Draft Technical Guidelines

Standard Operating Procedures for Residential Pesticide Exposure Assessment

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For Review and Comment

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Preamble

The 1996 Food Quality Protection Act (FQPA) expanded EPA risk assessment requirements under the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) and the Federal Food, Drugs, and Cosmetics Act (FFDCA) by emphasizing protection of infants and children including combining exposures from all potential pathways. Its directive for pesticide assessments to provide “reasonable certainty that no harm will result from aggregate exposure to the pesticide chemical residue, including all anticipated dietary exposures and all other exposures for which there is reliable information” resulted in the Agency routinely conducting both aggregate and cumulative risk assessments. Aggregate risk assessments include all exposure pathways (i.e., food, drinking water, and residential) and routes (i.e., oral, dermal, inhalation) to a single chemical. Cumulative risk assessments include all exposure pathways (i.e., food, drinking water, and residential) and routes (i.e., oral, dermal, inhalation) to multiple chemicals with a common mechanism of toxicity. In response, the Agency developed a series of science policies[1] which included the initial version of its *Standard Operating Procedures (SOPs) for Residential Exposure Assessments* (i.e., “SOPs” or “Residential SOPs”).

The SOPs were generally based on the Agency’s *Exposure Assessment Guidelines.*[2] The document outlined a wide array of exposure scenarios that were intended to address all major possible means by which individuals in the general public could be exposed to pesticides in a residential environment (i.e., home, schools, parks, athletic fields or other publicly accessible locations). Some notable scenarios include children playing on treated lawns or homeowners spraying their gardens. Specifically tailored for each scenario, methods for estimating dermal, inhalation, and non-dietary oral exposure were presented including descriptions and sources for factors included in exposure algorithms. Due to some novel aspects and the overall groundbreaking nature of the SOPs, they were first presented to the FIFRA Scientific Advisory Panel (SAP) in 1997 with a follow-up review of some modifications in 1999.[3]

Since 1997, the SOPs have been used to assess exposure in residential settings for pesticide regulatory decisions within the Office of Pesticide Programs (OPP) as required under FQPA. This document represents the Agency’s revised set of Residential SOPs using additional and, in some cases, more robust data and advanced assessment capabilities, such as stochastic and probabilistic tools. In most cases, the exposure scenarios and basic algorithms remain the same with changes made only to the algorithm inputs using more recent data sources. However, some new scenarios have been added to this set of SOPs reflecting new products and uses and some existing scenarios have modified exposure algorithms. In addition, where possible, distributions for the algorithm inputs are provided for use in probabilistic models. A direct comparison of this updated version of the SOPs with the 1997 version will reveal the specific differences between the two versions.

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[1] http://www.epa.gov/oppfead1/trac/science/
[2] http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=15263
[3] http://www.epa.gov/scipoly/sap/meetings/1997/090997_mtg.htm#materials and http://www.epa.gov/scipoly/sap/meetings/1999/092199_mtg.htm

The concept of using a “scenario-based” approach to complete exposure assessments is longstanding and outlined in many Agency guidance documents. In this document, the Agency has attempted to develop scenarios which can be used to calculate all manner of possible pesticide exposures that can occur in the general population, but given the multitude of ways in which pesticide products can be used it is likely that there are scenarios which have not been identified. Quantifying human behaviors is critical for development of pertinent exposure assessment methods and can be complex. For example, three separate methods and sets of factors for children playing football, baseball, and soccer on fields treated with pesticides could be used as the basis for an assessment. Instead, one broad category for children playing on lawns is considered applicable to all potential exposure scenarios on treated grass because the exposure metric on which it is based monitored individuals involved in a routine that comprehensively reflected typical outdoor behaviors based on reported time-activity data. This approach is broadly applied in the development of this document because it reduces needed resources and reasonably reflects typical behavior patterns. Given this premise, it will be unavoidably necessary for assessors in certain circumstances to use qualitative approaches to characterize some exposures. Thus, exposure assessors should not view this document as a prescriptive checklist, but as a guide to performing residential exposure assessments in conjunction with other relevant information pertinent to the pesticide under examination.

The conduct of both proposed and completed research which involves intentional exposure to humans is now subject to ethical and scientific review pursuant to 40 CFR 26, subpart K. In 2006, the Agency established the Human Studies Review Board (HSRB) that is charged with the evaluation of studies that involve intentional exposure of human subjects, from both a scientific and ethical perspective. Review by the HSRB was required for only a select few studies utilized in this document. For those not requiring HSRB review, an internal Agency review of the data for ethical concerns is required for studies conducted prior to that date and all of the studies within this document have been reviewed and are compliant with all applicable requirements. Upon formal completion of this internal review, this document will be updated to reflect any changes in available data.

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Section 1 Introduction

The Standard Operating Procedures for Residential Pesticide Exposure Assessment (hereafter referred to as “the SOPs” or “Residential SOPs”) provide methods for assessment of pesticide exposures unrelated to employment. The document covers two major components of all exposure scenarios: residential handler and post-application exposure assessments. The term “handler” refers to an individual who mixes, loads, and/or applies a pesticide.[4] The term “post-application” refers to exposure as a result of contact with pesticide residues in previously treated areas.

The exposure assessment methods in this document are scenario-based and reflect homeowners who purchase pesticides and complete their own applications as well as post-application exposures resulting from both homeowner and professional or commercial applications. Prior to outlining exposure assessment methodologies for specific scenarios (Sections 3.0 – 10.0), this document provides general information, including:

- Section 1.1: General Principles of Exposure Assessment;
- Section 1.2: Guidance on Residential Pesticide Usage;
- Section 1.3: Residential Exposure Assessment Guidance; and
- Section 2.0: Universal Exposure Factors.

Exposure assessment methodologies are then outlined for the following major residential scenarios:

- Section 3.0: Lawns and Turf
- Section 4.0: Gardens and Trees
- Section 5.0: Indoor Environments
- Section 6.0: Insect Repellents
- Section 7.0: Indoor Environments
- Section 8.0: Pets
- Section 9.0: Impregnated Materials
- Section 10.0: Paints and Wood Preservatives

[4] Unlike occupational settings where different individuals typically will perform each separate task, in residential exposure assessment it is assumed that the same individual will perform the pesticide mixing/loading, and application.

1.1 General Principles of Exposure Assessment

Exposure assessment is the process by which: (1) potentially exposed populations are identified; (2) potential pathways of exposure are identified; and (3) chemical intakes/potential doses are quantified. The populations considered in these SOPs are those individuals who are potentially exposed to pesticides in non-occupational or residential settings (e.g., homes, parks, schools, athletic fields or any other area frequented by the general public). Exposures to pesticides may occur from applying pesticides or from being in areas previously treated with pesticides and contacting residues through oral, inhalation, or dermal routes.

Calculation of Exposure

Exposure is commonly defined as contact of visible external physical boundaries (i.e., mouth, nostrils, and skin) with a chemical agent (U.S. EPA, 1992). As described in the *Guidelines for Exposure Assessment* (U.S. EPA, 1992), exposure is dependent upon the intensity, frequency, and duration of contact. The intensity of contact is typically expressed in terms of the concentration of contaminant per unit mass or volume (i.e., ug/g, ug/L, mg/m^3, ppm, etc.) in the medium to which humans are exposed (U.S. EPA, 1992). Exposure can be calculated as follows:

$$E = C * CR \qquad (1.1)$$

where:

E = exposure (mg/day);
C = contaminant concentration in the media (mg/cm^2; mg/m^3, mg/g); and
CR = contact rate with that media (cm^2/day; m^3/day; gm/day).

Calculation of Absorbed Dose

Dose refers to the amount of chemical to which individuals are exposed that crosses the external boundary. Dose is dependent upon contaminant concentration and the rate of intake (i.e., inhalation or ingestion) or uptake (i.e., dermal absorption) and may be normalized to body weight as a function of time (i.e., mg/kg-day). Daily dose is the amount of chemical that could be ingested, inhaled, or deposited upon the skin per day (U.S. EPA, 1992) and can be calculated as follows:

$$D = \frac{E * AF}{BW} \qquad (1.2)$$

where:

D = dose (mg/kg-day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

Exposure/Dose Amortization

An accurate estimate of exposure over the course of weeks, years or a lifetime is difficult to predict as exposure likely differs from one day to the next due to product-specific application regimens, residue dissipation, human behavior and activity patterns, and the extent to which an individual's exposure varies due to behavior changes. Approaches for amortizing dose over various exposure durations are explained in more detail in *Section 1.3*; however an example would be amortization of an individual's daily dose over their lifetime necessary for calculating exposures for cancer risk assessments. This amortized dose is known as the lifetime average daily dose (LADD) and it can be calculated as follows:

$$LADD = \frac{D * EF * ET}{AT * CF} \tag{1.3}$$

where:

LADD	= lifetime average daily dose (mg/kg-day);
D	= dose (mg/kg-day);
EF	= exposure frequency (i.e., frequency of product use) (days/year);
ET	= exposure time (years);
AT	= averaging time (i.e., life expectancy) (years); and
CF	= conversion factor (365 days/year).

1.2 Guidance on Residential Pesticide Usage

Prior to conducting a residential exposure assessment, all end-use product labels for the active ingredient under consideration should be researched to capture the information discussed below in order to define the overall scope of the assessment as well as specific exposure scenarios to consider.

Potential Use in Residential Settings

Assessors should assume that a product may be used at residential sites unless specific labeling statements indicate otherwise. Restricted Use Product (RUP) classification indicates that the product cannot be bought or applied by homeowners (i.e., no residential handler exposure/risk assessment required), but it may be applied by commercial applicators to residential sites; therefore, a post-application risk assessment may be required. However, statements such as "For use by commercial or professional applicators only" or "Not for homeowner use" are considered unenforceable and do not preclude use in residential settings. In these cases, therefore, both a residential handler and post-application exposure assessment is required.

Formulation Type

The label will list the type of formulation as part of, or associated with, the brand name. Formulation type is important in an exposure assessment because different formulations can lead to higher or lower exposures for handlers as well as having different levels of surface residue transfer in post-application exposure scenarios. Examples of common residential formulations are as follows:

- Liquid formulations (all liquid formulations should have a statement listing the number of pounds active ingredient contained in a gallon of the liquid formulated product)
    - Emulsifiable concentrates (EC)

  - Soluble concentrates (SC)
  - Liquids (L)
  - Microencapsulated (ME)
- Solid Formulations
  - Dusts
  - Granules (G)
  - Water dispersible granules/dry flowable (WDG/DF)
  - Wettable Powder (WP)
- Other
  - Bait stations
  - Water soluble bags (WSB)
  - Aerosol cans
  - Trigger-pump sprayers

Use directions such as mixing/loading instructions, application equipment and application rate terminology may also indicate the formulation if it is not explicitly stated on the label. For example, solid products are typically measured in dry volume (e.g., ounces) and liquid products are typically measured in wet volume (e.g., pints, quarts, gallons, etc.).

Possible Methods of Application

Use directions often specify the methods of application for a product either by prohibiting specific application techniques (e.g., "do not apply in any type of irrigation equipment" or "spot treatment only") or by listing the application equipment to be used. Handler assessments should be performed for all equipment types applicable to the product and its application sites unless a specific piece of equipment is prohibited on the labeling or is obviously incompatible with the formulation or use directions.

Maximum Application Rates

Determine the maximum label-permitted application rate for each use site by comparing the directions for each use listed on the label. This is important because most exposure assessments consider the maximum application rates, at least initially, in order to account for individuals who use the highest rate possible. Label-specified lower rates or pest-specific rates should be noted as well in the event those are utilized in the assessment. Often there are multiple instructions with widely varying use rates because there are many uses associated with one label (e.g., indoor/outdoor use, types of pests, application timing, etc.). Maximum rates may vary by formulation, so the maximum rate for each formulation must be determined.

Use Frequency

Determine the number of applications per year or season and the re-treatment interval, typically estimated based on label directions for frequency of product application. Typical statements include "apply at 7-day intervals while pests are present," "apply in early spring before first mowing," or "apply a second spray in 3 to 5 days." Depending on the specific product, this can inform the expected duration of exposure as well as yearly exposure frequency for estimating lifetime exposure for cancer risk assessments.

1.3 Residential Exposure Assessment Guidance

Prior to conducting a residential pesticide exposure assessment, the following should be considered: (1) the various products containing the pesticide, (2) the products' use patterns, (3) the application methods (i.e., equipment), (4) the expected exposed populations (e.g., adults for handler activities and adults, teens, youths, toddlers, and infants for post-application activities), (5) the expected routes of exposure (e.g., dermal, inhalation, oral), and (6) the expected durations of exposure for the pesticide being assessed (e.g., one day, multiple days, over the course of a lifetime).

This section builds on the general exposure assessment concepts and basic use information presented in Section 1.1 and 1.2 above. The intent is to provide more specific guidance on the issues that should be addressed in the development of a residential pesticide exposure assessment. **Section 1.3.1: Potentially Exposed and Sentinel Populations** describes the various populations potentially exposed to pesticides in residential settings and how select sentinel populations are used in exposure assessment to encompass exposure and risks for all potentially exposed populations. **Section 1.3.2: Durations of Exposure** addresses issues related to how exposure patterns associated with the use of a pesticide, which can range from a single exposure event through a lifetime, should be reconciled with appropriate toxicological endpoints. **Section 1.3.3: Handler Exposure** and **Section 1.3.4: Post-application Exposure** describe special considerations for homeowners that apply pesticides and for those exposed while engaging in activities in areas previously treated with pesticides. **Section 1.3.5: Combining Exposure Scenarios** discusses the issues associated with the development of exposure patterns which account for combinations of behaviors which contribute to overall body burdens. **Section 1.3.6: Exposure Uncertainty and Characterization** introduces the concept of uncertainty and how to interpret its effect on residential exposure estimates. **Section 1.3.7: Overview of Probabilistic and Deterministic Exposure Assessment** describes the use of probabilistic and deterministic methods in exposure assessment.

1.3.1 Potentially Exposed and Sentinel Populations

In the beginning stages of an exposure and risk assessment, exposure assessors must first identify those populations potentially exposed for each scenario. The sentinel approach is then utilized to focus the exposure assessment process toward populations of concern because of unique behavioral characteristics that may lead to higher levels of exposure as well as strengths and limitations of available data. Quantitative assessments of the sentinel population would thus encompass the exposures and risks for all potentially exposed populations. This approach simplifies the assessment process and also focuses risk managers on the areas of most concern.

The Agency's *Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures for Environmental Contaminants*[5] recommends specific age groups for assessments, and the residential SOPs attempt to adhere to its guidance where appropriate. The guidance document considers both physiological and behavioral aspects of child development. The

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[5] http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=146583

concept of behaviorally-based developmental milestones is widely recognized as an approach for describing children in educational circles, and provides support for the Agency's approach.

Across the SOPs, adults are generally considered a sentinel population for all exposure routes with the exception of non-dietary ingestion exposure. They may not have the highest calculated body burden in all cases, but they represent a major proportion of the exposed population. Additionally, behavioral characteristics specifically for adults may allow for different risk management approaches.

Consideration of children in each residential SOP is dependent on upon the scenario because their exposures can vary greatly with life stage. While children of all ages are considered in the development of each SOP, only methods for the age groups with the highest calculated body burden values have been included for the reasons outlined above. In some cases, results are equivocal between various life stages depending upon the scenario. In those instances, a precautionary principle has been used and more than one age group is presented for consideration because pesticide assessments tend to have unique elements. For example, when indoor treatments are considered, methods for children of two distinct age groups are presented (1 to < 2 year olds and 3 to < 6 year olds). Young children (1 to < 2 years) tend to be less mobile than slightly older children, which could lead to lower dermal exposures, but they tend to exhibit higher rates of mouthing behaviors, which could enhance their overall body burden compared to older children. Older children (3+ years) are more mobile, which could increase dermal exposures, but mouthing behaviors tend to be reduced in children of this age.

The types and quality of data available can also influence the sentinel approach. For example, key scenarios in the SOPs include assessment of dermal exposure for children playing outdoors on treated turf, children interacting with treated pets, and children contacting treated surfaces indoors. The outdoor turf example is based on surveyed time activity data for people outdoors and the indoor assessment is based on a study in which subjects crawled around on treated carpets, both of which can be considered reasonable representations of toddler behaviors, but not exact matches. However, interaction with treated pets is based on professional groomer data since no other data are available. The use of professional groomer exposure data is likely to overestimate exposures, since groomers exhibit vigorous contact with numerous recently-treated dogs and handle concentrated product. A similar example is assessment of dermal exposures while gardening at home, which is based on exposures for professional harvesters typically paid by the piece. Thus, it is likely that their techniques and high rate of efficiency would result in more foliar contact and higher exposures than would be expected for home gardeners.

Providing a detailed discussion of this issue for all SOPs requires explanation of sentinel population selections for each scenario. Each SOP contains the specific rationale used to support the selection of the appropriate sentinel populations.

1.3.2 Durations of Exposure

Depending on the type of pesticide (i.e., insecticide, fungicide, etc.) and its use profile (i.e., application regimen) as well as behavioral/activity patterns and exposure pathways, the potential exists for individuals to experience exposure over a variety of exposure durations. Exposure can be on the order of one day, intermittently over multiple days, months, years or a lifetime, or continuously over multiple days, months, years or a lifetime. For the purposes of pesticide exposure assessment, exposure patterns are summarized as acute (i.e., a single exposure event, typically 1 day or less), short-term (i.e., 1-30 days), intermediate-term (i.e., 1-6 months), long-term (i.e., greater than 6 months), and lifetime (for assessing cancer risk). The following should be considered in determining the duration of exposure for a particular pesticide:

- **Use Pattern:** The application frequency, pests of concern, and regional differences impact use patterns. For example, more routine (i.e., repeated) treatments might occur in subtropical areas of the country where there is more constant pest pressure over the course of a year.
- **Environmental Persistence:** The extent to which pesticide residues persist in the environment can determine the frequency of exposure. For example, if a lawn is treated and the pesticide dissipates rapidly there is less chance of a sustained exposure for children playing on that lawn compared to a pesticide where residues dissipate more slowly.
- **Biological Persistence:** The route of exposure, distribution, metabolism, and excretion of a pesticide should also be considered in conjunction with the available toxicological database. For example, if a pesticide is used frequently but is rapidly excreted and exposed individuals recover quickly from the toxicological effect, extended exposure durations would be unexpected and would likely not need detailed consideration in an assessment. Conversely, if applications are infrequent but the pesticide is slowly eliminated from the body then extended periods of exposure would likely need further or more detailed consideration.
- **Toxicity Endpoint Reconciliation:** Toxicology studies are conducted using protocols which are designed to mimic various exposure patterns that can range from a one-time exposure event to a lifetime of expected exposures. It is important that the selection of a toxic endpoint be closely matched with expected pesticide exposure pattern to yield more accurate estimates of risk. In cases where this is not possible, assessors should acknowledge the issue and describe how this can impact the interpretation of calculated risk estimates.

In addition to these considerations, the expected exposure duration influences the calculation inputs used to estimate exposure. For example, if the goal in exposure assessment is to predict high-end exposures, an acute exposure assessment - since it is a one-time exposure event - should utilize high-end inputs for all exposure factors to capture those individuals who are less careful during applications or are exposed to residues immediately following application. For longer-term exposures (i.e., short-, intermediate-, long-term and lifetime exposures) where the relevant toxic endpoint is a multi-day endpoint however, one would be interested in capturing the high-end of the range of average exposures. And, in these scenarios, it is unlikely that individuals will consistently be less careful during applications over the course of a lifetime or be repeatedly exposed to residues equivalent to those immediately following applications over the course of a lifetime. Thus, the use of central tendency or average exposure factor inputs may be more appropriate to capture high-end average exposures for these durations.

There are several possible approaches for achieving these goals. The most straightforward example would be, as described above, to utilize high-end inputs for all exposure factors in an acute assessment. In this instance, using high-end inputs provides confidence that the assessment captures the high-end of possible one-time or single-day exposure events. However, when longer-term exposure patterns are expected via continuous or sporadic exposures and one is interested in the distribution of average exposures, both the exposure variability and the exposure factor inputs that would result in an exposure estimate representing the high-end of the distribution of these average exposure distribution are more difficult to define. As a result, exposure assessors have a variety of options for selecting exposure factor inputs. For example, since they provide confidence that the assessment captures the high-end of possible one-time or single-day exposure events, use of high-end inputs would also provide confidence that the high-end of possible short- or intermediate-term average exposures would be captured and could be used as a “screening-type” assessment. This example could be further refined while still using high-end exposure factor inputs by accounting for residue dissipation and re-treatment intervals. Alternatively, in the absence of longer-term exposure modeling capabilities, the use of central tendency exposure factor inputs may also provide confidence that the high-end of possible short- or intermediate-term average exposures would be captured due to the likelihood that most people experience an average exposure over time.

It is likely that each exposure assessment can utilize a different approach for addressing all possible durations of exposure depending upon what is known about the particular pesticide. The process of exposure assessment typically involves constant refinements as more information is known about a chemical and how exposures can occur. The sections below present options for addressing each key duration of exposure.

Acute Exposure (single exposure event, typically 1 day or less)

All residential handler and post-application exposures can be characterized as acute exposures and would be compared with acute toxicity endpoints if available to assess risk. In order to ensure the high-end of the acute exposure variability is captured, handler and post-application exposure assessments should incorporate maximum application rates and high-end assumptions for algorithm inputs. In the event an acute toxicity endpoint is unavailable, matching an acute exposure estimate (using the inputs described above) with a short-term toxicity endpoint could serve as an acute “screening-type” assessment.

Short-term Exposure (1-30 days)

Exposure over the course of a month can result from continuous daily pesticide exposure or as a result of a series of intermittent exposures. If residential handler or post-application exposure fits this pattern, an average exposure over this time period should be compared with toxicity studies of comparable duration to assess risk.

Though most residential handlers are not expected to re-treat the same sites repeatedly day after day, a short-term average exposure should be estimated in a residential handler assessment. Short-term handler assessments could include maximum application rates and high-end exposure factor inputs to ensure the high-end of the distribution of short-term average exposures is captured. Since an exposure estimate using these inputs would not be expected to be repeated day after day, it is likely that this overestimates the high-end of actual short-term average exposures and can be refined by accounting for the product-specific application regimen if intermittent uses are anticipated, or, alternatively, by using less conservative exposure factor inputs.

Post-application exposure can be reasonably characterized as short-term as well. For example, it is not unreasonable to assume a child would play on a treated home lawn for a number of consecutive days and thus be continuously exposed to residues resulting from a previous pesticide treatment. Short-term post-application assessments could include maximum application rates and high-end assumptions for all algorithm inputs to ensure the high-end of the distribution of short-term average post-application exposures is captured. However, as in residential handler assessments, an exposure estimate based on these inputs is not expected to occur repeatedly day after day; therefore, it is likely that this overestimates the high-end of actual short-term average post-application exposures and can be refined by accounting for residue dissipation and re-treatment intervals. For instance, if a product can be applied to residential lawns twice a year at 14 day intervals, this could be accounted for in the calculation of transferable residues for short-term post-application assessments.

Intermediate-term Exposure (1-6 months)

Exposure over the course of 1-6 months can result from continuous daily pesticide exposure or as a result of a series of intermittent exposures. If residential handler or post-application exposure fits this pattern, an average exposure over this time period should be compared with toxicity studies of comparable duration to assess risk.

Intermediate-term residential handler assessments are generally not required because individuals are not expected to re-treat the same sites repeatedly day after day for this duration, nor are a large number of pesticide applications resulting in intermittent exposures expected over this duration. Residential post-application exposure could, however, be characterized as intermediate-term. These assessments could utilize maximum rates and high-end assumptions for all algorithm inputs or utilize less conservative algorithm inputs as described for short-term exposure assessments. Additionally, as in short-term assessments, residue dissipation and re-treatment intervals should be considered in a refined assessment.

Long-term Exposure (greater than 6 months)

Exposure for more than 6 months can result from continuous daily pesticide exposure or as a result of a series of intermittent exposures. If residential handler or post-application exposure fits this pattern, an average exposure estimate over this time period should be compared with toxicity studies of comparable duration to assess risk.

Long-term residential handler assessments are not required because individuals are not expected to re-treat the same sites repeatedly day after day for this duration, nor are a large number of pesticide applications resulting in intermittent exposures expected over this duration. For a limited number of situations, however, post-application exposure could be characterized as long-term (e.g., post-application indoor inhalation following structural termiticide applications). These assessments could include maximum rates and high-end assumptions for all algorithm inputs as a “screening-type” assessment or, if necessary, utilize less conservative algorithm inputs or account for residue dissipation and re-treatment intervals as described for short- and intermediate-term assessments.

Lifetime Exposure

Calculation of pesticide exposure over an individual's lifetime is applicable only when the active ingredient under consideration exhibits potential cancer risk and, like short-, intermediate-, and long-term exposures, is calculated by averaging multiple days of exposure over many years. Cancer risk depends on the extent to which a person might be exposed (i.e., over a certain duration and to a certain quantity of the pesticide) over the course of their lifetime. Lifetime exposure is calculated using the lifetime average daily dose equation shown in *Equation 1-3* of *Section 1.1* and includes two factors that are generic (i.e., non-chemical specific) to cancer assessments: (1) the averaging time or lifetime, which is assumed to be 75 years and (2) the exposure time, which is typically assumed to be 55 years (or the adult lifetime of an individual who lives 70 years).

Residential handler cancer assessments should include typical application rates, if available (if not, available maximum rates should be used) and amounts handled. Additionally, absent reliable information, an assumption must be made as to the yearly exposure frequency (i.e., the number of times that an individual applies the pesticide per year), in order to conduct a residential handler cancer risk assessment. The exposure frequency will typically differ depending on the type of pesticide (e.g., fungicide, herbicide, insecticide) and could potentially differ across formulations.

Residential post-application cancer assessments should include typical application rates if available (if not, maximum rates should be used). For other algorithm inputs, average or central tendency estimates rather than high-end assumptions are likely more appropriate. Post-application cancer assessments are similar to short-, intermediate-, and long-term assessments in that dissipation and re-treatment intervals should be considered. As with handler cancer risk assessments, an assumption must be made as to the yearly exposure frequency and will typically be based on the number of times per year a pesticide can be applied and how quickly the pesticide dissipates.

In the past, cancer risk assessments have assumed that children are no more sensitive than adults to carcinogens (i.e., no adjustment was made to children's exposure estimates in calculating a cumulative lifetime exposure). More recently, the Agency's "Guidelines for Carcinogen Risk Assessment" (USEPA, 2005) and "Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens" (USEPA, 2005) proposed age-dependent adjustment factors to be applied to children's exposure. A 10x factor (exposure multiplier) is applied to exposure incurred from birth to 2 years and a 3x factor is applied to exposure incurred from 2 years to 16 years. No factor is applied to children age 16 years and beyond. These age-dependent factors are applied only to carcinogens shown to have a mutagenic mode of action. In general, most carcinogenic pesticides have not been shown to act through a mutagenic mode of action and thus this SOP document does not include further discussion of these adjustment factors. Any pesticide found to be a carcinogen acting through a mutagenic mode of action will be dealt with on a case by case basis and such an assessment should follow the Agency's 2005 guidance.

1.3.3 Handler Exposure

Handler exposure refers to an exposure scenario in which an adult individual is exposed during mixing, loading, and applying a pesticide. Residential handler exposure assessments estimate dermal and inhalation exposures for individuals using pesticides in and around their homes. Some key assumptions for residential handler assessments include:

- Residential handlers are assumed to be wearing shorts and short-sleeve shirts, shoes, and socks. This assumption differs from occupational handler assessments which assume handlers are wearing at least long pants, long-sleeved shirts, shoes, and socks.
- Personal protective equipment (PPE) is not considered a mitigation option for residential handlers because users are not trained and compliance would not be expected.
- Pesticides are assumed to be applied by adults only (i.e., individuals above 18 years old).
- All applicable application methods should be assessed unless prohibited by the product label.

Handler exposure can be estimated in the absence of chemical-specific exposure monitoring data with the following information:

- Application site (e.g., lawns, gardens, kitchen baseboards, etc.);
- Formulation (e.g., liquid, granule, etc.);
- Application equipment (e.g., aerosol can, sprinkler can, hose-end sprayer, etc.); and
- Application rate (e.g., lb ai/ft^2, lb ai/gal).

Given the information described above – application equipment, formulation, etc. – dermal and inhalation handler exposure can be predicted using a factor known as the unit exposure. Unit exposure is the ratio, for a given formulation and application equipment, of an individual's exposure to the amount of active ingredient handled (AaiH), expressed as mass active ingredient exposure per mass active ingredient handled (e.g., mg/lb ai). More specifically, this means that an individual's exposure will increase by a given (and constant) amount for every "unit" increase in the amount of active ingredient handled. It follows that the use of unit exposures assumes proportionality between exposure and the amount of active ingredient handled, such that if one doubles the amount handled, the resulting exposure would be doubled as well.

Exposure monitoring data for individuals mixing, loading, and applying pesticides enables derivation of unit exposure distributions for various pesticide formulations used in various application scenarios (e.g., granule formulations applied using a rotary spreader or liquid formulations applied via a handheld pump sprayer). These unit exposures can then be applied generically for use in estimating dermal or inhalation exposure for any active ingredient by estimating how much active ingredient an individual will handle using a particular piece of application equipment.[6] Appendix B references and summarizes all available handler exposure studies from which unit exposures are derived for use in residential exposure assessment.

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[6] This topic was discussed during a 2007 FIFRA SAP. See: http://www.epa.gov/scipoly/sap/meetings/2007/010907_mtg.htm.

Each SOP section provides information for two inputs that are necessary for calculating residential handler exposure: (1) unit exposures for each possible formulation/application equipment combination and (2) factors for deriving the amount of active ingredient handled such as area treated or volume used for each formulation/application equipment combination. Dermal and/or inhalation handler exposure calculations follow the general form shown below.

$$E = UE * AR * A \tag{1.4}$$

where:

E = exposure (mg/day);
UE = unit exposure (mg/lb ai);
AR = application rate (e.g., lb ai/ft^2, lb ai/gal); and
A = area treated or amount handled (e.g., ft^2/day, gal/day).

Dermal and/or inhalation doses are calculated as:

$$D = \frac{E * AF}{BW} \tag{1.5}$$

where:

D = dose rate (mg/kg-day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

As described in *Section 1.3.2* residential handlers are expected to experience acute and short-term exposures. Intermediate- and long-term exposures are not expected but should be considered with respect to regional differences and product label use directions. Additionally, selection of exposure factor inputs is dependent on various considerations related to the exposure duration. For residential handler exposure assessment, these considerations include product application regimens and the extent to which an individual's exposure varies from day-to-day (i.e., intra-individual exposure factor variability). Information on intra-individual variability is limited and not addressed in the SOPs.

1.3.4 Post-application Exposure

Post-application exposure refers to an exposure scenario in which an individual is exposed through dermal, inhalation, and/or incidental oral (non-dietary ingestion) pathways as a result of being in an environment that has been previously treated with a pesticide. Post-application dermal exposure is dependent on surface residues after treatment and surface-to-skin transfer. Post-application inhalation exposure depends on concentrations in the air after treatment and inhalation rates. Post-application oral exposures are based on the ingestion of residues that can result from transfer of residues from hand-to-mouth or object-to-mouth or via direct ingestion of residues through soil ingestion, dust ingestion, or ingestion of pesticide granules or baits.

Post-application dermal and inhalation assessments are typically conducted for adults, teens, youths, toddlers, and infants while non-dietary oral post-application exposure assessments are typically only conducted for toddlers and infants. Like residential handler assessments, residential post-application assessments differ from occupational post-application assessments in that they assume individuals are wearing shorts and short-sleeve shirts, shoes, and socks. Additionally, when managing occupational post-application risks the Agency typically uses an administrative control known as a Restricted Entry Interval (REI) which precludes worker activities in a treated area until residues dissipate to certain levels. This is not feasible in residential settings because excluding individuals from contact with their treated lawns or pets is not practical. Therefore, residential post-application exposure assessment needs to include an estimated dose based on residue on the day of application (i.e., “day 0”).

If applicable, each SOP section provides separate algorithms for assessing dermal, inhalation, and oral non-dietary post-application exposures. Because both residues and their transfer to the body are likely dependent on both the chemical and scenario (e.g., indoors vs. outdoors; smooth surfaces vs. textured surfaces, etc.), chemical- and scenario-specific data are most reliable when performing post-application exposure assessments. However, in the absence of such data, generic exposure factors outlined in the scenario-specific SOPs should be used to estimate exposure.

As described in *Section 1.3.2,* there is potential for individuals to experience post-application exposures for all possible exposure durations and selection of exposure factor inputs is dependent on various considerations related to the exposure duration. For post-application exposure assessment, these considerations include product application regimens, residue dissipation, longitudinal activity patterns, and intra-individual exposure factor variability. Both product application regimens and residue dissipation can be easily incorporated into exposure calculations. However, information on the last two factors is limited and not currently addressed in these SOPs.

1.3.5 Combining Exposure Scenarios

Each SOP provides methods for estimating daily doses for a number of potential exposure scenarios with the focus on assessment of single routes of exposure (i.e., separate assessments for dermal, inhalation, and non-dietary oral exposure). However, in reality, exposures to pesticides do not occur as single, isolated events, but rather as a series of sequential or concurrent events that may overlap or be linked in time and space. Based on this, risk estimates resulting from different exposure routes are combined when it is likely that they can occur simultaneously based on the use pattern and when the toxicological effects across different routes of exposure are the same.

There are several methods of measuring and aggregating risk. Two aggregation methods were developed by the Office of Pesticide Programs–the Total MOE and the Aggregate Risk Index (ARI). Arithmetically, the two approaches are the same when the uncertainty factors (UF) are the same for all routes of exposure. When the UF’s differ by route, however, the ARI is required.

Further discussion of these two approaches and the corresponding algorithms can be found in the Agency's *General Principles for Performing Aggregate Exposure and Risk Assessments*[7].

To the extent that information is available, it is important for the assessor to characterize the potential for co-occurrence as well as to characterize the assessment inputs when combining risks from multiple scenarios. Combining scenarios that use high-end, conservative inputs may not always be appropriate because the potential co-occurrence of multiple high-end exposure scenarios is highly unlikely. For example, it is likely that a toddler could experience dermal and hand-to-mouth exposures intermittently over a particular period of time while playing on previously treated turf. If each of those exposure scenarios is assessed using high-end inputs, one must consider the likelihood that those individual high-end exposures could co-occur at the same levels when combining them. Each scenario-specific SOP contains a more specific discussion and explanation of what routes of exposure should be combined.

1.3.6 Exposure Uncertainty and Characterization

A number of different types of uncertainty are present in these SOPs. Uncertainty may occur as a result of the techniques used to estimate environmental concentrations (i.e., analytical uncertainty), the underlying models and relationships assumed for certain types of data (e.g., exponential decay for surface residues), and the application of surrogate information or data for exposure scenarios and exposure factors lacking specific information. Uncertainty is also present in the form of variation in daily and longitudinal exposure patterns that are not easily quantified. While each scenario-specific SOP includes an exposure characterization and data quality section which attempts to lay out some of the uncertainties within the scenario, the following discussion outlines general or universal uncertainties across all the SOPs.

Surrogate Exposure Data

For many scenarios, specific information is lacking and available information for another exposure scenario is considered appropriate to use. Examples include using exposure data for individuals applying powder formulations to assess exposure for individuals applying liquid products or using post-application occupational field worker exposure data for home gardening activities. Though reasonable when exposure information is unavailable, the assessment should characterize the uncertainty and identify the data gap.

Exposure Data Analysis

Despite lacking true statistical sampling methodologies in many cases, the exposure data utilized across residential exposure assessments (e.g., handler exposure data, post-application exposure data, etc.) are considered reasonable for the purposes of establishing distributions and estimating exposure. The data are from actual applications using standardized exposure sampling methodologies and laboratory analyses.

Additionally, the use of exposure data in certain ways requires assumptions with regard to correlations or relationships between variables. For example, the underlying assumption of the

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[7] http://www.epa.gov/opp00001/trac/science/aggregate.pdf

use of exposure data as unit exposures – proportionality between the amount of active ingredient handled and exposure – is uncertain, though potentially conservative. However, as a prediction mechanism, it is considered practical and useful for the purposes of handler exposure assessment in a regulatory context. It provides a straightforward handler exposure calculation method and enables risk mitigation via formulation comparisons or decreased application rates. Where assumptions such as this are implicit, the assessment should characterize the associated uncertainty.

Longitudinal Exposure Variation

Information detailing the extent to which various residential pesticide exposure factors vary from day-to-day or application-to-application is scarce. Therefore, if no variation is assumed for short-, intermediate-, long-term or lifetime assessments, the likelihood of this pattern should be characterized.

1.3.7 Overview of Probabilistic and Deterministic Exposure Assessment

Deterministic methods are most commonly used for residential exposure assessments. In a deterministic exposure assessment, each algorithm input is represented by a single numeric value called a point estimate. The output of a deterministic exposure assessment, therefore, is also a single point estimate. Exposure estimate are easily calculated using deterministic methods and can be relatively straightforward to communicate to risk managers. In some cases, however, deterministic methods may make exposure assessments less transparent by reducing variability and uncertainty from multiple inputs to a single point estimate. As a result, deterministic assessment may not provide sufficient detail on the range of possible exposures or the level of confidence in the estimate of exposure used in risk assessment.

In order to address some of the limitations of deterministic methods, the Residential SOPs also provide input data in the form of probability distributions, so that probabilistic exposure assessments can be performed. In a probabilistic exposure assessment, each algorithm input is represented by a range of likely values that is defined by a probability distribution. Each probability distribution is then combined using the exposure algorithm and a modeling technique called Monte Carlo simulation. Using Monte Carlo simulation methods, a computer simulation is used to select values for each algorithm input based on their relative probability, which the computer simulation subsequently uses to calculate exposure. The simulation is repeated a sufficient number of times (typically 10,000 independent trials) to generate a set of exposure estimates that represents the range of possible exposures (U.S. EPA, 2001).

Selecting Probability Distributions

In order to derive probability distributions for the algorithm inputs presented in each SOP, data submitted as part of the registration process, peer-reviewed research, and general use information were reviewed. Probability distributions were then selected based on: 1) how well they approximated observed data and 2) mechanistic understanding of probability distributions that are most appropriate for particular algorithm inputs (e.g. chemical concentrations in environmental media commonly follow a lognormal distribution). Based on these criteria, several common probability distributions were considered, which are summarized in *Table 1-1*.

Table 1-1: Summary of Common Probability Distributions

Distribution	Distribution Parameter			Description
	Parameter 1	Parameter 2	Parameter 3	
Normal	Arithmetic Mean (AM)	Standard Deviation (SD)	-	The normal distribution is often used when a quantity is believed to cluster around a mean following the Central Limit Theorum.
Lognormal	Geometric Mean (GM)	Geometric Standard Deviation (GSD)	-	The lognormal distribution is often used to represent data that are positively skewed- meaning the data have more extreme values than would be expected if the data were normally distributed.
Beta	Alpha (α)	Beta (β)	Scale	The beta distribution is a flexible distribution capable of exhibiting a wide variety of shapes. It is often used to model bounded data, such as fraction of pesticide removed by saliva.
Weibull	Shape	Scale	-	The weibull distribution is commonly used to represent the time to an event. This distribution is less tail heavy than a lognormal distribution, so it assigns a lower probability to extreme events.
Exponential	Lamda (λ)			The exponential distribution is commonly used to represent the time between successive random events. The mode of an exponential distribution is zero and the probability of occurrence continually decreases with increased values.
Triangle	Minimum (Min)	Mode	Maximum (Max)	The triangle distribution is often used in the absence of data when it is believed that a range of central values is more likely than the lower and upper bounds of the range of possible values.
Uniform	Upper Bound	Lower Bound	-	The uniform distribution is often used in the absence of data when a quantity is believed to randomly vary between a lower and upper bound.

Normal, lognormal, and weibull distributions were considered when there was sufficient data and the algorithm input had no theoretical upper bound, based on mechanistic considerations. The beta distributions were also considered when sufficient data was available. However, beta distribution was generally only considered when algorithm inputs had theoretical finite upper/ lower bounds (e.g. Saliva Extraction Efficiency is bound by 0 and 1). Triangle and Uniform distributions were considered when limited data was available, but general use information was identified to reasonably characterize the lower and upper bounds and mode (triangle distribution only).

Advantages and Limitations of Probabilistic Methods

Probabilistic methods can offer several advantages over deterministic methods when there is sufficient data and a good mechanistic understanding of the exposure scenario. The probability distribution output identifies levels of exposure that are considered central tendency (e.g. mean or 50th percentile) and high-end (e.g. 90th to 99.9th percentile). Similarly, they can also be used to improve the characterization of point estimates calculated using deterministic methods. In particular, the conservatism of a high-end point estimate can be quantitatively assessed by determining its location in a probability distribution output. This type of information can improve the characterization of exposure and help inform risk management decisions. Additionally, probabilistic methods can be incorporated into more robust sensitivity analysis, based on each algorithm input's probability distribution. These sensitivity analyses can be useful at identifying the input that are the main contributors of exposure and can be used to prioritize additional research efforts (U.S. EPA, 2001).

While probabilistic methods offer several advantages, they do have disadvantages that should be considered when performing a residential exposure assessment. In particular, probabilistic methods may imply a greater level of validity and precision than the underlying data support. Therefore, probabilistic methods should be used with caution when data are limited or a strong mechanistic understanding has not been established. Similarly, probabilistic methods may make the assumptions and uncertainties of a model less transparent, since probabilistic methods add a greater level of complexity. The importance of assumptions that are difficult to quantify may be less obvious, for example, when an exposure assessment algorithm includes multiple exposure parameters that are each represented by a distribution. Finally, in some cases, risk assessors, risk managers, and the general public may be less familiar with probabilistic methods. As a result, greater resources may be required to conduct a probabilistic exposure assessment and it may be more difficult to communicate the results (U.S. EPA, 2001).

Section 2 Universal Exposure Factors

Many of the algorithm inputs discussed in this document are specific to a particular scenario. However, some factors are universal across the SOPs. These factors include: body weight, inhalation rate, body surface area, hand surface area mouthed, object surface area mouthed, and saliva extraction factor. Where applicable, each SOP refers to this section for discussion of these universal exposure factors.

Where appropriate, the recommended distributions are presented for the four major population categories potentially exposed during residential pesticide use (adults, teens, youths, and children). These are represented by the age groups 18 to 74 years (male and female combined), 11 to <16 years (male and female combined), 6 to <11 (male and female combined), and 3 to <6 years (male and female combined), respectively. The selection of these age groupings are based, in part, on discussions presented in *Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants* (USEPA, 2005). Distributions for different sub-populations can be used if there is a need to assess a more specific exposure population (e.g., female children 1-2 years old). The following sections provide summary descriptions and recommended exposure assessment inputs for each factor.

2.1 Body Weight

In order to estimate risk, toxicological points of departure (POD) are compared with exposure estimates. These PODs are typically normalized by body weight (e.g., mg/kg). Therefore, to make an appropriate comparison to estimate risk, exposure estimates must be expressed in a similar fashion. *Table 2-1* below provides distributions and point estimates of body weights for use in residential pesticide exposure assessment.

Table 2-1: Recommended Distributions and Point Estimates for Body Weight (kg)

Population	Percentiles										Point Estimate
	5	10	15	25	50	75	85	90	95	Mean	
Combined Adults 18 to 74	53.2	56.3	58.6	62.1	69.7	78.9	85.3	90.1	97.9	71.8	
Male Adults 18 to 74	58.6	62.3	64.9	68.7	76.9	85.6	91.3	95.7	102.7	78.1	
Female Adults 18 to 74	47.7	50.3	52.2	55.4	62.4	72.1	79.2	84.4	93.1	65.4	
Teens 11 to <16	34.0	37.2	40.6	45.0	54.2	65.0	73.0	79.3	88.8	56.8	
Youths 6 to <11	19.7	21.3	22.3	24.4	29.3	36.8	42.1	45.6	52.5	31.8	
Toddler 3 to <6	13.5	14.4	14.9	15.8	17.8	20.3	22.0	23.6	26.2	18.6	
Infants 1 to <2	8.9	9.3	9.7	10.3	11.3	12.4	13.0	13.4	14.0	11.4	

Source: U.S. EPA (1997, 2008)

2.2 Inhalation Rates

Inhalation rates are utilized in a number of the SOPs in this document. The inhalation rates presented in this section are metabolically derived based upon oxygen consumption (USEPA, 2009). This approach was developed by the Office of Research and Development's National Center for Environmental Assessment (ORD/NCEA). It uses the 1999-2002 National Health and Nutrition Examination Survey (NHANES) and U.S. EPA's Consolidated Human Activity Database (CHAD) and considers variability due to age, gender, and activity level. Data were grouped by age category and a simulated 24-hour activity pattern was generated by randomly sampling activity patterns from the set of participants with the same gender and age. Each activity was assigned a metabolic equivalent (METS) value based on the statistical sampling of the distribution assigned by CHAD to each activity code. The inhalation rate for each activity within the 24-hour simulated activity pattern for each individual was estimated as a function of oxygen consumption rate (VO_2), body weight, age, and gender.

Table 2-2 provides distributions and point estimates for inhalation rates on a per minute basis for males and a variety of activity types (sedentary/passive, light, moderate, and high), unadjusted for body weight. *Table 2-3* provides distributions and point estimates for inhalation rates on a per hour basis for males and a variety of activity types (sedentary/passive, light, moderate, and high), adjusted for body weight. Finally, *Table 2-4* provides distributions and point estimates for inhalation rates on a per day basis unadjusted and adjusted for body weights.

Table 2-2: Recommended Distributions and Point Estimates for Activity Specific per Minute Inhalation Rates Unadjusted for Body Weight (m^3/hr)

Population	Percentiles								Point Estimate(s)
	Mean	5th	10th	25th	50th	75th	90th	95th	
Sedentary and Passive Activities [1]									
Infant 1 to <2	0.28	0.20	0.21	0.24	0.28	0.31	0.36	0.39	
Toddler 3 to <6	0.27	0.20	0.21	0.24	0.27	0.30	0.33	0.35	
Youths 6 to <11	0.29	0.21	0.22	0.25	0.28	0.31	0.36	0.39	
Teens 11 to <16	0.33	0.24	0.25	0.28	0.32	0.36	0.41	0.45	
Combined Adults 16 to <51	0.30	0.22	0.24	0.26	0.30	0.34	0.38	0.41	
Combined Adults 16 to <61	0.31	0.23	0.24	0.27	0.30	0.34	0.39	0.42	
Combined Adults 16 to <71	0.32	0.23	0.25	0.28	0.31	0.35	0.39	0.42	
Combined Adults 16 to <81	0.32	0.24	0.26	0.28	0.31	0.35	0.39	0.42	
Light Intensity Activities [2]									
Infant 1 to <2	0.70	0.52	0.54	0.60	0.69	0.78	0.90	0.95	
Toddler 3 to <6	0.67	0.54	0.56	0.60	0.65	0.72	0.79	0.83	
Youths 6 to <11	0.68	0.52	0.55	0.60	0.66	0.74	0.84	0.91	
Teens 11 to <16	0.76	0.58	0.60	0.66	0.74	0.83	0.93	1.03	
Combined Adults 16 to <51	0.74	0.57	0.60	0.65	0.72	0.81	0.91	0.97	
Combined Adults 16 to <61	0.75	0.58	0.61	0.67	0.74	0.82	0.92	0.98	
Combined Adults 16 to <71	0.75	0.58	0.61	0.67	0.74	0.82	0.92	0.98	
Combined Adults 16 to <81	0.75	0.59	0.62	0.67	0.73	0.82	0.91	0.96	
Moderate Intensity Activities [3]									
Infant 1 to <2	1.28	0.90	0.97	1.09	1.25	1.43	1.63	1.75	
Toddler 3 to <6	1.23	0.95	1.00	1.10	1.21	1.34	1.48	1.59	
Youths 6 to <11	1.30	0.97	1.02	1.13	1.26	1.44	1.61	1.73	
Teens 11 to <16	1.50	1.12	1.20	1.30	1.45	1.64	1.87	2.05	
Combined Adults 16 to <51	1.60	1.13	1.20	1.35	1.54	1.79	2.08	2.27	
Combined Adults 16 to <61	1.63	1.15	1.23	1.38	1.57	1.82	2.10	2.30	
Combined Adults	1.61	1.16	1.23	1.37	1.56	1.79	2.07	2.26	

Table 2-2: Recommended Distributions and Point Estimates for Activity Specific per Minute Inhalation Rates Unadjusted for Body Weight (m^3/hr)									
Population	Percentiles								Point Estimate(s)
	Mean	5th	10th	25th	50th	75th	90th	95th	
16 to <71									
Combined Adults 16 to <81	1.60	1.16	1.23	1.37	1.55	1.77	2.03	2.21	
High Intensity Activities [4]									
Infant 1 to <2	2.32	1.67	1.77	1.98	2.29	2.60	2.98	3.16	
Toddler 3 to <6	2.21	1.69	1.79	1.92	2.13	2.43	2.76	2.91	
Youths 6 to <11	2.49	1.78	1.89	2.08	2.40	2.81	3.21	3.51	
Teens 11 to <16	2.92	1.96	2.12	2.41	2.83	3.31	3.81	4.18	
Combined Adults 16 to <51	3.00	1.98	2.16	2.48	2.87	3.40	3.99	4.44	
Combined Adults 16 to <61	3.03	2.01	2.19	2.51	2.91	3.44	4.04	4.48	
Combined Adults 16 to <71	3.00	1.99	2.17	2.49	2.88	3.40	3.98	4.39	
Combined Adults 16 to <81	2.97	1.99	2.16	2.47	2.85	3.37	3.92	4.33	

1 Sedentary and passive activities defined as sitting and standing.
2 Light intensity activity defined as walking at speed of 1.5 - 3.0 mph.
3 Moderate intensity activity defined as fast walking at speed of 3.3 - 4.0 mph and slow running at speed of 3.5 - 4.0 mph (for young children moderate intensity activity defined as play).
4 Heavy intensity activity defined as fast running at speed of 4.5 - 6.0 mph.

Table 2-3: Recommended Distributions and Point Estimates for Activity Specific per Hour Inhalation Rates Adjusted for Body Weight (m^3/hr-kg)									
Population	Percentiles								Point Estimate(s)
	Mean	5th	10th	25th	50th	75th	90th	95th	
Sedentary and Passive Activities [1]									
Infant 1 to <2	2.3E-02	1.8E-02	1.9E-02	2.1E-02	2.3E-02	2.5E-02	2.7E-02	2.9E-02	
Toddler 3 to <6	1.5E-02	1.0E-02	1.1E-02	1.3E-02	1.5E-02	1.7E-02	2.0E-02	2.1E-02	
Youths 6 to <11	9.6E-03	6.3E-03	6.9E-03	8.1E-03	9.6E-03	1.1E-02	1.3E-02	1.4E-02	
Teens 11 to <16	6.0E-03	4.5E-03	4.5E-03	5.1E-03	5.7E-03	6.9E-03	7.5E-03	8.1E-03	
Combined Adults 16 to <51	4.0E-03	2.8E-03	3.2E-03	3.5E-03	4.0E-03	4.5E-03	5.0E-03	5.3E-03	
Combined Adults 16 to <61	4.0E-03	2.8E-03	3.2E-03	3.5E-03	4.0E-03	4.6E-03	5.0E-03	5.3E-03	
Combined Adults 16 to <71	4.1E-03	2.9E-03	3.2E-03	3.6E-03	4.1E-03	4.6E-03	5.1E-03	5.3E-03	
Combined	4.2E-03	3.0E-03	3.3E-03	3.7E-03	4.2E-03	4.6E-03	5.1E-03	5.4E-03	

Table 2-3: Recommended Distributions and Point Estimates for Activity Specific per Hour Inhalation Rates Adjusted for Body Weight (m^3/hr-kg)

Population	Percentiles								Point Estimate(s)
	Mean	5th	10th	25th	50th	75th	90th	95th	
Adults 16 to <81									
Light Intensity Activities [2]									
Infant 1 to <2	5.7E-02	4.6E-02	4.8E-02	5.2E-02	5.6E-02	6.1E-02	6.7E-02	7.1E-02	
Toddler 3 to <6	3.8E-02	2.7E-02	2.9E-02	3.2E-02	3.7E-02	4.2E-02	4.7E-02	5.1E-02	
Youths 6 to <11	2.3E-02	1.6E-02	1.7E-02	1.9E-02	2.3E-02	2.6E-02	3.0E-02	3.2E-02	
Teens 11 to <16	1.4E-02	1.0E-02	1.1E-02	1.2E-02	1.4E-02	1.6E-02	1.8E-02	1.9E-02	
Combined Adults 16 to <51	9.8E-03	7.4E-03	7.7E-03	8.6E-03	9.6E-03	1.1E-02	1.2E-02	1.3E-02	
Combined Adults 16 to <61	9.8E-03	7.4E-03	7.7E-03	8.6E-03	9.6E-03	1.1E-02	1.2E-02	1.3E-02	
Combined Adults 16 to <71	9.7E-03	7.5E-03	7.8E-03	8.6E-03	9.5E-03	1.1E-02	1.2E-02	1.3E-02	
Combined Adults 16 to <81	9.7E-03	7.5E-03	7.8E-03	8.6E-03	9.6E-03	1.1E-02	1.2E-02	1.2E-02	
Moderate Intensity Activities [3]									
Infant 1 to <2	1.0E-01	8.1E-02	8.6E-02	9.3E-02	1.0E-01	1.1E-01	1.3E-01	1.3E-01	
Toddler 3 to <6	6.9E-02	4.8E-02	5.2E-02	5.9E-02	6.7E-02	7.9E-02	9.0E-02	9.7E-02	
Youths 6 to <11	4.4E-02	2.9E-02	3.2E-02	3.7E-02	4.3E-02	5.0E-02	5.7E-02	6.2E-02	
Teens 11 to <16	2.8E-02	2.0E-02	2.2E-02	2.4E-02	2.7E-02	3.1E-02	3.6E-02	3.9E-02	
Combined Adults 16 to <51	2.1E-02	1.5E-02	1.6E-02	1.8E-02	2.0E-02	2.4E-02	2.7E-02	3.0E-02	
Combined Adults 16 to <61	2.1E-02	1.5E-02	1.6E-02	1.8E-02	2.0E-02	2.4E-02	2.7E-02	3.0E-02	
Combined Adults 16 to <71	2.1E-02	1.5E-02	1.6E-02	1.8E-02	2.0E-02	2.3E-02	2.7E-02	2.9E-02	
Combined Adults 16 to <81	2.1E-02	1.5E-02	1.6E-02	1.8E-02	2.0E-02	2.3E-02	2.6E-02	2.8E-02	
High Intensity Activities [4]									
Infant 1 to <2	1.9E-01	1.4E-01	1.5E-01	1.7E-01	1.9E-01	2.1E-01	2.3E-01	2.4E-01	
Toddler 3 to <6	1.2E-01	8.7E-02	9.5E-02	1.1E-01	1.2E-01	1.4E-01	1.6E-01	1.8E-01	

Table 2-3: Recommended Distributions and Point Estimates for Activity Specific per Hour Inhalation Rates Adjusted for Body Weight (m^3/hr-kg)

Population	Percentiles								Point Estimate(s)
	Mean	5th	10th	25th	50th	75th	90th	95th	
Youths 6 to <11	8.2E-02	5.5E-02	6.0E-02	6.9E-02	8.1E-02	9.3E-02	1.1E-01	1.1E-01	
Teens 11 to <16	5.5E-02	3.7E-02	4.0E-02	4.5E-02	5.3E-02	6.3E-02	7.4E-02	8.0E-02	
Combined Adults 16 to <51	4.0E-02	2.6E-02	2.8E-02	3.3E-02	3.8E-02	4.5E-02	5.2E-02	5.7E-02	
Combined Adults 16 to <61	4.0E-02	2.6E-02	2.8E-02	3.3E-02	3.8E-02	4.5E-02	5.3E-02	5.7E-02	
Combined Adults 16 to <71	3.9E-02	2.5E-02	2.8E-02	3.2E-02	3.8E-02	4.4E-02	5.1E-02	5.6E-02	
Combined Adults 16 to <81	3.9E-02	2.5E-02	2.8E-02	3.2E-02	3.7E-02	4.4E-02	5.1E-02	5.6E-02	

[1] Sedentary and passive activities defined as sitting and standing.
[2] Light intensity activity defined as walking at speed of 1.5 - 3.0 mph.
[3] Moderate intensity activity defined as fast walking at speed of 3.3 - 4.0 mph and slow running at speed of 3.5 - 4.0 mph (for young children moderate intensity activity defined as play).
[4] Heavy intensity activity defined as fast running at speed of 4.5 - 6.0 mph.

Table 2-4: Recommended Distributions and Point Estimates for Daily Inhalation Rates

Daily Inhalation Rate, Unadjusted for Body Weight (m^3/day)

Population	Percentiles								Point Estimate(s)
	Mean	5th	10th	25th	50th	75th	90th	95th	
Infant 1 to <2	13.2	9.3	10.2	11.4	13.0	14.5	16.6	17.6	
Toddler 3 to <6	12.4	10.1	10.6	11.3	12.3	13.3	14.3	15.2	
Youths 6 to <11	12.9	10.0	10.5	11.4	12.5	14.1	15.8	17.0	
Teens 11 to <16	14.4	10.9	11.6	12.7	13.9	15.7	17.9	19.3	
Combined Adults 16 to <51	17.1	12.1	12.9	14.4	16.6	19.2	21.9	23.6	
Combined Adults 16 to <61	17.4	12.4	13.2	14.7	16.9	19.4	22.2	23.9	
Combined Adults 16 to <71	17.1	12.4	13.1	14.6	16.7	19.0	21.6	23.2	
Combined Adults 16 to <81	16.6	12.3	12.9	14.3	16.3	18.4	20.9	22.5	

Daily Inhalation Rate, Adjusted for Body Weight (m^3/day-kg)

Population	Percentiles								Point Estimate(s)
	Mean	5th	10th	25th	50th	75th	90th	95th	

Table 2-4: Recommended Distributions and Point Estimates for Daily Inhalation Rates									
Daily Inhalation Rate, Unadjusted for Body Weight (m^3/day)									
Population	**Percentiles**								**Point Estimate(s)**
	Mean	**5th**	**10th**	**25th**	**50th**	**75th**	**90th**	**95th**	
Infant 1 to <2	1.07	0.89	0.92	0.99	1.06	1.15	1.23	1.29	
Toddler 3 to <6	0.70	0.50	0.55	0.61	0.69	0.78	0.88	0.92	
Youths 6 to <11	0.44	0.30	0.33	0.37	0.43	0.50	0.55	0.58	
Teens 11 to <16	0.27	0.20	0.21	0.24	0.26	0.30	0.34	0.36	
Combined Adults 16 to <51	0.22	0.16	0.17	0.19	0.22	0.25	0.29	0.31	
Combined Adults 16 to <61	0.23	0.16	0.17	0.19	0.22	0.25	0.29	0.31	
Combined Adults 16 to <71	0.22	0.16	0.17	0.19	0.21	0.24	0.28	0.30	
Combined Adults 16 to <81	0.22	0.16	0.17	0.19	0.21	0.24	0.27	0.29	

2.3 Body Surface Area

Body Surface Area

Body surface area is utilized in a number of the SOPs. *Table 2-5* below provides a summary of distributions and point estimates for body surface area.

Table 2-5: Recommended Distributions and Point Estimates for Body Surface Area (m^2)										
Population	**Percentiles**									**Point Estimate**
	5	**10**	**15**	**25**	**50**	**75**	**85**	**90**	**95**	**Mean**
Combined Adults	1.56	1.61	1.65	1.70	1.82	1.95	2.02	2.09	2.19	1.82	
Male Adults 18 - 74	1.66	1.72	1.76	1.82	1.94	2.07	2.14	2.20	2.28	1.94	
Female Adults 18 - 74	1.45	1.49	1.53	1.58	1.69	1.82	1.91	1.98	2.09	1.69	
Teens 11 to <16	1.19	1.25	1.31	1.40	1.57	1.75	1.86	1.94	2.06	1.59	
Youths 6 to <11	0.81	0.85	0.88	0.93	1.05	1.21	1.31	1.36	1.48	1.08	
Toddler 3 to <6	0.61	0.64	0.66	0.68	0.74	0.81	0.85	0.89	0.95	0.76	
Infants 1 < 2	0.45	0.46	0.47	0.49	0.53	0.56	0.58	0.59	0.61	0.53	

Adjustments to Transfer Coefficients for Teens, Youths, and Children

One of the factors used in dermal post-application assessments, the transfer coefficient, is typically derived from studies which utilize adult volunteers. In order to translate these transfer coefficients to younger individuals, an adjustment factor is needed based on body surface area.

Teens, youths, toddlers and infants have a lower body surface area than adults and consequently, younger individuals have lower absolute exposures than adults, all else equal. This translation is performed using a number of simple surface area ratios depending on the age group under consideration.

For the adult component of this ratio, the mean surface area for males and females is used (i.e., [1.94 m^2 + 1.69 m^2]/2 = 1.82 m^2) (USEPA, 1997). Then the corresponding combined male and female mean for the age group under consideration is used to derive the adjustment factor. It is assumed that had other corresponding percentiles been used (e.g., 95th percentile adults to 95th percentile toddler) the ratio would be approximately the same. A summary of adjustment factors for relevant age groups, representing the respective ratios of mean body surface area to mean adult body surface area is provided in *Table 2-6* below.

Table 2-6: Transfer Coefficient Surface Area Adjustment Factor

Population	Surface Area (m^2) [Mean: Combined Males and Females[1]]	Adjustment Factor[2]
Infants (1 to < 2)	0.53	0.29
Toddler (3 to <6)	0.76	0.42
Youths (6 to <11)	1.08	0.59
Teens (11 to <16)	1.59	0.87

[1] USEPA Child-Specific Exposure Factors Handbook (CSEFH), Table 7-7
[2] Derived as ratio of adult surface area (1.82 m^2; average of male and female means) to combined male and female mean surface area for specified age group (e.g., 0.76 m^2 ÷ 1.82 m^2 = 0.418)

2.4 Fraction Hand Surface Area Mouthed (F_M)

An important factor used in hand-to-mouth post-application assessments is the fraction of a hand's surface area that is mouthed by a child. This value is used in a number of the SOPs. The fraction hand surface area mouthed values are from the Zartarian et al. (2005) analysis of data originally presented in Leckie et al. (2000). The Leckie et al. (2000) study consisted of a data set of 20 suburban children videotaped outdoors. Part of the videotape analysis performed by Leckie was to determine the amount of the hand that was mouthed by each child every time a mouthing event occurred. This was broken up into five categories, including:

- Outside mouth contact – defined as finger(s)/hand touching lips but no immersion in mouth
- Partial finger – defined as less than half the finger(s) are inside mouth
- Full finger – defined as more than half the finger(s) are inside mouth
- Partial palm with fingers – defined as fingers in mouth as well as part of the palm area
- Partial palm with out fingers – defined as fingers in mouth as well as part of the palm area

The analysis in Zartarian et al. (2005) consisted of assigning numerical values to each of the five scenarios discussed above. It was assumed that each finger is 10% of the hand, and that the surface area of palm that can be mouthed is 25% of the hand. For 1 "partial finger" inserted into the mouth a value of 5% of the hand was selected, 2 partial fingers 10%, *et cetera*. Based on an analysis of the data, it was determined that a beta distribution (α=3.7, β=25) best fits the observed data. *Table 2-7* provides distributions and point estimates of fraction hand surface area mouthed for use in residential pesticide exposure assessment. The data used to derive fraction of hand surface area mouthed is provided in *Section A.1 of Appendix A*.

Table 2-7: Fraction Hand Surface Area Mouthed	
Statistic	**Fraction**
50th percentile	0.118
75th percentile	0.164
95th percentile	0.243
AM (SD)	0.127 (0.0614)
GM (GSD)	0.114 (1.58)
Range	0.05 – 0.4
N	220
AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

2.5 Surface Area of Object Mouthed (SAM_O)

One of the factors used in object-to-mouth post-application assessments is the surface area (expressed in cm^2) of the object that is mouthed by a child, and is used in a number of the SOPs. Based on the area of hand mouthed by 2-5 year olds as reported by Leckie et al.(2000), and the assumption that children mouth a smaller area of an object than their hand, an exponential distribution with a minimum of 1 cm^2, a mean of 10 cm^2, and a maximum of 50 cm^2 was chosen. The maximum is comparable to the surface area of a ping-pong ball. Additional details and analyses are provided in *Section A.2 of Appendix A*.

2.6 Fraction of Pesticide Extracted by Saliva (SE)

One of the factors used in hand-to-mouth and object-to-mouth post-application assessments is the fraction of pesticide extracted from the hand/object via saliva. The values for fraction of pesticide extracted by saliva are based on analysis of data collected in a study by Camann et al. (1995). This study focused specifically on fraction of pesticide extracted by saliva from hands, not objects. However, there are currently no data available to address the removal of residues from objects by saliva during mouthing events so this study is being used for both hands and objects. The estimates of saliva extraction were derived using a beta distribution ($\alpha = 7.0$, $\beta = 7.6$). *Table 2-8* provides distributions and point estimates of pesticide extracted by saliva for use in residential pesticide exposure assessment. Additional details and analyses are provided in *Appendix A.3*.

Table 2-8: Fraction of Pesticide Extracted by Saliva	
Statistic	**Fraction of Pesticide Extracted by Saliva**
50th percentile	0.50
75th percentile	0.57
90th percentile	0.64
95th percentile	0.68
99th percentile	0.80
AM (SD)	0.48 (0.13)
GM (GSD)	0.46 (1.35
Range	0.22 – 0.71
N	27
AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

2.7 Life Expectancy Averaging Time

An important factor to consider when evaluating cancer risk is the length of an individual's life (e.g., life expectancy), because it is used to derive the lifetime average daily dose estimate. Life expectancy values are based on an analysis of U.S. Census Bureau data presented in the Exposure Factors Handbook Table 8-1 (USEPA, 1997). The table shows that the overall life expectancy has averaged approximately 75 years since 1982. In 1993, the average life expectancy for males was 72.1 years and 78.9 years for females. **Based on the available data, the recommended value for use in cancer risk assessments is 75 years.**

Section 3 Lawns/Turf

The residential turf SOP provides algorithms and inputs to assess a number of handler and post-application turf exposure scenarios. The populations considered in this SOP are those individuals who are potentially exposed to pesticides from either treating turf with a product available for sale to the general public or after contact with treated turf in many settings, including residential lawns, playgrounds, parks, recreation areas, schools, and golf courses.

Before the development of an exposure assessment for a turf scenario, the assessor should review the pesticide label to determine whether the scenario is appropriate based on the usage of the product. Specific labeling statements that indicate an assessment for residential lawns is needed are as follows:

- **Registered for Use on Turfgrass**: Determine whether the labeling contains directions for use on "turfgrass," "lawns," or "ornamental turf," or on specific species of turfgrasses, such as "bluegrass," "zoysia," "bentgrass," etc.

- **Limitation and Descriptive Statements**: Assume that a product registered for use on turfgrass is used on home lawns, unless a specific statement on the label indicates the product is not for use in residential settings. Examples include:

    - For golf course use only
    - For use only on commercial sod farms
    - Not for use on residential sites
    - Not for use on home lawns
    - Not for use in and around homes or dwellings

  Additionally, “Restricted Use Pesticide” classification indicates that the product cannot be bought or applied by homeowners (i.e., no residential handler exposure/risk assessment required), but it may be applied by commercial applicators to residential sites; therefore, a post-application risk assessment may be required. However, statements such as "For use by commercial or professional applicators only" or “Not for homeowner use” are considered unenforceable and do not preclude use in residential settings. In these cases both a residential handler and post-application exposure assessment is required.

- Post-application assessments do not need to be performed if label directions indicate the turf use is an edging use (e.g., along fence rows), a foundation perimeter treatment (e.g., 3 foot band around the perimeter of a house), or a specific spot treatment (e.g., ant mounds). These types of uses can result in residues on turf but residential exposure is likely to be low. Post-application assessments should be conducted for all other turf application scenarios.

If a turf use is possible, the assessment should then characterize and estimate the potential for exposure by route (e.g., dermal, non-dietary ingestion, inhalation) following the methodology outlined in this SOP. The assessor should also consider the durations of exposure for each route. Specific considerations include the following:

- The number of applications allowed per year or season and the re-treatment interval. Depending on the specific product, this can indicate if intermediate- or long-term assessments are required.

- The pesticide type (e.g., fungicide, herbicide, insecticide). Fungicides and herbicides can typically be applied at shorter re-treatment intervals, while the same insecticide may not be applied repeatedly over time due to possible resistance issues.

