used For Carbaryl Residential Risk Assessment On Turf** Presents the turf transferable residue values used for the dermal, hand-to-mouth, object-to-mouth, and soil ingestion risk assessments. Includes daily values which have been used for short-term exposures and 30 day average values which have been used for intermediate-term exposures.

- **Appendix H/Table 3: Adult Noncancer Risk Values For Carbaryl Residential Risk Assessment on Turf** Presents the risks for short-term and intermediate-term adult dermal exposures in on turf while engaged in high contact activity such as heavy lawncare ("On Residential Turf") or while playing golf on a treated course.

- **Appendix H/Table 5: Toddler Dermal Risk Values For Carbaryl on Turf** Presents the risks for short-term and intermediate-term toddler dermal exposures in on turf while engaged in high contact activity.

- **Appendix H/Table 6: Toddler Hand-to-Mouth Risk Values For Carbaryl on Turf** Presents the risks for short-term and intermediate-term toddler hand-to-mouth exposures in on turf while engaged in high contact activity.

- **Appendix H/Table 7: Toddler Object-to-Mouth Risk Values For Carbaryl on Turf** Presents the risks for short-term and intermediate-term toddler object-to-mouth exposures in on turf while engaged in high contact activity.

- **Appendix H/Table 8: Toddler Soil Ingestion Risk Values For Carbaryl on Turf** Presents the risks for short-term and intermediate-term toddler soil ingestion exposures in on turf while engaged in high contact activity.

- **Appendix H/Table 9: Toddler Aggregate Risk Values For Carbaryl on Turf** Presents the risks for short-term and intermediate-term toddler aggregate exposures in on turf while engaged in high contact activity.

- **Appendix I/Table 1: Carbaryl Postapplication Residential Garden and Tree Use Risk Assessment Inputs** Presents the numerical unit exposure values and other factors used in the tree and garden postapplication risk assessments.

- **Appendix I/Table 2: Carbaryl Residential Postapplication Adult Risk Assessment For Deciduous Tree Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix I/Table 4: Carbaryl Residential Postapplication Youth Risk Assessment For Deciduous Tree Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix I/Table 5: Carbaryl Residential Postapplication Adult Risk Assessment For Fruiting vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix I/Table 7: Carbaryl Residential Postapplication Youth Risk Assessment For Fruiting vegetable Crop Group** Risk values are presented for each exposure duration considered in the assessment (i.e., short-term and intermediate-term duration exposures, respectively).

- **Appendix J/Table 1: Carbaryl Residential Pet Risk Assessment For Toddlers Based On Current Agency Methods** Presents the risks for short-term and intermediate-term toddler exposure after contact with treated pets. Based on current Agency methods using no data from MRID 457922-01 (Zoecon Collar Transferable Residue Study).

- **Appendix J/Table 2: Carbaryl Liquid and Dust Residential Pet Risk Assessment For Toddlers Based On Zoecon Study Data** Presents the risks from dust and liquid use only for short-term and intermediate-term toddler exposure after contact with treated pets. Based on transferability factor of 2.6 percent from MRID 457922-01 (Zoecon Collar Transferable Residue Study).

- **Appendix J/Table 3: Carbaryl Residential Pet Collar Risk Assessment For Toddlers Based On Zoecon Study Residue Concentrations** Presents the risks pets treated with collars for short-term and intermediate-term toddler exposure after contact with treated pets. Based on transferability residue concentrations calculated from MRID 457922-01 (Zoecon Collar Transferable Residue Study).

- **Appendix J/Table 4: Summary of Zoecon Study Data (MRID 45792201)** Presents the data and analysis thereof from MRID 457922-01.

- **Appendix K: Determination of Deposition Factors For Carbaryl Mosquito Control Uses** Presents the calculations and the data used to determine the amount of residues deposited in treated residential areas after mosquito control applications by air and ground.

- **Appendix L/Table 1 : Carbaryl Postapplication Residential Mosquito Control Risk Assessment Inputs** Contains each numerical input utilized in the calculation of the residential mosquito control postapplication risk values.

- **Appendix L/Table 2 : Residue Levels Used For Carbaryl Residential Risk Assessment On Turf After Aerial Mosquito Control Application** Presents the turf transferable residue values used for the dermal, hand-to-mouth, object-to-mouth, and soil ingestion risk assessments. Includes daily values which have been used for short-term exposures and 30 day average values which have been used for intermediate-term exposures. These values have been adjusted for deposition from ULV aerial application.

- **Appendix L/Table 3 : Residue Levels Used For Carbaryl Residential Risk Assessment On Turf After Ground Mosquito Control Application** Presents the turf transferable residue values used for the dermal, hand-to-mouth, object-to-mouth, and soil ingestion risk assessments. Includes daily values which have been used for short-term exposures and 30 day average values which have been used for intermediate-term exposures. These values have been adjusted for deposition from ULV ground application.

- **Appendix L/Table 4: Adult Noncancer Risk Values For Carbaryl Residential Risk Assessment on Turf After Aerial Mosquito Control Application** Presents the risks for short-term and intermediate-term adult dermal exposures in on turf while engaged in high contact activity such as heavy lawncare ("On Residential Turf") or while playing golf on a treated course after the area has been treated for mosquito control using aerial equipment.

- **Appendix L/Table 5: Adult Noncancer Risk Values For Carbaryl Residential Risk Assessment on Turf After Ground Mosquito Control Application** Presents the risks for short-term and intermediate-term adult dermal exposures in on turf while engaged in high contact activity such as heavy lawncare ("On Residential Turf") or while playing golf on a treated course after the area has been treated for mosquito control using ground equipment.

- **Appendix L/Table 8: Toddler Dermal Risk Values For Carbaryl on Turf After Aerial Mosquito Control Application** Presents the risks for short-term and intermediate-term toddler dermal exposures on turf while engaged in high contact activity after the area has been treated for mosquito control using aerial equipment.

- **Appendix L/Table 9: Toddler Dermal Risk Values For Carbaryl on Turf After Ground Mosquito Control Application** Presents the risks for short-term and intermediate-term toddler dermal exposures on turf while engaged in high contact activity after the area has been treated for mosquito control using ground equipment.

- **Appendix L/Table 10: Toddler Hand-to-Mouth Risk Values For Carbaryl on Turf After Aerial Mosquito Control Application** Presents the risks for short-term and intermediate-term toddler hand-to-mouth exposures in on turf while engaged in high contact activity after the area has been treated for mosquito control using aerial equipment.

- **Appendix L/Table 11: Toddler Hand-to-Mouth Risk Values For Carbaryl on Turf After Ground Mosquito Control Application** Presents the risks for short-term and intermediate-term toddler hand-to-mouth exposures in on turf while engaged in high contact activity after the area has been treated for mosquito control using ground equipment.

- **Appendix L/Table 12: Toddler Object-to-Mouth Risk Values For Carbaryl on Turf After Aerial Mosquito Control Application** Presents the risks for short-term and intermediate-term toddler object-to-mouth exposures in on turf while engaged in high contact activity after the area has been treated for mosquito control using aerial equipment.

- **Appendix L/Table 13: Toddler Object-to-Mouth Risk Values For Carbaryl on Turf After Ground Mosquito Control Application** Presents the risks for short-term and intermediate-term toddler object-to-mouth exposures in on turf while engaged in high contact activity after the area has been treated for mosquito control using ground equipment.

- **Appendix L/Table 14: Toddler Soil Ingestion Risk Values For Carbaryl on Turf After Aerial Mosquito Control Application** Presents the risks for short-term and intermediate-term toddler soil ingestion exposures in on turf while engaged in high contact activity after the area has been treated for mosquito control using aerial equipment.

- **Appendix L/Table 15: Toddler Soil Ingestion Risk Values For Carbaryl on Turf After Ground Mosquito Control Application** Presents the risks for short-term and intermediate-term toddler soil ingestion exposures in on turf while engaged in high contact activity after the area has been treated for mosquito control using ground equipment.

- **Appendix L/Table 16: Toddler Aggregate Risk Values For Carbaryl on Turf After Aerial Mosquito Control Application** Presents the risks for short-term and intermediate-term toddler aggregate exposures in on turf while engaged in high contact activity after the area has been treated for mosquito control using aerial equipment.

- **Appendix L/Table 17: Toddler Aggregate Risk Values For Carbaryl on Turf After Ground Mosquito Control Application** Presents the risks for short-term and intermediate-term toddler aggregate exposures in on turf while engaged in high contact activity after the area has been treated for mosquito control using ground equipment.

- **Appendix M/Table 1: Summary of Carbaryl Data From Ecology's Post-Spray Samples (July 31 -August 4, 2000)** Presents summary water data for monitoring conducted by the Washington State Department of Ecology in Willapa Bay during 2000.

- **Appendix M/Table 2: Summary of Carbaryl Data From Shoalwater Bay Tribe (July 17 & 19, 2000)** Presents summary water data for monitoring conducted by the Shoalwater Bay Indian Tribe in Willapa Bay during 2000. [Note: These data were used as summarized from 2001 Washington State Dept of Ecology Report.]

- **Appendix M/Table 3: Carbaryl and 1-napthol Concentrations In Willapa Bay Post-Spray Sediment** Presents summary sediment data for monitoring conducted by the Washington State Department of Ecology in Willapa Bay during 1999.

- **Appendix M/Table 4: Carbaryl Concentrations In Day 60 Willapa Bay Pore Water** Presents summary water data for monitoring conducted 60 days after spraying by the Washington State Department of Ecology in Willapa Bay during 1999. [Note: Samples were collected in this study at 2 and 30 days after sampling which were not reported due to analytical problems.]

- **Appendix M/Table 5: Carbaryl Oyster Harvest/Beach Play Risk Assessment For Adults and Toddlers** Presents noncancer and cancer risk estimates for adults and toddlers while oyster harvesting or playing on a beach. This assessment is based on dermal contact with contaminated sediment and hand-to-mouth behavior for toddlers. The highest sediment concentration detected in any data available to the Agency was used to assure screening level nature of assessment.

- **Appendix M/Table 6: Carbaryl Oyster Harvest/Beach Play Risk Assessment For Adults and Toddlers** Presents noncancer and cancer risk estimates for adults if they were to swim in Willapa Bay. All calculations were completed with the Agency's SWIMODEL (V2.0). Results and model inputs are included in this table.

The Agency has addressed residential postapplication exposures to carbaryl using the standard set of scenarios that are prescribed in current guidance. There are many issues associated with the development of these scenarios and, in general, residential exposure methods. Readers should refer to the guidance documents that are presented above for further information concerning the development of scenarios for residential exposure assessment purposes. The uncertainty factors are similar to those applied to the residential handler assessments described above (i.e., 100 for both short-term and intermediate-term exposures).

Risk Summary:

Adult Short-term MOEs only for lawncare (i.e., heavy yardwork) exceed the Agency's level of concern on the day of application (i.e., 43 to 88). For this activity, it takes 1 and 5 days, respectively at the 4 and 8 lb ai/acre application rates, for residues to dissipate to a point where short-term MOEs are $\geq$100. In all other scenarios considered, short-term MOEs are $\geq$100 on the day of application. These other scenarios include vegetable gardening, golfing, tending fruit trees. More localized exposures that occur after mosquito control or from exposures associated with oyster bed treatments are also included. Intermediate-term MOEs were calculated using 30 day average exposures and the dissipation rate for carbaryl. In all cases, intermediate-term MOEs are

$\geq$100. Table 27 presents the postapplication MOE values calculated for adults after lawn and home garden applications of carbaryl.

Table 27: Summary of Carbaryl Noncancer Postapplication Residential MOEs For Adults				
Scenario	Descriptor	Results		
		Short-term MOE on Day 0	Days Short-term MOE$\geq$ UF	Intermediate-term MOE
Residential Turf (Lawncare)	Max Rate at 4 lb ai/A	88	1	842
	Max Rate at 8 lb ai/A	43	5	412
	Aerial - Mosquito Adulticide 0.016 to 1.0 lb ai/A	3700-231268 (1738 w/inhalation at 1 lb ai/acre)	0	35463-2216454
	Ground - Mosquito Adulticide 0.016 to 1.0 lb ai/A	7031-439409	0	67380-4211262
Golfing	Max Rate at 4 lb ai/A	1274	0	12297
	Max Rate at 8 lb ai/A	624	0	6021
	Aerial - Mosquito Adulticide 0.016 to 1.0 lb ai/A	53654-3353387	0	517764-32360224
	Ground - Mosquito Adulticide 0.016 to 1.0 lb ai/A	101943-6371435	0	983751-61484426
Home Garden (Deciduous Tree)	Very Low Exposure (propping)	17373	0	53139
	Low Exposure (irrigation, scout, weed)	1737	0	5314
	High Exposure (harvest, prune, train, tie)	1158	0	3543
	Very High Exposure (thin)	579	0	1771
Home Garden (Fruiting Vegetable)	Low Exposure (irrigation, scout, thin, weed)	1758	0	9468
	Medium Exposure (irrigation, scout)	1256	0	6763
	High Exposure (harvest, prune, stake, tie)	879	0	4734

Table 27: Summary of Carbaryl Noncancer Postapplication Residential MOEs For Adults				
Scenario	Descriptor	Results		
		Short-term MOE on Day 0	Days Short-term MOE≥ UF	Intermediate-term MOE
Oyster Beds	Oyster Harvest	967137	0	2680745
	Swimming	293651	0	No Data
Inhalation MOE for adult mosquito control calculated using a ground concentration of 40 ng/L calculated with AgDrift, a respiration rate for light activity, and a 20 minute duration to allow for dissipation of the spray. The MOE for inhalation is 3279.				

Youth-aged children (10 to 12 years old) were only considered in the home garden scenarios per Agency guidance. Short-term MOEs for these children were similar to those calculated for adults in that they were ≥100 for all of the gardening scenarios considered. Intermediate-term MOEs were calculated using 30 day average exposures and the dissipation rate for carbaryl. In all cases, intermediate-term MOEs are ≥100. Table 28 below summarizes the postapplication MOE values calculated for youth home garden applications of carbaryl.

Table 28: Summary of Carbaryl Noncancer Postapplication Residential MOEs For Youth-Aged Children				
Scenario	Descriptor	Results		
		Short-term MOE on Day 0	Days Short-term MOE≥ UF	Intermediate-term MOE
Home Garden (Deciduous Tree)	Very Low Exposure (propping)	19408	0	59364
	Low Exposure (irrigation, scout, weed)	1941	0	5936
	High Exposure (harvest, prune, train, tie)	1294	0	3958
	Very High Exposure (thin)	647	0	1979
Home Garden (Fruiting Vegetable)	Low Exposure (irrigation, scout, thin, weed)	1964	0	10577
	Medium Exposure (irrigation, scout)	1403	0	7555
	High Exposure (harvest, prune, stake, tie)	982	0	5289

Toddler (3 year old) MOEs were calculated for the lawncare and pet uses of carbaryl. Table 29 presents a summary of the MOE estimates for toddlers. Exposures were also addressed that resulted from residential application of carbaryl as a mosquito adulticide. Toddler MOEs from treated turf were calculated at the lower and upper ends of the maximum application rate range (i.e., different maximum rates of 4 to 8 lb ai/acre were specified for different pests). A range of application rates were also considered for the mosquito control uses.

Short-term MOEs from exposure to treated turf (in products labeled for direct application to turf) were <100 on the day of application for both rates considered (i.e., 4 and 8 lb ai/acre). In fact, short-term MOEs from individual pathways were not ≥100 for any turf scenario considered on the day of application except for the soil ingestion component of the turf assessment which is a very minor contributor to overall exposures. As a reminder, dermal, hand-to-mouth, and object-to-mouth exposure pathways were also considered. Total short-term MOEs (all pathways) were ≥100 at the lower 4 lb ai/acre application rate 14 days after application and 18 days at the higher 8 lb ai/acre application rate. Dermal and hand-to-mouth exposures were the key contributors while soil ingestion was a minor contributor to the total MOE estimates. See Appendix H for more detailed information on how each exposure pathway contributed to the overall exposures. Intermediate-term MOEs were calculated using 30 day average exposures and the dissipation rate for carbaryl. For both rates, intermediate-term MOEs were <100. Exposures to toddlers were also considered after application of carbaryl as a mosquito adulticide. Regardless of how applications are made (i.e., by ground or air), both short-term MOEs on the day of application and intermediate-term MOEs were ≥100. See Appendix L for more detailed information on how each exposure pathway contributed to the overall exposures.

Ingestion of carbaryl granules is also a potential source of exposure because children can eat them if they are found in treated lawns or gardens. This scenario is considered an episodic scenario by the Agency (i.e., acute dietary endpoints are always used). The concentration of carbaryl in granular products ranges generally from 2 to 10 percent. If this information is coupled with the body weight of a toddler (15 kg), the endpoint of 1 mg/kg/day for short-term assessments (which is also the same value used for the APAD), and the uncertainty factor of 100 the amount of formulation that can be consumed at the uncertainty factor MOE level can be calculated. The Agency generally presents these results based on the number of carbaryl granules that can be ingested. However, the number of homeowner formulations is extensive and impossible to characterize in that much detail so a general weight estimate is presented. If a 2 percent formulation is ingested, 7.5 mg represents exposure at an MOE of 100 (i.e., 1.6×10^{-5} lb). If a 10 percent formulation is ingested, 1.5 mg represents exposure at an MOE of 100 (i.e., 3.3×10^{-6} lb). For illustrative purposes, if one considers a 2 percent formulation and the density of soil (0.67 mL/gram, many granulars are clay based), only 0.005 mL of formulation would need to be ingested to have a risk concern (i.e., 7.5 mg * 1g/1000mg * 0.67 mL/gram). Note that this volume is orders of magnitude less than a teaspoon of granular formulation (i.e., 0.1% of a teaspoon where a tsp. = 5 mL).

The assessments for pet uses considered dermal and nondietary ingestion exposures and also calculated total MOEs. Short-term MOEs for pet uses using the Agency’s current approach were <100 even 30 days after application regardless of whether the formulation used was a dust, liquid or collar. Hand-to-mouth and dermal exposures are approximately equal contributors to the overall estimates for each product type. The results are similar for the intermediate-term MOEs for each scenario. There is one pet use which is also considered to be a chronic exposure by the Agency. Pet collars are assumed to be worn all of the time so chronic exposure can potentially occur. The chronic MOE for pet collars mirrors the short- and intermediate-term results. The Agency also utilized the results of the submitted study for comparative rangefinder purposes that quantified transferable residues from carbaryl collars (i.e., the Agency anticipates because of the slow collar release that corresponding transferable residues for collars would be lower than for other products). The Agency has concerns over the lack of quality control data in this study but opted to provide risk estimates based on it for comparison because it is a chemical-specific study. To reiterate, a transferability factor of 2.6 percent, instead of the Agency’s standard 20 percent, was developed from this study then used to complete assessments for dusts and liquid products   Even using the 2.6 percent factor, MOEs for dusts and liquid products were well <100 on the day of application. However, the intermediate-term MOE for liquids was >100 using this factor. Direct transferable residue concentrations from the study were also used to calculate risks for collars. Using these concentrations, MOEs exceeded Agency targets by a small margin. The Agency has concerns for the use of dust and liquid products on pets given that the risks associated with dusts and liquids, regardless of whether or not the collar study data were used in the assessment, did not exceed Agency targets (i.e., MOEs<100). The Agency believes that the use of the transferable residue concentrations from the collar study is reasonable to use for the collar assessment. However, because of the marginal quality of the study the Agency believes confirmatory data are needed because MOEs using these data are marginally above 100. The study cannot also be considered for use in any chronic assessment since it measured residue concentrations only out to 7 days after placement of the collars. See Appendix J for more detailed information on how each exposure pathway contributed to the overall exposures.

The assessments for beach play for toddlers after oyster bed treatment considered dermal and nondietary ingestion exposures and also calculated total MOEs. Short-term MOEs were >100 even if the highest monitored sediment concentration value from any study available to the Agency was used as the basis for the calculations. The intermediate-term results were similar. See Appendix M for more information on how each pathway contributed to the overall exposures.

Table 29: Summary of Carbaryl Noncancer Postapplication Residential Aggregate MOEs For Toddlers					
Scenario	Descriptor	Results			
		Short-term MOE on Day 0	Days For Short-term MOE≥ UF	Intermediate-term MOE	Chronic MOE
Pet Treatments	Liquids (Agency approach)	9.5	+30	18.6	NA
	Dusts (Agency approach)	0.10	+30	0.19	NA
	Collars (Agency approach)	84.5	+30	84.5	110 (need 300)
	Liquids (2.6% transferability based on collars)	73.2	7	143	NA
	Dusts (2.6% transferability based on collars)	0.73	+30	1.43	NA
	Collars (measured transferable residues over whole dog)	346	364 at 1 week	NA (only 7 day monitoring)	NA (only 7 day monitoring)
Residential Turf (High Activity)	Max Rate at 4 lb ai/A	11	14	91	NA
	Max Rate at 8 lb ai/A	5	18	45	NA
	Aerial - Mosquito Adulticide 0.016 to 1.0 lb ai/A	448-27983 (350 w/inhalation at 1 lb ai/acre)	0	3826-239095	NA
	Ground - Mosquito Adulticide 0.016 to 1.0 lb ai/A	851-53167	0	7269-454280	NA
Oyster Beds	Beach Play	29532	0	81859	NA
Inhalation MOE for children mosquito control calculated using a ground concentration of 40 ng/L calculated with AgDrift, a respiration rate for light activity, and a 20 minute duration to allow for dissipation of the spray. The MOE for inhalation is 1609.					

3.2.4 Residential Postapplication Exposure and Risk Estimates for Cancer

The residential postapplication exposure and cancer risk calculations are presented in this section. Cancer risks were calculated using a linear low-dose extrapolation approach in which a *Lifetime Average Daily Dose* (LADD) is first calculated and then compared with a Q_1* that has been calculated for carbaryl based on dose response data in the appropriate toxicology study ($Q_1^* = 8.75 \times 10^{-4}$ $(mg/kg/day)^{-1}$). Absorbed average daily dose (ADD) levels were used as the basis for calculating the LADD values. Section 2.1.3 above describes how the ADD values were first calculated for the noncancer MOE calculations. These values also serve as the basis for the cancer risk estimates. Dermal and inhalation ADD values were first added together to obtain combined ADD values. LADD values were then calculated and compared the Q_1* to obtain cancer risk estimates.

LADD and Cancer Risk Calculations: The use of dissipation data and the manner in which daily postapplication dermal exposure values were calculated were inherently different than with handler exposures. Once daily exposure values were determined, the calculation of LADD (Lifetime Average Daily Dose) and the resulting cancer risks use the same algorithms that were described above for the handler exposures (See Section 2.1.4).

As mentioned previously, the Agency has defined a range of acceptable cancer risks based on a policy issued in 1996. This memo refers to a predetermined quantified "level of concern" for residential carcinogenic risk. In summary, residential carcinogenic risks that are 1×10^{-6} or lower require no risk management action. In addition to the cancer risk estimates for an annual frequency of 1 time per year, the number of days of exposure per year required to get a $1x10^{-6}$ cancer risk have been calculated. In this calculation, the $1x10^{-6}$ cancer risk limit was divided by the calculated cancer risk for each scenario for a single day of exposure. This calculation would only be completed for situations where the cancer risks were less than $1x10^{-6}$ on the day of application.

Cancer Risk Summary All of the cancer risk calculations for the various residential carbaryl assessments are included in Appendices H, I, L and M for the turf, home garden, mosquito adulticide, and oyster treatment scenarios, respectively. The specifics of each of table included in these Appendices are described below. A summary of the results for each scenario considered for each timeframe is also provided below.

- **Appendix H/Table 4: Adult Cancer Risk Values For Carbaryl Residential Risk Assessment on Turf** Presents the risks for activities on turf including lawncare and golfing at the two application rates considered in the assessment.

- **Appendix I/Tables 3: Carbaryl Residential Postapplication Adult Cancer Risk Assessment For Deciduous Tree Crop Group** Risk values are presented for different activities in home tree crops.

- **Appendix I/Tables 6: Carbaryl Residential Postapplication Adult Cancer Risk Assessment For Fruiting Vegetable Crop Group** Risk values are presented for different activities in home vegetable gardens.

- **Appendix M/Table 5: Carbaryl Oyster Harvest/Beach Play Risk Assessment For Adults and Toddlers** Presents noncancer and cancer risk estimates for adults and toddlers while oyster harvesting or playing on a beach. This assessment is based on dermal contact with contaminated sediment and hand-to-mouth behavior for toddlers. The highest sediment concentration detected in any data available to the Agency was used to assure screening level nature of assessment.

- **Appendix M/Table 6: Carbaryl Oyster Harvest/Beach Play Risk Assessment For Adults and Toddlers** Presents noncancer and cancer risk estimates for adults if they were to swim in Willapa Bay. All calculations were completed with the Agency's SWIMODEL (V2.0). Results and model inputs are included in this table.

For all scenarios on turf, cancer risks are in the 10^{-8} range or less on the day of application when a single reentry event per year during lawncare activities is evaluated. For home gardening, golfing or from mosquito control, risks are slightly lower in the 10^{-9} to 10^{-12} range when a single reentry event per year is evaluated on the day of application. Table 29 below summarizes the postapplication risk values calculated for adults after applications of carbaryl. Risk managers should consider these values represent a single reentry day into a treated area over each year of a 50 year lifetime on the day of application and that the Agency lacks data to link the annual frequency of reentry activity to residential applications. As with the residential handler risks above, the Agency calculated the number of exposure days needed to reach a risk level of $1x10^{-6}$ for each scenario on the day of application, values range from 20 to over 365 days per year while most exceed 365 days per year.

Table 29: Summary of Carbaryl Postapplication Residential Cancer Risks For Adults

Scenario	Descriptor	Results	
		Risk on Day 0	Allowed Days/Year
Residential Turf (Lawncare)	Max Rate at 4 lb ai/A	2.5×10^{-8}	40
	Max Rate at 8 lb ai/A	5.1×10^{-8}	20
	Aerial - Mosquito Adulticide 0.016 to 1.0 lb ai/A	9.5×10^{-12} to 5.9×10^{-10}	>365
	Ground - Mosquito Adulticide 0.016 to 1.0 lb ai/A	5.0×10^{-12} to 3.1×10^{-10}	>365
Golfing	Max Rate at 4 lb ai/A	1.7×10^{-9}	>365
	Max Rate at 8 lb ai/A	3.5×10^{-9}	287
	Aerial - Mosquito Adulticide 0.016 to 1.0 lb ai/A	6.5×10^{-13} to 4.1×10^{-11}	>365
	Ground - Mosquito Adulticide 0.016 to 1.0 lb ai/A	3.4×10^{-13} to 2.1×10^{-11}	>365
Home Garden (Deciduous Tree)	Very Low Exposure (propping)	2.5×10^{-10}	>365
	Low Exposure (irrigation, scout, weed)	2.5×10^{-9}	>365
	High Exposure (harvest, prune, train, tie)	3.8×10^{-9}	266
	Very High Exposure (thin)	7.5×10^{-9}	133

Table 29: Summary of Carbaryl Postapplication Residential Cancer Risks For Adults			
Scenario	Descriptor	Results	
		Risk on Day 0	Allowed Days/Year
Home Garden (Fruiting Vegetable)	Low Exposure (irrigation, scout, thin, weed)	2.5×10^{-9}	>365
	Medium Exposure (irrigation, scout)	3.5×10^{-9}	289
	High Exposure (harvest, prune, stake, tie)	4.9×10^{-9}	202
Oyster Beds	Oyster Harvest	4.5×10^{-12}	>365
	Swimming	6.1×10^{-12}	>365

3.2.5 Summary of Residential Postapplication Risk Concerns and Data Gaps

The Agency considered a number of exposure scenarios for products that can be used in the residential environment representing different segments of the population including toddlers, youth-aged children and adults. Short-term and intermediate-term noncancer MOEs were calculated for all scenarios. Additionally, cancer risks were calculated for the exposure scenarios involving adults where methods are currently available. Cancer risks were not calculated for children per Agency policy. In residential settings, the Agency does not use REIs or other mitigation approaches to limit exposures because they are viewed as impractical and not enforceable. As such, risk estimates on the day of application are the key concern.

The Agency has short-term risk concerns for exposures to adults doing heavy yardwork, for toddlers playing on treated lawns, and for toddlers that have contact with pets treated with dust or liquid products. Activities associated with home gardening (e.g., harvesting) and golfing for adults, home gardening for youth-aged children, toddler contact with pets wearing carbaryl collars, or any age or activity considered in the adulticide mosquito control or oyster assessment do not have risk concerns even on the day of application (i.e., MOEs $\geq$100 on the day of application). For adults, the MOEs for heavy yardwork do not meet or exceed risk targets (i.e., MOE = 100) up to 5 days after application. For toddlers, the Agency has concerns for pet treatments and also for lawn uses. In fact, pet uses never reach acceptable levels even 30 days after application (using Agency approach on pets) and not until 18 days at the maximum application rate considered on turf. Toddler MOEs from pet and turf uses represent total exposures from many pathways. For the pet uses, dermal and hand-to-mouth exposures essentially both equally contribute to the overall estimate. For the turf uses, dermal and hand-to-mouth exposures are also the key contributors to the overall estimates.

The Agency does not have intermediate-term risk concerns for adults and youth-aged children for any of the uses considered including lawncare, home gardens, golfing, and any aspect of adulticide mosquito control or oyster bed uses. Likewise, the Agency does not have concerns for children’s contact with pets treated with carbaryl collars. In contrast, the Agency does have intermediate-term risk concerns for all toddler exposure scenarios considered except pet collars (i.e., pet treatments and lawncare uses). As with the short-term MOEs, pet and turf uses represent total exposures where the significant contributions to overall exposures are again made equally from the dermal and hand-to-mouth exposure pathways.

Cancer risks were calculated only for adults and were found to be in the 10^{-8} to 10^{-12} range, regardless of the scenarios considered, on the day of application (e.g., lawncare, golfing and gardening). Risks did not exceed $1x10^{-6}$ on the day of application for any scenario considered. All postapplication cancer risks were calculated based on an annual frequency of 1 exposure per year. It is likely that additional events could occur but data linking postapplication activities and carbaryl use patterns are not available. To address this issue, the Agency calculated the number of exposures that can occur under a cancer risk ceiling of $1x10^{-6}$ and determined that from 20 days per year to exposures every day of the year could occur depending upon the scenario. Results indicate most activities can occur from every day of the year even at residue levels present on the day of application..

Unlike many residential risk assessments, the postapplication residential assessment for carbaryl is based on a number of chemical-specific studies that have been used to calculate risks from turf uses (e.g., TTR study) and in gardens (i.e., DFR data). These studies are all considered state-of-the-art by the Agency. A transferable residue study from dogs treated with carbaryl collars was also submitted. This study was of marginal quality because of a lack of quality control information. However, it did provide useful information for risk assessment purposes along with the appropriate considerations related to data quality. Additional data could potentially be used to refine risk estimates for the other settings such as additional DFR data on different crops and TTR data which are more appropriate for hand-to-mouth and object-to-mouth exposures.

The Agency combines risks resulting from total exposures to individual chemicals when it is likely they can occur simultaneously based on the use pattern and the behavior associated with the exposed population. For carbaryl, the Agency has combined risk values (i.e., MOEs) for different kinds of exposures associated with the turf (dermal, hand-to-mouth, object-to-mouth, and soil ingestion) and pet scenarios (dermal and hand-to-mouth). These represent the standard set of exposures that are typically added together when chemicals are used on turf or on pets because it is logical they can co-occur. Typically, the Agency only adds exposures from different exposure scenarios together (e.g., spraying and gardening) when risks from both are not already a concern. For carbaryl, there are risk concerns for many residential handler scenarios already so the Agency did not add risk values from any postapplication exposure together with applicator risks.

In summary, the deterministic assessment for residential exposure presented in this section concludes that there are a significant number of risk concerns for carbaryl as it is currently used in a residential environment. However, as noted above, Bayer Crop Science has completed an a suburban resident biological monitoring study that should also be considered in context with these results as well as the probabilistic assessments which have been completed.

3.2.6 Recommendations For Refining Residential Postapplication Risk Assessment

In order to refine this residential assessment, data on actual use patterns including rates, timing, and the kinds of tasks that are required to better characterize carbaryl risks. Exposure studies for many cultural practices that lack data or that are not well represented in the current Agency guidance should also be considered based on the data gaps identified above (e.g., pet uses). Risk managers should consider that the risks associated with current label generally do not meet Agency targets, especially for the turf, pet and high exposure garden scenarios.

The Bayer Corporation has attempted to respond to many of the issues raised above by conducting the suburban resident biomonitoring study and providing supporting information on use patterns (e.g., REJV survey results) and pharmacokinetics. As such, the results of this assessment will be considered in context with the information presented in *Section 3.3: Carbaryl Suburban Resident Biomonitoring Study, Associated Data & Risks* where risks based on the suburban resident biological monitoring study have been presented. This assessment is based on a deterministic approach which should also be considered in context with the companion probabilistic assessments that have been (or will be) submitted/generated by Bayer Crop Sciences and the Chemistry and Exposure Branch of the Health Effects Division of OPP (see Section 3.4 below for further information). A large percentage of those monitored were residential dwellers which allows for direct comparison to the passive dosimetry based assessment presented in this section.

3.3 Carbaryl Suburban Resident Biomonitoring Study, Associated Data & Risks

In addition to the handler and postapplication residential deterministic risk assessments described above in Sections 3.1 and 3.2, a suburban resident biological monitoring study has also been conducted by the Bayer Corporation. The biological monitoring study, supporting data, and associated risks are examined in this section. The scenarios which are addressed by the suburban resident biological monitoring study are described in *Section 3.3.1: Scenarios Addressed In Biomonitoring Study*. *Section 3.3.2: Biological Monitoring and Associated Data/Assumptions* presents the all of the additional data/inputs used to evaluate and use the study for risk assessment purposes. Data presented in several scientific literature articles where carbaryl dose was monitored in the general population is also provided in this section for characterization purposes. *Section 3.3.3: Residential Noncancer Risks Based On Biological Monitoring Data* presents the risk estimates calculated by the Agency using the data as well as a comparison to those calculated by the Bayer Corporation. *Section 3.3.4: Residential Cancer Risks for Cancer Based On Biological Monitoring Data* is similar except that associated cancer risks are presented for adults. *Section 3.3.5: Summary of Residential Risk Concerns and Data Gaps Based On Biological Monitoring Data* summarizes the Agency's perspective on the results and appropriate use of these data as well as the associated risk estimates. *Section 3.3.6: Recommendations For Refining Residential Risk Assessment Based On Biological Monitoring Data* describes where the Agency believes additional analysis or data could improve the assessment based on the biological monitoring data.

3.3.1 Scenarios Addressed In Biomonitoring Study

The suburban resident biological monitoring study quantified exposures to those individuals who lived in households where the lawns and garden or ornamentals were treated with carbaryl Garden Tech liquid formulation via a hose-end sprayer. The hose-end sprayers were ready-to-use containers which eliminated the need for a mixing step by the applicators. Ten families were monitored in Missouri and 13 families were monitored in California. All applications to turf were broadcast across the entire lawn area. Exposures to all inhabitants of the treated residences were monitored including children of various ages (4 and up), non-applicator adults (considered anyone over 18 years old living in the homes), and adult applicators. Therefore, the monitoring regimen in this study included applicator scenarios and those of all ages who were exposed by reentering treated areas. There were no controls on activities for those who were monitored in this study. Some individuals spent time outdoors in proximity to the treated areas and others did not. Differences within individuals' activities and their exposures were examined in the analysis of the study data.

According to the results of the *Residential Exposure Joint Venture* survey, which is described in more detail below (Section 3.3.2), carbaryl use on lawns is not predominant in the residential market. Uses on vegetables and ornamentals account for the most use in the residential marketplace. Approximately 1.2 percent of the general United States population uses carbaryl on lawns and about 50 percent of that is for spot treatments which is considered a negligible exposure scenario by the Agency (i.e., about 0.5 percent of the population uses carbaryl on lawns in a way that creates a significant exposure source). Approximately 4 to 5 percent of the United States population uses carbaryl on vegetables and ornamentals. The likelihood of a co-occurrent application scenario, however, also needs to be understood to fully characterize the population that was monitored in this study. This was examined using a conditional probability approach. Conditional probabilities indicate that if a turf application is made, then 18 percent of the time that individual will also treat their vegetables or 44 percent of the time that individual will also treat their ornamentals. This means that no more than 0.09 percent of the general United States population will treat their lawns and their vegetables at the same time or that no more than 0.22 percent of the general United States population will treat their lawns and ornamentals at the same time with carbaryl as was monitored in this study. These population estimates need to be considered in the context of interpreting any companion probabilistic risk assessments where the 99.9th %tile is generally used for regulatory purposes. [Note: Also see section 3.3.2 below for more information concerning the analysis of the REJV data.]

The utility of the results described above related to the size of the exposed populations and level of co-occurrence is based on the premise that for each additional co-occurrent use pattern there is a direct increase in exposure because more chemical is used and there is more (and equal) likelihood for exposure in each microenvironment. This may or may not be the case but it is considered unlikely by the Agency because the use on lawns is believed to be the predominant contributor to carbaryl exposures in the residential environment, particularly for children. Based on this approach, the Agency believes that the scenario monitored in the suburban resident biological monitoring study is also a reasonable approximation for any use of carbaryl on a lawn (i.e., 0.5 percent of the general population) and use of these data should not just be limited to representing the smaller portions of the general population that happen to use carbaryl concurrently on lawns and vegetables or ornamentals. Another element that should be considered is that a series of comments were received by the Agency about how the study results could be used to characterize other types of exposure patterns (e.g., uses on pets). The Agency position at this time is that the data are insufficient to represent the suburban resident biological monitoring study as a bounding estimate for all exposures in the general population. For example, exposures to children who have been around treated pets may have similar or slightly higher exposures than those monitored in the study.

3.3.2 Biological Monitoring and Associated Data/Assumptions

All of the submissions from Bayer which were considered in this section are presented below. They include the following:

- **Carbaryl Mammalian Metabolism and Pharmacokinetics**; EPA MRID 457885-02; Report dated August 15, 2002; Authors: John Ross and Jeff Driver; Sponsor: Bayer Crop Science.

- **Measurement of Pesticide Exposure of Suburban Residents Associated With The Residential Use of Carbaryl**; EPA MRID 457885-01; Authors: Fred Rice and Joann Grant; Sponsor: Bayer Crop Science.

- **Analysis of Potential Carbaryl Exposure Resulting From Residential Lawn and Garden Use**; EPA MRID 457920-01; Report dated October 24, 2002; Authors: Curt Lunchick; Sponsor: Bayer Crop Science.

- **Assessment of Carbaryl Residential Use Patterns Using The Residential Exposure Joint Venture Database**; EPA MRID 456905-01; Report dated May 30, 2002; Authors: Curt Lunchick; Sponsor: Bayer Crop Science.

In addition to the studies submitted by Bayer, the following articles from the scientific literature were considered in the analysis and characterization of the data from the biomonitoring study. The articles which were used include:

- **A Longitudinal Investigation of Selected Pesticide Metabolites in Urine**; Journal of Exposure Analysis And Environmental Epidemiology 9, 494-501 (1999); Authors: MacIntosh, Needham, Hammerstrom, and Ryan.

- **Residential Environmental Measurements In The National Human Exposure Assessment Survey (NHEXAS) Pilot Study In Arizona: Preliminary Results For Pesticides and VOCs**; Journal Of Exposure Analysis and Environmental Epidemiology 9, 456-470 (1999); Authors: Gordon, Callahan, Nishioka, Brinkman, O'Rourke, Lebowitz, and Moschandreas. [Note: This article was reviewed but carbaryl was not sampled in this study.]

- **Pesticide Residues In Urine Of Adults Living In The United States: Reference Range Concentrations**; Environmental Research 77, 99-108 (1995); Authors: Hill, Head, Baker, Gregg, Shealy, Bailey, Williams, Sampson, and Needham.

- **Measurement Of Children's Exposure To Pesticides: Analysis Of Urinary Metabolite Levels In A Probability-Based Sample**; Environmental Health Perspectives Vol. 109, Number 6, 583-590, (June 2001); Authors: Adgate, Barr, Clayton, Eberly, Freeman, Lioy, Needham, Pellizzari, Quackenboss, Roy, and Sexton.

- **National Report on Human Exposure to Environmental Chemicals**; January 2003; Second Report completed by CDC, available at http://www.cdc.gov/exposurereport.

A review and summary of each of the documents is presented below. This includes a summary of the study, the key results, and any issues associated with using the data.

MRID 457885-02 (Carbaryl mammalian metabolism and pharmacokinetics - see separate review by Dr. Kit Farwell for further information): This document describes how Bayer Crop Sciences identified the appropriate metabolite to screen for in a biological monitoring study for carbaryl and also the metabolic factors that were used to calculate absorbed dose estimates. It was indicated "the purpose of this literature review is to document the most biologically relevant stoichiometric conversion of carbaryl to 1-naphthol metabolites in humans as an adjunct to interpreting human biomonitoring data and to contrast human metabolism with other animal species."

The reviewers conducted an analysis using existing research in which rodent metabolism of carbaryl was examined as was metabolism in various other mammalian species, including humans. No mention was made in the study concerning compliance with Common Rule requirements in the studies that involved humans. The approach proposed in the paper has been accepted by the Agency for risk assessment purposes. In the end, the authors relied on 3 oral studies in humans conducted by Knaak (2, both in 1968) and Lykins (1976). The authors proposed the following:

> "In summary, the recommended stoichiometric conversion factor to represent recent (within 96 hours post-exposure) 1-naphthol measurements in human urine samples as estimates of carbaryl-absorbed dose is 3.5 [i.e., 1-naphthol normalized concentration (per L) or dose (per kg body weight), corrected for analytical method recovery efficiency, x 3.5 = carbaryl concentration or dose.]"

The 3.5 factor was derived by multiplying a stoichiometric conversion factor based on molecular weight differences between carbaryl and 1-naphthol (i.e., 1.4 = MW carbaryl 201.2/MW 1-naphthol 144.2) by the partition coefficient of 2.5 developed based on the 3 human oral studies that indicate 40 percent of the administered dose is eliminated in the urine (i.e., 1.4 x 2.5 =3.5). The other key piece of information is the time it takes for a single dose to be eliminated in humans. The excretion profile indicates that it takes 96 hours for a single dose to be eliminated and that approximately 50 percent is eliminated throughout the first 24 hours after an exposure event then the rest in a steadily declining mode out to total elimination at 96 hours.

MRID 457885-01 (Suburban resident biomonitoring study): This study quantified exposures in August 2001 to carbaryl via biological monitoring of inhabitants in 23 suburban residences after application of Sevin GardenTech Ready-to-Spray formulation (22.5 % ai w/w). This formulation of carbaryl is labeled for use on lawns, gardens, and ornamentals for insect control. Ten families were monitored in Missouri and 13 families were monitored in California. Six total urine samples (24 hour composites) were collected from each resident, 4 years old and above, beginning 2 days prior to application and ending 3 days after application (i.e., samples collected -2, -1, 0, 1, 2, 3 days after application). A metabolite of carbaryl (1-naphthol) was measured and those levels were used to calculate absorbed dose estimates for carbaryl. All totaled, 106 people were monitored including 23 applicators, 28 non-applicator adults, and 55 children ages 4 to 17. The number of children, segmented by different age groups, were as follows: 4 to 5 years (13); 6 to 10 years (19); 11 to 15 years (20); and 16 to 17 years (3). The monitored families were from central Missouri near Columbia and southern California about 50 miles east of Los Angeles in Riverside. The objective of this study was to monitor people in residences while they were engaged in normal activities. No directives as to the use of personal protective equipment or hygiene issues related to pesticide exposure were provided by the investigators. Along with 1-naphthol results, the data provided for each person in the study included personal information (age, weight, sex, height); the time they spent outdoors and the nature of their activities (i.e., in a recall survey, they were asked if they performed certain activities that could lead to exposure such as yardwork or play); and information pertaining to the exposures received (e.g., daily creatinine output and urine volumes).

Ready-to-Use hose-end sprayer packages, which eliminate the need for mixing a solution from concentrated formulations, were used to make all applications. Applications were made to "lawn and/or garden or ornamental" areas. The protocol for this study required that each family treat their lawn and garden or ornamental area (i.e., at all sites, lawn areas were treated). An area treated value was reported for each application but there was no description of specifically how lawn and garden/ornamental areas were distributed in California although the report indicated for all sites "each applicator treated approximately 4,000 to10,000ft^2 of lawn and/or approximately 400 to 1,000 ft^2 of garden or ornamentals on the property or residence." Specific areas were reported for the Missouri sites. No indication was made in the study report concerning the level of clothing worn by the applicators. Most (18 of 23) applicators were men. The average age of the applicators was 39.4 years while the age ranged from 18 to 58 years old. According to the data provided in the report, the average amount of carbaryl applied was 0.71 lb ai/residence while the amount ranged from 0.56 to 1.35 lb ai/residence. The average area treated was approximately 5700 ft^2 which ranged from approximately 150 ft^2 to 14,300 ft^2. The amount of time spent outdoors was recorded for each individual because it represents a proximity for people to the source of exposure (i.e., treated lawns, gardens and/or ornamentals). The average amount of time that applicators spent outside (i.e., in activities that may contribute to exposure such as yardwork or play) over the period from application to the end of monitoring (i.e., days 0, 1, 2, and 3) was 158 minutes while the time ranged from 0 to 1080 minutes for all applicators.

Most (21 of 28) non-applicator adults (anyone ≥ 18 years old) were women. The average age of these non-applicator adults was 38.1 years while the age ranged from 18 to 73 years old. The average amount of time that non-applicator adults spent outside over the post-application monitoring period was 84 minutes while the time ranged from 0 to 690 minutes. Most (30 of 55) monitored children were from Missouri and most (~58% or 32 of 55) were female. The average age of all children monitored was 9.3 years while the age ranged from 4 to 17 years old. The average amount of time that children spent outside in proximity to treated lawns, ornamentals, and/or gardens over the post-application monitoring period was 201 minutes while the time ranged from 0 to 1200 minutes. The time spent outdoors did not significantly vary between Missouri and California. The results for children were segregated into different age groups that included 4 to 5 years olds, 6 to 10 year olds, 11 to 15 year olds, and 16 to 17 year olds where the average time spent outside for each age group was, respectively: 256 minutes, 213 minutes, 143 minutes, and 270 minutes. The range for each of these age groups for time spent outside was approximately 0 to > 800 minutes except for 11 to 15 year olds where the range was from 0 to 480 minutes.

Urine samples were collected in 4 liter plastic containers and kept in "Coleman-type" coolers on ice. Each individual had their own cooler. Samples were retrieved by the field staff on a daily basis and the volumes/weights of each sample were recorded. The analytical laboratory was in close proximity to the Missouri field sites so those bulk samples were processed and stored at the laboratory. For the California samples, three 100 mL aliquots were taken and sent for analysis on dry ice (the "majority" were received in good condition) while the remaining bulk samples were retained in California.

Urine samples were analyzed starting in December, 2001 and the analyses were complete in April, 2002. The carbaryl metabolite (1-naphthol) was extracted from urine using amino and C_{18} solid phase extraction columns in tandem. Residues were then eluted with methanol, which was solvent exchanged using evaporation with HPLC mobile phase, then quantified using fluormetric and UV detection in tandem. The conditions of the HPLC analysis were typical (Alltech ODS Column, Shimadzu Instrumentation, and methanol/acetonitrile/ammonium phosphate mobile phase). The LOQ or *Limit of Quantitation* for the method was 10ppb or 0.01ppm. Performance criteria were established for the method that required recovery values at the LOQ to be between 70 and 120 percent. Several types of quality control samples were generated in this study including laboratory method validation, laboratory recovery which were analyzed concurrently with the field samples, field recovery samples (these were spiked, refrigerated for 24 hours then frozen like the field samples), and travel recovery samples (these were spiked then placed directly in a freezer to evaluate residue losses over time in shipment & storage). Samples of each type were fortified at different levels. Table 30 provides a summary of the spiking levels and results for each type of quality control sample generated in this study. The average recovery for 1-naphthol was approximately 80 percent regardless of the type of sample. This indicates that there were no residue losses due to storage or transport and that the analytical method used could recover approximately this amount on a routine basis.

Table 30: Recovery Data For Suburban Resident Biomonitoring Study					
Sample Type	Fortification Level (ppm)	N	Recovery (%) of 1-naphthol		
			Avg.	Std.	CV
Method Validation	0.01 0.10 1.00 All	2 2 2 6	71.5 80.9 84.3 78.9	0.14 0.89 0.93 6	0.20 1.0 1.0 8
Field Recovery	0.10 1.00 All	10 9 19	73.1 85.2 78.8	6.74 2.6 8.0	9.2 3.1 10.1
Travel Recovery	0.10 1.00 All	12 12 24	74.2 83.0 78.6	7 5 7	9 6 9
Laboratory Recovery	0.01 to 5.0	49	81.2	11.5	14
According to the report, urine concentrations were corrected for "the overall average recovery form the field fortifications from both locations" which was 78 percent. Laboratory fortification levels were varied so just a summary was presented.					

The raw data included in this study (outside of the analytical recovery data presented above) and the Agency's analysis of those data are presented in Appendix N (Tables 1 through 8). The data tables can be identified by the following:

- **Appendix N/Table 1: Missouri Exposure Pattern Data** This table describes individuals personal statistics (e.g., height, weight, etc.), how much chemical was used at each site, and the activity diary for each person.

- **Appendix N/Table 2: Missouri Exposure Data (Carbaryl Absorbed Dose Values Are Creatinine Corrected If Appropriate)** This table describes individuals personal statistics (e.g., height, weight, etc.), daily urine volume output, daily creatinine output, and daily dose estimates (as carbaryl equivalents).

- **Appendix N/Table 3: Missouri Urine Output & Calculation Of Percent Deviation From Average** This table describes individuals daily urine volume output then calculates their daily deviations from their individual average.

- **Appendix N/Table 4: Missouri Creatinine Output & Calculation Of Percent Deviation From Average** This table describes individuals daily creatinine output then calculates their daily deviations from their individual average.

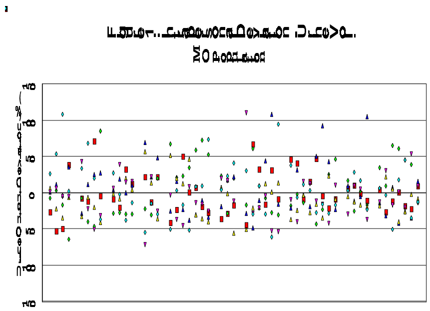
- **Appendix N/Table 5: California Exposure Pattern Data** This table describes individuals personal statistics (e.g., height, weight, etc.), how much chemical was used at each site, and the activity diary for each person.