Much of the data contained within this SOP is the result of an Agency Data-Call-In (DCI) that was issued to pesticide registrants in 1995, under the authority of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). This DCI required additional data which would allow for a more refined turf post-application exposure assessment. It impacted all pesticide registrants who produced products that could lead to post-application exposure on turf. In anticipation of the need to provide these data to the Agency, the industry-based Occupational and Residential Exposure Task Force (ORETF) was formed prior to the time that the DCI was issued. Ultimately – based on the information provided by ORETF and working in conjunction with the California Department of Pesticide Regulation (DPR) and Canada's Pest Management Regulatory Agency (PMRA) – a turf transferable residue collection method (the Modified California Roller Method) was agreed upon for all future turf transferable residue studies. Subsequently, a transfer coefficient study using the Modified California Roller Method was performed by the ORETF.

3.1 Handler Exposure Assessment

This residential turf handler SOP provides a standard method for estimating potential dermal and inhalation doses resulting from applying pesticides to residential turf. Such exposure is assumed to occur for adults only (i.e., individuals above 18 years old).

Dermal and Inhalation Handler Exposure Algorithm

As described in *Section 1.3.3*, daily dermal and inhalation exposure (mg/day) for residential pesticide handlers, for a given formulation-application method combination, is estimated by multiplying the formulation-application method-specific unit exposure by an estimate of the amount of active ingredient handled in a day, using the equation below:

$$E = UE * AR * A \tag{3.1}$$

where:

E = exposure (mg/day);
UE = unit exposure (mg/lb ai);
AR = application rate (e.g., lb ai/ft^2, lb ai/gal); and
A = area treated or amount handled (e.g., ft^2/day, gal/day).

Dermal and/or inhalation doses normalized to body weight are calculated as:

$$D = \frac{E * AF}{BW} \quad (3.2)$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

Handler exposure for applications to lawns and turf is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.3* such as the product-specific application regimen. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Dermal and Inhalation Handler Exposure Algorithm Inputs and Assumptions

Recommended values for handler exposure (inhalation and dermal) assessments are provided in *Table 3-1* and *Table 3-2*. Following these tables, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 3-1: Turf – Recommended Unit Exposure (mg/lb ai) Distributions and Point Estimates

Formulation	Equipment/Application Method	Dermal			Inhalation			Appendix Page Reference
		Distribution		Point Estimate	Distribution		Point Estimate	
		Type	Parameters		Type	Parameters		
Granules	Push-type spreaders	Lognormal	GM = 0.66 GSD = 1.89		Lognormal	GM = 0.0014 GSD = 3.14		B-4
	Belly grinders	Lognormal	GM = 239 GSD = 2.47		Lognormal	GM = 0.035 GSD = 4.47		B-11
	Spoon	Lognormal	GM = 3.72 GSD = 2.74		Lognormal	GM = 0.024 GSD = 4.97		B-20
	Cup	Lognormal	GM = 0.05 GSD = 3.40		NA	NA		B-24
	Hand dispersal	Lognormal	GM = 121 GSD = 2.17		Lognormal	GM = 0.28 GSD = 2.17		B-28
	Shaker can	No exposure data available for this application scenario. Dermal exposure data for granule applications using a cup and inhalation exposure data for granule applications using a spoon recommended as surrogate data.						
Liquid concentrates	Low-pressure handwand	Lognormal	GM = 46.3 GSD = 2.26		Lognormal	GM = 0.0043 GSD = 1.97		B-56
	Hose-end sprayer	Lognormal	GM = 36.5 GSD = 2.62		Lognormal	GM = 0.0012 GSD = 1.73		B-78
	Backpack	Lognormal	GM = 25.3 GSD = 6.04		Lognormal	GM = 0.06 GSD = 3.04		B-89
	Sprinkler can	No exposure data available for this application scenario. Exposure data for hose-end sprayer applications of liquid concentrates recommended as surrogate data.						
Ready-to-Use (RTU)	Hose-end sprayer	Lognormal	GM = 2.61 GSD = 4.66		Lognormal	GM = 0.010 GSD = 3.27		B-104
	Trigger-sprayers	Lognormal	GM = 54.2 GSD = 2.56		Lognormal	GM = 0.046 GSD = 2.10		B-109
	Aerosol can	Lognormal	GM = 329 GSD = 1.60		Lognormal	GM = 2.34 GSD = 2.01		B-130
Wettable Powder	Low-pressure handwand	Lognormal	GM = 34.2 GSD = 3.29		Lognormal	GM = 0.63 GSD = 2.93		B-138
	Hose-end sprayer	No exposure data available for this application scenario. Exposure data for hose-end sprayer applications of liquid concentrates recommended as surrogate data.						
	Backpack	No exposure data available for this application scenario. Exposure data for low-pressure handwand applications of wettable powders recommended as surrogate data.						
	Sprinkler can	No exposure data available for this application scenario. Exposure data for hose-end sprayer applications of liquid concentrates recommended as surrogate data.						

Table 3-1: Turf – Recommended Unit Exposure (mg/lb ai) Distributions and Point Estimates								
Formulation	**Equipment/Application Method**	**Dermal**			**Inhalation**			**Appendix Page Reference**
		Distribution		**Point Estimate**	**Distribution**		**Point Estimate**	
		Type	**Parameters**		**Type**	**Parameters**		
Wettable Powder in Water-soluble Packaging	Low-pressure handwand	No exposure data available for this scenario. Exposure data for low-pressure handwand applications of liquid concentrates recommended as surrogate data.						
	Hose-end sprayer	No exposure data available for this scenario. Exposure data for RTU hose-end sprayers recommended as surrogate data.						
	Backpack	No exposure data available for this scenario. Exposure data for low-pressure handwand applications of liquid concentrates recommended as surrogate data.						
	Sprinkler can	No exposure data available for this scenario. Exposure data for RTU hose-end sprayers recommended as surrogate data.						
Dry Flowable / Water-dispersible Granule	Low-pressure handwand	No exposure data available for this scenario. Application method-specific exposure data for wettable powders recommended as surrogate data.						
	Hose-end sprayer							
	Backpack							
	Sprinkler can							
Micro-encapsulates	Low-pressure handwand	No exposure data available for this scenario. Application method-specific exposure data for liquid concentrates recommended as surrogate data.						
	Hose-end sprayer							
	Backpack							
	Sprinkler can							

Table 3-2: Turf – Recommended Handler Exposure Factors Distributions and Point Estimates				
Exposure Factor (units)		Distribution		Point Estimate(s)
		Type	Parameters	
Application Rate mass ai per unit area		Product-specific	NA	Maximum labeled rate
Area Treated/Amount Handled	Push-type spreader (acres)	Point Estimate	NA	0.5
	Belly grinder (ft^2)	Point Estimate	NA	1,000
	Cup, Spoon, Hand (ft^2)	Point Estimate	NA	100
	Low-pressure handwand (gallons)	Point Estimate	NA	5
	Backpack sprayer (gallons)	Point Estimate	NA	5
	Hose-end sprayer (acres)	Point Estimate	NA	0.5
	Sprinkler can (ft^2)	Point Estimate	NA	1,000
	Trigger-sprayer (# bottles)	Point Estimate	NA	1
	Aerosol Can (# cans)	Point Estimate	NA	1
	Any equipment, fire ant mounds (# mounds)	Point Estimate	NA	5
Body Weight (kg)	Adult	Empirical	Mean = 71.8 95^{th} = 97.9	

Unit Exposures

As described in *Section 1.3.2*, the unit exposure is the ratio, for a given formulation/application method combination, between exposure and the amount of active ingredient handled, with units mass exposure per mass active ingredient handled (e.g., mg ai exposure/lb ai handled). **The recommended point estimates shown in *Table 3-1* represent approximately the [XX]th percentile of the respective distributions.** Data summaries can be found in *Appendix B*.

Amount of Active Ingredient Handled

The algorithm for estimating handler exposure requires some estimate of the amount of active ingredient handled per day. This factor varies based on the type of equipment or application method used and is estimated based on the application rate specified on the product label. First the assessor should assemble application rate information in terms of active ingredient per area treated (e.g., lb ai/acre, lb ai/1000 ft^2) and active ingredient per volume of spray (e.g., lb ai/gallon solution). For example, instructions for a granule formulation might direct application of 2 lbs of product per 100 square feet or a spray application might say to apply 2 gallons of solution per 100 square feet.

Data on the amount of active ingredient handled are limited and difficult to collect. The amounts of active ingredient handled presented in this SOP are assumed to be reasonable high-end conservative assumptions for typical residential turf application equipment. These values and the supporting data (where applicable) are discussed below.

- Push-type spreader: ½ an acre for broadcast applications. This value is supported by data from the Outdoor Residential Pesticide Use and Usage Survey and National Gardening Association Survey (Johnson, 1999) which showed that 73% of the people surveyed had lawns smaller than ½ acre.
- Belly grinder: 1,000 ft^2 for spot treatments. It is not believed that belly grinders are practical for broadcast lawn treatments.
- Cup, Spoon, or Hand: 100 ft^2 for spot treatments. It is not believed that cup, spoon, or hand applications of granules are practical for broadcast lawn treatments but are more appropriate for treating ant mounds, yellow jacket nests or dandelions (check label for pest directions).
- Low-pressure handwand sprayer: 5 gallons for spot treatments which assumes mixing/loading/applying two, 2.5 gallon sprayers. It is not believed that low-pressure hand sprayers are practical for broadcast lawn treatments due to the numbers of gallons generally required for broadcast sprays (e.g., 15 gallons/1000 sq ft).
- Backpack sprayer: 5 gallons for spot treatments which assumes mixing/loading/applying two, 2.5 gallon sprayers. It is not believed that backpack sprayers are practical for broadcast lawn treatments due to the numbers of gallons generally required for broadcast sprays (e.g., 15 gallons/1000 sq ft).
- Hose-end sprayer: ½ an acre for broadcast applications. This value is further supported by data from the Outdoor Residential Pesticide Use and Usage Survey and National Gardening Association Survey (Johnson, 1999) which showed that 73% of the people surveyed had lawns smaller than ½ acre.
- Sprinkler can: 1,000 ft^2 for spot treatments. It is not believed that sprinkler cans are practical for broadcast lawn treatments due to the numbers of gallons generally required for broadcast sprays (e.g., 15 gallons/1000 sq ft).
- Trigger sprayer: 1 bottle. It is not believed that trigger sprayers are practical for broadcast lawn treatments but are more appropriate for treating ant mounts, yellow jacket nests or dandelions (check label for pest directions).
- Aerosol can: 1 can. It is not believed that aerosol cans are practical for broadcast lawn treatments but are more appropriate for treating ant mounts, yellow jacket nests or dandelions (check label for pest directions).
- Fire ant mound treatments (any equipment): 5 individual mounds. Note: some labels have directions for broadcast applications to prevent invasion of fire ants of areas widely infested.

Future Research/Data Needs

Unavailable information that would refine handler exposure assessments for pesticide applications to turf include:

- Application intervals (i.e., how often chemicals are applied to gardens and trees) – either chemical-specific or generic intervals by pesticide-type (e.g., fungicides, insecticides, etc.)
- Survey information (preferably longitudinal) detailing:
    - General pesticide use to obtain, on a per capita basis, the probability of treating turf with pesticides;

  - Amount of product or formulation used or area treated per application; and,
  - Product-specific application rates to obtain the likelihood that the maximum rate is used.
- Handler exposure data:
  - Specific for turf applications as well as for those formulations and/or application methods currently unavailable as shown in *Table 3-1*;
  - Describing the extent to which an individual's exposure for a given formulation and application method varies from application-to-application (i.e., intra-individual exposure variability).

Exposure Characterization and Data Quality

The uncertainties associated with this assessment stem from the use of assumed amounts of active ingredient handled for typical residential turf application equipment. The estimated doses are believed to be high-end, conservative estimates.

Unit Exposures

- Despite lacking true statistical sampling methodologies, the exposure data underlying unit exposures are considered reasonable for the purposes of establishing distributions and estimating exposure. The data are from actual applications using standardized exposure sampling methodologies and laboratory analyses.
- The underlying assumption of the use of exposure data as unit exposures – proportionality between the amount of active ingredient handled and exposure – is uncertain, though potentially conservative. However, as a prediction mechanism, it is considered practical and useful for the purposes of handler exposure assessment in a regulatory context. It provides a straightforward handler exposure calculation method and enables risk mitigation in the form of formulation comparison and decreased application rates.
- The extent to which an individual's exposure (expressed via unit exposures) varies day-to-day or application-to-application is unknown; therefore, the assumption that there is no variation when assessing longer-term exposure durations is considered conservative.

Amount of active ingredient handled

- Information on the amount of product/formulation (thus, active ingredient) handled per application is lacking, making the estimates highly uncertain. The recommended point estimates are therefore intended to be high-end to ensure an appropriately conservative exposure estimate.
- The extent to which the amount an individual will handle per application varies from day-to-day or application-to-application is unknown; therefore, the assumption that there is no variation when assessing longer-term exposure durations is considered conservative.

3.2 Post-application Exposure Assessment

Post-application exposure can result from a number of activities following pesticide applications on turf. While exposure may occur for people of all ages, adults, teens, and toddlers are considered the sentinel populations depending on the exposure scenario based on behavioral characteristics and the strengths and limitations of available data.

The Agency has derived standard methods for estimating exposure and dose for eight scenarios resulting from contact with turf that has previously been treated with pesticides:

- Section 3.2.1 - adult/toddler inhalation exposure resulting from activities on turf;
- Section 3.2.2 - adult/toddler dermal exposure resulting from activities on turf;
- Section 3.2.3 - toddler non-dietary ingestion via hand-to-mouth activity;
- Section 3.2.4 - toddler non-dietary ingestion via object-to-mouth activity;
- Section 3.2.5 - toddler non-dietary ingestion via soil ingestion;
- Section 3.2.6 - toddler non-dietary ingestion via episodic granular ingestion;
- Section 3.2.7 - adult/teen dermal exposure resulting from mowing; and
- Section 3.2.8 – adult/teen dermal exposure resulting from golfing.

3.2.1 Post-application Inhalation Exposure Assessment

Post-application inhalation exposure while engaged in activities on or around previously treated turf is generally not assessed and should be handled on a case-by-case basis. The combination of low vapor pressure for chemicals typically used as active ingredients in outdoor residential pesticide products and dilution in outdoor air is likely to result in minimal inhalation exposure.

3.2.2 Post-application Dermal Exposure Assessment: Physical Activities on Turf

The residential turf post-application SOP provides a standard method for estimating potential dermal doses among adults and/or toddlers from dermal contact with turf that has previously been treated with pesticides. This scenario assumes that pesticide residues are transferred to the skin of adults/toddlers who enter treated lawns for play, recreation, yardwork, or other homeowner activities. Considering the strengths and limitations of available data and behavioral characteristics of potentially exposed populations, post-application dermal exposure is calculated for adults and toddlers.

It is assumed that individuals contact previously treated turf on the same day a pesticide is applied. However, the assessment can be refined to more accurately reflect exposure over a longer period of time (e.g., a week or month) if toxicological or activity information indicate the need for such estimates.

Post-application Dermal Exposure Algorithm – Physical Activities on Turf

Exposure resulting from contacting previously treated turf while performing physical activities is calculated as follows:

$$E = TTR_t * CF1 * TC * ET \quad (3.3)$$

where:

E = exposure (mg/day);
TTR_t = turf transferable residue on day t (μg/cm2);
CF1 = weight unit conversion factor (0.001 mg/μg);
TC = transfer coefficient (cm2/hr); and
ET = exposure time (hr/day).

If chemical specific TTR data are available, then surface residues from the day of application should be used (assume that individuals could be exposed to residues immediately after application). However, if data are not available, then TTR_t can be calculated using the following formula:

$$TTR_t = AR * F * (1-F_D)^t * CF2 * CF3 \quad (3.4)$$

where:

TTR_t = turf transferable residue on day t ($\mu g/cm^2$);
AR = application rate (lbs ai/ft^2 or lb ai/acre);
F = fraction of ai as transferable residue following application (unitless);
F_D = fraction of residue that dissipates daily (unitless);
t = post-application day on which exposure is being assessed;
CF2 = weight unit conversion factor (4.54×10^8 μg/lb); and
CF3 = area unit conversion factor (1.08×10^{-3} ft^2/cm^2 or 2.47×10^{-8} $acre/cm^2$).

Dermal doses are calculated as:

$$D = \frac{E * AF}{BW} \quad (3.5)$$

where:

D = dose rate (mg/kg-day);
AF = absorption factor (dermal); and
BW = body weight (kg).

Post-application dermal exposure following applications to lawns and turf is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Dermal Exposure Algorithm Inputs and Assumptions – Physical Activities on Turf

Recommended values for post-application dermal (physical activities on turf) exposure assessments are provided in *Table 3-3*. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 3-3: Turf (Physical Activities) – Recommended Distributions and Point Estimates for Post-Application Dermal Exposure Factors

Algorithm Notation	Exposure Factor (units)		Distribution		Point Estimate(s)
			Type	Parameters	
AR	Application rate (mass active ingredient per unit area)		Point Estimate	NA	
F	Fraction of AR as TTR following application	L/WP/WDG	Point Estimate	NA	
		Granules	Point Estimate	NA	
F_D	Daily residue dissipation (fraction)	L/WP/WDG	Point Estimate	NA	
		Granules	Point Estimate	NA	
TC	Transfer Coefficient (cm^2/hr)	Adult	Lognormal	GM = 178,000 GSD = 1.25	
		Toddler	Lognormal	GM = 63,900 GSD = 1.25	
ET	Exposure Time (hours per day)		Empirical	50^{th} = 0.9 90^{th} = 3.5	
BW	Body Weight (kg)	Adults	Empirical	Mean = 71.8 95^{th} = 97.9	
		Toddlers	Empirical	Mean = 18.6 95^{th} = 26.2	

L/WP/WDG = Liquids/Wettable Powders/Water-dispersible Granules
NA = not applicable
GM = geometric mean
GSD = geometric standard deviation

Turf Transferable Residue (TTR)

Following an application, some pesticide residue remains on turf for an individual to contact and remove. This is referred to as turf transferable residue (TTR) and is assumed to be the most significant source for dermal exposure in this scenario. TTR values for this scenario can be obtained directly from chemical-specific data or can be calculated from the maximum labeled turf application rate. Use of chemical specific TTR measurements are preferred if available and these should be used in all cases unless warranted by the quality of the study.

<u>Chemical-specific data</u>

When chemical-specific data are available, the TTR is the surface residue on Day 0 which assumes an individual could be exposed to residues immediately after application.

<u>Calculating from Application Rate</u>

When the application rate is in terms of mass active ingredient per area (e.g., lbs ai/ft^2 or lb ai/acre), the total deposited residue is assumed to be equivalent to the application rate.

Fraction of Active Ingredient Residue Available For Transfer (F)

If chemical specific TTR measurements are not available, it is necessary to use a generic value for the fraction of active ingredient available for transfer. For the purpose of this SOP, 59 studies that collected turf transferable residues using the Modified California Roller Method (36 studies using liquids, 11 studies using wettable powders/water dispersible granules, and 12 studies using granules) were analyzed. Only TTR data collected with the Modified California Roller Method were used because this was the turf residue collection method agreed upon by the Agency in the 1995 Turf DCI (USEPA, 1995). The transfer coefficient study for playing on treated turf also utilized the Modified California Roller Method to collect TTR. During the analysis of these studies, it was determined that there was no statistical difference between residues resulting from liquid, wettable powder (applied as a spray), or water dispersible granular (applied as a spray) applications; as a result, these data have been combined into one distribution (*See Appendix C.6.1*). Granular data have been kept separate. *Table 3-4* provides some summary statistical information about the fraction of active ingredient available for transfer distribution.

Table 3-4: Fraction of the Application Rate Available from Turfgrass as Transferable Residue when Various Formulations of Pesticides are Applied

Statistic	Liquids/WPs/WDGs	Granules
50th percentile	0.0050	0.00050
75th percentile	0.011	0.0018
95th percentile	0.035	0.012
99th percentile	0.080	0.045
AM (SD)	0.0086 (0.0094)	0.0017 (0.0021)
GM (GSD)	0.0051 (3.6)	0.00050 (6.9)
Range	0.000005–0.061	0.0000064–0.0069
N	131	37

AM (SD) = arithmetic mean (standard deviation)
GM (GSD) = geometric mean (geometric standard deviation)

Note that these distributions are only meant as a basis for selecting a generic estimate for the TTR on the day of application as a fraction of the application rate and they are inappropriate to use probabilistically. Because the data are comprised of a variety of chemicals under a variety of conditions, this distribution represents the variability associated with varying chemicals and situations. Within each particular TTR study, the distribution of the TTR on the day of application as a fraction of the application rate is much less variable; for a given chemical the range may be only 0.5 – 0.7%; not the 0.00005 – 6.1% range associated with the entire multi-chemical data set. Furthermore, because the chemical-specific variability of this input is small, a distribution for use probabilistically is unnecessary (i.e., it will not have much effect on the outcome) and a point estimate is appropriate for use in both deterministic and probabilistic assessments.

For liquid applications (including wettable powders/water dispersible granules applied as sprays, the recommended point estimate for use in post-application dermal exposure assessment [XX] represents approximately the [XX]th percentile. For granular applications, the recommended point estimate for use in post-application dermal exposure assessment [XX] represents approximately the [XX]th percentile.

Dissipation (F_D)

Post-application exposures must be assessed on the same day the pesticide is applied because it is assumed that individuals could be exposed to turfgrass immediately after application. Therefore, post-application exposures are based on residues found on the day of application (i.e., referred to as day 0). For subsequent days after application it is also important to estimate exposure based on pesticide dissipation rates because of possible concerns over longer term exposures (i.e., using an amortized dose) and possible re-treatment intervals. If no chemical specific TTR data are available, then a 10 percent dissipation rate per day should be assumed. This value is based on best professional judgment.

Transfer Coefficient (TC)

The transfer coefficients used for turf dermal scenarios were derived from data gathered while adult human volunteers performed an approximate 2-hour composite routine consisting of 12 sequential activities which children and adults routinely engage on residential turf (D. Klonne and D. Johnson, MRID 47292001). These activities represent behaviors that are reported in the National Human Activity Pattern Survey (NHAPS) for children aged 1 to 12 years (Klepeis, et. al., 2001). The two hour duration of the routine was chosen because NHAPS indicated that the upper-bound estimate of time children spend playing on turf is two hours per day. Two turf sites were treated during the study; one with a liquid formulation and the other with a granular formulation. A total of 40 participants performed the composite routine during the study; 10 participants each during a morning and afternoon session at the two treated turf sites.

The potential dermal exposure was measured by using whole-body dosimetry (inner and outer dosimeters), foot washes, hand washes, and face/neck wipes only from the first part of the day. OPP believes that the data obtained on the first part of the day are most appropriate for risk assessment as turf residues measured during the second part of the day were deemed invalid by the Agency. Therefore, only measurements from the first part of the day were used in the transfer coefficient calculations.

An analysis was performed to assess the statistical differences between the TCs calculated using the liquid data vs. the granular data. It was determined that these two distributions should not be combined because the upper percentile values are higher for the granular TCs vs. the liquid TCs even though the central tendency values of the two distributions are similar (*See Appendix C.6.1*). For toddlers, the transfer coefficient is adjusted for body surface area by a factor of 0.42 (i.e., a 58% reduction in the TC) as outlined in *Section 2.3*. *Table 3-5* provides some summary statistical information about the turf dermal transfer coefficient distribution.

For liquid applications, the recommended point estimate for use in post-application adult dermal exposure assessment [XX] cm^2/hr represents approximately the [XX]th percentile

and the recommended point estimate for use in post-application toddler dermal exposure assessment [XX] cm^2/hr represents approximately the [XX]th percentile.

For granular applications, the recommended point estimate for use in post-application adult dermal exposure assessment [XX] cm^2/hr represents approximately the [XX]th percentile and the recommended point estimate for use in post-application toddler dermal exposure assessment [XX] cm^2/hr represents approximately the [XX]th percentile.

Table 3-5: Dermal Exposure Transfer Coefficients (T-shirt and Shorts) for Individuals Performing CHAPS Activities

Statistic	Liquid Transfer Coefficient (cm^2/hr)		Granular Transfer Coefficient (cm^2/hr)	
	Toddler [1]	Adult	Toddler [1]	Adult
50th percentile	75,000	180,000	74,000	180,000
75th percentile	84,000	200,000	90,000	220,000
95th percentile	100,000	240,000	120,000	280,000
99th percentile	110,000	270,000	140,000	340,000
AM (SD)	76,000 (NA)	180,000 (31,000)	77,000 (NA)	180,000 (48,000)
GM (GSD)	75,000 (NA)	180,000 (1.2)	74,000 (NA)	180,000 (1.3)
Range	NA	112,133–261,175	NA	137,245–246,684
N	NA	10	NA	10

[1] A 58% reduction in the adult transfer coefficient is recommended because of the differences of body surface areas between adults and toddlers (3 to <6 years old).
AM (SD) = arithmetic mean (standard deviation)
GM (GSD) = geometric mean (geometric standard deviation)

Exposure Time (ET)

Another important variable for addressing post-application exposure from treated turf is the duration of time spent on turf. In order to be protective and to address the uncertainty in the upper percentiles of the exposure factor data when conducting a probabilistic assessment, empirical distributions were selected for adults and children (expressed as a cumulative distributions) from the Exposure Factors Handbook Table 15-80 (USEPA, 1997). These distributions represent the amount of time spent outdoors rather than just on lawns (see *Table 3-6*). Both the adult and children distributions were bounded at the 90th percentile. This adjustment allows for additional time that individuals may spend outdoors (such as parks and schools) where there is potential for additional contact with treated turf. **Based on these data, the recommended point estimates for use in post-application dermal exposure assessment for adults and children [XX] and [XX] hrs/day represent approximately the [XX]th and [XX]th percentiles, respectively.**

Table 3-6: Time Spent on Turf for Adults and Children		
Statistic	Hours per Day	
	Adults	Children
0 th percentile	0.00	0.00
5th percentile	0.46	0.25
25th percentile	0.88	0.33
50th percentile	1.1	0.90
75th percentile	1.7	2.5
90th percentile	2.4	3.5
100th percentile	2.4	3.5

Future Research/Data Needs

Unavailable information that would refine post-application dermal exposure assessments for pesticide applications to turf include:

- Application intervals (i.e., how often chemicals are applied to turf) – either chemical-specific or generic intervals by pesticide-type (e.g., fungicides, insecticides, etc.)
- Survey information (preferably longitudinal) detailing:
    - General pesticide use to obtain, on a per capita basis, the probability of treating turf with pesticides;
    - Product-specific application rates to obtain the likelihood that the maximum rate is used; and,
    - Daily activity patterns specific to turf.
- Post-application exposure data:
    - Describing the extent to which an individual's exposure for a given activity varies (i.e., intra-individual exposure variability)

Exposure Characterization and Data Quality

Turf Transferable Residue

- The Modified California Roller Method was used in the selected turf dermal transfer coefficient study to collect TTR. This TTR collection method was agreed upon by the ORETF, CDPR, PMRA, and the Agency. For all assessments, transfer coefficients from this study should only be used with TTR studies that utilize the Modified California Roller Method. If chemical specific TTR data collected via the Modified California Roller Method is not available, then default TTR data should be used.
- Absent chemical-specific data, estimates of turf transferable residue factors such as the amount available following application and dissipation are used generically based on existing data for a wide variety of chemicals. Use of the data generically, including using high-end estimates, may overestimate exposure for some chemicals.
- Assessors should recognize that factors such as rainfall/irrigation, grass growth, and grass mowing can greatly impact the dissipation rate of pesticides on turf when conducting turf post-application exposure assessments.

Exposure Time

- The extent to which the amount of time spent conducting certain activities varies over a long-term extended period of time is unknown; therefore, the assumption that there is no variation when assessing longer-term exposure times is considered conservative.

3.2.3 Post-application Non-Dietary Ingestion Exposure Assessment: Hand-to-Mouth

This SOP provides a standard method for estimating the dose from incidental ingestion of pesticide residues from previously treated turf. Considering the strengths and limitations of available data and behavioral characteristics of potentially exposed populations, exposure for toddlers is calculated in this scenario. It assumes that pesticide residues are transferred to the skin of toddlers playing on treated turf and are subsequently ingested as a result of hand-to-mouth transfer. It does not include residues ingested as a result of mouthing an object or via soil ingestion (*See Sections 3.2.4 and 3.2.5*).

Post-application Hand-to-Mouth Exposure Algorithm

Exposure from hand-to-mouth activity is calculated as follows (based on algorithm utilized in the Stochastic Human Exposure and Dose Simulation (SHEDS)-Multimedia model, http://www.epa.gov/heasd/products/sheds_multimedia/sheds_mm.html):

$$E = [HR * (F_M * SA_H) * (ET * N\_Replen) * (1- (1- SE)^{(Freq\_Replen/N\text{-}Replen)})] \quad (3.6)$$

where:

E = exposure (mg/day);
HR = hand residue loading (mg/cm^2);
F_M = fraction hand surface area mouthed / event (fraction/event);
SA_H = typical surface area of one hand (cm^2);
ET = exposure time (hr/day);
N_Replen = number of replenishment intervals per hour (intervals/hour);
SE = saliva extraction factor (ie, mouthing removal efficiency); and
Freq_Replen = number of hand-to-mouth contacts events per hour (events/hour).

and

$$HR = \frac{Faihands * DE}{SA_H * 2} \quad (3.7)$$

where:

HR = hand residue loading (mg/cm^2);
Fai_{hands} = fraction ai on hands compared to total surface residue from dermal transfer coefficient study (unitless);
DE = dermal exposure (mg); and
SA_H = typical surface area of one hand (cm^2).

and

Dose, normalized to body weight, is calculated as:

$$D = \frac{E}{BW} \tag{3.8}$$

where:

D	= dose (mg/kg-day);
E	= exposure (mg/day); and
BW	= body weight (kg).

Post-application hand-to-mouth exposure following applications to lawns and turf is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Hand-to-Mouth Algorithm Inputs and Assumptions

Recommended values for post-application hand-to-mouth exposure assessments are provided in *Table 3-7*. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 3-7: Turf - Recommended Distributions and Point Estimates for Post-Application Hand-to-Mouth Exposure Factors

Algorithm Notation	Exposure Factor (units)		Distribution Type	Distribution Parameters	Point Estimate(s)
Fai_{hands}	Fraction of ai on hands from dermal transfer coefficient study (unitless)	Liquid formulations	Point Estimate	NA	
		Granular formulations	Point Estimate	NA	
DE	Dermal exposure calculated in Section 3.2.2 (mg)		Point Estimate	NA	
SA_H	Typical surface area of one toddler hand (cm^2)		Point Estimate	NA	225
AR	Application rate (mass active ingredient per unit area)		Point Estimate	NA	Maximum labeled rate
HR	Residue available on the hands (mg/cm^2)		Point Estimate	NA	
F_M	Fraction hand surface area mouthed (fraction/event)		Beta	$\alpha = 3.7$ $\beta = 25$	
N_Replen	Replenishment intervals per hour (intervals/hr)		Point Estimate	NA	4
ET	Exposure time (hrs/day)		Empirical	$50^{th} = 0.9$ $90^{th} = 3.5$	
SE	Saliva extraction factor (fraction)		Beta	$\alpha = 7.0$ $\beta = 7.6$	
Freq_Replen	Hand-to-mouth events per hour (events/hr)		Weibull	Scale= 0.55 Shape= 5.53	
BW	Body Weight (kg)	Toddlers	Empirical	Mean = 18.6 $95^{th} = 26.2$	

NA = not applicable
AM = arithmetic mean
S-/I-T = short- and intermediate-term exposure

Fraction Active Ingredient on the Hands ($F_{aihands}$)

The fraction of active ingredient available on the hands was based on the turf dermal transfer coefficient study (D. Klonne and D. Johnson, MRID 47292001). These values were determined for liquids and granules by taking the average fraction of active ingredient on the hands and comparing that value to the average fraction of active ingredient on the entire body. This analysis resulted in values of 3.2% for liquids and 2.4% for granules.

Hand Residue Loading (HR)

Link hand loading to dermal exposure and assume the percent on the hands is equal to the percent of the residue on the hands from dermal transfer coefficient studies.

Examples:

Application rate: 0.87 lb ai/A for liquids and 0.65 lbs ai/A for granules
Dermal exposure for toddler on turf (liquid formulation; calculated): 6.36 mg
Dermal exposure for toddler on turf (granular formulation; calculated): 0.46 mg
Assume surface area of one toddler hand = 225 cm^2

Fraction of active ingredient on the hands compared to the active ingredient on the entire body (from Moses Lake dermal turf transfer coefficient study):

Liquid: 0.032

Granular: 0.024

Turf (liquid formulation) HR = (0.032 * 6.4 mg) / 2 = 0.102 mg/hand / 225 cm^2/hand = 0.00046 mg/cm^2

Turf (granular formulation) HR = (0.024 * 0.46 mg) / 2 = 0.0056 mg/hand / 225 cm^2/hand = 0.000025 mg/cm^2

Fraction Hand Surface Area Mouthed (F_M)

See *Section 2.4* of this SOP for discussion of the fraction of hand surface area mouthed distribution. **The recommended point estimate for use in post-application hand-to-mouth exposure assessment [XX] cm^2 represents approximately the [XX]th percentile.**

Hand Surface Area (SA_H)

The hand surface area for toddlers (3 to <6 year olds) of 225 cm^2, for one hand, was based on values from the Child-specific Exposure Factors Handbook (U.S. EPA, 2008).

Exposure Time (ET)

See discussion of exposure time in *Section 3.2.2* above. **The recommended point estimates for use in post-application dermal exposure assessment for adults and children [XX] and [XX] hrs/day represent approximately the [XX]th and [XX]th percentiles, respectively.**

Replenishment Intervals per Hour (N_Replen)

This SOP assumes an estimate of 4 replenishment intervals per hour (i.e., residues on the hand will be replenished every 15 minutes). This value was selected as a conservative assumption based on the use of 30 minutes in the SHEDS model to coincide with the Consolidated Human Activity Database (CHAD) diaries.

Fraction of Pesticide Extracted by Saliva (SE_H)

See section 2.6 of this SOP for discussion of fraction of pesticide extracted by saliva distribution. **The recommended point estimate for use in post-application hand-to-mouth exposure assessment [XX] represents approximately the [XX]th percentile.**

Hand-to-Mouth Events per Hour (Freq_Replen)

Frequency of hand-to-mouth events is an important variable for hand-to-mouth post-application exposure assessments. The estimates for frequency of hand-to-mouth events in outdoor environments are based on the Xue et al. (2007) meta-analysis. The turf SOP utilizes hand-to-mouth frequency data for the 3 to <6 year old age grouping to represent toddlers. The estimates of hand mouthing frequency (events/hour) for 3 to <6 year olds were derived from 4 studies representing 55 participants. Based on an analysis of the data by Xue et al., it was determined that a Weibull distribution best fits the observed data. *Table 3-8* provides distributions and point estimates of hand to mouth events for use in residential pesticide exposure assessment. **The recommended point estimate for use in post-application hand-to-mouth exposure assessment [XX] events/hr represents approximately the [XX]th percentile.**

Table 3-8: Frequency of Hand-to-Mouth Events (events/hour)	
Statistic	**3 to <6 year olds**
50th percentile	5.6
75th percentile	11.0
95th percentile	36
AM (SD)	8.5 (10.7)
Range	0 - 48.9
N	55
AM (SD) = arithmetic mean (standard deviation)	

Future Research/Data Needs

Unavailable information that would refine post-application hand-to-mouth exposure assessments for pesticide applications to turf include:

- Application intervals (i.e., how often chemicals are applied to turf) – either chemical-specific or generic intervals by pesticide-type (e.g., fungicides, insecticides, etc.)
- Survey information (preferably longitudinal) detailing:
    - General pesticide use to obtain, on a per capita basis, the probability of treating turf with pesticides;
    - Product-specific application rates to obtain the likelihood that the maximum rate is used; and,
    - Daily activity patterns specific to hand-to-mouth activities on turf (e.g., replenishment interval, hand-to-surface contacts).

Exposure Characterization and Data Quality

Turf Transferable Residue

- Absent chemical-specific data, estimates of turf transferable residue factors such as the amount available following application and dissipation are used generically based on existing data for a wide variety of chemicals. Use of the data generically, including using high-end estimates, may overestimate for some chemicals.
- Assessors should recognize that factors such as rainfall/irrigation, grass growth, and grass mowing can greatly impact the dissipation rate of pesticides on turf.

Exposure Time

- The extent to which the amount of time spent conducting certain activities varies over a long-term extended period of time is unknown; therefore, the assumption that there is no variation when assessing longer-term exposure times is considered conservative.

Fraction of Pesticide Extracted by Saliva

- There is limited data with which to determine the fraction of pesticide extracted by saliva from the hand. Use of this data are considered reasonable, but does add additional uncertainty.

3.2.4 Post-application Non-Dietary Ingestion Exposure Assessment: Object-to-Mouth

This SOP provides a standard method for estimating the dose from incidental ingestion of pesticide residues from previously treated turf. Considering the strengths and limitations of available data and behavioral characteristics of potentially exposed populations, exposure for toddlers is calculated in this scenario. It assumes that pesticide residues are transferred to a child's toy and are subsequently ingested as a result of object-to-mouth transfer. It does not include residues ingested as a result of soil ingestion (*see Section 3.2.5*).

Post-application Object-to-Mouth Exposure Algorithm

Exposure from object-to-mouth activity is calculated as follows (based on algorithm utilized in SHEDS-Multimedia, http://www.epa.gov/heasd/products/sheds_multimedia/sheds_mm.html):

$$E = [OR * CF1 * SAM_O * (ET * N\_Replen) * (1 - (1 - SE_O)^{(Freq\_Replen/N\_Replen)})] \qquad (3.9)$$

where:

E	= exposure (mg/day);
OR	= chemical residue loading on the object on day "t" (ug/cm^2);
CF1	= weight unit conversion factor (0.001 mg/µg);
SAM_O	= area of the object surface that is mouthed (cm^2/event);
ET	= exposure time (hr/day);
N_Replen	= number of replenishment intervals per hour (intervals/hour);
SE	= saliva extraction factor (ie, mouthing removal efficiency); and
Freq_Replen	= number of object-to-mouth contact events per hour (events/hour).

and

$$OR = AR * F_O * CF2 * CF3 \qquad (3.10)$$

where:

OR	= chemical residue loading on the object (µg/cm^2);
AR	= application rate (lbs ai/ft^2 or lb ai/acre);
F_O	= fraction of residue available on the object (unitless);
CF2	= weight unit conversion factor (4.54 x 10^8 µg/lb); and
CF3	= area unit conversion factor (1.08 x 10^{-3} ft^2/cm^2 or 2.47 x 10^{-8} acre/cm^2).

and

Dose, normalized to body weight, is calculated as:

$$D = \frac{E}{BW} \qquad (3.11)$$

where:

D	=	dose (mg/kg-day);
E	=	exposure (mg/day); and
BW	=	body weight (kg).

Post-application object-to-mouth exposure following applications to lawns and turf is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Object-to-Mouth Algorithm Inputs and Assumptions

Recommended values for post-application object-to-mouth exposure assessments are provided in *Table 3-9*. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 3-9: Turf - Recommended Distributions and Point Estimates for Post-Application Object-to-Mouth Exposure Factors

Algorithm Notation	**Exposure Factor (units)**	**Distribution**		**Point Estimate(s)**
		Type	**Parameters**	
AR	Application rate (to turf) (mass active ingredient per unit area)	Point Estimate	NA	Maximum labeled rate
F_O	Fraction of AR as OR following application [1]	Point Estimate	NA	
SAM_O	Surface area of object mouthed (cm^2/event)	Exponential	Min = 1 Max = 50 AM = 10	
N_Replen	Replenishment intervals per hour (intervals/hour)	Point Estimate	NA	4
SE_O	Saliva extraction factor (fraction)	Beta	α = 7.0 β = 7.6	
ET	Exposure time (hours per day)	Empirical	50^{th} = 0.9 90^{th} = 3.5	
Freq_Replen	Object-to-mouth events per hour (events/hr)	Weibull	Scale= 0.55 Shape= 5.38	
BW	Body Weight (kg) — Toddlers (3 to <6 years old)	Empirical	Mean = 18.6 95^{th} = 26.2	

[1] This SOP assumes that all of the residue on the turf could be transferred to the object (e.g., object residue is equal to turf transferable residue).
NA = not applicable

Table 3-9: Turf - Recommended Distributions and Point Estimates for Post-Application Object-to-Mouth Exposure Factors
Min = minimum Max = maximum AM = arithmetic mean

Fraction of Residue Available on the Object (F_O)

Following an application, some pesticide residue remains on turf. Some of this residue may be transferred to a child's toy and subsequently ingested via object-to-mouth activities. For this SOP, it is assumed that the residue that could be transferred to the object is the same as what is available for dermal transfer. As a result, the fraction of active ingredient residue available for transfer using the turf transferable residue data (see discussion above in *Section 3.2.2* for more detail) should be used as a conservative estimate for the fraction of residue available on the object. **Based on the available liquid TTR data, the recommended point estimate for use in post-application object-to-mouth exposure assessment [XX] represents approximately the [XX]th percentile.**

Surface Area of Object Mouthed (SAM_O)

See *Section 2.5* of this SOP for discussion of surface area of object mouthed. **The recommended point estimate for use in post-application object-to-mouth exposure assessment [XX] cm^2 represents approximately the [XX]th percentile.**

See discussion of exposure time in *Section 3.2.2* above. **The recommended point estimates for use in post-application dermal exposure assessment for adults and children [XX] and [XX] hrs/day represent approximately the [XX]th and [XX]th percentiles, respectively.**

Replenishment Intervals per Hour (N_Replen)

This SOP assumes an estimate of 4 replenishment intervals per hour (i.e., residues on the hand will be replenished every 15 minutes). This value was selected as a conservative assumption based on the use of 30 minutes in the SHEDS model to coincide with the CHAD diaries.

Fraction of Pesticide Extracted by Saliva (SE_O)

See *Section 2.6* of this SOP for discussion of fraction of pesticide extracted by saliva distribution. **The recommended point estimate for use in post-application object-to-mouth exposure assessment [XX] represents approximately the [XX]th percentile.**

Object-to-Mouth Events per Hour (Freq_Replen)

Frequency of object-to-mouth events is an important variable for object-to-mouth post-application exposure assessments. The estimates for frequency of object-to-mouth events in outdoor environments are based on the Xue et al. (accepted for publication) meta-analysis. The turf SOP utilizes object-to-mouth frequency data for the 3 to <6 year old age grouping to represent toddlers. The estimates of object mouthing frequency (events/hour) for 3 to <6 year olds were derived from 3 studies representing 53 participants. Based on an analysis of the data by Xue et al. (in press), it was determined that a Weibull distribution best fits the observed data. *Table 3-10* provides distributions and point estimates of hand to mouth events for use in residential pesticide exposure assessment. **Based on this analysis, the recommended point**

estimate for use in post-application object-to-mouth exposure assessment [XX] events/hr represents approximately the [XX]th percentile.

Table 3-10: Frequency of Object-to-Mouth Events (events/hour)	
Statistic	**3 to <6 year olds**
50th percentile	5.0
75th percentile	10.6
95th percentile	30.3
AM (SD)	8.3 (12.4)
Range	0 - 70
N	53
AM (SD) = arithmetic mean (standard deviation)	

Future Research/Data Needs

Unavailable information that would refine post-application object-to-mouth exposure assessments for pesticide applications to turf include:

- Application intervals (i.e., how often chemicals are applied to turf) – either chemical-specific or generic intervals by pesticide-type (e.g., fungicides, insecticides, etc.)
- Survey information (preferably longitudinal) detailing:
  - General pesticide use to obtain, on a per capita basis, the probability of treating turf with pesticides;
  - Product-specific application rates to obtain the likelihood that the maximum rate is used; and,
  - Daily activity patterns specific to object-to-mouth activities on turf (e.g., typical surface area of object that is mouthed).
- Data on the amount of residue transferred from treated turf to both hard and soft children's toys.

Exposure Characterization and Data Quality

Turf Transferable Residue

- The assumption that the entire available turf transferable residue is transferred to the object should be considered very conservative.
- Absent chemical-specific data, estimates of turf transferable residue factors such as the amount available following application and dissipation are used generically based on existing data for a wide variety of chemicals. Use of the data generically, including using high-end estimates, may overestimate for some chemicals.
- Assessors should recognize that factors such as rainfall/irrigation, grass growth, and grass mowing can greatly impact the dissipation rate of pesticides.

Exposure Time

- The extent to which the amount of time spent conducting certain activities varies over a long-term extended period of time is unknown; therefore, the assumption that there is no variation when assessing longer-term exposure times is considered conservative.

Fraction of Pesticide Extracted by Saliva

- There is no data with which to determine the fraction of pesticide extracted by saliva from an object. Use of the saliva extraction data for hands is considered a reasonable surrogate, but does add additional uncertainty.

3.2.5 Post-application Non-Dietary Ingestion Exposure Assessment: Incidental Soil Ingestion

This SOP provides a standard method for estimating dose from incidental ingestion of soil containing pesticide residues. Considering the strengths and limitations of available data and behavioral characteristics of potentially exposed populations, exposure for toddlers is calculated in this scenario. It assumes that pesticide residues in soil are ingested by toddlers who play on treated areas (e.g., lawns, gardens, playgrounds) as a result of normal mouthing activities (i.e., these estimates do not represent exposure among toddlers who exhibit pica, an abnormal ingestion behavior).

Post-application Incidental Soil Ingestion Exposure Algorithm

Exposure from incidental soil ingestion is calculated as follows:

$$E = SR_t * SIgR * CF1 \quad (3.12)$$

where:

- E = exposure (mg/day);
- SR_t = soil residue on day "t" (µg/g);
- $SIgR$ = ingestion rate of soil (mg/day); and
- $CF1$ = weight unit conversion factor (1×10^{-6} g/µg).

and

$$SR_t = AR * FS * (1-F_D)^t * CF2 * CF3 * CF4 \quad (3.13)$$

where:

- SRt = soil residue on day "t" (µg/g);
- AR = application rate (lbs ai/ft^2 or lb ai/acre);
- FS = fraction of ai available in uppermost cm of soil (fraction/cm);
- F_D = fraction of residue that dissipates daily (unitless);
- t = post-application day on which exposure is being assessed;
- $CF2$ = weight unit conversion factor (4.54×10^8 µg/lb);
- $CF3$ = area unit conversion factor (1.08×10^{-3} ft^2/cm^2 or 2.47×10^{-8} $acre/cm^2$); and
- $CF4$ = soil volume to weight unit conversion factor (0.67 cm^3/g soil).

Dose, normalized to body weight, are calculated as:

$$D = \frac{E}{BW} \tag{3.14}$$

where:

D	=	dose (mg/kg-day);
E	=	exposure (mg/day); and
BW	=	body weight (kg).

Post-application soil ingestion exposure following applications to lawns and turf is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Incidental Soil Ingestion Algorithm Inputs and Assumptions

Recommended values for post-application incidental soil ingestion exposure assessments are provided in *Table 3-11*. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions, ii) data sources used to derive recommended input values, and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 3-11: Turf - Recommended Distributions and Point Estimates for Post-Application Incidental Soil Ingestion Exposure Factors

Algorithm Notation	Exposure Factor (units)		Distribution		Point Estimate(s)
			Type	Parameters	
AR	Application rate (mass active ingredient per unit area)		Point Estimate	NA	Maximum labeled rate
FS	Fraction of AR available in uppermost 1 cm of soil (unitless)		Point Estimate	NA	100
SIgR	Soil ingestion rate (mg/day)		Point Estimate	NA	100
BW	Body weight (kg)	Toddlers	Empirical	Mean = 18.6 95^{th} = 26.2	
NA = not applicable					

Fraction of Residue Available in Soil (FS)

On the day of application, the Agency assumes a conservative assumption that 100 percent of the application rate is located within the soil's uppermost 1 cm.

Dissipation (F_D)

Post-application exposures must be assessed on the same day the pesticide is applied because it is assumed that individuals could be exposed to turfgrass and soil immediately after application. Therefore, post-application exposures are based on residues found on the day of application (i.e., referred to as day 0). For subsequent days after application, an assumed pesticide soil dissipation rate should be used, based on chemical-specific data.

Soil Ingestion Rate (SIgR)

The assumed soil ingestion rate for children (ages 1-6 years) is 100 mg/day. This is the central tendency value for ingestion rate of soil and outdoor settled dust recommended in Table 5-1 of the Child-Specific Exposure Factors Handbook (USEPA, 2008) for use in exposure/risk assessments.

The selected soil ingestion rate was estimated from research that studied children's soil ingestion behavior for short periods of time. These studies were typically conducted during the summer months and thus the central tendency soil ingestion rate should not be considered typical of year round soil intake. If longer term assessments of soil ingestion are deemed necessary for a specific chemical, then the ingestion rate of 100 mg/day should be considered a very high end assumption.

Soil Density

A standard soil density of 0.67 cm^3/g is used.

Future Research/Data Needs

Unavailable information that would refine post-application exposure assessments for pesticide applications to turf include:

- Application intervals (i.e., how often chemicals are applied to turf) – either chemical-specific or generic intervals by pesticide-type (e.g., fungicides, insecticides, etc.)
- Data could be produced to examine the potential for a range of pesticides to stay in the uppermost 1 cm of soil over a period of time.

Exposure Characterization and Data Quality

Soil Residue

- The uncertainties associated with this assessment stem from the use of an assumed amount of pesticide available in the uppermost 1 cm of soil, and assumptions regarding dissipation of chemical residues in the soil and soil ingestion. The estimated doses are should be considered high-end, conservative estimates.

3.2.6 Post-application Non-Dietary Ingestion Exposure Assessment: Episodic Granular Ingestion

This SOP provides a standard method for estimating post-application doses from incidental ingestion of pesticide pellets and granules that have been applied to lawns and gardens when adequate site-or chemical-specific field data are unavailable. Considering the strengths and limitations of available data and behavioral characteristics of potentially exposed populations, exposure for toddlers is calculated in this scenario. This scenario assumes that dry pesticide materials are ingested by toddlers who play in treated areas (e.g., lawns, gardens, playgrounds).

Post-application Episodic Granular Ingestion Exposure Algorithm

Exposure from incidental ingestion of pesticide pellets or granules is calculated as follows:

$$E = GIgR * FD * CF1 \quad (3.155)$$

where:

E	=	exposure (mg/day);
GIgR	=	ingestion rate of dry pesticide formulation (g/day);
FD	=	fraction of ai in dry formulation (unitless); and
CF1	=	weight unit conversion factor (1,000 mg/g).

Oral potential dose rates, normalized to body weight, are calculated as:

$$D = \frac{E}{BW} \quad (3.16)$$

where:

D	=	dose (mg/kg-day);
E	=	exposure (mg/day); and
BW	=	body weight (kg).

Post-application granular pesticide exposure following applications to lawns and turf would not occur as a result of routine behavior and is considered an acute exposure event related to poisoning. Thus, longer-term assessments are not conducted.

Post-application Episodic Granular Ingestion Algorithm Inputs and Assumptions

Recommended values for post-application episodic granular ingestion exposure assessments are provided in *Table 3-12*. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 3-12: Turf - Recommended Distributions and Point Estimates for Post-Application Episodic Granular Ingestion Exposure Factors

Algorithm Notation	Exposure Factor (units)		Distribution		Point Estimate(s)
			Type	Parameters	
FD	Fraction of active ingredient in dry formulation		Point Estimate	NA	Product specific
GIgR	Granule ingestion rate per day (g/day) [1]		Point Estimate	NA	0.3
BW	Body Weight (kg)	Toddlers	Empirical	Mean = 18.6 95^{th} = 26.2	
NA = not applicable					

Table 3-12: Turf - Recommended Distributions and Point Estimates for Post-Application Episodic Granular Ingestion Exposure Factors
[1] See discussion below on how this value may be adjusted if product specific information is available.

Fraction of Active Ingredient in the Dry Formulation (FD)

The fraction of active ingredient in the dry formulation should be determined by consulting the product label(s). In all cases, the formulation with the highest amount of active ingredient should be used to assess episodic granular ingestion.

Granular Product Application Rate (AR)

The amount of granule product applied per area of lawn should be indicated by the product label. The combination of this factor with the fraction of active ingredient in the product yields the application rate in terms of active ingredient per area.

Granular Ingestion Rate (GIgR)

The assumed ingestion rate for dry pesticide formulations (e.g., pellets and granules) is 0.3 gram/day for children (age 3 years). It is assumed that if 150 pounds of product were to be applied to a ½ acre lawn, the amount of product per square foot would be approximately 3 g/ft^2 and a child would consume one-tenth of the product available in a square foot.

If product specific information is available, the granular ingestion rate may be adjusted to reflect the amount of product applied on a per area basis if it is less or more than 150 pounds to a ½ acre lawn. For instance, if 50 pounds of product is meant to treat a ½ acre lawn, then the ingestion rate should be reduced by a third to 0.1 grams/day.

Future Research/Data Needs

There are currently no data needs for the episodic granular ingestion scenario.

Exposure Characterization and Data Quality

Exposure assessments addressing non-dietary ingestion of granules should indicate this is considered to be an episodic event, and should be addressed as a single scenario (i.e., the exposure should not be combined with any other sources of exposure to the pesticide). Granule size, granular color, particle density, and instructions such as "soil incorporate" should also be considered.

An alternative assessment methodology for episodic granular ingestion can be done which examines the amount of granular product that a child could eat before any adverse effects occur. This alternative methodology can be used as characterization in support of the episodic granular ingestion assessment methodology discussed above.

3.2.7 Post-application Dermal Exposure Assessment: Mowing

This SOP provides a method for estimating potential dermal doses from contact with turf that has previously been treated with pesticides. Considering the strengths and limitations of available data and behavioral characteristics of potentially exposed populations, exposure for adults and teens is calculated in this scenario. This scenario assumes that pesticide residues are transferred to the skin of adults and teens that enter treated lawns for mowing.

It is assumed that individuals can be mowing previously treated turf on the same day a pesticide is applied. However, the assessment can be refined to more accurately reflect exposure over a longer period of time (e.g., a week or month) if usage and activity information is available to allow for such calculations.

Post-application Dermal Exposure Algorithm – Mowing

Exposure resulting from contacting previously treated turf while mowing is calculated as follows:

$$E = TTR_t * CF1 * TC * ET \tag{3.17}$$

where:

- E = exposure (mg/day);
- TTR_t = turf transferable residue on day "t" (μg/cm^2);
- $CF1$ = weight unit conversion factor (0.001 mg/μg);
- TC = transfer coefficient (cm^2/hr); and
- ET = exposure time (hr/day).

and

$$TTR_t = AR * F * (1-F_D)^t * CF2 * CF3 \tag{3.18}$$

where:

- TTR_t = turf transferable residue on day "t" (μg/cm^2);
- AR = application rate (lbs ai/ft^2 or lb ai/acre);
- F = fraction of ai retained on turf (unitless);
- F_D = fraction of residue that dissipates daily (unitless);
- t = post-application day on which exposure is being assessed;
- $CF2$ = weight unit conversion factor (4.54 x 10^8 μg/lb); and
- $CF3$ = area unit conversion factor (1.08 x 10^{-3} ft^2/cm^2 or 2.47 x 10^{-8} acre/cm^2).

Dose, normalized to body weight, are calculated as:

$$D = \frac{E * AF}{BW} \tag{3.19}$$

where:

- D = dose (mg/kg-day);
- E = exposure (mg/day);
- AF = absorption factor (dermal); and
- BW = body weight (kg).

Post-application dermal exposure while mowing following applications to lawns and turf is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Dermal Exposure Algorithm Inputs and Assumptions - Mowing

Recommended values for post-application dermal mowing exposure assessments are provided in *Table 3-13*. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 3-13: Turf (Mowing) - Recommended Distributions and Point Estimates for Post-Application Dermal Exposure Factors

Algorithm Notation	Exposure Factor (units)		Distribution Type	Distribution Parameters	Point Estimate(s)
AR	Application rate mass active ingredient per unit area		Point Estimate	NA	Maximum labeled rate
F_{AR}	Fraction of AR as TTR following application	L/WP/WDG	Point Estimate	NA	
		Granules	Point Estimate	NA	
F_D	Daily residue dissipation	L/WP/WDG	Point Estimate	NA	
		Granules	Point Estimate	NA	
TC	Transfer Coefficient (cm^2/hr)	Adult	Lognormal	GM = 2,700 GSD = 3.5	
		Teens	Lognormal	GM = 2,300 GSD = 3.5	
ET	Exposure time (hours per day)		Point Estimate	NA	
BW	Body Weight (kg)	Adults	Empirical	Mean = 71.8 95^{th} = 97.9	
		Teens	Empirical	Mean = 56.8 95^{th} = 88.8	

NA = not applicable
GM = geometric mean
GSD = geometric standard deviation
L/WP/WDG = liquid/wettable powder/water dispersible granule

Turf Transferable Residue (TTR)

Following an application, some pesticide residue remains on turf for an individual to contact and remove. This is referred to as turf transferable residue (TTR) and is assumed to be the most significant source for dermal exposure in this scenario. TTR values for this scenario can be obtained directly from chemical-specific data or can be calculated from the maximum labeled turf application rate. Use of chemical specific TTR measurements are preferred if available and these should be used in all cases unless warranted by the quality of the study.

Chemical-specific data
When chemical-specific data are available, the TTR is the surface residue on Day 0 which assumes an individual could be exposed to residues immediately after application.

Calculating from Application Rate
When the application rate is in terms of mass active ingredient per area (e.g., lbs ai/ft^2 or lb ai/acre), the total deposited residue is assumed to be equivalent to the application rate.

Fraction of Active Ingredient Residue Available For Transfer (F_{AR})
If chemical specific TTR measurements are not available; then it is necessary to use a generic value for the fraction of active ingredient available for transfer. For the purpose of this SOP, 59 studies that collected turf transferable residues using the Modified California Roller Method (36 studies using liquids, 11 studies using wettable powders/water dispersible granules, and 12 studies using granules) were analyzed. Only TTR data collected with the Modified California Roller Method were used because this was the turf residue collection method agreed upon by the Agency in the 1995 Turf DCI (USEPA, 1995). The transfer coefficient study for mowing also utilized the Modified California Roller Method to collect TTR. During the analysis of these studies, it was determined that there was no statistical difference between residues resulting from liquid, wettable powder (applied as a spray), or water dispersible granular (applied as a spray) applications; as a result, these data have been combined into one distribution (See *Appendix C.6.1*). Granular data have been kept separate. *Table 3-14* provides some summary statistical information about the fraction of active ingredient available for transfer distribution.

Table 3-14: Fraction of the Application Rate Available from Turfgrass as Transferable Residue when Various Formulations of Pesticides are Applied

Statistic	Liquids/WPs/WDGs	Granules
50th percentile	0.0050	0.00050
75th percentile	0.011	0.0018
95th percentile	0.035	0.012
99th percentile	0.080	0.045
AM (SD)	0.0086 (0.0094)	0.0017 (0.0021)
GM (GSD)	0.0051 (3.6)	0.00050 (6.9)
Range	0.000005–0.061	0.0000064–0.0069
N	131	37

AM (SD) = arithmetic mean (standard deviation)
GM (GSD) = geometric mean (geometric standard deviation)

Note that these distributions are only meant as a basis for selecting a generic estimate for the TTR on the day of application as a fraction of the application rate and they are inappropriate to use probabilistically. Because the data are comprised of a variety of chemicals under a variety of conditions, this distribution represents the variability associated with varying chemicals and situations. Within each particular TTR study, the distribution of the TTR on the day of application as a fraction of the application rate is much less variable; for a given chemical the range may be only 0.5 – 0.7%; not the 0.00005 – 6.1% range associated with the entire multi-chemical data set. Furthermore, because the chemical-specific variability of this input is small, a distribution for use probabilistically is unnecessary (i.e., it will not have much effect on the outcome) and a point estimate is appropriate for use in both deterministic and probabilistic assessments.

For liquid applications (including wettable powders/water dispersible granules applied as sprays, the recommended point estimate for use in post-application dermal exposure assessment [XX] represents approximately the [XX]th percentile. For granular applications, the recommended point estimate for use in post-application dermal exposure assessment [XX] represents approximately the [XX]th percentile.

Dissipation (F_D)

Post-application exposures must be assessed on the same day the pesticide is applied because it is assumed that individuals could be exposed to turfgrass immediately after application. Therefore, post-application exposures are based on residues found on the day of application (i.e., referred to as day 0). For subsequent days after application it is also important to calculate risks based on pesticide dissipation rates because of possible concerns over longer term exposures (i.e., using an amortized dose) and possible re-treatment intervals. If no chemical specific TTR data are available, then a 10 percent dissipation rate per day should be assumed.

Transfer Coefficient (TC)

The transfer coefficients used for the "mower" dermal scenarios were derived from data collected during a golf course maintenance study (Klonne and Bruce, 2005). It was gathered while human volunteers mowed greens with a walk behind mower (8 participants) and mowed fairways with a riding mower (8 participants) on a golf course. The walk-behind mower activity consisted of mowing using a walk-behind reel mower with a grass catcher, emptying the grass catcher, and hosing off the mower with water at the conclusion of mowing. Greens mowing occurred in the morning and a monitoring replicate consisted of mowing 4 to 5 greens (approximately 2 to 3 hours). The riding mower activity consisted of mowing fairways (using a 5-reel riding mower), mowing tee boxes/surrounds (using a 3-reel riding mower), emptying the grass catcher, and hosing off the mower with water at the conclusion of mowing. Fairway mowing occurred in the morning and a monitoring replicate consisted of mowing either 5 to 6 fairways or tees/surrounds for 9 holes (approximately 2 to 4.5 hours). Post-application exposure resulting from golf course mowing was deemed as an appropriate surrogate for residential homeowner mowing.

An analysis was performed to assess the statistical differences between the TCs calculated using the walk-behind mower data vs. the riding mower data. It was determined that there was no statistical difference between these datasets and thus, in calculating the adult dermal "mower" transfer coefficient the data were combined (*See Appendix C.7.1*). For youths/teens, the transfer coefficient is adjusted for body surface area using a factor of 0.87 (i.e., a 13% reduction in the TC) as outlined in Section 2.3. *Table 3-15* provides some summary statistical information about the turf dermal transfer coefficient distribution.

The recommended point estimate for use in post-application adult dermal exposure assessment [XX] cm^2/hr represents approximately the $[XX]^{th}$ percentile and the recommended point estimate for use in post-application teen dermal exposure assessment [XX] cm^2/hr represents approximately the $[XX]^{th}$ percentile.

Table 3-15: Dermal Exposure Transfer Coefficients (T-shirt and Shorts) for Individuals Performing Mowing Activities

Statistic	Adult Transfer Coefficient (cm^2/hr)	Teen Transfer Coefficient (cm^2/hr) [1]
50^{th} percentile	2,700	2,300
75^{th} percentile	6,300	5,600
95^{th} percentile	22,000	19,000
99^{th} percentile	54,000	47,000
AM (SD)	5,500 (7,300)	4,800 (NA)
GM (GSD)	2,700 (3.5)	2,300 (NA)
Range	319–25,860	NA
N	16	NA

[1] A 13% reduction in the adult transfer coefficient is recommended to account for the differences of body surface areas between adults and youths/teens (11 to <16 years old).
AM (SD) = arithmetic mean (standard deviation)
GM (GSD) = geometric mean (geometric standard deviation)

Exposure Time (ET)

Another important variable for addressing post-application exposure from treated turf is the duration of time spent mowing. No microactivity data were available that specifically examined the amount of time a person spends mowing their home lawn; however the Bureau of Labor Statistics American Time Use Survey from 2007 (ATUS) examined the number of hours per day a person performs lawn and garden care activities around their home. **Based on these data, the recommended point estimate for use in post-application dermal exposure assessment [XX] hours/day represents approximately the $[XX]^{th}$ percentile.**

Future Research/Data Needs

Unavailable information that would refine post-application mowing exposure assessments for pesticide applications to turf include:

- Application intervals (i.e., how often chemicals are applied to turf) – either chemical-specific or generic intervals by pesticide-type (e.g., fungicides, insecticides, etc.)
- Survey information (preferably longitudinal) detailing:
    - General pesticide use to obtain, on a per capita basis, the probability of treating turf with pesticides;
    - Product-specific application rates to obtain the likelihood that the maximum rate is used; and,
    - Daily activity patterns specific to the typical amount of time a person spends mowing their home lawn.

Exposure Characterization and Data Quality

Transfer Coefficient

- The use of the mowing component from a golf course maintenance study as a surrogate for residential homeowner mowing is likely to be reasonably representative of the exposures related to residential mowing activities. OPP believes that residential mower's highest exposures are most likely to occur when clippings are removed by hand from collection bags for disposal and this activity was represented in the mowing activity of the golf course maintenance study.

Turf Transferable Residue

- The Modified California Roller Method was used in the selected turf dermal transfer coefficient study to collect TTR. This TTR collection method was agreed upon by the ORETF, CDPR, PMRA, and the Agency. For all assessments, transfer coefficients from this study should only be used with TTR studies that utilize the Modified California Roller Method. If chemical specific TTR data collected via the Modified California Roller Method are not available, then default TTR data should be used.
- Absent chemical-specific data, estimates of turf transferable residue factors such as the amount available following application and dissipation are used generically based on existing data for a wide variety of chemicals. Use of this data generically, including using high-end estimates, may overestimate for other chemicals.
- Assessors should recognize that mowing grass after an application may be limited by label directions indicating not to mow until a certain period of time has passed after application or else the product may not work.
- Assessors should recognize that real world factors such as rainfall/irrigation and grass growth can greatly impact the dissipation rate of pesticides on turf.

Exposure Time

- The extent to which the amount of time spent conducting certain activities varies over a long-term extended period of time is unknown; therefore, the assumption that there is no variation when assessing longer-term exposure times is considered conservative.

3.2.8 Post-application Dermal Exposure Assessment: Golfing

This SOP provides a standard method for estimating potential dermal doses from dermal contact with turf that has previously been treated with pesticides. Considering the strengths and limitations of available data and behavioral characteristics of potentially exposed populations, exposure for adults and teens is calculated in this scenario. This scenario assumes that pesticide residues are transferred to the skin of adults and teens that play golf on treated turf.

It is assumed that individuals can be golfing on previously treated turf on the same day a pesticide is applied. However, the assessment can be refined to more accurately reflect exposure over a longer period of time (e.g., a week or month) if toxicological or activity information is available to allow for such calculations.

Post-application Dermal Exposure Algorithm – Golfing

Exposure resulting from contacting previously treated turf while golfing is calculated as follows:

$$E = TTR_t * CF1 * TC * ET \quad (3.20)$$

where:

E = exposure (mg/day);
TTR_t = turf transferable residue on day "t" (µg/cm^2);
CF1 = weight unit conversion factor (0.001 mg/µg);
TC = transfer coefficient (cm^2/hr); and
ET = exposure time (hr/day).

and

$$TTR_t = AR * F * (1-F_D)^t * CF2 * CF3 \quad (3.21)$$

where:

TTR_t = turf transferable residue on day "t" (µg/cm^2);
AR = application rate (lbs ai/ft^2 or lb ai/acre);
F = fraction of ai retained on turf (unitless)'
F_D = fraction of residue that dissipates daily (unitless);
t = post-application day on which exposure is being assessed;
CF2 = weight unit conversion factor (4.54 x 10^8 µg/lb); and
CF3 = area unit conversion factor (1.08 x 10^{-3} ft^2/cm^2 or 2.47 x 10^{-8} acre/cm^2).

Dose, normalized to body weight, is calculated as:

$$D = \frac{E * AF}{BW} \quad (3.22)$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal); and
BW = body weight (kg).

Post-application dermal exposure while golfing following applications to golf course turf is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Dermal Exposure Algorithm Inputs and Assumptions - Golfing

Recommended values for post-application dermal golfing exposure assessments are provided in *Table 3-16*. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 3-16: Turf (Golfing) - Recommended Distributions and Point Estimates for Post-Application Dermal Exposure Factors

Algorithm Notation	Exposure Factor (units)		Distribution		Point Estimate(s)
			Type	Parameters	
AR	Application rate (mass active ingredient per unit area)		Point Estimate	NA	Maximum labeled rate
F	Fraction of AR as TTR following application	L/WP/WDG	Point Estimate	NA	
		Granules	Point Estimate	NA	
F_D	Daily residue dissipation	L/WP/WDG	Point Estimate	NA	
		Granules	Point Estimate	NA	
TC	Transfer Coefficient (cm^2/hr)	Adult	Lognormal	GM = 2,800 GSD = 3.30	
		Teens	Lognormal	GM = 2,400 GSD = 3.30	
ET	Exposure time (hours per day)	Pesticides used on greens, tees, and fairways	Point Estimate	NA	4
		Pesticides used only on greens and tees	Point Estimate	NA	1
BW	Body Weight (kg)	Adults	Empirical	Mean = 71.8 95^{th} = 97.9	
		Teens	Empirical	Mean = 56.8 95^{th} = 88.8	

NA = not applicable
GM = geometric mean
GSD = geometric standard deviation

Turf Transferable Residue (TTR)

Following an application, some pesticide residue remains on turf for an individual to contact and remove. This is referred to as turf transferable residue (TTR) and is assumed to be the most significant source for dermal exposure in this scenario. TTR values for this scenario can be obtained directly from chemical-specific data or can be calculated from the maximum labeled turf application rate. Use of chemical specific TTR measurements are preferred if available and these should be used in all cases unless warranted by the quality of the study.