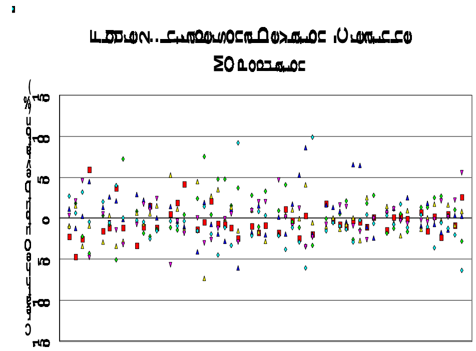
- **Appendix N/Table 6: California Exposure Data (Carbaryl Absorbed Dose Values Are Creatinine Corrected If Appropriate)** This table describes individuals personal statistics (e.g., height, weight, etc.), daily urine volume output, daily creatinine output, and daily dose estimates (as carbaryl equivalents).

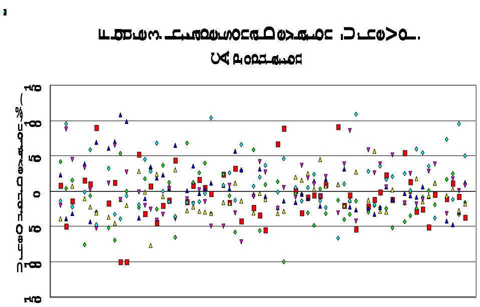
- **Appendix N/Table 7: California Urine Output & Calculation Of Percent Deviation From Average** This table describes individuals daily urine volume output then calculates their daily deviations from their individual average.

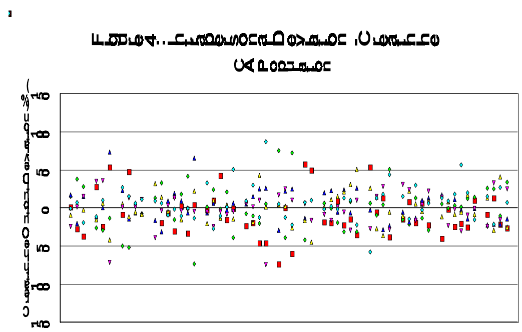
- **Appendix N/Table 8: California Creatinine Output & Calculation Of Percent Deviation From Average** This table describes individuals daily creatinine output then calculates their daily deviations from their individual average.

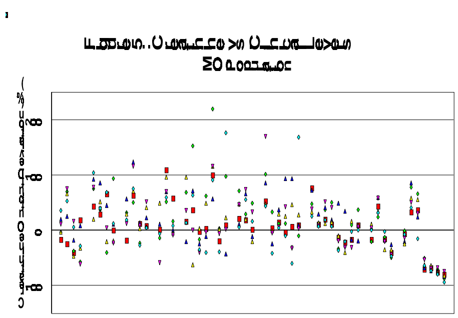
The first step in the analysis of the biological monitoring data was to evaluate the sample collection process. A review of the field sample collection procedures was completed and all processes appear appropriate. Daily urine volumes and creatinine outputs were examined to establish the level of variability within individuals. Extremely variable results would be an indication of suspect sampling events. This type of variability was not noted in these data. Average daily urine output and creatinine outputs were compared to the average for each person. The results for these analyses are presented in Figures 1 through 4. Along with the intrapersonal comparisons described above, comparisons using the daily output of creatinine of those monitored to clinically accepted values were made to ensure complete collection compared to recognized values (i.e., the standard values are from Reference Man, adults are considered >12 years old, 1.7 g/day for adult males, 1.0 g/day for adult females, and 0.08 g/day/years old for children ≤12 years old). This analysis was completed by calculating the percent deviation for each individual's daily output to clinical values. These results are presented in Figures 5 and 6.

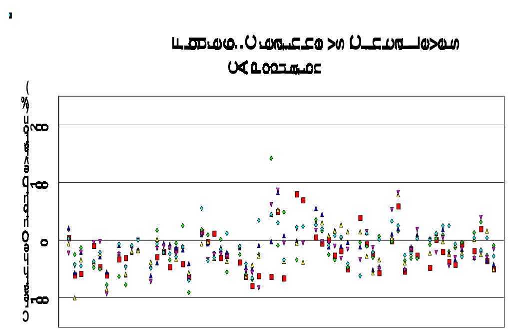












Overall, the data appear to be of sufficient quality for use in risk assessment as the intra-individual variability are what would be expected and the results indicate that most samples compare well with established clinical reference values indicating complete sample collection in this study. In California, the trend was slightly lower than the reference values while in Missouri the trend was reversed and most results exceed the reference values. The investigators corrected results in individual samples if creatinine levels, urine volumes, or other parameters were aberrant as described below:

> "The results for samples with missed voids reported by the participants, low urine volumes, or creatinine values greater than one standard deviation from the individual's mean creatinine value were corrected using the participant's average creatinine value from the remaining samples (excluding the outlier). No participant had a creatinine value that equaled or exceeded two standard deviations from the individual's mean value. In cases

with more than one outlier for an individual, the creatinine value based on age and gender was used."

There are several possible approaches for calculating dose levels that would be used for risk assessment purposes because of the duration it takes to eliminate carbaryl residues from the body (MRID 457885-02: 50 % in 24 hours, total in 96 hours), the non-controlled nature of the study, and the activity patterns that are described in the activity diaries for each individual. In order to complete a comprehensive analysis, the Agency has considered the data in several ways including:

- **Post-Application Total Dose:** All post-application dose values were added together over the sample collection timeframe of 96 hours. The justification for this approach is that it takes 96 hours for carbaryl residues to be eliminated from the body (i.e., the length of post-application monitoring in the study). There are considerations because it can overestimate dose if there are multiple exposures on separate days but it could also underestimate dose if significant contributing events to the overall dose occurred at a later point in the monitoring.

- **Individual Daily Dose:** Dose estimates were calculated based on results for each individual person-day monitored in the study. **This approach was used by Bayer in their analysis of the data.** There are considerations because it assumes what could be called a "quasi-steady state approach" but it does not account for mass balance over the 96 hours needed to eliminate residues which could severely underestimate exposures. Based on the pharmacokinetic information, only 50 percent of carbaryl residues are eliminated on the first day after exposure.

- **Individual Daily Dose Corrected For Mass Balance:** The individual person-day dose estimates were used but they were corrected for mass balance observed in the pharmacokinetic analysis which indicated only 50 percent of carbaryl residues are eliminated on the first day after exposure.

[Note: The Agency evaluated the data in the manner described above to examine the differences in each approach and the impacts upon the ultimate risk calculations. The differences which were identified are described below and a recommendation to use the *Post-Application Total Dose* for regulatory use is provided.]

The next step was to group data for individuals based on factors that included location, age, gender, and applicator status to statistically summarize the data and to examine if there were relationships between factors such as application rate or time spent outside and dose. These analyses are presented In Appendix N, tables 9 through 15. These tables can be identified by the following:

- **Appendix N/Table 9: Applicator Data Analysis** This table describes how the dose estimates for the applicators in the study were statistically summarized. Additionally, a series of regression analysis were completed to examine potential relationships between dose and amount applied, application rate, location, and time outdoors.

- **Appendix N/Table 10: Non-Applicator Adult Data Analysis** This table describes how the dose estimates for the non-applicator adults (anyone over 18 living in the treated homes) in the study were statistically summarized. Additionally, a series of regression analysis were completed to examine potential relationships between dose and amount applied, application rate, location, and time outdoors.

- **Appendix N/Tables 11 through 13 (a & b) : Children's Data Analysis** These tables describe how the dose estimates for monitored children in the study were statistically summarized. Additionally, a series of regression analysis were completed to examine potential relationships between dose and amount applied, application rate, location, and time outdoors.

- **Appendix N/Table 14: Children's Data Rank Order Analysis Based On Dose** This table describes how the dose estimates for all children were placed in rank order.

- **Appendix N/Table 15: Statistical Summary Of Data** This table provides a summary of the exposure statistics which were calculated in tables 9 through 14.

A summary of the data described in Appendix N is provided below. Table 31 provides the summary information for applicators. Table 32 provides the information for non-applicator adults. Tables 33 and 34 for small children of different ages (4 to 5 year olds and 6 to 10 year olds). Figures 7 also provides an overall graphical summary of the key results. For brevity, data for 11 through 17 year old children were not presented in a summary table here because in all cases their exposures were lower than the younger children as would be expected.

Table 31: Summary Statistics For Residential Carbaryl Applicators

Statistic	Age (Yrs)	Applied (lb ai)	Area Treated (ft^2)	Appl. Rate (lbai/1000 ft^2)	Total Time Outdoors (Min.)	Post Application Total Dose (µg/kg/day)	Individual Daily Dose (µg/kg/day)	Corrected Individual Daily Dose (µg/kg/day)
Avg.	39.4	0.710	5710	0.447	158	19.1	4.76	9.5
Minimum	18	0.562	150	0.047	0	1.5	0	0
Maximum	58	1.350	14340	3.745	1080	54.6	25.5	51.0
Median	41	0.562	6064	0.144	80	13.1	2.6	5.2
25^{th} %tile	35	0.562	1275	0.092	38	4.4	1.1	2.1
75^{th} %tile	46	0.901	9000	0.442	158	27.2	5.5	11.1

Table 31: Summary Statistics For Residential Carbaryl Applicators								
Statistic	Age (Yrs)	Applied (lb ai)	Area Treated (ft^2)	Appl. Rate (lbai/1000 ft^2)	Total Time Outdoors (Min.)	Post Application Total Dose (µg/kg/day)	Individual Daily Dose (µg/kg/day)	Corrected Individual Daily Dose (µg/kg/day)
95th %tile	56	0.901	13620	1.339	523	51.1	18.2	36.5
99th %tile	58	1.251	14221	3.230	961	54.0	22.0	44.1

The *Total Time Outdoors* represents the total amount of time spent outdoors by the subjects on the day of application and all monitored days thereafter. The *Post Application Total Dose* represents carbaryl equivalent dose residues in urine added together from the day of application through the last day of monitoring as the excretion profile of carbaryl/1-naphthol indicates a 96 hour clearance interval. *Individual Daily Dose* estimates represent 24 hour person-day samples not corrected for mass balance or adjusted with any other pharmacokinetic factor. *Corrected Individual Daily Dose* estimates represent 24 hour person-day samples which have been corrected for 50 percent mass balance/elimination on each day sampled. [Note: The Agency recommends Post Application Total Dose values for regulatory action because they account for mass balance and are conservative in nature compared with the other approaches.]

Table 32: Summary Statistics For Non-applicator Adults Who Reside In Houses Where Lawns And/Or Gardens Were Treated								
Statistic	Age (Yrs)	Applied (lb ai)	Area Treated (ft^2)	Appl. Rate (lbai/1000 ft^2)	Total Time Outdoors (Min.)	Post Application Total Dose (µg/kg/day)	Individual Daily Dose (µg/kg/day)	Corrected Individual Daily Dose (µg/kg/day)
Avg.	38.1	0.684	5102	0.428	84	8.1	2.0	4.0
Minimum	18	0.562	150	0.053	0	0.7	0	0
Maximum	73	1.350	14340	3.745	690	38.8	12.6	25.2
Median	38	0.562	4417	0.168	15	6.8	1.4	2.7
25th %tile	31	0.562	1350	0.098	0	3.0	0.6	1.2
75th %tile	43	0.817	9000	0.416	60	9.7	2.8	5.6
95th %tile	63	0.901	12916	1.175	438	16.5	5.2	10.3
99th %tile	71	1.229	14194	3.113	633	33.0	12.1	24.2

The *Total Time Outdoors* represents the total amount of time spent outdoors by the subjects on the day of application and all monitored days thereafter. The *Post Application Total Dose* represents carbaryl equivalent dose residues in urine added together from the day of application through the last day of monitoring as the excretion profile of carbaryl/1-naphthol indicates a 96 hour clearance interval. *Individual Daily Dose* estimates represent 24 hour person-day samples not corrected for mass balance or adjusted with any other pharmacokinetic factor. *Corrected Individual Daily Dose* estimates represent 24 hour person-day samples which have been corrected for 50 percent mass balance/elimination on each day sampled. [Note: The Agency recommends Post Application Total Dose values for regulatory action because they account for mass balance and are conservative in nature compared with the other approaches.]

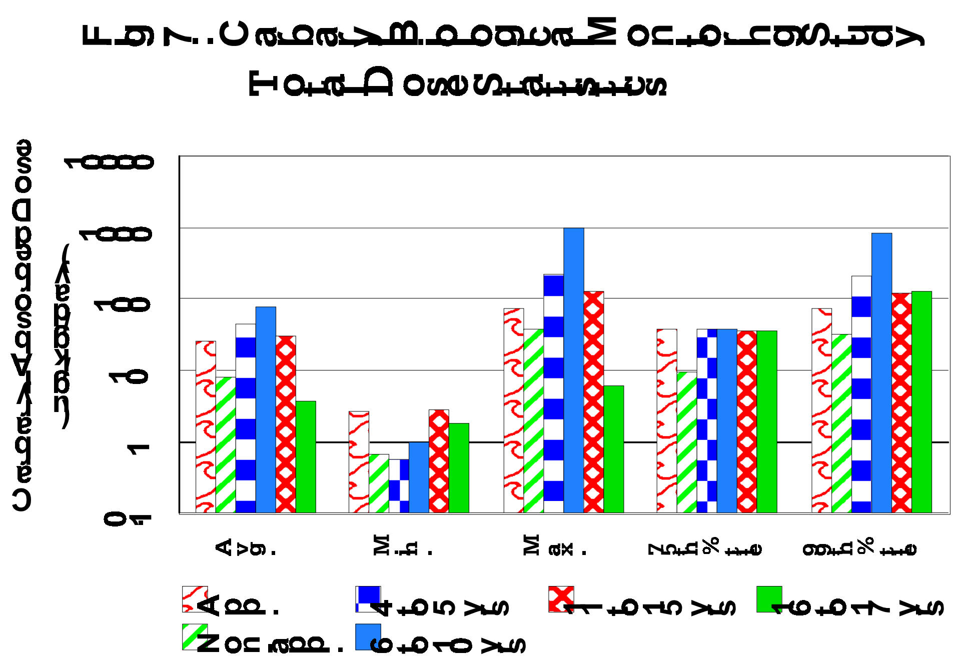
Table 33: Summary Statistics For Children (4 to 5 years) Who Reside In Houses Where Lawns And/Or Gardens Were Treated								
Statistic	Age (Yrs)	Applied (lb ai)	Area Treated (ft^2)	Appl. Rate (lbai/1000 ft^2)	Total Time Outdoors (Min.)	Post Application Total Dose (μg/kg/day)	Individual Daily Dose (μg/kg/day)	Corrected Individual Daily Dose (μg/kg/day)
Avg.	4.4	0.813	5961	0.327	256	44.6	11.2	22.3
Minimum	4	0.562	400	0.047	0	0.6	0	0
Maximum	5	1.350	12000	1.404	1200	219.9	126.0	252.0
Median	4	0.901	6707	0.144	60	21.9	4.5	9.0
25^{th} %tile	4	0.562	1400	0.104	45	12.3	1.6	3.2
75^{th} %tile	5	0.901	9404	0.401	240	39.2	10.0	19.9
95^{th} %tile	5	1.350	11565	0.983	966	164.9	57.4	114.8
99^{th} %tile	5	1.350	11913	1.320	1153	208.9	97.7	195.4

The *Total Time Outdoors* represents the total amount of time spent outdoors by the subjects on the day of application and all monitored days thereafter. The *Post Application Total Dose* represents carbaryl equivalent dose residues in urine added together from the day of application through the last day of monitoring as the excretion profile of carbaryl/1-naphthol indicates a 96 hour clearance interval. *Individual Daily Dose* estimates represent 24 hour person-day samples not corrected for mass balance or adjusted with any other pharmacokinetic factor. *Corrected Individual Daily Dose* estimates represent 24 hour person-day samples which have been corrected for 50 percent mass balance/elimination on each day sampled. [Note: The Agency recommends Post Application Total Dose values for regulatory action because they account for mass balance and are conservative in nature compared with the other approaches.]

Table 34: Summary Statistics For Children (6 to 10 years) Who Reside In Houses Where Lawns And/Or Gardens Were Treated								
Statistic	Age (Yrs)	Applied (lb ai)	Area Treated (ft^2)	Appl. Rate (lbai/1000 ft^2)	Total Time Outdoors (Min.)	Post Application Total Dose (μg/kg/day)	Individual Daily Dose (μg/kg/day)	Corrected Individual Daily Dose (μg/kg/day)
Avg.	8.0	0.768	5868	0.314	213	78.3	19.6	39.1
Minimum	6	0.562	400	0.053	0	1.0	0	0
Maximum	10	0.901	14340	1.404	810	996.6	447.0	894.0
Median	8	0.901	6064	0.134	120	18.5	2.7	5.4
25^{th} %tile	7	0.562	2250	0.120	53	8.3	1.4	2.8
75^{th} %tile	9	0.901	7526	0.281	278	39.4	7.7	15.4

Table 34: Summary Statistics For Children (6 to 10 years) Who Reside In Houses Where Lawns And/Or Gardens Were Treated								
Statistic	Age (Yrs)	Applied (lb ai)	Area Treated (ft^2)	Appl. Rate (lbai/1000 ft^2)	Total Time Outdoors (Min.)	Post Application Total Dose (µg/kg/day)	Individual Daily Dose (µg/kg/day)	Corrected Individual Daily Dose (µg/kg/day)
95th %tile	10	0.900	11582	1.400	810	208.2	57.2	114.3
99th %tile	10	0.901	13788	1.404	810	838.9	372.0	744.0

The *Total Time Outdoors* represents the total amount of time spent outdoors by the subjects on the day of application and all monitored days thereafter. The *Post Application Total Dose* represents carbaryl equivalent dose residues in urine added together from the day of application through the last day of monitoring as the excretion profile of carbaryl/1-naphthol indicates a 96 hour clearance interval. *Individual Daily Dose* estimates represent 24 hour person-day samples not corrected for mass balance or adjusted with any other pharmacokinetic factor. *Corrected Individual Daily Dose* estimates represent 24 hour person-day samples which have been corrected for 50 percent mass balance/elimination on each day sampled. [Note: The Agency recommends Post Application Total Dose values for regulatory action because they account for mass balance and are conservative in nature compared with the other approaches.]



In order to develop a better understanding of the exposures that occurred in this study, the Agency completed a series of regression analyses that compared exposures for different groups (e.g., applicators and non-applicator adults) against several elements of the supporting data. For applicators, exposures were compared against factors that included: the amount of active ingredient applied; the application rate; and the time spent outdoors on the day of application. [Note: In one case, no duration was reported so the Agency used a value of 1 minute for calculation purposes.] Similar analyses were completed for non-applicator adults and children. Analyses also were completed using an approach that considered whether location, age, or gender played roles in exposure trends. The Agency also completed regressions for each non-applicator individual to define if the time spent outdoors on a daily basis correlated with their daily exposures. This showed no clear cut trend between daily dose and daily time spent outdoors. [Note: This analysis was not completed for applicators since it is clear in their case that the amount ai handled per day is critical to their exposure.] The results of the analyses based on total exposure for each group are presented in Table 35.

Table 35:Total Exposure Regression Analysis Results For Carbaryl Suburban Resident Biomonitoring Study

Population	Subset	Correlation Coefficients		
		Total Exp vs. AI Applied	Total Exp vs. Appl. Rate	Total Exp vs. Duration
Applicators	MO	0.257	0.122	0.205
	CA	NA-all ai same	0.077	0.750
	All	0.535	0.235	0.437
Non-applicator Adult	MO	0.436	0.075	0.140
	CA	NA-all ai same	0.034	0.572
	All	0.028	0.007	0.371
Children - All Ages	MO	0.018	0.257	0.414
	CA	NA-all ai same	0.066	0.164
	All	0.215	0.069	0.095
Children - All Locations	4 to 5 yrs	0.404	0.228	0.677
	6 to 10 yrs	0.328	0.268	0.039
	11 to 15 yrs	0.449	0.001	0.192
	16 to 17 yrs	0.888	0.780	0.972

Results were similar for all locations and age groups when children were further subdivided by gender and a regression analysis completed. A rank order analysis also shows that 5 of the 10 children with the highest total dose in the entire monitored children's population were in the 11 to 15 year old age group.

The results of the regression analysis for all groups was in many ways inconclusive because there appeared to be little association between total exposures and any single exposure parameter that was examined. Some of the parameters, however, did appear to be more highly associated with exposures in certain cases compared to others. Results for the 16 to 17 year old children should also be considered circumspect because the size of the population for this analysis was only 3 individuals. For applicators, it does appear that the amount of active ingredient handled might be the best indicator of exposure although it is confounded by the lack of a result for California because all applicators there used identical amounts of chemical making the analysis impossible.

When the entire group was considered though, this parameter appears to have the highest association (i.e., the correlation coefficient is 0.535). Proximity to the source of exposure (i.e., time spent outdoors) appears to be the most associated parameter to overall exposure for those who were not involved in the application process regardless of whether or not they were adults or children. In fact, this parameter had the largest correlation coefficient (i.e., highest association) for a majority of the scenarios considered (i.e., 6 of 10). Further delineation of the population based on gender or location had no discernible effect. The results of this analysis were not unexpected to the Agency because of the complex nature of the residential environments that were evaluated in this study. None of the parameters which were possibly key indicators of exposure were controlled. As such, the Agency has treated the data from this study as a representative population for situations where there have been applications to lawns and gardens or ornamentals with carbaryl. Finally, it should also be noted that application rate in most cases has the weakest correlation in all populations when it is compared to dose.

MRID 457920-01 (Bayer's Analysis of Potential Carbaryl Exposure Resulting From Residential Lawn and Garden Use): This document describes the analysis of the suburban resident biological monitoring study data which was completed by Bayer Crop Science and aspects of the Joint Residential Exposure Joint Venture data. The document provided and introduction to and overview of the Agency's previous exposure and risk assessment. Bayer also provided an overview of the suburban resident biomonitoring study along with an analysis of the risks associated with the geometric means for each person-day of exposure.

The following list of "key findings" were excerpted directly from the study's executive summary:

- "The exposure to applicators applying carbaryl by hose-end spray applicator were comparable to the ORETF hose-end sprayer exposure study.
- Pre-application 1-naphthol urine levels were comparable to 1-naphthol levels reported from the NHEXAS surveys.
- The 4 to 12 year age group had the highest overall exposure of all cohort groups in the study.
- Yard activity was the primary determinant for post-application exposure potential.
- Application rate played less significant role in post-application exposure and the required post-application activity with treated areas to affect the exposure potential.
- Secondary routes of exposure such as vapor intrusion, track-in, or dust levels appear to be insignificant sources of exposure.
- Results from this study indicates that the Agency assessment of residential exposure overestimates actual monitored exposures because it overestimates the actual amount of active ingredient handled and the standardized activity pattern routines greatly overestimates the actual contact with treated turf.
- All cohorts had daily mean margins of exposure that exceeded 100."

The Agency concurs with all of these conclusions except the last two. The Agency completed an analysis that compared the biological monitoring results against the deterministic approaches. Additionally, the Agency's analysis of the Residential Exposure Joint Venture's use information for carbaryl does not preclude the use of the exposure factors (e.g., use rate or amount applied) contained in the previous assessment. It should also be noted that risk estimates were calculated using geometric mean individual daily dose values which were not corrected for mass balance as defined by Bayer's own pharmacokinetic analysis. Table 36 presents the geometric mean dose values calculated by Bayer and the corresponding arithmetic mean values calculated by the Agency. [Note: The Agency concurs with mathematical accuracy of the geometric mean values calculated by Bayer.]

It should also be mentioned that the other issues that were identified in Bayer's analysis approach that the Agency does not concur with include the age bins selected for the children in the study and no rationale was provided for the selection of the geometric mean as the measure of central tendency. The Agency believes that the age bins used by Bayer are too broad and do not appropriately reflect discernible developmental stages in children. It is also not clear why Bayer used only a measure of central tendency to calculate MOEs in each population.

Table 36: Dose Levels Calculated By Bayer Based On Suburban Resident Biomonitoring Study

Population	Location	Carbaryl Geometric Mean Dose Values Calculated By Bayer (µg/kg/day)					Agency Arith. Mean Dose (µg/kg/day)	
		Individual Daily Dose Day 0	Individual Daily Dose Day 1	Individual Daily Dose Day 2	Individual Daily Dose Day 3	Post-Application Total Dose	Individual Daily Dose All Days	Post-Application Total Dose
Applicators	MO	8.3	6.1	2.6	1.9	18.9	NA	NA
	CA	1.7	1.6	1.1	1.8	6.2	NA	NA
	All	NA	NA	NA	NA	NA	4.8	19.1
	Bayer indicated MOE on Day 0 in MO = 120. MOEs for their total dose estimate is 53 in MO and 161 in CA.							
Non-Applicator Adults	MO	0.57	0.77	0.92	1.85	4.1	NA	NA
	CA-spouse	0.54	0.96	0.83	0.42	2.8	NA	NA
	CA-resident	2.27	1.32	0.92	2.89	7.4	NA	NA
	All	NA	NA	NA	NA	NA	2.0	8.1
	Bayer indicated MOE on Day 3 in CA resident = 346. MOEs for their total dose estimate is 243 in MO and 135 in CA residents.							
Children Ages 13 - 17	MO	1.46	2.17	0.89	1.49	6.01	NA	NA
	CA	0.49	2.20	5.85	5.60	14.14	NA	NA
	All	NA	NA	NA	NA	NA	7.88	31.5
	Bayer indicated MOE on Day 2 in CA = 171. MOEs for their total dose estimate is 166 in MO and 70.7 in CA. [Note: Agency values based on 11 to 15 year olds.]							

Table 36: Dose Levels Calculated By Bayer Based On Suburban Resident Biomonitoring Study								
Population	Location	Carbaryl Geometric Mean Dose Values Calculated By Bayer (µg/kg/day)					Agency Arith. Mean Dose (µg/kg/day)	
		Individual Daily Dose Day 0	Individual Daily Dose Day 1	Individual Daily Dose Day 2	Individual Daily Dose Day 3	Post-Application Total Dose	Individual Daily Dose All Days	Post-Application Total Dose
Children Ages 4- 12	MO	1.96	3.26	1.50	3.32	10.04	NA	NA
	CA	3.19	6.10	7.98	5.10	22.37	NA	NA
	All	NA	NA	NA	NA	NA	19.56	78.3
	Bayer indicated MOE on Day 2 in CA = 125. MOEs for their total dose estimate is 100 in MO and 44.7 in CA. [Note: Agency values based on 6 to 10 year olds.]							

MRID 456905-01 (Assessment of Carbaryl Residential Use Patterns Using The Residential Exposure Joint Venture Database - see separate review by Steve Nako D284657 for further information): The *Residential Exposure Joint Venture* is a 12 month longitudinal survey that examined pesticide use in a residential environment. The data evaluated by the Agency in this analysis were information from the first 4 months of the survey that occurred from May through August of 2001. The data were only partially submitted by Bayer Crop Sciences. This information is critical because it can be used for comparison to the deterministic inputs used for the Agency's risk assessment, it can also be used to characterize the population that was monitored in the suburban resident biological monitoring study, and it can be used to characterize the results of the companion probabilistic risk assessments that have been/will be completed for carbaryl (see Section 3.4 below). The summary of the REJV data is presented in this section because it currently has the most impact on the Agency's characterization of the biological monitoring study. Based on the analysis of these data it seems as though the inputs which were used for deterministic risk assessment are included in the distributions which can be derived from the survey or the survey data lacked sufficient information to justify modifications.

Much of the information which is critical for this assessment is presented above in *Section 3.3.1: Scenarios Addressed In Biomonitoring Study* where the data have been used to characterize the population from that study. This survey indicated that about 67 percent of the general population uses pesticides. About 8.9 percent of all households use products containing carbaryl. It also indicated that about 1.2 percent of the population uses carbaryl on lawns, 4 to 5 percent on ornamentals or vegetables, and about 0.5 percent on pets. Dusts are the major formulations. The annual frequency for various scenarios ranged from 1 to 16 days per year. The possibility of co-occurrence was also examined as described above. If a turf application is made, then 44 percent of the time applications are also made to ornamentals and 18 percent of the time to vegetables. It also appears that turf applications are broadcast only about ½ of the time which is the main technique which could lead to exposure. The remainder of the time, turf applications appear to be spot treatments which are not believed by the Agency to be predominant contributors to overall exposure.

Various Literature Studies (specific references provided above): In addition to the studies submitted by Bayer Crop Sciences, several articles from the scientific literature were considered by the Agency in its analysis and characterization of the data from the biomonitoring study. Each study represented a source of population-based biological monitoring data. The publications by the various researchers are all elements of three large population-based studies including the National Human Exposure Assessment Survey (NHEXAS); the Third National Health And Nutrition Examination Survey (NHANES III); and NHANES 1999-2000. Summary statistics for spot sample urine concentrations of 1-naphthol were excerpted from each study and used to compare against the deterministic outputs contained in this assessment and also to compare with the summary statistics of the suburban resident biological monitoring study. The data from the studies which were used are presented in Table 37 below.

Table 37: Summary of Population-Based Biological Monitoring Data Used For Comparative Purposes

Study	Population	[1-naphthol] (µg/L)					
		Avg.	25th%tile	50th%tile	75th%tile	95th%tile	Max.
NHANES III (Hill et al, 1995)	1000 adults	17	1.7	4.4	12	43	2500
NHEXAS-MD (MacIntosh et al, 1999)	80 individuals (77 > 25 yrs)	34	1.6	4.2	9.3	52	2500
MNCPES-NHEXAS (Adgate et al, 2001)	102 children (3-13 yrs)	3.9	0.65	1	4	14	55
NHANES 1999-2000 (CDC, 2003)	833 adults (20-59 yrs)	1.79 (geo. mean)	<1	1.4	2.9	14.0	Not Rep.
NHANES 1999-2000 (CDC, 2003)	483 children (6-11 yrs)	Not Calc. (geo. mean)	<1	1.1	2.3	5.6	Not Rep.

3.3.3 Residential Noncancer Risks Based On Biological Monitoring Data

The results of this study were presented by the investigators as the absorbed dose of carbaryl for each individual (µg/kg/day) which, in turn, were used by the Agency to calculate statistical summaries of the data for different groups as described above. These statistical summaries were then used to calculate risk estimates. As described above in Section 3.3.2, the dose values can be calculated in different manners that include (1) ignoring mass balance in the excretion profile and using the daily values as reported (i.e., Individual Daily Dose); (2) correcting daily values for mass balance with a 50 percent factor (i.e., Individual Daily Dose Corrected For Mass Balance); and (3) adding daily dose estimates together over the monitoring period (i.e., Post-Application Total Dose). A scientific case can be made for calculating dose levels to be used in risk assessment in each manner. However, the Agency believes that the total dose approach is the most appropriate because it is the most conservative with regard to contributions from exposure on previous days and it accounts for mass balance. It should also be considered that the use of individual values may likely underestimate dose because of the lack of correction for mass balance making the results incomplete. The individual values which have been corrected for mass balance also appear to be appropriate for risk analysis. However, there is little difference between corrected highest daily values and total dose estimates. For comparative purposes, the Agency has calculated noncancer risks using each approach (Appendix N/Tables 16-18) but recommends that the dose estimates calculated based on the total dose approach be used for regulatory purposes. It is also possible to calculate risks in different ways based on the available hazard information as discussed in *Section 1.3: Summary of Hazard Concerns*. In this regard, the Agency believes that the most appropriate method is to base all risk analyses on the use of the short-term oral endpoint. The following tables in present the noncancer risks in Appendix N.

- **Appendix N/Table 16: Risk Calculations Based On The Post-Application Total Dose Measured Via Biological Monitoring** This table presents results based on the Agency recommended risk calculation method of adding the individual exposure-day estimates together for assessment.

- **Appendix N/Table 17: Risk Calculations Based On Individual Daily Dose Values Measured Via Biological Monitoring - Not Adjusted For Mass Balance** This table presents results based on Bayer's risk calculation method of just considering individual exposure-day estimates discreetly for each day of exposure.

- **Appendix N/Table 18: Risk Calculations Based On Individual Daily Dose Values Measured Via Biological Monitoring - Adjusted For Mass Balance** This table presents results based on individual exposure-day estimates discreetly for each day of exposure and adjusting them for mass balance (50% based on day 0 pharmacokinetic analysis).

The calculated risks presented in Appendix N are summarized below in Table 38.

Table 38: Noncancer Risk Estimates For Carbaryl Based On Suburban Resident Biomonitoring Study

Statistic Used	Noncancer MOEs						
	Applicator	Non-applicator adult	All Children	4 to 5 years old	6 to 10 years old	11 to 15 years old	16 to 17 years old
MOEs Calculated Based On Post-Application Total Dose Values (Agency Recommended Method)							
Avg.	52.5	124.0	20.3	22.4	12.8	31.7	268.9
Min.	673.0	1494.8	1796.0	1796.0	1030.6	358.2	533.6
Max.	18.3	25.8	1.0	4.6	1.0	7.6	158.3
Median	76.6	146.8	62.0	45.6	54.0	62.1	337.3
25^{th} %tile	228.3	328.8	128.4	81.4	120.6	118.2	158.3
75^{th} %tile	36.7	103.3	26.5	25.5	25.4	27.4	27.6

Table 38: Noncancer Risk Estimates For Carbaryl Based On Suburban Resident Biomonitoring Study							
Statistic Used	Noncancer MOEs						
	Applicator	Non-applicator adult	All Children	4 to 5 years old	6 to 10 years old	11 to 15 years old	16 to 17 years old
95th %tile	19.6	60.8	7.7	6.1	4.8	11.9	8.9
99th %tile	18.5	30.3	1.7	4.8	1.2	8.2	7.7
MOEs Calculated Based On Individual Daily Dose Values Not Corrected For Mass Balance (Bayer Calculation Method)							
Avg.	209.9	495.9	81.2	89.7	51.1	126.9	1075.5
Min.	NA	NA	NA	NA	NA	4032.3	NA
Max.	39.2	79.4	2.2	7.9	2.2	14.7	416.7
Median	386.9	743.5	369.0	221.7	373.8	381.0	1207.0
25th %tile	934.6	1675.0	826.5	619.2	704.2	871.5	2585.7
75th %tile	180.6	360.4	124.7	100.4	130.2	122.9	763.4
95th %tile	54.9	193.8	21.6	17.4	17.5	25.3	496.3
99th %tile	45.4	82.6	5.4	10.2	2.7	16.8	430.5

It is clear that the manner in which noncancer risks are calculated has an impact on the resulting risks. For both calculation techniques, however, the Agency has a concern (i.e., MOEs<100) at the upper percentiles of exposure regardless of how the dose estimate was calculated for adults and children alike (e.g., 95th %tile and up). In the Agency's approach, risks are still of concern based on whatever measure of central tendency is considered for all populations except older children. If single day values are considered, risks are not of concern based on geometric mean values but are of concern if the arithmetic mean is considered for children under 10 years of age. Risks are of most concern for applicators and the youngest children because they have the highest dose levels as would be expected (i.e., applicators are in proximity to product and young children spent time outdoors on treated lawns). The results of this assessment should be considered in the context of the population which was monitored as described by the Agency's interpretation of the *Residential Exposure Joint Venture* use survey (i.e., about 1.2 percent of the general population uses carbaryl on lawns and concurrent use of vegetable and ornamentals further lowers that figure to 0.18 and 0.44 percent, respectively). In summary, the biological monitoring study clearly illustrates that exposures leading to risks of concern for applicators and younger children can occur in households where carbaryl is used. Additionally, risks are of concern at the highest percentiles of exposure (95th %tile and up) regardless of how dose estimates are calculated. If the Agency approach for calculating total dose is considered, risks at the central tendency are also of concern (regardless of which specific exposure statistic is selected) . If the Bayer approach for calculating risks based on single day dose values is considered, risks are of not of concern based on certain measures of central tendency but it should be kept in mind that this approach does not account for mass balance as defined in the pharmacokinetic analysis of the excretion profile for carbaryl.

3.3.4 Residential Cancer Risks Based On Biological Monitoring Data

The Agency also used the absorbed dose estimates to calculate cancer risks for applicators and non-applicator adults. Complete calculations are also included in Appendix N/Tables 16 through 18 as described above for the noncancer values. Cancer risks were calculated by assuming the dose estimates represent a single day of exposure per year over a lifetime of 70 years, 50 of which are involved in gardening. The allowable number of days of exposure allowed per year over that 50 years of gardening in a lifetime were then calculated using $1x10^{-6}$ as an acceptable risk limit. The results for the cancer risk calculations are presented in Table 39 below.

Table 39: Cancer Risk Estimates For Carbaryl Based On Suburban Resident Biomonitoring Study				
Statistic Used	Risks Calculated Based On 1 Day Expo/Yr.		Allowable Expo Days/Year Under Target	
	App. Risks	Non-app Adult Risks	App.	Non-app Adult
Cancer Risks Calculated Based On Post-Application Total Dose Values (Agency Recommended Method)				
Avg.	3.26E-008	1.38E-008	31	72
Min.	2.54E-009	1.15E-009	>365	>365
Max.	9.35E-008	6.64E-008	11	15
Median	2.24E-008	1.17E-008	45	86
25^{th} %tile	7.50E-009	5.21E-009	133	192
75^{th} %tile	4.66E-008	1.66E-008	21	60
95^{th} %tile	8.75E-008	2.82E-008	11	35
99^{th} %tile	9.25E-008	5.65E-008	11	18
Cancer Risks Calculated Based On Individual Daily Dose Values Not Corrected For Mass Balance (Bayer Calculation Method)				
Avg.	8.16E-009	3.45E-009	123	290
Min.	NA	NA	NA	NA
Max.	4.37E-008	2.16E-008	23	46
Median	4.43E-009	2.30E-009	226	>365
25^{th} %tile	1.83E-009	1.02E-009	>365	>365
75^{th} %tile	9.48E-009	4.75E-009	105	210
95^{th} %tile	3.12E-008	8.84E-009	32	113
99^{th} %tile	3.77E-008	2.07E-008	26	48

It is clear as with the deterministic approaches described above that cancer risks are not the key concern for the Agency compared with the noncancer MOEs which have been calculated. When the allowable number of exposure days per year are calculated over a 50 year lifetime, the lowest estimate based on the Agency's calculation approach was 11 days per year which exceeds carbaryl use frequency as defined in the *Sevin User Survey* and the *Residential Exposure Joint Venture* survey of residential use. In this case, the manner in which risks are calculated (i.e., single day versus total dose) does not substantively impact the results.

3.3.5 Summary of Residential Risk Concerns and Data Gaps Based On Biological Monitoring Data

The suburban resident biological monitoring study for carbaryl has been used by the Agency to examine the exposure patterns and associated risks that can occur in households where the lawn and gardens or ornamentals have been treated. Based on use information alone, the population which was monitored in the study could be construed to represent a population which has the highest possible exposures associated with it because of the concurrent applications to different areas which were examined (i.e., in all cases lawns and another area was treated). However, the Agency believes that the lawn use was the key contributor to overall exposures which should be considered with the associated risks.

As with the companion deterministic assessments which have been completed for residential settings, noncancer risks are of most concern to the Agency when compared to cancer risks. There are different possible methods for calculating risks from this study because of the random nature of the exposure patterns and what the pharmacokinetics analysis determined about the excretion profile for carbaryl. The Agency placed individuals into likely groups for its analysis that included applicators, non-applicator adults, and children of various ages. The Agency also considered a number of possible approaches for evaluating the data in conjunction with the information about pharmacokinetics. The Agency recommended an approach in which post-application total dose values (i.e., daily outputs added together since the study monitored residues for 96 hours after application which is the time it takes for single carbaryl dose to be eliminated from the body) with the knowledge that this approach could overestimate exposure if multiple exposure events occurred early in the monitoring period. It should be noted, however, that if the key exposure events occurred later in the monitoring period that the total value could underestimate exposure due to incomplete sample collection. The Agency also used the data in same manner as Bayer which was using individual daily dose values, not corrected for mass balance, which would more than likely underestimate dose based on what is known about the pharmacokinetics and excretion profile for carbaryl.

It is clear that the manner in which noncancer risks are calculated has an impact on the resulting risks. For both calculation techniques, however, the Agency has a concern (i.e., MOEs<100) at the upper percentiles of exposure regardless of how the dose estimate was calculated for adults and children alike (e.g., 95^{th} %tile and up). In the Agency's approach, risks are still of concern based on whatever measure of central tendency is considered for all populations except older children. If single day values are considered, risks are not of concern based on geometric mean values but are of concern if the arithmetic mean is considered for children under 10 years of age. Risks are of most concern for applicators and the youngest children because they have the highest dose levels as would be expected (i.e., applicators are in proximity to product and young children spent time outdoors on treated lawns). The results of this assessment should be considered in the context of the population which was monitored as described by the Agency's interpretation of the *Residential Exposure Joint Venture* use survey (i.e., about 1.2 percent of the general population uses carbaryl on lawns and concurrent use of vegetable and ornamentals further lowers that figure to 0.18 and 0.44 percent, respectively). In summary, the biological monitoring study clearly illustrates that exposures leading to risks of concern for applicators and younger children can occur in households where carbaryl is used. Additionally, risks are of concern at the highest percentiles of exposure (95^{th} %tile and up) regardless of how dose estimates are calculated. If the Agency approach for calculating total dose is considered, risks at the central tendency are also of concern (regardless of which specific exposure statistic is selected) . If the Bayer approach for calculating risks based on single day dose values is considered, risks are of not of concern based on certain measures of central tendency but it should be kept in mind that this approach does not account for mass balance as defined in the pharmacokinetic analysis of the excretion profile for carbaryl. Additionally, it should be noted that cancer risks are not a concern compared to the noncancer risk estimates and that the risks calculated based on the biological monitoring data support those calculated in the deterministic assessments (i.e., body burden and associated risk numbers are very close).

3.3.6 Recommendations For Refining Residential Risk Assessment Based On Biological Monitoring Data

The suburban resident biological monitoring study represents a higher level of refinement than is generally found in most residential risk assessments. There are, however, areas where additional data, analysis, and analytical tools could further aid in the interpretation of the study. For example, significant concern has been expressed over how the population of carbaryl users should be represented in the Agency's decision making process especially given the fact that the Agency expects to receive a probabilistic aggregate assessment for carbaryl. Additional analysis of the Residential Exposure Joint Venture information (i.e., 12 month versus 4 month data) could potentially impact this characterization. Also, it is likely that further pharmacokinetic analysis related to cholinesterase reversibility could impact results. It should also be noted that the youngest children which were included in the biological monitoring study were 4 years old. The Agency's deterministic approach for calculating risks from treated turf are based on children who exhibit mouthing behaviors who can range in age down below 4 years old (e.g., 2 or less) up through 5 or 6 years old. Some characterization of younger age children's behavior and how it relates to the population which was monitored in this study should be provided.

3.4 Companion Probabilistic Assessments

As the Agency understands the current situation, Bayer Crop Sciences is in the process of completing assessments using the CARES and Lifeline models, both of which have been reviewed by the FIFRA Science Advisory Panel. The Agency will evaluate the inputs and analysis for both of these when and if they are submitted and if all appropriate criteria for submission have been met. For example, the public availability of any model used for probabilistic assessments is required.

3.5 Residential Risk Characterization

Characterization of the residential risks included in this document must consider each of the approaches used to calculate risks in this document as well as the information that could be forthcoming in any probabilistic assessment that is submitted for carbaryl. For clarity, characterization language relating to each of the individual components of the residential assessment is provided below. *Section 3.5.1: Characterization of Residential Handler Risks Based On Deterministic Approaches* describes the issues that should be considered with the interpretation of the deterministic assessments completed for residential handlers. *Section 3.5.2: Characterization Of Residential Postapplication Risks Based On Deterministic Approaches* describes the issues that should be considered with the interpretation of the deterministic assessments for residential postapplication exposures. *Section 3.5.3: Characterization of Residential Risks Based On Suburban Resident Biological Monitoring Study* describes the issues that should be considered with the interpretation of the suburban resident biological monitoring study. The Agency also urges readers to consider the results presented in this document in the context of associated probabilistic assessments should they become available.

3.5.1 Characterization Of Residential Handler Risks Based On Deterministic Approaches

The residential handler assessment for carbaryl is complex in that calculations were completed for 54 different equipment and application rate scenarios. Unlike the occupational assessments, only short-term exposures were considered for handlers because homeowner use patterns are not believed by the Agency to lead to intermediate-term exposures because of their sporadic nature. Cancer risks were also calculated using a linear, low-dose extrapolation model (i.e., Q_1*) for typical residential users (1 event/year). Cancer risks were also considered by calculating the number of days exposure that would be required per year to achieve a cancer risk of $1x10^{-6}$ to illustrate risk levels from another perspective. All totaled, when each type of calculation is considered, 108 different crop/application method calculations were completed for residential handlers.

The data that were used in the in the carbaryl residential handler assessment represent the best data and approaches that are currently available. For most of the major use patterns, carbaryl-specific data or data generated by the *Outdoor Residential Exposure Task Force* were used. These data generally are considered to be high quality by the Agency and the best source of information available for the scenarios where they are used. Carbaryl-specific data were used to address the garden and tree/ornamental scenarios with several types of equipment and formulations including liquid trigger sprayers, dusts, and liquid sprays using low pressure handwand and hose-end sprayers. Carbaryl-specific data were also available for dusting dogs. The ORETF data for hose-end sprayer applications to turf and granular applications to turf were also used to address those scenarios. In the remaining scenarios, the Pesticide Handlers Exposure Database (PHED) was used to develop the unit exposure values. The quality of the data included in PHED vary widely from scenarios that meet guideline requirements for studies to others where a limited number of poor quality datapoints are available. All data that have been used may not be of optimal quality but represent the best available data.

The inputs for application rate and other use/usage information (e.g., area treated and frequency of use) used by the Agency were supported by the available carbaryl labels and information supplied by the Bayer Corporation at the September 24, 1998 SMART Meeting. It is also very clear that since carbaryl is such as widely used chemical, with different use patterns, that it is likely every potential exposure scenario has not been captured. As more refined information becomes available on carbaryl use, the Agency will refine its assessment accordingly.

There are also many uncertainties in the assessment that are common with the occupational assessment as well. These factors and their impacts on the results should be considered as well in the interpretation of the results for residential handlers. Section 2.3.1 provides a summary of these issues.

In summary, with respect to residential handler risks, the Agency believes that the values presented in this assessment represent the highest quality results that could be produced given the exposure, use, and toxicology data that are available. However, there are certain elements where additional data are required. For example, it is difficult to ascertain where on a distribution certain input values may fall because the distributional data for exposure, application rates, acres treated and many other parameters are unrefined.

3.5.2 Characterization Of Residential Postapplication Risks Based On Deterministic Approaches

Like the residential handler assessment discussed above, the postapplication residential assessment for carbaryl is also complex in that noncancer MOE calculations were required based on the recently selected endpoints along with cancer risk calculations using a linear, low-dose extrapolation model. Carbaryl residues persist in the environment as indicated in the available DFR and TTR data for periods where intermediate-term as well as short-term noncancer risk estimates are required. Cancer risks were calculated only for adults per current Agency policy.

The general population can be exposed through many different pathways that result from uses on lawns and turf, in gardens, on ornamental plants, and from treated pets. People can also be exposed from mosquito adulticide applications and uses in oyster beds. Carbaryl labels do not currently allow for indoor residential uses (e.g., crack and crevice). Settings where such exposures could occur include around personal residences and in other areas frequented by the general public including parks, ball fields, and playgrounds. To represent the wide array of possible exposures, the Agency relies on the scenarios that have been defined in the *SOPs For Residential Exposure Assessment* and accompanying documents such as the overview presented to the FIFRA Science Advisory Panel. For turf uses, the Agency considered adults and toddlers (3 year olds) in the assessments. Adult activities included lawncare/maintenance and also golfing. Toddler MOEs were calculated for playing on turf (using exposure data from the Jazzercize model) and also addressed nondietary ingestion (hand-/object-to-mouth and soil ingestion). Exposures from tree and garden uses were evaluated by considering adults and youth-aged children (10 to 12 years old) doing gardening activities such as weeding and harvesting for different crop groups. Transfer coefficients from the fruiting vegetable crop group and the deciduous tree crop group were used, as described in the *SOPs For Residential Exposure Assessment* to represent exposures for these scenarios. MOEs from treated pets were evaluated for toddlers again for whom exposures may occur from dermal contact and hand-to-mouth behavior. Adulticide mosquito applications were considered by first defining how much residues are deposited on the ground after a mosquito control application then using the same methods approaches from the lawncare assessment to address adults doing heavy yardwork or golfing and also children playing on treated turf.

The data that were used in the carbaryl residential postapplication assessment represent the best data and approaches that are currently available. To the extent possible, the Agency has attempted to use carbaryl-specific data such as with the dislodgeable foliar residue (DFR) data used for the garden scenarios and the turf transferable residue (TTR) data used for the dermal component of the turf scenarios. When chemical-specific data were unavailable, the Agency used the current approaches for residential assessment, many of which include recent upgrades to the SOPs. For example, for the toddler hand-to-mouth calculations, the TTR data were not used but a 5 percent transferability factor was applied to calculate residue levels appropriate for this exposure pathway. Another key approach to consider is the use of the dermal hug approach for pet products which was proposed at the September 1999 meeting of the FIFRA Science Advisory Panel. Oyster bed uses were evaluated based on guidance from Superfund and the Agency's SWIMODEL. There are also many embedded uncertainties that should be considered in the interpretation of this assessment such as those associated with the use of Jazzercize and with the nondietary ingestion calculations. Readers should consider these in the interpretation of the overall risk estimates. Readers should also consider the screening nature of the *SOPs For Residential Exposure Assessment* and how additional data could refine the results.

Finally, the Agency believes that the values presented in this assessment represent the highest quality results that could be produced based on the currently available postapplication exposure data. Readers of this document should consider the quality of individual inputs when interpreting the results and make decisions accordingly. It is difficult to ascertain where, on a distribution, the calculated values fall because the distributional data for exposure, residue dissipation and many other parameters are unrefined. The Agency does believe, however, that the risks represent conservative estimates of exposure because maximum application rates are used to define residue levels upon which the calculations are based. Additionally, estimates are thought to be conservative even when measures of central tendency (e.g., most transfer coefficients are thought to be central tendency) are used because values that would be considered to be in the lower percentile aspect of any input parameter have not been used in the calculations.