<u>Chemical-specific data</u>

When chemical-specific data are available, the TTR is the surface residue on Day 0 which assumes an individual could be exposed to residues immediately after application.

Calculating from Application Rate

When the application rate is in terms of mass active ingredient per area (e.g., lbs ai/ft^2 or lb ai/acre), the total deposited residue is assumed to be equivalent to the application rate.

Fraction of Active Ingredient Residue Available For Transfer (F)

If chemical specific TTR measurements are not available; then it is necessary to use a generic value for the fraction of active ingredient available for transfer. For the purpose of this SOP, 59 studies that collected turf transferable residues using the Modified California Roller Method (36 studies using liquids, 11 studies using wettable powders/water dispersible granules, and 12 studies using granules) were analyzed. Only TTR data collected with the Modified California Roller Method were used because this was the turf residue collection method agreed upon by the Agency in the 1995 Turf DCI (USEPA, 1995). The transfer coefficient study for golfing also utilized the Modified California Roller Method to collect TTR. During the analysis of these studies, it was determined that there was no statistical difference between residues resulting from liquid, wettable powder (applied as a spray), or water dispersible granular (applied as a spray) applications; as a result, these data have been combined into one distribution (*See Appendix C.6.1*). Granular data have been kept separate. *Table 3-17* provides some summary statistical information about the fraction of active ingredient available for transfer distribution.

Note that these distributions are only meant as a basis for selecting a generic estimate for the TTR on the day of application as a fraction of the application rate and they are inappropriate to use probabilistically. Because the data are comprised of a variety of chemicals under a variety of conditions, this distribution represents the variability associated with varying chemicals and situations. Within each particular TTR study, the distribution of the TTR on the day of application as a fraction of the application rate is much less variable; for a given chemical the range may be only 0.5 – 0.7%; not the 0.00005 – 6.1% range associated with the entire multi-chemical data set. Furthermore, because the chemical-specific variability of this input is small, a distribution for use probabilistically is unnecessary (i.e., it will not have much effect on the outcome) and a point estimate is appropriate for use in both deterministic and probabilistic assessments.

For liquid applications (including wettable powders/water dispersible granules applied as sprays, the recommended point estimate for use in post-application dermal exposure assessment [XX] represents approximately the [XX]th percentile. For granular applications, the recommended point estimate for use in post-application dermal exposure assessment [XX] represents approximately the [XX]th percentile.

Table 3-17: Fraction of the Application Rate Available from Turfgrass as Transferable Residue when Various Formulations of Pesticides are Applied

Statistic	Liquids/WPs/WDGs	Granules
50th percentile	0.0050	0.00050
75th percentile	0.011	0.0018
95th percentile	0.035	0.012

99^{th} percentile	0.080	0.045
AM (SD)	0.0086 (0.0094)	0.0017 (0.0021)
GM (GSD)	0.0051 (3.6)	0.00050 (6.9)
Range	0.000005–0.061	0.0000064–0.0069
N	131	37
AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)		

Daily residue dissipation (F_D)

Post-application exposures must be assessed on the same day the pesticide is applied because it is assumed that individuals could be exposed to turfgrass immediately after application. Therefore, post-application exposures are based on residues found on the day of application (i.e., referred to as day 0). For subsequent days after application it is also important to calculate risks based on pesticide dissipation rates because of possible concerns over longer term exposures (i.e., using an amortized dose) and possible re-treatment intervals. If no chemical specific TTR data are available, then a 10 percent dissipation rate per day should be assumed.

Transfer Coefficient (TC)

A golfer exposure study was recently conducted by the University of Massachusetts (Putnam et al., 2008), which examined a number of pesticides typically used on golf courses. This study was reviewed by the Agency ethics officer and found to be not ethically acceptable for regulatory purposes.

Since the golfer exposure study was deemed unacceptable from an ethics standpoint, the transfer coefficients used for the "golfer" dermal scenarios were derived from data collected during a golf course maintenance study (Klonne and Bruce, 2005). Data were gathered while human volunteers moved cups on golf greens (6 participants). The cup changing activity consisted of making a new hole with a hand operated cup cutter, putting the plastic cup liner from the old hole into the new hole, filling the old hole with sand and the plug from the new hole. Some cup changers also repaired ball marks on the greens with a hand tool similar to those used by golfers. Cup changing occurred first thing in the morning and a monitoring replicate consisted of changing 18 cups. Most workers performed the cup changing while bending over and not contacting the turf with anything, but their shoes and hands; however, one worker routinely kneeled on one knee and two other workers kneeled for a few holes. OPP has fit a distribution from the 6 cup changing replicates to calculate a surrogate transfer coefficient for golfers (*See Appendix C.7.1*).

For youths/teens, the transfer coefficient is adjusted for body surface area using a factor of 0.87 (i.e., a 13% reduction in the TC) as outlined in Section 2.3. *Table 3-18* provides some summary statistical information about the turf dermal transfer coefficient distribution.

The recommended point estimate for use in post-application adult dermal exposure assessment [XX] cm^2/hr represents approximately the [XX]th percentile.

Table 3-18: Dermal Exposure Transfer Coefficients (T-shirt and Shorts) for Individuals Golfing		
Statistic	Adult Transfer Coefficient	Teen Transfer Coefficient

	(cm^2/hr)	(cm^2/hr) [1]
50th percentile	2,800	2,500
75th percentile	6,400	5,600
95th percentile	21,000	18,000
99th percentile	49,000	43,000
AM (SD)	5,300 (7,000)	4,700 (NA)
GM (GSD)	2,800 (3.3)	2,500 (NA)
Range	988–18,863	NA
N	6	NA

[1] A 13% reduction in the adult transfer coefficient is recommended to account for the differences of body surface areas between adults and youths/teens (11 to <16 years old).
AM (SD) = arithmetic mean (standard deviation)
GM (GSD) = geometric mean (geometric standard deviation)

Exposure Time (ET)

Another important variable for addressing post-application exposure from treated turf while golfing is the duration of time spent golfing. The duration is assumed to be 4 hours for a chemical that can be used on all parts of a golf course (greens, tees, and fairways). This estimate is the average time it takes to play a round of golf and is based on a report completed by the Center for Golf Course Management (1992).

It should also be noted that some chemicals are limited to use on greens and tees or are primarily used on just greens and tees for cultural reasons. When chemicals meet these criteria, the exposure time is 1 hour because contact time is proportionately lower with the treated area. If a chemical has a label restriction for greens and tees then a single exposure calculation should be completed for the 1 hour duration.

Future Research/Data Needs

Unavailable information that would refine post-application golfing exposure assessments for pesticide applications to turf include:

- Application intervals (i.e., how often chemicals are applied to turf) – either chemical-specific or generic intervals by pesticide-type (e.g., fungicides, insecticides, etc.)
- Survey information (preferably longitudinal) detailing:
  - General pesticide use to obtain, on a per capita basis, the probability of treating golf course turf with pesticides;
  - Product-specific application rates to obtain the likelihood that the maximum rate is used; and,
  - Daily activity patterns specific to the typical amount of time a person spends golfing.

Exposure Characterization and Data Quality

Risk assessments for children (< 11 years old) golfing are complex because of the increased uncertainties associated with extrapolation of adult dermal exposure data and because of the increased likelihood of other behaviors that might contribute to exposure, such as mouthing contaminated hands or golf balls. Therefore, the risk associated with children in a golfing scenario is addressed qualitatively below:

- Five-year-old children are assumed to be the age group for children in a golfing scenario since younger children are not believed to be a viable population for the purposes of assessing risk from a golfing scenario. The surface area to body weight ratio (SA/BW) for male children 5 years of age (i.e., the difference is larger for males compared to female making the value more protective) was calculated by using the 95th percentile for body surface area and the 50th percentile for body weight. The ratio was intentionally skewed to account for the uncertainties that would be expected with calculating dose levels for children if more definitive data were available, and for potential additional exposure that may occur from mouthing behaviors. This skewed SA/BW ratio for children was compared to that of the average adult, and found to be approximately 70 percent greater. Based on this parameter alone, the child's exposure could be almost twice that of the adult golfer; however, it should be noted that a child is not expected to use the golf course for the same length of time as an adult. While an adult is likely to play a full round of golf (i.e., 18 holes), which takes approximately 4 hours, a child would probably only spend about 2 hours (i.e., the 75th percentile for time spent playing on grass by children aged 1-4 years and 5-11 years) on the course. Thus, the child's shorter duration on the golf course offsets the higher SA/BW ratio, and therefore, the child golfer's exposure is likely to be similar to that of the adult golfer.

Transfer Coefficient

The use of the cup changing component from a golf course maintenance study is an acceptable surrogate for golfer exposure because it is assumed that a golfer's highest exposures are most likely to occur when contacting residues from turf on and around the greens and residues remaining on the golf ball. The actions associated with cup changing in the golf course maintenance study are similar to these golfer actions and as a result, the actions should result in similar exposures.

Turf Transferable Residue

- The Modified California Roller Method was used in the selected turf dermal transfer coefficient study to collect TTR. This TTR collection method was agreed upon by the ORETF, CDPR, PMRA, and the Agency. For all assessments, transfer coefficients from this study should only be used with TTR studies that utilize the Modified California Roller Method. If chemical specific TTR data collected via the Modified California Roller Method are not available, then default TTR data should be used.
- Absent chemical-specific data, estimates of turf transferable residue factors such as the amount available following application and dissipation are used generically based on existing data for a wide variety of chemicals. Use of the data generically, including using high-end estimates, may result in overestimates for some chemicals.
- Assessors should recognize that real world factors such as rainfall/irrigation, grass growth, and grass mowing can greatly impact the dissipation rate of pesticides on turf. Irrigation and mowing are of particular importance to the golfer scenario in that both of

these activities occur on almost a daily basis at most golf courses. Based on these factors, the golfer exposure scenario should be considered conservative in nature when compared to possible real world exposures.

Exposure Time

- The extent to which the amount of time spent conducting certain activities varies over a long-term extended period of time is unknown; therefore, the assumption that there is no variation when assessing longer-term exposure times is considered conservative.

3.2.9 Combining Post-application Scenarios

Risk estimates resulting from different exposure scenarios are combined when it is likely that they can occur simultaneously based on the use pattern and when the toxicological effects across different routes of exposure are the same (see *Section 1.3.5*). When combining scenarios, it is important to fully characterize the potential for co-occurrence as well as characterizing the risk inputs and estimates. Risk estimates should be combined even if any one scenario or route of exposure exceeds the level of concern because this allows for better risk characterization for risk managers. The following issues should be considered when combining scenarios for the residential turf SOP:

- There are a number of non-dietary ingestion exposure scenarios that could potentially be combined with the dermal exposure scenario. These non-dietary ingestion scenarios should be considered inter-related and it is likely that they occur interspersed amongst each other across time. For example a child may place his hand in his mouth X number of times as well as place an object in his mouth Y number of times during a certain period of time. Each of these events could result in a potential transfer of residue but could also result in a soil ingestion event as soil may be present on the hand or object during mouthing. The potential combinations of co-occurrence of the hand-to-mouth/object-to-mouth/soil ingestion scenarios across a particular period of time are limitless. Combining all three of these scenarios with the dermal exposure scenario would be overly-conservative because of the conservative nature of each individual assessment. Based on this discussion, the post-application exposure scenarios that should be combined for acute and short-term exposure durations are the dermal and hand-to-mouth scenarios. This combination should be considered a protective estimate of children's exposure to pesticides used on turf.

Section 4 Gardens and Trees

The procedures outlined in this section should be used to assess dermal and inhalation exposure during (i.e., handler) and following pesticide applications (i.e., post-application) to gardens and trees at home by professional pesticide applicators or homeowners themselves or at “pick-your-own” farms. This includes plants maintained indoors as well as potential post-application exposure from treated plants purchased at retail locations. It does not include dietary exposure resulting from fruits or vegetables treated with pesticides at home. For the purposes of this section a “pick-your-own” farm is a commercial farming operation that allows public access for harvesting fruits and vegetables or other commodities in large-scale fields treated with commercially labeled pesticides.

The following are example use sites from pesticide product labeling that would necessitate an assessment for this scenario:

- Gardens:
  - Flowers (e.g., chrysanthemums)
  - Fruits (e.g., strawberries)
  - Vegetables (e.g., tomatoes, squash, etc.)

- Trees:
  - Fruits (e.g., apples, citrus)
  - Nuts (e.g., pecans)
  - Shrubs (e.g., boxwood)
  - Ornamentals (e.g., maples)

The exposure assessor should assume use is permitted by the product label in residential settings unless a specific statement on the label indicates the product is not for use in residential settings. Examples include:

- Commercial or research greenhouse use only
- For nursery-grown ornamentals
- For use in commercial plantings only
- Not for use on residential sites
- Not for use in home gardens
- Not for use in and around homes or dwellings

Additionally, the “Restricted Use Pesticide” classification indicates that the product cannot be bought or applied by homeowners (i.e., no residential handler exposure/risk assessment required), but it may be applied by commercial applicators to residential sites; therefore, a post-application risk assessment may be required. However, statements such as "For use by commercial or professional applicators only" or “Not for homeowner use” are considered unenforceable statements and do not preclude use in residential settings. In these cases, therefore, both a residential handler and post-application exposure assessment is required.

Once scenarios are identified, the assessment should then characterize and estimate the potential for exposure by route (i.e., dermal, inhalation) using the methodologies outlined in this section.

4.1 Handler Exposure Assessment

Handler exposure can result from treating home gardens and trees with pesticides. Some key assumptions for these assessments include:

- Adults are considered the sentinel population for this scenario as it is assumed that pesticides are applied by adults only (i.e., individuals above 18 years old).
- All application equipments and methods are assumed feasible unless prohibited by the product label.

Dermal and Inhalation Handler Exposure Algorithm

As described in *Section 1.3.3*, daily dermal and inhalation exposure (mg/day) for residential pesticide handlers, for a given formulation-application method combination, is estimated by multiplying the formulation-application method-specific unit exposure by an estimate of the amount of active ingredient handled in a day, using the equation below:

$$E = UE * AR * A \tag{4.1}$$

where:

E = exposure (mg/day);
UE = unit exposure (mg/lb ai);
AR = application rate (e.g., lb ai/ft^2, lb ai/gal); and
A = area treated or amount handled (e.g., ft^2/day, gal/day).

Dermal and/or inhalation potential doses normalized to body weight are calculated as:

$$D = \frac{E * AF}{BW} \tag{4.2}$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

Handler exposure for applications to gardens and trees is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.3* such as the product-specific application regimen. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Dermal and Inhalation Handler Exposure Algorithm Inputs and Assumptions

Recommended values for handler exposure (inhalation and dermal) assessments are provided in *Table 4-1* and *Table 4-2*. Following these tables, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values, and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 4-1: Gardens and Trees – Recommended Unit Exposure (mg/lb ai) Distributions and Point Estimates								
Formulation	**Equipment/Application Method**	**Dermal**			**Inhalation**			**Appendix Page Reference**
		Distribution		**Point Estimate**	**Distribution**		**Point Estimate**	
		Type	**Parameters**		**Type**	**Parameters**		
Granules	Push-type spreaders	Lognormal	GM = 0.66 GSD = 1.9		Lognormal	GM = 0.0014 GSD = 3.1		B-4
	Belly grinders	Lognormal	GM = 240 GSD = 2.5		Lognormal	GM = 0.035 GSD = 4.5		B-11
	Spoon	Lognormal	GM = 3.7 GSD = 2.7		Lognormal	GM = 0.024 GSD = 5.0		B-20
	Cup	Lognormal	GM = 0.05 GSD = 3.4		NA	NA		B-24
	Hand dispersal	Lognormal	GM = 120 GSD = 2.2		Lognormal	GM = 0.28 GSD = 2.2		B-28
	Shaker can	No exposure data available for this application scenario. Exposure data for granule applications using a cup recommended as surrogate data.						
Dusts/Powders	Plunger duster	Lognormal	GM = 150 GSD = 2.8		Lognormal	GM = 0.50 GSD = 4.8		B-32
	Bulb duster	No exposure data available for this application scenario. Exposure data for plunger duster applications recommended as surrogate data.						
	Electric/power duster	No exposure data available for this application scenario. Exposure data for shaker can applications of dusts/powders recommended as surrogate data.						
	Hand crank duster	No exposure data available for this application scenario. Exposure data for shaker can applications of dusts/powders recommended as surrogate data.						
	Shaker can	Lognormal	GM = 3600 GSD = 1.8		Lognormal	GM = 9.4 GSD = 3.1		B-36
Liquid concentrates	Low-pressure handwand	Lognormal	GM = 46 GSD = 2.3		Lognormal	GM = 0.0043 GSD = 2.0		B-56
	Hose-end sprayer	Lognormal	GM = 37 GSD = 2.6		Lognormal	GM = 0.0012 GSD = 1.7		B-78
	Backpack	Lognormal	GM = 25 GSD = 6.0		Lognormal	GM = 0.064 GSD = 3.0		B-89
	Sprinkler can	No exposure data available for this application scenario. Exposure data for hose-end sprayer applications of liquid concentrates recommended as surrogate data.						
Ready-to-Use (RTU)	Hose-end sprayer	Lognormal	GM = 2.6 GSD = 4.7		Lognormal	GM = 0.010 GSD = 3.3		B-104
	Trigger-sprayers	Lognormal	GM = 54 GSD = 2.6		Lognormal	GM = 0.046 GSD = 2.1		B-109

Table 4-1: Gardens and Trees – Recommended Unit Exposure (mg/lb ai) Distributions and Point Estimates								
Formulation	Equipment/Application Method	Dermal			Inhalation			Appendix Page Reference
		Distribution		Point Estimate	Distribution		Point Estimate	
		Type	Parameters		Type	Parameters		
	Aerosol Can	Lognormal	GM = 330 GSD = 1.6		Lognormal	GM = 2.3 GSD = 2.0		B-130
Wettable Powder	Low-pressure handwand	Lognormal	GM = 34 GSD = 3.3		Lognormal	GM = 0.63 GSD = 2.9		B-138
	Hose-end sprayer	No exposure data available for this application scenario. Exposure data for hose-end sprayer applications of liquid concentrates recommended as surrogate data.						
	Backpack	No exposure data available for this application scenario. Exposure data for low-pressure handwand applications of wettable powders recommended as surrogate data.						
	Sprinkler can	No exposure data available for this application scenario. Exposure data for hose-end sprayer applications of liquid concentrates recommended as surrogate data.						
Wettable Powder in Water-soluble Packaging	Low-pressure handwand	No exposure data available for this scenario. Exposure data for low-pressure handwand applications of liquid concentrates recommended as surrogate data.						
	Hose-end sprayer	No exposure data available for this scenario. Exposure data for RTU hose-end sprayers recommended as surrogate data.						
	Backpack	No exposure data available for this scenario. Exposure data for low-pressure handwand applications of liquid concentrates recommended as surrogate data.						
	Sprinkler can	No exposure data available for this scenario. Exposure data for RTU hose-end sprayers recommended as surrogate data.						
Dry Flowable / Water-dispersible Granule	Low-pressure handwand Hose-end sprayer Backpack Sprinkler can	No exposure data available for this scenario. Application method-specific exposure data for wettable powders recommended as surrogate data.						
Micro-encapsulates	Low-pressure handwand Hose-end sprayer Backpack Sprinkler can	No exposure data available for this scenario. Application method-specific exposure data for liquid concentrates recommended as surrogate data.						

Table 4-2: Gardens and Trees – Recommended Handler Exposure Factor Distributions and Point Estimates				
Exposure Factor (units)		**Distribution**		**Point Estimate(s)**
		Type	**Parameters**	
Application Rate (mass ai per unit area)		Product-specific		
Garden Size (ft^2)		Lognormal	GM = 80 GSD = 10	
Amount product / solution used	Low-pressure handwand (gallons)	Uniform	2 – 5	
	Backpack (gallons)	Uniform	2 – 5	
	Hose-end sprayer (gallons)	Normal	Mean = 11 SD = 5.1	
	Sprinkler can (gallons)	Uniform	2 – 5	
	Aerosol can (cans)	Uniform	0.5 – 2	
	Trigger-sprayer (bottles/containers)	Uniform	0.5 – 2	
Body Weight (kg)		Empirical	Mean = 72 95^{th} = 98	
GM = geometric mean GSD = geometric standard deviation				

Unit Exposures

As described in *Section 1.3.3*, the unit exposure is the ratio, for a given formulation/application method combination, between exposure and the amount of active ingredient handled, with units mass exposure per mass active ingredient handled (e.g., mg ai exposure/lb ai handled). **The recommended point estimate shown in *Table 4-1* represent approximately the [XX]th percentile of the respective distribution.** Data summaries can be found in *Appendix B*.

Amount of active ingredient Handled

The algorithm for estimating handler exposure requires some estimate of the amount of active ingredient handled per day. This factor varies based on the type of equipment or application method used and is estimated based on the application rate specified on the product label. First the assessor should assemble application rate information in terms of active ingredient per area treated (e.g., lb ai/1000 ft^2) and active ingredient per volume of spray (e.g., lb ai/gallon solution). For example, instructions for a granule formulation might direct application of 2 lbs of product per 100 square feet or a spray application might say to apply 2 gallons of solution per 100 square feet. Additionally, the assessment must reflect exposure resulting from use of the product and chemical at the maximum allowable application rate found on the product label. The probability of using a product at its maximum allowable rate at home is unknown, so additional information (e.g., use surveys or pest-specific application rates), can be used, if available, to characterize the exposure resulting from use at the maximum allowable rate.

Once the application rate is determined, an amount of area treated or amount of volume sprayed is used to convert the application rate into the amount of active ingredient handled (which is then used with the unit exposure to estimate handler exposure). For this scenario, the amount of area treated is estimated using information about garden size from a survey (Johnson, 1999). Note that these results represent garden sizes, not gardens areas treated. *Table 4-3* below presents a statistical summary assuming a lognormal distribution for garden size to be used when application rates are in terms of area. **The recommended point estimate represents the [XX]th percentile of the garden size distribution.**

Table 4-3: Statistical Summary – Garden Size (ft^2)	
50th percentile	80
75th percentile	390
95th percentile	3700
99th percentile	18000
AM (SD)	1200 (18000)
GM (GSD)	80 (10)
Range	unknown
N	364
AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

An estimate for the amount of spray solution volume sprayed is necessary if the application rate is used in terms of active ingredient per volume solution. Such a rate would be used for spraying trees where an "area-based" approach would not be appropriate or useful. However, this factor is likely application method-specific (i.e., one might apply more solution using a hose-end sprayer than a sprinkler can) and explicit information on volumes sprayed in home applications is unavailable.

For hose-end sprayers, application volume was derived from a study measuring exposure during applications of liquid formulations to fruit trees and ornamental shrubs using a hose-end sprayer (Merricks, 1998). A statistical summary assuming a normal distribution for application volume is provided in *Table 4-4* below. **The recommended point represents the [XX]th percentile of the application volume distribution.**

Table 4-4: Statistical Summary – Application Volume (gallons) for Hose-end Sprayers	
50th percentile	11
75th percentile	14
95th percentile	19
99th percentile	22
AM (SD)	11 (5.1)
GM (GSD)	10 (1.6)
Range	6 – 21
N	20
AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

For all other applications, reliable information on the amount of product used is unavailable. For low-pressure handwands, backpacks, and sprinkler cans a volume of **[XX]** gallons is assumed as an upper-end point estimate and a uniform distribution of 2 to 5 gallons is recommended for probabilistic assessments. For aerosol cans and trigger-sprayers, **[XX]** cans or containers per application are assumed as an upper-end point estimate and a uniform distribution of 0.5 to 2 cans/containers is recommended for probabilistic assessments.

Future Research/Data Needs

Unavailable information that would refine handler exposure assessments for pesticide applications to gardens and trees include:

- Application intervals (i.e., how often chemicals are applied to gardens and trees) – either chemical-specific or generic intervals by pesticide-type (e.g., fungicides, insecticides, etc.)
- Survey information (preferably longitudinal) detailing:
  - Daily/weekly/monthly probability of treating gardens and trees with pesticides;
  - Amount of product or formulation used or area treated per application;
  - Product-specific application rates to obtain the likelihood that the maximum rate is used.
- Handler exposure data:
  - Specific for garden and tree applications as well as for those formulations and/or application methods currently unavailable as shown in *Table 4-1*;
  - Describing the extent to which an individual's exposure for a given formulation and application method varies from application-to-application (i.e., intra-individual exposure variability).

Exposure Characterization and Data Quality

This section relies on surrogate data considered reasonable for estimating handler exposure for scenarios that are lacking data. Additionally, the assumed proportional relationship between exposure and amount of active ingredient handled is reasonable though recognized as uncertain.

Information on the amount of product/formulation (thus, active ingredient) handled per application is lacking, making the estimates highly uncertain. The recommended point estimates are therefore intended to be high-end to ensure an appropriately conservative exposure estimate.

4.2 Post-application Exposure Assessment

Post-application exposure can result from conducting activities such as gardening or picking fruits following pesticide applications by professional pesticide applicators or by homeowners themselves. This also includes the potential post-application exposure as a result of contacting treated plants purchased at retail locations.

Adults and youths (e.g., ages 6 – 11) are considered the sentinel populations for this exposure scenario as it is assumed that young children (i.e., < 6 years old) will neither engage in the types of activities associated with these areas (e.g., gardening or picking fruits) nor utilize these areas for playing. Additionally, by law, "pick-your-own" farms cannot spray pesticides within the pre-harvest interval (PHI), typically a period of 7 or 14 days prior to harvest. Therefore, assessments for activities at "pick-your-own" farms should account for residue dissipation during the PHI (i.e., residue @ "day of application + PHI").

This section addresses standard methods for estimating exposure and dose for three scenarios resulting from contact with gardens and/or trees that have previously been treated with pesticides:

- Section 4.2.1 - adult/youth inhalation exposure resulting from activities in gardens and/or trees;
- Section 4.2.2 - adult/youth dermal exposure resulting from activities in gardens and/or trees;
- Section 4.2.3 - toddler non-dietary ingestion.

4.2.1 Post-application Inhalation Exposure Assessment

Post-application inhalation exposure while performing activities in previously treated gardens or trees is rarely assessed as the combination of low vapor pressure for chemicals typically used as active ingredients in outdoor residential pesticide products and dilution in outdoor air is expected to result in minimal exposure. These should be handled on a case-by-case basis.

4.2.2 Post-application Dermal Exposure Assessment

Post-application dermal exposure resulting from contact with previously treated gardens and trees is dependent on three exposure factors: foliar residue, leaf-to-skin residue transfer, and exposure time.

Post-application Dermal Exposure Algorithm

The algorithm to calculate daily exposure and dose (i.e., exposure and dose on a single day) is shown below. As discussed in *Section 1.3.4* residential post-application exposure assessment must include calculation of exposure on the day of application. Therefore, though an assessment can present exposures for any day “t” following the application, it must include “day 0” exposure.

$$E = DFR_t * CF1 * TC * ET \qquad (4.3)$$

where:

E = exposure (mg/day);
DFR_t = dislodgeable foliar residue on day "t" (µg/cm^2);
CF1 = weight unit conversion factor (0.001 mg/µg);
TC = transfer coefficient (cm^2/hr); and
ET = exposure time (hrs/day).

In the absence of chemical-specific data, DFR_t can be calculated as follows:

$$DFR_t = AR * F_{AR} * (1-F_D)^t * CF2 * CF3 \qquad (4.4)$$

where:

DFR_t = dislodgeable foliar residue on day "t" (µg/cm^2);
AR = application rate (lbs ai/ft^2 or lb ai/acre);
F_{AR} = fraction of ai as dislodgeable residue following application (unitless);
F_D = fraction of residue that dissipates daily (unitless);
t = post-application day on which exposure is being assessed;
CF2 = weight unit conversion factor (4.54 x 10^8 µg/lb); and
CF3 = area unit conversion factor (1.08 x 10^{-3} ft^2/cm^2 or 2.47 x 10^{-8} acre/cm^2).

Dermal dose, normalized to body weight, is calculated as:

$$D = \frac{E * AF}{BW} \tag{4.5}$$

where:
D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

Post-application dermal exposure following applications to gardens and trees is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Dermal Exposure Algorithm Inputs and Assumptions

Recommended values for post-application dermal exposure assessments are provided in *Table 4-5* below. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 4-5: Gardens, Trees, and "Pick-your-own" Farms – Recommended Distributions and Point Estimates for Post-Application Dermal Exposure Factors						
Algorithm Notation	**Exposure Factor (units)**			**Distribution**		**Point Estimate(s)**
				Type	**Parameters**	
AR	Application rate (mass ai per unit area)			Point Estimate		
F_{AR}	DFR following application (fraction)			NA	NA	
F_D	Daily residue dissipation (fraction)			NA	NA	
TC	Transfer Coefficient (cm^2/hr)	Gardens[1]	Adults	Custom	Mean = 8400 95th = 31000	

Table 4-5: Gardens, Trees, and "Pick-your-own" Farms – Recommended Distributions and Point Estimates for Post-Application Dermal Exposure Factors							
Algorithm Notation	Exposure Factor (units)				Distribution		Point Estimate(s)
					Type	Parameters	
			Youths		Custom	Mean = 5000 95th = 19000	
		Trees and Retail Plants[a]	Adults		Custom	Mean = 1700 95th = 3300	
			Youths		Custom	Mean = 1000 95th = 2000	
		Indoor Plants	Adults		Lognormal	GM = 200 GSD = 1.6	
			Youths		Lognormal	GM = 100 GSD = 1.6	
ET	Exposure Time (hours per day)	Home activities[b]	Gardens	Adults	Custom	Mean = 2.2 95th = 6.9	
				Youth	Custom	Mean = 1.1 95th = 3.5	
			Trees and Retail Plants	Adults	Custom	Mean = 1.0 95th = 3.4	
				Youth	Custom	Mean = 0.50 95th = 1.7	
			Indoor Plants	Adults	Custom	Mean = 1.0 95th = 3.4	
				Youth	Custom	Mean = 0.50 95th = 1.7	
		"Pick-your-own" Farms	Adults		Empirical	Mean = 5.0 95th = 13.0	
			Youths		Empirical	Mean = 1.9 95th = 4.4	
BW	Body weight (kg)		Adults		Empirical	Mean = 72 95th = 98	
			Youths		Empirical	Mean = 32 95th = 53	

[a] Transfer coefficient point estimates from a composite distribution assuming equal proportion of each respective activity. See "Transfer Coefficient" section below. Youth TC derived using surface area adjustment (see Section 2.3).
[b] Activity time point estimates from a composite distribution assuming equal proportion of each respective activity. Time for youths derived using hrs/day ratio adjustment. See "Exposure Time" section below and *Appendix C.8.1*
NA = not applicable

Application Rate

The assessment must reflect exposure resulting from use of the product and chemical at the maximum allowable application rate found on the product label. The probability of using a product at its maximum allowable rate at home or at "pick-your-own" farms is unknown, so additional information (e.g., use surveys), can be used, if available, to characterize the exposure resulting from use at the maximum allowable rate.

When chemical-specific residue information is unavailable, the assessment methodologies outlined in this section require the application rate to be in terms of mass active ingredient per area (e.g., lb ai/ft^2). Typically this is listed on the label, however sometimes must be estimated based on the solution concentration (e.g., lb ai/gallon dilute solution) and the volume of solution applied (e.g., 0.5 gallons solution/ft^2). This "area-based" approach is intuitive for garden applications where a user can approximate their garden's size and spray accordingly.

This is more difficult, however, for applications to trees since a user would not typically spray trees on a square footage basis. More likely, the product label directs the user to "spray to run off" or "as needed". In these cases, a label indicating the chemical's application rate for orchards or other trees used by professional applicators should be used – typically listed as an "area-based" rate in pounds of active ingredient per acre (lb ai/acre). In the event there is no professional label, the "area-based" application rate from sprays to gardens should be used. The assumption of similar foliar concentration for gardens and trees is reasonable absent chemical- and site-specific residue data.

Dislodgeable Foliar Residue

Estimates of Chemical Residue following Pesticide Applications

Following an application, some pesticide residue remains on the leaves of the target plant for an individual to contact and remove from the leaf surface. This is referred to as dislodgeable foliar residue (DFR). DFR can be either measured in a field study or estimated from the application rate. Either way, the goal is to establish an average concentration of pesticide residue per unit area of foliage (e.g., ug/cm^2) an individual can potentially contact over the course of the exposure period. Exposure can then be predicted using a surface-to-skin residue "transfer coefficient" (discussed below) – a metric which accounts for contact with treated surfaces based on the type of crop and activity being performed (e.g., harvesting apples).

As stated previously, it is assumed that contact with previously treated residential gardens or trees occur on the same day of application. Therefore, whether measured or estimated, the exposure assessment needs to include an estimated exposure based on the DFR on the day of application (i.e., $DFR_{t=0}$). For "pick-your-own" farms, however, individuals cannot conduct activities until the PHI has expired, therefore residue should be representative of residue that has dissipated for a number of days (e.g., $DFR_{t=7}$).

When chemical- and crop-specific data are available, DFR on the day of application and subsequent days can typically be estimated using a standard exponential decay model. In the absence of data, however, DFR can be estimated using generic assumptions for both the initial residue available (i.e., $DFR_{t=0}$) and residue dissipation.

Analysis of DFR data from field studies for various types of crops and various active ingredients indicate that, on the day of application, the amount of dislodgeable residue, expressed as a fraction of the application rate, ranges from 0.02 to 0.89 (i.e., 2% to 89%). The data were fit to a lognormal distribution with a geometric mean of 0.18 and a geometric standard deviation of 2.21. Because dislodgeable residue cannot physically be greater than that deposited, the distribution must be truncated at 1.0 (i.e., 100% of the application rate). Complete data analysis can be found in *Appendix C.6.2*.

Table 4-6 below summarizes the statistical information for this data set. Note that this distribution is only meant as a basis for selecting a generic estimate for the DFR on the day of application as a fraction of the application rate and is inappropriate to use probabilistically. Because the data are comprised of a variety of chemicals on a variety of crops under a variety of conditions, this distribution represents the variability of many different situations. Within each particular DFR study, because the nature of the sampling results in an *average* DFR estimate, the distribution of the DFR on the day of application as a fraction of the application rate is much less variable – indicating that, for a given chemical the range may be only 2 – 5% or 30 – 35%, not 2 – 89%. Furthermore, because the chemical-specific variability of this fraction is small, a distribution for use probabilistically is unnecessary (i.e., it will not have much effect on the outcome) and a point estimate is appropriate for use in both deterministic and probabilistic assessments.

Table 4-6: Statistical Summary – Fraction of Application Rate as DFR on the Day of Application	
50^{th} percentile	0.18
75^{th} percentile	0.31
95^{th} percentile	0.66
99^{th} percentile	> 1.0
AM (SD)	0.25 (0.23)
GM (GSD)	0.18 (2.2)
Range	0.024 – 0.89
N	60
Statistics based on a lognormal distribution. AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

The recommended generic value for the fraction of application rate as dislodgeable foliar residue following application is [XX] and represents approximately the [XX]th percentile of the distribution.

Residue Dissipation

An analysis of various available studies was conducted to determine residue dissipation for use in exposure assessment in the absence of chemical-specific data. Expressed as a fraction per day, residue dissipation ranges from 0.03 to 0.47 (i.e., 3% to 47%) with a geometric mean of 0.16 and a geometric standard deviation of 2.18. Complete data analysis can be found in *Appendix C.6.2*.

Table 4-7 below summarizes the statistical information for this data set. With respect to use of this distribution, the same principle holds as for the fraction of the application rate as DFR on the day of application. That is, this distribution is meant as a basis for estimation of a point estimate for daily dissipation after looking at the distribution of dissipation rates over a variety of chemicals and conditions, and is inappropriate for use probabilistically.

Table 4-7: Statistical Summary – DFR Dissipation (Fraction per Day)	
50^{th} percentile	0.160
25^{th} percentile	0.094
5^{th} percentile	0.044
1^{st} percentile	0.026
0.1^{st} percentile	0.014
AM (SD)	0.22 (0.20)
GM (GSD)	0.16 (2.2)
Range	0.033 – 0.47
N	19
Statistics based on a lognormal distribution. AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

The recommended generic residue dissipation for use in exposure assessment is [XX] (approximately the [XX]th percentile of the distribution) and corresponds to a half-life of approximately [XX] days. Information on within-day residue dissipation is unavailable and is therefore not considered in estimates of daily exposure.

While it may be the case that both estimates for DFR on the day of application and residue dissipation are dependent on a number of conditions (e.g., active ingredient, leaf-type, crop growth stage, method of pesticide application, etc.) – and not adequately characterized by single distributions – the distributions and point estimates are based on a variety of chemicals and conditions and are reasonable surrogates in the absence of chemical- and/or crop-specific data.

Transfer Coefficient

Post-application dermal exposure can be predicted using estimates for foliar residue, leaf-to-skin residue transfer for individuals contacting treated foliage during certain activities, and exposure time. The measure of leaf-to-skin residue transfer for a given crop and activity is known as the transfer coefficient (TC). Transfer coefficients are derived from concurrent measurements of exposure and foliar residue, and is the ratio of exposure rate, measured in mass of chemical per time (e.g., ug/hr), to residue, measured in mass of chemical per foliar surface area (e.g., ug/cm^2). In other words, transfer coefficients are exposure rates (e.g., mg/hr) normalized to residue (e.g., mg/cm^2), with resulting units of cm^2/hr. It follows that exposure rate for a given crop and activity can then be predicted from a given residue using the transfer coefficient. Additionally, transfer coefficients are typically applied generically – that is, for any given chemical, crop-activity transfer coefficients (e.g., apple harvesting) can be used.

Data to adequately characterize exposure for individuals who contact previously treated residential gardens, trees, retail plants, or indoor plants is unavailable. Unlike occupational settings where individuals generally perform one task on one crop throughout the day (e.g., harvesting apples), individuals in residential settings are likely to conduct various activities. Therefore, transfer coefficients from occupational reentry exposure studies conducted by the Agricultural Reentry Task Force (ARTF), were used to establish composite transfer coefficients representing activities likely to occur in residential settings. Additionally, also unlike occupational settings, the transfer coefficients represent individuals wearing shorts and short-sleeve shirts by using "outer dosimeter" exposure measurements for the forearm and lower leg sections. Despite the uncertainty of using occupational reentry monitoring studies, where workers likely conduct activities in a much different fashion than those in residential settings, the transfer coefficients outlined below are considered reasonable for use in residential exposure assessment absent post-application exposure studies for individuals in residential settings.

Transfer coefficients were derived for activities conducted in gardens and in trees (both at home and at "pick-your-own" farms) as well as for indoor plants and retail plants treated at commercial locations. *Table 4-8* below lists the representative crops and activities and the occupational field reentry studies used to derive their respective transfer coefficients. Complete data analysis for all transfer coefficients can be found in *Appendix C.7.2*.

Table 4-8: Gardens, Trees, and "Pick-your-own" Farms – Transfer Coefficient Studies

Residential Post-application Activity	Representative Crop/Activity Combinations	Study Code	
		MRID	**ARTF #**
Gardens (vegetables and flowers)	Cabbage weeding	45191701	ARF037
	Tomato tying	45530103	ARF051
	Squash harvesting	45491902	ARF049
	Chrysanthemum pinching	45344501	ARF039
Trees and Retail Plants (fruits, nuts, ornamentals, shrubs, bushes)	Ornamental citrus tree pruning	45469501	ARF043
	Apple harvesting	45138202	ARF025
	Orange harvesting	45432302	ARF041
	Grapefruit harvesting	45432302	ARF042
Indoor Plants	Ornamental citrus tree pruning	45469501	ARF043

Because the individuals monitored in these studies were adults, use of these transfer coefficients to assess post-application exposure for youths requires an adjustment for body surface area as described in Section 2.3. **The recommended adjustment factor is 0.6.** In practice this means that a transfer coefficient for youths are expected to be approximately 60% of an adult transfer coefficient (i.e., Adult TC * 0.6).

<u>Garden Activities</u>

Transfer coefficients for residential gardening were derived using studies representing likely residential gardening activities such as weeding and picking flowers and vegetables. Four separate exposure studies were used: a study each for cabbage weeding (Klonne, 2000; MRID 45191701), tomato tying (Klonne, 2001; MRID 45530103), squash harvesting (Klonne, 2001; MRID 45491902), and chrysanthemum pinching (Klonne, 2000; MRID 45344501).

Each individual study was fit to a lognormal distribution, and then combined into a single custom distribution via simulation assuming an equal proportion (e.g., 25%) for each distribution. The resulting custom distribution has a transfer coefficient range of 160 cm^2/hr to 41000 cm^2/hr with a mean of 8400 cm^2/hr. *Table 4-9* below summarizes the statistical information for this data set. **The recommended point estimate for use in post-application dermal exposure assessment ([XX] cm^2/hr) represents approximately the [XX]th percentiles.**

Table 4-9: Statistical Summary – Gardening Transfer Coefficients (cm^2/hr)	
50th percentile	3200
75th percentile	13000
95th percentile	31000
99th percentile	38000
AM (SD)	NA
GM (GSD)	NA
Range	160 – 41000
N	67
Note: Distributional parameters are not applicable (NA) for this distribution. Users are directed to the distributional parameters for each of the sub-distributions outlined in *Appendix C.7.2*.	

Tree Activities

Transfer coefficients were derived representing activities at home and at "pick-your-own" farms that individuals would perform on trees such as picking roses or apples or thinning shrubs and bushes. They are also recommended for use in assessing exposure while conducting activities in retail plants previously treated with pesticides at commercial locations. Four separate exposure studies were used: a study each for apple harvesting (Klonne, 2000; MRID 45138202), orange harvesting (Klonne, 2000; MRID 45432301), grapefruit harvesting (Klonne, 2000; MRID 45432302), and ornamental citrus tree pruning (Klonne, 2000; MRID 45469501).

Each individual study was fit to a lognormal distribution, and then combined into a single custom distribution via simulation assuming an equal proportion (e.g., 25% each) for each distribution. The resulting custom distribution has a transfer coefficient range of 90 cm^2/hr to 3400 cm^2/hr with a mean of 1700 cm^2/hr. *Table 4-10* below summarizes the statistical information for this data set. **The recommended point estimate for use in post-application dermal exposure assessment ([XX] cm^2/hr) represents approximately the [XX]th percentile.**

Table 4-10: Statistical Summary – Tree Activity Transfer Coefficients (cm^2/hr)	
50th percentile	1900
75th percentile	2600
95th percentile	3300
99th percentile	3900
AM (SD)	NA
GM (GSD)	NA
Range	90 – 3400
N	60
Note: Distributional parameters are not applicable (NA) for this distribution. Users are directed to the distributional parameters for each of the sub-distributions outlined in *Appendix C.7.2*.	

Indoor Plant Activities

Transfer coefficients were derived representing activities for indoor plants using the study measuring exposure while pruning ornamental citrus trees (Klonne, 2000; MRID 45469501). As previously discussed and shown in *Appendix C.7.2*, this study was fit to a lognormal distribution with a geometric mean of 200 cm^2/hr and geometric standard deviation of 1.6 cm^2/hr. **The recommended point estimate for use in post-application dermal exposure assessment ([XX] cm^2/hr) represents approximately the [XX]th percentile.**

Table 4-11: Statistical Summary – Indoor Plant Activities Transfer Coefficients (cm^2/hr)	
50th percentile	200
75th percentile	270
95th percentile	440
99th percentile	620
AM (SD)	220 (120)
GM (GSD)	200 (1.6)
Range	90 – 500
N	15
Statistics based on a lognormal distribution. AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

Exposure Time

As shown in the post-application dermal exposure algorithm and stated previously, daily exposure while contacting previously treated gardens and trees in residential settings can be predicted using foliar residue, a generic crop/activity transfer coefficient, and exposure time.

<u>Home Activities</u>

Exposure times for activities associated with gardens and trees at home were derived using a residential survey (Johnson, 1999) and information from the U.S. EPA Exposure Factors Handbook (U.S. EPA, 1997). While the Exposure Factors Handbook includes information on "time spent working with soil in a garden or other circumstances working" for all age groups including youths (Vol. III, Table 15-62), the data are presented as hours/month, thus difficult to interpret daily exposure times necessary for exposure assessments of short duration. The residential survey, on the other hand, asked about specific types of residential landscaping and maintenance activities and the amount of time an individual spends conducting such activities quantified in "hours per week" and "days per week". However, because this survey only included individuals 18 years or older, the Exposure Factors Handbook information was used to adjust these results for those under 18 years. Analysis of this survey information can be found in *Appendix C.8.1*.

<u>Gardening</u>

As for transfer coefficients for gardening, a custom distribution for home gardening was simulated using cumulative distributions derived from the survey results for vegetable gardening and flower gardening in equal proportion (i.e., 50% each). Each cumulative distribution was truncated at 16 hours per day (i.e., 16 hrs = 100th percentile) to subtract for 8 hours of sleep. Additionally, as described, in *Appendix C*, based on information from the Exposure Factors Handbook, activity time for youths is considered to be approximately half that for adults and are adjusted accordingly. The cumulative percentiles for each gardening activity's daily exposure time (hrs/day) are provided in *Table 4-12* below.

Table 4-12: Cumulative Percentile Distributions for Activity Times for Gardens		
Activity Time (hrs/day)	Cumulative Percentiles	
	Vegetable Gardening	Flower Gardening
0	0	0
0.5	19	30
1	36	55
1.5	51	66
2.5	69	81
3.5	80	91
5	89	97
7.5	94	99
10	97	NA
16	100	100
Note: Vegetable gardening was the only activity with survey responses greater than 7.5 hours per day.		

Table 4-13 below provides a statistical summary of the composite distribution for time spent in home garden and tree activities. The **recommended point estimates for use in post-application dermal exposure assessment ([XX] hrs/day for adults; [XX] hours per day for youths) represent approximately the [XX]th percentiles.**

Table 4-13: Home Gardens and Trees – Activity Time (hrs/day) Statistical Summary		
Statistic	Gardening	
	Adults	Youths
50th percentile	1.4	0.7
75th percentile	2.9	1.5
95th percentile	6.9	3.5
99th percentile	13	6.5
AM (SD)	NA	NA
GM (GSD)	NA	NA
N	883	NA
Notes: - Distributions are truncated at 16 hours per day - Distributional parameters are not applicable (NA) for this distribution. Users are directed to the distributional parameters for each of the sub-distributions outlined in *Appendix C.8.1*.		

Activities for Fruit, Nut, and Ornamental Trees/Shrubs/Bushes and Indoor Plants

A custom distribution for activity time in trees at home was simulated using cumulative distributions derived from the survey results for roses, shrubs/bushes, and fruit/nut trees (i.e., 33% each). This distribution is also considered a reasonable representation for time spent during activities associated with indoor plants. Each cumulative distribution was truncated at 16 hours per day (i.e., 16 hrs = 100th percentile) to subtract for 8 hours of sleep. The cumulative percentiles for each gardening activity's daily exposure time (hrs/day) are provided in *Table 4-14* below.

Table 4-14: Cumulative Percentile Distributions for Activity Times for Trees			
Activity Time (hrs/day)	Cumulative Percentiles		
	Roses	Shrubs/Bushes	Fruit/Nut Trees
0	0	0	0
0.5	46	52	46
1	76	75	57
1.5	83	81	64
2.5	95	94	86
3.5	98	96	92
5	99	99.5	97
7.5	99.5	99.9	99
16	100	100	100

Table 4-15 below provides a statistical summary of the composite distribution. **The recommended point estimates for use in post-application dermal exposure assessment ([XX] hrs/day for adults; [XX] hrs/day for youths) represent approximately the [XX]th percentile.**

Table 4-15: Home Gardens and Trees – Activity Time (hrs/day) Statistical Summary		
Statistic	Fruit, Nut, and Ornamental Trees and Bushes and Shrubs	
	Adults	Youths
50th percentile	0.5	0.25
75th percentile	1.4	0.7
95th percentile	3.4	1.7
99th percentile	6.3	3.2
AM (SD)	NA	NA
GM (GSD)	NA	NA
N	831	NA
Notes: - Distributions are truncated at 16 hours per day - Distributional parameters are not applicable (NA) for this distribution. Users are directed to the distributional parameters for each of the sub-distributions outlined in *Appendix C.8.1*.		

"Pick-your-own" Farm Activities

Survey information specifically for the amount of time spent at "pick-your-own" farms is unavailable. Therefore, information from the US EPA Exposure Factors Handbook (US EPA, 1997) for amount of time "spent outdoors at a farm." Adults aged 18-64 years ranged from 5 minutes to 16 hours per day while youths aged 5-11 ranged from 25 minutes to 4.4 hours per day. Note that, while the upper-end of the distribution indicates the time spent for adults is near 16 hours per day, it is assumed that anything greater than 8 hours at a "pick-your-own" farm is unlikely and values higher than this are likely a product of the data set used to estimate this exposure factor (i.e., "time spent outdoors at a farm" is not necessarily representative of "time spent at a "pick-your-own" farm). *Table 4-16* below provides a statistical summary of this data.

Table 4-16: Time Spent at "Pick-your-own" Farms (hrs/day) Statistical Summary

Population	Age	Statistics									
		N	Mean	Summary Percentiles							
				5	25	50	75	90	95	98	99
Adults	18-64	91	5.0	0.3	1.3	3.8	8.3	10.6	13.0	15.6	15.9
Youths	5-11	7	1.9	0.4	0.8	1.7	2.2	4.4	4.4	4.4	4.4

Source: 1997 EPA Exposure Factors Handbook (Vol. III; Table 15-112)

The recommended values in *Table 4-5* for use in post-application exposure assessment are [XX] and [XX] hrs/day for adults and youths, respectively, and are considered to be high-end point estimates.

Future Research/Data Needs

Unavailable information that would refine post-application dermal exposure assessments for pesticide applications to gardens and trees include:

- Application intervals (i.e., how often chemicals are applied to gardens and trees) – either chemical-specific or generic intervals by pesticide-type (e.g., fungicides, insecticides, etc.)
- Survey information (preferably longitudinal) detailing:
  - Daily/weekly/monthly probability of treating gardens and trees with pesticides;
  - Product-specific application rates to obtain the likelihood that the maximum rate is used; and,
  - Daily activity patterns specific to gardens and trees.
- Post-application exposure data:
  - Specific for residential garden and tree activities;
  - Describing the extent to which an individual's exposure for a given activity varies (i.e., intra-individual exposure variability)

Exposure Characterization and Data Quality

<u>Transfer Coefficient:</u> Because exposure data for deriving "residential" transfer coefficients were unavailable, they were derived using occupational exposure studies. This introduces uncertainty as workers may experience more or less exposure compared to an individual conducting a similar activity at home (e.g., picking apples). Additionally, the relationships underlying the use of post-application exposure data as transfer coefficients – proportionality between exposure and time and between exposure rate (i.e., mg/hr) and residue – are uncertain, though potentially conservative.

<u>Dislodgeable Foliar Residue:</u> Absent chemical-specific data, estimates of dislodgeable foliar residue factors such as the amount available following application and dissipation are used generically based on existing data for a wide variety of chemicals. Use of this data generically, including using high-end estimates, may overestimate for other chemicals.

<u>Exposure Time:</u> Information on the amount of time spent conducting certain activities, while from a robust survey, was not available in a "per day" format. Thus, to normalize weekly data on a "per day" basis the assumption was made (based on the responses for "days per week" for these activities) that individuals conducted activities 2 days per week. Additionally, the survey

did not provide information on individuals younger than 18 years of age; therefore, an adjustment was made to the survey information based on the distributional ratio of adults to youths for "time spent working with soil in a garden or other circumstances working" from the Exposure Factors Handbook. Both of these data adjustments are considered reasonable, but add uncertainty.

Information on time spent at a "pick-your-own" farm is unavailable; therefore "time spent outdoors on a farm" was used as a surrogate dataset. The unknown extent of difference between the two adds uncertainty.

4.2.3 Post-application Non-Dietary Ingestion Exposure Assessment

As a standard practice, post-application non-dietary ingestion exposure (i.e., hand-to-mouth, object-to-mouth, soil ingestion, etc.) for adults is not assessed – it is assumed that an adult would not place hands, objects, or soil in their mouth.

Additionally, post-application non-dietary ingestion exposure is not assessed for children either. Unlike treated grass at home or in recreational areas where children are likely to spend extended periods of time, for this scenario non-dietary ingestion exposure is not assessed because it is assumed that young children (i.e., < 6 years old) will neither engage in the types of activities associated with these areas (e.g., gardening or picking fruits) nor utilize these areas for prolonged periods of play.

4.2.4 Combining Post-application Scenarios

Aggregation of post-application exposure is generally not applicable to activities associated with gardens and trees. In the event post-application inhalation exposure is assessed, it should be combined with post-application dermal exposure for adults and youths.

Section 5 Outdoor Fogging/Misting Systems

This section covers the following exposure scenarios:

- Outdoor aerosol spray area foggers (handler/post-application)
- Candles, coils, torches, mats (post-application)
- Outdoor residential misting systems (handler/post-application)
- Horse barn misting systems (handler/post-application)

Each of these exposure scenarios is designated for outdoor use fogging products only. Each section offers additional description of the exposure scenario and the handler and/or post-application exposure. Indoor fogging products (i.e., "bug bombs") are covered in *Section 7*. While barns and stables are "indoors", they are included in this section because of methodological similarities and because barns often have significantly more air exchange than standard indoor commercial or residential spaces.

5.1 Outdoor Aerosol Spray Area Foggers

Aerosol spray area foggers are insecticide products available in aerosol cans formulated to kill or repel outdoor flying pests. This section provides a standard method for estimating handler (i.e., applicator) exposure and post-application exposure to aerosol spray area foggers (ASAF) used to kill or repel flying insects in outdoor spaces like yards or patios. This exposure scenario can also be used to assess wasp/hornet spray products that typically have a more directed spray pattern than other types of outdoor foggers, for lack of scenario-specific data for these types of products. For handlers, inhalation and dermal exposure may occur during the application of the aerosol spray product (i.e., the spray event), thus dermal and inhalation exposure should be assessed. Post-application exposure may occur from inhalation exposure following a spray application, as well as dermal exposure resulting from residues deposited on the turf or lawn.

5.1.1 Handler Exposure Assessment

This section provides a standard method for completing handler exposure assessments for adults treating an outdoor space with outdoor aerosol spray foggers. It is assumed that only individuals 18 years of age or older apply (i.e. handle) pesticides. The basis for this scenario is that handler exposure occurs as the aerosol spray is being applied by the applicator holding the product can and activating the spray. The method should be used for estimating potential doses that residential users may receive during aerosol applications from inhalation and dermal contact when chemical specific data are unavailable.

This scenario assumes that pesticides may be inhaled or may come into contact with the skin during the application of aerosol spray products. The method to determine handler inhalation and dermal exposure to pesticides from aerosol applications relies on data from a study in which dermal and inhalation exposures were measured during use of an aerosol spray for indoor insecticide crack and crevice treatment, and is used in this scenario to represent an outdoor aerosol spray (see Appendix B). Thus, this method should be used in the absence of chemical-specific data, or as a supplement to estimates based on chemical-specific data.

Dermal and Inhalation Handler Exposure Algorithm

As described in *Section 1.3.3*, daily dermal and inhalation exposure (mg/day) for residential pesticide handlers is estimated by multiplying a unit exposure appropriate for the formulation and application method by an estimate of the amount of active ingredient handled in a day, using the equation below:

$$E = UE * AR \tag{5.1}$$

where:

- E = exposure (mg/day);
- UE = unit exposure (mg/lb ai); and
- AR = application rate (lb ai/day).

The application rate can be calculated as follows:

$$AR = A_{product} * A.I. * CF1 * N \tag{5.2}$$

where:

- AR = application rate (lb ai/ day);
- $A_{product}$ = amount of product in 1 can (oz or g/can);
- A.I. = percent active ingredient in product (% ai);
- CF1 = weight conversion factor (1 lb/16 oz or 1 lb/454 g); and
- N = number of cans used in one application (cans/day).

Alternatively, if the aerosol can contents are expressed as a volume in milliliters, the application rate for use in the exposure assessment can be calculated as follows:

$$AR = A_{product} * A.I. * CF1 * D_{product} * N \tag{5.3}$$

where:

- AR = application rate (lb ai/ day);
- $A_{product}$ = amount of product in 1 can (mL/can);
- A.I. = percent active ingredient in product (% ai);
- CF1 = weight conversion factor (1 lb/454 g);
- $D_{product}$ = density of product (g/mL); and
- N = number of cans used in one day (cans/day).

Dermal and/or inhalation doses normalized to body weight are calculated as:

$$D = \frac{E * AF}{BW} \tag{5.4}$$

where:

D	= dose (mg/kg-day);	
E	= exposure (mg/day);	
AF	= absorption factor (dermal and/or inhalation); and	
BW	= body weight (kg).	

Handler exposure for aerosol area spray applications is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.3* such as the product-specific application regimen. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Dermal and Inhalation Handler Exposure Algorithm Inputs and Assumptions

Recommended values for handler exposure (inhalation and dermal) assessments are provided in *Table 5-1* and *Table 5-2.* Following these tables, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 5-1: Area Foggers – Recommended Unit Exposure (mg/lb ai) Distributions and Point Estimates									
Formulation	**Equipment/Application Method**	**Dermal**			**Inhalation**			**Appendix Page Reference**
		Distribution		**Point Estimate**	**Distribution**		**Point Estimate**	
		Type	**Parameters**		**Type**	**Parameters**		
Ready-to-Use (RTU)	Aerosol can	Lognormal	GM = 329 GSD = 1.60		Lognormal	GM = 2.34 GSD = 2.01		B-130

Table 5-2. Residential Handler Scenario: Aerosol Spray Aerial Foggers Exposure Factors: Recommended Distributions and Point Estimates					
Algorithm Notation	Exposure Factor (units)		Distribution		Point Estimates
			Type	Parameters	
AR	Application rate (lb ai/ day)		Point Estimate	NA	
$D_{product}$	Density of product (g/mL)	Water-based products	Point Estimate	NA	1.0
		Solvent-based products	Point Estimate	NA	0.8
N	Number of cans used per day		Point Estimate	NA	
A.I.	Percent ai in product		Point Estimate	NA	
$A_{product}$	Amount of product per can (ounces, grams or milliliters)		Point Estimate	NA	
BW	Body weight (kg)		Empirical	Mean = 71.8 95^{th} = 97.9	
NA = not applicable					

Unit Exposures

As described in *Section 1.3.3*, the unit exposure is the ratio, for a given formulation/application method combination, of exposure to amount of active ingredient handled, with units of mass exposure per mass active ingredient handled (e.g., mg ai exposure/lb ai handled).

Application Rate (AR)

For the purposes of ASAF handler exposure assessment, the application rate is the amount of active ingredient applied per day. The application rate can be determined from product specific factors that are listed on the label or from generic factors listed above.

Number of cans (N)

Absent product- or chemical-specific data, it is assumed that 1 full can of product is applied by a residential handler at one time, and that one can of product represents a residential handler's complete insecticidal aerosol product use per day. According to the Residential Exposure Joint Venture (REJV) survey (REJV, 2002) no household surveyed used more than one aerosol spray area fogger product in one day. If extensive pest pressure exists, residential users would likely seek alternative application equipment.

Density ($D_{product}$)

The density should represent the product being assessed. If the product is water-based, the assessor should use the density of water (1.0 g/mL). If the product is solvent-based, the assessor should use 0.8 g/mL, an average based on an informal survey of various organic solvents described in CRC (Lide, 1981).

Amount of product (A product)

The amount of product (ounces, grams or milliliters per can) is a product-specific value and can be found on the product label.

Future Research/Data Needs

There are several main research/data needs with respect to the aerosol handler scenario. The monitoring study in which the unit exposures were derived was as study in which the spray application was completed indoors to baseboard. A monitoring study is needed in which the spray is conducted in a manner consistent with outdoor aerosol sprays to fully characterize dermal and inhalation handler exposure potential. Another data need is use pattern information to more accurately determine the amount of aerosol spray used by residential handlers. A use survey can provide information to obtain a probabilistic distribution for use in the ASAF handler assessment. In addition, there is a need for scenario-specific data to assess wasp/ hornet directed aerosol spray products, as these products typically have a modified delivery system (i.e. directed spray) than other outdoor foggers.

Exposure Characterization and Data Quality

The uncertainties associated with the handler assessment stem from the use of assumed amounts of aerosol product/active ingredient handled for typical residential aerosol applications, the use of insecticide crack and crevice unit exposures derived from one study to represent an outdoor exposure scenario, and the limited data source for the unit exposure values. As this one study represents the only available unit exposures for residential handlers of aerosol spray products, it is used to represent residential handler exposure. As mentioned above in the future research/data needs, the monitoring study in which the unit exposures were derived was completed indoors where applicators directed the aerosol spray towards the baseboards of a residence. The unit exposures were originally intended to represent an indoor insecticide crack/crevice treatment and may underestimate dermal and inhalation exposure to the upper body of the residential handler.

5.1.2 Post-application Exposure Assessment

Post-application exposure can result from activities performed in a treated patio or yard following aerosol spray area fogger pesticide applications. While exposure may occur for people of all ages, adults and toddlers are considered the sentinel populations based on behavioral characteristics and the strengths and limitations of available data.

This section addresses standard methods for estimating exposure and dose for three scenarios resulting from use of area foggers:

- Section 5.1.2.1 - adult/toddler inhalation exposure;
- Section 5.1.2.2 - adult/toddler dermal and toddler non-dietary exposure.

Post-application exposure is not anticipated to occur following pesticide application of wasp/ hornet products. These products are applied directly to insect nests/ hives and it is not likely that residential bystanders would be present in these areas.

5.1.2.1 Post-application Inhalation Exposure Assessment

The well-mixed box (WMB) model was used to develop the exposure equation for the aerosol area foggers post-application inhalation scenario (*See Appendix C.3* for additional detail on the WMB). The WMB was used to model pesticide air concentrations within an enclosed, fixed volume (i.e., a box) over time after an initial aerosol spray application of an area fogger. The WMB model incorporates a number of simplifying assumptions: fresh air (having no pesticide concentration) enters the box at a constant airflow rate; a turbulent internal airflow thoroughly mixes the fresh air with the pesticide-laden air resulting in a uniform pesticide air concentration within the box; and the perfectly mixed air exits the box at the same constant airflow rate (i.e., the inflow rate equals the outflow rate). Thus, the outdoor area where the aerosol is being applied is assumed to be in an enclosed box. Using the WMB model is conservative for estimation of exposures for an open patio or deck where dissipation is expected to be greater than the enclosed space that the WMB depicts.

The evacuation of the aerosol from the box depends on airflow. For an outdoor scenario, the airflow, Q, is the product of the cross-sectional area and the wind velocity. The WMB model developed for this scenario models the pesticide air concentrations *after* an initial, instantaneous release of an aerosol spray area repellant. Only dissipation due to airflow into and out of the box is modeled.

For the inhalation route of exposure, the point of departure (POD) could be based on the reference concentration (RfC) methodology. In the RfC methodology, air concentrations are not converted to doses, rather, risks are assessed on the basis of comparison of exposure concentrations with reference concentrations typically determined from animal studies. This approach is not always available for every chemical; therefore, the exposure assessor should discuss the possibility of this approach with a toxicologist.

Post-application Inhalation Exposure Algorithm

Post-application inhalation exposure to adults or toddlers in an area that has been treated with an aerosolized pesticide is largely dependent on the amount applied and the airflow. Due to the rapid dissipation of pesticide air concentrations from outdoor aerosol spray area repellants, exposure time is not a significant factor in the exposure calculation. Based on the minimum airflow rate in *Table 5-3*, the pesticide air concentration within the enclosed space is virtually zero (less than 0.1% of the initial concentration) after approximately 7 minutes. Additionally, a volume parameter is used in the WMB model equation describing the pesticide air concentrations over time, which is integrated to derive the exposure equation. However, the integration of the WMB model equation results in the volume term used to calculate the initial concentration (mass of active ingredient/volume of box) canceling out the volume term from the decay rate constant (See *Appendix C.3.1* for equation description and derivation).

$$E = \frac{IR * AR}{Q} \tag{5.5}$$

where:

E = exposure (mg/day);

IR = inhalation rate (m^3/hour);
AR = application rate (mg ai/day); and
Q = airflow through the treated area (m^3/hour).

and

The airflow through the treated space can be calculated as follows:

$$Q = AV * CF1 * CF2 * A_{cross\text{-}section} \quad (5.6)$$

where:

Q = airflow through treated space (m^3/hr);
AV = air velocity (m/s);
CF1 = time unit conversion factor (60 seconds/1 minute);
CF2 = time unit conversion factor (60 minutes / hour); and
$A_{cross\text{-}section}$ = cross-section of outdoor space treated (m^2).

and

The application rate can be calculated as follows:

$$AR = A_{product} * A.I. * CF1 * N \quad (5.7)$$

where:

AR = application rate (mg ai/ day);
$A_{product}$ = amount of product in 1 can (oz or g/can);
A.I. = percent active ingredient in product (% ai);
CF1 = weight conversion factor (28350 mg/oz or 1000mg/g); and
N = number of cans applied per day in one application (cans/day).

Alternatively, if the aerosol can contents are expressed as a volume in milliliters, the application rate for use in the exposure assessment can be calculated as follows:

$$AR = A.I. * A_{product} * CF * D_{product} * N \quad (5.8)$$

where:

AR = application rate (mg ai/day);
A.I. = percent active ingredient in product (% ai);
$A_{product}$ = amount of product per can (mL/can);
CF =conversion factor to convert grams to milligrams (1,000 mg/1 g);
$D_{product}$ = density of product (g/mL); and
N = number of cans applied per day in one application (cans/day).

Inhalation dose normalized to body weight is calculated as:

$$D = \frac{E * AF}{BW} \tag{5.9}$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

Post-application inhalation exposure following applications of outdoor aerosol foggers is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Inhalation Exposure Algorithm Inputs and Assumptions

Recommended parameters for post-application inhalation exposure assessments are provided in *Table 5-3* below. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 5-3: Aerosol Spray Area Foggers – Recommended Inhalation Exposure Factors Distributions and Point Estimates

Algorithm Notation	Exposure Factor (units)		Distribution		Point Estimate(s)
			Type	Parameters	
AR	Application rate (mg ai/ day)		Point Estimate	NA	
$A_{cross\text{-}section}$	Cross sectional area of area treated (m^2)		Point Estimate	NA	15
AV	Air velocity (m/sec)		Uniform	0.1 - 1.5	
Q	Airflow through treated area (m^3/hr)		Uniform	5,400 -81,000	
N	Number of cans applied per day in one application (cans/day)		Point Estimate	NA	
$D_{product}$	Density of product (g/mL)	Water-based products	Point Estimate	NA	1.0
		Solvent-based	Point Estimate	NA	0.8

Table 5-3: Aerosol Spray Area Foggers – Recommended Inhalation Exposure Factors Distributions and Point Estimates					
Algorithm Notation	**Exposure Factor (units)**		**Distribution**		**Point Estimate(s)**
			Type	**Parameters**	
		products			
A.I.	Percent ai in product (%)		Point Estimate	NA	
$A_{product}$	Amount of product (mL/can)		Point Estimate	NA	
IR	Inhalation rate (m^3/hour)	Adult	Empirical	Mean = 0.32 95^{th} = 0.42	
		Toddler	Empirical	Mean = 0.27 95^{th} = 0.35	
BW	Body Weight (kg)	Adult	Empirical	Mean = 71.8 95^{th} = 97.9	
		Toddler	Empirical	Mean = 18.6 95^{th} = 26.2	

Application Rate (AR)

The application rate is the amount of active ingredient applied per day. The application rate can be determined from product specific factors that are listed on the product label. This application rate is determined by amount of product in a can, how many cans are used in an application, and the percentage of active ingredient.

Air Velocity (AV)

The air velocity is the speed of the air moving through the treated area defined for the well-mixed box model. The fraction of the chemical available for inhalation in outdoor air is a function of the ventilation rate in the backyard "box". The air velocity determines the rate at which the contents of the outdoor area treated are evacuated. Wind velocity is an influencing factor affecting mosquito attraction. Bidlingmayer et al. (1995) examined the effect of wind velocity on suction trap catches. Their research noted that trap catches declined as wind velocities increased over the entire range of observed velocities. Wind velocities within the range of normal mosquito flights, about 1 m/s resulted in trap catch reductions on significant nights of approximately 50% by wind of 0.5 m/s and 75% at 1.0 m/s.