3.5.3: Characterization of Residential Risks Based On Suburban Resident Biological Monitoring Study

The use of biological monitoring can be a powerful tool in the risk assessment process. However, study design issues and the representativeness of the population must be thoroughly understood in order to assure that the results are considered in the appropriate context. Additionally, technical issues associated with the interpretation of the study also need to be thoroughly understood. The Residential Exposure Joint Venture survey results indicate that carbaryl use on lawns represents about 1.2 percent of the general population. This population decreases accordingly when concurrent uses on vegetables or ornamentals is considered. In fact, only 18 percent of the lawn user population also uses carbaryl on their vegetables and 44 percent also use it on their ornamentals. The survey also indicated that about 50 percent of all lawn use is a spot-type treatment which is not anticipated by the Agency to represent a major source of exposure. These population estimates are presented here because it is necessary to describe the nature of the population which was evaluated in the biological monitoring study. There is one caveat to this analysis in that the Agency believes that most of the exposures in the study come from either the application process or contact with treated turf because applicators and small children had the highest exposures in the study. As such, the fact that concurrent applications were made to gardens or ornamentals probably has little bearing on the overall exposure patterns. With this in mind, the Agency believes that the population evaluated in this study can easily be used to represent lawn broadcast applications as well as the concurrent application scenarios examined in the study.

A number of analyses were completed with the study data that are included in Appendix N of this document. In tables 19 through 22 of Appendix N, an analysis was completed that compared varying exposure statistics for the different groups of individuals in the biological monitoring study to the deterministic scenarios that were included in the Agency's assessment. For most of the homeowner applicator scenarios (Table 19), the biological monitoring data for applicators exceeds the body burden estimates which were calculated in the deterministic assessment regardless of the exposure statistic selected. In most cases, the results are within a factor of 5 or so indicating good basic agreement between the two approaches. Results are similar for the post-application scenarios when they are compared to the non-applicator adults and children of various age from the biomonitoring study. In most cases, the results are again within a factor of 5 or so indicating good basic agreement between the two approaches. It should also be pointed out that on or near the day of application that body burden estimates from the deterministic approaches generally exceed those from the biological monitoring study supporting the conservative (screening level) nature of the assessment approaches. There was a significant level of discussion in this document concerning the methods used to calculate absorbed carbaryl dose estimates from the biological monitoring study.

In fact, three distinct options were considered that included Bayer's approach based on using single day values and not correcting them for mass balance. The others included correcting single day values for mass balance and adding daily values together to get total dose estimates. As discussed previously, the Agency opted to recommend the use of total dose estimates for regulatory purposes but did an evaluation that compared that approach to the values that would be anticipated if daily estimates were corrected for mass balance (Appendix N/Tables 23 through 25). Essentially, the results show that there is little or no difference between the use of total dose estimates (i.e., adding over days) and adjusting single day estimates for mass balance as one would anticipated. In fact, the average difference between the two methods was about 10 to 12 percent. Another analysis which was completed (Appendix N/Tables 26 through 31) compared the results of the biomonitoring study with other recognizable population-based biological monitoring studies identified in the scientific literature (i.e., various publications related to NHANES & NHEXAS). For both adults and children the biological monitoring data representing post-application exposures are within 2 orders of magnitude of each other. Differences are greatest for children and applicator adults after an application because they have recently been exposed and the population-based monitoring results likely represent something closer to background levels from the diet and drinking water. Agreement between the pre-exposure samples and the population-based studies is better (i.e., within a factor of 3 or so in most cases). [Note: Bayer arrived at essentially the same conclusion.]

In summary, the biological monitoring study is very useful in that it can be used to evaluate the range of exposures that are expected in a treated residential environment. The data also support the deterministic assessments which have been completed for carbaryl as body burden values calculated in those assessments are similar to the biological monitoring data. The population which was monitored also resembles the general population as there is good agreement between the pre-exposure dose values and general population monitoring data available from NHANES and NHEXAS. [Note: The biological monitoring study and associated data were evaluated for adherence with the Agency's policy on human studies and were found to be in compliance.]

Appendix A: Use Information For Carbaryl

Quantitative Usage Analysis for Carbaryl
Case Number: 0080 PC Code: 56801
Date: December 17, 2002 Analyst: Frank Hernandez

Based on available pesticide survey usage information for the years of 1992 through 2001, an annual estimate of carbaryl total domestic usage averaged approximately one million nine hundred thousand pounds active ingredient (a.i.) for about one million three hundred thousand acres treated. Carbaryl is an insecticide with its largest markets in terms of total pounds active ingredient allocated to apples (13%), pecans (10%), grapes(7%), alfalfa (6%), oranges (6%), and corn (6%). Most of the usage is in CA, MI, IN, IL, OH, TX, GA, OK, MS, and AR.

Crops with a high percentage of the total U.S. planted acres treated include avocados (38%), asparagus (35%), okra (33%), cranberries (32%), and apples (24%).

Crops with less than 1 percent of the crop treated include sugar cane, woodland, wheat, corn, oats, sod, soybeans, cotton, sorghum, canola, sunflower, flax, sweet corn, alfalfa, walnuts, green peas, dry beans, and safflower.

Site	Acres Grown (000)	Acres Treated (000)		% of Crop Treated		LB AI Applied (000)		Average Application Rate			States of Most Usage
		Wtd Avg	Est Max	Wtd Avg	Est Max	Wtd Avg	Est Max	lb ai/ acre/yr	#appl / yr	lb ai/ A/appl	(% of total lb ai used on this site)
Alfalfa	22,745	118	254	0.52	1.12	121	351	1.0	1.0	1.0	NE SD OK MT AND IL 80%
Almonds	427	3	6	0.70	1.41	6	15	2.0	1.0	2.0	CA 100%
Apples	587	139	207	23.68	35.26	242	296	1.7	1.4	1.2	WA MI NY CA CT IN 80%
Asparagus	92	32	41	34.78	44.57	36	49	1.1	1.2	0.9	MI WA 95%
Avocados	81	31	53	38.27	65.43	1	2	0.0	1.5	0.0	
Beans, Dry	1,825	10	48	0.55	2.63	4	19	0.4	1.0	0.4	CA AND CO 80%

Site	Acres Grown (000)	Acres Treated (000)		% of Crop Treated		LB AI Applied (000)		Average Application Rate			States of Most Usage
		Wtd Avg	Est Max	Wtd Avg	Est Max	Wtd Avg	Est Max	lb ai/ acre/yr	#appl / yr	lb ai/ A/appl	(% of total lb ai used on this site)
Beans, Lima, Fresh	5	0	0	3.00	8.00	0	1	1.7	1.2	1.4	GA 100%
Beans, Snap, Fresh	83	8	12	9.64	14.46	11	18	1.4	1.6	0.9	NC FL 85%
Beans, Snap, Proc.	230	22	32	9.57	13.91	26	41	1.2	1.6	0.7	IL OR 85%
Beets	11	2	3	16.36	26.36	1	2	0.5	1.0	0.5	WI TX OR 95%
Blackberries	6	1	2	18.33	30.00	2	3	1.9	1.0	1.9	OR 100%
Blueberries	60	13	26	21.93	43.86	26	53	2.0	1.2	1.7	MI NJ 85%
Broccoli	115	3	7	2.61	6.09	2	6	0.7	1.0	0.7	CA OR TX 85%
Brussels Sprouts	3	0	1	15.04	37.61	0	1	0.8	1.1	0.7	
Cabbage, Chinese	10	2	4	18.24	38.50	1	2	0.6	1.1	0.5	CA 80%
Cabbage, Fresh	83	2	4	1.81	4.94	3	5	2.0	1.6	1.2	NC NY 85%
Canola	37	0	2	0.35	4.59	0	1	0.5	1.0	0.5	MT 100%
Cantaloupes	115	10	15	8.70	13.04	11	17	1.1	1.1	1.0	CA IL GA TX 80%
Carrots	109	4	7	3.67	6.42	9	21	2.2	2.5	0.9	WI MI NY 90%

Site	Acres Grown (000)	Acres Treated (000)		% of Crop Treated		LB AI Applied (000)		Average Application Rate			States of Most Usage
		Wtd Avg	Est Max	Wtd Avg	Est Max	Wtd Avg	Est Max	lb ai/ acre/yr	#appl / yr	lb ai/ A/appl	(% of total lb ai used on this site)
Cauliflower	59	1	2	1.10	2.54	1	2	1.2	1.0	1.2	OR CA WA 85%
Celery	38	1	2	1.45	4.21	1	3	1.8	1.8	1.0	MI WI 90%
Cherries, Sweet	49	11	16	22.45	32.65	30	44	2.7	1.4	1.9	WA MI CA 85%
Cherries, Tart	51	5	10	9.80	19.61	12	25	2.4	1.3	1.9	MI NY 90%
Collards	10	0	1	4.50	10.90	0	1	0.8	1.0	0.8	NJ 88%
Corn	71,693	78	148	0.11	0.21	103	197	1.3	1.3	1.0	MO NE MS IN IL 50%
Cotton	11,874	23	69	0.19	0.58	28	83	1.2	1.1	1.1	TN MS TX CA 85%
Cranberries	31	10	21	32.26	67.74	21	39	2.1	1.0	2.1	WI MA 95%
Cucumbers	147	10	32	6.80	21.77	12	31	1.2	1.0	1.2	NC SC NY VA DE 70%
Cucumbers, Proc.	119	3	10	2.52	8.40	5	12	1.7	2.2	0.8	NC MI 80%
Eggplant	120	7	16	5.83	13.33	10	37	1.4	2.1	0.7	FL NJ TX IL CA 65%
Flax	175	1	2	0.45	1.03	1	2	1.1	1.0	1.1	AND 100%
Grapefruit	201	12	22	5.97	10.95	27	41	2.2	1.6	1.4	FL TX 95%
Grapes	851	58	88	6.82	10.34	134	201	2.3	1.6	1.4	NY CA OR PA MI AR 80%

Site	Acres Grown (000)	Acres Treated (000)		% of Crop Treated		LB AI Applied (000)		Average Application Rate			States of Most Usage
		Wtd Avg	Est Max	Wtd Avg	Est Max	Wtd Avg	Est Max	lb ai/ acre/yr	#appl / yr	lb ai/ A/appl	(% of total lb ai used on this site)
Hazelnuts (Filberts)	25	1	2	2.80	8.00	2	6	2.9	1.0	2.9	
Lemons	67	1	2	1.49	2.99	2	8	2.0	1.3	1.5	CA 90%
Lettuce, Head	210	4	9	1.90	4.29	5	11	1.2	1.2	1.0	CA 80%
Melons, Honeydew	28	3	10	10.71	35.71	3	8	1.0	1.2	0.8	CA 100%
Nectarines	31	2	4	6.45	12.90	7	16	3.5	1.1	3.2	CA 90%
Oats/Rye	6,225	7	17	0.11	0.27	5	12	0.7	1.0	0.7	MN MS AND TX MT MI 75%
Okra	3	1	2	33.33	53.33	2	4	1.7	1.0	1.7	TX 85%
Olives	30	2	4	6.67	13.33	11	27	5.5	1.0	5.5	CA 100%
Onions, Dry	159	5	17	3.14	10.69	22	69	4.4	7.0	0.6	MI 100%
Oranges	874	21	34	2.40	3.89	105	158	5.0	1.3	3.8	CA FL 99%
Pasture	87,540	29	71	0.03	0.08	27	79	0.9	1.0	0.9	NC TX SC NE LA 85%
Peaches	221	19	27	8.60	12.22	62	115	3.3	2.8	1.2	GA CA TX SC MI 70%
Peanuts	1,640	45	87	2.74	5.30	48	98	1.1	1.4	0.8	GA NC AL VA 80%
Pears	80	2	4	2.50	5.00	3	7	1.5	1.5	1.0	WA OR CA PA NY OH 75%

Site	Acres Grown (000)	Acres Treated (000)		% of Crop Treated		LB AI Applied (000)		Average Application Rate			States of Most Usage
		Wtd Avg	Est Max	Wtd Avg	Est Max	Wtd Avg	Est Max	lb ai/ acre/yr	#appl / yr	lb ai/ A/appl	(% of total lb ai used on this site)
Peas, Dry	237	3	11	1.27	4.64	3	12	1.0	1.0	1.0	WA ID TX 90%
Peas, Green	390	2	5	0.51	1.28	3	7	1.5	1.0	1.5	MN OR 80%
Peas, Green, Proc.	331	2	8	0.60	2.42	3	8	1.5	1.0	1.5	OR 100%
Pecans	492	76	89	15.45	18.09	207	495	2.7	2.2	1.3	GA TX SC 90%
Peppers, Bell	57	3	7	5.26	12.28	4	9	1.3	1.7	0.8	FL CA MI 90%
Peppers, Sweet	78	6	11	7.69	14.10	8	15	1.3	1.0	1.3	CA FL KY LA IL 80%
Pistachios	53	7	18	13.21	33.96	23	64	3.3	1.0	3.3	CA 80%
Plums	65	3	5	4.62	7.69	11	21	3.7	1.0	3.7	CA 80%
Potatoes	1,421	24	38	1.70	2.68	34	50	1.4	1.7	0.8	AND WA MI ID FL NY 59%
Pumpkins	38	7	9	18.42	23.68	21	42	3.0	1.5	2.0	IL MI NY OH 80%
Raspberries	12	0	1	2.50	6.67	1	2	2.7	1.0	2.7	OR MI 90%
Rice	3,105	29	37	0.93	1.19	25	47	0.9	1.1	0.8	TX CA 80%
Safflower	110	1	6	0.91	5.36	0	2	0.3	1.0	0.3	CA 100%
Sod	147	0	4	0.14	2.93	0	8	2.0	1.0	2.0	TX NH 100%
Sorghum	10,850	19	41	0.18	0.38	25	54	1.3	1.2	1.1	MO KS TX LA NE MS 75%

Site	Acres Grown (000)	Acres Treated (000)		% of Crop Treated		LB AI Applied (000)		Average Application Rate			States of Most Usage
		Wtd Avg	Est Max	Wtd Avg	Est Max	Wtd Avg	Est Max	lb ai/ acre/yr	#appl / yr	lb ai/ A/appl	(% of total lb ai used on this site)
Soybeans	63,543	95	185	0.15	0.29	74	146	0.8	1.0	0.8	MN NE SD NC IL 60%
Squash	54	7	13	12.96	24.07	9	17	1.3	1.0	1.3	NJ FL MI CA NY TX 90%
Strawberries	52	9	14	17.31	26.92	25	57	2.8	2.1	1.3	CA FL NC PA 80%
Sugar Beets	1,312	19	42	1.45	3.20	28	114	1.5	1.1	1.3	CA TX WA MN OR 80%
Sugarcane	845	0	1	0.04	0.07	0	0	0.2	1.1	0.1	FL 100%
Sunflower	2,820	10	38	0.35	1.35	7	29	0.7	1.1	0.7	SD AND 90%
Sweet Corn, Fresh	235	7	16	2.98	6.81	23	47	3.3	2.5	1.3	CA MI IL 80%
Sweet Corn, Proc.	540	5	15	0.93	2.78	12	42	2.4	2.9	0.8	IL 100%
Sweet Potatoes	89	15	34	16.85	38.20	24	53	1.6	1.0	1.6	LA MS NC 85%
Tobacco	702	9	18	1.28	2.56	16	42	1.8	1.5	1.2	NC KY SC TN 85%
Tomatoes, Fresh	138	8	14	5.80	10.14	15	31	1.9	2.6	0.7	CA FL TX 85%
Tomatoes, Proc.	341	21	31	6.16	9.09	31	78	1.5	1.2	1.2	CA 97%
Walnuts	206	1	3	0.53	1.50	2	5	1.9	1.1	1.7	CA 100%

Site	Acres Grown (000)	Acres Treated (000)		% of Crop Treated		LB AI Applied (000)		Average Application Rate			States of Most Usage
		Wtd Avg	Est Max	Wtd Avg	Est Max	Wtd Avg	Est Max	lb ai/ acre/yr	#appl / yr	lb ai/ A/appl	(% of total lb ai used on this site)
Watermelons	261	22	31	8.43	11.88	11	23	0.5	1.0	0.5	FL GA NC TX 75%
Wheat, Spring	20,845	22	45	0.11	0.22	14	29	0.6	1.0	0.6	AND MN MT 90%
Wheat, Winter	44,762	45	98	0.10	0.22	38	69	0.8	1.0	0.8	KY NC TX WY OR MD 70%
Woodland	63,750	32	73	0.05	0.11	28	56	0.9	1.2	0.7	PA MI AND OH IA 80%
		1,271	1,842			1,917	2,914				

COLUMN HEADINGS

Wtd Avg = Weighted average--the most recent years and more reliable data are weighted more heavily.
Est Max = Estimated maximum, which is estimated from available data.
Average application rates are calculated from the weighted averages.

NOTES ON TABLE DATA

Usage data primarily covers 1992 - 2001 Calculations of the above numbers may not appear to agree because they are displayed as rounded to the nearest 1000 for acres treated or lb. a.i. (Therefore 0 = < 500)
to two decimal percentage points for % of crop treated.

R.E.D. Use Profile Report

A. Chemical Overview

Chemical Name: Carbaryl
Case No: 0080
Chemical Code: 056801

B. Use Profile

Type of Pesticide: Acaricide/Insecticide and Plant regulator

Mode of Action: Acetylcholine esterase inhibitor

Use Sites:

Terrestrial Food Crop

Cucurbits - Cumber, Melons, Chinese okra, pumpkin, and squash
Flavoring and Spice Crops - Dill
Fruiting Vegetables - Eggplant and Pepper
Grain Crops - Prosso millet
Leafy and Stem Vegetables - Beets, Broccoli, Brussels sprouts, Cabbage, Chinese cabbage, Cauliflower, Celery, Swiss chard, Collards, Dandelion, Endive (Escarole), Hanover Salad, Kale, Kohlrabi, Lettuce (Head, Crisphead types, Leaf types), Mustard, Parsley, Rhubarb, and Spinach
Miscellaneous Fruits - Avocado, Olive, Pricklypear
Miscellaneous Vegetables - Asparagus
Nut Crops - Almond, Chestnut, Filbert (Hazelnut), Pecan, Pistachio, and Walnut (English/black)
Pome Fruits - Crabapple, pear, and quince
Root Crop Vegetables - Beets, Carrot (including tops), Horseradish, Radish, Rutabaga, Salsify, and Sweet Potato

Small Fruits - Blackberry, Blueberry, Boysenberry, Caneberries, Cranberry, Dewberry, Loganberry, Raspberry (Black, Red), and Strawberry
Specialized Field Crops - Okra
Stone Fruits - Apricot, Cherry, Nectarine, Peach, Plum, and Prune

Terrestrial Food+Feed Crop

Citrus Fruits - Citrus fruits

Crops Grown for Oil - Field corn, Flax, and Sunflower
Fiber Crops - Flax
Fruiting Vegetables - Tomato
Grain Crops - Field corn, Rice, Sorghum and Wheat
Groups of Agricultural Crops Which Cross Established Crop Groupings - Cotton, Peanuts, Peas, Sorghum, Soybeans, and Vegetables
Leafy and Stem Vegetables - Mustard and Turnip
Nut Crops - Almond, and Tree nuts
Pome Fruits - Apple and Pome Fruits
Root Crop Vegetables - Parsnip, White/Irish potato, Salsify, and Turnip
Seed and Pod Vegetables - Beans (Dried type), Succulent beans (Lima and Snap), Cowpea/Blackeyed pea, Cowpea/Sitao, Lentils, Peanuts, Peas (Dried type), Field peas, Southern peas, Succulent peas, and Soybeans (edible)
Small Fruits - Grapes and Small fruits
Specialized Field Crops - Pop corn, Sweet corn, and Sunflower
Sugar Crops - Sugar beet

Terrestrial Feed Crop

Forage Grasses - Corn, Grass forage/fodder/hay, Millet (Proso), Pastures, Rangeland, Rice, Sorghum, and Wheat

Forage Legumes and Other Nongrass Forage Crops - Alfalfa, Clover, Cotton, and Trefoil
Grain Crops - Proso millet
Groups of Agricultural Crops Which Cross Established Crop Groupings - Grasses grown for seed

Terrestrial non-food crop

Agricultural Uncultivated Areas - Agricultural fallow/idleland and Agricultural rights-of way/fencerows/hedgerows
Commercial/Industrial/Institutional Premises and Equipment
Commercial/Institutional/Industrial premises/Equipment (Outdoor)
Fiber Crops
Forest Trees - Christmas tree plantations
Groups of Agricultural Crops Which Cross established Crop Groupings - Fruits (unspecified)
Miscellaneous Fruits - Longan and Mango
Nonagricultural Uncultivated Areas - Outdoor buildings/structures, rights-of-way/fencerows/hedgerows,

uncultivated areas/soils, and recreational areas
Ornamental Lawns and Turf - Commercial/Industrial lawns, Golf course turf, Ornamental sod farm (turf), and recreational area lawns
Specialized Field Crops - Tobacco
Wide Area/General Outdoor Treatments - Fencerows/Hedgerows, Urban areas, and Wide area/General outdoor treatment (Public health use)

Terrestrial non-food+outdoor residential
- Nonagricultural Uncultivated Areas - Rights-of-way/Fencerows/Hedgerows
- Ornamental Herbaceous Plants
- Ornamental Lawns and Turf
- Ornamental Nonflowering Plants
- Ornamental Woody Shrubs and Vines
- Ornamental and/or Shade Trees
- Wide Area/General Outdoor Treatments - Fencerows/Hedgerows

Terrestrial+Greenhouse non-food crop
- Ornamental Herbaceous Plants
- Ornamental Woody Shrubs and Vines
- Ornamental and/or Shade Trees

Aquatic food crop
- Aquatic Sites - Commercial fishery water systems
- Grain Crops - Rice
- Small Fruits - Cranberry

Aquatic non-food industrial
- Aquatic Sites - Drainage systems

Forestry
- Forest Trees - Forest plantings (Reforestation programs, tree farms, tree plantations, etc), forest trees (all or unspecified), maple (forest), and Shelterbelt plantings

Outdoor residential

Households/Domestic Dwellings - Outdoor premises
Ornamental Herbaceous Plants
Ornamental Lawns and Turf - Residential lawns
Pets - Pet living/sleeping quarters

Indoor food
Poultry - Egg/Meat

Indoor non-food
Pets

Target Pests for Single Active Ingredient:

Invertebrates (insects and related organisms);

Adelgid (Cooley spruce gall)
Ataenius (Black turfgrass
Ants (Carpenter, Fire, Imported fire)
Aphids (Apple, Balsam twig, Black cherry, Blackmargined, Cooley spruce gall, Eastern spruce gall, Elm leaf, European raspberry, Filbert, Gall, Mealy plum, Rose, Rosy apple, Wooly?, Wooly apple)
Appleworm (Lesser)
Armyworm (Fall, True, Western yellowstriped, Yellowstriped)
Bagworm
Bees
Beetle (Asparagus, Bean leaf, Beet leaf, Blister, Cereal leaf, Chafer, Colorado potato, Corn rootworm, Cucumber, Darkling, Darkling ground?, Elm bark, Elm leaf, Engraver, European alfalfa, Flea, Fuller rose, Green june, Ips engraver, Japanese, June, Litter, May, Mexican bean, Mountain pine, Rose, Roundheaded pine, Sap, Spruce bark?, Spruce?, Striped blister, Sunflower, Tobacco flea, Tortoise, Western pine, Whitefringed, Willow leaf)
Billbugs (Bluegrass)
Borer (European corn, Lesser peachtree, Limabean pod, Locust, Olive ash, Peach twig, Southwestern corn, West Indian sugarcane root)
Budworm (Jack pine, Spruce, Tobacco, Western spruce)
Bug (Bed, Black Grass, Boxelder, Chinch, Harlequin, Lace, Lygus, Plant, Squash, Stink, Tarnished plant)

Cabbageworm (Imported)
Cankerworm (Fall, Spring)
Casebearer (Pecan nut)
Caterpillar (Alfalfa, Eastern tent, Forest tent, Oleander, Painted lady, Puss, Range, Redhumped, Saltmarsh, Spiny elm, Spring elm, Tent, Thistle butterfly, Velvetbean, Walnut, Woolybear)
Centipedes
Chafer (European, Rose)
Chiggers (Redbugs)
Cicada (Apache, Periodical)
Clipper (Strawberry)
Cloverworm (Green)
Cockroach (American, Australian, Brown, Smoky brown)
Colaspis (Grape)
Crickets (Mole, Morman, Snowy tree)
Curculio (Cowpea, Plum)
Cutworm (Army, Citrus, Cotton, Western bean)
Earwigs (European)
Earworm (Corn)
Firebrats
Fireworm (Cranberry, Yellowheaded)
Fleahopper (Cotton)
Fleas
Fly (Cherry fruit, European crane, Rangeland crane)
Forester (Eightspotted)
Fruitworm (Cherry, Cranberry, Green, Raspberry, Sparganothis, Strawberry, Tomato)
Girdler (Cranberry, Twig)
Grasshoppers
Grubs (White)
Hornworms (Poinsettia, Sweet potato, Tobacco, Tomato)
Leafcutter (Maple)
Leaffolder (Grape)
Leafhopper (Aster, Avocado, Cotton, Potato, Prune, Redbanded, Three cornered alfalfa, White apple)
Leafminer (Alfalfa blotch, Azalea, Birch, Boxwood, Holly, Oak, Tentiform)
Leafroller (Avocado, Filbert, Fruittree, Grape, Oak, Omnivorous, Redbanded, Strawberry, Variegated)

Leaftier (Omnivorous)
Leafworm (Cotton)
Lecanium (European fruit)
Lice
Looper (Alfalfa, Pine, Striped grass, Western hemlock)
Maggot (Apple, Blueberry)
Maker (Hackberry nipplegall)
Mapleworm (Greenstriped)
Mealworm (Lesser)
Mealybug (Apple, Cherry)
Melonworm
Midges (Gall)
Millipedes
Mites (Apple rust, Chicken, Citrus rust, Eriophyid, Fuschia gall, Fuschia?, Northern fowl, Pear rust, Pearleaf blister)
Moth (Browntail, Codling, Cyprus tip, Diamondback, Douglas-fir tussock, European pine shoot, Eyespotted bud, Grape berry, Gypsy, Holly bud, Lawn, Lucerne, Maple shoot, Nantucket pine tip, Oak, Oriental fruit, Pitch pine tip, Subtropical pine tip, Sunflower, Tussock, Western tussock)
Mosquito
Needleminers (Jeffrey pine, Spruce)
Notcher (Little leaf)
Oakworm (Orangestriped, Redhumped)
Orangedog (California)
Orangeworm (Navel)
Pandemis (Apple)
Peanutworm (Rednecked)
Pearslug (California)
Phylloxera (Pecan leaf?, Pecan?)
Pickleworm
Pillbug/Sowbugs
Pinworm (Tomato)
Prominent (Saddled)
Psylla (Pear)
Roseslug

- Sawfly (European apple, Pear, Pine, Raspberry)
- Scale (Black, Brown soft, Calico, California red, Citricola, Citrus Snow, Forbes, Frosted, Lecanium, Olive, Oystershell, Red, San Jose, Yellow)
- Scorpions
- Shrimp (Ghost, Mud, Tadpole)
- Shuckworm (Hickory)
- Silverfish
- Skeletonizer (Oak, Western Grapeleaf)
- Skipper (Essex, Fiery)
- Spanworm (Elm)
- Spiders
- Spinx (Catalpa)
- Spittlebug (Meadow, Pecan, Pine)
- Springtails
- Sucker (Apple)
- Suckfly
- Thornbug
- Thrips
- Ticks (Amblyomma spp., Bear, Blacklegged, Brown dog, Deer, Fowl, Ixodes spp., Lone star)
- Tortrix (Orange)
- Treehoppers
- Wasps (Gall)
- Webworm (Fall, Lesser, Mimosa, Sod)
- Weevil (Alfalfa, Bluegrass, Chestnut nut, Citrus root, Clover head, Cotton boll, Egyptian alfalfa, Hyperodes, Pea Leaf?, Pea?, Pecan, Strawberry bud?, Strawberry?, Sugarcane rootstalk borer, Sunflower stem, Sweet potato, Yellow-poplar)

- Whiteflies
- Worm (Filbert)

Weeds

- Aster
- Blessed thistle
- Boxelder

Plant regulator - abscission agen, flower inhibitor, fruit thinning, inhibit fruiting
White ash
Yellow poplar

Formulation Types Registered (% AI):

Technical Grade Material

Form not identified/solid	99.0000%
Manufacturing product dust	80.0000%
Emulsifiable concentrate	97.5000%

End Use Product

Bait/solid	10.0400%
Emulsifiable concentrate	22.5000 to 48.0000%
Flowable concentrate	43.0000 to 43.4000%
Granular	5.0000 to 7.0000%
Liquid-ready to use	39.7000%
Pelleted/tableted	5.0000%
Wettable powder	50.0000 to 85.0000%

Methods and Rates of Application:

Types of Treatment:

Animal bedding/litter treatment; Animal treatment (spray); Bait application; Band treatment; Bark treatment; Basal spray treatment; Broadcast; Chemigation; Dip treatment; Directed spray; Drench; Ground spray; High volume spray (dilute); Indoor general surface treatment; Low volume spray (concentrate); Mound drench; Mound treatment; Perimeter treatment; Premise treatment; Soil drench treatment; Soil incorporated treatment by irrigation; Soil treatment; Soil/media treatment; Spray; Surface treatment; Trunk drench; Ultra low volume

Equipment:

Airblast; Aircraft; Band sprayer; Chest-mounted equipment; Compressed air sprayer; Dip tank; Drencher; Electric fogger; Fogger; Granule applicator; Ground; Hand held duster; Hand held sprayer; High pressure sprayer; High volume ground sprayer; Hose-end sprayer; Hydraulic sprayer; Knapsack sprayer; Low pressure; Low pressure ground sprayer; Low volume ground sprayer; Mechanical sprayer; Mist blower; Mist sprayer; Not on label; Pail; Power sprayer; Pressure sprayer; Sprayer; Spreader; Sprinkler can; Sprinkler irrigation; Tank

Timing:

Bloom; Boot; Containerized; Cool weather (65 - 80 F); Delayed dormant; Dormant; Foliar; Fruit thinning; Heading; Nonbearing; Nurserystock; Petal fall; Pink; Plant bed; Popcorn; Post-bloom; Postharvest; Prebloom; Preharvest; Preplant; Seed bed; Silk; Tassel; Transplant; When needed

Use Practice Limitations: (that apply to all uses on all products)

Appendix B: Carbaryl Occupational Handler Exposure Data

Appendix B/Table 1: Field Recovery Results For MRID 44658401 (Commercial Pet Groomers During Application of Adams Carbaryl Shampoo					
Matrix	Level (concentration)	Recovery Range (%)	Recovery Mean (%)	Recovery S.D. (%)	Coefficient of Variation (%)
Facial swabs	Low (0.10 µg/ml)	97 - 110	106	5.2	4.9
	Medium (0.50 µg/ml)	96 - 99	97	1.5	1.5
	High (1.0 µg/ml)	93 - 98	95	1.7	1.8
Hand Washes	Low (0.10 µg/ml)	100 - 113	106	5.6	5.3
	Medium (0.50 µg/ml)	92 - 100	97	3.1	3.2
	High (1.0 µg/ml)	91 - 104	98	5	5.1
Whole body dosimeters	Low (1.0 µg/ml)	85 - 100	91	5.8	6.4
	Medium (5.0 µg/ml)	82 - 95	87	6.1	7
	High (10 µg/ml)	81 - 89	83	5	6
Glass fiber filter/support pad	Low (1.0 µg/ml)	83 - 100	92	7.4	8
	Medium (5.0 µg/ml)	68 - 89	80	8.4	11
	High (10 µg/ml)	85 - 95	91	3.8	4.2

Appendix B/Table 2: Dermal Exposures from Whole Body Dosimeter Parts (Adjusted for Field Recovery Results)[a] For MRID 44658401 (Commercial Pet Groomers During Application of Adams Carbaryl Shampoo)						
Replicate	Lower Arm (µg)	Upper Arm (µg)	Lower Leg (µg)	Front Torso (µg)	Rear Torso (µg)	Total (mg)
1	7543	185	0.57	1941	1	9.7
2	6341	157	4	389	3	6.9
3	1382	232	0.57	43	0.57	1.4
4	2986	3.9	0.57	65	0.57	3.1
5	5441	61	31	6.6	5.9	5.5
6	1680	589	3	420	0.57	2.7
7	2457	99	1.03	38	0.57	2.6
8	2497	277	8	445	8.2	3.2
9	1224	7.01	0.57	1.6	0.57	1.2
10	14947	30	1330	10	1.8	16.3
11	839	0.34	0.57	0.92	0.57	0.84
12	1730	2518	35	10	1281.6	5.6
13	4611	12	5.4	1.4	0.57	4.6
14	4757	29	3.4	166	2.2	5
15	1180	162	15	30	10	1.4
16	763	0.23	0.57	3.9	0.57	0.77
Average	3774	260	90	223	82	4.4
Geometric Mean	2647	35	3.7	30	2	3.1
Median	2477	46	3.2	34	0.8	3.1

a Field recovery for 100% cotton union suits averaged 87%. The values in this table represent the values found in study divided by 0.87.
Example: Replicate 1 Lower arm; 6562µg (actual) ÷ 0.87 = 7543µg.

b Total (mg) =(Lower Arm + Upper Arm + Lower Leg + Front Torso + Back Torso) * 1mg/1000µg.

Appendix B/Table 3: Unit Exposures For MRID 44658401 (Commercial Pet Groomers During Application of Adams Carbaryl Shampoo)

Replicate No.	ai used (mg)	Whole Body Dosimeter (mg)	Hand Rinses (mg)	Head Exposure (mg)	Total Dermal Exposure (mg)	Inhalation Exposure (µg)	mg ai/ lb ai handled		mg ai/ hr application		mg ai/ lb dog	
							dermal	inhalation	dermal	inhalation	dermal	inhalation
1	2290	9.76	0.294	0.00897	10.1	1.96	1994	0.389	3.493	0.00068	0.207	4.04×10^{-5}
2	684	6.918	0.175	0.00533	7.1	0.05	4714	0.006	2.752	0	0.623	7.63×10^{-7}
3	916	1.462	0.134	0.0007	1.6	0.86	793	0.426	0.521	0.00028	0.0382	2.05×10^{-5}
4	2004	3.056	0.248	0.00631	3.31	0.57	750	0.129	1.335	0.00023	0.184	3.17×10^{-5}
5	1640	6.367	0.124	0.00338	6.49	0.65	1795	0.18	2.107	0.00021	0.18	1.81×10^{-5}
6	1204	2.711	0.164	0.00325	2.88	0.54	1086	0.204	0.906	0.00017	0.0847	1.59×10^{-5}
7	659	2.603	0.082	0.0007	2.69	0.59	1852	0.406	0.918	0.0002	0.113	2.47×10^{-5}
8	373	3.28	0.105	0.00208	3.39	0.41	4123	0.499	1.246	0.00015	0.105	1.27×10^{-5}
9	600	1.233	0.062	0.0003	1.3	0.05	984	0.007	0.323	0	0.0556	3.72×10^{-7}
10	1747	16.544	0.466	0.012	17	1.4	4423	0.364	4.387	0.00036	0.379	3.12×10^{-5}
11	945	0.841	0.292	0.00163	1.14	0.22	548	0.106	0.36	0.0001	0.0268	5.16×10^{-6}
12	3715	15.329	0.145	0.00806	15.5	0.97	1889	0.118	3.822	0.00024	0.325	2.04×10^{-5}
13	1132	4.762	0.119	0.01177	4.89	1.18	1962	0.473	0.994	0.00024	0.173	4.17×10^{-5}
14	1148	4.961	0.141	0.00429	5.11	0.05	2020	0.003	1.481	0	0.312	5.31×10^{-7}
15	706	1.459	0.239	0.00254	1.7	0.76	1093	0.489	0.561	0.00025	0.096	4.29×10^{-5}
16	1929	0.768	0.107	0.00111	0.88	0.48	207	0.113	0.293	0.00016	0.0362	1.98×10^{-5}
Average	1356	5.1	0.18	4.5	5.3	0.67	1900	0.24	1.6	0.0002	0.18	2.0×10^{-5}
Geometric Mean	1148	3.4	0.16	2.9	3.6	0.43	1800	0.12	1.1	0.00096	0.13	1.1×10^{-5}
Median	1140	3.2	0.14	3.3	3.4	0.58	1800	0.19	1.1	0.00021	0.14	2.0×10^{-5}

Appendix C: Carbaryl Occupational Handler Risk Assessment

Appendix C/Table 1: Sources of Exposure Data Used In The Occupational Carbaryl Handler Exposure And Risk Calculations			
Exposure Scenario (Number)	Data Source	Standard Assumptions (8-hr work day)	Comments
Mixer/Loader Descriptors			
Mixing/Loading Dry Flowable Formulations (1a through 1f)	PHED V1.1 (May 1997 Surrogate Table)	350 and 1200 acres for aerial applications (7500 for wide area uses), 40 acres for airblast, 80 and 200 acres for groundboom in agriculture and 40 acres on turf, 5 acres for handguns on turf, and 1000 gallons for handgun applications	**Baseline:** Hand, inhalation, and dermal data = acceptable grades. Hands = 7 replicates; Dermal = 16 to 26 replicates; and Inhalation = 23 replicates. Low confidence in hand/dermal data because of number of hand replicates. Inhalation data are high confidence. No protection factor was needed to define the unit exposure value. **PPE:** As appropriate, the same dermal and inhalation data were used as for the baseline coupled with a 50% protection factor to account for an additional layer of clothing. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). Hands = acceptable grades. Hands = 21 replicates. High confidence in all dermal data. **Engineering Controls:** A protection factor of 98% was used to calculate exposures using the baseline exposure data. Water soluble packet data (Scenario 4) could also be used to address this scenario. **A protection factor has been used but the WSP rate/acre inputs are the same as for DF formulations (refer to Scenario 4).**
Loading Granular Formulations (2a/2b)	PHED V1.1 (May 1997 Surrogate Table)	350 and 1200 acres for aerial applications, 80 acres for agriculture and 40 acres on turf	**Baseline:** Hands = all grades; dermal = ABC grade; inhalation = acceptable grade. Hands = 10 replicates; Dermal = 33 to 78 replicates; and inhalation = 58 replicates. Low confidence in hand/dermal data because of number of hand replicates and quality. Inhalation data are high confidence. No protection factor was needed to define the unit exposure value. **PPE:** Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). Hands = acceptable grades. Hands = 45 replicates. High confidence in hand data. Dermal w/coveralls = ABC grade. Dermal w/coveralls = 12 to 59 replicates. Low confidence in dermal data because of low number of replicates and grades. **Engineering Controls:** A 98 percent protection factor was applied to the baseline data to account for the use of an engineering control (e.g., closed loading system).
Mixing/Loading Liquid Formulations (3a through 3f)	PHED V1.1 (May 1997 Surrogate Table)	350 and 1200 acres for aerial applications (7500 for wide area uses), 40 acres for airblast, 80 and 200 acres for groundboom in agriculture and 40 acres on turf, 5 acres for handguns on turf, and 1000 gallons for handgun applications	**Baseline:** Hands, dermal, and inhalation = acceptable grades. Hands = 53 replicates; Dermal = 72 to 122 replicates; and Inhalation = 85 replicates. High confidence in hand, dermal, and inhalation data. No protection factor was needed to define the unit exposures. **PPE:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Hands = acceptable grades. Hands = 59 replicates. High confidence in hand data. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls:** Hands, dermal, and inhalation = acceptable grades. Hands = 31 replicates; Dermal = 16 to 22 replicates; and Inhalation = 27 replicates. High confidence in hand, dermal, and inhalation data. **Gloves were used coupled with engineering controls since empirical data without gloves were not available and back calculation of gloves to a no glove scenario is believed to give erroneously high estimates. Gloves are also required by WPS based on acute toxicity concerns.**

Appendix C/Table 1: Sources of Exposure Data Used In The Occupational Carbaryl Handler Exposure And Risk Calculations			
Exposure Scenario (Number)	Data Source	Standard Assumptions (8-hr work day)	Comments
Mixing/Loading Wettable Powder Formulations (4a through 4f)	PHED V1.1 (May 1997 Surrogate Table)	350 and 1200 acres for aerial applications (7500 for wide area uses), 40 acres for airblast, 80 and 200 acres for groundboom in agriculture and 40 acres on turf, 5 acres for handguns on turf, and 1000 gallons for handgun applications	**Baseline:** Hands, dermal, and inhalation = ABC grades. Hands = 7 replicates; Dermal = 22 to 45 replicates, and Inhalation = 44 replicates. Low confidence in the dermal/hands data due to the low number of hand replicates. Medium confidence in inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Hands = ABC grades. Hands = 24 replicates. Medium confidence in hand data. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls**: Dermal = AB grade. Hand and inhalation = all grade. Hands = 9 replicates; dermal = 6 to 15 replicates; and inhalation = 15 replicates. Low confidence in the hand, dermal, and inhalation data. No protection factor was needed to define the unit exposure value. Engineering controls are water soluble packets. **Gloves were used coupled with engineering controls since empirical data were available and risk estimates for some scenarios need gloves to attain risk targets. Gloves are also required by WPS based on acute toxicity concerns**
Applicator Descriptors			
Applying Sprays with a Fixed-wing Aircraft (5a)	PHED V1.1 (May 1997 Surrogate Table)	350 acres and 1,200 acres for agriculture and 7500 acres for wide area uses	**Engineering Controls:** Hands = acceptable grade, dermal and inhalation = ABC grade. Hands= 34 replicates, dermal = 24 to 48 replicates, and inhalation = 23 replicates. Medium confidence in dermal and inhalation data. High confidence in hand data. No protection factor was needed to define the unit exposure value. **Engineering controls are the only plausible exposure scenario for this application method as open-cab aircraft are not available and not considered a viable application tool. Protective gloves not used.**
Applying Sprays with a Fixed-wing Aircraft (5b)	PHED V1.1 (May 1997 Surrogate Table)	350 acres and 1,200 acres for agriculture	**Engineering Controls:** Hands and inhalation = all grade, dermal = C grade. Hands= 4 replicates, dermal = 0 to 13 replicates, and inhalation = 13 replicates. Low confidence in all data. No protection factor was needed to define the unit exposure value. **Engineering controls are the only plausible exposure scenario for this application method as open-cab aircraft are not available and not considered a viable application tool. Protective gloves not used.**
Applying Sprays with an Airblast Sprayer (6)	PHED V1.1 (May 1997 Surrogate Table)	40 acres	**Baseline:** Dermal, hand, and inhalation = acceptable grades. Hands = 22 replicates, dermal = 32 to 49 replicates, and inhalation = 47 replicates. High confidence in all data. No protection factor was needed to define the unit exposure value. **PPE:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Hands = acceptable grades. Hands = 18 replicates. High confidence in hand data. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). A 50% protection factor was applied to the head/neck exposure to account for protective headgear. This adjustment has been made based on a Bayer Corporation comment about addition of these to carbaryl labels/compliance with WPS requirements. **Engineering Controls:** Hands and dermal = acceptable grade, and inhalation = ABC grade. Hands= 20 replicates; dermal = 20 to 30 replicates; and inhalation = 9 replicates. High confidence in hand and dermal data. Low confidence for inhalation data. **Gloves were used coupled with engineering controls since empirical data without gloves were not available and back calculation of gloves to a no glove scenario is believed to give erroneously high (130µg/lb ai) estimates for a closed cab scenarios.**

Appendix C/Table 1: Sources of Exposure Data Used In The Occupational Carbaryl Handler Exposure And Risk Calculations			
Exposure Scenario (Number)	Data Source	Standard Assumptions (8-hr work day)	Comments
Applying Sprays with a Groundboom Sprayer (7)	PHED V1.1 (May 1997 Surrogate Table)	80 and 200 acres for groundboom in agriculture and 40 acres on turf	**Baseline**: Hand, dermal, and inhalation = acceptable grades. Hands =29 replicates, dermal = 23 to 42 replicates, and inhalation = 22 replicates. High confidence in hand, dermal, and inhalation data. No protection factors were needed to define the unit exposure values. **PPE:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Hands = ABC grades. Hands = 21 replicates. Medium confidence in hand data. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls**: Hand and dermal = ABC grade. Inhalation = acceptable grades. Hands = 16 replicates; dermal = 20 to 31 replicates; and inhalation = 16 replicates. Medium confidence in the hand and dermal data. High confidence in inhalation data. No protection factor needed to define the unit exposure value. Protective gloves not used.
Applying Granulars with a Tractor Drawn Spreader (8)	PHED V1.1 (May 1997 Surrogate Table)	80 and 200 acres for groundboom in agriculture and 40 acres on turf	**Baseline:** Hand, dermal, and inhalation = acceptable grades. Hands =5 replicates, dermal = 1 to 5 replicates, and inhalation = 5 replicates. Low confidence in hand, dermal, and inhalation data. No protection factors were required to define the unit exposure values. **PPE:** As appropriate, the same dermal, hand, and inhalation data are used as for the baseline coupled with a 50% protection factor to account for an additional layer of clothing, a 90% protection factor to account for the use of chemical resistant gloves. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls:** Hand, inhalation, and dermal = acceptable grades. Hands = 17 replicates; dermal = 27 to 30 replicates; and inhalation = 37 replicates. High confidence in all data. No protection factor needed to define the unit exposure value. Protective gloves not used.
Applying with Aerosol Cans (9)	PHED V1.1 (May 1997 Surrogate Table)	2 cans	**Baseline:** Hand, dermal, and inhalation = acceptable grades. Hands = 15 replicates; dermal = 15 replicates; and inhalation = 15 replicates. High confidence in all data. No protection factor was needed to define the unit exposure values. **PPE:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Hands = acceptable grades. Hands = 15 replicates. High confidence in hand data. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls:** Not considered feasible for this exposure scenario.

Appendix C/Table 1: Sources of Exposure Data Used In The Occupational Carbaryl Handler Exposure And Risk Calculations			
Exposure Scenario (Number)	Data Source	Standard Assumptions (8-hr work day)	Comments
Applying with Trigger Pump Sprayer (10)	MRID 410547-01	1 bottle	**Single Layer Clothing & Glove Scenario Monitored In Study:** Hand, dermal, and inhalation = acceptable grades. Hands = 15 replicates; dermal = 15 replicates; and inhalation = 15 replicates. High confidence in all data. No protection factor was needed to define the unit exposure values. **Engineering Controls:** Not considered feasible for this exposure scenario. **There are no data compensation issues associated with this study as there is a signed PHED data waiver.**
Applying with a Right of Way Sprayer (11)	PHED V1.1 (May 1997 Surrogate Table)	1,000 gallons	**Baseline:** Hand and inhalation = acceptable grades. Dermal = ABC grades. Hands = 16 replicates; dermal = 4 to 20 replicates; and inhalation = 16 replicates. Low confidence in hand and dermal data due to low number of replicates. High confidence in inhalation data. No protection factor was needed to define the unit exposure values. **PPE:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Hands = acceptable grades. Hands = 4 replicates. Low confidence in hand data. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls:** Not considered feasible for this exposure scenario.
Applying with a High Pressure Handwand (12)	PHED V1.1 (May 1997 Surrogate Table)	1,000 gallons	**Baseline:** Hand, dermal, and inhalation = all grades. Hands = 2 replicates; dermal = 9 to 11 replicates; and inhalation = 11 replicates. Low confidence in hand, dermal, and inhalation data. No protection factor was needed to define the unit exposure values. **PPE:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Hands = all grades. Hands = 9 replicates. Low confidence in hand data. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls:** Not considered feasible for this exposure scenario.
Dog Grooming With Shampoo (13)	MRID 446584-01	½ of 6 oz bottle	**Clothing (short-sleeved tee-shirt, smock & long pants) & No Gloves Scenario Monitored In Study:** Hand, dermal, and inhalation = acceptable grades. Hands = 16 replicates; dermal = 16 replicates; and inhalation = 16 replicates. High confidence in all data. No protection factor was needed to define the unit exposure values. **Engineering Controls:** Not considered feasible for this exposure scenario. **There are no data compensation issues associated with this study as it was sponsored by Bayer using Carbaryl.**

Appendix C/Table 1: Sources of Exposure Data Used In The Occupational Carbaryl Handler Exposure And Risk Calculations			
Exposure Scenario (Number)	Data Source	Standard Assumptions (8-hr work day)	Comments
Dusting an Animal (14)	SOPs for Residential Exposure Assessments (7/97)	½ of 4 lb bottle per SOPs	The SOPs For Residential Exposure Assessment served as the basis for this assessment (i.e., the assumptions that were used to predict exposures from pet use products in which a percentage of the application rate is the predictor of potential dermal dose). The scenario is based on the use of a baseline clothing scenario. Calculations in which additional PPE are applied are not appropriate given the basis for the assessment. Additionally, the use of engineering controls are not considered feasible for this exposure scenario.
Dispersing Granulars & Baits By Hand (15)	PHED V1.1 (May 1997 Surrogate Table)	1 acre	**Baseline:** Values not included because barehanded data were not available and hand exposures are key to this scenario. **PPE:** Dermal, hand, and inhalation = ABC grades. Hands = 15 replicates, dermal = 16 replicates, and inhalation = 16 replicates. Medium confidence in all data. The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls:** Not considered feasible for this exposure scenario.
Dispersing Granulars & Baits With a Spoon (16)	MRID 452507-01	1 acre	**Baseline:** Values not included because barehanded data were not available and hand exposures are key to this scenario. **PPE:** Dermal, hand, and inhalation = acceptable grades. Hands = 10 replicates, dermal = 10 replicates, and inhalation = 10 replicates. Low confidence in all data because dernal dosimeters were unprotected and the number of replicates. Protective gloves were worn. A 50% protection factor to account for a layer of clothing was used. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls:** Not considered feasible for this exposure scenario. **There are no data compensation issues associated with this study as it was sponsored by Bayer.**

Appendix C/Table 1: Sources of Exposure Data Used In The Occupational Carbaryl Handler Exposure And Risk Calculations			
Exposure Scenario (Number)	Data Source	Standard Assumptions (8-hr work day)	Comments
Mixer/Loader/Applicator Descriptors			
Mixing/Loading/ Applying Liquid Sprays w/Low Pressure, High Volume Turfgun (17)	MRID 449722-01	5 acres	**Baseline:** Values back-calculated using 90% protection factor for gloves. Non-hand dermal data for single layer monitored (see PPE). **PPE:** See EPA review for data quality (Bangs, 2001), data are considered high quality. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). A 50% protection factor to account for an additional layer of clothing. Study monitored single layer clothing with gloves. **Engineering Controls:** Not considered feasible for this exposure scenario. **There are no data compensation issues associated with this study as it was sponsored by ORETF (Bayer is a member). Turfgun, no glove data were not back calculated using a 90 percent protection factor as it is deemed unreliable. WP formulation in WSP packaging used for turfgun assessment as the unit exposures for this scenario were slightly higher than for the other scenarios and deemed representative of current products/packaging.**
Mixing/Loading/ Applying Wettable Powders with a Low Pressure Sprayer (18a)	PHED V1.1 (May 1997 Surrogate Table)	40 gallons for ornamentals and 20,000ft2 for poultry houses	**Baseline:** The only empirical data that are available are based on the use of chemical-resistant gloves. It is not appropriate to back-calculate a non-glove hand exposure level for this scenario as it is considered an overestimate of exposure because the hands are a key contributor to exposure. **PPE**: Dermal and inhalation= ABC grades; and hands = acceptable grades. Dermal = 16 replicates; hands = 15 replicates; and inhalation = 16 replicates. Medium confidence in inhalation, dermal, and hand data. A 50% protection factor to account for an additional layer of clothing. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls:** Not considered feasible for this exposure scenario.
Mixing/Loading/ Applying Liquids with a Low Pressure Sprayer (18b)	PHED V1.1 (May 1997 Surrogate Table)	40 gallons for ornamentals and 20,000ft2 for poultry houses	**Baseline:** Hands = all grades; dermal and inhalation = ABC grades. Dermal = 9 to 80 replicates; hands = 70 replicates; and inhalation = 80 replicates. Medium confidence in inhalation data. Low confidence in dermal and hand data. No protection factor was needed to define the unit exposure values. **PPE**: The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Hand = 10 replicates. Hands= ABC grades Low confidence in hand data. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls:** Not considered feasible for this exposure scenario.