The wind speed range considered here corresponds with the lower two tiers of the Beaufort wind force scale, an empirical measure for describing wind speed. The Beaufort wind force scale range a numerical basis of 0-10, from still air conditions up to hurricane force winds. This SOP covers Beaufort number 0-1. The Beaufort number 0 corresponds with calm wind conditions of <0.3 m/s [18 meters/minute; 0.7 mph]. The Beaufort number 1 corresponds with light air conditions of 0.3-1.5 m/s [18-90 meters/minute; 0.7–3.4 mph]. Thus, this SOP provides a distribution of wind velocities from 0.1-1.5 m/s [0.2-3.4 mph], the upper limit for "light air" condition on the Beaufort scale and a reasonable upper bound for wind velocities where these products would be used to control flying pests. This windspeed represents a range of values foreseeable where ASAF products may be used (i.e., in a yard or on an outdoor patio where flying pests may pose a nuisance). When wind velocities are higher than 1.5 m/s, these products are less likely to be used because of reduced flying pest pressure.

The recommended point estimate for use in a deterministic exposure assessment is **[XX]**. Probabilistic assessments should use a range of air velocities from 0.1 m/s to 1.5 m/s.

Airflow (Q)

In the well-mixed box model, the airflow through the treated space is the product of the air velocity and the cross-sectional area, with units m^3/hour. Airflow is defined as the volume of natural air that uniformly passes through a given area in a specified period of time. The airflow is a function of the cross-sectional area and wind velocity. A cross-sectional area of the space treated it is assumed to be 20 ft x 8 ft (160 ft^2 or 15 m^2). A conservative wind velocity of 0.1 m/s is assumed to represent calm air conditions, with a maximum wind velocity of 1.5 m/s. Therefore, the airflow for a typical space treated is assumed to range from 5,400 m^3/hour (as the conservative default value) to 81,000 m^3/hour (representing a high-end wind velocity for calm air conditions).

$A_{cross\ section}$

$A_{cross\text{-}section}$ represents the cross-sectional area of the volume of treated space for this exposure scenario, with units m^2. Unless otherwise specified by the product label, the exposure scenario for aerosol spray considers a 20 ft. x 20 ft. x 8 ft. space treated. Therefore, the cross-sectional area for the treated space of is 160 ft^2 (20 ft width x 8 ft height) or 15 m^2 (see description of volume of treated space in the Outdoor Residential Misting System *Section 5.3.2.1*).

Number of Cans per Day (N)

Absent product- or chemical-specific data, it is assumed that 1 full can of product is applied by a residential handler at one time, and that one can of product represents a residential handler's complete insecticidal aerosol product use per day. According to the Residential Exposure Joint Venture (REJV) survey (REJV, 2002) no household surveyed used more than one aerosol spray area fogger product in one day. If extensive pest pressure exists, residential users would likely seek alternative application equipment.

Density ($D_{product}$)

The density should represent the product being assessed. If the product is water-based, the assessor should use the density of water (1.0 g/mL). If the product is solvent-based, the assessor should use 0.8 g/mL, an average based on an informal survey of various organic solvents described in CRC (Lide, 1981).

Amount of product ($A_{product}$)

The amount of product (ounces, grams, or milliliters per can) is a product-specific value and should be stated on the label.

Future Research/Data Needs

There are three main potential research/data needs with respect to the post-application aerosol spray area fogger scenario. (1) The ASAF exposure scenario assumes that residential users treat a 20 ft x 20 ft space, unless otherwise specified on the label. Survey and efficacy data could be produced to examine the actual size of the amount of space treated by typical aerosol spray area foggers. (2) No data are available to indicate the spatio-temporal distribution pattern that results from the release of an aerosol spray can. Studies could be designed to capture the deposition pattern of aerosol spray pesticides in outdoor conditions. (3) Survey data could be produced to examine the amounts of aerosol spray product/active ingredient handled during typical outdoor treatment scenarios.

Exposure Characterization and Data Quality

The uncertainties associated with this assessment stem from the use of assumed amount of aerosol product during the product application, the typical area treated, and the use of the well-mixed box model. The simplifying assumptions implicit in the well-mixed box model identified in the first two paragraphs of *Section 5.2.1.1* would tend to be health protective, since the modeled air concentrations would dissipate less rapidly (resulting in higher pesticide concentrations) in the artificially defined fixed volume compared to a true open outdoor space. The ASAF exposure scenario makes the conservative assumption that all of the applied pesticide is in the air available for inhalation exposure, and then that all of the applied pesticide settles onto the turf and is available for dermal exposure. The estimated doses derived from this exposure scenario are believed to be high-end, conservative estimates.

5.1.2.2 Post-application Dermal and Non-dietary Ingestion Exposure Assessment

Dermal and incidental oral post-application exposures are expected to occur after the spray settles onto the turf areas of a treated yard. This settling is assumed to occur in a uniform fashion throughout the treated area, similar to a direct lawn broadcast treatment. Once the application rate is determined, the turf transferable residues and resulting dermal and incidental oral exposures should be assessed following the methodologies outlined in *Section 3.2*.

The following equation can be used to convert the application rate in pounds ai per square foot as is deposited on the turf:

$$AR = \frac{\mathrm{A_{product}} * \mathrm{A.I.} * \mathrm{CF1} * \mathrm{N}}{T_A} \tag{5.10}$$

where:

AR	= application rate (lb ai/ ft^2 or lb ai/A);
$A_{product}$	= amount of product per can (oz or g/can);
A.I.	= percent active ingredient in product (% ai);
CF1	= weight conversion factor (1 lb/16 oz or 1 lb/454 g);
N	= number of cans applied per day in one application (cans); and
T_A	= treated area (ft^2 or A).

Alternatively, if the aerosol can contents are expressed as a volume in milliliters, the application rate for use in the exposure assessment can be calculated as follows:

$$AR = \frac{\mathrm{A_{product}} * \mathrm{A.I.} * \mathrm{CF} * \mathrm{D_{product}} * \mathrm{N}}{T_A} \tag{5.11}$$

where:

- AR = application rate (lb ai/ft^2 or lb ai/A);
- A.I. = percent active ingredient in product (% ai);
- $A_{product}$ = amount of product per can (mL/can);
- CF = conversion factor (1 lb/ 454 g);
- $D_{product}$ = density of product (g/mL);
- N = number of cans per day in one application (cans); and
- T_A = treated area (ft^2 or A).

Post-application dermal and non-dietary ingestion exposure following applications of outdoor aerosol foggers is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Dermal and Non-Dietary Ingestion Algorithm Inputs and Assumptions

The following provides a general discussion for each exposure factor and derivation of recommended distributions and point estimates for use in exposure assessment.

Application Rate (AR)

The application rate is the amount of spray applied per unit area. The application rate per day/spray can be determined from product specific factors that are listed on the label or from generic factors listed above. This application rate is calculated in lbs ai/ ft^2 or lb ai/A.

Amount of product ($A_{product}$)

The amount of product (ounces, grams, or milliliters per can) is a product-specific value and should be stated on the label.

Number of cans per day (cans)

Absent product- or chemical-specific data, it is assumed that 1 full can of product is applied by a residential handler at one time, and that one can of product represents a residential handler's complete insecticidal aerosol product use per day. According to the Residential Exposure Joint Venture (REJV) survey (REJV, 2002) no household surveyed used more than one aerosol spray area fogger product in one day. If extensive pest pressure exists, residential users would likely seek alternative application equipment.

Percent Active Ingredient in Product (A.I.)

The percent active ingredient in the product being assessed can be determined from the product label.

Treated Area (T_A)

The recommended treated area is based on a recent survey on U.S. decking market which was conducted by the Center for International Trade in Forest Products (CINTRAFOR). In this survey, CINTRAFOR contacted a random sample of U.S. homebuilders via telephone. Based on the survey results, it was determined that the mean deck size for spec homes (n=109) was 361ft^2. This translates to approximately a 20 ft x 18 ft surface area. The mean deck size for custom homes (n=174) was 490 ft^2 (Eastin, et al. 2005). This translates to approximately 20 ft x 24.5 ft surface area. The overall mean deck size identified in this survey is believed to be is an appropriate surrogate for the amount of outdoor living space treated by aerosol fogging products. Therefore, in the absence of additional information, 20 ft. x 20 ft. x 8 ft. is used as the volume of space that is treated with an aerosol fogger and 20 ft x 20 ft is used as the surface area of a treated area.

Future Research/Data Needs

There are four main potential research/data needs with respect to the post-application aerosol spray area fogger scenario. (1) The ASAF exposure scenario assumes that residential users treat a 20 ft x 20 ft space unless otherwise specified on the product label. Survey and efficacy data could be produced to examine the actual size of the amount of space treated by typical aerosol spray area foggers. (2) No data are available to indicate the deposition pattern that results from the release of an aerosol spray can. Studies could be designed to capture the deposition pattern of aerosol spray pesticides in outdoor conditions. (3) Survey data could be produced to examine the amounts of aerosol spray product/active ingredient handled during typical outdoor treatment scenarios. (4) No data are available to indicate the extent of dermal deposition on skin from airborne particles as a result of aerosolized pesticide sprays. Studies could be designed to capture the extent of dermal deposition as a result of aerosolized pesticide sprays.

Exposure Characterization and Data Quality

The uncertainties associated with this assessment stem from the use of assumed amount of aerosol product during the product application, the typical area treated, and the surface deposition resulting from use of aerosolized pesticide sprays. The ASAF exposure scenario makes the conservative assumption that all of the applied pesticide is in the air available for inhalation exposure, and then that all of the applied pesticide settles onto the turf and is available for dermal exposure.

5.1.2.3 Combining Post-application Scenarios

Risks resulting from different exposure scenarios are combined when it is likely that they can occur simultaneously based on the use pattern and when the toxicological effects across different routes of exposure are the same. When combining scenarios, it is important to fully characterize the potential for co-occurrence as well as characterizing the risk inputs and estimates. Risks should be combined even if any one scenario or route of exposure exceeds the level of concern because this allows for better risk characterization for risk managers.

It is likely that toddlers could be exposed to an area treated by ASAF product via inhalation, dermal and non-dietary ingestion (hand-to-mouth) routes and that these scenarios could occur simultaneously. Therefore, these exposure scenarios should be combined when toxicological effects are the same across these routes of exposure.

5.2 Candles, Coils, Torches & Mats (CCTM)

Candles, coils, torches and mats (CCTM) are pesticide products that are ignited or placed on a burner to release the active ingredient as a smoke or vapor in order to repel insects. The scenario represents use of CCTM products for a gathering of people outdoors in a yard or on a patio using the product(s) to repel flying pests. This section provides standard methods for estimating potential exposure to pesticides from the use of pesticidal candle, coil, torch or mat for the purposes of outdoor pest control.

Handler exposure, both dermal and inhalation, is expected to be negligible as the application activity (i.e., product activation) does not involve application (e.g., spraying liquids or spreading granules) in the typical sense. However, adult and toddler post-application inhalation exposure resulting from being in proximity to CCTM products following activation is the primary exposure route. Post-application dermal exposure from CCTM use is expected to be negligible.

5.2.1 Handler Exposure Assessment

Pesticidal candles, coils, torches and mats are typically marketed for residential use to repel flying insects and pests. Upon activation (i.e., ignition or heating), these products emit small particles (<2 µm) over the useful life of the product (Lucas, J., EPA, Allethrins SMART Meeting, 10/17/03). Handler exposure need not be assessed quantitatively because the ignition or activation of these products is instantaneous.

5.2.2 Post-Application Exposure Assessment

Post-application exposure can result from presence in a patio or yard following use of candles, coils, torches, or mats containing pesticides. While exposure may occur for people of all ages, adults and toddlers are considered the sentinel populations based on behavioral characteristics and the strengths and limitations of available data.

This section addresses standard methods for estimating exposure and dose for three scenarios resulting from use of candles, coils, torches, and mats:

- Section 5.2.2.1 - adult/toddler inhalation exposure;
- Section 5.2.2.2 - adult/toddler dermal and toddler non-dietary exposure.

5.2.2.1 Post-application Inhalation Exposure Assessment

Post-application inhalation exposure occurs as a result of inhalation of the airborne emission released by the pesticidal candle, coil, torch or mat. This section provides a standard method for completing post-application inhalation exposure assessments for adults and toddlers during the use of pesticidal candles, coils, or mats for short-term pest control.

As with the outdoor fogger, the algorithm assumes a simple WMB model adequately represents the exposure scenario (See *Appendix C.2* for additional details on the WMB). The algorithms represented in this scenario assume that no further inhalation exposure occurs after the CCTM is spent or extinguished. Since the exposure potential to CCTM products is higher while the products are in use, the exposure scenario assumes that the CCTM product is in use for the entire exposure time.

The WMB model was used to develop the exposure equation for the CCTM post-application inhalation scenario (Fan, et al, 2001). The CCTM scenarios differs from the other exposure scenarios in this SOP section in that the WMB model includes a constant emission rate term during the exposure time and thus results in a more complex exposure equation. The WMB was used to model pesticide air concentrations within an enclosed, fixed volume (i.e., a box) over time during the constant emission of a pesticide from a CCTM product. The WMB model incorporates a number of simplifying assumptions: fresh air (having no pesticide concentration) enters the box at a constant airflow rate; a turbulent internal airflow thoroughly mixes the fresh air with the pesticide-laden air resulting in a uniform pesticide air concentration within the box; and the perfectly mixed air exits the box at the same constant airflow rate (i.e., the inflow rate equals the outflow rate). Thus, the outdoor area where the CCTM product is being applied is assumed to be in an enclosed box. Using the WMB model is conservative for estimation of exposures for an open patio or deck where dissipation is expected to be greater than the enclosed space that the WMB depicts.

The evacuation of the CCTM emission from the box depends on airflow. For an outdoor scenario, the airflow, Q is the product of the cross-sectional area and the wind velocity. The WMB model developed for this scenario models the pesticide air concentrations *during* a constant emission of pesticide from a CCTM product. Only constant emission and dissipation due to airflow into and out of the box is modeled.

For the inhalation route of exposure, the point of departure (POD) could be based on the reference concentration (RfC) methodology. In the RfC methodology, air concentrations are not converted to doses, rather, risks are assessed on the basis of comparison of exposure concentrations with reference concentrations typically determined from animal studies. This approach is not always available for every chemical; therefore, the exposure assessor should discuss the possibility of this approach with a toxicologist.

Post-application Inhalation Exposure Algorithm

The following algorithm is used to determine post-application inhalation exposure to the CCTM products (See *Appendix C.3.2* for equation description and derivation):

$$E = \frac{IR \cdot V_E \cdot ER}{Q}\left(ET - \frac{V}{Q}\right) \qquad (5.12)$$

where:

E = exposure (mg/day);
IR = inhalation rate (m^3/hr);
V_E = vaporization efficiency (%);

ER = emission rate (mg ai/hr);
ET = exposure time (hr/day);
V = volume of treated space (m^3); and
Q = airflow (m^3/hr).

The airflow through the treated space can be calculated as follows:

$$Q = AV * CF1 * CF2 * A_{cross\text{-}section} \tag{5.13}$$

where:

Q	=	airflow through treated space (m^3/hr);
AV	=	air velocity (m/s);
CF1	=	time unit conversion factor (60 seconds/1 minute);
CF2	=	time unit conversion factor (60 minutes / hour); and
$A_{cross\text{-}section}$	=	cross-section of outdoor space treated (m^2).

The emission rate from a CCTM product can be calculated as follows:

$$ER = \frac{A * N_P}{UL} \tag{5.14}$$

where:

ER = emission rate (mg ai/hr);
A = amount of mg ai in CCTM product (mg ai/product);
N_P = number of products used (products); and
UL = useful life of product (hours).

Inhalation dose normalized to body weight is calculated as:

$$D = \frac{E * AF}{BW} \tag{5.15}$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (inhalation); and
BW = body weight (kg).

Post-application inhalation exposure following uses of candles, coils, torches, or mats is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Inhalation Exposure Algorithm Inputs and Assumptions

Recommended values for post-application inhalation exposure assessments are provided in *Table 5-4* below. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 5-4: CCTM – Recommended Inhalation Exposure Factor Distributions and Point Estimates

Algorithm Notation	Exposure Factor (units)		Distribution Type	Distribution Parameters	Point Estimate(s)
V_E	Vaporization efficiency (percent)		NA	NA	100% assumed unless registrant provides data for product
A	Amount of ai in the product (mg)		Point Estimate	NA	
ER	Emission rate (mg ai/hr)		Point Estimate	NA	
UL	Useful life (hours)	Candles/Coils/Torches	Uniform	4-6	5
		Mats	Point Estimate	NA	10
ET	Exposure time (hours)	Adults	Empirical	50^{th} = 0.9 90^{th} = 3.5	
		Toddlers	Empirical	50^{th} = 0.9 90^{th} = 3.5	
V	Volume of treated space (m^3)		Point Estimate	NA	51
Q	Airflow through treated area (m^3/hr)		Uniform	4,000 – 60,000	
AV	Air velocity (m/s)		Uniform	0.1 – 1.5	
N_P	Number of products used (# products)		Point Estimate	NA	
$A_{cross-section}$	Cross sectional area of area treated (m^2)		Point Estimate	NA	11
IR	Inhalation rate (m^3/hour)	Adults	Empirical	Mean = 95^{th} =	
		Toddler	Empirical	Mean = 95^{th} =	
BW	Body Weight (kg)	Adults	Empirical	Mean = 71.8 95^{th} = 97.9	
		Toddler	Empirical	Mean = 18.6 95^{th} = 26.2	

Vaporization Efficiency (V_E)

Vaporization efficiency is the percentage of active ingredient in the product that becomes available for inhalation exposure through heating, burning, or activation of the product.

As a CCTM product is heated or burned, it is likely that not all of the active ingredient in the product will be available for inhalation exposure. If this information is available through product efficacy studies or other sources, it can be used in the equation. In the absence of data, 100% vaporization efficiency will be assumed for the active ingredient.

Amount of Active Ingredient in Product (A)

The amount of active ingredient available in the product (e.g., mg ai/product) found on the product label.

Emission Rate (ER)

The emission rate (mg ai/hour) is the amount of active ingredient available in the product, measured in milligrams ai/product divided by the Useful Life (UL) of the product.

Useful Life (UL)

The Useful Life is the time (measured in hours) that the CCTM product is active (i.e. is active as an emission source). For example, many candles and coils have a 4-6 hour useful life. Mosquito mats often have a useful life of 10 hours. This can also be a product-specific input. (Lucas, J., EPA Allethrins SMART Meeting, 10/17/03).

Exposure Time (ET)

Another important variable for addressing post-application exposure is the duration of time spent in areas treated by CCTM products. The exposure time for adults and toddlers conservatively assumes that the time spent in the volume of treated space is equivalent to the time spent outdoors. In order to be protective of children and to address the uncertainty in the upper percentiles of the exposure factor data when conducting a probabilistic assessment, an empirical distribution (which was expressed as a cumulative distribution function) from the Exposure Factors Handbook Table 15-80 (USEPA, 1997) with a bound of 3.5 hours for children should be used. This distribution represents the amount of time spent outdoors (see *Table 5-5*). **Based on these data, the recommended point estimate for use in post-application dermal exposure assessment [XX] hrs/day represents approximately the [XX]th percentile.**

Table 5-5: Time Spent Outdoors for Adults and Children	
Statistic	**Hours per Day**
0th percentile	0.00
5th percentile	0.25
25th percentile	0.33
50th percentile	0.90
75th percentile	2.45
90th percentile	3.5
100th percentile	3.5

Volume (V)

The volume of treated space is assumed to be 51 m^3 for CCTM products, unless otherwise noted on an available product label. The 51 m^3 volume represents a 15 ft. x 15 ft. x 8 ft. (1800 ft^3)

treated patio or yard area. This represents a typical treated space based on the experience and professional judgment and review of current product labels that pertain to this exposure scenario.

Airflow (Q)
In the well-mixed box model, the airflow through the treated space is the product of the air velocity and the cross-sectional area, and is measured in m^3/hour. Airflow is defined as the volume of natural air that uniformly passes through a given area in a specified period of time. The airflow is a function of the cross-sectional area and wind velocity. A cross-sectional area of the space treated it is assumed to be 15 ft x 8 ft (120 ft^2, or 11 m^2). A conservative wind velocity of 0.1 m/s is assumed to represent calm air conditions, with a maximum wind velocity assumed to be 1.5 m/s. Therefore, the airflow for a typical space treated is assumed to range from 4,000 m^3/hour (as the conservative default value) to 60,000 m^3/hour.

Air Velocity (AV)
The air velocity is the speed of the air moving through the treated volume defined for the well-mixed box model. The fraction of the chemical available for inhalation in outdoor air is a function of the ventilation rate in the backyard "box". The air velocity determines the rate at which the contents of the outdoor area treated are evacuated. Wind velocity is an influencing factor affecting mosquito attraction. Bidlingmayer et al. 1995 examined the effect of wind velocity on suction trap catches. Their research noted that trap catches declined as wind velocities increased over the entire range of observed velocities. Wind velocities within the range of normal mosquito flights, about 1 m/s resulted in trap catch reductions on significant nights of approximately 50% by wind of 0.5 m/s and 75% at 1.0 m/s.

The wind speed range considered here corresponds with the lower two tiers of the Beaufort wind force scale, an empirical measure for describing wind speed. The Beaufort wind force scale range a numerical basis of 0-10, from still air conditions up to hurricane force winds. This SOP covers Beaufort number 0-1. The Beaufort number 0 corresponds with calm wind conditions of <0.3 m/s [18 meters/minute; 0.7 mph]. The Beaufort number 1 corresponds with light air conditions of 0.3-1.5 m/s [18-90 meters/minute; 0.7–3.4 mph]. Thus, this SOP provides a distribution of wind velocities from 0.1-1.5 m/s [0.2-3.4 mph], the upper limit for "light air" condition on the Beaufort scale and a reasonable upper bound for wind velocities where these products would be used to control flying pests. This windspeed represents a range of values foreseeable where CCTM products may be used (i.e., in a yard or on an outdoor patio where flying pests may pose a nuisance). When wind velocities are higher than 1.5 m/s, these products are less likely to be used because of reduced flying pest pressure.

The recommended point estimate for use in a deterministic exposure assessment is **[XX]**. Probabilistic assessments should use a range of air velocities from 0.1 m/s to 1.5 m/s.

Number of Products Used (Np)
The number of products is related to the size of the space treated by the product user. A product user is typically directed to use a proportional amount of product per area (e.g., if 1 CCTM treats a 15 ft x 15 ft area, then treating twice the space would require double the product). The airborne concentration of active ingredient is the same in both examples. Therefore, the CCTM exposure scenario considers the smallest typical treatment area (i.e., 15 ft x 15 ft). The recommended point

estimate for use in a deterministic exposure assessment is 1 product used for the default treated space size (15 ft x 15 ft area). This value can be adjusted based on product-specific label directions for how many CCTM products can treat the typical 15 ft by 15 ft area.

$A_{cross\ section}$

$A_{cross\text{-}section}$ represents the cross-sectional area of the volume of treated space for this exposure scenario, measured in m^2. Unless otherwise specified by the product label, the exposure scenario for CCTM considers a 15ft x 15 ft x 8 ft area; therefore the cross-sectional area for the treated space is 15 ft width x 8 ft height (120 ft^2) or 11 m^2.

Future Research/Data Needs

No data are available to indicate the extent of dermal deposition on human skin from airborne particles released from the activation of candles, coils, torches, and mats. Studies could be designed to capture the extent of dermal deposition as a result of airborne pesticide particles.

Exposure Characterization and Data Quality

The uncertainties associated with this assessment stem from the use of assumed amount of active ingredient released during the product use, the vaporization efficiency term, and the use of the well-mixed box model. The simplifying assumptions implicit in the well-mixed box model identified in the first two paragraphs of *Section 5.2.1.1* would tend to be health protective, since the modeled air concentrations would dissipate less rapidly (resulting in higher pesticide concentrations) in the artificially defined fixed volume compared to a true open outdoor space.

Due to relative long life (e.g., 4-6 hours for candles & ~10 hours for mats) of CCTM products compared to the time spent outdoors, the algorithm models the air concentration during the "burn time" of the CCTM products. Exposure time is typically less than the burn time of the product. If time spent outdoors (exposure time) were to exceed the useful life of such products, the exposure equation derived for this section would need to be modified to account for the change in the emission rate of the product. However, the use of the exposure equation in this section represents a health protective approach since a source emission continued beyond the useful life of the product would overestimate pesticide air concentrations.

5.2.2.2 Post-application Dermal and Non-Dietary Ingestion Exposure Assessment

The inhalation route of exposure is expected to be the primary route. Residues deposited on patios or other surfaces are expected to be negligible after use of a CCTM product. Due to the size fraction of particles released from the activation of CCTM products, particles are expected to remain airborne rather than be deposited on surfaces. Therefore, dermal and incidental oral post-application exposures to surface residues do not need to be quantitatively assessed.

5.2.2.3 Combining Post-application Scenarios

Risks resulting from different exposure scenarios are combined when it is likely that they can occur simultaneously based on the use pattern and when the toxicological effects across different routes of exposure are the same. When combining scenarios, it is important to fully characterize the potential for co-occurrence as well as characterizing the risk inputs and estimates. Risks should be combined even if any one scenario or route of exposure exceeds the level of concern because this allows for better risk characterization for risk managers.

As no residues from CCTM products are expected to be deposited on patios or other surfaces, no post-application dermal and non-dietary ingestion exposures are expected to occur. Therefore, these exposure scenarios are not assessed, and are not combined with post-application inhalation exposure.

5.3 Outdoor Residential Misting Systems

Outdoor residential misting systems (sometimes called "mosquito misters") are application systems designed to spray pesticides in a fine mist to kill mosquitoes and other insects outdoors. Misting systems include spray nozzles that are mounted around the perimeter of a home in the lawn or landscaping, or on parts of the house or fence. The spray nozzles are connected by tubing to a supply of insecticide. These systems can operate automatically (i.e., at preset intervals) or manually (e.g., remote control or switch).

This section provides standard methods for estimating potential doses from pesticides applied using outdoor residential misting systems (ORMS) in yards or on patios. Adults filling the ORMS drums with the pesticide have the potential for dermal and inhalation exposure. Adults and toddlers occupying the yard or patio following the application of a pesticide using an ORMS have the potential for inhalation, dermal and incidental oral exposure. This section provides the methods for estimating the potential dose for handlers using ORMS, the method for estimating the potential dose from post-application inhalation exposure to a treated yard or patio, as well as the method for estimating residue deposited on the lawn following a pesticidal treatment from the ORMS which can be used in conjunction with methods outlined in *Section 3.2* to estimate dermal and oral post-application doses following direct applications to lawns.

5.3.1 Handler Exposure Assessment

Mosquito misters are typically marketed as systems that include a mix tank, a timer controlled pump, and fixed pipes or hoses that run to the nozzles. The systems are often professionally installed and include a service contract to cover maintenance and insecticide refilling. However, it is possible for residential homeowners to purchase the pesticide and load the tank (or drums); therefore residential handler scenario is included.

This section provides a standard method for completing handler exposure assessments for adults mixing and loading pesticides to be used in outdoor residential misting systems. It is assumed that only individuals 18 years of age or older mix and load (i.e. handle) pesticides. The basis for this scenario is that handler exposure occurs as the pesticide is poured into the drum by the applicator holding the product container; no applicator scenario was assessed as the misting nozzles spray the pesticide in the treatment area automatically.

This scenario assumes that pesticides are available to be inhaled or have the potential to come into contact with the skin during the mixing and loading of the pesticide products in the drums as part of the residential misting system. The method to determine handler inhalation and dermal exposure to pesticides from these activities relies on data measuring dermal and inhalation exposure during mixing and loading (pouring a liquid pesticide). Thus, this method should be used in the absence of chemical-specific data, or as a supplement to estimates based on chemical-specific data.

Dermal and Inhalation Handler Exposure Algorithm

As described in *Section 1.3.3*, daily dermal and inhalation exposure (mg/day) for residential pesticide handlers, for a given formulation-application method combination, is estimated by multiplying the formulation-application method-specific unit exposure by an estimate of the amount of active ingredient handled in a day, using the equation below:

$$E = UE * AR \qquad (5.16)$$

where:

E = exposure (mg/day);
UE = unit exposure (mg/lb ai); and
AR = application rate (lb ai/day).

and

The application rate can be calculated as follows:

$$AR = V_D * N * DR * A.I. * D_{H2O} \qquad (5.17)$$

where:

AR = application rate per day (lb ai/ day);
V_D = volume of the drum of the misting system (gallons/drum);
N = number of drums filled per day (drums/day)
DR = dilution rate (volume product / volume total solution);
A.I. = percent active ingredient in product (%); and
D_{H2O} = water density (lb/gal).

Dermal and/or inhalation doses normalized to body weight are calculated as:

$$D = \frac{E * AF}{BW} \qquad (5.18)$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

Handler exposure for outdoor residential misting systems is generally considered either acute or short-term in duration as filling the centralized reservoir tanks typically occur once in a 90 day period. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.3* such as the product-specific application regimen. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Dermal and Inhalation Handler Exposure Algorithm Inputs and Assumptions

Recommended values for handler exposure (inhalation and dermal) assessments are provided in *Table 5-6* and *Table 5-7*. Following these tables, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 5-6: Outdoor Residential Misting Systems – Recommended Unit Exposure (mg/lb ai) Distributions and Point Estimates

Formulation	Equipment/Application Method	Dermal			Inhalation			Appendix Page Reference
		Distribution		Point Estimate	Distribution		Point Estimate	
		Type	Parameters		Type	Parameters		
Liquid concentrates	Mixing/loading	NA	NA		NA	NA		NA
Note: Unlike other tables describing unit exposures, these are directly from the Pesticide Handlers Exposure Database (PHED) and thus are not presented in a statistical distribution context.								

Table 5-7: Outdoor Residential Misting Systems – Recommended Handler Exposure Factor Distributions and Point Estimates				
Algorithm Notation	**Exposure Factor (units)**	**Distribution**		**Point Estimate(s)**
		Type	**Parameters**	
AR	Application rate (lb ai/ day)	Point Estimate	NA	
D_{H20}	Density of product (lb/gal)	Point Estimate	NA	8.34
V_D	Volume of Drum (gallons/drum)	Point Estimate	NA	
DR	Dilution Rate (volume product / volume total solution)	Point Estimate	NA	Product-specific
N	Number of drums filled per day (drums/day)	Point Estimate	NA	
A.I.	Percent ai in product (%)	Product-specific	NA	
BW	Body weight (kg)	Empirical	Mean = 71.8 95^{th} = 97.9	
NA = not applicable				

Unit Exposure (UE)

As described in *Section 1.3.3*, the unit exposure is the ratio, for a given formulation/application method combination, between exposure and the amount of active ingredient handled, with units mass exposure per mass active ingredient handled (e.g., mg ai exposure/lb ai handled). The recommended point estimate shown in *Table 5-6* represents a central tendency value from the Pesticide Handler Exposure Database (PHED) and is derived from studies monitoring mixing/loading and applying liquid formulations.

Drum Volume (V_D)

The drum feeds into the plumbing that leads to the nozzles of the residential misting system. The default drum size is based on a typical drum size (30 or 55 gallons).

Number of drums filled per day (N)

One drum is assumed to be filled per day, as residential misting systems are likely only connected to one drum.

Dilution Rate (DR)

The label should state the amount (e.g., gallons) of concentrated product per amount of water. This can also be given as parts of product per parts of water. Dilution rate is the volume of the product amount stated on the label divided by the sum of product volume and water volume (i.e., volume total solution).

Water Density (D_{H2O})

The dilute solution of pesticide for application through the misting system is assumed to have the same density as water (i.e., 8.34 lbs/gallon), since pesticide concentrate is typically mixed with large volumes of water.

Future Research/Data Needs

There is one main research/data need with respect to the outdoor residential misting system scenario. (1) Research by OPP and ORD revealed little about the prevalence and use of these systems by the general public. Survey data could be produced to examine the prevalence of these systems, the breakdown of maintenance (i.e., characterizing the percentage of systems that are professional maintained versus homeowner maintained) and to better characterize the frequency of the mixing/loading activity by residential handlers (i.e. how often the systems are refilled/reloaded).

Exposure Characterization and Data Quality

These unit exposures are from the "All Liquids, Open Mixing and Loading" Scenario in the SOPs for Residential Exposure Assessments (July 18, 1997) which are from PHED. The SOP states that "this scenario is not completely representative of homeowner products because the data are based on the use of agricultural products. In these scenarios, more chemical would typically be handled and the material is generally packaged in larger quantities. However, these data represent the best available data set for determining exposures during open pouring with liquid chemicals. No data are available to assess the differences between the agricultural and the residential scenarios."

5.3.2 Post-Application Exposure Assessment

Post-application exposure can result from conducting physical activities following applications of residential misting systems. While exposure may occur for people of all ages, adults and toddlers are considered the sentinel populations depending on the exposure scenario based on behavioral characteristics and the strengths and limitations of available data.

Automatic spray systems were originally used in animal housing structures such as dairy barns to control flying insects. Recently, these systems have been adapted for use in residential sites including residential yards to control mosquitoes. These systems are fed from a central holding tank and utilize an array of spray nozzles to automatically deliver a fine mist of dilute solution at specified intervals throughout the day.

It is currently unclear whether these systems are intended to target flying insects or insect resting surfaces. According to a discussion paper written by the Consumer Specialty Products Association (CSPA, 2005), these systems are designed to apply product to resting surfaces where insects seek harborage during non-feeding periods. In an efficacy study conducted by Florida A & M University, however, it was determined that the system was only efficacious against flying insects (Cilek, et. al, 2008). Despite the discrepancy, it is reasonable to assume that some residue deposits on outdoor surfaces and is available for both dermal and ingestion exposure.

This section addresses standard methods for estimating exposure and dose for three scenarios resulting from contact during outdoor activities in patios and backyards following use of an outdoor residential misting system:

- Section 5.3.2.1 - adult/toddler inhalation exposure resulting from activities on patios and backyards;
- Section 5.3.2.2 - adult/toddler dermal and toddler non-dietary ingestion exposure.

5.3.2.1 Post-application Inhalation Exposure Assessment

This SOP provides a standard method for completing post-application inhalation exposure assessments for adults and toddler after a pesticide treatment in an outdoor space. The basis for this scenario is that inhalation exposure occurs from the airborne aerosols released by mister nozzles. The well-mixed box (WMB) model was used to develop the exposure equation for the outdoor residential misting systems (ORMS) post-application inhalation scenario.[8] The WMB model incorporates a number of simplifying assumptions: fresh air (having no pesticide concentration) enters the box at a constant airflow rate; a turbulent internal airflow thoroughly mixes the fresh air with the pesticide-laden air resulting in a uniform pesticide air concentration within the box; and the perfectly mixed air exits the box at the same constant airflow rate (i.e., the inflow rate equals the outflow rate). Thus the outdoor area where the aerosol is being applied is assumed to be in an enclosed box. Using the WMB model is conservative for estimation of exposures for an open patio or deck where dissipation is expected to be greater than the enclosed space that the WMB depicts. Also, this scenario assumes instantaneous spray releases, that is, the total amount of aerosol released at each spray event is modeled to occur instantaneously.

The evacuation of the aerosol from the box depends on airflow. For an outdoor scenario, the airflow, Q is the product of the cross-sectional area and the wind velocity. The WMB model developed for this scenario models the pesticide air concentrations *after* multiple instantaneous aerosol spray releases at regular time intervals[9]. Only dissipation due to airflow into and out of the box is modeled.

For the inhalation route of exposure, the point of departure (POD) could be based on the reference concentration (RfC) methodology. In the RfC methodology, air concentrations are not converted to doses, rather, risks are assessed on the basis of comparison of exposure concentrations with reference concentrations typically determined from animal studies. This approach is not always available for every chemical; therefore, the exposure assessor should discuss the possibility of this approach with a toxicologist.

[8] For the ORMS and horse barn scenarios, the WMB models describing the air concentrations over time have the same form. The parameterization of these models is the only difference. For the ORMS scenario, the decay rate constant is specified by the ratio of the airflow rate and the volume of the treated space; whereas for the horse barn scenario, the decay rate constant is specified by the air changes per hour.
[9] The regular spray applications are assumed to continue for the entire time spent outdoors.

Post-Application Inhalation Exposure Algorithm

The following algorithm is used to determine post-application inhalation exposure to the ORMS (See *Appendix C.3.3* for equation description and derivation):

$$E = \frac{IR * C_0 * V}{Q}\left[\text{int}(ET \cdot PR) + \frac{(1 - R^{frac(ET \cdot PR)})}{(1 - R)}\right] \quad (5.19)$$

where:

E	= exposure (mg/day);
IR	= inhalation rate (m^3/hr);
C_0	= initial air concentration (mg/m^3);
V	= volume of treated space (m^3);
Q	= airflow (m^3/hr).
ET	= exposure time (hours/day);
PR	= pulse rate (sprays/hr);
frac(ET·PR)	= fraction portion of the product of the exposure time and the pulse rate;
R	= integer portion of the product of the exposure time (ET), and the pulse rate (PR), (i.e. number of spray events per hour).

$R = e^{-\frac{Q}{V}T_{BA}}$, int(ET·PR) is the integer (i.e., whole number) part of the product of the exposure time, ET and the pulse rate, PR (i.e. number of spray events per hour) and frac(ET·PR) is the fractional part of the product of the exposure time and the pulse rate. T_{BA} is the time between application events (i.e., the inverse of the pulse rate, or 1/PR). For example, if the time between applications is 40 minutes or 2/3 hour (i.e. T_{BA} = 0.67) or equivalently, the pulse rate is 3/2 sprays/hour (i.e. PR = 1.5); and the exposure time is three hours (ET = 3), then int(ET·PR) = int(3 × 1.5) = int(4.5) = 4; and frac(ET·PR) = frac(4.5) = 0.5.

The airflow in the patio/backyard is determined as follows:

$$Q = AV * CF1 * CF2 * A_{cross\text{-}section} \quad (5.20)$$

where:

Q	= airflow through treated space (m^3/hr);
AV	= air velocity (m/s);
CF1	= time unit conversion factor (60 seconds/1 minute);
CF2	= time unit conversion factor (60 minutes / hour); and
$A_{cross\text{-}section}$	= cross-section of outdoor space treated (m^2).

If chemical specific data are available, air concentration is the air concentration at time 0. Specifically the scenario assumes that individuals could be exposed to the air concentration immediately after application. While most product labels indicate that ORMS must be programmed so that "people or pets may not be present", there are frequently no restrictions on reentry time into the treated area. If data are not available, then the initial air concentration can be calculated using the following formula:

$$C_0 = AR * CF1 * CF2 \tag{5.21}$$

where:

C_0 = initial air concentration (mg/m^3);
AR = application rate per spray event (lbs ai/ft^3);
CF1 = weight unit conversion factor (454,000 mg/lb); and
CF2 = volume unit conversion factor (35.3 ft^3/ 1.0 m^3).

If application rates are given on the label, these rates should be used. Application rates are typically given in ounces of solution per 1000 ft^3. The following equation can be used to convert this rate to pounds ai per ft^3:

$$AR = \frac{AR_{label} * A.I. * CF * D_{H2O}}{V_{NC}} \tag{5.22}$$

where:

AR = application rate per spray (lb ai/ ft^3);
AR_{label} = application rate on label (given as ounces per 1000 ft^3) (oz);
A.I. = percent active ingredient in product (%);
CF = volume unit conversion factor (1 gallon/128 ounces);
D_{H2O} = water density (lb/gal); and
V_{NC} = nozzle coverage volume (as stated on label) (1000 ft^3).

If application rate is not given on the label, it can be calculated as follows:

$$AR = \frac{A.I. * DR * GPM * SD * D_{H2O}}{V_{NC}} \tag{5.23}$$

where:

AR = application rate per spray (lb ai/ft^3);
A.I. = percent active ingredient in product (%);
DR = dilution rate (volume of product/volume total solution);
GPM = nozzle flowrate (gal/min);
SD = spray duration (min);
D_{H2O} = water density (lb/gal); and
V_{NC} = nozzle coverage volume (ft^3).

Inhalation dose normalized to body weight is calculated as:

$$D = \frac{E * AF}{BW} \tag{5.24}$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

Post-application inhalation exposure following applications by outdoor residential misting systems is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Inhalation Exposure Algorithm Inputs and Assumptions

Recommended values for post-application inhalation exposure assessments are provided in *Table 5-8* below. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 5-8: Outdoor Residential Misting Systems – Recommended Inhalation Exposure Factors Distributions and Point Estimates

Algorithm Notation	Exposure Factor (units)	Distribution		Point Estimate(s)
		Type	Parameters	
AR	Application rate (lb ai/1000 ft^3)	Point Estimate	NA	
PR	Pulse Rate (pulses/hr)	Point Estimate	NA	1 (unless otherwise specified on label)
DR	Dilution Rate (volume product/ volume total solution)	Point Estimate	NA	
GPM	Nozzle flowrate (gal/min)	Uniform	0.011-0.014	
SD	Spray duration (min)	Uniform	0.5 -1	1
D_{H2O}	Water density (lb/gal)	Point Estimate	NA	8.34
V_{NC}	Nozzle coverage volume (ft^3)	Uniform	880- 1440	
V	Volume of treated space (m^3)	Point Estimate	NA	90.6
Q	Airflow (m^3/hr)	Uniform	5,400- 81,000	
AV	Air velocity (m/s)	Uniform	0.1 – 1.5	
C_0	Initial air concentration (mg/m^3)	Point Estimate	NA	
$A_{cross\text{-}section}$	Cross sectional area of area treated (m^2)	Point Estimate	NA	15 m^2

Table 5-8: Outdoor Residential Misting Systems – Recommended Inhalation Exposure Factors Distributions and Point Estimates					
Algorithm Notation	**Exposure Factor (units)**		**Distribution**		**Point Estimate(s)**
			Type	**Parameters**	
ET	Exposure time (hours/day)		Empirical	50^{th} = 0.9 90^{th} = 3.5	
IR	Inhalation rate (m^3/hour)	Adult	Empirical	Mean = 0.32 95^{th} = 0.42	
		Toddler	Empirical	Mean = 0.27 95^{th} = 0.35	
BW	Body weight (kg)	Adult	Empirical	Mean = 71.8 95^{th} = 97.9	
		Toddler	Empirical	Mean = 18.6 95^{th} = 26.2	
NA = not applicable					

Application Rate (AR)

The application rate is the amount of spray applied per unit area times the number of sprays applied per day. The application rate can be determined from product specific factors that are listed on the label or from generic factors listed above. This application rate needs to be determined both on an area basis (i.e. lbs ai applied per 1,000 square feet) to assess incidental oral and dermal exposures and on a volume basis (i.e. lb ai applied per 1000 cubic feet) to determine inhalation exposures.

Dilution Rate (DR)

The label should state the amount (e.g., gallons) of concentrated product per amount of water. This can also be given as parts of product per parts of water. Dilution rate is the volume of the product amount stated on the label divided by the sum of product volume and water volume (i.e., volume total solution).

Pulse Rate (PR): Number of Spray Events per hour

The pulse rate, or number of spray events per hour, is label-specific. A default of 1 spray event per hour is assumed when no product-specific data are available (CSPA 2005). This value is combined with exposure time (hours/day) to determine exposure to the individual. It is assumed that the airborne residues would disperse between applications.

Nozzle Flowrate (GPM)

The nozzle flowrate is a function of the amount of water the system will use in a 24 hr period. It is assumed a nozzle flowrate (gal/min) of 0.011-0.014 gal/min (CSPA, 2005; Celik, 2007). The nozzle flow rate is a function of the number of nozzles on the system and the number of minutes that the system operates each day. This is the amount of diluted product released from the nozzle per unit of time.

Spray Duration (SD)

Available information indicates the spray duration is approximately 30-60 seconds (0.5 – 1.0 min) in length (CSPA, 2005). The recommended point estimate for use in a deterministic risk assessment is 60 seconds (1 minute).

Water Density (D_{H2O})

The dilute solution of pesticide for application through the misting system is assumed to have the same density as water (i.e., 8.34 lbs/gallon), as the pesticide concentrate is typically mixed with large volumes of water.

Nozzle Coverage Volume (V_{NC})

The nozzle coverage volume is specified in the product label. If no volume is specified, the volume coverage of 1,000 ft^3 per nozzle is assumed. The range of volume coverage is 880-1440 ft^3 per nozzle (CSPA, 2005; Celik, 2007),

Volume of Treated Space (V)

An outdoor living space with dimensions of 20 ft. x 20 ft. x 8 ft. (i.e., 3,200 ft^3 or 90.6 m^3) is assumed when calculating airborne concentration levels. This value is based on a recent survey on U.S. decking market which was conducted by the Center for International Trade in Forest Products (CINTRAFOR). In this survey, CINTRAFOR contacted a random sample of U.S. homebuilders via telephone. Based on the survey results, it was determined that the mean deck size for spec homes (n=109) was 361ft^2. This translates to approximately a 20 ft x 18 ft surface area. The mean deck size for custom homes (n=174) was 490 ft^2 (Eastin, et al. 2005). This translates to approximately 20 ft x 24.5 ft surface area. The overall mean deck size identified in this survey is believed to be is an appropriate surrogate for the amount of outdoor living space treated by aerosol fogging products. Therefore, in the absence of additional information, 20 ft. x 20 ft. x 8 ft. is used as the volume of outdoor space that is treated with an aerosol fogger and 20 ft x 20 ft is used as the surface area of a treated area.

$A_{cross\ section}$

$A_{cross\text{-}section}$ represents the cross-sectional area of the volume of treated space for this exposure scenario, measured in m^2. Unless otherwise specified by the product label, the exposure scenario for misting systems considers a 20ft x 20 ft x 8 ft area; therefore the cross-sectional area for the treated space of 20 ft width x 8 ft height (160 ft^2) or 15 m^2.

Airflow (Q)

In the well-mixed box model, the airflow through the treated space is the product of the air velocity and the cross-sectional area, and is measured in m^3/hour. Airflow is defined as the volume of natural air that uniformly passes through a given area in a specified period of time. The airflow is a function of the cross-sectional area and wind velocity. A cross-sectional area of the space treated it is assumed to be 20 ft x 8 ft (160 ft^2 or 15 m^2). A conservative wind velocity of 0.1 m/s is assumed to represent calm air conditions, with maximum wind velocity assumed to be 1.5 m/s. Therefore, the airflow for a typical space treated is assumed to range from 5,400 m^3/hour (as the conservative default value) to 81,000 m^3/hour.

Air velocity (AV)

The air velocity is the speed of the air moving through the treated area defined for the well-mixed box model. The fraction of the chemical available for inhalation in outdoor air is a function of the ventilation rate in the backyard "box". The air velocity determines the rate at which the contents of the outdoor area treated are evacuated. Wind velocity is an influencing factor affecting mosquito attraction. Bidlingmayer et al. 1995 examined the effect of wind velocity on suction trap catches. Their research noted that trap catches declined as wind velocities increased over the entire range of observed velocities. Wind velocities within the range of normal mosquito flights, about 1 m/s resulted in trap catch reductions on significant nights of approximately 50% by wind of 0.5 m/s and 75% at 1.0 m/s.

The wind speed range considered here corresponds with the lower two tiers of the Beaufort wind force scale, an empirical measure for describing wind speed. The Beaufort wind force scale range a numerical basis of 0-10, from still air conditions up to hurricane force winds. This SOP covers Beaufort number 0-1. The Beaufort number 0 corresponds with calm wind conditions of <0.3 m/s [18 meters/minute; 0.7 mph]. The Beaufort number 1 corresponds with light air conditions of 0.3-1.5 m/s [18-90 meters/minute; 0.7–3.4 mph]. Thus, this SOP provides a distribution of wind velocities from 0.1-1.5 m/s [0.2-3.4 mph], the upper limit for "light air" condition on the Beaufort scale and a reasonable upper bound for wind velocities where these products would be used to control flying pests. This windspeed represents a range of values foreseeable where CCTM products may be used (i.e., in a yard or on an outdoor patio where flying pests may pose a nuisance). When wind velocities are higher than 1.5 m/s, these products are less likely to be used because of reduced flying pest pressure.

The recommended point estimate for use in a deterministic exposure assessment is 0.1 m/s (0.22 mph). Probabilistic assessments should use a range of air velocities from 0.1 m/s to 1.5 m/s.

Air Concentration (C_0)

The initial concentration is based upon instantaneous release of diluted product and mixing into a fixed space (nozzle coverage area). It is assumed there is complete mixing of the applied product in the area.

Exposure Time (ET)

Another important variable for addressing post-application exposure is the duration of time spent in areas treated by outdoor residential misting systems. The exposure time for adults and children conservatively assumes that the time spent in the volume of treated space is equivalent to the time spent outdoors. In order to be protective of children and to address the uncertainty in the upper percentiles of the exposure factor data when conducting a probabilistic assessment, an empirical distribution (which was expressed as a cumulative distribution function) from the Exposure Factors Handbook Table 15-80 (USEPA, 1997) with a bound of 3.5 hours for children should be used. This distribution represents the amount of time spent outdoors (see *Table 5-9*). **Based on these data, the recommended point estimate for use in post-application dermal exposure assessment [XX] hrs/day represents approximately the [XX]th percentile.**

Table 5-9: Time Spent Outdoors for Adults and Children	
Statistic	**Hours per Day**
0th percentile	0.00
5th percentile	0.25
25th percentile	0.33

50th percentile	0.90
75th percentile	2.45
90th percentile	3.5
100th percentile	3.5

Future Research/Data Needs

There are two main research/data needs with respect to the post-application ORMS scenario. (1) Limited air monitoring data are available for ORMS. Studies could be designed to characterize the air concentration of aerosolized pesticide sprays. (2) No data are available to characterize the prevalence of outdoor residential misting systems in different regions of the U.S. A survey could be conducted to determine ORMS use patterns.

Exposure Characterization and Data Quality

The simplifying assumptions implicit in the well-mixed box model identified in the first two paragraphs of *Section 5.3.2.1* would tend to be health protective, since the modeled air concentrations would dissipate less rapidly (resulting in higher pesticide concentrations) in the artificially defined fixed volume compared to a true open outdoor space. The ORMS exposure scenario makes the conservative assumption that all of the applied pesticide is in the air available for inhalation exposure, and then that all of the applied pesticide settles onto the turf and is available for dermal exposure. The estimated doses derived from this exposure scenario are believed to be high-end, conservative estimates.

5.3.2.2 Post-application Dermal and Non-dietary Ingestion Exposure Assessment

Dermal and incidental oral post-application exposures are expected to occur after the spray settles onto the turf areas. While exposure may occur for people of all ages, adults and toddlers are considered the sentinel populations based on behavioral characteristics and the strengths and limitations of available data. This settling is assumed to occur in a uniform fashion throughout the treated area, similar to a direct lawn broadcast treatment. Once the application rate is determined, the turf transferable residues and resulting dermal and incidental oral exposures should be assessed following the methodologies outlined in Section 3.2.

To calculate the residue on turf, use one of the following equations.

If application rates are given on the label, these rates should be used. Application rates are typically given in ounces per 1000 ft^3. A high-end height estimate of 8 feet 1) allows for a smaller turf surface area for the pesticide to be deposited on and 2) a low surface area of turf has a higher concentration of residue available. The following equation can be used to convert the application rate in pounds ai per square foot as is deposited on the turf:

$$AR = \frac{AR_{label} * A.I. * CF * D_{H2O} * H}{V_{NC}} \quad (5.25)$$

where:

AR = application rate per spray (lb ai/ ft^2);

AR_{label} = application rate on label (in ounces per 1,000 cubic feet) (oz);
A.I. = percent active ingredient in product (%);
CF = conversion factor to convert ounces to gallons (1 gallon/128 ounces);
D_{H2O} = water density (lb/gal);
H = height of nozzle (8 ft); and
V_{NC} = nozzle coverage volume (ft^3).

If application rate is not given on the label, it can be calculated using the following formulas:

$$AR = \frac{\text{A.I.} * \text{DR} * \text{GPM} * \text{SD} * \text{D}_{\text{H2O}}}{A_{NC}} \quad (5.26)$$

where:

AR = application rate per spray (lb ai/ft^2);
A.I. = percent active ingredient in product (%);
DR = dilution rate (volume product/volume total solution);
GPM = nozzle flowrate (gal/min);
SD = spray duration (min);
D_{H2O} = water density (lb/gal); and
A_{NC} = nozzle coverage area (ft^2).

Post-application dermal exposure following applications by outdoor residential misting systems is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Dermal and Non-Dietary Ingestion Algorithm Inputs and Assumptions

The following provides a general discussion for each exposure factor and derivation of recommended distributions and point estimates for use in exposure assessment.

Application Rate (AR)

The application rate is the amount of spray applied per unit area times the number of sprays applied per day. The application rate can be determined from product specific factors that are listed on the label or from generic factors listed above. This application rate needs to be determined on an area basis (i.e. lbs ai applied per square foot) to assess incidental oral and dermal exposures.

Dilution Rate (DR)

The label should state the amount (e.g., gallons) of concentrated product per amount of water. This can also be given as parts of product per parts of water. Dilution rate is the volume of the product amount stated on the label divided by the sum of product volume and water volume (i.e., volume total solution).

Nozzle Flowrate (GPM)

The nozzle flowrate is a function of the amount of water your system will use in a 24 hr period. It is assumed a nozzle flowrate (gal/min) of 0.011-0.014 gal/min (Celik et al. 2007; CSPA, 2005). The nozzle flow rate is a function of the number of nozzles on the system and the number of minutes that the system operates each day. This is the amount of diluted product released from the nozzle per unit of time.

Spray Duration (SD)

Each spray event is assumed to last for 30-60 seconds approximately (0.5 – 1.0 min) (CSPA, 2005). The recommended point estimate for use in a deterministic risk assessment is 60 seconds (1 minute).

Water Density (D_{H2O})

The dilute solution of pesticide for application through the misting system is assumed to have the same density as water (i.e., 8.34 lbs/gallon), as the pesticide concentrate is typically mixed with large volumes of water.

Nozzle Coverage Area (A_{NC})

The nozzle coverage volume is specified in the product label as 1,000 ft^3 per nozzle. A conservative height estimate of 8 ft is assumed, making the ground area coverage 125 ft^2 per nozzle. A high-end height estimate of 8 feet 1) allows for a smaller turf surface area for the pesticide to be deposited on and 2) a low surface area of turf has a higher concentration of residue available, this making the exposure estimate conservative. 8 foot height is also the assumed height of the box model, and a reasonable high end estimate of the height of the residential misting system based on professional judgment.

Future Research/Data Needs

There are three main research/ data needs with respect to the post-application ORMS scenario. (1) No data are available to characterize the prevalence of outdoor residential misting systems in different regions of the U.S. A survey could be conducted to determine ORMS use patterns. (2) No data are available to characterize the deposition pattern of ORMS systems in the outdoor environment. Studies could be designed to capture the deposition patterns for ORMS. (3) No data are available to indicate the extent of dermal deposition on human skin from aerosolized pesticides released from ORMS. Studies could be designed to capture the extent of dermal deposition as a result of airborne aerosols released from ORMS.

Exposure Characterization and Data Quality

Outdoor Residential Misting Systems typically operate on timed applications or by remote control activation. The ORMS scenario models residential bystander exposure in that it assumes bystanders are present immediately following a spray event, not during the application. The ORMS exposure scenario makes the conservative assumption that all of the applied pesticide is in the air available for inhalation exposure, and then that all of the applied pesticide settles onto the turf and is available for dermal exposure.

5.3.2.3 Combining Post-application Scenarios

Risks resulting from different exposure scenarios are combined when it is likely that they can occur simultaneously based on the use pattern and when the toxicological effects across different routes of exposure are the same. When combining scenarios, it is important to fully characterize the potential for co-occurrence as well as characterizing the risk inputs and estimates. Risks should be combined even if any one scenario or route of exposure exceeds the level of concern because this allows for better risk characterization for risk managers.

It is likely that toddlers could be exposed to an area treated by ORMS via inhalation, dermal and non-dietary ingestion (hand-to-mouth) routes and that these scenarios could occur simultaneously. Therefore, these exposure scenarios should be combined when toxicological effects are the same across these routes of exposure.

5.4 Horse Barn Misting Systems

Horse barn residential misting systems are application systems designed to spray an aerosolized insecticide to kill mosquitoes and other nuisance insects in and around barns. These systems are fed from a central holding tank and utilize an array of spray nozzles to automatically deliver an aerosolized insecticide at specified intervals throughout the day. The spray nozzles are typically mounted between 8-10 feet high. These systems operate automatically (i.e., at preset intervals) or manually (e.g., via remote control or switch).

There is potential for adult handler exposure and adult and youth post-application inhalation exposure to areas previously treated with pesticide by these misting systems.

Dermal exposure is expected to be negligible as compared to inhalation exposure as the pesticide is present more readily in the air from its application method. Also, the activity pattern of adults and children inside a horse barn after pesticide application by a misting system is not likely to result in a significant amount of dermal exposure (i.e., unlike lawns or indoor carpets, they are not likely to be in frequent contact with barn floors). While children may be present in animal barns, hand-to-mouth activities are expected to be minimal and need not be quantitatively assessed.

5.4.1 Handler Exposure Assessment

Barn misters are typically marketed as systems that include a mix tank, a timer-controlled pump, and fixed plumbing that run to the spray nozzles. The systems are generally expected to be professionally installed and include a service contract to cover maintenance and insecticide refilling. However, it is possible for a residential user to purchase pesticide concentrates and load the drum/holding tank to refill these systems. Therefore, a residential handler scenario may be assessed.

This section provides a standard method for completing handler exposure assessments for adults who are mixing and loading insecticides to be used in barn misting systems. The basis for this scenario is that handler exposure occurs as the pesticide is poured into the drum by the applicator holding the product container; no applicator scenario is required to be assessed as the misting nozzles spray the pesticide in the treatment area automatically (without contact with the residential handlers).

This scenario assumes that pesticides are available to be inhaled or have the potential to come into contact with the skin during the mixing and loading of the pesticide products in drums/holding tanks as part of the barn misting system. It is assumed that only individuals 18 years of age or older mix and load (i.e., handle) pesticides. The method to determine handler inhalation and dermal exposure to pesticides from these activities relies on data measuring dermal and inhalation exposure during mixing and loading (e.g., pouring a liquid pesticide). Thus, this method should be used in the absence of chemical-specific data, or as a supplement to estimates based on chemical-specific data.

Dermal and Inhalation Handler Exposure Algorithm

As described in *Section 1.3.3*, daily dermal and inhalation exposure (mg/day) for residential pesticide handlers, for a given formulation-application method combination, is estimated by multiplying the formulation-application method-specific unit exposure by an estimate of the amount of active ingredient handled in a day, using the equation below:

$$E = UE * AR \qquad (5.27)$$

where:

E = exposure (mg/day);
UE = unit exposure (mg/lb ai); and
AR = application rate (lb ai/day).

and

The application rate can be calculated as follows:

$$AR = V_D * N * DR * A.I. * D_{H2O} \qquad (5.28)$$

where:

AR = application rate per day (lb ai/ day);
V_D = volume of the drum of the misting system (gallons/drum);
N = number of drums filled per day (drums/day);
DR = dilution rate (volume of product/ volume of total solution);
A.I. = percent active ingredient in product (%); and
D_{H2O} = water density (lb/gal).

Dermal and/or inhalation doses normalized to body weight are calculated as:

$$D = \frac{E * AF}{BW} \qquad (5.29)$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

Handler exposure for horse barn misting systems is generally considered either acute or short-term in duration as filling the centralized reservoir tanks typically occur once in a 90 day period. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.3* such as the product-specific application regimen. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Dermal and Inhalation Handler Exposure Algorithm Inputs and Assumptions

Recommended values for handler exposure (inhalation and dermal) assessments are provided in *Table 5-10* and *Table 5-11*. Following these tables, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 5-10: Horse Barn Misting Systems – Recommended Unit Exposure (mg/lb ai) Distributions and Point Estimates								
Formulation	Equipment/Application Method	Dermal			Inhalation			Appendix Page Reference
		Distribution		Point Estimate	Distribution		Point Estimate	
		Type	Parameters		Type	Parameters		
Liquid concentrates	Mixing/loading	NA	NA		NA	NA		NA
Note: Unlike other tables describing unit exposures, these are directly from the Pesticide Handlers Exposure Database (PHED) and thus are not presented in a statistical distribution context.								

Table 5-11: Horse Barn Misting Systems – Recommended Handler Exposure Factors Distributions and Point Estimates				
Algorithm Notation	**Exposure Factor (units)**	**Distribution**		**Point Estimates**
		Type	**Parameters**	
AR	Application rate (lb ai/ day)	Point Estimate	NA	
D_{H20}	Density of product (lb/gal)	Point Estimate	NA	8.34
V_D	Volume of Drum (gallons/drum)	Triangular	Min = 30 Median = 55 Max = 125	
DR	Dilution Rate (volume of product / volume of total solution)	Point Estimate	NA	
N	Number of drums filled per day (drums/day)	Point Estimate	NA	1
A.I.	Percent ai in product concentrate (%)	Point Estimate	NA	
BW	Body weight (kg)	Empirical	Mean = 71.8 95^{th} = 97.9	
NA = not applicable				

Unit Exposure (UE)

As described in *Section 1.3.3*, the unit exposure is the ratio, for a given formulation/application method combination, between exposure and the amount of active ingredient handled, with units mass exposure per mass active ingredient handled (e.g., mg ai exposure/lb ai handled). The recommended point estimate shown in Table 5-10 represents a central tendency value from the Pesticide Handler Exposure Database (PHED) and is derived from studies monitoring mixing/loading and applying liquid formulations.

Drum Volume (V_D)

The default assessment can provide risk estimates based on three typical drum/holding tank sizes (30, 55, or 125 gallons) as part of the horse barn misting system, unless additional scenario-specific information is provided on the product labels. The 30 and 55 gallon drums represent likely configurations of a residential horse barn misting system and the 55 and 125 gallon systems represent likely configurations of the commercial stable horse misting system.

Number of drums filled per day (N)

One drum is assumed to be filled per day, as residential misting systems are likely only connected to one drum.

Dilution Rate (DR)

The label should state the amount (e.g., gallons) of concentrated product per amount of water. This can also be given as parts of product per parts of water. Dilution rate is the volume of the product amount stated on the label divided by the sum of product volume and water volume (i.e., volume total solution).

Water Density (D_{H2O})

Pesticide products used in misting systems are typically mixed with large volumes of water. Therefore, the dilute insecticide solution applied through the misting system is assumed to have the same density as water (i.e., 8.34 lbs/gallon).

Future Research/Data Needs

There is one main research/data need with respect to the horse barn misting system scenario. (1) Research by OPP and ORD revealed little about the prevalence and use of these systems by the general public. Survey data could be produced to examine the prevalence of these systems, the breakdown of maintenance (i.e., characterizing the percentage of systems that are professional maintained versus homeowner maintained) and to better characterize the frequency of the mixing/loading activity by residential handlers (i.e. how often the systems are refilled/reloaded).

Exposure Characterization and Data Quality

These unit exposures are from the “All Liquids, Open Mixing and Loading” Scenario in the SOPs for Residential Exposure Assessments (July 18, 1997) which are from PHED. The SOP states that “this scenario is not completely representative of homeowner products because the data are based on the use of agricultural products. In these scenarios, more chemical would typically be handled and the material is generally packaged in larger quantities. However, these data represent the best available data set for determining exposures during open pouring with liquid chemicals. No data are available to assess the differences between the agricultural and the residential scenarios.” However, in this scenario of mixing/loading for use in misting systems, the residential user is expected to be loading a large amount of pesticide (30 or 55 gallons) compared to typical residential user pesticide application. Therefore, these unit exposure values are more representative for the horse barn misting system handler scenario than typical residential handler scenarios.

5.4.2 Post-application Exposure Assessment

Post-application exposure can result from presence in residential barns or commercial stables following pesticide applications. While exposure may occur for people of all ages, adults, teens, and toddlers are considered the sentinel populations depending on the exposure scenario based on behavioral characteristics and the strengths and limitations of available data

This section addresses standard methods for estimating exposure and dose for three scenarios resulting from time spent in horse barns that have previously been treated by a misting system:

- Section 5.4.2.1 - adult/toddler inhalation exposure;
- Section 5.4.2.2 - adult/toddler dermal and toddler non-dietary ingestion exposure;

5.4.2.1 Post-application Inhalation Exposure Assessment

This section provides a standard method for completing post-application inhalation exposure assessments for adults and children after a pesticide treatment in a horse barn. The basis for this scenario is that inhalation exposure occurs from the airborne aerosols released by mister nozzles. As with the ORMS scenario, the well-mixed box (WMB) model was used to develop the exposure equation for the horse barn misting systems post-application inhalation scenario[10]. The WMB model incorporates a number of simplifying assumptions: fresh air (having no pesticide concentration) enters the box at a constant airflow rate (based on the number of air changes per hour), a turbulent internal airflow thoroughly mixes the fresh air with the pesticide-laden air resulting in a uniform pesticide air concentration within the box, and the perfectly mixed air exits the box at the same constant airflow rate (i.e., the inflow rate equals the outflow rate). Thus the indoor area where the aerosol is being applied (i.e., barn) is assumed to be in an enclosed box, which is a reasonable assumption for a walled, indoor, space. This scenario assumes instantaneous spray releases, that is, the total amount of aerosol released at each spray event is modeled to occur instantaneously.

The evacuation of the aerosol from the box depends on airflow. For an indoor scenario, the airflow is the product of the volume of the treated space and the number of air changes per hour, ACH. The WMB model developed for this scenario models the pesticide air concentrations *after* multiple instantaneous aerosol spray releases at regular time intervals[11]. Only dissipation due to airflow into and out of the box is modeled.

For the inhalation route of exposure, the point of departure (POD) could be based on the reference concentration (RfC) methodology. In the RfC methodology, air concentrations are not converted to doses, rather, risks are assessed on the basis of comparison of exposure concentrations with reference concentrations typically determined from animal studies. This approach is not always available for every chemical; therefore, the exposure assessor should discuss the possibility of this approach with a toxicologist.

Post-Application Inhalation Exposure Algorithm

Post-application inhalation exposure resulting for adults/toddlers resulting from horse barns that have been previously treated with pesticide can be calculated using the following equations (See *Appendix C.3.4* for equation description and derivation):

.

$$E = \frac{IR * C_0}{ACH}\left[\text{int}(ET \cdot PR) + \frac{(1 - R^{frac(ET \cdot PR)})}{(1 - R)}\right] \qquad (5.30)$$

where:

E = exposure (mg/day);

[10] For the ORMS and horse barn scenarios, the WMB models describing the air concentrations over time have the same form. The parameterization of these models is the only difference. For the ORMS scenario, the decay rate constant is specified by the ratio of the airflow rate and the volume of the treated space; whereas for the horse barn scenario, the decay rate constant is specified by the air changes per hour.

[11] The regular spray applications are assumed to continue for the entire time spent inside the horse barn.

IR = inhalation rate (m^3/hr);
ACH = air changes per hour ($hour^{-1}$);
C_0 = initial concentration (mg/m^3);
PR = pulse rate (number of sprays/hr);
ET = exposure time (hrs/day); and
R = integer portion of the product of the exposure time (ET), and the pulse rate (PR), (i.e. number of spray events per hour).

$R = e^{-ACH \cdot T_{BA}}$, int(ET·PR) is the integer (i.e. whole number) part of the product of the exposure time, ET and the pulse rate, PR (i.e. number of spray events per hour) and frac(ET·PR) is the fractional part of the product of the exposure time and the pulse rate. T_{BA} is the time between application events (i.e., the inverse of the pulse rate, or 1/PR). For example, if the time between applications is 40 minutes or 2/3 hour (i.e. T_{BA} = 0.67) or equivalently, the pulse rate is 3/2 sprays/hour (i.e. PR = 1.5); and the exposure time is three hours (ET = 3), then int(ET·PR) = int(3 × 1.5) = int(4.5) = 4; and frac(ET·PR) = frac(4.5) = 0.5.

If product-specific data are available, air concentration is the residue immediately after a spray, typically referred to as “time 0”. This exposure scenario assumes that individuals are exposed to the air concentration immediately after the application event. However, if chemical-specific data are not available, the initial air concentration can be calculated using the following formula:

$$C_0 = AR * CF1 * CF2 \qquad (5.31)$$

where:
C_0 = initial air concentration (mg/m^3);
AR = application rate per spray event (lbs ai/ft^3);
CF1 = weight unit conversion factor (454,000 mg/lb); and
CF2 = volume unit conversion factor (35.3 ft^3/ 1.0 m^3).

If application rates are given on the product label, this equation should be used. Application rates are typically given on product labels in ounces per 1000 ft^3. The following equation can be used to convert the application rate from ounces per 1000 ft^3 to pounds ai per ft^3:

$$AR = \frac{AR_{label} * A.I. * CF * D_{H2O}}{V_{NC}} \qquad (5.32)$$

where:
AR = application rate per spray (lb ai/ ft^3);
AR_{label} = application rate on label (given as ounces per 1000 ft^3) (oz);
A.I. = percent active ingredient in product (%);
CF = volume unit conversion factor (1 gallon/128 ounces);
D_{H2O} = water density (lb/gal); and
V_{NC} = nozzle coverage volume (as stated on label) (1000 ft^3).