Appendix C/Table 1: Sources of Exposure Data Used In The Occupational Carbaryl Handler Exposure And Risk Calculations			
Exposure Scenario (Number)	Data Source	Standard Assumptions (8-hr work day)	Comments
Mixing/Loading/ Applying with a Backpack Sprayer (19)	PHED V1.1 (May 1997 Surrogate Table)	40 gallons for ornamentals and 20,000ft2 for poultry houses	**Baseline:** Dermal and inhalation = acceptable grades. Dermal = 9 to 11 replicates and inhalation = 11 replicates. Low confidence in dermal and inhalation data. **The only empirical data that are available are based on the use of chemical-resistant gloves.** It is generally not appropriate to back-calculate a non-glove hand exposure levels, an extrapolation has been completed for this scenario, however, because the empirical data indicate that hands are a minor contributor to overall exposure levels. **PPE:** Hands = C grades. Hands = 11 replicates. Low confidence in hand data. The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls:** Not considered feasible for this exposure scenario.
Loading/Applying Granulars with a Belly Grinder (20)	PHED V1.1 (May 1997 Surrogate Table)	1 acre	**Baseline:** Inhalation = acceptable grades; dermal and hands = ABC grades. Dermal = 29 to 45 replicates; hands = 23 replicates; and inhalation = 40 replicates. High confidence in inhalation data. Medium confidence in dermal and hand data. No protection factor was needed to define the unit exposure values. **PPE:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Hands = all grades. Hands = 20 replicates. Low confidence in hand data. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls:** Not considered feasible for this exposure scenario.
Loading/Applying granulars with a push spreader (21)	PHED V1.1 (May 1997 Surrogate Table)	5 acres	**Baseline:** Values back-calculated using 90% protection factor for gloves. Non hand dermal data for single layer monitored (see PPE). **PPE:** See EPA review for data quality (Bangs, 2001), data are considered high quality. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). A 50% protection factor to account for an additional layer of clothing. Study monitored single layer clothing with gloves. **Engineering Controls:** Not considered feasible for this exposure scenario. **There are no data compensation issues associated with this study as it was sponsored by ORETF (Bayer is a member).**
Mixing/Loading/ Applying with a Handheld Fogger (22)	No Data	No Data	No Data

Appendix C/Table 1: Sources of Exposure Data Used In The Occupational Carbaryl Handler Exposure And Risk Calculations			
Exposure Scenario (Number)	Data Source	Standard Assumptions (8-hr work day)	Comments
Mixing/Loading/ Applying with a Handheld Fogger (23)	No Data	No Data	No Data
Mixing/Loading/ Applying with a Granular Backpack Applicator (24)	MRID 451672-01	1 acre	**Clothing (coverall and apron worn on back) & Gloves Scenario Monitored In Study:** High confidence in all data. No protection factor was needed to define the unit exposure values. **Engineering Controls:** Not considered feasible for this exposure scenario. **There are no data compensation issues associated with this study as it was sponsored by Bayer using Carbaryl.**
Mixing/Loading/ Applying with a Tree Injector (25)	No Data	No Data	No Data
Drench/Dipping Forestry & Ornamentals (26)	PHED V1.1 (May 1997 Surrogate Table)	100 gallons of solution prepared	Addresses only solution preparation aspects of process. This has been addressed using open mixing liquid data presented above in Scenario 3. Engineering controls are not appropriate for this scenario.
Mixing/Loading/ Applying with a Sprinkler Can (27)	PHED V1.1 (May 1997 Surrogate Table)	10 gallons	**Scenario assessed using hose-end sprayer data which are believed to result in similar exposures. However, the extrapolation should be considered rangefinder in nature.** **Baseline:** Inhalation = ABC grades; dermal = C grade; and hands = E grade. Dermal = 8 replicates; hands = 8 replicates; and inhalation = 8 replicates. Low confidence in all data. Study monitored total deposition. A 50% protection factor to account for single layer of clothing was used to define the unit exposure values. **PPE:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. A 90 % protection factor was used to account for the use of protective gloves. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls:** Not considered feasible for this exposure scenario.

Appendix C/Table 1: Sources of Exposure Data Used In The Occupational Carbaryl Handler Exposure And Risk Calculations			
Exposure Scenario (Number)	Data Source	Standard Assumptions (8-hr work day)	Comments
Flagger Descriptors			
Flagging Aerial Spray Applications (28a)	PHED V1.1 (May 1997 Surrogate Table)	350 acres and 1,200 acres	**Baseline:** Hands, dermal, and inhalation = acceptable grades. Dermal = 18 to 28 replicates; hands = 30 replicates; and inhalation = 28 replicates. High confidence in dermal, hand, and inhalation data. No protection factor was required to calculate unit exposures. **PPE**: The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Hand = acceptable grades. Hands= 6 replicates. Low confidence in hand data. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls**: The same data are used as for baseline coupled with a 98% protection factor to account for the use of an engineering control (e.g., sitting in a vehicle).
Flagging Aerial Spray Applications (28b)	PHED V1.1 (May 1997 Surrogate Table)	350 acres and 1,200 acres	**Baseline:** Hands and inhalation = All grades. Dermal = ABC grades. Dermal = 16 to 20 replicates; hands = 4 replicates; and inhalation = 4 replicates. Low confidence in all data. Study monitored total deposition. A 50% protection factor to account for single layer of clothing was used to define the unit exposure values. **PPE**: The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing and a 90% protection factor to account for the use of gloves. Respirator protection factors of either 5 or 10 applied to account for the use of either dust/mist masks or cannister type devices (e.g., organic vapor removing half face device). **Engineering Controls**: The same data are used as for baseline coupled with a 98% protection factor to account for the use of an engineering control (e.g., sitting in a vehicle).

- All *Standard Assumptions* are based on an 8-hour work day as estimated by the Agency.
- All handler exposure assessments in this document are based on the "Best Available" data as defined by the PHED SOP for meeting Subdivision U Guidelines (i.e., completing exposure assessments). Best available grades are assigned to data as follows: matrices with A and B grade data (i.e., Acceptable Grade Data) and a minimum of 15 replicates; if not available, then grades A, B and C data and a minimum of 15 replicates; if not available, then all data regardless of the quality (i.e., All Grade Data) and number of replicates. High quality data with a protection factor take precedence over low quality data with no protection factor. Generic data confidence categories are assigned as follows:
  High = grades A and B and 15 or more replicates per body part
  Medium = grades A, B, and C and 15 or more replicates per body part
  Low = grades A, B, C, D and E or any combination of grades with less than 15 replicates.
- **PHED grading criteria do not reflect overall quality of the reliability of the assessment. Sources of the exposure factors should also be considered in the risk management decision.**

Appendix D: Carbaryl Residue Dissipation (DFR & TTR) Data

Appendix E: Carbaryl Occupational Postapplication Risk Assessment

Appendix F: Carbaryl Residential Handler Exposure Data

Appendix F/Table 1: Exposure Data From MRID 444399-01
(Carbaryl Applicator Exposure Study During Application of Sevin® 5 Dust to Dogs By the Non-Professional)

Replicate	lb ai used	Inner (µg)				Outer (µg)		Hand (µg)	Face/Neck (µg)	Total Dermal Exposure[a] (mg)	Inhalation Exposure (µg)
		Upper Arm	Front Torso	Back Torso	Upper Leg	Lower Arm	Lower Leg				
1	0.0034	40.7	217	122	70.7	8810	13100	5770	98.1	28	383
2	0.016	173	445	230	130	28300	37000	12500	215	79	232
3	0.0079	21.8	77.7	60.9	56.4	4240	1630	3890	43.5	10	252
4	0.0042	23.3	43.9	50.9	40.8	4110	13800	5380	26.8	23	244
5	0.0083	37.6	216	108	64.3	26200	24200	8140	180	59	149
6	0.0025	16.4	25	38.3	9.06	2470	541	4940	23.3	8.1	37.4
7	0.003	11.7	97.3	99.3	31.4	3150	2570	4490	61.6	11	66.3
8	0.0068	41.9	111	89.5	21.8	6450	380	10500	43.4	18	170
9	0.0068	27.2	79.4	215	31.7	3400	345	11600	65.4	16	158
10	0.012	145	648	224	278	67900	11500	11900	263	93	525
11	0.0047	20	79.4	78.1	53.2	12800	581	7300	280	21	244
12	0.022	97.4	454	435	232	44100	8310	24600	73.5	78	486
13	0.0093	50.5	85.6	64.5	42.3	7680	577	4350	31	13	173
14	0.0014	5.03	17.2	16.7	4.92	1710	133	3870	11.9	5.8	82.5
15	0.0085	14.8	159	129	18.6	6320	1350	5980	74	14	216
16	0.014	61.7	138	138	40.3	22000	1960	5140	41	30	509
17	0.0069	15.5	110	53	20	15600	1060	4570	33.1	21	209
18	0.0064	16.3	102	91.8	61.7	13500	651	6830	104	21	67.4
19	0.006	5.12	33.2	39.7	13.8	3830	271	9080	20.3	13	37.1
20	0.004	47.3	66.1	121	127	2720	1990	7650	41.8	13	170

Appendix F/Table 2: Exposure Data For Hose-End Sprayers From MRID 444598-01
(Mixer Loader Applicator Exposure to RP-2 Liquid (21%).Carbaryl Mixer/Loader/Applicator Exposure Study during Application of RP-2 Liquid (21%) Sevin® Ready to Use Insect Spray or Sevin® 10 Dust to Home Garden Vegetables)

Rep	Carbaryl Applied (lb)	Inner Dosimeter (µg)	Outer Dosimeter - Lower Arm (µg)	Outer Dosimeter - Lower leg (µg)	Hand (µg)	Face/Neck Wipe (µg)	Total Dermal Exposure[a] (µg)	Inhalation Exposrue (µg)
1	0.11	19.1	71.3	571	2770	0.5	3.43	0.24
2	0.076	3.0	7.26	2548	1030	0.5	3.59	0.07
3	0.045	8.8	34.1	624	291	0.5	0.96	0.07
4	0.025	10.3	10.9	337	1560	0.5	1.92	0.07
5	0.05	3.0	1.97	1776	1100	17	2.90	0.07
6	0.083	15.3	32.9	4080	2170	0.5	6.30	0.25
7	0.047	3.0	3.01	710	462	0.5	1.18	0.15
8	0.052	9.8	62.5	937	618	0.5	1.63	0.23
9	0.041	4.4	26	320	437	0.5	0.79	0.07
10	0.053	6.6	32.2	194	691	0.5	0.92	0.07
11	0.07	3.0	0.5	2008	331	0.5	2.34	0.07
12	0.051	183.3	61.9	673	3380	0.5	4.30	0.21
13	0.031	3.0	7	28.6	693	0.5	0.73	0.07
14	0.075	3.0	44	465	3700	0.5	4.21	0.07
15	0.026	6.4	3.4	130	62.6	0.5	0.20	0.07
16	0.036	30.7	48.8	2587	4440	58	7.16	0.16
17	0.051	85.1	3037	1969	3240	0.5	8.33	0.07
18	0.095	3.0	23.3	422	612	0.5	1.06	0.07
19	0.052	10.1	158	537	385	0.5	1.09	0.23
20	0.025	3.0	0.5	22.8	149	0.5	0.18	0.07

Appendix F/Table 3: Exposure Data For Low Pressure Handwand Sprayers From MRID 444598-01
(Mixer Loader Applicator Exposure to RP-2 Liquid (21%).Carbaryl Mixer/Loader/Applicator Exposure Study during Application of RP-2 Liquid (21%) Sevin® Ready to Use Insect Spray or Sevin® 10 Dust to Home Garden Vegetables)

Rep	Carbaryl Applied (lb)	Inner Dosimeter (µg)	Outer Dosimeter - Lower Arm (µg)	Outer Dosimeter -Lowel leg (µg)	Hand (µg)	Face/Neck Wipe (µg)	Total Dermal Exposure[a] (mg)
1	0.02	3.0	20.6	921.0	215.0	0.5	1.16
2	0.02	3.0	15.8	476.0	381.0	0.5	0.88
3	0.02	3.0	14.3	76.7	208.0	0.5	0.30
4	0.02	30.0	214.0	485.0	2100.0	9.8	2.84
5	0.01	3.0	2.5	36.8	168.0	0.5	0.21
6	0.02	7.9	84.4	3449.0	165.0	0.5	3.71
7	0.02	5.2	7.7	85.3	235.0	0.5	0.33
8	0.02	18.6	41.4	876.0	205.0	0.5	1.14
9	0.02	3.0	9.7	99.4	203.0	0.5	0.32
10	0.02	10.0	5.9	259.0	378.0	0.5	0.65
11	0.02	3.0	2.1	157.0	50.6	0.5	0.21
12	0.01	3.0	69.4	64.6	451.0	0.5	0.59
13	0.02	3.0	9.9	247.0	1550.0	0.5	1.81
14	0.02	3.0	5.4	242.0	219.0	0.5	0.47
15	0.02	7.9	3.5	2278.0	100.0	0.5	2.39
16	0.02	5.6	28.3	245.0	415.0	0.5	0.69
17	0.02	4.5	0.5	245.0	203.0	0.5	0.45
18	0.02	3.0	2.6	299.0	188.0	0.5	0.49
19	0.02	16.4	5.5	47.5	86.3	0.5	0.16
20	0.02	17.5	328.0	255.0	118.0	0.5	0.72

Appendix F/Table 4: Exposure Data For Ready-to-use Sprayers From MRID 444598-01 (Mixer Loader Applicator Exposure to RP-2 Liquid (21%).Carbaryl Mixer/Loader/Applicator Exposure Study during Application of RP-2 Liquid (21%) Sevin® Ready to Use Insect Spray or Sevin® 10 Dust to Home Garden Vegetables)								
Rep	Carbaryl Applied (lb)	Inner Dosimeter (µg)	Outer Dosimeter - Lower Arm (µg)	Outer Dosimeter - Lowel leg (µg)	Hand (µg)	Face/Neck Wipe (µg)	Total Dermal Exposure[a] (mg)	Inhalation Exposure (µg)
1	0.0024	3.0	7.43	21.6	270	0.5	0.31	0.66
2	0.0022	5.5	10.5	33.7	81.9	0.5	0.13	0.56
3	0.0028	7.2	10.2	26.1	654	0.5	0.70	0.29
4	0.0025	6.4	13.3	82.9	225	0.5	0.33	0.42
5	0.002	3.0	8.43	80.8	197	0.5	0.29	0.36
6	0.0022	3.0	7.92	41.1	150	0.5	0.20	0.07
7	0.002	4.9	5.5	22	301	0.5	0.33	0.36
8	0.0022	4.3	6.65	40.4	115	0.5	0.17	0.44
9	0.0021	3.0	0.5	1.72	44.5	0.5	0.05	0.07
10	0.0022	3.0	0.5	2.46	98.1	0.5	0.11	0.07
11	0.0021	3.0	0.5	2.3	45.1	0.5	0.05	0.07
12	0.0022	10.0	2.29	7.22	198	0.5	0.22	0.19
13	0.0022	3.0	5.41	3.51	44.8	0.5	0.05	0.07
14	0.0021	7.2	2.46	18.4	16.5	0.5	0.05	0.23
15	0.002	3.0	3.84	4.48	28.2	0.5	0.04	0.07
16	0.0022	61.8	5.12	6.33	392	11.9	0.48	0.07
17	0.0022	5.2	2.23	12.2	3.67	0.5	0.02	0.07
18	0.0022	3.0	0.5	2.54	34.8	0.5	0.04	0.07
19	0.0022	3.0	4.39	17.2	67.2	0.5	0.09	0.07
20	0.0022	3.0	2.79	18	23.7	0.5	0.05	0.07

Appendix F/Table 5: Exposure Data For Dust Applications From MRID 444598-01 (Mixer Loader Applicator Exposure to RP-2 Liquid (21%).Carbaryl Mixer/Loader/Applicator Exposure Study during Application of RP-2 Liquid (21%) Sevin® Ready to Use Insect Spray or Sevin® 10 Dust to Home Garden Vegetables)								
Rep	Carbaryl Applied (lb)	Inner Dosimeter (µg)	Outer Dosimeter - Lower Arm (µg)	Outer Dosimeter - Lowel leg (µg)	Hand (µg)	Face/Neck Wipe (µg)	Total Dermal Exposure[a] (mg)	Inhalation Exposure (µg)
1	0.0033	126.9	296	902	884	3.23	2.22	7.5
2	0.025	98.9	346	932	13300	23.5	14.70	15.1
3	0.0072	57.1	112	1281	526	12.5	1.99	9.93
4	0.012	96.5	453	243	719	34.4	1.55	26.8
5	0.012	150.0	139	282	1530	5.85	2.11	3.57
6	0.013	38.4	309	381	488	3.62	1.22	7.94
7	0.0045	50.4	359	83	568	3.97	1.06	21.9
8	0.0093	26.0	1815	59.8	228	5.53	2.13	0.07
9	0.013	86.5	230	95.4	667	15.9	1.10	27.4
10	0.015	25.0	452	127	413	13.3	1.03	5.73
11	0.019	53.1	167	306	1020	7.25	1.55	40.7
12	0.012	21.6	90.9	66.9	2920	1.96	3.10	7.89
13	0.029	77.7	381	587	423	8.95	1.48	57.7
14	0.0026	44.1	227	305	3030	2.35	3.61	37.1
15	0.02	71.4	153	219	351	1.21	0.80	2.51
16	0.0086	165.7	174	624	1440	1.88	2.41	9.34
17	0.03	93.4	275	413	494	6.89	1.28	42.1
18	0.044	82.2	282	949	259	12.7	1.59	24.9
19	0.013	171.1	1022	133	1500	23.7	2.85	29.7
20	0.026	36.0	221	65.5	1210	2.52	1.54	6.74

Appendix F/Table 6: Exposure Data For Hose-End Sprayers From MRID 445185-01
(Carbaryl Mixer/Loader/Applicator Exposure Study during Application of RP-2 Liquid (21%) to Fruit Trees and Ornamental Plants)

Rep	Carbaryl Applied (lb)	Inner Dosimeter (µg)	Outer Dosimeter - Lower Arm (µg)	Outer Dosimeter - Lowel leg (µg)	Hand (µg)	Face/Neck Wipe (µg)	Total Dermal Exposure[a] (mg)	Inhalation Exposure (µg)
1	0.026	4.5	15	37	128	0.5	0.19	0.07
2	0.02	3.8	133	1890	227	0.5	2.45	0.07
3	0.066	17.0	995	2218	5480	3.6	8.71	0.07
4	0.053	26.5	193	1230	13200	2.2	14.65	0.15
5	0.026	3.7	337	348	952	0.5	1.64	0.29
6	0.026	18.5	49	161	82	0.5	0.31	0.07
7	0.02	3.0	99	220	1060	0.5	1.38	0.07
8	0.022	3.6	78	213	694	0.5	0.99	0.07
9	0.021	4.6	28	87	779	0.5	0.90	0.07
10	0.02	4.3	298	226	460	1.9	0.99	0.07
11	0.035	10.4	47	119	248	0.5	0.43	0.08
12	0.046	5.1	23	72	130	0.5	0.23	0.07
13	0.042	3.0	270	181	2060	0.5	2.52	0.07
14	0.09	9.1	567	1824	1400	0.5	3.80	0.23
15	0.029	3.0	123	193	428	0.5	0.75	0.07
16	0.026	11.3	36	181	2850	0.5	3.08	0.07
17	0.062	3.0	75	878	643	0.5	1.60	0.07
18	0.024	21.5	251	97	1830	0.5	2.20	0.07
19	0.073	3.0	180	301	736	0.5	1.22	0.07
20	0.024	3.9	9.4	124	521	0.5	0.66	0.07

Appendix F/Table 7: Exposure Data For Low Pressure Handwand Sprayers From MRID 445185-01 (Carbaryl Mixer/Loader/Applicator Exposure Study during Application of RP-2 Liquid (21%) to Fruit Trees and Ornamental Plants)								
Rep	Carbaryl Applied (lb)	Inner Dosimeter (µg)	Outer Dosimeter - Lower Arm (µg)	Outer Dosimeter - Lowel leg (µg)	Hand (µg)	Face/Neck Wipe (µg)	Total Dermal Exposure[a] (mg)	Inhalation Exposure (µg)
1	0.018	3.0	5.6	11	432	0.5	0.45	0.07
2	0.015	6.7	55	467	259	0.5	0.78	0.07
3	0.02	34.0	571	491	1450	20	2.57	0.07
4	0.019	4.9	34	88	381	0.5	0.51	0.07
5	0.013	5.5	133	1297	3080	0.5	4.52	0.07
6	0.014	8.4	56	147	567	0.5	0.78	0.07
7	0.018	7.5	906	378	825	0.5	2.12	0.07
8	0.02	12.1	95	440	2970	1.2	3.52	0.32
9	0.017	15.2	27	182	524	0.5	0.75	0.16
10	0.015	5.0	42	146	414	1.3	0.61	0.24
11	0.019	25.2	59	303	493	0.5	0.88	0.07
12	0.018	3.0	15	108	139	0.5	0.27	0.07
13	0.018	9.0	79	281	271	0.5	0.64	0.07
14	0.02	9.5	209	522	917	0.5	1.66	0.07
15	0.015	11.4	131	780	247	1.8	1.17	0.37
16	0.017	9.2	25	437	864	0.5	1.33	0.2
17	0.02	3.0	78	639	198	0.5	0.92	0.07
18	0.017	3.0	51	285	267	0.5	0.61	0.38
19	0.02	6.9	41	81	373	0.5	0.50	0.07
20	0.018	8.9	81	605	436	1.4	1.13	0.33

Appendix G: Carbaryl Residential Handler Risk Assessment

Appendix G/Table 1: Residential Handler Scenario Descriptions for the Use of Carbaryl			
Exposure Scenario (Number)	Data Source	Standard Assumptions (8-hr work day)	Comments[a]
Mixer/Loader/Applicator Descriptors			
Garden: Ready-to-use trigger sprayer (1)	MRID 444598-01	1/4 to 1 bottle (1 bottle is SOP requirement, others shown for characterization)	A total of 40 replicates were monitored in this study. Half of the people wore gloves and the other half did not. The clothing scenario represents short-sleeved shirt, short pants, and no gloves. The data are considered high quality by the Agency. **There are no data compensation issues associated with this study as it was sponsored by Bayer**
Garden: Ornamental Duster (2)	MRID 444598-01	1/4 to 1 bottle (1 bottle is SOP requirement, others shown for characterization)	A total of 20 replicates were monitored in this study. No individuals wore gloves. The clothing scenario represents short-sleeved shirt, short pants, and no gloves. The data are considered high quality by the Agency. **There are no data compensation issues associated with this study as it was sponsored by Bayer**
Garden: Hose-end Sprayer (3)	MRID 444598-01	1000 ft^2 or 100 gallons output (1000ft^2 is SOP requirement, others shown for characterization)	A total of 40 replicates were monitored in this study. Half of the people wore gloves and the other half did not. The clothing scenario represents short-sleeved shirt, short pants, and no gloves. The data are considered high quality by the Agency. **There are no data compensation issues associated with this study as it was sponsored by Bayer**
Garden: Low Pressure Handwand Sprayer (4)	MRID 444598-01	5 gallons or 1000 ft^2 (5 gallons is SOP requirement, others shown for characterization)	A total of 40 replicates were monitored in this study. Half of the people wore gloves and the other half did not. The clothing scenario represents short-sleeved shirt, short pants, and no gloves. The data are considered high quality by the Agency. **There are no data compensation issues associated with this study as it was sponsored by Bayer**
Trees and Ornamentals: Low Pressure Handwand Sprayer (5)	MRID 445185-01	5 gallons or 1000 ft^2 (5 gallons is SOP requirement, others shown for characterization)	A total of 20 replicates were monitored in this study. No individuals wore gloves. The clothing scenario represents short-sleeved shirt, short pants, and no gloves. The data are considered high quality by the Agency. **There are no data compensation issues associated with this study as it was sponsored by Bayer**
Trees and Ornamentals: Hose-end Sprayer (6)	MRID 445185-01	100 gallons or 1000 ft^2 (1000 ft^2 is SOP requirement, others shown for characterization)	A total of 20 replicates were monitored in this study. No individuals wore gloves. The clothing scenario represents short-sleeved shirt, short pants, and no gloves. The data are considered high quality by the Agency. **There are no data compensation issues associated with this study as it was sponsored by Bayer**
Mixing/Loading/Applying with a Backpack Sprayer (7)	PHED V1.1 (7/97 Residential SOP Surrogate Table)	5 gallons or 1000 ft^2 (5 gallons is SOP requirement, others shown for characterization)	Inhalation and dermal = acceptable grades. Hand data = C grade. Dermal = 9 to 11 replicates, hand = 11 replicates, and inhalation = 11 replicates. Low confidence in data. **Hand exposure values were back-calculated using empirical data that were generated using chemical-resistant gloves and a 90 percent protection factor. An additional 10x safety factor was applied to the hand exposure value because the calculated hand exposure value did not correspond to the level expected given the other dermal exposure values for the scenario (the 10x factor addition was completed based on instructions contained in the Residential SOPs).**