If application rate is not given on the label, it can be calculated as follows:

$$AR = \frac{\text{A.I.} * \text{DR} * \text{GPM} * \text{SD} * \text{D}_{\text{H2O}}}{V_{NC}} \tag{5.33}$$

where:

AR = application rate per spray (lb ai/ft^3);
A.I. = percent active ingredient in product (%);
DR = dilution rate (volume of product/volume of total solution);
GPM = nozzle flowrate (gal/min);
SD = spray duration (min);
D_{H2O} = water density (lb/gal); and
V_{NC} = nozzle coverage volume (ft^3).

Inhalation dose normalized to body weight is calculated as:

$$D = \frac{E * AF}{BW} \tag{5.34}$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

Post-application inhalation exposure following applications by misting systems in horse barns is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Inhalation Exposure Algorithm Inputs and Assumptions

Recommended values for post-application inhalation exposure assessments are provided in *Table 5-12* below. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 5-12: Horse Barn Misting Systems – Recommended Inhalation Exposure Factors Distributions and Point Estimates					
Algorithm Notation	Exposure Factor (units)		Distribution		Point Estimate(s)
			Type	Parameters	
AR	Application rate per spray event (lb ai/ ft^3)		Point Estimate	NA	
DR	Spray dilution rate (volume of product/ volume of total solution)		Point Estimate	NA	
GPM	Nozzle flowrate (gal/min)		Point Estimate	Label-specific	
			Uniform	0.011-0.014	
SD	Spray duration (min)		Point Estimate	NA	
V_{NC}	Nozzle coverage volume (ft^3)		Uniform	880 – 1,440	
ACH	Air changes per hour ($hour^{-1}$)		Uniform	4 -8	
D_{H2O}	Water density (lb/gal)		Point Estimate	NA	8.34
PR	Pulse Rate (sprays/hr)		Point Estimate	NA	
C_0	Initial air concentration (mg/m^3)		Point Estimate	NA	Concentration at time "0"
ET	Exposure time (hr/day)	Adult	Point Estimate	NA	4
		Youth	Point Estimate	NA	2
IR	Inhalation rate (m^3/hour)	Adult	Empirical	Mean = X 95^{th} = X	
		Youth	Empirical	Mean = X 95^{th} = X	
BW	Body weight (kg)	Adult	Empirical	Mean = 71.8 95^{th} = 97.9	
		Youth	Empirical	Mean = 31.8 95^{th} = 52.5	
NA = not applicable					

Application Rate (AR)

The application rate is the amount of spray applied per unit volume per spray event. The application rate can be determined from product specific factors that are listed on the label or from generic factors listed above. This application rate needs to be determined on a volume basis (i.e. lb ai applied per 1000 cubic feet) to determine inhalation exposures.

Dilution Rate (DR)

The label should state the amount (e.g., gallons) of concentrated product per amount of water. This can also be given as parts of product per parts of water. Dilution rate is the volume of the product amount stated on the label divided by the sum of product volume and water volume (i.e., volume total solution).

Nozzle Flowrate (GPM)

The nozzle flowrate is a function of the amount of water the system will use in a 24 hr period. It is assumed a nozzle flowrate (gal/min) of 0.011-0.014 gal/min (CSPA, 2005; Celik, 2007). The nozzle flow rate is a function of the number of nozzles on the system and the number of minutes that the system operates each day. This is the amount of dilute pesticide spray released from the nozzle per unit of time.

Spray Duration (SD)

Each spray event is assumed to last for approximately 30-60 seconds (0.5 – 1.0 min) (CSPA, 2005).

Nozzle Coverage Volume (V_{NC})

The nozzle coverage volume is specified in the product label). If no volume is specified, it is assumed that the nozzle coverage area is 1,000 ft^3 per nozzle (CSPA, 2005; Celik, 2007). The range is 880-1440 ft^3.

Air Changes per Hour (ACH)

Air changes per hour is the rate that air within an indoor environment is replaced by outdoor air. For a typical barn the air exchange rate is believed to range between 4 and 8 air changes per hour. This is the ratio of the airflow over the volume of space (Q/V). Typical equine references suggest this range of air changes per hour to maintain fresh air conditions and good air quality in the more challenging stable environments. A lower number of air changes per hour reflect winter conditions and a higher number of air changes represent warmer weather conditions (Horse Stable Ventilation Publication, Penn State University 2003).

Water Density (D_{H2O})

Pesticide products used in these systems are typically mixed with large volumes of water. Therefore, the dilute pesticide solution applied through the misting system is assumed to have the same density as water (i.e. 8.34 lbs/gallon).

Air Concentration (C_0)

The initial concentration is based upon instantaneous release of diluted product and mixing into a fixed space (nozzle coverage area). It is assumed there is complete mixing of the applied product in the area.

Pulse Rate (PR): Number of Spray Events per Hour

The number of spray events per hour is label-specific. A default value of 1 spray event per hour will be assumed when no product-specific data are available (CSPA 2005). Based on an evaluation of product information, this value is considered a high end assumption.

Exposure Time (ET)

The exposure time of adults who spend time in and around horse barns is 4 hours per day in the treated space. Children are assumed to spend 2 hours per day in the treated space. These recommended exposure time values are based on a study that examined the relationship between respiratory problems and time spent in horse barns (Mazan, 2009). In this study, it was reported that anecdotal evidence suggests that casual riders are unlikely to spend more than 1-2 hours per day and a total 2-5 days per week in a barn. Based on this anecdotal evidence, 4 hours per day is believed to be a conservative estimate of time spent inside a horse barn for the adult rider who also performs some non-occupational barn-related tasks. Similarly, since casual child riders are likely to spend less time performing non-riding activities than adults, 2 hours per day is believed to be a conservative estimate for children.

Future Research/Data Needs

There are three main research/data needs with respect to the post-application horse barn misting system scenario. (1) Limited air monitoring data are available for horse barn misting systems. Studies could be designed to characterize the air concentration of aerosolized pesticide sprays. (2) No data are available to characterize the prevalence of horse barn misting systems in different regions of the U.S. A survey could be conducted to determine horse barn misting system use patterns. (3) No data are available to determine how much time a person spends in a residential horse barn and a commercial horse stable. A time-activity survey could be conducted to determine the breakdown of activities and time spent in horse barns.

Exposure Characterization and Data Quality

Horse Barn Misting Systems typically operate on timed applications or by remote control activation. The scenario models residential bystander exposure in that it assumes bystanders are present immediately following a spray event, not during the application.

5.4.2.2 Post-application Dermal and Non-Dietary Ingestion Exposure Assessment

Non-dietary ingestion post-application exposure is expected to be negligible compared to the inhalation exposure as the pesticide is present more readily in the air from its application method, and thus dermal and non-dietary ingestion exposure need not be quantitatively assessed. It is expected that those children entering horse barns are typically under adult supervision and also of the age where hand-to-mouth activity is greatly diminished. Therefore, hand-to-mouth exposure need not be quantitatively assessed.

Although there is no algorithm specific to assessing post-application dermal exposure from use of a horse barn misting system, there is potential for exposure once the aerosol settles on surfaces inside the barn. A person could potentially be exposed to these residues when cleaning the barn, taking out equipment, and interacting with horses. As products typically used in horse barns misting systems are also used in outdoor residential misting systems, the post-application dermal assessment for outdoor residential misting systems (*Section 5.3*) is a conservative estimate of post-application dermal exposure of these products that can be used to cover both of these scenarios. Persons are not likely to be participating in activities on the floors of a horse barn that would result in as high significant transferable residue available for dermal exposure as the activities the ORMS post-application dermal assessment assumes (activities on turf), therefore the ORMS post-application dermal methodology is a conservative surrogate to estimate horse barn post-application dermal exposure.

5.4.2.3 Combining Post-application Scenarios

Risks resulting from different exposure pathways are combined when it is likely that they can occur simultaneously based on the use pattern, the behavior associated with the exposed population, and when the toxicological effects across different routes of exposure are the same. For horse barn misting system scenarios, it is unlikely for hand-to-mouth activities to occur as the children present in horse barns are typically beyond the age where they demonstrate hand-to-mouth behavior. Therefore, this SOP focuses on the inhalation route of exposure as the most significant for residential post-application exposure in horse barns.

Section 6 Insect Repellants

This section provides an outline of the procedures used to assess, estimate and characterize exposures resulting from the use of personal insect repellents available in many formulations such as aerosol sprays, lotions, pump sprays, gels, towelettes and wrist bands. It also includes repellents formulated with sunscreens. Other repellent-type products are covered under separate sections such as mosquito coils (Section 5.2), misting systems (Section 5.1), or repellent-impregnated clothing or textiles (Section 9).

Exposure results from deliberate application to the skin and clothing of individuals. Repellent use can be on the order of days or weeks or longer, depending on the activity pattern and geographic area. Insect repellents are used on people of all ages, thus, while exposure may occur for people of all ages, in this SOP, because of the expected use of repellents the assessment for adults and toddlers are considered the sentinel populations whose exposure estimates are expected to encompass those for all age-based sub-populations.

Repellents are all "ready-to-use" (i.e., there is no mixing of liquid concentrates or powders) and are sprayed or otherwise applied onto the skin or clothing. The individual applying insect repellents is, for the purposes of this section, the "handler". Adults are assumed to experience both dermal and inhalation handler exposure, as well as post-application dermal and, potentially, inhalation exposure. While it is assumed that only adults apply repellents to themselves or to others, for aerosol and pump-spray repellents individuals to whom the products are being applied can experience inhalation exposure during the application. For children, post-application exposure consists of dermal, (potentially) inhalation, and hand-to-mouth exposure.

6.1 Handler Exposure Assessment

Unlike other pesticide applications, "handler" and "post-application" exposures resulting from repellent applications are not truly separate events since many applications are self-applications. Therefore, for the purposes of this SOP, "handler" dermal exposure can be considered in concert with "post-application" dermal exposure. However, for aerosol and pump-sprayer repellent products, inhalation exposure for adults and children during the application process is possible and can be assessed under the standard "handler" process described below.

Dermal and Inhalation Handler Exposure Algorithm

As described in *Section 1.3.3*, daily dermal and inhalation exposure (mg/day) for residential pesticide handlers, for a given formulation-application method combination, is estimated by multiplying the formula-application method-specific unit exposure by an estimate of the amount of active ingredient handled in a day, using the equation below:

$$E = UE * AR \qquad (6.1)$$

where:

E = exposure (mg/day);

UE = unit exposure (mg/lb ai);
AR = application rate (e.g., lb ai/day)

Dermal and/or inhalation potential doses normalized to body weight are calculated as:

$$D = \frac{E * AF}{BW} \tag{6.2}$$

where:
D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

Handler exposure for repellent applications is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.3* such as the product-specific application regimen. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Dermal and Inhalation Handler Exposure Algorithm Inputs and Assumptions

Recommended values for repellent handler exposure (inhalation only) assessments are provided in *Table 6-1* and *Table 6-2*. Following these tables, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions, ii) data sources used to derive recommended input values, and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 6-1: Insect Repellents – Recommended Unit Exposure (mg/lb ai) Distributions and Point Estimates								
Formulation	**Equipment/Application Method**	**Dermal**			**Inhalation**			**Appendix Page Reference**
		Distribution		**Point Estimate**	**Distribution**		**Point Estimate**	
		Type	**Parameters**		**Type**	**Parameters**		
Ready-to-Use (RTU)	Aerosol Can	Dermal handler exposure for repellent applications considered as part of post-application dermal exposure.			Lognormal	GM = 2.3 GSD = 2.0		B-130
	Pump-sprayers				Lognormal	GM = 0.046 GSD = 2.1		B-109

Table 6-2: Insect Repellents – Recommended Handler Exposure Factors Distributions and Point Estimates				
Exposure Factor (units)		**Distribution**		**Point Estimate(s)**
		Type	**Parameters**	
Application Rate (% ai in product)		Point Estimate	NA	
Amount used	# aerosol cans or pump sprays per day	Point Estimate	NA	
Body Weight (kg)	Adult	Empirical	Mean = 72 95^{th} = 98	
	Toddler	Empirical	Mean = 19 95^{th} = 26	

Unit Exposures

As described in *Section 1.3.3*, the unit exposure is the ratio, for a given formulation/application method combination, between exposure and the amount of active ingredient handled, with units mass exposure per mass active ingredient handled (e.g., mg ai exposure/lb ai handled). **The recommended point estimate shown in *Table 6-1* represents approximately the [XX]th percentile of the respective distribution.** Data summaries can be found in *Appendix B*.

Amount of active ingredient Handled

The algorithm for estimating handler exposure requires some estimate of the amount of active ingredient handled per day. For repellents, this factor varies based on the type of product being applied and is estimated based on the percentage of active ingredient specified on the product label and the amount of product being sprayed. Both of these can be determined on a product- and chemical-specific basis, however, as a default, **[XX]** cans or pump sprays should be assumed used per day for handlers.

Future Research/Data Needs

Unavailable information that would refine handler exposure assessments for repellents include:

- Application intervals (i.e., how often repellents are applied)
- Survey information detailing:
  - Daily/weekly/monthly probability of using a repellent product;
  - Amount of product or formulation used per application; and,
- Handler exposure data:
  - Specific for repellent applications;
  - Describing the extent to which an individual's exposure for a given formulation and application method varies from application-to-application (i.e., intra-individual exposure variability).

Exposure Characterization and Data Quality

Unit Exposures

This section relies on surrogate data considered reasonable for estimating handler exposure for scenarios that are lacking data. Additionally, the assumed proportional relationship between exposure and amount of active ingredient handled is reasonable though recognized as uncertain.

Information on the amount of product/formulation (thus, active ingredient) handled per application is lacking, making the estimates highly uncertain. The recommended point estimates are therefore intended to be high-end to ensure an appropriately conservative exposure estimate.

6.2 Post-application Exposure Assessment

Post-application dermal and non-dietary ingestion exposure may occur as a direct result of a repellent application via dermal absorption and hand-to-mouth activities, respectively. Post-application exposure is also possible via chemical volatilization. While post-application exposure may occur for people of all ages, the assessment for adults and toddlers are expected to encompass the exposures for all age-based sub-populations.

This section addresses standard methods for estimating exposure and dose for three individual scenarios resulting from use of insect repellents:

- Section 6.2.1 - adult/toddler inhalation exposure;
- Section 6.2.2 - adult/toddler dermal exposure; and
- Section 6.2.3 - toddler non-dietary ingestion via hand-to-mouth activity.

6.2.1 Post-application Inhalation Exposure Assessment

Post-application inhalation exposure resulting from insect repellents is generally not assessed and should be handled on a case-by-case basis. The combination of low vapor pressure for chemicals typically used as active ingredients in insect repellent products and dilution in outdoor air is expected to result in minimal inhalation exposure.

6.2.2 Post-application Dermal Exposure Assessment

This SOP provides a standard method for estimating dermal doses among adults and toddlers from skin treated with insect repellents as well as sunscreens containing insect repellents.

Post-application Dermal Exposure Algorithm

Post-application dermal exposure resulting from repellent treatments is a function of the amount of product, and therefore active ingredient, applied to the body. Thus, it is dependent on three factors:

- The application rate (i.e., the target concentration of chemical on the skin per application);
- The total area of the body to which the repellent is applied; and,
- The number of applications.

If reliable product-specific information is available that details the target concentration of active ingredient applied to the skin (e.g., mg active ingredient per square centimeter of skin), that information is preferable and should be used in this SOP in the formula below. However, in the event that such information is unavailable, or otherwise considered unreliable, the assessor can use a formulation-specific rate described in this SOP combined with the label-specified percentage of active ingredient to obtain a reasonable estimate of the target skin concentration of active ingredient (see the formula below). The algorithms to calculate dose are presented below. Discussion of each factor is presented in the remainder of this SOP.

If product-specific information is available, dose is calculated as:

$$D = AR_P * ET * AppF * SA/BW * F_{Body} * AF \qquad (6.3)$$

where:

D = dose (mg/kg-day);
AR_P = product-specific application rate (mg ai/cm^2 skin);
ET = exposure time (hours/day);
AppF = application frequency (applications/hour);
SA/BW = total body surface area to body weight ratio (cm^2/kg);
F_{Body} = clothing-dependent fraction of body exposed (fraction exposed/application); and
AF = absorption factor.

If product-specific information is unavailable, dose is calculated as:

$$D = AR_F * F_{AI} * ET * AppF * SA/BW * F_{Body} * AF \quad (6.4)$$

where:

D =dose (mg/kg-day);
AR_F = formulation-specific application rate (mg product/cm^2 skin);
F_{AI} = product-specific fraction of active ingredient (mg ai/mg product);
ET = exposure time (hours/day);
AppF = application frequency (applications/hour);
SA/BW = total body surface area to body weight ratio (cm^2/kg);
F_{Body} = clothing-dependent fraction of body exposed (fraction exposed/application); and
AF = absorption factor.

Post-application exposure following repellent applications is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as product-specific application intervals and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Dermal Exposure Algorithm Inputs and Assumptions

Recommended values for post-application dermal exposure assessments are provided in *Table 6-3* below. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions, ii) data sources used to derive recommended input values, and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 6-3: Insect Repellents - Recommended Distributions and Point Estimates for Post-Application Dermal Exposure Factors					
Algorithm Notation	**Exposure Factor (units)**		**Distribution**		**Point Estimate(s)**
			Type	**Parameters**	
AR_F	Formulation-specific application rate (mg product/cm^2 skin)	Aerosol	Lognormal	GM = 0.9 GSD = 2.0	
		Pump spray	Lognormal	GM = 0.50 GSD = 1.9	
		Lotion	Lognormal	GM = 1.9 GSD = 1.5	
		Towelette	Lognormal	GM = 1.1 GSD = 1.4	
F_{AI}	Amount of active ingredient (%)		NA	NA	
F_{Body}	Fraction of body exposed per application	Light use	Point Estimate	NA	
		Medium use	Point Estimate	NA	
		Heavy use	Point Estimate	NA	
SA/BW	Surface Area to Body Weight Ratio (cm^2/kg)	Adult	Empirical	50^{th} = 290 95^{th} = 330	
		Toddler	Empirical	50^{th} = 620 95^{th} = 850	
ET	Exposure Time (hours/day)	Adult	Empirical	50^{th} = 1.1 95^{th} = 5.1	
		Toddler	Empirical	50^{th} = 2.5 95^{th} = 10	
AppF	Application Frequency (applications/hour)	Traditional	Point Estimate	NA	
		With sunscreen	Point Estimate	NA	
NA = not applicable GM = geometric mean GSD = geometric standard deviation S-/I-/LT = short-/intermediate-/long-term exposure					

Application Rate (AR_F; mg product/cm^2 skin)

It is expected that most of the products assessed will not have labels that state active-ingredient-based application rates in quantifiable terms (e.g., mg ai/cm^2). Application rates vary depending on the formulation, with lotions being applied most heavily. Efficacy studies were used as the basis for application rates since these data are formulation specific and are from actual repellent applications (Carroll, S.P. 2007a, 2007b, 2007c, 2007d, 2007e, 2008a, 2008b). While the studies themselves vary with respect to the application location and different types of active ingredients, in general, the repellent efficacy studies that EPA receives are conducted by treating a portion of a subject's skin with insect repellent, and then exposing the treated skin to mosquitoes and then observing the rate at which the insects "bite" the subject's skin. See *Appendix C.11* for detailed information on application rates for various formulations.

Table 6-4 provides a summary for the formulation-based application rates.

Table 6-4: Statistical Summary – Repellent Product Application Rate (mg product/cm^2)				
Statistic	**Aerosol**	**Pump-spray**	**Lotion**	**Towelette**
50th percentile	0.92	0.50	1.9	1.1
75th percentile	1.5	0.78	2.4	1.3
95th percentile	2.9	1.5	3.5	1.8
99th percentile	4.7	2.3	4.6	2.3
AM (SD)	1.1 (0.93)	0.62 (0.45)	2.0 (0.80)	1.1 (0.36)
GM (GSD)	0.92 (2.0)	0.50 (1.9)	1.9 (1.5)	1.1 (1.4)
Range	0.17 – 3.5	0.056 – 2.3	0.68 – 4.5	0.5 – 2.5
N	144	420	120	240
Statistics based on lognormal distributions. AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)				

Exposure Time (ET)

<u>Adults</u>

Another important variable for addressing post-application exposure from insect repellents is the duration of time during which repellents are applied. An empirical distribution (which was expressed as a cumulative distribution function) from the Exposure Factors Handbook Table 15-80 (USEPA, 1997) for adults was selected that represents the amount of time spent "outdoor playing" (see *Table 6-5*). It is likely that insect repellents would be used when individuals are performing outdoor activities, so this dataset was considered a reasonable surrogate. **The recommended point estimate for use in post-application hand-to-mouth exposure assessment [XX] hours/day represents approximately the [XX]th percentile.**

Table 6-5: Time Spent in Outdoor Playing Adults (18 to 64 year olds)	
Statistic	**Hours per Day**
5th percentile	0.5
25th percentile	0.9
50th percentile	1.1
75th percentile	1.7
90th percentile	2.4
95th percentile	5.1
99th percentile	7.3

<u>Toddlers</u>

For duration of time during which repellents are applied for toddlers, an empirical distribution (which was expressed as a cumulative distribution function) from the Child-Specific Exposure Factors Handbook Table 16-16 (USEPA, 2008) for toddlers (3 to <6 year olds) was selected that represents the amount of time spent performing outdoor recreational activities (see *Table 6-6*). This age group is considered the major toddler sub-population group because of the expected greater use of repellents compared with younger children due to time spent in activities during which repellents would be used. Additionally, it is likely that insect repellents would be used when children are performing outdoor activities, so this dataset was considered a reasonable surrogate. Note that only the "doers" are represented in this distribution which means individuals who did not respond that they perform outdoor recreational activities were excluded.

The recommended point estimate for use in post-application hand-to-mouth exposure assessment [XX] hours/day represents approximately the [XX]th percentile.

Table 6-6: Time Spent Performing Outdoor Recreational Activities for Toddlers (3 to <6 year olds)	
Statistic	**Hours per Day**
5th percentile	0.5
10th percentile	0.5
25th percentile	1.0
50th percentile	2.5
75th percentile	4.0
90th percentile	9.8
95th percentile	10
99th percentile	10

Application Frequency (AppF):

The assessor should consider the exposure scenario, formulation, and target pest while determining the number of applications per hour. Most insect repellent labels do not specify the number of applications to be made per hour. More commonly, a label will carry a statement such as “reapply as needed.” Efficacy studies are designed to measure the duration of repellency provided by the products tested. If product-specific information on the duration of efficacy repellency is available, the assessor should use it in their assessment to determine the application frequency specific to the individual product.

However, if this information is unavailable, **a generic application frequency of [XX] every [XX] hours ([XX] apps/hour) is recommended for traditional repellents while an application frequency of [XX] every [XX] hours ([XX] apps/hour) is recommended for repellents formulated with sunscreens.** Sunscreen applications are assumed to occur more frequently. This is based on information from the Center for Disease Control (CDC) indicating effective repellency times vary from 2-6 hours (i.e., 1 application every 2-6 hours) depending on the product and formulation (Fradin and Day, 2002).

Body Weight and Surface Area

The exposure algorithm uses surface area (SA) and body weight (BW) as a ratio instead of as two separate factors. *Table 6-7* provides a summary of this exposure parameter.

Table 6-7: Surface Area to Body Weight Ratio (cm^2/kg)			
%tile	**Adult**	**Youth**	**Child**
	Males and Females; > 18 yrs.	**Males and Females; 2-18 yrs.**	**Males and Females; < 2 yrs.**
95	329	594	846
90	316	501	784
75	302	454	719
50	286	422	617
25	270	376	563
10	244	328	507
5	238	291	470
Source: U.S. EPA (1997) Exposure Factors Handbook, Vol. I Table 6-9; 2008 CSEFH, Table 7-10.			

Fraction of Body Exposed (F_{Body})

Clothing-dependent fraction of body exposed (surface area body exposed/total body surface area) are presented in *Table 6-8* below. These estimates are based on Wong, et al (2000) and are intended to represent a range of exposure scenarios in different activity and weather conditions. 17% represents an individual wearing a long-sleeve shirt, pants, socks, and shoes; 31% represents an individual wearing a short-sleeve shirt, shorts, socks, and shoes; 75% represents an individual wearing shorts (males) or shorts and a top (females).

Table 6-8: Percentage of Total Body Surface Area Exposed

Clothing Scenario	Body Parts Exposed	% of Body SA Exposed	
		Per Body Part	Total
Long-sleeve shirt, pants, socks, shoes	Face/Neck	5%	17%
	Hands/wrists	6%	
	Ankles	6%	
Short-sleeve shirt, shorts, socks, shoes	Lower thighs/upper shins	13%	31%
	Forearms	6%	
	Face/Neck	6%	
	Feet	7%	
Shorts (males); Shorts and top (females)	Torso	38%	75%
	Arms		
	Lower thighs/upper shins	13%	
	Lower shins	6%	
	Feet	7%	
	Hands	5%	
	Face/Neck	5%	

Future Research/Data Needs

Unavailable information that would refine post-application dermal exposure assessments for pesticide applications to insect repellents include:

- Measurements of "whole body" exposure following repellent applications under differing situations (e.g., single-event as well as longitudinal repeated applications at campsites, beaches, etc.) to replace method of extrapolating from forearm or leg measurements
- Survey information detailing:
    - Daily/weekly/monthly probability of using a repellent
    - Repellent application regimens (i.e., applications per day) – both daily and longitudinal frequencies

Exposure Characterization and Data Quality

Formulation-specific Application Rates: The formulation-specific application rates were derived from available repellent efficacy studies where the amount of repellent applied to a known surface area (i.e., the area of a certain section of forearm or leg) was measured typically via a "before-and-after" weighing. The extent to which the data in these studies present a true statistical representation of repellent applications rates is unknown. Furthermore, because the applications were to legs or forearms only, the application of the rates for use in the post-application dermal exposure equation requires extrapolation to the rest of the body which adds uncertainty.

Fraction of Body Exposed: The three "scenarios" described by the amount of body exposed per application are meant to represent the broad range of repellent exposure situations. This is because, for example, the proportion of total repellent applications comprising heavy-use repellent applications (i.e., an application to 75% of a person's skin) is unknown.

Daily Application Frequency: The number of repellent applications per day would be highly chemical-specific, since it would be dependent on the product's efficacy. However, in the event this information is unknown, the range of 1 application every 2-6 hours (Fradin and Day, 2002) is reasonable and the recommended point estimate of X application every X hours (i.e., X per hour) is considered conservative.

6.2.3 Post-application Non-Dietary Ingestion Exposure Assessment: Hand-to-Mouth

This SOP provides a standard method for estimating the dose for toddlers from incidental ingestion of pesticide residues from skin treated with insect repellents. This scenario assumes that pesticide residues resulting from the application of insect repellents on the skin of toddlers and are subsequently ingested as a result of hand-to-mouth transfer.

Post-application Hand-to-Mouth Exposure Algorithm

Exposure from hand-to-mouth activity is calculated as follows (based on the algorithm utilized in SHEDS-Multimedia, http://www.epa.gov/heasd/products/sheds_multimedia/sheds_mm.html):

$$E = [HR * (F_M * SA_H) * (ET * N\_Replen) * (1- (1- SE)^{(Freq\_Replen/N\text{-}Replen)})] \quad (6.5)$$

where:

E	= exposure (mg/day);
HR	= hand residue loading (mg/cm^2);
F_M	= fraction hand surface area mouthed / event (fraction/event);
SA_H	= typical surface area of one hand (cm^2);
ET	= exposure time (hr/day);
N_Replen	= number of replenishment intervals per hour (intervals/hour);
SE	= saliva extraction factor (ie, mouthing removal efficiency); and
Freq_Replen	= number of hand-to-mouth contacts events per hour (events/hour).

and

$$HR= AR_F * F_{AI} \quad (6.6)$$

where:

HR	= hand residue loading (mg/cm^2);
AR_F	= formulation-specific application rate (mg ai/cm^2 skin);
F_{AI}	= product-specific fraction of active ingredient (mg ai/mg product);

Oral dose, normalized to body weight, are calculated as:

$$D = \frac{E}{BW} \tag{6.7}$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day); and
BW = body weight (kg).

Post-application hand-to-mouth exposure following repellent applications is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Hand-to-Mouth Exposure Algorithm Inputs and Assumptions

Recommended values for post-application hand-to-mouth exposure assessments are provided in *Table 6-9*. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions, ii) data sources used to derive recommended input values, and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 6-9: Insect Repellents - Recommended Distributions and Point Estimates for Post-Application Hand-to-Mouth Exposure Factors

Algorithm Notation	Exposure Factor (units)		Distribution		Point Estimate(s)
			Type	Parameters	
AR_F	Formulation-specific application rate (mg product/cm^2 skin)	Aerosol	Lognormal	GM = 0.9 GSD = 2.0	
		Pump spray	Lognormal	GM = 0.50 GSD = 1.9	
		Lotion	Lognormal	GM = 1.9 GSD = 1.5	
		Towelette	Lognormal	GM = 1.1 GSD = 1.4	
F_{AI}	Amount of active ingredient (%)		NA	NA	
SA_H	Typical surface area of one toddler hand (cm^2)		Point Estimate	NA	225
F_M	Fraction hand surface area mouthed (fraction/event)		Beta	$\alpha = 3.7$ $\beta = 25$	
N_Replen	Replenishment intervals (intervals/hr)		Point Estimate	NA	
ET	Exposure Time (hours/day)		Empirical	50th = 2.5 95th = 10	
SE	Saliva extraction factor (fraction)		Beta	$\alpha = 7.0$ $\beta = 7.6$	

Table 6-9: Insect Repellents - Recommended Distributions and Point Estimates for Post-Application Hand-to-Mouth Exposure Factors				
Freq_Replen	Hand-to-mouth events per hour (events/hr)	Weibull	Scale= 0.80 Shape= 7.51	
BW	Body Weight (kg)	Empirical	Mean = 18.6 95^{th} = 26.2	
NA = not applicable				

Hand Residue Loading (HR)

The application rate described in the post-application dermal exposure section is assumed to be equally distributed across the body. Therefore, those rates can be directly used as the concentration on the hands following a repellent application. Thus, the concentration on the hands is the product of the formulation-specific rates shown in *Table 6-9* and the amount of active ingredient in the repellent.

Fraction Hand Surface Area Mouthed (F_M)

See *Section 2.4* of this SOP for discussion of the fraction of hand surface area mouthed distribution. **The recommended point estimate for use in post-application hand-to-mouth exposure assessment [XX] cm^2 represents approximately the $[XX]^{th}$ percentile.**

Hand Surface Area (SA_H)

The hand surface area for toddlers (3 to <6 year olds) of 225 cm^2, for one hand, was based on values from the Child-specific Exposure Factors Handbook (U.S. EPA, 2008).

Exposure Time (ET)

For duration of time during which repellents are applied for toddlers, an empirical distribution (which was expressed as a cumulative distribution function) from the Child-Specific Exposure Factors Handbook Table 16-16 (USEPA, 2008) for toddlers (3 to <6 year olds) was selected that represents the amount of time spent performing outdoor recreational activities (see *Table 6-10*). Only the "doers" are represented in this distribution which means individuals who did not respond that they perform outdoor recreational activities were excluded. It is likely that insect repellents would be used when children are performing outdoor activities, so this dataset was considered a reasonable surrogate. **The recommended point estimate for use in post-application hand-to-mouth exposure assessment [XX] hours/day represents approximately the $[XX]^{th}$ percentile.**

Table 6-10: Time Spent Performing Outdoor Recreational Activities (3 to <6 year olds)	
Statistic	**Hours per Day**
5^{th} percentile	0.5
10^{th} percentile	0.5
25^{th} percentile	1.0
50^{th} percentile	2.5
75^{th} percentile	4.0
90^{th} percentile	9.8

95th percentile	10.1
99th percentile	10.4

Replenishment Intervals per Hour (N_Replen)

Unlike other hand-to-mouth scenarios where replenishment can come from treated indoor surfaces or treated turf, replenishment for insect repellents is assumed to only occur when an application occurs. As a result, application frequency is used to represent replenishment intervals per hour. Most insect repellent labels do not specify the number of applications to be made per hour. More commonly, a label will carry a statement such as "reapply as needed." Efficacy studies are designed to measure the duration of repellency provided by the products tested. If product-specific information on the duration of efficacy repellency is available, the assessor should use it in their assessment to determine the application frequency specific to the individual product. However, if this information is unavailable, **a generic application frequency of [XX] every [XX] hours ([XX] apps/hour) is recommended.** This is based on information from the Center for Disease Control (CDC) indicating effective repellency times vary from 2-6 hours (i.e., 1 application every 2-6 hours) depending on the product and formulation (Fradin and Day, 2002).

Fraction of Pesticide Extracted by Saliva (SE_H)

See *Section 2.6* for discussion of the distribution of values for the fraction of pesticide extracted by saliva distribution. **The recommended point estimate for use in post-application hand-to-mouth exposure assessment [XX] represents approximately the [XX]th percentile.**

Hand-to-Mouth Events per Hour (Freq_Replen)

Frequency of hand-to-mouth events is an important variable for hand-to-mouth post-application exposure assessments. However, there are currently no data available that specifically address the number of hand-to-mouth events that occur relative to the amount of time a child is in contact with an insect repellent. As a result, the estimates for frequency of hand-to-mouth events in outdoor environments from the Xue et al. (2007) meta-analysis were selected as a surrogate. The outdoor data were selected because they represent the most likely time when insect repellents will be used on children. The insect repellent SOP utilizes hand-to-mouth frequency data for the 3 to <6 year old age grouping to represent toddlers. Distributions for different sub-populations can be used if there is a need to assess a more specific exposure population. The estimates of hand mouthing frequency (events/hour) for 3 to <6 year olds were derived from 4 studies representing 55 participants. A Monte Carlo simulation was performed using the data and it was determined that a Weibull distribution best fits the observed data. *Table 6-11* provides distributions and point estimates of hand-to-mouth events for use in residential pesticide exposure assessment. **The recommended point estimate for use in post-application hand-to-mouth exposure assessment [XX] events/hour represents approximately the [XX]th percentile.**

Table 6-11: Frequency of Hand-to-Mouth Events (events/hour)	
Statistic	**3 to <6 year olds**
50th percentile	4.7
75th percentile	11.4
95th percentile	30.2
99th percentile	50.7
AM (SD)	8.4 (10.7)
GM (GSD)	7.7 (2.7)
Range	0 - 48.9
N	55
AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

Future Research/Data Needs

Unavailable information that would refine post-application dermal exposure assessments for the application of insect repellents include:

- Repellent application regimens – both daily and longitudinal frequencies
- Survey information detailing:
  - Daily/weekly/monthly probability of using a repellent;
  - Product- and/or formulation-specific application rates enabling determination of hand-specific concentrations under differing scenarios as well as repeat applications to measure the extent to which the rate varies per individual (i.e., intra-individual exposure variability).

Exposure Characterization and Data Quality

Formulation-specific Application Rates: The formulation-specific application rates were derived from available repellent efficacy studies where the amount of repellent applied to a known surface area (i.e., the area of a certain section of forearm or leg) was measured typically via a "before-and-after" weighing. The extent to which the data in these studies present a true statistical representation of repellent applications is unknown. Furthermore, because the applications in these studies were to legs or forearms only, the use of these application rates to assess the hands in the post-application hand-to-mouth exposure equation adds uncertainty.

Daily Application Frequency: The number of repellent applications per day would be highly chemical-specific, since it would be dependent on the product's efficacy. However, in the event this information is unknown, the range of 1 application every 2-6 hours (Fradin and Day, 2002) is reasonable and the recommended point estimate of **[XX]** application every **[XX]** hours (i.e., **[XX]** per hour) is considered conservative.

6.2.4 Combining Post-application Scenarios

Risks resulting from different exposure scenarios are combined when it is likely that they can occur simultaneously based on the use pattern and when the toxicological effects across different routes of exposure are the same (see *Section 1.3.4*). When combining scenarios, it is important to fully characterize the potential for co-occurrence as well as characterizing the risk inputs and estimates. Risks should be combined even if any one scenario or route of exposure exceeds the level of concern because this allows for better risk characterization for risk managers. For insect repellents, the post-application exposure scenarios that should be combined are the dermal and hand-to-mouth scenarios. This combination should be considered a protective estimate of children's exposure from the use of insect repellents.

Section 7 Indoor Environments

This section considers those individuals who are potentially exposed to pesticides from either treating indoor areas with a product available for sale to the general public or after contact with treated indoor surfaces in many settings including homes, schools, and daycares. Before the development of an exposure assessment for this scenario, the assessor should review the pesticide label to determine whether it is appropriate based on the usage of the product. For the purposes of this SOP, the following definitions are used:

A fogger is a device (can) created for spreading a fog of pesticide in a water-based formulation and single phase solvent systems containing propellant. A total release aerosol or fogger is an aerosol pesticide device designed to automatically release its total content in one operation for the purpose of creating a permeating fog within a confined space to deliver the pesticide throughout the space. Total release aerosols do not need any other application equipment (PR NOTICE 98-6, 1998). For the purposes of the indoor *post-application* scenarios, foggers are assessed as broadcast applications.

Broadcast application is defined as an application to broad expanses of surfaces such as walls, floors, and ceilings (U.S. EPA, 1996); a coarse spray of liquid insecticide or application of a dust insecticide in a room; should be evenly distributed (University of Nebraska–Lincoln Extension, 2006).

Perimeter application is defined as a coarse spray of liquid insecticide or application of a dust insecticide in a wide band or strip; usually several inches wide from the wall (University of Nebraska–Lincoln Extension, 2006).

Spot application is defined as a coarse spray of liquid or application of a dust insecticide over a small area (< 2 ft^2) (38 FR 21685, 1973).

Crack and crevice application is defined as an application of small amounts of pesticides, *with the use of a pin stream nozzle*, into cracks and crevices in which pests hide or through which they may enter a building. Such openings commonly occur at expansion joints, between different elements of construction, and between equipment and floors. These openings may lead to voids such as hollow walls, equipment legs and bases, conduits, motor housings, and junction or switch boxes (U.S. EPA, 1996).

Specific labeling considerations for indoor treatments are as follows:

Registered for Use as a Pesticide to be Applied as a Broadcast, Fogger, Perimeter, Spot, or Crack and Crevice Treatment: Determine whether the pesticide label contains directions for use as a broadcast, fogger, perimeter, spot or crack and crevice treatment (i.e., with a pin stream nozzle inside cracks).

Registered for Use as a Pesticide to be Applied to Carpets or Hard Surfaces: Determine whether the pesticide label contains directions for use on carpets or hard surfaces, such as walls, countertops, hard floors, or cabinets.

Limitation and Descriptive Statements: Look for statements describing or limiting the use of these products. These statements may be on the front panel of the label associated with the brand or trade name or in the use-directions section of the labeling. Assume that such products are used at residential sites, including daycares, schools, or other sites where children may be present, unless a specific labeling statement indicates otherwise. Examples of statements that restrict use in residential sites, and therefore, would preclude a residential handler assessment, include:

- Not for use on residential sites
- Not for use in and around homes or dwellings
- For use on commercial sites only

Additionally, RUP classification indicates that the product cannot be bought or applied by homeowners (i.e., no residential handler exposure/risk assessment required), but it may be applied by commercial applicators to residential sites; therefore, a post-application risk assessment may be required. However, statements such as "For use by commercial or professional applicators only" or “Not for homeowner use” are considered unenforceable statements and do not preclude use in residential settings. In these cases, therefore, both a residential handler and post-application exposure assessment is required.

If an indoor use is possible, the assessment should then characterize and estimate the potential for exposure by route (i.e., dermal, inhalation, non-dietary ingestion) following the methodology outlined in this SOP. The assessor should consider the durations of exposure for each route. Specific considerations include the number of applications allowed per year and the re-treatment interval required between those treatments. Depending on the specific product, this can indicate if intermediate- or long-term assessments are required.

7.1 Handler Exposure Assessment

The residential indoor handler SOP provides a standard method for estimating potential dermal and inhalation doses resulting from applying pesticides indoors. Adults are considered the sentinel population for this scenario as it is assumed that pesticides are applied by adults only (i.e., individuals18 years or older).

Dermal and Inhalation Handler Exposure Algorithm

As described in *Section 1.3.3*, daily dermal and inhalation exposure (mg/day) for residential pesticide handlers, for a given formulation-application method combination, is estimated by multiplying the formula-application method-specific unit exposure by an estimate of the amount of active ingredient handled in a day, using the equation below:

$$E = UE * AR * A \tag{7.1}$$

where:

E = exposure (mg/day);
UE = unit exposure (mg/lb ai);
AR = application rate (e.g., lb ai/ft^2, lb ai/gal); and
A = area treated or amount handled (e.g., ft^2/day, gal/day).

Dermal and/or inhalation potential doses normalized to body weight are calculated as:

$$D = \frac{E * AF}{BW} \tag{7.2}$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

Handler exposure for indoor applications is generally considered either acute or short-term in duration. Thus, the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.3*, such as the product-specific application regimen. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Dermal and Inhalation Handler Exposure Algorithm Inputs and Assumptions

Recommended values for handler exposure (inhalation and dermal) assessments are provided in *Table 7-1*and *Table 7-2*. Following these tables, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 7-1: Indoor Scenario – Recommended Unit Exposure (mg/lb ai) Distributions and Point Estimates								
Formulation	Equipment/ Application Method	Dermal			Inhalation			Appendix Page Reference
		Distribution		Point Estimate	Distribution		Point Estimate(s)	
		Type	Parameters		Type	Parameters		
Dusts/Powders	Plunger duster	Lognormal	GM = 148 GSD = 2.76		Lognormal	GM = 0.50 GSD = 4.75		B-32
	Bulb duster	No exposure data available for this application scenario. Exposure data for plunger duster applications recommended as surrogate data.						
	Electric/power duster	No exposure data available for this application scenario. Exposure data for shaker can applications of dusts/powders recommended as surrogate data.						
	Hand crank duster	No exposure data available for this application scenario. Exposure data for shaker can applications of dusts/powders recommended as surrogate data.						
	Shaker can	Lognormal	GM = 3629 GSD = 1.76		Lognormal	GM = 9.42 GSD = 3.05		B-36
Liquid concentrates	Low-pressure handwand (w/ or w/o pin stream nozzle)	No exposure data available for this application scenario. Exposure data for low-pressure handwand applications of wettable powder recommended as surrogate data.						
Ready-to-Use (RTU)	Aerosol can (w/ or w/o pin stream nozzle)	Lognormal	GM = 329 GSD = 1.60		Lognormal	GM = 2.34 GSD = 2.01		B-130
	Trigger-sprayer	Lognormal	GM = 54.2 GSD = 2.56		Lognormal	GM = 0.046 GSD = 2.10		B-109
	Gels	No exposure data available for this application scenario. Exposure data for low-pressure handwand applications of wettable powder recommended as surrogate data.						
	Pastes	No exposure data available for this application scenario. Exposure data for low-pressure handwand applications of wettable powder recommended as surrogate data.						
	Foams	No exposure data available for this application scenario. Exposure data for low-pressure handwand applications of wettable powder recommended as surrogate data.						
Wettable Powder	Low-pressure handwand (w/ or w/o pin stream nozzle)	Lognormal	GM = 34.2 GSD = 3.29		Lognormal	GM = 0.63 GSD = 2.93		B-138
Wettable Powder in Water-soluble Packaging	Low-pressure handwand (w/ or w/o pin stream nozzle)	No exposure data available for this application scenario. Exposure data for low-pressure handwand applications of liquid concentrates recommended as surrogate data.						

Table 7-2: Indoor Scenario – Recommended Handler Exposure Factors Distributions and Point Estimates

Exposure Factor (units)			Distribution Type	Distribution Parameters	Point Estimate(s)
Application Rate (mass ai per unit area)			Product-specific	NA	Maximum labeled rate
Amount product / /solution used	Low-pressure handwand (gallons)	Broadcast Perimeter/Spot	Point Estimate	NA	0.5
	Low-pressure handwand (w/pin stream nozzle) (gallons)	Crack and crevice	Point Estimate	NA	0.25
	Bulb duster (pounds dust)	Crack and crevice	Point Estimate	NA	0.25
	Plunger duster (pounds dust)	Broadcast Perimeter/Spot	Point Estimate	NA	0.5
	Electric/power duster (pounds dust)	Broadcast Perimeter/Spot	Point Estimate	NA	
	Hand crank duster pounds dust	Broadcast Perimeter/Spot	Point Estimate	NA	
	Shaker can (# containers)	Broadcast Perimeter/Spot	Point Estimate	NA	1
	Aerosol can (# cans)	Broadcast Perimeter/Spot	Point Estimate	NA	1
	Aerosol can (w/ pin stream nozzle) (# cans)	Crack and crevice	Point Estimate	NA	0.5
	Trigger-pump sprayer (# containers)	Broadcast Perimeter/Spot	Point Estimate	NA	1
	Gels (# containers)	Crack and crevice	Point Estimate	NA	1
	Pastes	Crack and crevice			
	Foams	Crack and crevice			
Body Weight (kg)			Empirical	Mean = 71.8 95^{th} = 97.9	
NA = not applicable					

Unit Exposures

As described in *Section 1.3.3*, the unit exposure is the ratio, for a given formulation/application method combination, between exposure and the amount of active ingredient handled, with units of mass exposure per mass active ingredient handled (e.g., mg ai exposure/lb ai handled). **The recommended point estimate for use in handler dermal and inhalation exposure assessments represents approximately the [XX]th percentile.** Data summaries can be found in Appendix B.

Estimating the Amount of Active Ingredient Handled

The algorithm for estimating handler exposure requires some estimate of the amount of active ingredient handled per day. This factor varies based on the type of equipment or application method used and is estimated based on the application rate specified on the product label. First, the assessor should assemble application rate information in terms of active ingredient per volume of spray (e.g., lb ai/gallon solution). For example, instructions for a liquid formulation might direct application of 0.5 gallons of solution per 100 square feet. For handler indoor assessments, the following are the recommended amounts of active ingredient handled for typical indoor application equipment.

- Low-pressure handwand: 0.5 gallons for broadcast, perimeter, and spot treatments and 0.25 gallons for crack and crevice treatments. These values are supported by data from the Pesticide Handler Exposure Database (PHED), which indicate about 0.5 gallons for a commercial applicator crack/crevice and limited surface treatment in residences.
- Dusters: 0.5 pounds of dust for broadcast, perimeter, and spot treatments and 0.25 pounds of dust for crack and crevice treatments. These values are based on best professional judgment since no data are available.
- Shaker can: 1 can for broadcast, perimeter and spot treatments. These values are based on best professional judgment since no data are available.
- Aerosol Can: 1 can for broadcast, perimeter, and spot treatments and 1/2 can for crack and crevice treatments. These values are supported by data from the Pesticide Handler Exposure Database (PHED), which indicate one 15-oz can is used to make applications to crack, crevices, baseboards, under sinks, behind appliances, etc.
- Trigger-pump sprayer: 1 container for broadcast, perimeter, and spot treatments. These values are based on best professional judgment since no data are available.
- Gels/Pastes/Foams: 1 container. These values are based on best professional judgment since no data are available.

Future Research/Data Needs

Unavailable information that would refine handler exposure assessments for indoor pesticide applications include:

- Information on the amount handled or area treated for the various scenarios.
- Information on unit exposures for several formulation/equipment combinations (e.g., gels, pastes, and foams).

Exposure Characterization and Data Quality

Active ingredient/Product handled:

- The uncertainties associated with this assessment stem from the use of assumed amounts of active ingredient handled for typical residential indoor application equipment. The estimated exposures are believed to be high-end, conservative estimates.

7.2 Post-application Exposure Assessment

Post-application exposure can result from contact with indoor surfaces following a pesticide application. While exposure may occur for people of all ages, adults, toddlers (3 to <6 years) and infants (1 to <2 years) are considered the sentinel populations for this exposure scenario based on behavioral characteristics and the strengths and limitations of available data.

This section addresses standard methods for estimating exposure and dose for five individual post-application scenarios resulting from exposure to pesticides that have been used to treat indoor areas:

- Section 7.2.1 - adult/toddler/infant inhalation exposures;
- Section 7.2.2 - adult/toddler/infant dermal exposures;
- Section 7.2.3 – toddler/infant non-dietary ingestion via hand-to-mouth activity;
- Section 7.2.4 – toddler/infant non-dietary ingestion via object-to-mouth activity; and
- Section 7.2.5 – toddler/infant non-dietary ingestion via dust ingestion.

7.2.1 Post-application Inhalation Exposure Assessment

This SOP provides a standard method for completing post-application inhalation exposure assessments for adults and children after a pesticide treatment in their residence. The basis for each scenario is that non-handler inhalation exposure occurs while occupying living spaces within a residence after a pesticide treatment. It covers fogger, aerosol and surface spray (i.e., broadcast, perimeter, and crack and crevice) applications.

Inhalation exposure primarily occurs through breathing air containing pesticides as vapors or aerosols. Aerosols are typically a spray of fine particles, which tend to settle out of the air after a certain time period depending on the particle size. Some examples of indoor devices that produce aerosols include foggers and aerosol space sprays. Vapors occur when the pesticide volatilizes after a surface spray application (e.g., broadcast or crack and crevice) has occurred. Volatilization of a pesticide indoors is dependent on many factors, including the vapor pressure of the chemical, the media on which it has been applied, and air temperature.

<u>Indoor Foggers</u>

For indoor foggers, post-application inhalation exposure would be expected to be a result of exposure to aerosols. Fogger devices are expected to spread a fog of pesticide filling the room with aerosols, which will eventually settle out of the air. To address exposure to aerosols from fogger applications, most fogger labels typically require statements such as: "Do Not Reenter Building for Four Hours; then open exterior doors and windows and allow to air for 60 minutes before reoccupying area" with the intention of reducing exposure. Based on information provided by manufacturers, the particle distribution for most total release foggers ranges from 15 micrometers (um) to 60 um. Using this information, the average settling time for various particle sizes was calculated. At 15 um, the average settling time is estimated to be around 2.5 hours (for more information on the calculation of settling time for foggers, see Appendix C1). If the reentry time restriction on the label is at least 2.5 hours, then post-application inhalation exposure should not be a concern because all particles should have settled out of the air. However, if the reentry time restriction is less than 2.5 hours, then post-application inhalation exposure should be assessed for the fogger according to the procedure for aerosols.

<u>Indoor Aerosol and Surface Spray applications</u>
For indoor aerosol applications, post-application inhalation exposure is anticipated to be to the pesticide aerosols after an application has been made. For surface spray applications (i.e., broadcast, perimeter, and crack and crevice), post-application inhalation exposure is anticipated to be to the pesticide vapor after an application has been made. This SOP provides methods to assess inhalation exposure to both vapors and aerosols.

For the inhalation route of exposure, the point of departure (POD) could be based on the reference concentration (RfC) methodology. In the RfC methodology, air concentrations are not converted to doses, rather, risks are assessed on the basis of comparison of exposure concentrations with reference concentrations typically determined from animal studies. This approach is not always available for every chemical; therefore, the exposure assessor should discuss the possibility of this approach with a toxicologist

If the inhalation exposure calculations need to be refined, it is recommended that specialized computer software be used. One computer model is the *MCCEM* model or Multi-Chamber Concentration and Exposure Model. This model is the current model used by the Agency. The *MCCEM* was peer reviewed in 1998 (Eastern Research Group, 1998). The appendix to this SOP provides standard model inputs for using *MCCEM* in exposure assessments, but the assessor should refer to the *MCCEM* User's Manual for details on the operation of *MCCEM* and for information concerning the underlying assumptions and limitations of each (U.S. EPA, 1995). One notable limitation is that MCCEM treats all emissions as vapors. Air flows in the model were developed using vapors, not aerosols. Therefore, the air concentration calculations for aerosols using the MCCEM model will be overestimations, since a certain amount of the pesticide in the air is expected to settle out. All specific model inputs and calculations represented in this SOP are based on *MCCEM* Version 1.2 (available on the EPA website: http://www.epa.gov/opptintr/exposure/pubs/mccem.htm).

Post-Application Inhalation Exposure Algorithm

Instantaneous Release/Aerosol Applications

For instantaneous release/aerosol applications, the initial air concentration must first be calculated. If chemical-specific data are available, the initial air concentration is the air concentration at time 0 (assuming that individuals could be exposed to the air concentration immediately after application). If data are not available, then the initial air concentration can be calculated using the following formula:

$$C_0 = AR * CF1 \quad (7.3)$$

where:

C_0 = initial air concentration (mg/m^3);
AR = application rate ($lbs\ ai/m^3$); and
CF1 = conversion factor (454,000 mg/lb).

If an application rate is given on the label in terms of unit area, this should be used. The following equation can be used to calculate the application rate if it's not provided:

$$AR = \frac{A.I. * V_{product} * D_{product} * CF1 * CF2}{V_{room}} \quad (7.4)$$

where:

AR = application rate (lbs ai/m^3);
A.I. = percent active ingredient in product (% ai);
$V_{product}$ = volume of product in 1 can (mL);
$D_{product}$ = density of product (g/mL);
CF1 = conversion factor (1,000 mg/g);
CF2 = conversion factor (2.2×10^{-6} lb/mg); and
V_{room} = volume of room (m^3).

As a check to determine whether the air concentration has exceeded the saturation concentration, the exposure assessor should also calculate the saturation concentration and compare to the calculated air concentration for their scenario. The calculated air concentration *should not exceed* the saturation concentration. If it does, then the saturation concentration should be used as a worst-case scenario. The following equation can be used to calculate the saturation concentration of a specific chemical:

$$C_{sat} = \frac{VP * CF1 * MW * CF2 * CF3}{R * T} \quad (7.5)$$

where:

C_{sat} = Saturation concentration (mg/m^3),
VP = Vapor pressure (mmHg),
MW = Molecular weight (g/mol),
R = Gas constant = 0.0821 L-atm/mol-K,
T = Temperature of the air (296 K),
CF1 = Conversion factor (atm/760 mm Hg),
CF2 = Conversion factor (10^3 mg/g), and
CF3 = Conversion factor (10^3 L/m^3).

If the POD is based on the RfC methodology, then the calculated air concentration can be compared directly to the reference concentration. However, if the POD is a No-Observed-Adverse-Effect-Level (NOAEL) or Lowest-Observed-Adverse-Effect-Level (LOAEL), inhalation potential doses must be calculated in order to compare to the appropriate POD. The Instantaneous Release Box Model for aerosols can be used to calculate exposure for this type of application scenario.

This section provides a standard method for completing post-application inhalation exposure assessments for adults and children after an aerosol treatment indoors. The basis for this scenario is that inhalation exposure occurs from the airborne aerosols released after an aerosol application. The well-mixed box (WMB) model was used to develop the exposure equation for the instantaneous release/aerosol post-application inhalation scenario. The WMB model incorporates a number of simplifying assumptions: fresh air (having no pesticide concentration) enters the box at a constant airflow rate (based on the number of air changes per hour), a turbulent internal airflow thoroughly mixes the fresh air with the pesticide-laden air resulting in a uniform pesticide air concentration within the box, and the perfectly mixed air exits the box at the same constant airflow rate (i.e., the inflow rate equals the outflow rate). Thus, the indoor area where the aerosol is being applied is assumed to be in an enclosed box, which is a reasonable assumption for a walled, indoor space. This scenario assumes instantaneous spray release, that is, the total amount of aerosol released is modeled to occur instantaneously.

The evacuation of the aerosol from the box depends on airflow. For an indoor scenario, the airflow is the product of the volume of the treated space and the number of air changes per hour, ACH. The WMB model developed for this scenario models the pesticide air concentrations *after* an instantaneous aerosol spray release. Only dissipation due to airflow into and out of the box is modeled.

Post-application inhalation exposure for adults/children resulting from aerosols can be calculated using the following equation (See *Appendix C.3.5* for equation description and derivation):

$$E = \frac{C_o * IR}{ACH} * \left[1 - e^{(-ACH * ET)}\right] \quad (7.6)$$

where:

- E = exposure (mg/day);
- C_o = initial concentration (mg/m^3);
- IR = inhalation rate (m^3/hr);
- ACH = air changes per hour (hour^{-1}); and
- ET = exposure time (hr/day).

Inhalation dose normalized to body weight is calculated as:

$$D = \frac{E * AF}{BW} \quad (7.7)$$

where:

- D = dose (mg/kg-day);
- E = exposure (mg/day);
- AF = absorption factor (dermal and/or inhalation); and
- BW = body weight (kg).

Vapor Emission for Surface Sprays

For this exposure scenario, an emission rate that decreases over time is modeled. This decreasing emission rate is based on a first-order decay rate constant (k). Evans (1994) proposed calculating such a decay rate based on work done by Chinn (1981). Chinn developed a relationship between the volatility (v) of a chemical and time required for 90% of the chemical to evaporate (EvapT). Chinn proposed the following equation for calculating volatility based on room temperature (T) and the chemical-specific properties molecular weight (MW) and vapor pressure (VP):

$$\mathrm{v} = \frac{\mathrm{MW} * \mathrm{VP} * 16{,}036}{\mathrm{T}} \tag{7.8}$$

where:

v = volatility (mg/m^3);
MW = molecular weight of active ingredient (g/mol);
VP = vapor pressure of active ingredient (mmHg); and
T = temperature (296 K).

Chinn further describes the relationship between volatility and the 90% evaporation time with the following equation:

$$\mathrm{EvapT} = 10^{[7.3698 - 0.9546 * \log_{10}(\mathrm{v})]} \tag{7.9}$$

where:

EvapT = evaporation time (sec); and
v = volatility (mg/m^3).

Evans proposed the following equation to calculate the decay rate that defines the change in the emission rate based on the evaporation time described by Chinn:

$$k = \frac{[\ln(0.1) * CF1]}{EvapT} \tag{7.10}$$

where:

k = first order decay rate (1/hr),
CF1 = conversion factor (sec/hr), and
EvapT = evaporation time (sec).

This section provides a standard method for completing post-application inhalation exposure assessments for adults and children after a surface spray treatment indoors. The basis for this scenario is that inhalation exposure occurs from emission of a pesticide from a treated surface. The well-mixed box (WMB) model was used to develop the exposure equation for the vapor emission post-application inhalation scenario. The WMB was used to model pesticide air concentrations within an enclosed, fixed volume (i.e. a box) over time during the variable emission of a pesticide from a treated surface. The model incorporates a number of simplifying assumptions: fresh air (having no pesticide concentration) enters the box at a constant airflow rate (based on the number of air changes per hour), a turbulent internal airflow thoroughly mixes the fresh air with the pesticide-laden air resulting in a uniform pesticide air concentration within the box, and the perfectly mixed air exits the box at the same constant airflow rate (i.e., the inflow rate equals the outflow rate). Thus, the indoor area where the aerosol is being applied is assumed to be in an enclosed box, which is a reasonable assumption for a walled, indoor space.

The evacuation of the aerosol from the box depends on airflow. For an indoor scenario, the airflow is the product of the volume of the treated space and the number of air changes per hour, ACH. The WMB model developed for this scenario models the pesticide air concentrations *after* surface spray application. Only dissipation due to airflow into and out of the box is modeled.

Post-application inhalation exposure for adults/children resulting from surface spray applications that have been made indoors can be calculated using the following equation (See *Appendix C.3.5* for equation description and derivation):

$$E = \frac{IR * M}{ACH * V} * \frac{\left[1 - \left(ACH * e^{-k*ET}\right) - \left(k * e^{-ACH*ET}\right)\right]}{ACH - k} \quad (7.11)$$

where:

E = exposure (mg/day);
IR = inhalation rate (m^3/hr);
M = mass of active ingredient applied (mg);
V = volume of room (m^3);
ACH = air exchanges per hour (1/hr);
k = first order decay rate (1/hr); and
ET = exposure time (hr).

Inhalation dose normalized to body weight is calculated as:

$$D = \frac{E * AF}{BW} \quad (7.12)$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

Post-application inhalation exposure following applications indoors is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Inhalation Exposure Algorithm Inputs and Assumptions

Recommended values for post-application inhalation exposure assessments are provided in *Table 7-3* below. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions, ii) data sources used to derive recommended input values, and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 7-3: Indoors – Recommended Inhalation Exposure Factor Distributions and Point Estimates

Algorithm Notation	Exposure Factor (units)		Distribution		Point Estimate(s)
			Type	Parameters	
C_o	Initial air concentration (mg/m^3)		Point Estimate	NA	Calculated; concentration at time "0"
AR	Application rate (lb ai/ ft^3)		Point Estimate	NA	Product-specific
A.I.	Percent ai in product (%)		Point Estimate	NA	Product-specific
$V_{product}$	Volume of product (mL)		Point Estimate	NA	Product-specific
$D_{product}$	Product density (lb/gal)		Point Estimate	NA	Label-specific
IR	Inhalation rate (m^3/hour)	Adult	Empirical	Mean = 0.32 95th = 0.42	
		Toddler	Empirical	Mean = 0.27 95th = 0.35	
		Infant	Empirical	Mean = 0.28 95th = 0.39	
k	First order decay rate		Point Estimate	NA	Pesticide-specific
C_{VE}	Air concentration resulting from vapor emissions (mg/m^3)		Point Estimate	NA	Calculated
V	Volume of room (m^3)		Point Estimate	NA	33
ET	Exposure time (hr/day)		Empirical	Mean = 16 95th = 24	
ACH	Air changes per hour (hr^{-1})		Empirical	Mean = 0.63 90th = 1.26	
BW	Body weight (kg)	Adult	Empirical	Mean = 71.8 95th = 97.9	
		Toddler	Empirical	Mean = 18.6 95th = 26.2	
		Infant	Empirical	Mean = 11.4 95th = 14.0	
NA = not applicable					

The following provides a general discussion for each post-application inhalation exposure factor and derivation of recommended distributions and point estimates for use in exposure assessment. Note that recommended body weight and inhalation rate distributions and point estimates are included under *Sections 2.1* and *2.2*, respectively, since they are not specific to any particular exposure scenarios.

Air Concentration (C_o)

The initial concentration is based upon instantaneous release of diluted product and complete mixing into an enclosed space.

Application Rate (AR)

The application rate is the amount of spray applied. The application rate can be determined from product specific factors that are listed on the label.

Percent A.I. in product (A.I.)

The percent of active ingredient (ai) in the product is a product-specific value and should be stated on the label.

Volume of product ($V_{product}$)

The volume of product (mL/can) is a product-specific value and should be stated on the label.

Product Density ($D_{productO}$)

The product density is product specific and should be obtained from the Confidential Statement of Formula (CSF).

Inhalation Rate (IR)

See *Section 2.2* for discussion of inhalation rates. For indoor post-application exposure, it is recommended that the inhalation rate for sedentary and passive activities be used in the exposure calculation. **The recommended point estimate for use in post-application inhalation exposure assessments represents approximately the [XX]th percentile**.

First Order Decay Rate (k)

The decay rate, k, defines the change in the emission rate from the treated surface. As proposed by Evans (1994), the decay rate constant is based on the 90% drying time. The 90% drying time, in turn, is calculated based on the evaporation time and volatility of the chemical using equations from Chinn (1981).

Air Concentration Resulting from Vapor Emissions (C_{VE})

The air concentration resulting from vapor emissions is based upon the emission of vapors from a surface spray and is dependent on the decay rate and air changes per hour in a room.

Volume of a Room (V)

The volume of a room is based on typical dimensions of residential rooms from Exposure Factors Handbook (U.S. EPA, 1997). For a 12 foot by 12 foot room, with an 8 foot high ceiling, the typical volume is 33 m^3.

Air Changes per Hour (ACH)

Air changes per hour is the rate that air within an indoor environment is replaced by outdoor air. An empirical distribution for typical house air changes per hour from the Exposure Factors Handbook (U.S. EPA, 1997) should be used for post-application inhalation assessment. The distribution is provided in *Table 7-4*. These values are representative of all seasons and all regions.

Table 7-4: Air Changes per Hour (ACH)

Statistic	ACH (1/hour)
10th percentile	0.18

Table 7-4: Air Changes per Hour (ACH)

Statistic	ACH (1/hour)
50th percentile	0.45
90th percentile	1.26
AM (SD)	0.63 (0.65)
GM (SD)	0.46 (2.25)

AM (SD) = arithmetic mean (standard deviation)
GM (SD) = geometric mean (geometric standard deviation)

Exposure Time (ET)
Another important variable for addressing inhalation post-application exposure indoors is the time spent in a residence. Empirical distributions for adults and children are provided in the Exposure Factors Handbook (U.S. EPA, 1997) and the Child-Specific Exposure Factors Handbook (U.S. EPA, 2008). The distribution for exposure time for adults (18-64 years) is used to represent all populations and is provided in *Table 7-5*. **The recommended point estimate for use in post-application inhalation exposure assessments represents approximately the [XX]th percentile**.

Table 7-5: Exposure Time (ET)

Statistic	Time (hours)
5th percentile	9
25th percentile	13
50th percentile	15
75th percentile	19
90th percentile	23
95th percentile	24
AM (SD)	16 (5)

AM (SD) = arithmetic mean (standard deviation)

Future Research/Data Needs

Unavailable information that would refine post-application inhalation exposure assessments for indoor pesticide applications include:

- Distinction between broadcast and "true" crack and crevice applications in terms of air concentrations indoors.
- Further research on actual air concentration measurements indoors for various pesticides.
- More information on fogger particle sizes and settling time.

Exposure Characterization and Data Quality

Air concentration:

- The indoor post-application inhalation SOP makes the conservative assumption that all of the applied pesticide is in the air available for inhalation exposure, and then that all of the applied pesticide settles onto the floor and is available for dermal exposure. In addition, dissipation of pesticides indoors is not taken into account for post-application inhalation exposure. The estimated doses derived from this exposure scenario are believed to be high-end, conservative estimates.

7.2.2 Post-application Dermal Exposure Assessment

Post-application dermal exposure can result from pesticide residue transfer to the skin of individuals who contact previously treated indoor surfaces (e.g., carpets, floors, furniture, and other surfaces) during standard activities such as recreation, housework or other occupant activities. While exposure may occur for people of all ages, adults, toddlers (3 to <6 years) and infants (1 to <2 years) are assessed based on behavioral characteristics and the strengths and limitations of available data.

Post-Application Dermal Exposure Algorithm

Post-application dermal exposure resulting from contact with previously treated carpets and hard surfaces is dependent on three exposure factors: transferable residue (TR), transfer coefficient (TC), and exposure time (ET). The algorithm to calculate exposure is as follows:

$$E = TR_t * CF1 * TC * ET \qquad (7.13)$$

where:

E = exposure (mg/day);
TR_t = indoor surface transferable residue on day "t" (µg/cm^2);
CF1 = conversion factor (0.001 mg/µg);
TC = transfer coefficient (cm^2/hr); and
ET = exposure time (hr/day).

If chemical-specific TR data are available, this is preferred and should be used to calculate exposure. However, if data are not available, then TR_t can be calculated using the following formula:

$$TR_t = DepR * F_{ai} * (1-F_D)^t \qquad (7.14)$$

where:

TR_t = indoor surface transferable residue on day "t" (µg/cm^2);
DepR = deposited residue (ug/cm^2), based on:
(1) Chemical-specific residue deposition data (ug/cm^2),
(2) Application rate (lb ai/area), or
(3) Default residue based on percent spray of product (ug/cm^2);
F_{ai} = fraction of ai available for transfer from carpet or hard surface (unitless);
F_D = fraction of residue dissipating daily (unitless); and
t = post-application day on which exposure is being assessed.

Dermal dose, normalized to body weight, are calculated as:

$$D = \frac{E * AF}{BW} \qquad (7.15)$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor; and
BW = body weight (kg).

Post-application dermal exposure following indoor applications is generally considered either acute or short-term in duration. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in Sections 1.3.2 and 1.3.4, such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Dermal Exposure Algorithm Inputs and Assumptions

Recommended values for post-application dermal exposure assessments are provided in *Table 7-6* below. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 7-6: Indoors – Recommended Dermal Exposure Factors Distributions and Point Estimates

Algorithm Notation	Exposure Factor (units)		Distribution Type		Distribution Parameters	Point Estimate(s)
TR	Transferable residue (ug/cm^2)		Point Estimate Lognormal	(dependent on input)	NA	(1) Chemical-specific transferable residue data OR (2) DepR * F
DepR	Deposited residue (ug/cm^2)		Point Estimate Lognormal	(dependent on input)	NA	(1) Chemical-specific residue deposition data, (2) Application rate, or (3) Default residue based on percent spray of product
F_{ai}	Fraction of DepR as TR following application	Carpets	Point Estimate		NA	
		Hard surfaces	Point Estimate		NA	
F_D	Daily residue dissipation (fraction)		Point Estimate		NA	If available, chemical specific information should be used. If chemical-specific data are not available, then a default dissipation fraction of 0.1/day should be assumed.
TC	Transfer Coefficient (cm^2/hr)	Adult	Lognormal		GM = 5,800 GSD = 3.8	
		Toddler	Lognormal		GM = 2,400 GSD = 3.8	
		Infant	Lognormal		GM = 1700 GSD = 3.8	

Table 7-6: Indoors – Recommended Dermal Exposure Factors Distributions and Point Estimates						
Algorithm Notation	**Exposure Factor (units)**			**Distribution**		**Point Estimate(s)**
				Type	**Parameters**	
ET	Exposure Time (hrs/day)	Adults	Carpets	Empirical	Mean = 8 95th = 12	
			Hard Surfaces	Empirical	Mean = 2 95th = 6	
		Toddler	Carpets	Empirical	Mean = 5 95th = 9	
			Hard Surfaces	Empirical	Mean = 1 95th = 4	
		Infant	Carpets	Empirical	Mean = 4 95th = 8	
			Hard Surfaces	Empirical	Mean = 1 95th = 4	
BW	Body weight (kg)	Adult		Empirical	Mean = 72 95th = 98	
		Toddler		Empirical	Mean = 19 95th = 26	
		Infants		Empirical	Mean = 11 95th = 14	
NA = not applicable GM = geometric mean GSD = geometric standard deviation						

Transferable Residue (TR)

Following an application, pesticide residue, which remains on carpets and hard surfaces, could be contacted by an individual and removed. The residue available for transfer is referred to as transferable residue (TR) and is assumed to be the most significant source for dermal exposure in this scenario. If chemical-specific transferable residue data are available for a specific chemical, this is preferred and should be used for the estimation of exposure. However, if data are not available, the TR can be calculated as a fraction of the deposited residue (DepR).