Appendix G/Table 1: Residential Handler Scenario Descriptions for the Use of Carbaryl			
Exposure Scenario (Number)	Data Source	Standard Assumptions (8-hr work day)	Comments[a]
Lawncare: Hose-end Sprayer (8)	MRID -44972201	1000 ft^2 for spot treatments and 20,000ft^2 for broadcast applications	A total of 60 replicates were monitored in this study. Half of the subjects used ready-to-use packaging while the others used open pour. The values used for assessment were open pour. The clothing scenario represents short-sleeved shirt, short pants, and no gloves. The data are considered high quality by the Agency. **There are no data compensation issues associated with this study as it was sponsored by Bayer**
Dusting a Dog (9)	MRID 444399-01	½ bottle of product	A total of 40 replicates were monitored in this study. Half of the people wore gloves and the other half did not. The clothing scenario represents short-sleeved shirt, short pants, and no gloves. The data are considered high quality by the Agency. **There are no data compensation issues associated with this study as it was sponsored by Bayer**
Dipping a Dog (10)	SOPs for Residential Exposure Assessments (7/97)	½ bottle of product	The SOPs For Residential Exposure Assessment served as the basis for this assessment (i.e., the assumptions that were used to predict exposures from pet use products in which a percentage of the application rate is the predictor of potential dermal dose). The scenario is based on the use of a residential clothing scenario (i.e., short pants, short-sleeved shirt, no gloves, no respirator). Note that the same value is used as for the occupational handler scenarios. The refinement of the SOPs for Residential Exposure Assessment is such that further delineation based on clothing scenario is not appropriate (i.e., to alter value based on use of short vs. long pants and long-sleeved vs. short-sleeved shirts).
Lawncare: Granular and Baits By Bellygrinder (11)	SOPs for Residential Exposure Assessments (7/97)	1000 ft^2 for spot treatment	Inhalation = acceptable grades. Hand and dermal data = ABC grade. Dermal = 20 to 45 replicates, hand = 23 replicates, and inhalation = 40 replicates. Medium confidence in dermal and hand data. High confidence in inhalation data.
Lawncare: Granular and Baits By Push-type Spreader (12)	MRID -44972201	20,000ft^2 for broadcast applications	A total of 30 replicates were monitored in this study. The clothing scenario represents short-sleeved shirt, short pants, and no gloves. The data are considered high quality by the Agency. **There are no data compensation issues associated with this study as it was sponsored by Bayer**
Lawncare: Granular and Baits By Hand (13)	SOPs for Residential Exposure Assessments (7/97)	1000 ft^2 for spot treatment	Dermal, hand and inhalation data = ABC grade. Dermal = 16 replicates, hand = 16 replicates, and inhalation = 16 replicates. Medium confidence in all data.
Aerosol Can (14)	SOPs for Residential Exposure Assessments (7/97)	1 can	Hand data = acceptable grades. Dermal and inhalation data = ABC grade. Dermal = 30 replicates, hand = 15 replicates, and inhalation = 30 replicates. Medium confidence in all data.

Appendix G/Table 1: Residential Handler Scenario Descriptions for the Use of Carbaryl			
Exposure Scenario (Number)	Data Source	Standard Assumptions (8-hr work day)	Comments[a]
Flea Collar (15)	SOPs for Residential Exposure Assessments (7/97)	1 collar	The SOPs For Residential Exposure Assessment served as the basis for this assessment (i.e., the assumptions that were used to predict exposures from pet use products in which a percentage of the application rate is the predictor of potential dermal dose). The scenario is based on the use of a residential clothing scenario (i.e., short pants, short-sleeved shirt, no gloves, no respirator). Note that the same value is used as for the occupational handler scenarios. The refinement of the SOPs for Residential Exposure Assessment is such that further delineation based on clothing scenario is not appropriate (i.e., to alter value based on use of short vs. long pants and long-sleeved vs. short-sleeved shirts).
Sprinkler Can (16)	MRID 445185-01	5 gallons	Data from hose-end sprayer applications to trees and ornamentals was used to assess this scenario. The results should be considered as rangefinder in nature to account for the extrapolation completed for this assessment.
Ornamental Paint On (17)	SOPs for Residential Exposure Assessments (7/97)	1 gallon	Hand data = acceptable grade. Dermal and inhalation data = C grade. Dermal = 14 to 15 replicates, hand = 15 replicates, and inhalation = 15 replicates. Low to medium confidence in all data.

a All *Standard Assumptions* are based on an 8-hour work day as estimated by HED. BEAD data were not available.

b All handler exposure assessments in this document are based on the "Best Available" data as defined by the PHED SOP for meeting Subdivision U Guidelines (i.e., completing exposure assessments). Best available grades are assigned to data as follows: matrices with A and B grade data (i.e., Acceptable Grade Data) and a minimum of 15 replicates; if not available, then grades A, B and C data and a minimum of 15 replicates; if not available, then all data regardless of the quality (i.e., All Grade Data) and number of replicates. High quality data with a protection factor take precedence over low quality data with no protection factor. Generic data confidence categories are assigned as follows:

High = grades A and B and 15 or more replicates per body part
Medium = grades A, B, and C and 15 or more replicates per body part
Low = grades A, B, C, D and E or any combination of grades with less than 15 replicates.

c **PHED grading criteria do not reflect overall quality of the reliability of the assessment. Sources of the exposure factors should also be considered in the risk management decision.**

Appendix H: Carbaryl Residential Postapplication Risk Assessment For Turf Uses

Appendix I: Carbaryl Residential Postapplication Risk Assessment For Garden/Ornamental Uses

Appendix J: Carbaryl Residential Postapplication Risk Assessment For Pet Uses

Appendix K: Determination of Deposition Factors For Carbaryl Mosquito Control Uses

Background Information: Carbaryl has been historically used for the control of insect pests such as mosquitoes and black flies in a manner that has employed the use of Ultra-low Volume (ULV) application methods over wide areas. As the reregistration process has progressed, the labels for these types of applications have been reviewed and the Bayer Corporation has submitted a draft label for the Sevin XLR (4 lb ai/gallon) product which has been used to develop the risk assessment for these uses. Bayer is interested in maintaining this use pattern even though the marketshare for carbaryl in this area has declined in recent years due to the use of the synthetic pyrethroids and other chemistries.

According to the Sevin XLR label, applications can be made using ground, aerial or handheld equipment suitable for fogging urban environments (e.g., backpack or handheld foggers). ULV type applications or thermal fogging applications are allowable based on the label. The label indicates that the optimal droplet size is 8 to 30 µm by mass median diameter (MMD) or volume median diameter (VMD) calculations for ground fogger applications. For aerial applications, the droplet spectra that is specified has a calculated VMD of less than 50 µm and no more than 5 percent of the droplets should be larger than 80 µm.

The label presents a range of application rates from 0.016 to 1.0 lb ai/acre (i.e., 0.016, 0.15, and 1.0 lb ai/acre). These use rates have not been linked to specific pests or pest pressures on the label. Applications can be made using undiluted material or with a 1:1 or 1:2 dilution rate.

Agricultural Engineering Considerations: With few notable exceptions such as public health scenarios (e.g., mosquito control), the general intent during most pesticide applications is to confine the deposition of applied chemicals to specific target areas such as agricultural fields. Economic concerns, health concerns, environmental concerns, and efficacy are the generally recognized rationale for limiting off-target deposition. Pesticide applicators can control deposition patterns through the use of specific types of equipment and by controlling application parameters. Several application parameters can potentially impact deposition patterns of liquid-form pesticides in the environment during application (e.g., nozzle size, application pressure, vehicle configuration and speed, meteorological conditions including environmental stability, and physical-chemical characteristics of the formulation).

As indicated above, ULV mosquito control applications serve as the basis for this assessment. The general intent of these types of applications is antithetical to most pesticide applications in that spray drift is generally not inhibited but promoted in order to broaden the effective treatment area and ensure that the resulting droplets stay aloft for as long as possible. In fact, the efficacy of mosquito adulticide compounds is based on droplets contacting in-flight mosquitos. As a result, there are significant agricultural engineering differences that were considered by The Agency in this assessment. These include:

- Release heights for mosquito control aerial ULV applications are typically 100 to 500 feet (or even higher) as opposed to most typical agricultural aerial applications where the release height is generally as low as the pilot can go (i.e., often 10 feet or less). Release height can significantly impact spray drift (i.e., the higher the release, the longer to time of impact with target area, and the more potential for drift). A release height of 300 feet was used in this assessment (i.e., the upper limit application height allowed in the *AgDRIFT* model).

- Nozzle configurations are such that extremely small droplets are released as opposed to typical aerial applications (i.e., Sevin XLR label specifies VM of 50 µm while the values for most agricultural applications are 100 µm or more).

- Larger aircraft are generally used to make malaria control applications. For example, Lee County Florida, one of the largest Florida mosquito abatement districts, has a fleet of Douglas DC3s and Huey Helicopters. The DC3 is a much larger aircraft than the common agricultural application fixed-wing aircraft (e.g., Air Tractor AT401). These differences are significant when predicting deposition and were addressed in the Agency calculation of deposition after an aerial ULV application. The DC3 was used as the basis for all AgDRIFT calculations completed by The Agency.

Predictive Tools and Data: The Agency has used state-of-the-art tools in order to calculate deposition rates resulting from ground-based and aerial ULV applications as well as to calculate the postapplication dermal exposures that result from entry into areas previously treated with carbaryl using these techniques. The Agency used AgDrift V2.01 to predict the amount of residues that would deposit in residential areas after aerial ULV application, published data were used to predict deposition after ground ULV applications, and the latest residential exposure assessment methods were used to calculate the risks associated with these residues.

The first aspect of this exposure/risk assessment required the calculation of realistic deposition rates from the aerial and ground-based ULV applications of carbaryl (i.e., addressed in this appendix - residential exposure methods are discussed in detail in Section 3 of the document). The Agency could have taken a very simplistic approach of assigning the application rate as the deposition after an application. However, The Agency did not utilize this approach given the current state of knowledge pertaining to spray drift and recent industry and agency efforts in this area (i.e., this approach would generally be considered as unrealistic given the intent of mosquito control applications). There are a number of predictive tools and open literature articles that pertain to this technical area. Given that ground-based and aerial ULV applications are allowable, models and data were identified to support a human health exposure/risk assessment for each scenario. [Note: The Agency recognizes that there are potential issues with the selection and use of these models in this assessment. As such, the use of each model for completing this exposure/risk assessment is appropriately characterized (see below).]

<u>Aerial ULV:</u> In order to calculate deposition from aerial ULV applications, The Agency used *AgDRIFT* (V 2.01) which is the model that was developed as a result of the efforts of the *Spray Drift Task Force (SDTF).* The SDTF is a coalition of pesticide registrants whose primary objectives were to develop a comprehensive database of off-target drift information in support of pesticide registrations and an appropriate model system. This model was selected based on the consensus of several experts in the spray drift area because it represents the current state-of-the-art. The Agency discussed the issue of model selection with several experts in the spray drift community prior to selecting *AgDRIFT* (e.g., Sandra L. Bird, U.S. EPA; Steven G. Perry, U.S. EPA; Milton E. Teske, Continuum Dynamics; Pat Skyler, U.S. Forest Service; Arnet Jones, U.S. EPA; and Harold Thistle, U.S. Forest Service). The Agency considered using the *USDA Forest Service Cramer-Barry-Grim Model* (commonly referred to as *FSCBG*). *FSCBG* was developed through support from the U.S. Forest Service, in cooperation with the U.S. Army, and has been in existence for over 20 years in various iterations. Actual support and development of *FSCBG* was completed by Continuum Dynamics, Inc. located in Princeton, New Jersey under the technical direction of Milton E. Teske. However, it was decided that *AgDRIFT* should be used because it is based on essentially the same algorithms as *FSCBG* (personal communication with Milton E. Teske of Contiuum Dynamics), it has undergone extensive validation by the *SDTF*, and it is very user-friendly compared to *FSCBG.*

AgDRIFT is a *Microsoft Windows*-based personal computer program that is provided to the U.S.

Environmental Protection Agency's Office of Pesticide Programs as a product of the Cooperative Research and Development Agreement (CRADA) between EPA's Office of Research and Development and the *SDTF*. *AgDRIFT* predicts the motion of spray material released from aircraft, including the mean position of the material and the position variance about the mean as a result of turbulent fluctuations. *AgDRIFT* enhancements include a significant solution speed increase, an in-memory computation of deposition and flux as the solution proceeds, and extensive validation based on 180 separate aerial treatments performed during field trials in 1992 and 1993 by the SDTF.

Ground ULV: In contrast to the aerial ULV scenario, the data available to predict deposition patterns and resulting exposures from ground-based ULV malaria applications are limited. In fact, The Agency utilized two published journal articles and a preliminary model developed for the Environmental Fate and Effects Division of OPP by EPA's Office of Research and Development as the basis of this effort. These documents include:

Mass Recovery of Malathion in Simulated Open Field Mosquito Adulticide Tests: N.S. Tietze, P.G. Hester, and K.R. Shaffer; Archives of Environmental Contamination and Toxicology; 26: 473-477 (1994). [Note: This document was used as the primary source of deposition rates resulting from ground-based ULV mosquito applications.]

Downwind Drift and Deposition of Malathion on Human Targets From Ground Ultra-Low Volume Mosquito Sprays: J.C. Moore, J.C. Dukes, J.R. Clark, J. Malone, C.F. Hallmon, and P.G. Hester; Journal of the American Mosquito Control Association; Vol. 9, No. 2 (June, 1993).[Note: This document was used as the primary source of deposition rates resulting from ground-based ULV mosquito applications and as a confirmatory source of exposure data.]

Modeling of Deposition From Mosquito Adulticide Applications: S.G. Perry and W.B. Petersen of EPA/ORD for Arnet Jones of EPA/OPP (February 7, 1995). [Note: This is an internal document that has not been peer reviewed. It was used only for confirmatory purposes in this exposure/risk assessment.]

Determination of Deposition Rates: Deposition rates were determined for both aerial and ground-based ULV application methods as a percentage of the nominal application rate (i.e., how much of the target application rate actually deposited on outdoor surfaces such as turf). The application rates used to complete the assessment are the range specified above. As indicated above, *AgDRIFT V 2.01* was used to calculate the deposition rate from aerial ULV applications. The following inputs were used as the basis of the *AgDRIFT* calculations:

- **AgDRIFT Model Tier:** 3.
- **Droplet Size Distribution:** $D_{v0.1}$ = 25.59 µm; $D_{v0.5}$ = 51.0 µm; $D_{v0.9}$ = 74.27 µm; and <141 µm = 100 percent (developed to reflect droplet spectrum requirements of Sevin XLR label). **[Note: The droplet distribution was developed based on the Sevin label. No proprietary SDTF data were used in the completion of this assessment.]**

- **Spray Material:** User-defined option (oil option). Inputs include: nonvolatile rate 0.5 lb per acre, specific gravity 1.2 (calculated based on approximately 10 pounds per gallon), spray rate 0.25 gallons/acre, active ingredient application rate (0.5 lb ai/acre), and evaporation rate (1 μm^2/deg C/sec). [Note: Several of these parameters do not exactly coincide with the Sevin XLR label but were used because the Sevin XLR label inputs exceeded the allowable input parameters. These differences are not expected to significantly effect the AgDRIFT results because a nonvolatile oil was selected, hence the critical input is the active ingredient application rate. Additionally, **no proprietary SDTF physical property data were used in the completion of this assessment.**]

- **Aircraft:** User-defined option (fixed-wing option). Inputs include: Douglas DC3, wingspan: 94.6 ft (semispan 47.28 ft), typical application airspeed: 228 mph, weight: 21397 pounds, planform area: 999 ft^2, propeller RPM: 2550, propeller radius: 5.81 feet, engine vertical distance: -4.003 feet, and engine forward distance: 20.01 feet. [Note: DC3-specific inputs were obtained from the *FSCBG (V4)* aircraft library.]

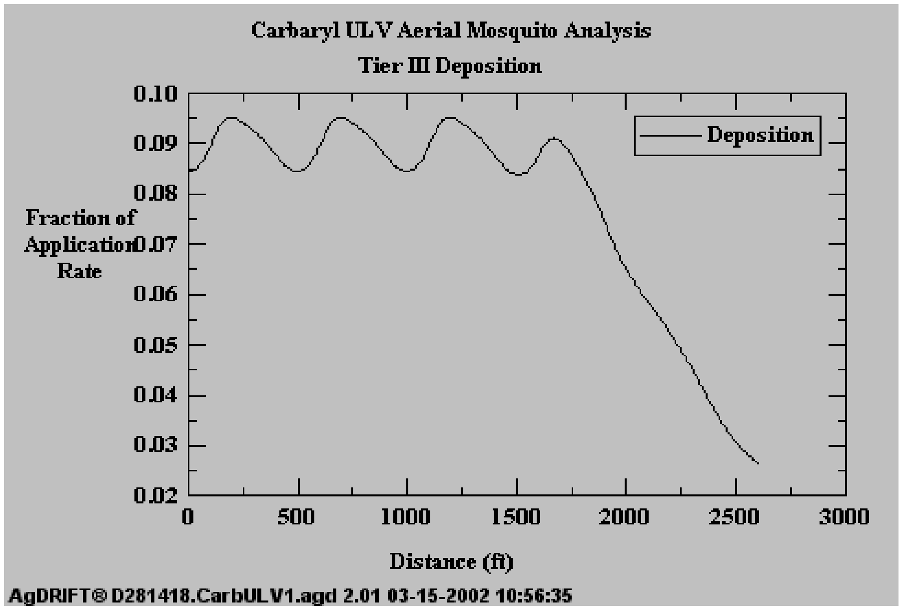
- **Nozzles:** User-defined option. Inputs include number of nozzles: 60, vertical distance of nozzles from wing: -2.66 feet, horizontal distance from wing: -0.82 feet, and horizontal distance limit: 75 percent.

- **Meteorology:** Inputs were not changed from Tier 3 recommendations of wind speed: 2 mph, wind direction: -90 degrees (perpendicular to flight path), temperature: 86°F, and relative humidity: 50 percent.

- **Control:** Inputs were altered from the Tier 3 recommendations. The parameters that were used included a spray release height of 300 feet, 20 spray lines (aircraft passes) in each application event, a swath width of 500 feet, and a swath displacement based on the aircraft centerline.

- **Advanced Settings:** Inputs were not changed from Tier 3 recommendations of wind speed height (2 meters), maximum compute time (600 seconds), maximum downwind distance (795 meters), vortex decay rate (0.56 m/s), aircraft drag coefficient (0.1), propeller efficiency (0.8), and ambient pressure (1013 mb).

AgDRIFT is capable of producing a variety of useful outputs. The key for The Agency in this assessment was to determine from the model what percentage of the application volume remained aloft and what percentage of the resulting droplets deposited on the surfaces in the treatment area as well as downwind from the treatment area. AgDRIFT is generally intended to calculate deposition rates in areas that are downwind from the treatment area (i.e., presented from the border of the treatment area to areas of interest downwind). The Agency has used the values at the border of the treatment area to represent the deposition rate within the treated area. It is clear from the results that from the edge of the treatment area to 2000 feet downwind, approximately 9.5 percent of the theoretical application is deposited. This value is intuitively consistent with what one might suspect would occur considering the agricultural engineering parameters associated with mosquito applications (see graph below).



As indicated above, two published journal articles served as the basis for predicting deposition rates, as a percentage of the application rate, after ground-based ULV application for mosquito control (i.e., Tietze, *et al*, 1994 and Moore, *et al*, 1993). Both of these studies were completed using ULV formulations of malathion (91 and 95 percent). The Agency anticipates that the "behavior" of these formulations in the referenced studies would not be significantly different from the Sevin XLR formulation because the physical-chemical properties of the malathion formulations and the nature of the application would be expected to be similar (i.e., the Agency believes the malathion formulations to be acceptable surrogates for Baytex in this analysis).

In the study conducted by Moore, *et al* both human exposure and deposition was quantified over 5 separate application events. A 91 percent formulation of malathion was applied in April and May of 1989 in the early evening (a time of day for relative atmospheric stability). A Leco HD ULV cold aerosol generator (Lowndes Engineering Company, Valdosta Georgia) was used to make each application. The application parameters included a fluid flow rate of 4.3 fluid ounces per minute, a vehicle groundspeed of 10 mph, and a nominal application rate of 0.05 lb ai/acre (i.e., equates to a deposition rate of 0.51 $\mu g/cm^2$). Deposition was monitored at three locations downwind from the treatment area (i.e., 15.2m, 30.4m, and 91.2m). For the events considered in the deposition calculations, "average amounts of malathion deposited on ground level at 15.2, 30.4, and 91.2 m were not significantly different." The percentage of the application rate reported to have deposited ranged from 1 to 14 percent. The mean deposition value for all measurements was 4.3 percent (n=35, CV=98).

In the study conducted by Tietze, *et al* only deposition was quantified over 6 separate application events (i.e., one event was not included in deposition calculations "due to negative air stability"). The application parameters were similar to that used by Moore *et al*. A 95 percent formulation of malathion was applied from May to August of 1993. A Leco 1600 ULV cold aerosol generator (Lowndes Engineering Company, Valdosta Georgia) was also used to make each application. The application parameters included a fluid flow rate of 4.3 fluid ounces per minute, a vehicle groundspeed of 10 mph, and a nominal application rate of 0.057 lb ai/acre (i.e., equates to a deposition rate of 0.58 $\mu g/cm^2$). Deposition was monitored at four locations downwind from the treatment area (i.e., 5 m, 25 m, 100 m and 500 m). For the events considered in the deposition calculations, "malathion mass deposited differed significantly between the 500 m site and the three closer sites (df = 3; F-value = 3.42; $P<0.05$)." The percentage of the application rate reported to have deposited (not including 500 m samples which were much less) ranged up to 5.8 percent. The mean deposition value for all measurements was 3.8 percent.

Considering the data that are available in the Tietze *et al* and Moore *et al* papers, an off-target deposition rate of 5 percent was used by The Agency to evaluate ground-based ULV applications. A value slightly higher than the mean values for both studies was selected because of the variability in the data and the limited number of datapoints. It should be noted that this value is also consistent with the draft modeling assessment for ground-ULV approaches completed by S.T. Perry and W.B. Petersen of EPA's Office of Research and Development (i.e., within a factor of 5). Perry and Petersen used "the INPUFF Lagrangian puff model" as the basis for their assessment (Petersen and Lavdas, 1986: *INPUFF 2.0 - A Multiple Source Gaussian Puff Dispersion Algorithm, User's Guide,* EPA/600/8-86/024). Depending on the scenario selected from this document, deposition rates ranged from approximately 2.5 percent deposition 450 m downwind to 15 to 20 percent deposition **immediately adjacent** to the treatment zone.

The following deposition rates presented as a percentage of the application rate served as the basis of the postapplication exposure calculations completed by The Agency:

- Ground-based ULV = 5 percent of application rate, and

- Aerial ULV = 9.5 percent of application rate.

The air concentration was also calculated at ground level with the vertical profile set at 0 feet downwind. The analysis shows that the air concentration was 40 ng/L (0.040 mg/m^3) which was used to calculate MOEs for adults and children only on the day of application. It was assumed the spray cloud diminished within 20 minutes but the Agdrift model concentration calculated all material that passes across the vertical profile in one hour. As such, it is likely that the air concentration estimate used in the calculation is somewhat conservative. Adult calculations were completed using a breathing rate for moderate activity of 1.6 m^3/hr (0.533 $m^{3/}20$ minutes). Calculations for children were based on a light activity inhalation rate of 0.7 m^3/hr (0.233 $m^3/20$ minutes).

Appendix L: Carbaryl Residential Postapplication Risk Assessment For Mosquito Control

Appendix M: Carbaryl Residential Postapplication Risk Assessment For Oyster Bed Uses

Appendix N: Results & Associated Risks For Carbaryl Suburban Resident Biological Monitoring Study