Deposited Residue (DepR)

The deposited residue is the residue that is deposited onto carpets and hard surfaces following an application. It can be obtained either from (1) chemical-specific deposition data, (2) calculated from the application rate of the product, or (3) default values based on the percent spray of the product. These options should be prioritized based on the data available for a particular chemical. Chemical-specific deposition data are preferred, if available. If chemical-specific data are not available, then the deposited residue should be estimated based on the label-specified application rate. If neither is available, default deposited residues should be used based on the percent spray of the product. *Figure 7-1* provides a summary of these three options and also shows the approaches for the different types of application methods (e.g., broadcast, perimeter, and crack and crevice), which are discussed in more detail below.

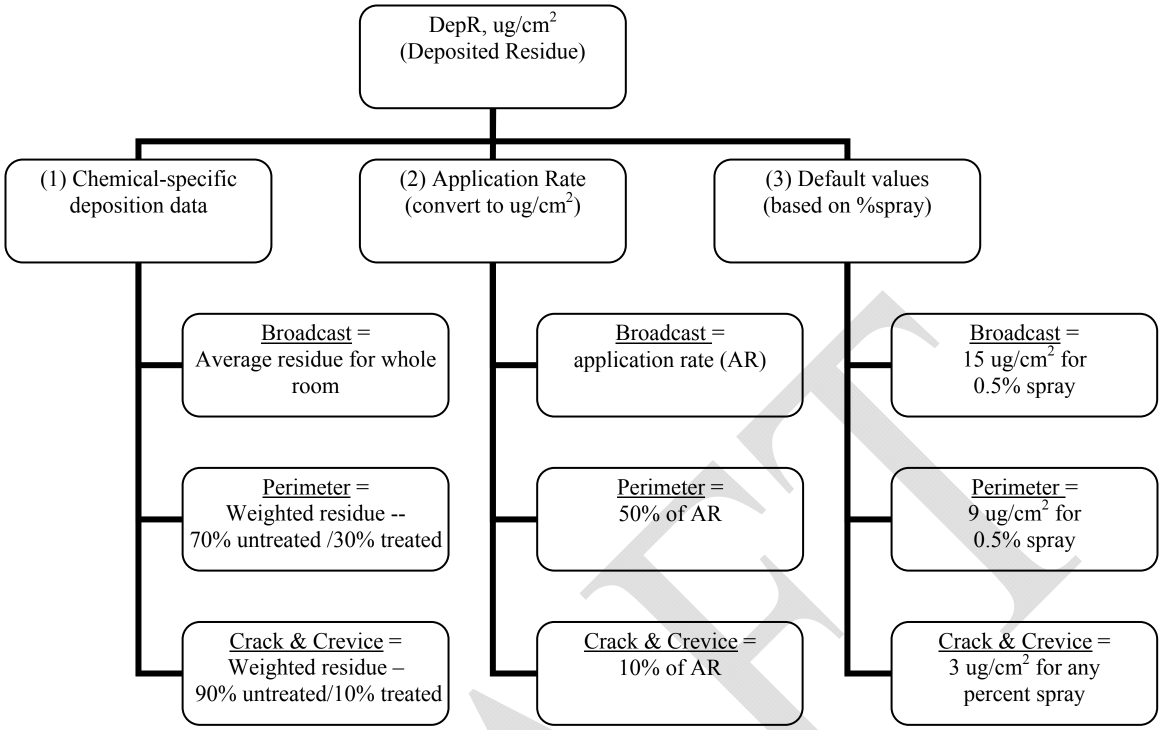


Figure 7-1: Summary of approaches for calculating the deposited residue for use in the dermal post-application exposure calculation

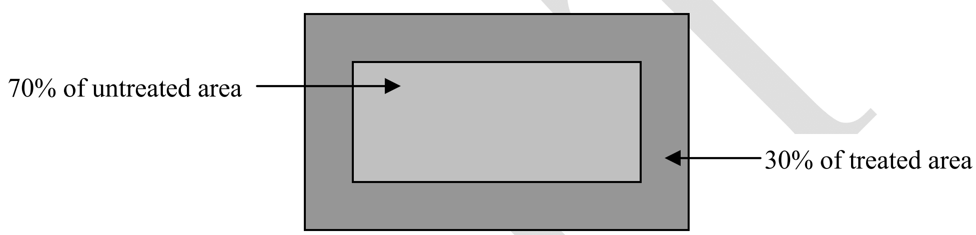
(1) Chemical-specific deposition data

The deposited residue value used in exposure calculations is dependent on the type of application made (i.e., broadcast, perimeter, or crack and crevice) because the distribution of residues in a room will differ markedly between the three types of applications, and consequently a person's exposure will also differ. The following deposited residue values should be used when chemical-specific deposition data are available:

For broadcast applications, the deposited residue is equal to the average deposited residue for the entire treated area.

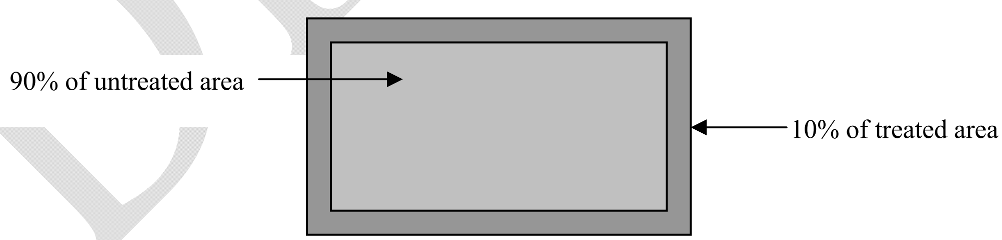
For perimeter, spot, and crack and crevice applications, the method of application and distribution of residues in a room is taken into consideration in calculating a residue value. Each type of application will differ in terms of the distribution of residues in the room. Unlike broadcast applications where the residue is evenly distributed throughout the floor of a room, the other methods of application result in higher levels of residues at or near the target site compared to the rest of the room. Therefore, a weighted residue value is calculated taking the distribution of residues into consideration (i.e., treated versus untreated areas of the room). An assumption as to how much time a person would come in contact with treated versus untreated areas of the room is used to adjust the estimate of deposited residue.

For perimeter and spot applications, it is assumed that a person would come in contact with treated areas 30% of the time and untreated areas 70% of the time. This is based on preliminary information for surface contact probabilities (Brinkman et al., 1999; SHEDS-Multimedia, http://www.epa.gov/heasd/products/sheds_multimedia/sheds_mm.html) and on surface residue data from Selim (2008) and U.S. EPA (1993). Therefore, the deposited residue is equal to the sum of 70% of the average deposited residue for the untreated area of the room and 30% of the average deposited residue for the treated area of the room.



(70% * average residue untreated area) + (30% * average residue treated area)

For crack and crevice applications (*pin stream nozzle applications ONLY*), it is assumed that a person would come in contact with treated areas 10% of the time and untreated areas 90% of the time. This is based on preliminary information for surface contact probabilities (Brinkman et al., 1999; SHEDS-Multimedia, http://www.epa.gov/heasd/products/sheds_multimedia/sheds_mm.html) and on surface residue data from Selim (2008). Therefore, the deposited residue is equal to the sum of 90% of the average deposited residue for the untreated area of the room and 10% of the average deposited residue for the treated area of the room.



(90% * average residue untreated area) + (10% * average residue treated area)

(2) Application Rate

When the application rate is in terms of mass active ingredient per area (e.g., lb ai/ft^2), the deposited residue can be estimated from the application rate. A unit conversion can be performed in order to obtain a residue value in terms of ug/cm^2.

For broadcast applications, the deposited residue is assumed to be equivalent to the application rate.

As with the previous method of calculating residue values, for perimeter, spot, and crack and crevice applications, the method of application and distribution of residues in a room is considered when calculating a residue value based on the application rate. Using residue information from studies where broadcast, perimeter and/or crack and crevice applications were made, estimates can be made as to what percent of broadcast residues (which are assumed to be equivalent to the application rate) are perimeter or crack and crevice residues.

For perimeter and spot applications, it is assumed that the deposited residue is equivalent to 50% of the deposited residue from a broadcast application (i.e., 50% of the application rate) based on studies that have examined deposited residues resulting from various types of applications (Selim, 2008, U.S. EPA, 1993). For more information and further analysis, refer to Appendix C5.

For crack and crevice applications (*pin stream nozzle applications ONLY*), it is assumed that the deposited residue is equivalent to 10% of the deposited residue from a broadcast application (i.e., 10% of the application rate) based on a study that has examined deposited residues resulting from various types of applications (Selim, 2008). For more information and further analysis, refer to Appendix C5.

For foggers, the application rate is not always provided in terms of mass active ingredient per area, but can be calculated from the amount of active ingredient (ai) in the fogger, the volume that the fogger is intended to treat and an assumed ceiling height of 8 feet. If, for example, a six ounce fogger containing 1% ai is used in a 33 cubic meter (1165 cubic foot) room with an eight foot ceiling, the surface residue would be calculated as follows:

Step 1 – Calculate amount of ai applied in ug

ai applied (ug) = (fogger weight (ounces) * (percent ai/100) * 454,000,000 ug/lb) / 16 ounces/lb = 1,700,000 ug

Step 2 – Calculate Area Treated in cm^2

Area Treated (cm^2) = 1165 ft^3/8 ft ceiling = 146 ft^2 * 929 cm^2/ft^2 = 135,000 cm^2

Step 3 – Calculate ug/cm^2

1,700,000 ug/135,000 cm^2 = 12.6 ug/cm^2

(3) Default Residue Values based on Percent Spray

If chemical-specific deposition data are not available, no application rate is provided on the product label and the product is only expressed as a percent spray, the following default values should be used for deposition values:

Broadcast applications – Based on a literature review, the range for total deposited residue for 0.5% sprays applied as broadcast applications is approximately 7 to 15 µg/cm^2 (Vaccaro et al., 1991, Fenske et al., 1990, Krieger et al., 2001, Gurunathan et al., 1998). A high end value of 15 µg/cm^2 is used as a default deposition value when no application rate is available. *This value can be proportionately adjusted depending on the percent spray indicated on a particular label.*

Example calculation for adjusting residue value:

Product for specific chemical: 0.25% spray

(0.5% spray ÷ 15 ug/cm^2) = (0.25% spray ÷ X ug/cm^2)

X ug/cm^2 = (15 ug/cm^2 * 0.25% spray) / 0.5% spray

X ug/cm^2 = 7.5 ug/cm^2

Perimeter applications – Based on the available data for perimeter applications and the two approaches described above (i.e., 70/30 weighted average for deposition data or 50% of the residue from a broadcast application), the default residue value for perimeter applications was based on a 70/30 weighted average of deposition data from an EPA study. In the study, measurements were taken after a treatment was made to a baseboard in an unfurnished room in the EPA study "Protocol for Dermal Exposure Assessment" (U.S. EPA, 1993). Mean residues of 28.9 µg/cm^2, 12.07 µg/cm^2, and 0.13 µg/cm^2 were measured within 1 foot of the baseboard, between 1 and 3 feet and greater than 3 feet from the baseboard, respectively. For a perimeter treatment, it is assumed that a person would be exposed to treated areas 30% of the time and to untreated areas 70% of the time. This is based on preliminary information for surface contact probabilities (Brinkman et al., 1999; SHEDS-Multimedia, http://www.epa.gov/heasd/products/sheds_multimedia/sheds_mm.html) and on surface residue data from Selim (2008) and U.S. EPA (1993). Therefore, the default deposited residue for a 0.5% spray based on this assumption would be 9 ug/cm^2. *This value can be proportionately adjusted depending on the percent spray indicated on a particular label (see example provided above).*

Crack and crevice applications (*pin stream nozzle applications ONLY*) – Based on the available data for crack and crevice applications and the two approaches described above (i.e., 90/10 weighted average for deposition data or 10% of the residue from a broadcast application), the default residue value for crack and crevice applications was based on 10% of a broadcast residue value. In order to provide a conservative default residue value for a crack and crevice application in the absence of other available data, 10% of the default residue value determined for a 1% spray broadcast application is recommended (10% * 30 ug/cm^2 = 3 ug/cm^2). This value should not be adjusted up or down depending on the percent spray indicated on a particular label. *It is assumed that for crack and crevice applications, the deposited residue is driven more by method of application than percent active ingredient. Therefore, this value should be used as a screening level residue for all percent sprays for crack and crevice applications.*

For more information and further analysis of the default deposition values, refer to *Appendix C.5*.

A summary of the recommended values for default residues for broadcast, perimeter and crack and crevice applications is provided in *Table 7-7*.

Table 7-7: Recommended Residue Concentrations for Percent Spray Applications

Type of Application	Percent Spray	Residue concentration (ug/cm^2)
Broadcast[a]	0.5%	15
Perimeter[a]		9
Crack and Crevice[b]	N/A -- see explanation above	3

a. Adjust residue concentration proportionately according to the percent spray of product
b. Use as screening level for all percent sprays

Fraction of Residue Available For Transfer (F_{ai})

Once the deposited residue is determined for an indoor scenario, the TR is then calculated as a fraction of that residue (F_{ai}). The values for fraction of residue transferred from carpets and hard surfaces are based on two sources, which examine transferability of chemicals from both surfaces. Beamer *et. al* (2008) performed an extensive analysis of numerous transfer efficiency studies, which covered various methods (including the cloth roller, drag sled, PUF roller, and bare hand press) and various chemicals. Out of a total of 35 studies initially identified, only nine studies were ultimately used to fit transfer efficiency distributions for three chemicals (chlorpyrifos, pyrethrins and piperonyl butoxide) based on the availability of a complete dataset (i.e., raw data, not just means). In addition to the Beamer *et. al* paper, data provided by the Non-Dietary Exposure Task Force (NDETF) was analyzed as well. The NDETF studies examined transferability for bare hand-presses on carpets and vinyl surfaces for deltamethrin, permethrin, piperonyl butoxide and pyrethrin. For the purposes of this SOP, the datasets were combined for the two types of surfaces (carpet and vinyl/hard surfaces). For further information and full analysis of the fraction transferred factor, see *Appendix C.6*.

For this parameter, the following decision tree should be used:

(1) Use chemical-specific data, if it is submitted.
(2) If no chemical-specific data are submitted, but the chemical is included in *Table 7-8* (carpet) and *Table 7-9* (hard surface), use the data provided in those tables, which is

based on the chemical-specific data provided in the NDETF studies and Beamer *et. al* (2008).

(3) If no chemical-specific data are submitted and the chemical is not included in *Table 7-8* (carpet) and *Table 7-9* (hard surface), use the surrogate data in *Table 7-10*, which is based on data provided in the NDETF studies and Beamer *et. al* (2008).

The recommended point estimate for use in post-application dermal exposure assessments ([XX]) represents approximately the [XX]th percentile.

Table 7-8: Chemical-specific Fraction transferred (F_{ai}) for Carpets

Statistic	Pyrethrin	Permethrin	PBO	Chlorpyrifos	Deltamethrin
50th percentile	0.02	0.02	0.02	0.01	0.01
75th percentile	0.04	0.02	0.03	0.02	0.02
90th percentile	0.05	0.03	0.04	0.03	0.02
95th percentile	0.07	0.02	0.05	0.03	0.03
99th percentile	0.11	0.04	0.07	0.05	0.04
99.9th percentile	0.19	0.05	0.10	0.08	0.05
AM (SD)	0.03 (0.12)	0.02 (0.06)	0.02 (0.08)	0.02 (0.06)	0.01 (0.05)
GM (GSD)	0.02 (2.00)	0.02 (1.38)	0.02 (1.70)	0.01 (1.72)	0.01 (1.56)
Range	0.003 - 0.121	0.010 - 0.032	0.005 - 0.078	0.002 - 0.041	0.005 - 0.020

AM (SD) = arithmetic mean (standard deviation)
GM (GSD) = geometric mean (geometric standard deviation)

Table 7-9: Chemical-specific Fraction transferred (F_{ai}) for Hard Surfaces

Statistic	Pyrethrin	Permethrin	PBO	Chlorpyrifos	Deltamethrin
50th percentile	0.03	0.02	0.02	0.04	0.04
75th percentile	0.05	0.03	0.04	0.07	0.06
90th percentile	0.09	0.05	0.07	0.11	0.08
95th percentile	0.13	0.02	0.09	0.15	0.10
99th percentile	0.24	0.11	0.16	0.26	0.15
99.9th percentile	0.48	0.19	0.30	0.50	0.24
AM (SD)	0.04 (0.27)	0.03 (0.12)	0.03 (0.18)	0.05 (0.29)	0.05 (0.18)
GM (GSD)	0.03 (2.45)	0.02 (2.06)	0.02 (2.32)	0.04 (2.33)	0.04 (1.80)
Range	0.003 - 0.245	0.006 - 0.049	0.004 - 0.258	0.005 - 0.382	0.017 - 0.124

AM (SD) = arithmetic mean (standard deviation)
GM (GSD) = geometric mean (geometric standard deviation)

Table 7-10: *Generic* Fraction transferred (F_{ai})

Statistic	Carpets	Hard surfaces
50th percentile	0.02	0.03
75th percentile	0.03	0.05
90th percentile	0.04	0.08
95th percentile	0.05	0.11
99th percentile	0.07	0.20
99.9th percentile	0.11	0.39
AM (SD)	0.02 (0.08)	0.04 (0.23)
GM (GSD)	0.02 (1.82)	0.03 (2.37)
Range	0.002 – 0.12	0.003 – 0.38

AM (SD) = arithmetic mean (standard deviation)

Table 7-10: *Generic* Fraction transferred (F_{ai})		
Statistic	**Carpets**	**Hard surfaces**
GM (GSD) = geometric mean (geometric standard deviation)		

Transfer Coefficient (TC)

The transfer coefficient (TC) provides a measure of surface-to-skin residue transfer and is derived from concurrent measurements of exposure and surface residue. Specifically, the TC is the ratio of exposure rate, measured in mass of chemical per time (i.e., ug/hr), to residue, measured in mass of chemical per surface area (i.e., ug/cm^2).

Table 7-11 provides the distribution for the assumption of transfer coefficient for indoor surfaces. There are no studies available that measure both exposure and surface residue while subjects are performing typical indoor activities. Therefore, the transfer coefficients used for indoor scenarios are derived from information provided in two different studies: (1) a study which measured exposure and surface residues while subjects performed a Jazzercise™ routine (Krieger, 2000) and (2) a study which measured biomonitoring doses while adults performed scripted activities for 4 hours on carpet (Vaccaro, 1991).

Table 7-11: Transfer coefficient (TC)			
Statistic	**Adult Transfer coefficient (cm^2/hr)**	**Toddler Transfer coefficient[a] (cm^2/hr)**	**Infant Transfer coefficient[b] (cm^2/hr)**
50th percentile	5,800	2,400	1,700
75th percentile	14,000	6,000	4,200
95th percentile	54,000	23,000	16,000
99th percentile	130,000	56,000	39,000
99.9th percentile	370,000	160,000	110,000
AM (SD)	13,000 (16,000)	5,300 (6,500)	3,700 (4,500)
GM (GSD)	5,800 (3.8)	2,400 (3.8)	1700 (3.8)
Range	1,200 – 49,000	500 – 20,000	360 – 14,000

[a] A 58% reduction in the adult transfer coefficient is recommended because of the differences of body surface areas between adults and toddlers (3 to <6 years old).
[b] A 71% reduction in the adult transfer coefficient is recommended because of the differences of body surface areas between adults and infants (1 to < 2 years old).
AM (SD) = arithmetic mean (standard deviation)
GM (GSD) = geometric mean (geometric standard deviation)

In the Krieger study, a Jazzercise™ routine was performed to achieve maximum contact of the entire body with a surface using low impact aerobic movements. All body surfaces (dorsal, ventral, and lateral) contacted the treated surface. The potential dermal exposure was measured by using whole-body dosimetry. The dosimeters were expected to normalize differences in surface contact and to increase the total sample area relative to patches. The assumption is that the dosimeter represents the skin and that the dose retained by the dosimeter is equivalent to dermal exposure. In the Vaccaro study, adult males, dressed in bathing suits only, performed different activities over a 4-hour activity period. These activities included: sitting-playing with blocks, on hands and knees crawling, walking on carpet, laying on back, and laying on abdomen.

Although activity was minimal during the last 2 activities, considerable surface area was in contact with the carpets during these times. Using information from both of these studies on residue transfer, exposure and dose provides an estimated transfer coefficient for indoor activities. It is assumed that the shorter duration of high contact activity (i.e., Jazzercise™) can be used to estimate exposure during longer durations of low contact activity. For more information and full analysis of the transfer coefficient factor, see *Appendix C.7.3*.

For adults, the recommended TC point estimate for post-application dermal exposure assessments ([XX]) represents approximately the [XX]th percentile.

The transfer coefficients for toddlers (3 to <6 year olds) and infants (1 to < 2 years) are calculated based on an adjustment of the adult transfer coefficient for differences in body surface area outlined in Section 2.3. For toddlers a factor of 0.42 (i.e., a 58% TC reduction) is used while a factor of 0.29 (i.e., a 71% TC reduction) is used for infants. **For toddlers, the recommended TC point estimate for post-application dermal exposure assessments ([XX]) represents approximately the [XX]th percentile**. **For infants, the recommended TC point estimate for post-application dermal exposure assessments ([XX]) represents approximately the [XX]th percentile**.

Dissipation (F_D)

Post-application exposures must be assessed on the same day the pesticide is applied because it is assumed that individuals could be exposed to residues immediately after application. Therefore, post-application exposures are based on residues found on the day of application (i.e., referred to as day 0).

For subsequent days after application, it is also important to calculate risks based on pesticide dissipation rates because of possible concerns over longer term exposures (i.e., using an amortized dose) and possible re-treatment intervals. There are several factors that can influence dissipation of pesticides in an indoor environment. These include: loss of solvent inerts, which maintain the pesticide in a transferable thin film solution; absorption of the pesticide into the carpet fiber; chemical or electrostatic binding of the pesticide onto the carpet fiber surface; and degradation of the pesticide into non-detectable products.

If chemical-specific information is available on dissipation, it should be included when calculating longer-term exposures. If no chemical-specific data are available, then a default value of 10% dissipation per day should be assumed. This value is based on preliminary information collected by EPA/ORD on the dissipation of 3 chemicals (propoxur, permethrin and cypermethrin) in air and on surfaces in the U.S. EPA "Test House" (Dr. Dan Stout, EPA/ORD, personal communication, June 17, 2009).

Exposure Time (ET)

Another important variable for addressing dermal post-application exposure indoors is the time spent on different types of floor surfaces. An empirical distribution based on values from the Exposure Factors Handbook (U.S. EPA, 1997) and the Child-Specific Exposure Factors Handbook (U.S. EPA, 2008) should be used for indoor post-application dermal assessments. The distributions for exposure time for adults (18-64 years), toddlers (3 to <6 years), and infants

(1 to < 2 years) are provided in *Table 7-12*. For carpets, the distributions are based on the time spent inside a residence, not including time spent sleeping. For hard surfaces, the distributions are based on time spent in kitchens and bathrooms.

For adults on carpets, the recommended ET point estimate for post-application dermal exposure assessments ([XX]) represents approximately the [XX]th percentile. For adults on hard surfaces, the recommended ET point estimate in post-application dermal exposure assessments ([XX]) represents approximately the [XX]th percentile.

For toddlers on carpets, the recommended ET point estimate for post-application dermal exposure assessments ([XX]) represents approximately the [XX]th percentile. For toddlers on hard surfaces, the recommended ET point estimate for post-application dermal exposure assessments ([XX]) represents approximately the [XX]th percentile.

For infants on carpets, the recommended ET point estimate for post-application dermal exposure assessments ([XX]) represents approximately the [XX]th percentile. For infants on hard surfaces, the recommended ET point estimate for post-application dermal exposure assessments ([XX]) represents approximately the [XX]th percentile.

Table 7-12: Exposure Time (ET)

Statistic	Carpet			Hard surfaces		
	Adult (hours)	Toddler (hours)	Infants (hours)	Adult (hours)	Toddler (hours)	Infants (hours)
5^{th} percentile	4	1	1	0.25	0	0
25^{th} percentile	6	3	4	1	0	0
50^{th} percentile	7	4	5	1	1	1
75^{th} percentile	10	6	6	3	2	2
90^{th} percentile	12	8	9	4	3	3
95^{th} percentile	12	9	8	6	4	4
AM (SD)	8 (3)	5 (--[a])	4 (--[a])	2 (2)	1(--[a])	1(--[a])

a. The Child-specific Exposure Factor Handbook (U.S. EPA, 2008) did not provide these values.
AM (SD) = arithmetic mean (standard deviation)

Future Research/Data Needs

Unavailable information that would refine post-application dermal exposure assessments for indoor pesticide applications include:

- Methods for incorporating transfer of residues to carpet dust for longer term assessments.
- Transferable residue data for a wider variety of chemicals and formulations.
- Indoor dissipation data for a variety of chemicals.
- Distinction between broadcast and crack and crevice applications including spatial probabilities to differentiate exposure potential based on application methods.
- Exposure data representative of participants doing "typical" activities indoors as well as parameters measured that enable calculation of a dermal transfer coefficient.

Exposure Characterization and Data Quality

Residue:

- Reviewers should recognize that factors such as vacuuming, transfer to clothing, re-suspension and impaction into carpet can greatly impact the dissipation rate of pesticides on indoor surfaces when conducting dermal post-application exposure assessments.

Transfer Coefficient:

- Because there are no studies available that measure both exposure and surface residue while subjects are performing typical indoor activities, the indoor transfer coefficient was derived from information provided in two different studies (a Jazzercise™ study and a biomonitoring study where participants performed "typical" indoor activities). This introduces uncertainty since a comparison is being made between high contact activities and low contact activities in two separate situations.

Fraction Transferred:

- In instances where chemical-specific data are not available, estimates of the fraction of residue available for transfer are used generically based on existing data for a wide variety of chemicals. Use of this data generically, including using high-end estimates, may overestimate for other chemicals.

Exposure Time:

- Information on the amount of time spent on carpets and hard surfaces, specifically, is not available. Distributions were available for time spent inside a residence, time spent sleeping, time spent in kitchens, and time spent in bathrooms. The values for different percentiles of each distribution were either added together or subtracted to represent the correct exposure time for a particular surface (e.g., time spent on carpet = time spent in a residence – time spent sleeping). This is considered reasonable, but does add additional uncertainty.

7.2.3 Post-application Non-Dietary Ingestion Exposure Assessment: Hand-to-Mouth

This SOP provides a standard method for estimating the dose for toddlers and infants from incidental ingestion of pesticide residues from previously treated indoor areas. This scenario assumes that pesticide residues are transferred to the skin of children playing on treated indoor surfaces and are subsequently ingested as a result of hand-to-mouth transfer. It does not include residues ingested as a result of mouthing an object or via dust ingestion (See *Sections 7.2.4* and *7.2.5*).

Post-application Hand-to-Mouth Exposure Algorithm

Exposure from hand-to-mouth activity is calculated as follows (based on algorithm utilized in SHEDS-Multimedia, http://www.epa.gov/heasd/products/sheds_multimedia/sheds_mm.html):

$$E = [HR * (F_M * SA_H) * (ET * N\_Replen) * (1- (1- SE)^{(Freq\_Replen/N\text{-}Replen)})] \qquad (7.16)$$

where:

E	= exposure (mg/day);
HR	= hand residue loading (mg/cm^2);
F_M	= fraction hand surface area mouthed / event (fraction/event);
ET	= exposure time (hr/day);
SA_H	= surface area of one hand (cm^2);
N_Replen	= number of replenishment intervals per hour (intervals/hour);
SE	= saliva extraction factor (ie, mouthing removal efficiency); and
Freq_Replen	= number of hand-to-mouth contacts events per hour (events/hour).

and

$$HR = AR * F_H * CF1 \quad (7.17)$$

where:

HR	= hand residue loading (mg/cm^2),
AR	= application rate (lb ai/ft^2),
F_H	= fraction ai transferred to hands (unitless); based on dry and wet hand-press data, and
CF	= conversion factor (lb ai/ft^2 to mg/cm^2).

and

Oral dose, normalized to body weight, is calculated as:

$$D = \frac{E}{BW} \quad (7.18)$$

where:

D	= dose (mg/kg-day);
E	= exposure (mg/day); and
BW	= body weight (kg).

Post-application hand-to-mouth exposure following indoor applications is generally considered either acute or short-term in duration. Thus, the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in Sections 1.3.2 and 1.3.4, such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Hand-to-Mouth Exposure Algorithm Inputs and Assumptions

Recommended values for post-application hand-to-mouth exposure assessments are provided in *Table 7-13* below. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 7-13: Indoors – Recommended Hand-to-Mouth Exposure Factors Distributions and Point Estimates

Algorithm Notation	Exposure Factor (units)			Distribution Type	Distribution Parameters	Point Estimate(s)
HR	Residue available on the hands (mg/cm^2)			Point Estimate	NA	
SA_H	Surface area of one hand (cm^2)	Toddlers		Point Estimate	NA	
		Infants				
AR	Application rate (mass active ingredient per unit area)			Point Estimate	NA	Maximum labeled rate
F_H	Fraction ai transferred to hands , from wet and dry indoor hand press data (fraction)			Point Estimate	NA	
F_M	Fraction of hand mouthed per event (fraction/event)			Beta	$\alpha = 3.75$ $\beta = 25$	
N_Replen	Replenishment intervals per hour (intervals/hr)			Point Estimate	NA	4
ET	Exposure time (hours per day)	Toddlers	Carpets	Empirical	Mean = 5 $95^{th} = 9$	
			Hard Surfaces	Empirical	Mean = 1 $95^{th} = 4$	
		Infants	Carpets	Empirical	Mean = 4 $95^{th} = 8$	
			Hard Surfaces	Empirical	Mean = 1 $95^{th} = 4$	
SE	Saliva extraction factor (fraction)			Beta	$\alpha = 7.0$ $\beta = 7.6$	
Freq_Replen	Hand-to-mouth events per hour (events/hr)	Toddlers		Weibull	Scale= 0.73 Shape= 11.96	
		Infants		Weibull	Scale= 0.91 Shape= 18.79	
BW	Body Weight (kg)	Toddlers		Empirical	Mean = 18.6 $95^{th} = 26.2$	
		Infants		Empirical	Mean = 11.4 $95^{th} = 14.0$	

NA = not applicable

Hand Residue (HR)

Example calculations for toddler on carpet or hard surface indoor:

- Application rate = 0.0001 lb ai/ft^2
- Surface area of one toddler hand = 225 cm^2

Link to wet and dry hand-press data

- A 15-minute replenishment interval equals 4 replenishment intervals per hour.
- Use activity data from Leckie (2000), which provides the number of hand contacts with various surfaces indoor per hour.
- The number of hand contacts per replenishment interval for various surfaces:
  - Carpets: 15 hand contacts per hour –> 4 hand contacts per replenishment interval
  - Hard surfaces: 61 hand contacts per hour –> 15 hand contacts per replenishment interval

Using single wet hand and multiple dry hand-press data:

- Fraction transfer after 4 hand-presses on carpet = 0.15
- Fraction transfer after 15 hand-presses on hard surfaces = 0.36

$HR = AR * F_H * CF1$

Indoor carpet HR = 0.0001 lb ai/ft^2 * 0.15 * CF1 (lb ai/ft^2 to mg/cm^2) = 0.015 mg/cm^2

Indoor hard surface HR = 0.0001 lb ai/ft^2 * 0.36 * CF1 (lb ai/ft^2 to mg/cm^2) = 0.035 mg/cm^2

Fraction ai Transferred to Hands (F_H)
The fraction of active ingredient transferred to hands is determined based on the replenishment interval and NDETF hand press data. As indicated above, the number of hand contacts per replenishment interval for carpets is 4 and for hard surfaces is 15. For carpets, after 4 presses, the fraction of residue transferred to the hands is 0.15. For hard surfaces, after 15 presses, the fraction transferred to the hands is 0.36.

Fraction of Hand Mouthed per Event (F_M)
See *Section 2.4* of this SOP for discussion of the fraction of hand mouthed. **The recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile**.

Hand Surface Area (SA_H)
The hand surface area for toddlers (3 to <6 year olds) and infants (1 to <3 year olds) was based on values from the Child-specific Exposure Factors Handbook (U.S. EPA, 2008). These values are 225 cm^2 for toddlers and 150 cm^2 for infants, for one hand.

Fraction of Pesticide Extracted by Saliva (SE_H)
See *Section 2.6* of this SOP for discussion of the fraction of pesticide extracted by saliva distribution. **The recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile**.

Exposure Time (ET)

An empirical distribution based on values from the Exposure Factors Handbook (U.S. EPA, 1997) and the Child-Specific Exposure Factors Handbook (U.S. EPA, 2008) should be used for indoor post-application hand-to-mouth assessments. The distributions for exposure time for toddlers (3 to <6 years) and infants (1 to < 2 years) are provided in *Table 7-14*. For carpets, the distributions are based on the time spent inside a residence, not including time spent sleeping. For hard surfaces, the distributions are based on time spent in kitchens and bathrooms.

For toddlers on carpets, the recommended ET point estimate for post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile. For toddlers on hard surfaces, the recommended ET point estimate for post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile.

For infants on carpets, the recommended ET point estimate for post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile. For infants on hard surfaces, the recommended ET point estimate for post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile.

Table 7-14: Exposure Time (ET)

Statistic	Carpet		Hard surfaces	
	Toddler (hours)	Infants (hours)	Toddler (hours)	Infants (hours)
5th percentile	1	1	0	0
25th percentile	3	4	0	0
50th percentile	4	5	1	1
75th percentile	6	6	2	2
90th percentile	8	9	3	3
95th percentile	9	8	4	4
AM (SD)	5 (--[a])	4 (--[a])	1(--[a])	1(--[a])

a. The Child-specific Exposure Factor Handbook (U.S. EPA, 2008) did not provide these values.
AM (SD) = arithmetic mean (standard deviation)

Replenishment Intervals per Hour (N_Replen)

This SOP assumes an estimate of 4 replenishment intervals per hour (i.e., residues on the hand will be replenished every 15 minutes). This value was selected as a conservative assumption based on the use of 30 minutes in the SHEDS model to coincide with the CHAD diaries.

Hand-to-Mouth Events per Hour (Freq_Replen)

Frequency of hand-to-mouth events is an important variable for hand-to-mouth post-application exposure assessments. The estimates for frequency of hand-to-mouth events in indoor environments are based on the Xue et al. (2007) meta-analysis. The indoor SOP utilizes hand-to-mouth frequency data for the 3 to <6 year old age grouping to represent toddlers and the 1 year old age grouping to represent infants. Distributions for different sub-populations can be used if there is a need to assess a more specific exposure population. *Table 7-15* provides distributions and point estimates of hand to mouth events for use in residential pesticide exposure assessment.

The recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile.

Table 7-15: Frequency of Hand-to-Mouth Events (events/hr)[a]		
Statistic	**3 to <6 year olds**	**1 to < 2 year olds**
5th percentile	0	0
25th percentile	3	6
50th percentile	8	14
75th percentile	20	27
95th percentile	57	63
AM (SD)	14 (19)	20 (20)
GM (GSD)	--[b]	--[b]
Range	--[b]	--[b]
N	160	245

AM (SD) = arithmetic mean (standard deviation)
GM (GSD) = geometric mean (geometric standard deviation)
[a] The values provided in this table are not directly from the Xue et. al (2007) paper since that paper included a study that was deemed unethical by the Agency. The author reanalyzed the data, excluding that particular study, and those results are presented here.
[b] Not provided

Future Research/Data Needs

Unavailable information that would refine post-application incidental oral hand-to-mouth exposure assessments for indoor pesticide applications include:

- More refined data on hand to surface contacts per hour and replenishment interval. The available published literature on hand to surface contacts per hour could be combined and analyzed in a meta-analysis to obtain a distribution for this input. Furthermore, available videography data could be analyzed to obtain a distribution for the replenishment interval input.

Exposure Characterization and Data Quality

Residue:

- Reviewers should recognize that factors such as vacuuming, transfer to clothing, re-suspension and impaction into carpet can greatly impact the dissipation rate of pesticides on indoor surfaces when conducting dermal post-application exposure assessments.

7.2.4 Post-application Non-Dietary Ingestion Exposure Assessment: Object-to-Mouth

This SOP provides a standard method for estimating the dose for toddlers and infants from incidental ingestion of pesticide residues from previously treated indoor surfaces. This scenario assumes that pesticide residues are transferred to a child's toy and are subsequently ingested as a result of object-to-mouth transfer. It does not include residues ingested as a result of dust ingestion (see *Section 7.2.5*).

Post-application Object-to-Mouth Exposure Algorithm

Exposure from object-to-mouth activity is calculated as follows (based on algorithm utilized in SHEDS-Multimedia, http://www.epa.gov/heasd/products/sheds_multimedia/sheds_mm.html):

$$E = OR * CF1 * SAM_O * (ET * N\_Replen) * (1- (1- SE_O)^{(Freq\_Replen/N\_Replen)})] \qquad (7.19)$$

where:

E	=	exposure (mg/day);
OR	=	chemical residue loading on an object (ug/cm^2);
CF1	=	weight unit conversion factor (0.001 mg/µg);
SAM_O	=	area of the object surface that is mouthed (cm^2/event);
ET	=	exposure time (hr/day);
N_Replen	=	number of replenishment intervals per hour (intervals/hour);
SE	=	saliva extraction factor (ie, mouthing removal efficiency); and
Freq_Replen	=	number of object-to-mouth contact events per hour (events/hour).

and

$$OR = AR * F_O * CF2 * CF3 \qquad (7.20)$$

where:

OR	=	chemical residue loading on the object (µg/cm^2);
AR	=	application rate (lbs ai/ft^2);
F_O	=	fraction of residue available on the object (unitless);
CF2	=	weight unit conversion factor (4.54 x 10^8 µg/lb); and
CF3	=	conversion factor (1.08 x 10^{-3} ft^2/cm^2).

and

Oral dose, normalized to body weight, is calculated as:

$$D = \frac{E}{BW} \qquad (7.21)$$

where:

D	=	dose (mg/kg-day);
E	=	exposure (mg/day); and
BW	=	body weight (kg).

Post-application object-to-mouth exposure following indoor applications is generally considered either acute or short-term in duration. Thus, the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in Sections 1.3.2 and 1.3.4, such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Object-to-Mouth Exposure Algorithm Inputs and Assumptions

Recommended values for post-application object-to-mouth exposure assessments are provided in *Table 7-16* below. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 7-16: Indoors – Recommended Object-to-Mouth Exposure Factors Distributions and Point Estimates

Algorithm Notation	Exposure Factor (units)			Distribution Type	Distribution Parameters	Point Estimate(s)
AR	Application rate (mass active ingredient per unit area)			Point Estimate	NA	Maximum labeled rate
F_O	Fraction of AR as OR following application	Carpets		Point Estimate	NA	
		Hard surfaces		Point Estimate	NA	
SAM_O	Surface area of object mouthed (cm^2/event)			Exponential	Min = 1 Max = 50 AM = 10	
N_Replen	Replenishment intervals per hour (intervals/hour)			Point Estimate	NA	4
SE_O	Saliva extraction factor			Beta	α = 7.0 β = 7.6	
ET	Exposure Time (hours per day)	Toddlers	Carpets	Empirical	Mean = 5 95^{th} = 9	
			Hard Surfaces	Empirical	Mean = 1 95^{th} = 4	
		Infants	Carpets	Empirical	Mean = 4 95^{th} = 8	
			Hard Surfaces	Empirical	Mean = 1 95^{th} = 4	
Freq_Replen	Object-to-mouth events per hour (events/hour)	Toddlers		Weibull	Scale= 0.6 Shape= 6.8	
		Infants		Weibull	Scale= 1.4 Shape= 15.5	
BW	Body Weight (kg)	Toddlers		Empirical	Mean = 18.6 95^{th} = 26.2	
		Infants		Empirical	Mean = 11.4 95^{th} = 14.0	

NA = not applicable
Min = minimum
Max = maximum
AM = arithmetic mean

Fraction of Residue Available on the Object (F_O)

Following an application, some pesticide residue remains on indoor surfaces. Some of this residue may be transferred to a child's toy and subsequently ingested via object-to-mouth activities. For this SOP, it is assumed that the residue that could be transferred to the object is the same as what is available for dermal transfer. As a result, the fraction of residue available for transfer assumed for dermal exposure for both carpets and hard surfaces (see discussion above in *Section 7.2.2* for more detail) should be used as a conservative estimate for the fraction of residue available on the object.

For carpets, the recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile. For hard surfaces, the recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile.

Surface Area of Object Mouthed (SAM_O)

See *Section 2.5* of this SOP for discussion of surface area of object mouthed. **The recommended value for use in acute (i.e., one day) and longer-term exposure assessments ([XX]), represents the [XX]th percentile.**

Fraction of Pesticide Extracted by Saliva (SE_O)

See *Section 2.6* of this SOP for discussion of fraction of pesticide extracted by saliva distribution. T**he recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile**.

Exposure Time (ET)

An empirical distribution based on values from the Exposure Factors Handbook (U.S. EPA, 1997) and the Child-Specific Exposure Factors Handbook (U.S. EPA, 2008) should be used for indoor post-application hand-to-mouth assessments. The distributions for exposure time for toddlers (3 to <6 years) and infants (1 to < 2 years) are provided in *Table 7-17*. For carpets, the distributions are based on the time spent inside a residence, not including time spent sleeping. For hard surfaces, the distributions are based on time spent in kitchens and bathrooms.

For toddlers on carpets, the recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile. **For toddlers on hard surfaces, the recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile**.

For infants on carpets, the recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile. **For infants on hard surfaces, the recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile**.

Table 7-17: Exposure Time (ET)

Statistic	Carpet		Hard surfaces	
	Toddler (hours)	Infants (hours)	Toddler (hours)	Infants (hours)
5th percentile	1	1	0	0
25th percentile	3	4	0	0
50th percentile	4	5	1	1
75th percentile	6	6	2	2
90th percentile	8	9	3	3
95th percentile	9	8	4	4
AM (SD)	5 (--[a])	4 (--[a])	1(--[a])	1(--[a])
a. The Child-specific Exposure Factor Handbook (U.S. EPA, 2008) did not provide these values. AM (SD) = arithmetic mean (standard deviation)				

Replenishment Intervals per Hour (N_Replen)

This SOP assumes an estimate of 4 replenishment intervals per hour (i.e., residues on the hand will be replenished every 15 minutes). This value was selected as a conservative assumption based on the use of 30 minutes in the SHEDS model to coincide with the CHAD diaries.

Object-to-Mouth Events per Hour (Freq_Replen)

Frequency of object-to-mouth events is an important variable for object-to-mouth post-application exposure assessments. The estimates for frequency of object-to-mouth events in indoor environments are based on the Xue et al. (in press) meta-analysis. The indoor SOP utilizes object-to-mouth frequency data for the 3 to <6 year old age grouping to represent toddlers and the 1 to <2 year old age grouping to represent infants. Distributions for different sub-populations can be used if there is a need to assess a more specific exposure population. *Table 7-18* provides distributions and point estimates of object-to-mouth events for use in residential pesticide exposure assessment.

The recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile.

Table 7-18: Frequency of Object-to-Mouth Events (events/hr) [a]		
Statistic	**3 to <6 year olds**	**1 to <2 year olds**
5th percentile	0	2
25th percentile	1	7
50th percentile	5	12
75th percentile	13	19
95th percentile	40	34
AM (SD)	10 (15)	14 (10)
GM (GSD)	--[b]	--[b]
Range	--[b]	--[b]
N	158	137

Table 7-18: Frequency of Object-to-Mouth Events (events/hr) [a]		
Statistic	**3 to <6 year olds**	**1 to <2 year olds**
AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation) [a] The values provided in this table are not directly from the Xue et.al (in press) paper since that paper included a study that was deemed unethical by the Agency. The author reanalyzed the data, excluding that particular study, and those results are presented here. [b] Not provided		

Future Research/Data Needs

Unavailable information that would refine post-application incidental oral object-to-mouth exposure assessments for indoor pesticide applications include:

- Data could be produced to examine the potential for a range of pesticides to be transferred from treated indoor surfaces to both hard and soft children's toys.
- Specific activity data could be produced examining the typical surface area of a toy that is mouthed by children.

Exposure Characterization and Data Quality

Residue:

- Reviewers should recognize that factors such as vacuuming, transfer to clothing, re-suspension and impaction into carpet can greatly impact the dissipation rate of pesticides on indoor surfaces when conducting dermal post-application exposure assessments. The assumption that the entire available indoor transferable residue is transferred to the object should be considered very conservative.

7.2.5 Post-application Non-Dietary Ingestion Exposure Assessment: Dust Ingestion

The dust ingestion scenario for the indoor SOP is currently a work in progress and section "placeholders" are included. This type of scenario has not been assessed previously for indoor areas. There are several data needs associated with this scenario, which are outlined in the future research/data needs section.

This SOP provides a standard method for estimating dose among toddlers and infants from incidental ingestion of dust containing pesticide residues. This scenario assumes that pesticide residues in dust are ingested by children who play on treated indoor areas (i.e., carpets or hard surfaces) as a result of normal mouthing activities.

Post-application Dust Ingestion Exposure Algorithm

Exposure from dust ingestion is calculated as follows:

$$E = DR_t * IgR * CF1 \qquad \textbf{((7.22)}$$

where:

E = exposure (mg/day);
DR_t = dust residue on day "t" (μg/g);

IgR = ingestion rate of dust (mg/day); and
CF1 = conversion factor (1×10^{-6} g/µg).

and

$$DR_t = AR * F * \frac{1}{DL} * (1 - D)^t * CF2 * CF3 \tag{7.23}$$

where:
DR_t = dust residue on day "t" (µg/g);
AR = application rate (lb ai/ft^2);
F = fraction of application rate transferred to the dust (unitless);
DL = average dust load (g/cm^2);
D = fraction of residue dissipating daily (unitless);
t = post-application day on which exposure is being assessed;
CF2 = conversion factor (4.54×10^5 µg/lb); and
CF3 = conversion factor (1.08×10^{-3} ft^2/cm^2).

Dermal dose, normalized to body weight, is calculated as:

$$D = \frac{E * AF}{BW} \tag{7.24}$$

where:
D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal); and
BW = body weight (kg).

Post-application dust ingestion exposure following indoor applications is generally considered either acute or short-term in duration. Thus, the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in Sections 1.3.2 and 1.3.4, such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Dust Ingestion Exposure Algorithm Inputs and Assumptions

Recommended values for post-application dust ingestion exposure assessments are provided in *Table 7-19* below. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions, ii) data sources used to derive recommended input values, and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 7-19: Indoors – Recommended Dust Ingestion Exposure Factors Distributions and Point Estimates

Algorithm Notation	Exposure Factor	Units	Distribution		Point Estimate(s)
			Type	Parameters	
[PLACEHOLDER]					

Fraction of residue transferred to dust

[PLACEHOLDER]

Dust load

[PLACEHOLDER]

Dust Ingestion Rate (IgR)
The assumed dust ingestion rate for children (ages 1 to <6 years) is [X] mg/day. This is the [X] dust ingestion rate value recommended in Table 5-1 of the Child-Specific Exposure Factors Handbook (U.S. EPA, 2008) for use in exposure/risk assessments.

Future Research/Data Needs

Unavailable information that would refine post-application incidental oral dust ingestion exposure assessments for indoor pesticide applications include:

- Data on the residue to dust ratio using measurement study wipes versus dust concentrations.
- Method for estimating a dust residue from an application rate.
- Methods to determine amount of active ingredient available for transfer and ingestion from dust.
- Additional dust ingestion algorithms.

7.2.6 Combining Post-application Scenarios

Risks resulting from different exposure scenarios are combined when it is likely that they can occur simultaneously based on the use pattern and when the toxicological effects across different routes of exposure are the same. When combining scenarios, it is important to fully characterize the potential for co-occurrence as well as characterizing the risk inputs and estimates. Risks should be combined even if any one scenario or route of exposure exceeds the level of concern because this allows for better risk characterization for risk managers. The following issues should be considered when combining scenarios for the residential indoor SOP:

- There are a number of non-dietary ingestion exposure scenarios that could potentially be combined with the dermal exposure scenario. These non-dietary ingestion scenarios should be considered inter-related and it is likely that they occur interspersed amongst each other across time. For example, a child may place his hand in his mouth “X” number of times as well as place an object in his mouth “Y” number of times during a certain period of time. The potential combinations of co-occurrence of the hand-to-mouth/object-to-mouth scenarios across a particular period of time are limitless. Combining both of these scenarios with the dermal exposure scenario would be overly-conservative because of the conservative nature of each individual assessment. Based on this discussion, it is recommended that the dermal and hand-to-mouth scenarios be combined for acute and short-term exposure durations and this combination should be considered a protective estimate of children's exposure to pesticides used on indoor surfaces.

Section 8 Treated Pets

This section provides the methods for estimating potential dose that individuals may receive from dermal, inhalation and/or hand-to-mouth exposure resulting from the treatment of pets with a pesticide product. Products include liquid concentrate (dip, shampoo and sponge), liquid ready-to-use (aerosol can, collar, spot-on and trigger pump sprayer) and solid ready-to-use (dusts and powders) formulations. Exposure from treated pets is anticipated to occur through dermal and inhalation routes when handling or applying the treatment (adults). Further, exposure is anticipated to occur from the dermal (adults and toddler) and hand-to-mouth routes (infants and toddlers) from contact with treated fur.

This SOP updates the algorithms and inputs used to estimate handler and post-application dermal and post-application hand-to-mouth exposure. While the SOP builds on methods previously developed by the Agency, it relies mainly upon review of data submitted to EPA in support of pet pesticide product registration. The submitted data were used to estimate anticipated exposure from 1) the application of pet pesticide treatments and 2) post-application activity with treated pets. The Agency used data from open literature when available, though few sources were identified.

The exposure assessor should assume use on pets unless label language indicates otherwise. Look for statements describing or limiting the use of the product. These statements may be on the front panel of the label associated with the brand or trade name or in the use-directions section of the labeling. RUP classification indicates that the product cannot be bought or applied by homeowners and, therefore, a residential handler exposure assessment is not applicable. However, because the pets often return to residential sites following professional treatments, a residential post-application exposure assessment is required. Label language such as such as "for use by veterinarians or veterinary assistants only" is considered unenforceable and does not preclude use in residential settings. In this case, therefore, both a residential handler and post-application exposure assessment is required.

8.1 Handler Exposure Assessment

As described in *Section 1.3.3*, handler exposure refers to an adult individual exposed during mixing, loading, and applying of a pesticide. The Agency assumes that dermal and inhalation pesticide handler exposure can occur while applying pesticides to pets. This SOP provides unit exposures for each formulation/application equipment combination that are relevant to calculating handler exposure to pet pesticide products in the absence of chemical-specific handler data.

The unit exposures in this section are based on a review of 6 studies of varying formulations which provided information on the amount of active ingredient applied and resulting exposure (dermal and inhalation) to the handler. Formulations for which data have been identified include dips, dusts, trigger-pump spray, shampoo and top-spot. No data were identified for pet collar, powder or aerosol spray formulations; however, surrogate unit exposures have been determined for the assessment of these formulations. More information can be found in Appendix B.

Label information is important for selecting appropriate data inputs for the handler exposure assessment. The maximum application rate specified on the label should be used to estimate handler dose. Additional information provided by the label such as use directions, application-specific animal weight ranges and re-treatment intervals should be considered as a part of the exposure assessment.

Prior to the development of a handler exposure assessment for a pet treatment scenario, the assessor should review the pesticide label to determine whether the scenario is appropriate based upon the pesticide formulation and usage characteristics of the product. Specific labeling considerations for pet treatment products are as follows:

- Determine whether the labeling contains directions for use on pets.
- Identify from product labeling the formulation of the pet pesticide.
- Determine maximum rate(s) of application for differing ranges of animal weight.
- For formulations of pet pesticides which specify application rate as it corresponds to animal weight (i.e., collars and top-spots), labeled weight ranges should be used to determine application rate. The weight range which corresponds to the greatest amount of active ingredient applied should be used for the assessment of handler exposure. Many application methods of pet products (i.e., dips, shampoos and aerosol/trigger-pump sprays) do not specify application rate as it corresponds to pet weight ranges. When not specified it should be assumed that 1/2 of the contents of the can or bottle of product is applied per animal treated based on experience and professional judgment.
- Only adults are assumed to handle/ apply pesticides to pets.

Dermal and Inhalation Handler Exposure Algorithm

As described in *Section 1.3.3*, daily dermal and inhalation exposure (mg/day) for residential pesticide handlers, for a given formulation-application method combination, is estimated by multiplying the formula-application method-specific unit exposure by an estimate of the amount of active ingredient handled in a day, using the equation below:

$$E = UE * AR * A \tag{(8.1}$$

where:

E = exposure (mg/day);
UE = unit exposure (mg/lb ai);
AR = application rate (lb ai/pet); and
A = number of animals treated per day.

Dermal and/or inhalation dose normalized to body weight is calculated as:

$$D = \frac{E * AF}{BW} \tag{(8.2}$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal and/or inhalation); and
BW = body weight (kg).

Handler exposure for applications to pets is generally considered either acute or short-term in duration. Thus, the dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term, multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.3* such as the product-specific application regimen. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Dermal and Inhalation Handler Exposure Algorithm Inputs and Assumptions

Recommended values for handler exposure (inhalation and dermal) assessments are provided in *Table 8-1* and *Table 8-2*. Following these tables, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 8-1: Pet Treatments – Recommended Unit Exposure (mg/lb ai) Distributions and Point Estimates									
Formulation	**Equipment/Application Method**	**Dermal**			**Inhalation**			**Appendix Page Reference**
		Distribution		**Point Estimate**	**Distribution**		**Point Estimate**	
		Type	**Parameters**		**Type**	**Parameters**		
Liquid-Concentrate	Dip	Lognormal	GM = 67 GSD = 2.5		Lognormal	GM = 0.023 GSD = 1.1		B-70
	Sponge	Lognormal	GM = 920 GSD = 2.9		Lognormal	GM = 0.17 GSD = 1.2		B-74
Ready-to-Use (RTU) - Liquid	Trigger-pump sprayers	Lognormal	GM = 510 GSD = 2.7		Lognormal	GM = 2.2 GSD = 2.5		B-109
	Shampoo	Lognormal	GM = 1700 GSD = 1.9		Lognormal	GM = 2.1 GSD = 2.8		B-120
	Spot-on	Lognormal	GM = 29 GSD = 5.3		Inhalation exposure is unavailable, however is considered negligible.			B-126
	Collar	No exposure data available for this application scenario. Exposure data for spot-on applications recommended as surrogate data.						
	Aerosol Can	No exposure data available for this application scenario. Exposure data for trigger sprayer applications recommended as surrogate data.						
Dusts/Powders	Shaker Can	Lognormal	GM = 3600 GSD = 1.8		Lognormal	GM = 9.4 GSD = 3.1		B-36

Unit Exposures

As described in *Section 1.3.3*, the unit exposure is the ratio of exposure and the amount of active ingredient handled for a given formulation/application method combination, with units of mass exposure per mass active ingredient handled (e.g., mg exposure/lb ai handled). **The recommended point estimates shown in *Table 8-1* represent approximately the [XX]th percentile of the respective distribution.** Data summaries for all UE inputs can be found in *Appendix B*.

Number of Animals Treated

It is assumed that residential handlers of pet treatment products will treat 2 animals per application (N). This estimate is based upon data from the American Pet Products Manufacturers Association (APPMA) 2007-2008 National Pet Owners Survey, which reports that pet owners have an average of 1.7 dogs and 2.3 cats.

8.2 Post-application Exposure Assessment

Post-application exposure can result from conducting physical activities such as petting or otherwise interacting with pets following pesticide applications. While exposure may occur for people of all ages, adults and toddlers are considered the sentinel populations for this exposure scenario based on behavioral characteristics and the strengths and limitations of available data.

It is assumed that individuals contact previously treated pets on the same day the pesticide treatment is applied. Therefore, this scenario is always assessed. However, the assessment can be refined to more accurately reflect exposure over longer periods of time (e.g., a month) if toxicological endpoint or activity information is available to allow for such calculations.

This section addresses standard methods for estimating exposure and dose for three individual post-application scenarios resulting from exposure to pesticides that have been used to treat pets:

- Section 8.2.1 - adult/toddler inhalation exposures;
- Section 8.2.2 - adult/toddler dermal exposures; and
- Section 8.2.3 - toddler non-dietary ingestion via hand-to-mouth activity.

8.2.1 Post-application Inhalation Exposure Assessment

Post-application inhalation exposure is generally not assessed for pets and should be handled on a case-by-case basis. The combination of low vapor pressure for chemicals typically used as active ingredients in pet pesticide products and the small amounts of pesticide applied to pets is likely to result in minimal inhalation exposure.

8.2.2 Post-application Dermal Exposure Assessment

This SOP provides a revised standard method for estimating potential dermal pesticide exposure among adults and/or toddlers that contact pets previously treated with pesticide products. The method for determining post-application dermal dose is based on the relationship between the amount of pesticide applied and contact activities. It was developed to incorporate chemical-specific data; however, standard values and assumptions are included that can be used in the absence of data.

General assumptions and factors used in the revised residential pet SOPs are as follow:

- Post-application exposure must be assessed on the same day the pesticide is applied since it is assumed that an adult or child could be exposed to a pet immediately after application. Therefore, post-application exposure must include an estimated dose based on the day of application residues (i.e., day 0).

- If no chemical-specific data are available, a default value of 14% dissipation per day should be used to assess post-application exposure beyond the day of application for all application methods except collars. Collars are assumed to emit at a more constant rate and, therefore, dissipation is not anticipated.

Post-application Dermal Exposure Algorithm

The following method is used to calculate dermal exposures that are attributable to an adult or toddler contacting a treated companion pet.

$$E = \frac{TC * TR}{n * K} * \frac{\left(1 - e^{-ET*K}\right) * \left(1 - \left(1 - d\right)^{n}\right)}{d} \tag{8.3}$$

where:

E	= exposure (mg/day);
TC	= transfer coefficient (cm^2/hr);
TR	= transferable residue (mg/cm^2);
d	= dissipation rate (unitless);
ET	= exposure time (hours/day);
n	= number of days of exposure; and
K	= decay constant.

and

$$K = \frac{\ln(1 - d)}{-24} \tag{8.4}$$

$$TR = \frac{AR * F_{AR}}{SA} \tag{8.5}$$

where:

TR	= transferable residue (mg/cm^2);
AR	= application rate or amount applied to animal (mg);
F_{AR}	= fraction of the application rate available as transferable residue; and

SA = surface area of the pet (cm^2).

Dermal dose, normalized to body weight, is calculated as:

$$D = \frac{E * AF}{BW} \tag{8.6}$$

where:

D = dose (mg/kg-day);
E = exposure (mg/day);
AF = absorption factor (dermal); and
BW = body weight (kg).

Post-application exposure assessment following applications to pets is generally considered either acute or short-term in duration. Thus, the dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4* such as residue dissipation, product-specific re-treatment intervals (i.e., monthly, bi-monthly), and activity patterns.

Due to temperate climates in some parts of the country, the potential exists for pet pest pressures and resulting treatment to extend beyond a short-term duration. In order to account for longer terms of residential post-application exposure from treated pets, intermediate- and, to a lesser extent, long-term durations should be assessed when label directions indicate these exposures are likely to occur. The estimated dose should take into account factors similar to those considered for short-term, multi-day assessment to more accurately reflect the exposure profile.

Post-application Dermal Exposure Algorithm Inputs and Assumptions

Recommended values for post-application dermal exposure assessments are provided in *Table 8-2* below. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 8-2: Residential Post-application Scenario – Pet Treatment SOP Dermal Exposure Factors: Recommended Distributions and Point Estimates

Algorithm Notation	Exposure Factor Units		Distribution Type	Distribution Parameters	Recommended Point Estimates
AR	Application rate (mg)		Point Estimate	NA	Labeled Rate for Each Weight Range Specified (Small, Medium, Large)
SA	Surface Area of Animal (cm^2)	Small Cat, Dog	Point Estimate	NA	
		Medium Cat, Dog	Point Estimate	NA	
		Large Cat, Dog	Point Estimate	NA	
F_{AR}	Fraction of AR Available for Transfer		Point Estimate	NA	
d	Daily residue dissipation unitless		Point Estimate	NA	
TC	Transfer Coefficient – Liquids (cm^2/hr)	Adult	Lognormal	GM: 6,500 GSD: 2.3	
		Toddler	Lognormal	GM: 2,700 GSD: 2.3	
	Transfer Coefficient – Solids (cm^2/hr)	Adult	Lognormal	GM: 210,000 GSD: 1.8	
		Toddler	Lognormal	GM: 87,000 GSD: 1.8	
ET	Exposure Time (hours per day)		Triangular	Min. = 0.03 Median = 0.11 Max. = 1.0	
BW	Body weight (kg)	Adult	Empirical	Mean = 72 95^{th} = 98	
		Toddler	Empirical	Mean = 19 95^{th} = 26	

NA = not applicable, GM = geometric mean, GSD = geometric standard deviation, S-/I-T= short-/intermediate-term exposure

Transfer Coefficient (TC)

Post-application dermal exposure can be predicted using estimates for residue transfer to individuals contacting treated pets during certain activities and exposure times. Residue transfer from a given formulation and activity is an empirical value, known as the transfer coefficient (TC). For the purpose of determining exposure to treated pets, TC can be defined as animal surface area contact per unit time (cm^2/hr). It is the ratio of exposure rate, measured in mass of chemical per time (e.g., ug/hr), to residue, measured in mass of active ingredient per surface area of the animal (e.g., ug/cm^2).

The transfer coefficients used for pet exposure were derived from two studies representing application and grooming activities with dogs, one using a carbaryl shampoo product (Mester, 1998) and the other using a carbaryl dust product (Merricks, 1997); these are used to represent TCs for liquid and solid formulations, respectively. Data were gathered while human volunteers applied pet pesticide products to various dogs of differing sizes and fur lengths.

Since TCs were established from studies using adult volunteers, they have been scaled to adjust for assessment of toddler exposure as outlined in Section 2.3 using a factor of 0.42 (i.e., a 58% reduction in the adult TC).

A TC of **[XX]** cm^2/hr for adults and **[XX]** cm^2/hr for toddlers (based on the **[XX]**th percentile) is recommended for addressing all durations of post-application exposure for all liquid formulations (or formulations that behave as liquids) including ready-to-use (RTU) liquid formulations (i.e., aerosol/trigger sprays, dips, pet collars, shampoos and top-spots). *Table 8-3* provides a statistical summary of dermal exposure TCs derived for liquid formulations. A transfer coefficient of **[XX]** cm^2/hr for adults and **[XX]** cm^2/hr for toddlers (based on the **[XX]**th percentile) is recommended for addressing all durations of post-application exposure for ready-to-use (RTU) solid formulations (i.e., dust and powder). *Table 8-4* provides a statistical summary of dermal exposure TCs derived for solid formulations. A description of these studies and statistical derivations can be found in *Appendix C.7.4*.

Table 8-3: Dermal Exposure Transfer Coefficients - Liquid Formulations

Statistic	**Transfer Coefficient (cm^2/hr) [a, b]**	
Liquids (Dips, Shampoos, Aerosol/Trigger Sprays, Collars and Top-Spots)		
	Toddler	**Adult**
50^{th} Percentile	2,700	6,500
75^{th} Percentile	4,800	11,000
95^{th} Percentile	11,000	26,000
99^{th} Percentile	19,000	46,000
AM (SD)	3,600 (X)	8,700 (6,700)
GM (GSD)	2,700 (2.3)	6,500 (2.3)
Range	NA [c]	929 – 22,866
N	NA [c]	16

a. Represents individuals wearing short-sleeve shirts, shorts, and no chemical-resistant gloves
b. Dermal liquid formulation TC based on a lognormal distribution fit with data from MRID 46658401 (*See Appendix C.7.4*).
c. NA = Not applicable. Toddler values were derived by scaling adult data.

Table 8-4: Dermal Exposure Transfer Coefficients - Solid Formulations		
Statistic	**Transfer Coefficient (cm^2/hr)** [a, b]	
Solids (Dusts/Powders)		
	Toddler	**Adult**
50th Percentile	87,000	210,000
75th Percentile	130,000	310,000
95th Percentile	230,000	560,000
99th Percentile	350,000	840,000
AM (SD)	101,000 (X)	240,000 (120,000)
GM (GSD)	87,000 (1.8)	210,000 (1.8)
Range	NA [c]	51,180 – 566,918
N	NA [c]	20
a. Represents individuals wearing short-sleeve shirts, shorts, and no chemical-resistant gloves b. Dermal liquid formulation TC based on a lognormal distribution fit with data from MRID 44439901 (*See Appendix C.7.4*). c. NA = Not applicable. Toddler values were derived by scaling adult data.		

Transferable Residue (TR)

Transferable residue (TR) is a measure of the concentration of pesticide active ingredient per surface area of the treated pet that is anticipated to transfer to the exposed person. The concentration of pesticide residue per surface area of animal is determined by normalizing the maximum amount of ai deposited on the pet from a single treatment to the surface area (SA) of the treated animal and multiplying by the fraction of application rate (F_{AR}) anticipated to transfer from the haircoat of the treated animal to the exposed individual. The following selection criteria should be used to determine TR.

1) Use the measure of TR by means of a chemical-specific exposure study (i.e., pet wipe study), if submitted.

2) In the absence of a chemical-specific study, the fraction of the application rate (F_{AR}) should be used.

Fraction Application Rate (F_{AR})

If chemical specific TR measurements are not available, then a generic value for the fraction of active ingredient available for transfer is used. In this SOP, a default F_{AR} was selected based on the review of 5 petting studies submitted to the Agency. Measurements of residue availability were derived by taking the ratio of the amount of active ingredient on a bare or gloved hand (on the day of application) to the amount of active ingredient applied. Petting studies were performed by means of volunteers "petting" or "stroking" animals treated with a known amount of active ingredient and determining the amount of residue transferred to the hands. F_{AR} studies varied in the number, location and intensity of petting and stroking actions. All 5 petting studies were reviewed for ethical conduct and no barriers were identified in law or regulation for their being relied upon by the Agency.

Based on the available studies, the F_{AR} available to dislodge for all durations assessed (short-/intermediate-/long-term) is estimated to be **[XX]** (**[XX]**th percentile). *Table 8-5* provides a statistical summary of F_{AR} data available for transfer distribution. References and a description of the 5 studies, as well as statistical derivation can be found in *Appendix C.6.4*.

Table 8-5: Dermal Exposure Fraction of Application Rate (F_{AR})	
Statistic	**F_{AR}**
50th Percentile	0.0045
75th Percentile	0.0069
95th Percentile	0.012
99th Percentile	0.022
AM (SD)	0.0054 (0.0043)
GM (GSD)	0.0043 (2.0)
Range	0.0006 – 0.031
N	91

Exposure Time (ET)

The exposure time (ET) for adults and toddlers with treated pets is assumed to be 1.0 hours per day based on the results of an observational study (Freeman et al, 2001). In the study, macroactivity and microactivity data were collected via questionnaires and videotaping of 19 children (aged 3 to 12) for a four hour period. The videotapes from the observational portion of this study were analyzed to determine frequency of contacts for several mouthing behaviors, as well as duration of time each child spent in various locations around the home. The results of this study include several measurements for the duration of time the observed children spent with their pets. The time spent in this activity was assumed to follow a triangular distribution with a minimum value of 0.03 hours, a median value of 0.11 hours, and a maximum value of 1.0 hours per day. A description of the input and study can be found in *Appendix C.8.4*.

Table 8-6: Daily Continuous Exposure Time (ET) with Pet (Adults and Toddlers)	
Statistic	**ED (hours)**
Minimum	0.03
Median	0.11
Maximum	1.0

Dissipation (d)

Short-term post-application exposure is typically assessed on the same day the pesticide is applied (day 0) since it is assumed that individuals could be exposed to pets immediately after application. Therefore, short-term post-application exposures are based on residues found on day 0. Exposure is also likely to occur for longer (intermediate-/long-term) durations. In these cases, it is necessary to use a pesticide daily dissipation rate (d) to estimate a range of anticipated risk for the treatment period. If no chemical-specific dissipation data are available, a default value should be used. A default of 14% (0.014) dissipation per day was determined based upon the review of the same 5 dermal post-application exposure studies (liquid and solid formulation) used to determine F_{AR}. A description of these studies can be found in *Appendix C.6.4.*

No studies were identified for collars for which dissipation data could be derived. Unlike the other pet product application methods which have shorter treatment intervals and dissipate rapidly, collars are intended to be affective for longer intervals and, likewise, emit at a more constant rate. Therefore, dissipation is not anticipated for collars and should not be accounted for when assessing longer term durations of exposure.

Table 8-7: Pet Insecticide Daily Dissipation Rate (d)	
Statistic	**d**
50th Percentile	0.14
75th Percentile	0.17
95th Percentile	0.18
99th Percentile	0.18
AM (SD)	0.14 (0.034)
GM (GSD)	0.14 (1.3)
Range	0.098 – 0.18
N	6

Application Rate (AR)

The pesticide label should be used to determine the amount of active ingredient used during each treatment. The maximum application rates allowed by labels are always considered in risk assessments. For pet pesticide formulations which specify application rate in relation to animal weight (i.e., collars and top-spots), a rate should be quantified for small, medium and large weight classifications as assigned by the Agency. The weight ranges are as follow:

- Cats – Small (up to 5 lbs), Medium (6 to 12 lbs), Large (13 lbs and up).
- Dogs - Small (up to 20 pounds), Medium (21 to 50 lbs) and Large (51 lbs and up).

Many application methods of pet pesticides (i.e., dips, shampoos and aerosol/trigger sprays) are not specific about application rate in relation to pet weight. If not specified, then it should be assumed that 1/2 of the contents of the can or bottle of product is applied to the pet based on experience and professional judgment.

Surface Area (SA)

Animal surface area (SA) is determined by inputting animal weight (lbs) into an algorithm (12.3*((animal body weight (lbs)*454)^0.65)) as referenced from US EPA (1993) Wildlife Exposure Factors Handbook. Representative surface areas have been calculated for the assigned cat and dog weight ranges. The surface areas for assessment are as follows:

- Cats – Small (1500 cm^2), Medium (2500 cm^2) and Large (4000 cm^2).
- Dogs – Small (3000 cm^2), Medium (7000 cm^2) and Large (11000 cm^2).

Future Research/Data Needs

Areas of research and data needs for the assessment of post-application dermal exposure from treated pets are many. Product survey data could be useful in refinement of the Agency's current, high-end assumptions for use patterns of particular pet pesticide application methods. Observational studies conducted to determine residue transfer occurring from actual adult and toddler activities with treated pets could provide a more realistic estimate of transfer (TC). Furthermore, if the activity durations and pet contacts were recorded (either video or reported) the Agency could potentially refine its exposure time (ET) assumption.

Exposure Characterization and Data Quality

The amount of product applied to the animal can at times be uncertain for particular application methods (e.g., aerosol and trigger sprays, and dusts). Due to the lack of specific product labeling and the lack of data to inform typical application method use patterns, the Agency assumes that 1/2 of the can or bottle can be applied for each animal. While this estimate is likely a high-end assumption for use, it results in a greater potential dose to the exposed individual and, therefore, a more protective estimate of human health.

The Agency did not identify any studies which were conducted to capture the range of residential activities with a treated pet. While studies were conducted to determine the fraction of application rate transferred from the treated pet to a human hand, they describe a scripted activity patterns employed (i.e., a pre-determined number of wipes to the animal's coat) and provide hand only exposure measurements, limit their utility for the estimation of actual activities, contact and resulting exposure to the whole body of exposed individuals. Applicator and groomer studies were, therefore, identified as a data source for reasonable upper bound estimates of contact with an animal. In the absence of data, the Agency assumes that applying and grooming activities are likely to result in more consistent and reliable contact factors than petting, hugging or sleeping with a pet and, therefore, an appropriate source from which to derive a TC.

The exposure time (ET) assumed by the Agency is considered to represent continuous contact (i.e., constant loading) rather than the intermittent contact typically associated with pet care (i.e., feeding, walking, etc.). Time spent in and around the home and/or sleeping in the same bed with a treated pet is not likely to result in contact for the entire duration of the activity. Therefore, the Agency believes that 1.0 hours per day of continuous exposure, in conjunction with high-end TCs derived from groomer studies, represents a protective estimate of adult and toddler exposure to a treated pet. Furthermore, the study was the only identified by the Agency which specifically monitored human activity duration, as well as, contact with pets and is, therefore, the best available source of data for the exposure time input.

8.2.3 Post-application Non-Dietary Ingestion Exposure Assessment: Hand-to-Mouth

This SOP provides a standard method for estimating the potential dose from incidental ingestion of pesticide residues from previously treated pets. Considering the strengths and limitations of available data and behavioral characteristics of potentially exposed populations, exposure for toddlers is calculated in this scenario. This scenario assumes that pesticide residues are transferred to the skin of toddlers contacting treated pets and are subsequently ingested as a result of hand-to-mouth transfer.

Post-application Hand-to-Mouth Exposure Algorithm

Exposure from hand-to-mouth activity is calculated as follows (based on algorithm utilized in SHEDS-Multimedia, http://www.epa.gov/heasd/products/sheds_multimedia/sheds_mm.html):

$$E = [HR * (F_M * SA_H) * (ET * N\_Replen) * (1- (1- SE)^{(Freq\_Replen/N\text{-}Replen)})] \qquad (8.7)$$

where:

E	= exposure (mg/day);
HR	= hand residue loading (mg/cm^2);
SA_H	= surface area of one toddler hand (cm^2);
F_M	= fraction hand surface area mouthed /event (fraction/event);
ET	= exposure time (hr/day);
N_Replen	= number of replenishment intervals per hour (intervals/hour);
SE	= saliva extraction factor (i.e., mouthing removal efficiency); and
Freq_Replen	= number of hand-to-mouth contacts events per hour (events/hour).

and

$$HR = \frac{DE * F_{aihands}}{2 * SA_H} \tag{8.8}$$

where:

HR_t	= hand residue loading (mg/cm^2);
DE	= dermal exposure (mg);
$F_{aihands}$	= fraction of a.i. on hands compared to total residue from dermal transfer coefficient study (unitless);
SA_H	= surface area of one toddler hand (cm^2).

Oral dose, normalized to body weight, is calculated as:

$$D = \frac{E}{BW} \tag{8.9}$$

where:

D	= dose (mg/kg-day);
E	= exposure (mg/day); and
BW	= body weight (kg).

Post-application hand-to-mouth ingestion exposure following applications to pets is generally considered either acute or short-term in duration. Thus, the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in Sections 1.3.2 and 1.3.4, such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Post-application Hand-to-Mouth Exposure Algorithm Inputs and Assumptions

Recommended values for post-application hand-to-mouth exposure assessments are provided in Table 8-8 below. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 8-8: Pet Treatments – Recommended Hand-to-Mouth Exposure Factors Distributions and Point Estimates					
Algorithm Notation	Exposure Factor (units)		Distribution		Point Estimate(s)
			Type	Parameters	
Fai_{hands}	Fraction of a.i. on hands from transfer coefficient studies (unitless)		Point Estimate	NA	
F_M	Fraction hand surface area mouthed /event (fraction/event)		Beta	α = 3.75 β = 25	
N_Replen	Replenishment intervals per hour (intervals/hr)		Point Estimate	NA	4
ET	Exposure time (hours/day)		Triangle	Min.: 0.03 Median = 0.11 Max.: 1.0	
SE	Saliva extraction factor		Beta	α = 7.0 β = 7.6	
Freq_Replen	Hand-to-mouth events per hour (events/hr)	Toddlers	Weibull	Scale= 0.73 Shape= 12	
SA_H	Typical surface area of one toddler hand (cm^2)	Toddlers	Point Estimate	NA	225
BW	Body Weight (kg)	Toddlers	Empirical	Mean = 19 95^{th} = 26	
GM = geometric mean GSD = geometric standard deviation S-/I-/LT = short-/intermediate-/long-term exposure					

Fraction Active Ingredient on the Hands ($F_{aihands}$)

The fraction of active ingredient available on the hands was based on two dermal pet transfer coefficient studies that represent application and grooming activities with dogs. One study used a carbaryl shampoo product (Mester, 1998) and the other used a carbaryl dust product (Merricks, 1997). These values were determined for liquid and solid formulations by taking the average fraction of active ingredient on the hands and comparing that value to the average fraction of active ingredient on the entire body. This analysis resulted in values of 3.9% for liquid formulations and 37% for solid formulations.

Hand Residue Loading (HR)

Link hand loading to dermal exposure and assume the percent on the hands is equal to the percent of the residue on the hands from dermal transfer coefficient studies.

Examples:

Dermal exposure for toddler to pets (liquid formulation; calculated): 1 mg
Dermal exposure for toddler to pets (solid formulation; calculated): 5 mg
Assume surface area of one toddler hand = 225 cm^2
Fraction of active ingredient on the hands compared to the active ingredient on the entire body:

Liquid: 0.039

Granular: 0.37

Pets (liquid formulation) HR = (0.039 * 1 mg) / 2 = 0.102 mg/hand / 225 cm^2/hand = 0.000087 mg/cm^2
Pets (solid formulation) HR = (0.37 * 5 mg) / 2 = 0.925 mg/hand / 225 cm^2/hand = 0.0041 mg/cm^2

Fraction Hand Surface Area Mouthed (F_M)

See Section 2.4 for discussion of fraction hand surface area mouthed. The recommended F_M value for use in post-application non-dietary ingestion exposure assessments, **[XX]**, represents approximately the **[XX]**th percentile.

Hand Surface Area (SA_H)

The hand surface area for toddlers (3 to <6 year olds) of 225 cm^2, for one hand, was based on values from the Child-specific Exposure Factors Handbook (U.S. EPA, 2008).

Exposure Time (ET)

The exposure time (ET) for toddlers exposed to pesticide treated pets is assumed to be the same as described in Section 8.2.2 for post-application dermal exposure. The recommended ET value for use in post-application non-dietary ingestion exposure assessments is 1.0 hours per day based on the results of an observational study (Freeman et al, 2001).

Replenishment Intervals per Hour (N_Replen)

This SOP assumes an estimate of 4 replenishment intervals per hour (i.e., residues on the hand will be replenished every 15 minutes). This value was selected as a conservative assumption based on the use of 30 minutes in the SHEDS model to coincide with the CHAD diaries.

Fraction of Pesticide Extracted by Saliva (SE_H)

See section 2.6 of this SOP for discussion of fraction of pesticide extracted by saliva distribution. **The recommended value for use in post-application non-dietary ingestion exposure assessments, [XX], represents approximately the [XX]th percentile.**

Hand-to-Mouth Events per Hour (Freq_Replen)

Frequency of hand-to-mouth events is an important variable for post-application non-dietary ingestion exposure assessments. However, there are currently no data available that specifically address the number of hand-to-mouth events that occur relative to the amount of time a child spends with a pet. As a result, the estimates for frequency of hand-to-mouth events in indoor environments from the Xue et al. (2007) meta-analysis were used as a surrogate. The indoor data were selected, even though toddler exposure to treated pets can occur either indoors or outdoors, because the indoor data result in a greater frequency of contacts. Therefore, using these data are the most conservative and thus the most health protective estimate of exposure. The pet SOP uses hand-to-mouth frequency data for the 3 to <6 year old age grouping to represent toddlers. *Table 8-9* provides distributions and point estimates of hand to mouth events for use in residential pesticide exposure assessment. **The recommended point estimate for use in post-**

application non-dietary exposure assessments, [XX], represents approximately the [XX]th percentile for the 3 to <6 year old.

Table 8-9: Frequency of Hand-to-Mouth Events (events/hr)[a]	
Statistic	**3 to <6 year olds**
5th percentile	0
25th percentile	3
50th percentile	8
75th percentile	20
95th percentile	57
AM (SD)	14 (19)
GM (GSD)	--[b]
Range	--[b]
N	160

AM (SD) = arithmetic mean (standard deviation)
GM (GSD) = geometric mean (geometric standard deviation)
[a] The values provided in this table are not directly from the Xue et. al (2007) paper since that paper included a study that was deemed unethical by the Agency. The author reanalyzed the data, excluding that particular study, and those results are presented here.
[b] Not provided

Future Research/Data Needs

There are three main potential research/ data needs with respect to the incidental ingestion scenario: (1) The available published literature on hand-to-surface contacts per hour could be combined and analyzed in a meta-analysis to obtain a distribution for this input. (2) Available videography data could be analyzed to obtain a distribution for the replenishment interval input. (3) Additional videography data could be collected focusing on the number of hand-to-mouth events which occur in relationship to the amount of time a child spends with a pet.

Exposure Characterization and Data Quality

The majority of inputs identified for the estimation of toddler incidental ingestion of pesticides from exposure to a treated pet are reasonable. While not specific to toddler activity with treated pets, most reflect general activity and behavior patterns exhibited by children within the age group and, therefore, are not likely to vary dependent upon the object being contacted (i.e., frequency of hand to mouth events per hour and the surface area of the hand mouthed). The Agency's assessment of incidental ingestion could improve, however, through continued research and analysis of available data.

The Agency currently assumes that toddlers are exposed to a treated pet for 1.0 hours per day. As described in *Section 8.2.2*, the Agency believes that this estimate represents a protective estimate of toddler exposure to a treated pet since it assumes continual contact and is paired with high-end TCs from applicator and groomer studies. Furthermore, the study was conducted to observe the behaviors of children in household environments.

8.2.4 Combining Post-application Scenarios

Risks resulting from different exposure scenarios are combined when it is likely that they can occur simultaneously based on the use pattern and when the toxicological effects across different routes of exposure are the same. When combining scenarios, it is important to fully characterize the potential for co-occurrence as well as characterizing the risk inputs and estimates. Risks should be combined even if any one scenario or route of exposure exceeds the level of concern because this allows for better risk characterization for risk managers.

It is likely that toddlers could be exposed to a treated pet via post-application dermal and non-dietary ingestion (hand-to-mouth) routes and that these scenarios could occur simultaneously. Therefore, these exposure scenarios should be combined when toxicological effects are the same across these routes of exposure.

Section 9 Impregnated Materials

This chapter provides methodologies for assessing pesticide exposures from pesticide impregnated materials, including textiles (e.g. clothing, mattress linings, upholstery, etc.), carpets, flooring, and plastic materials. When assessing pesticide exposure from impregnated materials, the primary exposure routes that may need to be addressed include post-application dermal absorption and non-dietary ingestion. Exposure from these routes may result in pesticide exposures in the general population. However, some population groups, such as military personnel, outdoor workers, and children, may display activity patterns that have the potential to result higher levels of exposure (e.g., military personnel and outdoor workers who may wear impregnated clothing for extended periods of time and child hand-to-mouth activity), which may need to be addressed more explicitly when performing exposure assessments.

Before developing an exposure assessment for an impregnated material, the appropriate exposure scenarios should be identified using information on the product's pesticide label. Specific label information that should be considered is described below.

- **Impregnated Materials with Pesticidal Claims:** Some impregnated materials contain conventional pesticides and have a pesticide label. The labels of such products make claims about pest control, such as "kills fleas and ticks" or "kills flying insects." These labels contain information on the active ingredient and should be used when performing exposure assessments using the methods described in this chapter.

- **Impregnated Materials with No Pesticidal Claims:** Many impregnated materials (e.g., mattress covers, shower curtains, paper, and adhesives) contain biocide pesticides and do not require a pesticide label. The pesticide in these products is present as a biocide, which is added during the manufacturing process. Biocides are more routinely assessed by OPP's Antimicrobial Division (OPP/AD) and are not addressed in this chapter.

- **Limiting and Descriptive Statements:** It should be assumed that impregnated products may be used used in non-occupational settings, unless the label indicates that the use of the product is restricted to professionals. Examples of labels that may appear on products that are intended for non-occupational settings include:
  - Insect repellant apparel
  - For treatment of nets, tents, sleeping bags
  - For fabric product on and around beds

9.1 Handler Exposure Assessment

For impregnated materials treated with non-biocide pesticides (e.g. insecticides and repellants), exposure during the manufacturing process is not typically assessed.[12] There are some situations following the treatment process, however, where individuals may contact large volumes of impregnated material. The handling of impregnated materials following the treatment process is addressed in the post-application dermal exposure scenario described in *Section 9.2.3*.

9.2 Post-Application Exposure Assessment

Post-application exposure can result from contacting impregnated materials, such as wearing pesticide impregnated clothing, object-to-mouth and hand-to-mouth behavior. Depending on the application of the impregnated material, potential exposed populations include both adults and children. While exposure may occur for people of all ages, adults, toddlers, and infants are considered potential sentinel populations based on behavioral characteristics and the strengths and limitations of available data. Additionally, when assessing exposures that are more likely to occur in outdoor environments, it is recommended that toddlers be used as the sentinel population because they are more likely to spend time outdoors than infants. When assessing exposures that are more likely to occur in indoor environments, it is recommended that infants be used as the sentinel population.

This section addresses standard methods for estimating exposure and dose for four post-application scenarios resulting from pesticide impregnated materials:

- Section 9.2.1 - inhalation exposures;
- Section 9.2.3 - adult/toddler/infant dermal exposures; and
- Section 9.2.4 – toddler/infant non-dietary ingestion via object-to-mouth activity;
- Section 9.2.5 – toddler/infant non-dietary ingestion via hand-to-mouth activity.

9.2.1 Post-Application Inhalation Exposure Assessment

In most cases inhalation exposure from impregnated materials is expected to be negligible, since many pesticides that are used in impregnated materials have relatively low vapor pressures. As a result, inhalation exposure is not expected to result in appreciable exposure, when compared with dermal and non-dietary ingestion exposure, and not explicitly addressed in these SOPs.

9.2.2 Post-Application Surface Residue Concentration

When assessing dermal and non-dietary ingestion exposure scenarios, the product label and registrant should be consulted to obtain information on the surface residue concentration in terms of active ingredient (a.i.) that is present on the surface area of the impregnated material (e.g. mg

[12] Safety issues associated with potential chemical exposure during the manufacturing process are more typically addressed by the Occupational Safety and Health Administration.

a.i./ cm^2). In some cases, however, information on surface residue concentration may only be available in terms of percent a.i. in terms of total product mass (e.g. Fraction of a.i. in treated material). In these cases, surface residue concentration can be estimated by finding the product of the weight fraction of a.i. in treated material and the material's weight:surface area density (See *Table 10-1*), as illustrated in the equation below.

$$SR = WF * MD \tag{9.1}$$

where:

SR = Surface residue concentration (mg a.i./cm^2) ;
WF = Weight fraction of a.i. in treated material (% a.i. w/w); and
MD = Material weight:surface area density (mg material/ cm^2).

Table 9-1: Recommended weight-to-surface area values for selected fabrics/materials

Material	Material weight:surface area ratio	Source
Textiles		
Cotton [a]	20 mg/cm^2	Unpublished Henkel data from HERA (2005)
Light Cotton/Synthetic Mix [a]	10 mg/cm^2	Unpublished Proctor & Gamble data from HERA (2005)
Heavy Cotton/Synthetic Mix	24 mg/cm^2	Nylon/cotton battle dress uniform data published in Snodgrass (1987)
All Synthetics	1 mg/cm^2	Unpublished Proctor & Gamble data from HERA (2005)
Carpets		
Household Carpets	120 mg/cm^2	USAF (2003)
Hard Surfaces and Plastics		
Plastic Polymers	100 mg/cm^2	OPP/AD information on a polyethylene highchair
Vinyl Flooring	40 mg/cm^2	OPP/AD information on the density (1300 mg/cm^3) and thickness (0.03 cm) of polyvinyl chloride tiling

[a] Comparable weight:surface area ratio values are also reported for cotton and cotton/synthetic sheets analyzed in a submitted study (MRID 45256001).

Regardless of how residue concentration is reported, the value used in post-application exposure assessments should always be based on the maximum concentration reported on a product's label. This approach is believed to overestimate exposure since the concentration of pesticide residue is expected to decrease over time due to laundering (textiles only) and dissipation over time. With regard to textiles, it has been demonstrated that 20 – 30 percent of pesticide can be removed after first laundering (Snodgrass, 1992) and as high as 90 percent of pesticide residue is removed after twenty launderings (Faulde et al., 2003).[13] Similarly, it is believed to be reasonable that some pesticide residue in impregnated materials, including both textiles and hard surfaces (e.g. flooring, linings, and plastics), may dissipate through decay and weathering over time. Since laundering and dissipation are not specifically incorporated into the post-application

[13] These percent changes were approximated from a graphical chart presented in Faulde et al. (2003).

exposure assessment methods, the approach used to estimate surface residue concentration is believed to be conservative because it is assumed that no pesticide residue is lost due to laundering or dissipation and individuals are always exposed to the maximum concentration listed on the label.

9.2.3 Post-Application Dermal Exposure Assessment

This SOP provides methods for estimating adult and toddler post-application dermal exposure. In contrast to the other SOPs for other exposure scenarios, the method for determining post-application dermal dose is based on the amount of pesticide that may be transferred to the skin during continuous contact with an impregnated material, such as wearing impregnated clothing or sleeping on a bed with an impregnated mattress liner

Post-Application Dermal Exposure Algorithm

Post-application dermal exposure is calculated as follows:

$$E = SR * SA * F * TE * PF \tag{9.2}$$

where:

E = Daily exposure rate (mg/kg-day)
SR = Surface residue concentration (mg/cm^2)
SA = Surface area of entire body (cm^2)
F = Fraction of body that contacts residue (unitless)
TE = Daily material-to-skin transfer efficiency (fraction/day)
PF = Protection factor to account for the presence of a single layer of fabric (e.g. clothing, bed sheet, etc.) between the impregnated material and individual (unitless)

Dermal dose, normalized to body weight, is then calculated as:

$$D = \frac{E * AF}{BW} \tag{9.3}$$

where:

D = Dose rate (mg/kg-day)
AF = Dermal absorption factor
BW = Body weight (kg)

Post-application dermal exposure from impregnated materials is generally considered either acute or short-term in duration. Thus, the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in Sections 1.3.2 and 1.3.4, such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, such as in cases where the impregnated material may be routinely replaced or re-treated, similar refinements to more accurately reflect the exposure profile are recommended.

Post-Application Dermal Exposure Assessment Inputs and Assumptions

Recommended values for post-application dermal exposure assessments of impregnated materials are provided in *Table 9-2*. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure

Table 9-2: Summary of recommended values for post-application dermal exposure assessment.

Algorithm Notation	Exposure Factor (Units)		Recommended Input Values: Distribution Type	Distribution Parameter	Point Estimates
SR	Residue Concentration (mg a.i. /cm^2)		Point Estimate	NA	Label
WF	Percent A.I. by Weight (% w/w)		Point Estimate	NA	Label
MD	Material weight:surface area ratio (mg/cm^2)	Textile: Cotton	Point Estimate	NA	20
		Textile: Light Cotton/Synthetic Mix			10
		Textile: Heavy Cotton/Synthetic Mix			24
		Textile: All Synthetics			1
		Household Carpets			120
		Plastic Polymers			100
		Vinyl Flooring			40
F	Fraction of body exposed	Pants, Jacket, or Shirts	Point Estimate	N/A	0.50
		Total Body Coverage			1.0
		Mattresses, Carpets, or Flooring			0.50
		Handlers			0.11
TE	Daily Material-to-skin Transfer Efficiency (fraction/day)	Textiles or Carpeting	Point Estimate	N/A	0.05
		Flooring or Hard Surfaces			0.14
PF	Protection Factor	Protective layer present (Mattresses)	Point Estimate	N/A	0.50
		Protective layer not present			1.0
SA	Surface area of entire body (cm^2)	Adult	Empirical	Mean = 18,200 95th = 21,900	
		Toddler	Empirical	Mean = 7,600 95th = 9,500	
		Infant	Empirical	Mean = 5,300 95th = 6,300	
BW	Bodyweight (kg)	Adult	Empirical	Mean = 71.8 95th = 97.9	
		Toddler	Empirical	Mean = 18.6 95th = 26.2	
		Infants	Empirical	Mean = 11 95th = 14	

Surface Residue Concentration (SR)

Surface residue concentration is the concentration of pesticide residue on the surface of an impregnated material. Product-specific information, such as weight fraction of a.i., should be used to estimate the residue concentration. This information may be found on labels or other information provided by the registrant/manufacturer. After obtaining this information, the surface residue concentration can be estimated using the methods described in *Section 9.2.2*.

Fraction of Body Exposed (F)

Fraction of body that contacts residue should be representative of the parts of the body that are expected to frequently contact the impregnated material. *Table 9-3* provides the recommended inputs for assessing exposures from impregnated textiles, including jackets/shirts, total body coverage, and garment workers who may handle large volumes of clothing during their workday, and exposures from impregnated carpets, flooring, and hard surfaces. The recommended values are based on the surface area of different parts of the body and judgment about the fraction of the body that could potentially be exposed to different garments and surfaces. An impregnated shirt or pants, for example, contacts roughly half of the body. Similarly, it is assumed that no more than half of the body contacts a mattress, carpet, or flooring. This assumption recognizes that the entire surface of the body has the potential to contact an impregnated surface. It is believed to be a reasonable assumption because it is unlikely that more half the body can contact a surface at a given time (e.g. roughly half of the body is in contact with a mattress when sleeping).

Table 9-3: Recommended input values for fraction of body surface area that contacts residue.

Exposure Scenario (s)	Representative Body Part	Fraction of Body
Pants, Jacket, or Shirts	50 percent of total body	0.50
Mattresses, Carpets, or Flooring	50 percent of total body	0.50
Total Body Coverage	Complete upper and lower torso	1.0
Handlers	Hands and Forearms [a]	0.11

[a] Derived from U.S. EPA (2008).

Daily Material-to-Skin Transfer Efficiency (TE)

Daily material-to-skin transfer efficiency is the percent of pesticide residue that is transferred from an impregnated material to an individual's skin during a one-day period. There is currently only limited data available to characterize the daily material-to-skin pesticide transfer efficiency for impregnated materials. In the absence of application-specific data, the rate of material-to-skin transfer can be determined using a worst-case screening where it is assumed that all of the a.i. that is available on the surface of an impregnated material is transferred to the skin. For refinement a lower fraction of residue is assume transferred, based on data on the fraction of a.i. that is available for transfer after carpet or hard surface pesticide treatment. For this refinement, manufacturers should submit confirmatory data that supports the use of a transfer efficiency value.

Based on this approach, daily material-to-skin transfer efficiency values have been estimated using more recent data on the fraction of a.i. that is available for transfer from carpets and hard surfaces, which is described in the indoor exposure assessment SOPs provided in *Section 7.2.2* of the *Indoor Environments Section*. Based on the data, the recommended values for textiles/

carpets and hard surfaces are **[XX]** and **[XX]** per day, respectively, which are summarized below.

Table 9-4: Recommended daily material-to-skin transfer efficiency values for textiles and hard surfaces.	
Material	**Daily Material-to-Skin Transfer Efficiency**
Textiles or Carpeting	[XX]/day
Flooring or Hard Surfaces	[XX]/day

While this approach has its limitations, it is expected to overestimate dermal exposure to impregnated materials. This is because the default material-to-skin transfer efficiency rates are based on data from carpets and hard surfaces that have had a pesticide applied to their external surface only. A lower fraction of pesticide is expected to be available for transfer because the pesticide compound is impregnated to the material and believed to have a lower potential for transfer. Additionally, the limited data that are available suggest that the material-to-skin transfer rate may more typically be an order of magnitude lower than the recommended values. Examples of the data that are available to characterize material-to-skin transfer efficiency from impregnated materials are described in more detail below.

- **Permethrin-Treated Clothing:** Snodgrass (1992) characterized the material-to-skin transfer rate for permethrin-treated battle-dress uniforms (BDUs). In this study, which was subsequently incorporated into the National Research Council's assessment of permethrin-impregnated BDUs (National Research Council, 1994), radiolabeled (^{14}C) permethrin-treated fabric patches were applied to the backs of 22 male New Zealand white rabbits in four treatment groups based on environment (temperate vs. subtropical) and fabric type (cotton vs. 50:50 nylon/cotton blend). After seven days, the average percent migration to skin for each treatment group was estimated using the recovery of ^{14}C from excreta and skin. Based on this approach, the overall fraction of a.i transferred per day was 0.005 and ranged from an average ± standard deviation of 0.004 ± 0.09 fraction a.i. transferred per day in the subtropical/NYCO group to 0.0065 ± 0.10 fraction of a.i. transferred per day in the subtropical/cotton treatment group.

- **TBTM-Treated Carpets:** In a leaching study (MRID 45746802), tri-n-butyltin maleate (TBTM)-treated carpets swatches were immersed in alkaline and acidic simulated sweat solutions to determine the maximum amount of TBTM that may leach from treated carpets in 2-hour and 24-hour periods. In the study, the highest percent leaching was observed in saline and alkaline (pH 9.2) simulated sweat solutions and the overall average leaching during the 24-hour period (9.0%) was approximately 1.8 times greater than the overall average leaching during the 2-hour period (5.1%). However, the continuous 24-hour immersion method used in the study is likely to overestimate exposure from dermal contact with an impregnated material, since it represents the amount of residue that leaches from a material when placed in solution (Evans, 2005).

Table 9-5: Summary statistics for 24-hour material-to-skin transfer rates for Impregnated Clothing (Snodgrass, 1992) and Mattresses/Bedding (MRID 45256001).								
Source	Treatment Group	n	24-hour material-to-skin transfer efficiency (fraction/day)					
			Mean ± SD	Percentile				Range
				50th	75th	90th	95th	
Permethrin BDUs (Snodgrass, 1992)	All Groups	18	0.005± 0.006	0.005	0.006	0.007	0.008	0.003 – 0.008
TBTM Carpets (MRID 45746802)	2-Hour	12	0.05± 0.02	0.05	0.07	0.07	0.08	0.02 – 0.10
	24-Hour	12	0.09 ± 0.04	0.09	0.11	0.14	0.15	0.05 – 0.15

When compared to the limited available transfer data, the recommended generic inputs result in conservative estimates of exposure. The range of 24-hour transfer efficiency values from Snodgrass (1992), for example, ranged from 0.003 – 0.008 fraction a.i. transferred per day and are around an order of magnitude lower than values recommended in *Table 9-4*.[14] Therefore, in the absence of chemical-specific data, it is believed that the recommended approach provides a conservative estimate of transfer efficiency.[15]

Protection Factor (PF)

Bed sheets and other fabrics can act as a protective barrier when placed between an impregnated surface and an exposed individual's skin. The protection factor, therefore, accounts for a decrease in pesticide residue transfer that is expected when bed sheets or other protective barriers are present. In these cases, the recommended input value is 0.50- meaning that it is assumed that only 50% of the available pesticide residue is transferred from the material to the potentially exposed individual's skin. This default value is based on the PHED protection factor for a single layer of clothing and is also used by OPP/AD when conducting biocide exposure assessments involving mattresses. In cases other than mattresses, it should generally be assumed that no protective barrier is present. When no protective barrier is present, the recommended input value is 1.0.

Future Research/Data Needs

There is currently only limited data available to characterize the daily material-to-skin pesticide transfer efficiency for impregnated materials. While recommended methods are believed to provide conservative estimates of exposure, additional research is needed to more fully characterize the dermal transfer of pesticide residue from impregnated materials. In addition, survey data on the use patterns of impregnated materials could also help further characterize exposure. Specific survey information could help characterize general use patterns to further refine exposure estimates.

[14] The study on TBTM-treated carpets found an average 24-hour leaching rate of 9.0%. As previously indicated, however, the study was an extraction study which is likely to overestimate exposure from dermal contact (DP Barcode: 314711).

[15] While it is emphasized that the available data are not sufficient to derive a generic transfer fraction for all possible chemicals, it is also acknowledged that it may be appropriate to derive transfer efficiency values from the summarized data sources when assessing materials impregnated with permethrin.

Exposure Characterization and Data Quality

Due to insufficient exposure data on impregnated materials, the exposure assessment scenarios presented in this chapter are based on data on externally treated surfaces that may not be completely representative of impregnated materials. As a consequence, the methods rely on conservative assumptions that cannot be completely characterized quantitatively. These assumptions include: 1) laundering and dissipation are not accounted for in the algorithm, so it is assumed that individuals are always exposed to the maximum surface residue concentration; and 2) daily material-to-skin transfer efficiency was characterized using data on residue transfer from treated surfaces, rather than impregnated materials.

9.2.4 Post-Application Non-Dietary Ingestion Exposure Assessment: Object-to-Mouth (Textiles Only)

This SOP provides the methods for assessing non-dietary object-to-mouth ingestion of pesticide residues from impregnated materials by children. In general, object-to-mouth exposure assessments should be used to assess non-dietary exposure to impregnated textiles (e.g. clothing and other impregnated fabrics), but not other impregnated materials, such as carpeting and flooring, which are less likely to be mouthed.

Non-Dietary Object-to-Mouth Ingestion Algorithm

Exposure from object-to-mouth activity is calculated as follows (based on algorithm utilized in SHEDS-Multimedia, http://www.epa.gov/heasd/products/sheds_multimedia/sheds_mm.html):

$$E = OR * CF1 * SAM_O * (ET * N\_Replen) * (1 - (1 - SE_O)^{(Freq\_Replen/N\_Replen)})] \quad (9.4)$$

where:

E	=	exposure (mg/day);
OR	=	chemical residue loading on an object (ug/cm^2);
CF1	=	weight unit conversion factor (0.001 mg/µg);
SAM_O	=	area of the object surface that is mouthed (cm^2/event);
ET	=	exposure time (hr/day);
N_Replen	=	number of replenishment intervals per hour (intervals/hour);
SE	=	saliva extraction factor (ie, mouthing removal efficiency); and
Freq_Replen	=	number of object-to-mouth contact events per hour (events/hour).

and

$$OR = SR * F_O \quad (9.5)$$

where:

OR	=	chemical residue loading on the object (µg/cm^2);
SR	=	surface residue (µg/cm^2);
F_O	=	fraction of residue available on the object (unitless);

Non-dietary oral dose, normalized to body weight, is then calculated as:

$$D = \frac{E * AF}{BW} \qquad (9.6)$$

where:

D = dose rate (mg/kg-day);
AF = oral absorption factor; and
BW = body weight (kg).

Post-application object-to-mouth exposure from impregnated materials is generally considered either acute or short-term in duration. Thus, the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in Sections 1.3.2 and 1.3.4, such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Non-Dietary Object-to-Mouth Exposure Assessment Inputs and Assumptions

Recommended values for non-dietary object-to-mouth ingestion exposure assessments are provided in *Table 9-6*. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 9-6: Summary of recommended values for non-dietary object-to-mouth ingestion exposure assessment.					
Algorithm Notation	**Exposure Factor (units)**		**Distribution**		**Point Estimate(s)**
			Type	**Parameters**	
SR	Residue Concentration ($\mu g/cm^2$)		Point Estimate	NA	Maximum labeled rate
WF	Percent A.I. by Weight (WF) (% w/w)		Point Estimate	NA	
MD	Material weight:surface area ratio (mg/cm^2)	Cotton	Point Estimate	NA	20
		Light Cotton/Synthetic Mix			10
		Heavy Cotton/Synthetic Mix			24
		All Synthetics			1
F_O	Fraction of AR as OR following application	Carpets	Point Estimate	NA	
		Hard surfaces	Point Estimate	NA	
SAM_O	Surface area of object mouthed per event (cm^2/event)		Exponential	Min = 1 Max = 50 AM = 10	
N_Replen	Replenishment intervals per hour (intervals/hour)		Point Estimate	NA	4
SE_O	Saliva extraction factor		Beta	α = 7.0 β = 7.6	
ET	Exposure Time (hours per day)	Indoor Environments (Infants)	Empirical	Mean = 5 95^{th} = 9	
		Outdoor Environments (Toddlers)	Empirical	50^{th} = 2.5 95^{th} = 10.1	
Freq_Replen	Object-to-mouth events per hour (events/ hour)	Indoor Environments (Infants)	Weibull	Scale= 1.4 Shape= 15.5	
		Outdoor Environments (Toddlers)	Weibull	Scale= 0.55 Shape= 5.38	
BW	Body Weight (kg)	Toddlers	Empirical	Mean = 18.6 95^{th} = 26.2	
		Infants	Empirical	Mean = 11.4 95^{th} = 14	

NA = not applicable
Min = minimum
Max = maximum
AM = arithmetic mean

Surface Residue Concentration (SR)

Surface residue concentration is the concentration of pesticide residue on the surface of an impregnated material. Product-specific information, such as weight fraction of a.i., should be used to estimate the residue concentration. This information may be found on labels or other information provided by the manufacturer. After obtaining this information, the surface residue concentration can be estimated using the methods described in *Section 9.2.2*.

Fraction of Residue Available on the Object (F_O)

For this SOP, it is assumed that the residue that could be transferred to the object is the same as what is available for dermal transfer. As a result, the fraction of residue available for transfer assumed for dermal exposure for both carpets and hard surfaces should be used, which is provided in *Section 7.2.2*.

Surface area of object mouthed (SAM_O)

Surface area of object mouthed (SAM_O) is the area of an impregnated object that may contact a child's mouth during mouthing behavior. SAM_O is a universal exposure factor that is described in more detail in *Section 2.5*.

Replenishment interval (N_Replen)

This SOP assumes an estimate of 4 replenishment intervals per hour (i.e., residues on the hand will be replenished every 15 minutes). This value was selected as a conservative assumption based on the use of 30 minutes in the SHEDS model to coincide with the CHAD diaries.

Fraction of Pesticide Extracted by Saliva (SE_O)

See *Section 2.6* of this SOP for discussion of fraction of pesticide extracted by saliva distribution. T**he recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile**.

Exposure Time (ET)

Exposure time is the amount of time that a child is an environment where they may contact a surface containing an impregnated material. There is currently no data available to characterize the amount of time that children spend in indoor and outdoor environments where they may contact impregnated materials. In the absence of scenario-specific data, recommended exposure time value for exposures that may occur in indoor environments is based on the infant exposure time values discussed in *Section 7.2.4* of the Indoor Environment SOPs. Similarly, the recommended exposure time for outdoor environments is based on the toddler exposure time values discussed in *Section 6.2.3* of the Repellent SOPs.

Based on this data, the recommended exposure time values for indoor and outdoor environments ([XX] and [XX], respectively) represent approximately the [XX]th percentile of their respective distributions.

Object-to-Mouth Events (Freq_Replen)

Object-to-mouth event is the number of mouthing events that occur per hour. There is currently no data available that specifically address the number of object-to-mouth events that occur relative to the amount of time a child is in contact with an impregnated material. As a result, the estimate for frequency of object-to-mouth events in outdoor environments is based on the Xue et al. (2007) meta-analysis of object-to-mouth behavior that has previously been summarized in *Section 3.2.4 of the* Laws/Turf SOPs. Similarly, the estimate for frequency of object-to-mouth events in indoor environments is based on the Xue et al. (in press) meta-analysis of object-to-mouth behavior that is summarized in *Section 7.2.4* of the Indoor Environment SOPs.

Based on this data, the recommended exposure time values for outdoor and indoor environments ([XX] and [XX], respectively) represent approximately the [XX]th percentile of their respective distributions.

Future Research/Data Needs

A priority for future research should be developing a database of studies, which characterize pesticide transfer from impregnated materials to skin and objects that could mouthed by toddlers. An important focus should be on charactering the transfer of pesticide residue from impregnated materials following mouthing behavior by young children and toddlers. Collecting this transfer data are important because mouthing behavior and saliva extraction is believed to be the most important drivers of non-dietary ingestion from object-to-mouth exposure.

Exposure Characterization and Data Quality

Due to insufficient exposure data on impregnated materials, the exposure assessment scenarios presented in this chapter are based on data on externally treated surfaces that may not be completely representative of impregnated materials. As a consequence, the methods rely on conservative assumptions that cannot be completely characterized quantitatively. These assumptions include: 1) laundering and dissipation are not accounted for in the algorithm, so it is assumed that individuals are always exposed to the maximum surface residue concentration; and 2) daily material-to-skin transfer efficiency was characterized using data on residue transfer from treated surfaces, rather than impregnated materials.

9.2.5 Post-Application Non-Dietary Ingestion Exposure: Hand-to-Mouth (Carpets, Flooring, and Hard Surfaces Only)

This SOP provides the methods for assessing non-dietary hand-to-mouth ingestion of pesticide residues from impregnated materials by toddlers. In general, hand-to-mouth exposure assessment should be performed when assessing impregnated carpets, flooring, and hard surfaces, since infants may routinely contact these objects with their hands.

Non-Dietary Hand-to-Mouth Ingestion Exposure Algorithm

Exposure from hand-to-mouth activity is calculated as follows (based on algorithm utilized in SHEDS-Multimedia, http://www.epa.gov/heasd/products/sheds_multimedia/sheds_mm.html):

$$E = [HR * (F_M * SA_H) * (ET * N\_Replen) * (1 - (1 - SE)^{(Freq\_Replen/N\text{-}Replen)})] \qquad (9.7)$$

where:

E = exposure (mg/day);

HR	= hand residue loading (mg/cm^2);
F_M	= fraction hand surface area mouthed / event (fraction/event);
ET	= exposure time (hr/day);
SA_H	= surface area of one hand (cm^2);
N_Replen	= number of replenishment intervals per hour (intervals/hour);
SE	= saliva extraction factor (ie, mouthing removal efficiency); and
Freq_Replen	= number of hand-to-mouth contacts events per hour (events/hour).

In this algorithm, hand residue concentration is calculated as:

$$HR = SR * F_H \tag{9.8}$$

where:

HR	= hand residue concentration (mg/cm^2);
SR	= surface residue ($\mu g/cm^2$); and
F_H	= fraction ai transferred to hands.

After calculating exposure, oral dose, normalized to body weight, is calculated as:

$$D = \frac{E}{BW} \tag{9.9}$$

where:

D	= dose (mg/kg-day);
E	= exposure (mg/day); and
BW	= body weight (kg).

Post-application hand-to-mouth exposure from impregnated materials is generally considered either acute or short-term in duration. Thus, the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in Sections 1.3.2 and 1.3.4, such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, such as in cases where the impregnated material may be routinely replaced or re-treated, similar refinements to more accurately reflect the exposure profile are recommended.

Non-Dietary Hand-to-Mouth Exposure Assessment Inputs and Assumptions

Recommended values for non-dietary hand-to-mouth ingestion exposure assessments are provided in *Table 9-7*. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 9-7: Summary of recommended values for non-dietary hand-to-mouth ingestion exposure assessment.

Algorithm Notation	Exposure Factor (units)			Distribution Type	Distribution Parameters	Point Estimate(s)
SR	Surface Residue Concentration (mg a.i. /cm^2)			Point Estimate	NA	Product-Specific Label
WF	Percent A.I. by Weight (WF) (% w/w)			Point Estimate	NA	
MD	Material weight:surface area ratio (mg/cm^2)	Cotton		Point Estimate	NA	20
		Light Cotton/ Synthetic Mix				10
		Heavy Cotton/ Synthetic Mix				24
		All Synthetics				1
F_H	Fraction ai transferred to hands	Carpets		Point Estimate	NA	
		Hard Surfaces		Point Estimate	NA	
F_M	Fraction of hand mouthed per event (fraction/event)			Beta	α = 3.75 β = 25	
SA_H	Typical surface area of one toddler hand (cm^2)			Point Estimate	NA	225
N_Replen	Replenishment intervals (intervals/hr)			Point Estimate	NA	4
ET	Exposure Time (hours per day)	Toddlers	Carpets	Empirical	Mean = 5 95^{th} = 9	
			Hard Surfaces	Empirical	Mean = 1 95^{th} = 4	
		Infants	Carpets	Empirical	Mean = 4 95^{th} = 8	
			Hard Surfaces	Empirical	Mean = 1 95^{th} = 4	
SE	Saliva extraction factor (fraction)			Beta	α = 7.0 β = 7.6	
Freq_Replen	Hand-to-mouth events per hour (events/hour)	Toddlers		Weibull	Scale = 0.73 Shape = 11.96	
		Infants		Weibull	Scale = 0.91 Shape = 18.79	
BW	Body Weight (kg)	Toddler		Empirical	Mean = 18.6 95^{th} = 26.2	
		Infants		Empirical	Mean = 11.4 95^{th} = 14.0	

NA = not applicable
AM = arithmetic mean
S-/I-T = short- and intermediate-term exposure

Surface Residue Concentration (SR)

Surface residue concentration is the concentration of pesticide residue on the surface of an impregnated material. Product-specific information, such as weight fraction of a.i., should be used to estimate the residue concentration. This information may be found on labels or other information provided by the manufacturer. After obtaining this information, the surface residue concentration can be estimated using the methods described in *Section 9.2.2*.

Fraction ai transferred to hands (F_H)

For this SOP, it is assumed that the residue that could be transferred to the object is the same as what is available for dermal transfer. As a result, the fraction of residue available for transfer assumed for dermal exposure for both carpets and hard surfaces should be used, which are provided in *Section 7.2.2* of the *Indoor Environments Section*.

Fraction of Hand Mouthed per Event (F_M)

See *Section 2.4* of this SOP for discussion of the fraction of hand mouthed. **The recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile**.

Hand Surface Area (SA_H)

The hand surface area for toddlers (3 to <6 year olds) of 225 cm^2, for one hand, was based on values from the Child-specific Exposure Factors Handbook (U.S. EPA, 2008).

Replenishment Intervals (N_Replen)

This SOP assumes an estimate of 4 replenishment intervals per hour (i.e., residues on the hand will be replenished every 15 minutes). This value was selected as a conservative assumption based on the use of 30 minutes in the SHEDS model to coincide with the CHAD diaries.

Exposure Time (ET)

Exposure time is the amount of time that a child is an environment where they may contact a surface containing an impregnated material. There is currently no data available to characterize the amount of time that children spend in environments where they may contact impregnated materials. In the absence of scenario-specific data, recommended exposure time values are based on *Section 7.2.4* of the Indoor Environment SOPs, which provides a summary of data from the Child-Specific Exposure Factors Handbook.

Based on this data, the recommended exposure time values for toddlers on carpets and hard surfaces ([XX] and [XX], respectively) represent approximately the [XX]th percentile of their respective distributions. Similarly, the recommended exposure time values for infants on carpets and hard surfaces ([XX] and [XX], respectively) represent approximately the [XX]th percentile of their respective distributions.

Fraction of Pesticide Extracted by Saliva (SE_H)

See *Section 2.6* of this SOP for discussion of the fraction of pesticide extracted by saliva distribution. **The recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile**.

Hand-to-mouth events (Freq_Replen)

Frequency of hand-to-mouth events refers to the number of hand-to-mouth events per hour. There is currently no data available to characterize the children's hand-to-mouth behavior that is associated with impregnated materials. In the absence of scenario-specific data, recommended frequency of hand-to-mouth events is based on *Section 7.2.4* of the Indoor Environment SOPs. The estimates for frequency of hand-to-mouth events in indoor environments from the Xue et al. (2007) meta-analysis were used as a surrogate.

Based on this data, the recommended point estimate for use in post-application non-dietary exposure assessments of toddlers and infants ([XX] and [XX]) represents approximately the [XX]th percentile.

Future Research/Data Needs

A priority for future research should be developing a database of studies, which characterizes pesticide transfer from impregnated materials to skin and objects that could mouthed by toddlers. An important focus should be on charactering the transfer of pesticide residue from impregnated materials to the hands, particularly for young children and toddlers. Collecting this transfer data is important because characterizing residue transfer from impregnated materials is believed to be the most important driver of non-dietary ingestion from hand-to-mouth activity.

Exposure Characterization and Data Quality

Due to insufficient exposure data on impregnated materials, the exposure assessment scenarios presented in this chapter are based on data on externally treated surfaces that may not be completely representative of impregnated materials. As a consequence, the methods rely on conservative assumptions that cannot be completely characterized quantitatively. These assumptions include: 1) laundering and dissipation are not accounted for in the algorithm, so it is assumed that individuals are always exposed to the maximum surface residue concentration; and 2) daily material-to-skin transfer efficiency was characterized using data on residue transfer from treated surfaces, rather than impregnated materials.

9.2.6 Combining Post-application Scenarios

Risks resulting from different exposure scenarios are combined when it is likely that they can occur simultaneously based on the use pattern and when the toxicological effects across different routes of exposure are the same. When combining scenarios, it is important to fully characterize the potential for co-occurrence as well as characterizing the risk inputs and estimates. Risks should be combined even if any one scenario or route of exposure exceeds the level of concern because this allows for better risk characterization for risk managers.

For impregnated materials, there is potential for exposure from both dermal and non-dietary ingestion exposure assessment pathways. When assessing impregnated textiles, including impregnated clothing and other textiles, aggregate exposure assessments should only combine dermal and non-dietary object-to-mouth ingestion exposure pathways. Similarly, when assessing impregnated surfaces, including carpets and flooring, aggregate exposure assessments should only combine dermal and non-dietary hand-to-mouth ingestion exposure pathways.

Section 10 Treated Paints & Preservatives

This chapter provides the standard operating procedures (SOPs) for assessing pesticide exposures from pesticide-treated paints and wood preservatives. The sources of pesticide exposure that are addressed in this chapter include pesticide-treated paints and wood preservatives and materials containing pesticide-treated paints and preservatives. Exposure assessment scenarios that are addressed in this chapter include residential handler exposure during mixing and application activities, post-application dermal and non-dietary incidental ingestion exposure, and potential inhalation of volatile pesticide compounds.[16]

Before the development of an exposure assessment of a paint/preservative, the appropriate exposure scenarios should be identified using information on the product's pesticide label. Specific label information that should be considered is described below.

- **Paints/Preservatives with Pesticide Claims:** Paints/preservatives may be treated with conventional pesticides and contain a pesticide label that makes claims, such as "kills mildew," "prevents wood rot," or "kills algae." These labels contain information on the active ingredient and should be used when performing exposure assessments using the methods described in this chapter.

- **Paints/Preservatives without Pesticide Claims:** Many paints/preservatives do not have a pesticide label on their container and their labels do not make claims about pest control. The pesticide in these paints/preservatives is present as a biocide, which is added during the manufacturing process. Biocides are more routinely assessed by OPP's Antimicrobial Division (OPP/AD) and are not addressed in this chapter.

- **Limiting and Descriptive Statements:** A label may include language that restricts the use of a paint/preservative to non-residential settings only. In these cases, a residential exposure assessment does not need to be performed, since no residential use is expected. However, if a label does not indicate that the product is only intended for commercial applications, it should be assumed the product could be used in a residential setting. In addition, labels may also indicate that a product cannot be purchased or applied by a residential home owner. In these cases, residential handler exposure assessments do not need to be performed, since the paint/preservative can only be handled by a commercial applicator.

10.1 Residential Handler Exposure Assessment

[16] In the past, exposure assessment procedures have been provided for ingestion of paint chips. There procedures are no longer provided, since it is believed that children would have to ingest an unreasonably high quantity of paint chips to have an exposure that represents an unacceptable risk.

This SOP provides the standard methods for assessing dermal and inhalation exposures that can result from mixing and applying treated paints and preservatives by residential handlers. There are currently limited exposure data on treated paint and preservative activities, so it is assumed that they are similar to other handler activities as described below:

- Aerosol spray cans handler activities are represented by pesticide aerosol data;
- Paints brush handler activities are represented by paint brush data;
- Roller painting handler activities are represented by paint roller data;
- Painting/staining with a low pressure sprayer handler activities are represented by mixer/loader/applicator low pressure sprayer data; and
- Painting/staining with an airless sprayer handler activities are represented by mixer/loader/applicator low pressure airless sprayer data.

When assessing risks associated with dermal exposure, the methods described in the remainder of this section are recommended. Since this approach relies on surrogate data, it is recommended that it should only be used in the absence of, or as a supplement to adequate existing chemical-specific data.

Dermal and Inhalation Handler Exposure Algorithm

Residue concentration is most commonly reported as percent a.i. in terms of total paint/preservative mass (e.g. Weight fraction of a.i. in treated paint/preservative). In these cases, residue concentration can be estimated and subsequently used to determine the potential daily dose rate, as shown below.

$$AR = V * \rho * WF * CF1 \qquad (10.1)$$

where:

AR = Mass of active ingredient applied per paint can (lbs a.i./can);
V = Volume of paint contained in each can (mL/can);
ρ = Paint density (g/mL);
WF = Weight fraction of a.i. in treated paint/preservative (% a.i. w/w); and
CF1 = Gram-to-pound conversion factor ($2.2*10^{-3}$ lbs/g).

$$E = \frac{UE * AR * N}{BW} \qquad (10.2)$$

where:

E = Daily exposure rate (mg/kg-day);
UE = unit exposure (mg/lb a.i. applied);
AR = Mass of active ingredient applied per paint can (lbs a.i./can); and
N = number of cans paint used per exposure day (cans/day).

After calculating exposure, dose, normalized to body weight, is calculated as:

$$D = \frac{E * AF}{BW} \tag{10.3}$$

where:

D = Dose (mg/kg-day);
E = Exposure (mg/day);
AF = absorption factor (dermal and/or inhalation); and
BW = Body weight (kg).

Handler exposure for paint or wood preservative applications is generally considered either acute or short-term in duration. Thus the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.3* such as the product-specific application regimen. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, similar refinements to more accurately reflect the exposure profile are recommended.

Dermal and Inhalation Handler Exposure Algorithm Inputs and Assumptions

Recommended values for handler exposure (inhalation and dermal) assessments are provided in *Table 10-1* and *Table 10-2*. Following these tables, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 10-1: Paints and Stains – Recommended Unit Exposure (mg/lb ai) Distributions and Point Estimates								
Formulation	Equipment/ Application Method	Dermal			Inhalation			Appendix Page Reference
		Distribution		Point Estimate	Distribution		Point Estimate	
		Type	Parameters		Type	Parameters		
Ready-to-Use (RTU)	Aerosol can	Lognormal	GM = 329 GSD = 1.60		Lognormal	GM = 2.34 GSD = 2.01		B-130
Paints and Stains	Airless Sprayer	Lognormal	GM = 88 GSD = 3.01		Lognormal	GM = 0.38 GSD = 2.40		B-42
	Brush	Lognormal	GM = 390 GSD = 1.74		Lognormal	GM = 0.19 GSD = 1.34		B-48
	Roller	No exposure data available for this application scenario. Exposure data for brush applications of paints/stains recommended as surrogate data.						

Table 10-2: Paints and Stains – Recommended Handler Exposure Factors Distributions and Point Estimates				
Exposure Factor (units)		Distribution		Point Estimate(s)
		Type	Parameters	
Application Rate mass ai per unit area		Point	NA	Maximum labeled rate
Amount of active ingredient (AR) (lbs a.i./can)		Point	NA	Maximum labeled rate
Number of cans applied per day (N)	Aerosol Spray Cans	Point	NA	3 twelve-ounce cans
	Paints with Brush	Point	NA	2 one-gallon cans
	Roller Painting	Point	NA	2 one-gallon cans
	Low pressure sprayer	Point	NA	3 one-gallon cans
	Airless sprayer	Point	NA	5 one-gallon cans
Body Weight (BW) (kg)	Adult	Empirical	Mean = 71.8 95^{th} = 97.9	

Unit Exposure (UE)

Unit exposure values for paints/preservatives are summarized in *Appendix B*. As indicated, there are some exposure data on painting with a brush or roller, but limited exposure data on paint/preservative exposure scenarios involving aerosols, low pressure sprayers, and airless sprayers. In these cases, data for conventional pesticide application activities are assumed to be reasonable surrogates of exposure.

Amount of Active Ingredient (AR)

The amount of a.i. applied per paint/preservative container should be determined using label information on the maximum concentration of a.i. that is mixed with a paint/preservative. In some cases, this information may not be directly reported on the label. When this information is not directly available, however, data on the volume of paint per container, specific gravity of paint/preservative solution, and weight fraction of a.i. in paint/preservative can be used to estimate the amount of active ingredient applied per container

Number of Paint Cans (N)

The number of paint cans is the amount of paint that is handled during a residential application. The recommended input values for each handler exposure scenario are based on data presented in U.S. EPA's Exposure Factors Handbook (1996) and summarized in *Table 10-3*.

Table 10-3: Recommended number of gallon input values for paint and wood preservative exposure scenarios.

Exposure Scenario	Paint Cans Number	Justification
Aerosol Spray Cans	3 twelve-ounce cans	Upper-percentile assumption for the amount handled is 3 cans (12 ounces each) used per event (the 90th percentile amount of spray paint used per event is 36.11 oz/use, U.S. EPA, 1996).
Paints with Brush	2 one-gallon cans	90th percentile value of 8 gallons of latex paint used per year divided by the mean frequency of 4 painting events per year (U.S. EPA, 1996).
Roller Painting	2 one-gallon cans	90th percentile value of 8 gallons of latex paint used per year divided by the mean frequency of 4 painting events per year (U.S. EPA, 1996).
Low pressure sprayer painting/staining	3 one-gallon cans	Professional judgment assuming that more products would be used with a low pressure sprayer than with a roller or brush, but less than that used with a high pressure sprayer.
Airless sprayer painting/staining	5 one-gallon cans	A homeowner is assumed to use three 5-gallon cans of ready-to-use product or of finished spray prepared from a concentrated product and water. This is based on a coverage rate of 200 ft^2/gallon and a house size with a surface area of 2,800 ft^2.

Source: U.S. EPA Exposure Factors Handbook (1997).

Future Research/Data Needs

The handler exposure assessment methods are based on generic assumptions about the amount of treated paint/preservative that is handled by residential homeowners. The approach used is believed to provide conservative estimates of exposure because the amount of paint/preservative handled is based on information on the use of non-treated painted that is more commonly used. Therefore, more refined information on how treated paints/preservatives are used by residential home owners could help improve the handler exposure assessment methods. Specific information that could refine the exposure assessment methods includes:

- General use information on treated paints
- Frequency of treated paint/preservative applications
- Location of treated paint/preservatives in residential environments
- Typical surface of area of treated areas

Exposure Characterization and Data Quality

Unit Exposures

- Despite not being representative and lacking true statistical sampling methodologies, the exposure data underlying unit exposures are considered reasonable for the purposes of establishing distributions and estimating exposure. The data are from actual applications using standardized exposure sampling methodologies and laboratory analyses.
- The underlying assumption of the use of exposure data as unit exposures – proportionality between the amount of active ingredient handled and exposure – is uncertain, though potentially conservative. However, as a prediction mechanism, it is considered practical and useful for the purposes of handler exposure assessment in a regulatory context. It provides a straightforward handler exposure calculation method and enables risk mitigation in the form of formulation comparison and decreased application rates.
- The extent to which an individual's exposure (expressed via unit exposures) varies day-to-day or application-to-application is unknown; therefore, the assumption that there is no variation when assessing longer-term exposure durations is considered conservative.

Amount of active ingredient handled

- Information on the amount of product/formulation (thus, active ingredient) handled per application is lacking, making the estimates highly uncertain. The recommended point estimates are therefore intended to be high-end to ensure an appropriately conservative exposure estimate.
- The extent to which the amount an individual will handle per application varies from day-to-day or application-to-application is unknown; therefore, the assumption that there is no variation when assessing longer-term exposure durations is considered conservative.

10.2 Post-Application Exposure Assessment

Post-application exposure can result from contacting surfaces that have been painted with treated paint or wood preservative. Potential exposed populations include both adults and children. While exposure may occur for people of all ages, adults, toddlers, and infants are considered potential sentinel populations based on behavioral characteristics and the strengths and limitations of available data. Additionally, when assessing exposures that are more likely to occur in outdoor environments, it is recommended that toddlers be used as the sentinel population because they are more likely to spend time outdoors than infants. When assessing exposures that are more likely to occur in indoor environments, it is recommended that infants be used as the sentinel population.

This section addresses standard methods for estimating exposure and dose for three individual post-application scenarios resulting from exposure to pesticide-containing paints, stains, or wood preservatives:

- Section 10.2.1 - adult/toddler/infant dermal exposures;
- Section 10.2.2 – toddler/infant non-dietary ingestion via hand-to-mouth activity; and
- Section 10.2.3 - adult/toddler inhalation exposures.

10.2.1 Post-Application Dermal Exposure Assessment

This SOP provides the standard methods for assessing dermal exposure scenarios following the application of pesticide-treated paint or wood preservatives on indoor and outdoor surfaces, such as home walls, outdoor decks, and play-sets. The exposure assessment methods presented in this section are based primarily on the approach developed for an exposure assessment of children who contact chromated copper arsenate treated playsets using the EPA/ORD Stochastic Human Exposure and Dose Simulation Model for the Wood Preservative Scenario (SHEDS-WOOD) (U.S. EPA, 2005).

Post-Application Dermal Exposure Algorithm

The algorithm to calculate post-application dermal exposure is calculated as follows:

$$E = SR * SA * F_{body} * TE \tag{10.4}$$

where:

E = Daily Exposure (mg/kg-day);
SR = Surface residue concentration (mg/cm^2) ;
SA = Surface area of entire body (cm^2);
F_{body} = Fraction of total body skin surface area that is unclothed (unitless);
TE = Daily residue transfer efficiency from treated surface to skin (fraction/day); and
BW = Bodyweight (kg).

Dermal dose, normalized to body weight, is then calculated as:

$$D = \frac{E * AF}{BW} \tag{10.5}$$

where:

D = Dose rate (mg/kg-day);
AF = Dermal absorption factor; and
BW = Body weight (kg).

Post-application dermal exposure from paints or wood preservatives containing pesticides is generally considered either acute or short-term in duration. Thus, the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in Sections 1.3.2 and 1.3.4, such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, such as in cases where the impregnated material may be routinely replaced or re-treated, similar refinements to more accurately reflect the exposure profile are recommended.

Post-Application Dermal Exposure Assessment Assumptions and Recommendations

A summary table of the recommended values for post-application dermal exposure assessment of paints/preservatives is provided in *Table 10-4.* Following this summary table, each scenario-specific input parameter, excluding the universal body surface area and bodyweight inputs, is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 10-4: Summary of recommended values for post-application dermal absorption.

Algorithm Notation	Exposure Factor (Units)		Recommended Input Values		
			Distribution		Point Estimates
			Type	Parameter	
SR	Surface Residue Concentration (mg a.i. /cm^2)		Point Estimate	NA	Maximum Labeled Rate
WF	Percent A.I. by Weight (% w/w)		Point Estimate	NA	Label
F_{body}	Fraction of body that contacts residue		Point Estimate	NA	0.31
TE	Material-to-skin transfer efficiency (fraction/day)		Lognormal	GM= 0.143 GSD= 2.33	
SA	Surface area of entire body (cm^2)	Adult	Empirical	Mean = 18,200 95th = 9,500	
		Toddler	Empirical	Mean = 21,900 95th = 9,500	
		Infants	Empirical	Mean = 5,300 95th = 6,300	
BW	Bodyweight (kg)	Adult	Empirical	Mean = 71.8 95th = 97.9	
		Toddler	Empirical	Mean = 18.6 95th = 26.2	
		Infants	Empirical	Mean = 11.4 95th = 14.0	

Surface Residue Concentration (SR)
Surface residue concentration is the concentration of pesticide residue on the surface of a painted/treated surface. Whenever possible, product-specific information should be used to estimate the surface residue concentration. This information may be found on labels or other information provided by the manufacturer.

Material-to-Skin Transfer Efficiency (TE)
Surface-to-skin transfer efficiency is the fraction of pesticide residue that is transferred from a painted/treated surface to the skin. Whenever possible, product -specific information should be used to estimate the surface-to-skin transfer efficiency. In the absence of product-specific information, the recommended transfer efficiency is based on warm weather data on the transfer of arsenic from chromated copper arsenate treated wood (American Chemistry Council, 2003). This data was incorporated into the SHEDS-CCA assessment and used to obtain a lognormal distribution with a geometric mean and geometric standard deviation of 0.143 and 2.33, respectively. **Based on this data, the recommended transfer value is [XX], which represented the [XX]th percentile.**

Fraction of Total Body Exposed (F_{body})
This term refers to the fraction of the body that is unclothed. The recommended default value for this input was derived using the U.S. EPA's Child-Specific Exposure Factors Handbook (2008), which is described in more detail in *Table 6-8*. The recommended input value of 0.31 represents the fraction of surface area of the torso and arms, lower thighs, shins, feet, hands, and neck. This value is believed to be representative of the fraction of the body that may be exposed in warm weather.

Future Research/Data Needs
While data are available on the transfer of arsenic from chromated copper arsenate treated wood, there is limited data on transfer of other pesticide additives. Therefore, additional research/ data may be needed on the transfer of non-preservative pesticide additives. Additionally, more detailed information on how treated paints/preservatives are used by residential home owners could help improve the exposure assessment methods. Specific information that could help refine the exposure assessment methods includes:

- General use information on treated paints
- Frequency of treated paint/preservative applications
- Location of treated paint/preservatives in residential environments
- Typical surface of area of treated areas

Exposure Characterization and Data Quality
Many of the methods presented in this section are based on the approach used to assess chromated copper arsenate treated playsets. Therefore, an important limitation of the exposure assessment methods presented is that they are based on a single chemical that is used a wood preservative, rather than conventional pesticide (e.g. insecticide, herbicide, fungicide, etc.).

10.2.2 Post-Application Non-Dietary Ingestion Exposure Assessment: Hand-to-Mouth

This SOP provides the dose estimation methods for assessing incidental ingestion from hand-to-mouth behavior following contact with treated paint/preservative surfaces.

Non-Dietary Hand-to-Mouth Ingestion Exposure Algorithm

Exposure from hand-to-mouth activity is calculated as follows (based on algorithm utilized in SHEDS-Multimedia, http://www.epa.gov/heasd/products/sheds_multimedia/sheds_mm.html):

$$E = [HR * (F_M * SA_H) * (ET * N\_Replen) * (1- (1- SE)^{(Freq\_Replen/N\text{-}Replen)})] \qquad (10.6)$$

where:

E	= exposure (mg/day);
HR	= hand residue loading (mg/cm^2);
F_M	= fraction hand surface area mouthed / event (fraction/event);
ET	= exposure time (hr/day);
SA_H	= surface area of one hand (cm^2);
N_Replen	= number of replenishment intervals per hour (intervals/hour);
SE	= saliva extraction factor (ie, mouthing removal efficiency); and
Freq_Replen	= number of hand-to-mouth contacts events per hour (events/hour).

In this algorithm, hand residue concentration is calculated as:

$$HR = SR * TE \qquad (10.7)$$

where:

HR	= hand residue concentration (mg/cm^2);
SR	= surface residue (µg/cm^2); and
TE	= transfer Efficiency.

After calculating exposure, oral dose, normalized to body weight, is calculated as:

$$D = \frac{E}{BW} \qquad (10.8)$$

where:

D	= dose (mg/kg-day)
E	= exposure (mg/day)
BW	= body weight (kg)

Post-application hand-to-mouth exposure from paints or wood preservatives containing pesticides is generally considered either acute or short-term in duration. Thus, the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4*, such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, such as in cases where the impregnated material may be routinely replaced or re-treated, similar refinements to more accurately reflect the exposure profile are recommended.

Non-dietary Hand-to-Mouth Ingestion Exposure Assessment Assumptions and Recommendations

Recommended values for non-dietary hand-to-mouth ingestion exposure assessments are provided in *Table 10-5*. Following this table, each scenario-specific input parameter is described in more detail. This description includes a summary of i) key assumptions; ii) data sources used to derive recommended input values; and iii) discussion of limitations that should be addressed when characterizing exposure.

Table 10-5: Summary of recommended values for post-application hand-to-mouth incidental ingestion.

Algorithm Notation	Exposure Factor (units)		Distribution		Point Estimate(s)
			Type	Parameters	
SR	Surface Residue Concentration (mg a.i. /cm^2)		Point Estimate	NA	Maximum Labeled Rate
TE	Material-to-skin transfer efficiency		Lognormal	GM= 0.143 GSD= 2.33	
F_M	Fraction of hand mouthed per event (fraction/event)		Beta	α = 3.75 β = 25	
SA_H	Typical surface area of one toddler hand (cm^2)		Point Estimate	NA	225
N_Replen	Replenishment intervals (intervals/hr)		Point Estimate	NA	4
ET	Exposure Time (hours per day)	Outdoor Environments (Toddlers)	Empirical	Mean = 5 95th = 9	
		Indoor Environments (Infants)	Empirical	Mean = 1 95th = 4	
SE	Saliva extraction factor (fraction)		Beta	α = 7.0 β = 7.6	
Freq_Replen	Hand-to-mouth events (events/hour)	Outdoor Environments (Toddlers)	Weibull	Scale= 0.55 Shape= 5.53	
		Indoor Environments (Infants)	Weibull	Scale= 0.91 Shape= 18.79	
BW	Body Weight (kg)	Toddlers	Empirical	Mean = 18.6 95th = 26.2	
		Infants	Empirical	Mean = 11.4 95th = 14.0	

NA = not applicable
AM = arithmetic mean
S-/I-T = short- and intermediate-term exposure

Surface Residue Concentration (SR)

Surface residue concentration is the concentration of pesticide residue on the surface of an impregnated material. Product-specific information, such as weight fraction of a.i., should be used to estimate the residue concentration. This information may be found on labels or other information provided by the manufacturer. After obtaining this information, the surface residue concentration can be estimated using the methods described in *Section 9.2.2*.

Material-to-Skin Transfer Efficiency (TE)

Surface-to-skin transfer efficiency is the fraction of pesticide residue that is transferred from a painted/treated surface to the skin. Whenever possible, product -specific information should be used to estimate the surface-to-skin transfer efficiency. In the absence of product-specific information, the recommended transfer efficiency is based on warm weather data on the transfer of arsenic from chromated copper arsenate treated wood (American Chemistry Council, 2003). This data was incorporated into the SHEDS-CCA assessment and used to obtain a lognormal distribution with a geometric mean and geometric standard deviation of 0.143 and 2.33, respectively. **Based on this data, the recommended transfer value is [XX], which represented the [XX]th percentile.**

Fraction of Hand Mouthed per Event (F_M)

See *Section 2.4* of this SOP for discussion of the fraction of hand mouthed. **The recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile**.

Hand Surface Area (SA_H)

The hand surface area for toddlers (3 to <6 year olds) of 225 cm^2, for one hand, was based on values from the Child-specific Exposure Factors Handbook (U.S. EPA, 2008).

Replenishment Intervals (N_Replen)

This SOP assumes an estimate of 4 replenishment intervals per hour (i.e., residues on the hand will be replenished every 15 minutes). This value was selected as a conservative assumption based on the use of 30 minutes in the SHEDS model to coincide with the CHAD diaries.

Exposure Time (ET)

Exposure time is the amount of time that a child is an environment where they may contact a surface containing an impregnated material. There is currently no data available to characterize the amount of time that children spend in environments where they may contact surfaces with treated paints and preservatives. In the absence of scenario-specific data, recommended exposure time value for exposures that may occur in indoor environments is based on the infant exposure time values discussed in *Section 7.2.4* of the Indoor Environment SOPs. Similarly, the recommended exposure time for outdoor environments is based on the toddler exposure time values discussed in *Section 3.2.2* of the Lawns/Turf SOPs.

Based on this data, the recommended exposure time values for indoor and outdoor environments ([XX] and [XX], respectively) represent approximately the [XX]th percentile of their respective distribution.

Fraction of Pesticide Extracted by Saliva (SE_H)

See *Section 2.6* of this SOP for discussion of the fraction of pesticide extracted by saliva distribution. **The recommended point estimate for use in post-application incidental oral exposure assessments ([XX]) represents approximately the [XX]th percentile**.

Hand-to-mouth events per hour (Freq_Replen)

Frequency of hand-to-mouth events refers to the number of hand-to-mouth events per hour. There is currently no data available that specifically address the number of hand-to-mouth events that occur relative to the amount of time a child is in contact surfaces containing treated paints/preservatives. In the absence of scenario-specific data, the frequency of hand-to-mouth events in indoor environments is based on *Section 7.2.4* of the Indoor Environment SOPs, which provides a summary of data from a meta-analysis performed by Xue et al. (2007). Similarly, the frequency of hand-to-mouth events in outdoor environments is based on *Section 3.2.3* of the Lawns/Turf SOPs, which provides a summary of the outdoor hand-to-mouth data from the same Xue et al. (2007) meta-analysis.

Based on this data, the recommended exposure time values for indoor and outdoor environments ([XX] and [XX], respectively) represent approximately the [XX]th percentile of their respective distribution.

Future Research/Data Needs

While data are available on the transfer of arsenic from chromated copper arsenate treated wood, there is limited data on transfer of other pesticide additives. Therefore, additional research/ data may be needed on the transfer of non-preservative pesticide additives. Additionally, more detailed information on how treated paints/preservatives are used by residential home owners could help improve the exposure assessment methods. Specific information that could help refine the exposure assessment methods includes:

- General use information on treated paints
- Frequency of treated paint/preservative applications
- Location of treated paint/preservatives in residential environments
- Typical surface of area of treated areas

Exposure Characterization and Data Quality

Many of the methods presented in this section are based on the approach used to assess chromated copper arsenate treated playsets. Therefore, an important limitation of the exposure assessment methods presented is that they are based on a single chemical that is used a wood preservative, rather than conventional pesticide (e.g. insecticide, herbicide, fungicide, etc.).

10.2.3 Post-Application Inhalation Exposure Assessment

In many cases, inhalation exposure from impregnated paints is expected to be negligible, since many non-preservative pesticides have low vapor pressures and would be designed to be incorporated into the treated surface. When treated paints/wood preservatives contain more volatile pesticide chemicals, however, it may be necessary to assess post-application inhalation exposures. The recommended methodology is described in the remainder of this section.

Wall Paint Exposure Model

EPA's Wall Paint Exposure Model (WPEM) version 3.2 is used estimate post-application air concentrations resulting from the use of paint preserved with *volatile* chemicals (2001). WPEM was developed under a contract by Geomet Technologies for EPA OPPT to provide estimates of potential air concentrations and consumer/worker exposures to chemicals emitted from wall paint which is applied using a roller or a brush. WPEM uses mathematical models developed from small chamber data to estimate the emissions of chemicals from oil-based (alkyd) and latex wall paint. The emission data can then be combined with detailed use, workload and occupancy data (e.g., amount of time spent in the painted room, etc,) to estimate exposure. Specific input parameters include: the type of paint (latex or alkyd) being assessed, density of the paint (default values available), and the chemical weight fraction, molecular weight, and vapor pressure. Detailed information and the executable model can be downloaded from http://www.epa.gov/opptintr/exposure/pubs/wpem.htm.

It should be noted that WPEM's emission models are based on a limited set of chemicals and an associated range of molecular weights and vapor pressures. The models may not be valid for chemicals outside of these ranges. The valid vapor pressure ranges are 0.4 to 18.7 torr (or mmHg) for chemicals in alkyd paint and 0.002 to 0.2 torr (or mmHg) for chemicals in latex paint.

For volatile chemicals, use WPEM and chemical specific data (i.e., vapor pressure and molecular weight) to determine air concentrations. For the do-it-yourself residential painter, use the default WPEM scenario "RESDIY" to estimate chemical specific air concentrations. This WPEM default scenario assumes that a do-it-yourself painter is exposed to a chemical in paint while applying one coat paint to the bedroom of a house. For a detailed description of the default RESDIY scenario, see the WPEM User's Guide.

The model provides several dose measures (i.e., LADD, ADD), air concentration measures (i.e., peak, 15-min, 8hr), and a comma-separated (.csv) file as outputs. The comma-separated file contains details on time-varying concentrations within the modeled building (i.e., conc in zone 1, conc in zone 2) as well as concentrations to which the individual is exposed (i.e., Conc@person). This file can be read directly into spreadsheet software (e.g., Excel) for calculating additional summary statistics. The output data in comma-separated file should be used to estimate air concentrations over time durations that are in comparable time-durations to the toxicity endpoints. For the adult DIY painter, a 4-hr average air concentration (i.e., the time it takes to paint the bedroom) should be used in the following equation used for calculating the inhalation dose:

$$D = \frac{C * IR * ET}{BW} \tag{10.9}$$

where:

- D = Potential Daily Dose (mg/kg-day);
- C = 4-Hour Average Air concentration (mg a.i./m^3);
- IR = Inhalation rate (Standard Value= m^3/hour);
- ET = Exposure time (Standard Value= hours/day); and
- BW = Bodyweight (kg).

For the adult and child bystander and post-application exposure scenario, use the default WPEM scenario "RESADULT" to estimate chemical specific air concentrations. This WPEM default scenario assumes that a resident located in the non-painted part of the house (i.e., zone 2) is exposed to the chemical in the paint while a bedroom is painted with one coat of primer and one coat of paint by a professional. This resident then moves in, out, and throughout the house following the paint application. For a detailed description of the default RESADULT scenario, see the WPEM User's Guide. The "RESCHILD"scenario should be used to assess child exposure even though the application scenario is the same as in the adult assessment because WPEM moves the person around in the home (i.e., in the painted room, in non-painted rooms, and outdoors) based on activity patterns and the activity patterns for the child and adult are different.

The output data in comma-separated file should be used to estimate air concentrations over time durations that are in comparable time-durations to the toxicity endpoints. For the bystander/post-application exposure the data in the "Conc@person" column of the output file should be used to estimate 24-hr average and subsequently used in the following equation for calculating the post-application inhalation dose is:

$$D = \frac{C * IR * ET}{BW} \tag{10.10}$$

where:

- D = Potential Daily Dose (mg/kg-day)
- C = 24-Hour Average Air concentration (mg a.i./m^3)
- IR = Inhalation rate (m^3/hour)
- ET = Exposure time (hours/day)
- BW = Bodyweight (kg)

Post-application inhalation exposure from paints or wood preservatives containing pesticides is generally considered either acute or short-term in duration. Thus, the daily dose estimate should be used for both durations. Refinement of this dose estimate to reflect a more accurate short-term multi-day exposure profile can be accomplished by accounting for the various factors outlined in *Sections 1.3.2* and *1.3.4*, such as residue dissipation, product-specific re-treatment intervals, and activity patterns. If longer-term assessments (i.e., intermediate-, long-term, or lifetime exposures) are deemed necessary, such as in cases where the impregnated material may be routinely replaced or re-treated, similar refinements to more accurately reflect the exposure profile are recommended.

Section 11 References

Introduction

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Appendix A Supporting Data Analysis and Documentation for Universal Exposure Factors for Residential Exposure Assessment

A.1 Generic Estimates of Fraction Hand Surface Area Mouthed

The generic estimates of fraction hand surface area mouthed are based on an analysis presented in Zartarian et al. (2005). Based on this analysis, it was determined that a beta distribution (3.7, 25) best fits the observed data. *Table A-1* provides the raw data from this study.

Table A-1: Fraction Hand Surface Area Mouthed Data

Mouthing Category	Frequency	Age of Child	Child ID	Fraction of Hand	Finger
partial fingers	5	1	453F01	3	1
partial fingers	1	1	453F01	5	2
partial fingers	0	1	453F01	7	3
partial fingers	1	1	453F01	9	4
partial fingers	0	1	453F01	11	5
full fingers	1	1	453F01	15	1
full fingers	0	1	453F01	29	2
full fingers	0	1	453F01	43	3
full fingers	0	1	453F01	57	4
full fingers	0	1	453F01	71	5
palm w/ fingers	0	1	453F01	49	1
palm w/ fingers	0	1	453F01	78	2
palm w/ fingers	0	1	453F01	106	3
palm w/ fingers	0	1	453F01	134	4
palm w/ fingers	0	1	453F01	163	5
palm w/out fingers	0	1	453F01	41	0
partial fingers	2	1	248M01	3	1
partial fingers	0	1	248M01	5	2
partial fingers	2	1	248M01	7	3
partial fingers	0	1	248M01	9	4
partial fingers	0	1	248M01	11	5
full fingers	26	1	248M01	15	1
full fingers	3	1	248M01	29	2
full fingers	0	1	248M01	43	3
full fingers	0	1	248M01	57	4
full fingers	0	1	248M01	71	5

Table A-1: Fraction Hand Surface Area Mouthed Data					
Mouthing Category	Frequency	Age of Child	Child ID	Fraction of Hand	Finger
palm w/ fingers	0	1	248M01	49	1
palm w/ fingers	0	1	248M01	78	2
palm w/ fingers	0	1	248M01	106	3
palm w/ fingers	0	1	248M01	134	4
palm w/ fingers	0	1	248M01	163	5
palm w/out fingers	2	1	248M01	41	0
partial fingers	3	1	958F01	3	1
partial fingers	60	1	958F01	5	2
partial fingers	4	1	958F01	7	3
partial fingers	14	1	958F01	9	4
partial fingers	3	1	958F01	11	5
full fingers	0	1	958F01	15	1
full fingers	14	1	958F01	29	2
full fingers	0	1	958F01	43	3
full fingers	0	1	958F01	57	4
full fingers	0	1	958F01	71	5
palm w/ fingers	0	1	958F01	49	1
palm w/ fingers	0	1	958F01	78	2
palm w/ fingers	0	1	958F01	106	3
palm w/ fingers	0	1	958F01	134	4
palm w/ fingers	0	1	958F01	163	5
palm w/out fingers	1	1	958F01	41	0
partial fingers	0	1	550M01	3	1
partial fingers	3	1	550M01	5	2
partial fingers	0	1	550M01	7	3
partial fingers	0	1	550M01	9	4
partial fingers	0	1	550M01	11	5
full fingers	0	1	550M01	15	1
full fingers	0	1	550M01	29	2
full fingers	0	1	550M01	43	3
full fingers	0	1	550M01	57	4
full fingers	0	1	550M01	71	5
palm w/ fingers	0	1	550M01	49	1
palm w/ fingers	0	1	550M01	78	2
palm w/ fingers	0	1	550M01	106	3
palm w/ fingers	0	1	550M01	134	4
palm w/ fingers	0	1	550M01	163	5
palm w/out fingers	0	1	550M01	41	0

Table A-1: Fraction Hand Surface Area Mouthed Data					
Mouthing Category	Frequency	Age of Child	Child ID	Fraction of Hand	Finger
partial fingers	0	2	420M02	3	1
partial fingers	0	2	420M02	5	2
partial fingers	0	2	420M02	7	3
partial fingers	0	2	420M02	9	4
partial fingers	0	2	420M02	11	5
full fingers	0	2	420M02	15	1
full fingers	0	2	420M02	29	2
full fingers	0	2	420M02	43	3
full fingers	0	2	420M02	57	4
full fingers	0	2	420M02	71	5
palm w/ fingers	0	2	420M02	49	1
palm w/ fingers	0	2	420M02	78	2
palm w/ fingers	0	2	420M02	106	3
palm w/ fingers	0	2	420M02	134	4
palm w/ fingers	0	2	420M02	163	5
palm w/out fingers	0	2	420M02	41	0
partial fingers	2	2	638F02	3	1
partial fingers	1	2	638F02	5	2
partial fingers	0	2	638F02	7	3
partial fingers	1	2	638F02	9	4
partial fingers	0	2	638F02	11	5
full fingers	0	2	638F02	15	1
full fingers	0	2	638F02	29	2
full fingers	0	2	638F02	43	3
full fingers	0	2	638F02	57	4
full fingers	0	2	638F02	71	5
palm w/ fingers	0	2	638F02	49	1
palm w/ fingers	0	2	638F02	78	2
palm w/ fingers	0	2	638F02	106	3
palm w/ fingers	0	2	638F02	134	4
palm w/ fingers	0	2	638F02	163	5
palm w/out fingers	0	2	638F02	41	0
partial fingers	0	2	587F02	3	1
partial fingers	0	2	587F02	5	2
partial fingers	1	2	587F02	7	3
partial fingers	0	2	587F02	9	4
partial fingers	0	2	587F02	11	5
full fingers	6	2	587F02	15	1
full fingers	0	2	587F02	29	2
full fingers	0	2	587F02	43	3
full fingers	0	2	587F02	57	4
full fingers	0	2	587F02	71	5
palm w/ fingers	0	2	587F02	49	1
palm w/ fingers	0	2	587F02	78	2
palm w/ fingers	0	2	587F02	106	3

Table A-1: Fraction Hand Surface Area Mouthed Data					
Mouthing Category	Frequency	Age of Child	Child ID	Fraction of Hand	Finger
palm w/ fingers	0	2	587F02	134	4
palm w/ fingers	0	2	587F02	163	5
palm w/out fingers	1	2	587F02	41	0
partial fingers	5	2	806M02	3	1
partial fingers	0	2	806M02	5	2
partial fingers	0	2	806M02	7	3
partial fingers	1	2	806M02	9	4
partial fingers	0	2	806M02	11	5
full fingers	0	2	806M02	15	1
full fingers	0	2	806M02	29	2
full fingers	0	2	806M02	43	3
full fingers	0	2	806M02	57	4
full fingers	0	2	806M02	71	5
palm w/ fingers	0	2	806M02	49	1
palm w/ fingers	0	2	806M02	78	2
palm w/ fingers	0	2	806M02	106	3
palm w/ fingers	0	2	806M02	134	4
palm w/ fingers	0	2	806M02	163	5
palm w/out fingers	0	2	806M02	41	0
partial fingers	1	3	165M03	3	1
partial fingers	7	3	165M03	5	2
partial fingers	1	3	165M03	7	3
partial fingers	1	3	165M03	9	4
partial fingers	0	3	165M03	11	5
full fingers	0	3	165M03	15	1
full fingers	0	3	165M03	29	2
full fingers	0	3	165M03	43	3
full fingers	0	3	165M03	57	4
full fingers	0	3	165M03	71	5
palm w/ fingers	0	3	165M03	49	1
palm w/ fingers	0	3	165M03	78	2
palm w/ fingers	0	3	165M03	106	3
palm w/ fingers	0	3	165M03	134	4
palm w/ fingers	0	3	165M03	163	5
palm w/out fingers	0	3	165M03	41	0
partial fingers	0	3	129M03	3	1
partial fingers	0	3	129M03	5	2
partial fingers	0	3	129M03	7	3
partial fingers	1	3	129M03	9	4
partial fingers	0	3	129M03	11	5
full fingers	0	3	129M03	15	1
full fingers	2	3	129M03	29	2
full fingers	0	3	129M03	43	3
full fingers	0	3	129M03	57	4
full fingers	1	3	129M03	71	5

Table A-1: Fraction Hand Surface Area Mouthed Data					
Mouthing Category	Frequency	Age of Child	Child ID	Fraction of Hand	Finger
palm w/ fingers	0	3	129M03	49	1
palm w/ fingers	0	3	129M03	78	2
palm w/ fingers	0	3	129M03	106	3
palm w/ fingers	0	3	129M03	134	4
palm w/ fingers	0	3	129M03	163	5
palm w/out fingers	0	3	129M03	41	0
partial fingers	0	3	317F03	3	1
partial fingers	0	3	317F03	5	2
partial fingers	0	3	317F03	7	3
partial fingers	0	3	317F03	9	4
partial fingers	0	3	317F03	11	5
full fingers	0	3	317F03	15	1
full fingers	0	3	317F03	29	2
full fingers	0	3	317F03	43	3
full fingers	0	3	317F03	57	4
full fingers	0	3	317F03	71	5
palm w/ fingers	0	3	317F03	49	1
palm w/ fingers	0	3	317F03	78	2
palm w/ fingers	0	3	317F03	106	3
palm w/ fingers	0	3	317F03	134	4
palm w/ fingers	0	3	317F03	163	5
palm w/out fingers	0	3	317F03	41	0
partial fingers	7	4	422F04	3	1
partial fingers	3	4	422F04	5	2
partial fingers	5	4	422F04	7	3
partial fingers	1	4	422F04	9	4
partial fingers	0	4	422F04	11	5
full fingers	3	4	422F04	15	1
full fingers	0	4	422F04	29	2
full fingers	0	4	422F04	43	3
full fingers	0	4	422F04	57	4
full fingers	0	4	422F04	71	5
palm w/ fingers	1	4	422F04	49	1
palm w/ fingers	0	4	422F04	78	2
palm w/ fingers	0	4	422F04	106	3
palm w/ fingers	1	4	422F04	134	4
palm w/ fingers	0	4	422F04	163	5
palm w/out fingers	0	4	422F04	41	0
partial fingers	0	4	772M04	3	1
partial fingers	0	4	772M04	5	2
partial fingers	0	4	772M04	7	3
partial fingers	0	4	772M04	9	4
partial fingers	0	4	772M04	11	5
full fingers	0	4	772M04	15	1
full fingers	0	4	772M04	29	2

Table A-1: Fraction Hand Surface Area Mouthed Data					
Mouthing Category	Frequency	Age of Child	Child ID	Fraction of Hand	Finger
full fingers	0	4	772M04	43	3
full fingers	0	4	772M04	57	4
full fingers	0	4	772M04	71	5
palm w/ fingers	0	4	772M04	49	1
palm w/ fingers	0	4	772M04	78	2
palm w/ fingers	0	4	772M04	106	3
palm w/ fingers	0	4	772M04	134	4
palm w/ fingers	0	4	772M04	163	5
palm w/out fingers	2	4	772M04	41	0
partial fingers	0	4	575F04	3	1
partial fingers	0	4	575F04	5	2
partial fingers	0	4	575F04	7	3
partial fingers	0	4	575F04	9	4
partial fingers	0	4	575F04	11	5
full fingers	0	4	575F04	15	1
full fingers	0	4	575F04	29	2
full fingers	0	4	575F04	43	3
full fingers	0	4	575F04	57	4
full fingers	0	4	575F04	71	5
palm w/ fingers	0	4	575F04	49	1
palm w/ fingers	0	4	575F04	78	2
palm w/ fingers	0	4	575F04	106	3
palm w/ fingers	0	4	575F04	134	4
palm w/ fingers	0	4	575F04	163	5
palm w/out fingers	0	4	575F04	41	0
partial fingers	0	5	919F05	3	1
partial fingers	1	5	919F05	5	2
partial fingers	0	5	919F05	7	3
partial fingers	0	5	919F05	9	4
partial fingers	0	5	919F05	11	5
full fingers	0	5	919F05	15	1
full fingers	1	5	919F05	29	2
full fingers	0	5	919F05	43	3
full fingers	0	5	919F05	57	4
full fingers	0	5	919F05	71	5
palm w/ fingers	0	5	919F05	49	1
palm w/ fingers	0	5	919F05	78	2
palm w/ fingers	0	5	919F05	106	3
palm w/ fingers	0	5	919F05	134	4
palm w/ fingers	0	5	919F05	163	5
palm w/out fingers	0	5	919F05	41	0
partial fingers	0	5	280M05	3	1
partial fingers	1	5	280M05	5	2
partial fingers	1	5	280M05	7	3
partial fingers	0	5	280M05	9	4

Table A-1: Fraction Hand Surface Area Mouthed Data					
Mouthing Category	Frequency	Age of Child	Child ID	Fraction of Hand	Finger
partial fingers	0	5	280M05	11	5
full fingers	0	5	280M05	15	1
full fingers	0	5	280M05	29	2
full fingers	0	5	280M05	43	3
full fingers	0	5	280M05	57	4
full fingers	0	5	280M05	71	5
palm w/ fingers	0	5	280M05	49	1
palm w/ fingers	0	5	280M05	78	2
palm w/ fingers	0	5	280M05	106	3
palm w/ fingers	0	5	280M05	134	4
palm w/ fingers	0	5	280M05	163	5
palm w/out fingers	0	5	280M05	41	0
partial fingers	0	5	557F05	3	1
partial fingers	0	5	557F05	5	2
partial fingers	0	5	557F05	7	3
partial fingers	0	5	557F05	9	4
partial fingers	0	5	557F05	11	5
full fingers	0	5	557F05	15	1
full fingers	0	5	557F05	29	2
full fingers	0	5	557F05	43	3
full fingers	0	5	557F05	57	4
full fingers	0	5	557F05	71	5
palm w/ fingers	0	5	557F05	49	1
palm w/ fingers	0	5	557F05	78	2
palm w/ fingers	0	5	557F05	106	3
palm w/ fingers	0	5	557F05	134	4
palm w/ fingers	0	5	557F05	163	5
palm w/out fingers	0	5	557F05	41	0
partial fingers	1	6	257F06	3	1
partial fingers	0	6	257F06	5	2
partial fingers	0	6	257F06	7	3
partial fingers	0	6	257F06	9	4
partial fingers	0	6	257F06	11	5
full fingers	0	6	257F06	15	1
full fingers	0	6	257F06	29	2
full fingers	0	6	257F06	43	3
full fingers	0	6	257F06	57	4
full fingers	0	6	257F06	71	5
palm w/ fingers	0	6	257F06	49	1
palm w/ fingers	0	6	257F06	78	2
palm w/ fingers	0	6	257F06	106	3
palm w/ fingers	0	6	257F06	134	4
palm w/ fingers	0	6	257F06	163	5
palm w/out fingers	0	6	257F06	41	0
partial fingers	2	6	338F06	3	1

Table A-1: Fraction Hand Surface Area Mouthed Data					
Mouthing Category	Frequency	Age of Child	Child ID	Fraction of Hand	Finger
partial fingers	2	6	338F06	5	2
partial fingers	1	6	338F06	7	3
partial fingers	0	6	338F06	9	4
partial fingers	0	6	338F06	11	5
full fingers	0	6	338F06	15	1
full fingers	0	6	338F06	29	2
full fingers	0	6	338F06	43	3
full fingers	0	6	338F06	57	4
full fingers	0	6	338F06	71	5
palm w/ fingers	0	6	338F06	49	1
palm w/ fingers	0	6	338F06	78	2
palm w/ fingers	0	6	338F06	106	3
palm w/ fingers	0	6	338F06	134	4
palm w/ fingers	0	6	338F06	163	5
palm w/out fingers	0	6	338F06	41	0
partial fingers	1	6	331F06	3	1
partial fingers	5	6	331F06	5	2
partial fingers	2	6	331F06	7	3
partial fingers	4	6	331F06	9	4
partial fingers	0	6	331F06	11	5
full fingers	2	6	331F06	15	1
full fingers	0	6	331F06	29	2
full fingers	0	6	331F06	43	3
full fingers	0	6	331F06	57	4
full fingers	0	6	331F06	71	5
palm w/ fingers	0	6	331F06	49	1
palm w/ fingers	0	6	331F06	78	2
palm w/ fingers	0	6	331F06	106	3
palm w/ fingers	0	6	331F06	134	4
palm w/ fingers	0	6	331F06	163	5
palm w/out fingers	0	6	331F06	41	0

Statistics such as standard deviations and select percentiles are presented in *Figure A-2* below.

Table A-2: Fraction Hand Surface Area Mouthed	
Statistic	**Fraction Hand Surface Area Mouthed**
50th percentile	0.118
75th percentile	0.164
95th percentile	0.243
AM (SD)	0.127 (0.0614)
GM (GSD)	0.114 (1.58)
Range	0.05 – 0.4
N	220

AM (SD) = arithmetic mean (standard deviation)
GM (GSD) = geometric mean (geometric standard deviation)

A.2 Generic Estimates of Object Surface Area Mouthed

A factor used in object-to-mouth post-application assessments is the surface area of the object that a child puts in its mouth. This value (expressed in cm^2) is utilized in a number of the SOPs in this document. Based on the area of hand mouthed by 2-5 year olds as reported by Leckie et al.(2000), and the assumption that children mouth a smaller area of an object than their hand, an exponential distribution with a minimum of 1 cm^2, a mean of 10 cm^2, and a maximum of 50 cm^2 was chosen. The maximum is comparable to the surface area of a ping-pong ball. *Figure A-1* presents the Monte Carlo simulation based on the distribution derived from Leckie et al. (2000).

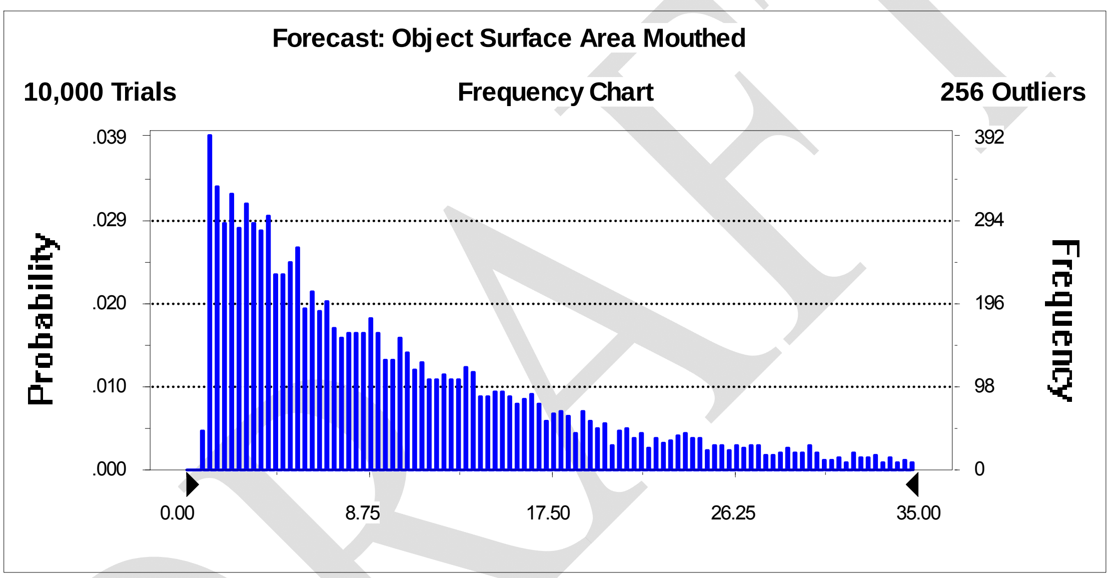


Figure A-1: Monte Carlo Simulation for Object Surface Area Mouthed (cm^2) Assuming an Exponential Distribution (Minimum= 1 cm^2, Mean= 10cm^2, Maximim= 50cm^2)

A.3 Generic Estimates of Fraction of Pesticide Extracted by Saliva

Fraction of pesticide extracted by saliva is an important variable for hand-to-mouth and object-to-mouth post-application exposure assessments. The fraction of pesticide extracted by saliva has historically been referred to as the saliva extraction factor or mouthing removal efficiency. It is used in hand-to-mouth and object-to-mouth assessments to account for removal of pesticides from hands or objects via saliva. Data to adequately characterize the fraction of pesticide extracted by saliva are limited and difficult to collect. However, one study, Camann et al. (1995), is available to determine generic values for the fraction of pesticide extracted by saliva.

The Camann et al. study examined the removal efficiencies from hands with gauze moistened with artificial and human saliva. This activity was meant to simulate removal of pesticides resulting from placement of a hand into the mouth. Only the data collected with human saliva are presented here. Triplicate samples were collected three times for three different pesticides (chlorpyrifos, pyrethrin, and PBO). This resulted in a total of twenty-seven samples (nine for each pesticide). All data were compiled and it was determined that the distribution of saliva extraction values was best approximated by a beta distribution ($\alpha = 7.0$, $\beta = 7.6$). *Table A-3* provides the raw data for the study. Following this table, Figure A-2 provides a comparison of the recommended beta distribution and actual observed values and *Figure A-3* provides the results of a Monte Carlo simulation using this distribution. Based on the recommended distribution, the summary statistics presented in *Table A-4* were derived for fraction of pesticide extracted by saliva. Note: This study focused specifically on fraction of pesticide extracted by saliva from hands; not objects. However, there are currently no data available to address the removal of residues from objects by saliva during mouthing events so this study is being used for both hands and objects.

Table A-3: Fraction of Pesticide Extracted by Saliva Data

	Subject	Day	Hand	Amount Transferred to Hand (ug)	Amount Removed by Salivary Wipe (ug)	Salivary Wipe Efficiency
Chlorpyrifos	Subject A	1	RIGHT	5.58	2.01	0.360
	Subject A	3	LEFT	6.63	2.13	0.321
	Subject A	4	RIGHT	7.29	3.21	0.440
	Subject B	2	LEFT	5.36	3.59	0.670
	Subject B	3	RIGHT	6.47	3.16	0.488
	Subject B	5	LEFT	4.7	2.74	0.583
	Subject C	1	LEFT	7.46	3.75	0.503
	Subject C	2	RIGHT	7.17	5.11	0.713
	Subject C	4	LEFT	7.78	4.7	0.604
Pyrethrin	Subject A	1	RIGHT	24.8	10.6	0.427
	Subject A	3	LEFT	26.8	10	0.373
	Subject A	4	RIGHT	31.3	13.6	0.435
	Subject B	2	LEFT	20.8	12.4	0.596
	Subject B	3	RIGHT	26	15.5	0.596
	Subject B	5	LEFT	19.4	9.6	0.495
	Subject C:	1	LEFT	32.2	19	0.590
	Subject C:	2	RIGHT	29.1	18.6	0.639
	Subject C:	4	LEFT	33.3	18.2	0.547
PBO	Subject A	1	RIGHT	28.1	11.9	0.423
	Subject A	3	LEFT	43.1	11.1	0.258
	Subject A	4	RIGHT	53.3	15.1	0.283
	Subject B	2	LEFT	20.5	10.7	0.522
	Subject B	3	RIGHT	40.4	8.9	0.220
	Subject B	5	LEFT	19.6	10.8	0.551
	Subject C	1	LEFT	51.2	22.6	0.441
	Subject C	2	RIGHT	51.9	31.1	0.599
	Subject C	4	LEFT	58.7	21.1	0.359

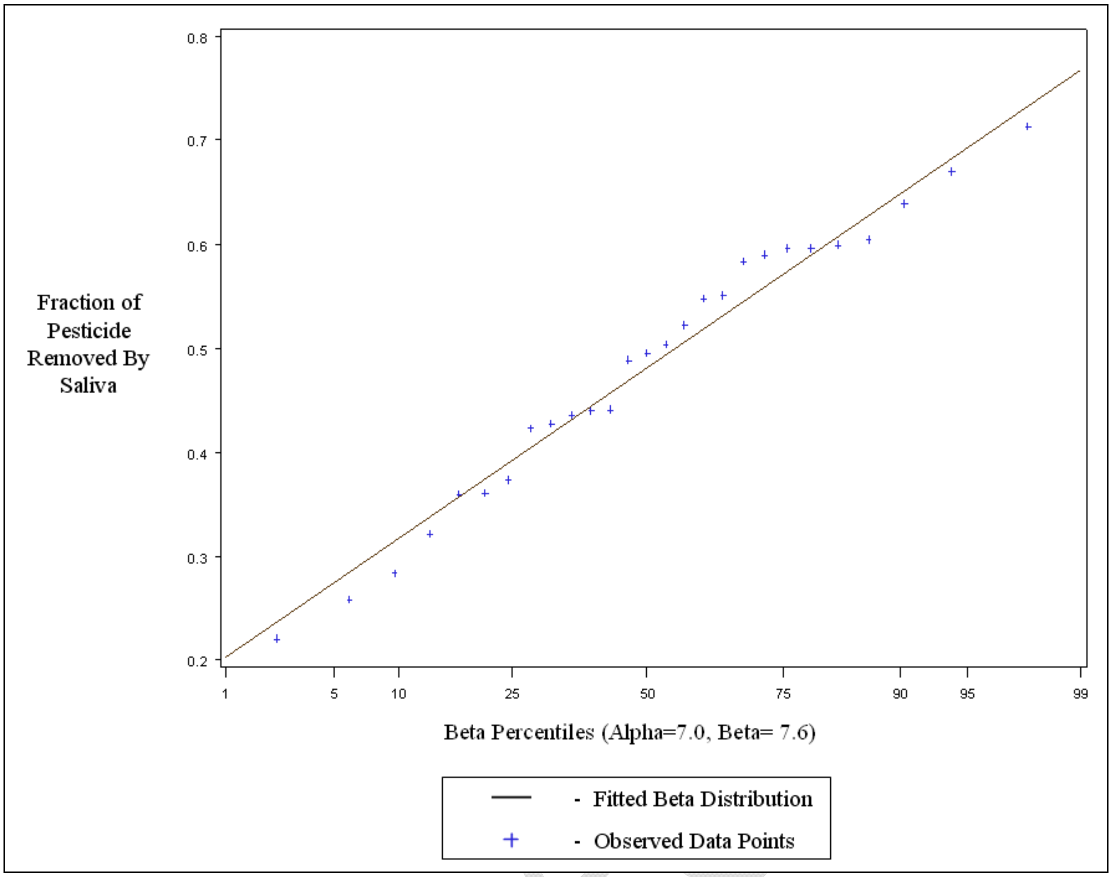


Figure A-2: Comparison of the Recommended Beta Distribution (α = 7.0, β = 7.6) and the observed data points from Camann et al. (1995).

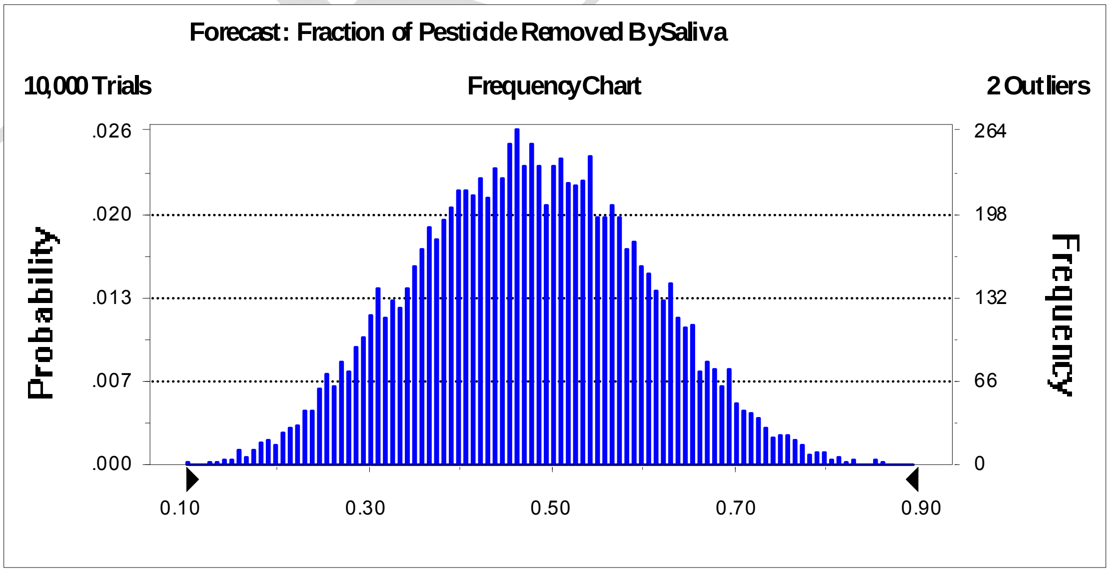


Figure A-3: Monte Carlo Simulation for Fraction of Pesticide Extracted by Saliva Using a Beta Distribution (α = 7.0, β = 7.6)

Table A-4: Fraction of Pesticide Extracted by Saliva	
Statistic	Fraction of Pesticide Extracted by Saliva
50th percentile	0.50
75th percentile	0.57
90th percentile	0.64
95th percentile	0.68
99th percentile	0.80
Arithmetic Mean	0.48
Arithmetic Standard Deviation	0.13
Geometric Mean	0.46
Geometric Mean Standard Deviation	1.35

Appendix B Supporting Data Analysis and Documentation for Residential Handler Exposure Assessment

B.1 Summary of Exposure Data Used to Generate Residential Unit Exposures

Throughout the Residential SOPs, references are made to formulation- and application method-specific unit exposures for use in various handler exposure assessment scenarios. The following appendix provides summary information on the exposure studies that serve as the basis for those unit exposures. It includes:

- Scenario summaries organized by formulation, equipment/application methods, and application site(s);
- References for all available studies that could potentially be used for residential exposure assessment;
- Brief study descriptions;
- Tables outlining relevant characteristics for each study with respect to its potential use in residential handler exposure assessments; and,
- Study-specific data summaries, including limitations and uncertainties.

Analytical commonalities for all studies include:

- Statistics for all exposure studies are based on fitting lognormal distributions;
- Unit exposures are representative of individuals wearing short-sleeve shirts; shorts, shoes/socks, and no chemical resistant gloves;
- Using ½ the limit of detection or limit of quantification for non-detect samples as is standard practice;
- 90% protection is assumed when back-calculating gloved hand exposure to bare hand exposure;

- 50% protection is assumed when back-calculating covered forearm and shin exposure to bare forearm and shin exposure;
- Corrections for field fortification recoveries as appropriate;
- Using a breathing rate of 16.7 liters per minute, representing light activities (USEPA, 1997), to extrapolate air samples to residential handler inhalation exposure; and,
- Means and standard deviations calculated using the minimum variance unbiased estimator for lognormal distributions.

Note that the exposure studies recommended for use in residential handler exposure assessment inform only the default unit exposure data for each scenario and does not mean that a study not recommended for use cannot ever be used. Should a non-recommended study in this appendix be deemed useful given a unique situation, the assessment should provide justification for its use and deviation from the default data.

Table B-1: List of Handler Scenarios

Formulation	Equipment/Application Method	Application Site(s)	Page Number
Granules	Push-type Spreader	outdoors (lawn, gardens)	*B-4*
	Belly grinder	outdoors (lawn, gardens, trees/bushes, perimeter, mounds/nest)	*B-11*
	Spoon	outdoors (lawn, gardens, trees/bushes, perimeter, mounds/nest)	*B-20*
	Cup	outdoors (lawn, gardens, trees/bushes, perimeter, mounds/nest)	*B-24*
	Hand dispersal	outdoors (lawn, gardens, trees/bushes, perimeter, mounds/nest)	*B-28*
Dusts/Powders	Plunger duster	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests), indoors (general broadcast treatments)	*B-32*
	Shaker can	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests), indoors (general broadcast treatments), pets/animals	*B-36*
Paints and Stains	Airless sprayer	outdoors and indoors (general paint and stain applications)	*B-42*
	Brush	outdoors and indoors (general paint and stain applications)	*B-48*
Mothballs	Hand placement	cabinets, sheds, closets	*B-52*
Liquids (emulsifiable concentrates, soluble concentrates, etc.)	Low-pressure handwand	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests), indoors (general broadcast treatments, baseboards, cracks and crevices)	*B-56*
	Handheld Fogger	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests)	*B-67*
	Dipping	pets/animals	*B-70*
	Sponge	pets/animals	*B-74*
	Hose-end sprayer	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests)	*B-78*
	Backpack sprayer	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests)	*B-89*
Ready-to-use (RTU)	Hose-end sprayer	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests)	*B-104*

	Trigger-pump sprayer	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests), indoors (plants, cracks and crevices), pets/animals	*B-109*
	Shampoo	pets/animals, children	*B-120*
	Spot-on	pets/animals	*B-126*
	Aerosol can	outdoors (gardens, trees/bushes, perimeter, mounds/nests), indoors (general broadcast treatments, baseboards, cracks and crevices), pets/animals	*B-130*
Wettable Powder (WP)	Low-pressure handwand	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests), indoors (general broadcast treatments, baseboards, cracks and crevices)	*B-138*
	Backpack sprayer	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests), indoors (general broadcast treatments, baseboards, cracks and crevices)	*B-146*

Scenario Summary

Table B-2: Scenario Description and Available Exposure Studies	
Formulation	Granules
Equipment/Application Method	Push-type Spreader (also: rotary spreader, cyclone spreader, "Scotts" spreader)
Application Site(s)	Outdoors (lawn, gardens)
Available Exposure Studies	Klonne, D. (1999); MRID 44972201
	Rosenheck, L.; Phillips, J.; Selman, F. (1993); MRID 43016506
	Solomon, K. R., Harris, S. A, Stephenson, G. R. (1993)

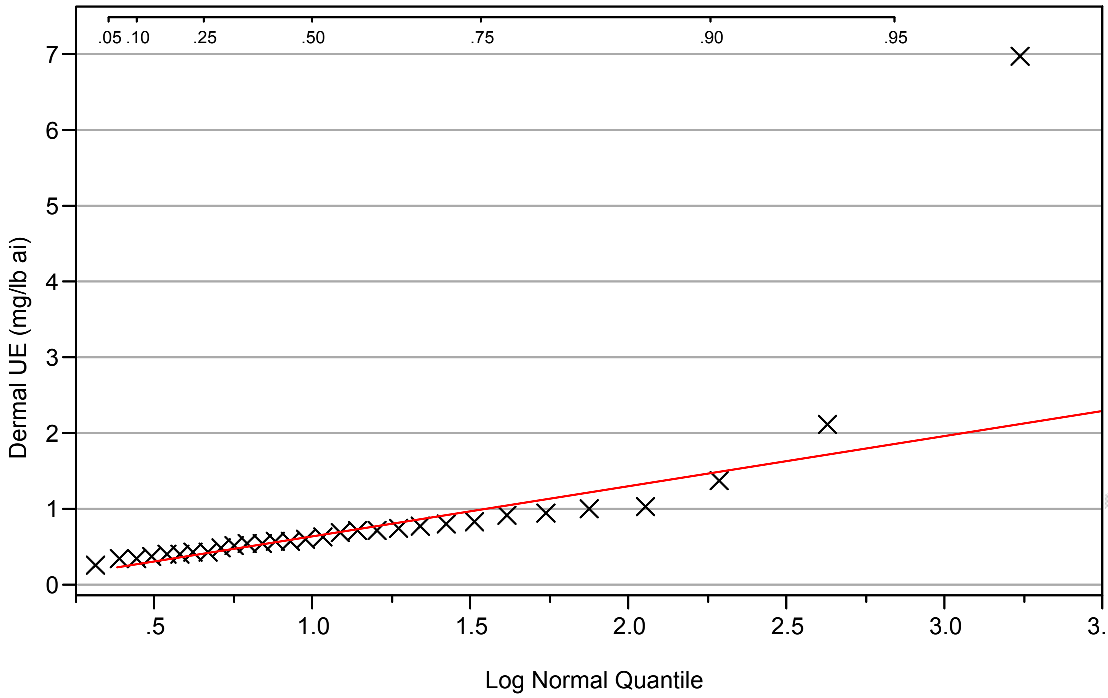
Table B-3: Unit Exposures (mg/lb ai) – Granule Push-type Spreader Applications		
Statistic	**Dermal**	**Inhalation**
50^{th} percentile	0.66	0.0014
75^{th} percentile	1.0	0.0029
95^{th} percentile	1.9	0.0089
99^{th} percentile	2.9	0.019
99.9^{th} percentile	4.7	0.047
AM (SD)	0.81 (0.57)	0.0026 (0.0043)
GM (GSD)	0.66 (1.9)	0.0014 (3.1)
Range	0.25 – 7.0	0.00013 – 0.019
N	30	45

<u>Dermal Unit Exposure Data Summary:</u> The recommended dermal unit exposures for push-type spreader applications of granule pesticide formulations is based on a lognormal distribution fit with exposure monitoring data from Klonne, D. (1999) [EPA MRID 44972201]. This study monitored 30 applications of a granule formulation for approximately 20 minutes to approximately 10,000 square feet of turf in North Carolina using a rotary spreader.

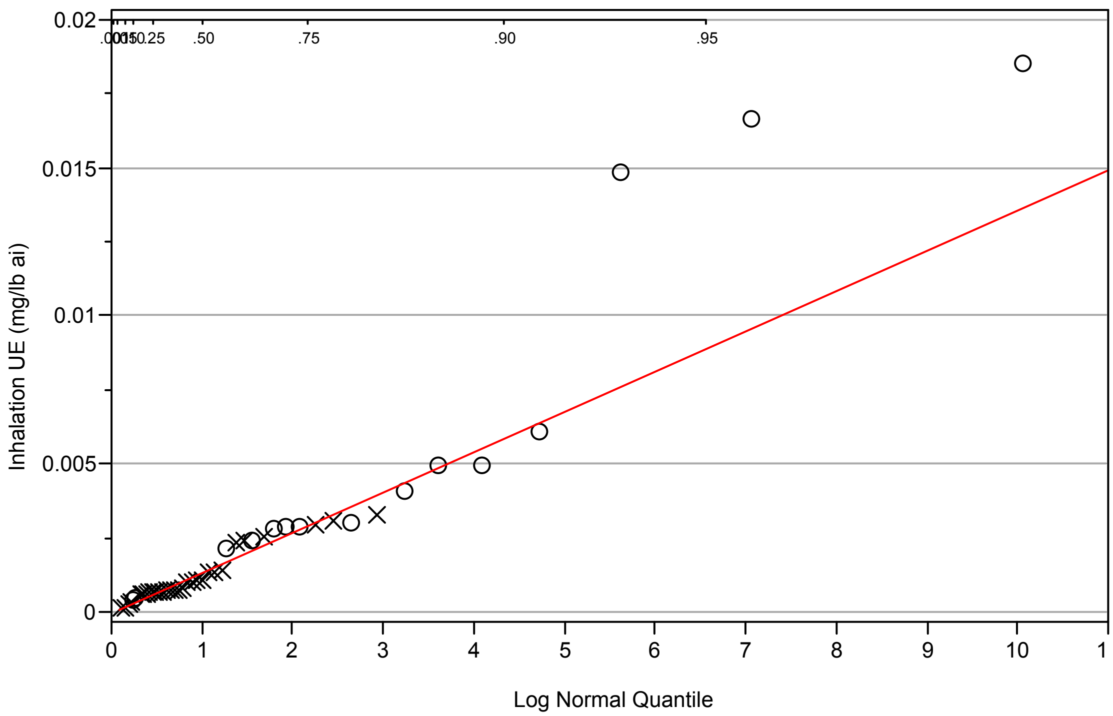
<u>Inhalation Unit Exposure Data Summary:</u> The recommended inhalation unit exposures for push-type spreader applications of granule pesticide formulations is based on a lognormal distribution fit with exposure monitoring data from Klonne, D. (1999) [EPA MRID 44972201] and Rosenheck, L. et al (1993) [EPA MRID 43016506]. Klonne, D. (1999) monitored 30 individuals while applying a granule formulation for approximately 20 minutes to approximately 10,000 square feet of turf in North Carolina using a rotary spreader. Rosenheck, L. et al (1993) monitored 15 applications of a granule formulation for approximately 30-40 minutes to turf in North Carolina using a push cyclone spreader.

Lognormal Probability Plots

Legend: X = Klonne, D. (1999)



Legend: X = Klonne, D. (1999); O = Rosenheck, L., et al (1993)



Available Handler Exposure Studies

Table B-4: Study Identification Information	
Citation	Klonne, D. 1999. Integrated Report on Evaluation of Potential Exposure to Homeowners and Professional Lawn Care Operators Mixing, Loading, and Applying Granular and Liquid Pesticides to Residential Lawns. Sponsor/Submitter: Outdoor Residential Exposure Task Force.
EPA MRID	449722201
ORETF Code	OMA003
EPA Review	D261948
	EPA Memo from G. Bangs to D. Fuller (3/5/03)
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: A total of 30 individuals 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% dacthal) 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). The target application rate was approximately 2 lb ai/acre, with each individual handling approximately 0.45 lb of active ingredient. The average application time was 22 minutes, including loading the rotary push-spreader and disposing of empty bags.

Dermal exposure was measured using inner and outer whole body dosimeters, hand washes, and face/neck washes, such that exposure could be constructed for various clothing scenarios (including a short-sleeve shirt and shorts). Inhalation exposure was measured using standard personal air monitoring devices set at 1.5 liters per minute. 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 quantification (LOQ) for dacthal, and 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%. Mean field fortification recoveries over the four study days for each fortification level ranged from 83 to 97%.

Table B-5: MRID 44972201 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-6: MRID 44972201 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
1	0.45	0.24	0.000058	0.53	0.00013
2	0.45	0.18	0.000311	0.39	0.00071
3	0.45	0.30	0.000449	0.67	0.00102
4	0.45	0.31	0.001113	0.69	0.00253
5	0.45	0.15	0.000056	0.33	0.00013
6	0.45	0.17	0.000278	0.37	0.00063
7	0.45	0.16	0.000286	0.36	0.00065
8	0.45	0.27	0.000585	0.60	0.00133
9	0.45	0.15	0.000298	0.34	0.00068
10	0.45	0.25	0.000564	0.56	0.00128
11	0.45	0.32	0.001048	0.71	0.00238
12	0.45	0.11	0.000242	0.25	0.00055
13	0.45	0.35	0.001436	0.79	0.00326
14	0.45	0.23	0.001324	0.51	0.00301
15	0.45	0.45	0.000601	1.00	0.00137
16	0.45	0.19	0.000311	0.41	0.00071
17	0.45	0.19	0.000289	0.43	0.00066
18	0.45	0.41	0.000438	0.92	0.00099
19	0.45	0.34	0.000423	0.76	0.00096
20	0.45	0.37	0.000334	0.83	0.00076
21	0.45	0.28	0.000253	0.62	0.00058
22	0.45	0.33	0.000115	0.73	0.00026
23	0.45	0.25	0.000251	0.55	0.00057
24	0.45	0.95	0.000461	2.10	0.00105
25	0.45	0.61	0.001290	1.36	0.00293
26	0.45	0.41	0.001025	0.91	0.00233
27	0.45	0.23	0.000265	0.52	0.00060
28	0.45	3.14	0.000322	6.98	0.00073
29	0.45	0.21	0.000276	0.46	0.00063
30	0.45	0.46	0.000138	1.02	0.00031

1 Amount of active ingredient Handled
2 Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
3 Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
4 Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of granule pesticide formulations using a push-type spreader, the following limitations are noted:

- Each individual handled the same amount of active ingredient, making analysis of the relationship between exposure and the amount of active ingredient handled (the underlying basis of unit exposures) difficult.

Table B-7: Study Identification Information	
Citation	Rosenheck, L.; Phillips, J.; Selman, F. (1993). Worker Mixer/Loader and Applicator Exposure to Atrazine
EPA MRID	43016506
ORETF Code	NA
EPA Review	None
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: A total of 15 application events were monitored using 8 volunteers loading and applying granules to turf sites in North Carolina using a "push cyclone spreader". Each individual handled approximately 110 lbs of granule formulation (1.02% atrazine; 1.1 lbs atrazine) and spent approximately 30-40 minutes per application. Dermal exposure was measured using whole body dosimetry underneath work clothing – a long-sleeve shirt, pants, socks and shoes – and hand washes were used to collect exposure to bare hands (no chemical-resistant gloves were worn). Inhalation exposure was measured using standard pumps (set at 1.5 liters per minute), cassettes, and tubing. Percent recovery (mean ± SD) for laboratory fortifications is as follows: 97.2 ± 19.2% for glass fiber filter, 96.3 ± 29.4% for handwash, 107 ± 12.1% for facial swipe, and 105 ± 32.3% for whole-body dosimeter. With the exception of one low average recovery, 42.4% for handwashes at site 1, average field fortification recoveries ranged from 61.5% to 98.2%. The majority of the individual fortification recoveries fell within the 50% to 120% range with the noted exception of the high-level fortification of the handwash solutions, facial swabs, and whole-body dosimeters at Site 1, which averaged from 61.6% to 68.2%.

Table B-8: MRID 43016506 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only inhalation exposure data are included since the dermal exposure data are not recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-9: MRID 43016506 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation

A	1.1100	--	0.0006	--	0.0005
A	1.1100	--	0.0024	--	0.0022
A	1.1100	--	0.0032	--	0.0029
A	1.1100	--	0.0056	--	0.0050
A	1.1100	--	0.0046	--	0.0041
A	1.1100	--	0.0055	--	0.0050
B	1.1100	--	0.0206	--	0.0186
B	1.1100	--	0.0032	--	0.0029
B	1.1100	--	0.0032	--	0.0028
B	1.1100	--	0.0027	--	0.0024
C	1.1100	--	0.0068	--	0.0061
C	1.1100	--	0.0165	--	0.0149
C	1.3900	--	0.0042	--	0.0030
C	1.3900	--	0.0006	--	0.0004
C	1.0500	--	0.0175	--	0.0167

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of granule pesticide formulations using a push-type spreader, the following limitations are noted:

- Each individual handled practically the same amount of active ingredient, making analysis of the relationship between exposure and the amount of active ingredient handled (the underlying basis of unit exposures) difficult.

Table B-10: Study Identification Information	
Citation	Solomon, K. R., Harris, S. A, Stephenson, G. R. (1993). Applicator And Bystander Exposure To Home Garden And Landscape Pesticides. American Chemical Society, 1993, pp. 262-273
EPA MRID	none
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: A total of 20 application events were monitored using volunteers loading and applying granules using a "drop spreader". Eleven of the applications were conducted while wearing "protective" clothing, while 9 applications were conducted while wearing "normal" clothing. The exact nature of the clothing worn was not provided. Each individual handled approximately 0.3 – 2.6 lbs of 2, 4-D per application. Exposure was measured using biomonitoring with passive monitoring only conducted for inhalation exposure using standard pumps (set at 1 liter per minute), cassettes, and tubing. All except one inhalation exposure sample was a non-detect (limit of detection = 0.0001 ug/L). Recoveries from field fortifications of exposure sampling matrices were generally above 85% with little variation (standard deviation approximately 3%).

<table>
<tr><th colspan="3">Table B-11: Solomon, et al. (1993) – Checklist and Use Recommendation</th></tr>
<tr><th rowspan="2">Study Criteria</th><th colspan="2">Exposure Component</th></tr>
<tr><th>Dermal</th><th>Inhalation</th></tr>
<tr><td>Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?</td><td colspan="2">Yes</td></tr>
<tr><td>Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?</td><td>No</td><td>NA</td></tr>
<tr><td>Was exposure to the hands representative of bare hands?</td><td>No</td><td>NA</td></tr>
<tr><td>Was the study intended to simulate “residential” exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?</td><td colspan="2">Yes</td></tr>
<tr><td>Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Should this study be recommended for use in residential handler exposure assessments?</td><td>No</td><td>No</td></tr>
</table>

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Scenario Summary

Table B-12: Scenario Description and Available Exposure Studies	
Formulation	Granules
Equipment/Application Method	Belly grinder (also: hand cyclone spreader, whirly-bird spreader)
Application Site(s)	outdoors (lawn, gardens, trees/bushes, perimeter, mounds/nest)
Available Exposure Studies	Rosenheck, L.; Phillips, J.; Selman, F. (1993); MRID 43016506
	Hamburger, S.J. (1984); MRID 00149007
	Dean, V.C. (1988); MRID 41054704
	Shurdut, B.A. and Murphy, P.G. (1993); MRID 46807004
	Spencer, et al. (1997)

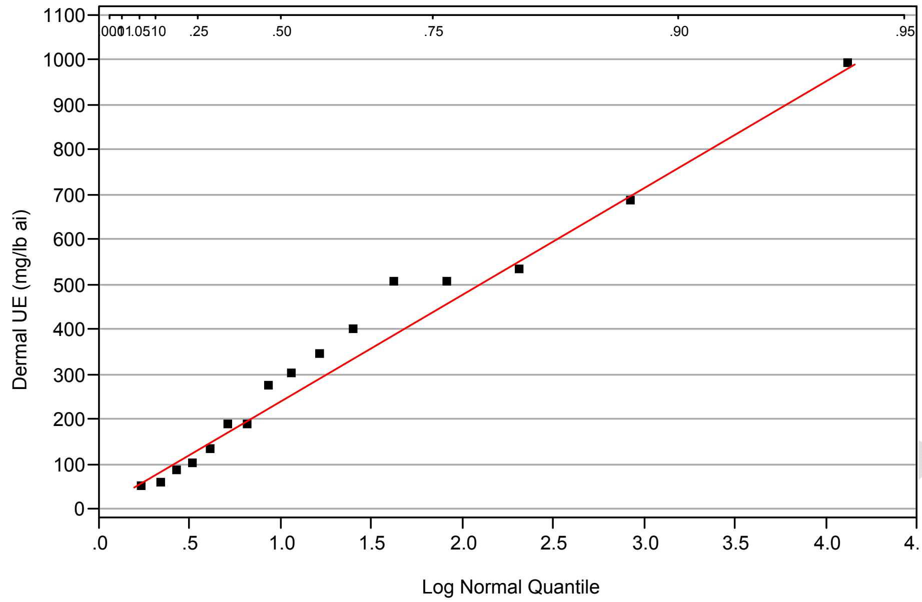
Table B-13: Unit Exposures (mg/lb ai) – Granule Belly Grinder Applications		
Statistic	Dermal	Inhalation
50^{th} percentile	240	0.035
75^{th} percentile	440	0.095
95^{th} percentile	1100	0.41
99^{th} percentile	2000	1.1
99.9^{th} percentile	3900	3.6
AM (SD)	360 (405)	0.11 (0.31)
GM (GSD)	240 (2.5)	0.035 (4.5)
Range	49 – 990	0.0017 – 0.29
N	16	44

Dermal Unit Exposure Data Summary: The recommended dermal unit exposures for belly grinder applications of granule pesticide formulations is based on a lognormal distribution fit with exposure monitoring data from Dean, V.C. (1988) [EPA MRID 41054704]. Dean, V.C. (1988) monitored 16 applications of a granule formulation foundations, patios, driveways, and sidewalks of houses using a "whirly-bird spreader".

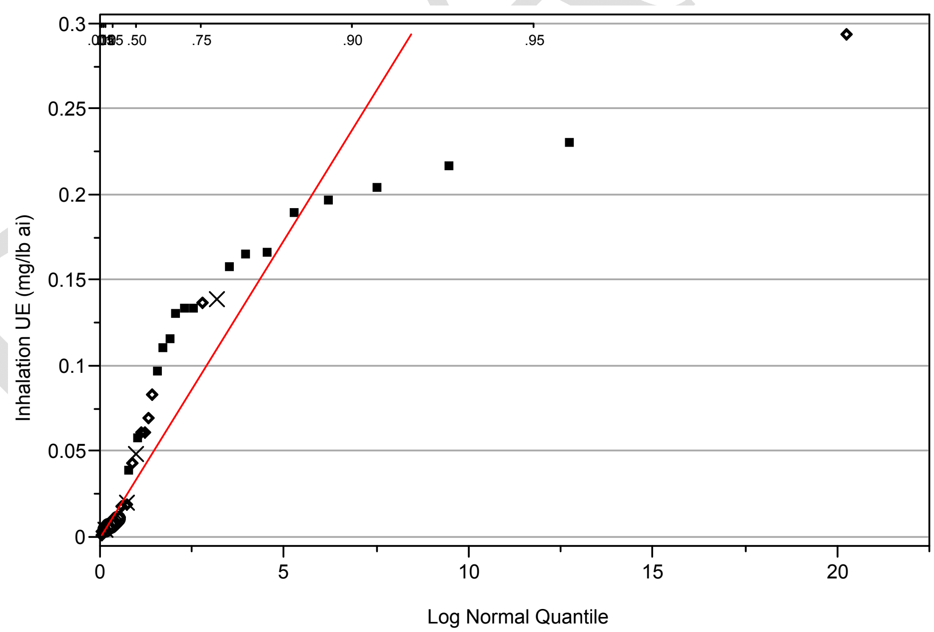
Inhalation Unit Exposure Data Summary: The recommended inhalation unit exposures for push-type spreader applications of granule pesticide formulations is based on a lognormal distribution fit with exposure monitoring data from Dean, V.C. (1988) [EPA MRID 41054704], Rosenheck, L. et al (1993) [EPA MRID 43016506], Hamburger, S.J. (1984) [EPA MRID 00149007], and Shurdut, B.A., et al (1993) [EPA MRID 46807004]. Dean, V.C. (1988) monitored 16 applications of a granule formulation foundations, patios, driveways, and sidewalks of houses using a "whirly-bird spreader". Rosenheck, L. et al (1993) monitored 15 applications of a granule formulation for approximately 30-40 minutes to turf in North Carolina using a push cyclone spreader. Hamburger, S.J. (1984) monitored 5 applications of a granule formulation to approximately 2 acres of container ornamentals in California using chest-mounted application equipment. Shurdut, B.A., et al (1993) monitored 9 applications of a granule formulation for approximately 4 hours to approximately 1 acre of turf in Michigan using a "hand cyclone spreader".

Log-normal Probability Plots

Legend: ■ = Dean, V.C., (1988)



Legend: X = Hamburger, S.J., (1984); ◊ = Rosenheck, L., et al (1993); ■ = Dean, V.C., (1988); O = Shurdut, B.A., et al (1993)



Available Handler Exposure Studies

Table B-14: Exposure Study Identification Information	
Citation	Rosenheck, L.; Phillips, J.; Selman, F. (1993). Worker Mixer/Loader and Applicator Exposure to Atrazine
EPA MRID	43016506
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: A total 15 application events were monitored using 8 volunteers loading and applying granules to turf sites in North Carolina using a "hand cyclone spreader" (i.e., a belly grinder). Each individual handled approximately 170 lbs granule formulation (1.02% atrazine; 1.7 lbs atrazine) and spent approximately 30-40 minutes per application. Dermal exposure monitoring represented an individual wearing a long-sleeve shirt, pants, shoes, socks, and no chemical-resistant gloves. Inhalation exposure was measured using standard pumps (set at 1.5 liters per minute), cassettes, and tubing. Percent recovery (mean ± SD) for laboratory fortifications is as follows: 97.2 ± 19.2% for glass fiber filter, 96.3 ± 29.4% for handwash, 107 ± 12.1% for facial swipe, and 105 ± 32.3% for whole-body dosimeter. With the exception of one low average recovery, 42.4% for handwashes at site 1, average field fortification recoveries ranged from 61.5% to 98.2%. The majority of the individual fortification recoveries fell within the 50% to 120% range with the noted exception of the high-level fortification of the handwash solutions, facial swabs, and whole-body dosimeters at Site 1, which averaged from 61.6% to 68.2%.

Table B-15: MRID 43016506 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only inhalation exposure data are included since the dermal exposure data are not recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-16: MRID 43016506 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation

D	1.84	--	0.008	--	0.0043
D	1.49	--	0.013	--	0.0087
D	1.67	--	0.021	--	0.0126
D	1.67	--	0.009	--	0.0054
D	1.67	--	0.031	--	0.0186
E	1.67	--	0.072	--	0.0431
E	1.67	--	0.032	--	0.0192
E	1.67	--	0.116	--	0.0695
E	1.67	--	0.104	--	0.0623
E	1.67	--	0.103	--	0.0617
E	1.67	--	0.140	--	0.0838
F	1.65	--	0.486	--	0.2945
F	1.65	--	0.227	--	0.1376
F	1.67	--	0.003	--	0.0018
F	1.67	--	0.006	--	0.0036

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of granule pesticide formulations using a belly grinder, the following limitations are noted:

- Each individual handled practically the same amount of active ingredient, making analysis of the relationship between exposure and the amount of active ingredient handled (the underlying basis of unit exposures) difficult.

Table B-17: Exposure Study Identification Information	
Citation	Hamburger, S.J. 1984. Assessment of Exposure to Chipco Ronstar G® during application to container ornamentals.
EPA MRID	00149007
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Three workers were monitored over the course of three days (totaling 5 monitored application events) while applying a granule formulation of the active ingredient oxadiazon using "chest-mounted application equipment" to container ornamentals in California. Each application consisted of applying approximately 174 lbs product/acre (3.5 lbs ai/acre) to approximately 2 acres of container ornamentals. Dermal exposure was measured using gauze patches placed strategically across the workers' bodies (inside and outside the work clothing) as well as hand washes underneath chemical-resistant gloves. Inhalation exposure was measured using standard pumps (4-7 liters of air collected per application; flow rate unknown), cassettes, and tubing. Recoveries from field fortifications of exposure sampling matrices were generally above 90%, though inhalation sampling varied widely from 68 to 97% recovery.

Table B-18: MRID 00149007 – Checklist and Use Recommendation

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	No	No
Should this study be recommended for use in residential handler exposure assessments?	**No**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only inhalation exposure data are included since the dermal exposure data are not recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-19: MRID 00149007 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	6.0000	--	0.833	--	0.139
A	8.1200	--	--	--	--
B	6.0000	--	0.116	--	0.019
B	7.5200	--	0.358	--	0.048
C	7.2000	--	0.028	--	0.004

1 Amount of active ingredient Handled
2 Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
3 Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
4 Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of granule pesticide formulations using a belly grinder, the following limitations are noted:

- The study monitored workers in a California nursery; therefore, using this study for residential assessments introduces uncertainty.
- The second application for Worker A was not used as the collection pump reportedly malfunctioned.

Table B-20: Exposure Study Identification Information	
Citation	Dean, V.C. 1988. Exposure of applicators to Propoxur during application of Baygon 2% bait insecticide around foundations, patios, driveways or sidewalks. Report No. 99131.
EPA MRID	41054704
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: A total of 16 applications were monitored using 3 volunteers loading and applying 2% propoxur granules around foundations, patios, driveways, and sidewalks of houses using a "whirly-bird spreader" (i.e., belly grinder). Each worker applied approximately 5.7 oz of the bait formulation per 1000 ft^2 resulting in a range of 0.0069 to 0.0425 lbs of active ingredient (propoxur) per application. The sampling time ranged from 4 to 11 minutes. Dermal exposure was monitored using gauze patches strategically placed on each body part both inside and outside the individuals clothing. This methodology allows for representation of individuals wearing shorts, a short-sleeve shirt, shoes and socks. Chemical-resistant gloves were worn so exposure values to bare hands had to be back-calculated assuming 90% protection from chemical-resistant gloves. Inhalation exposure was measured using standard pumps (set at 1 liter per minute), cassettes, and tubing. Average laboratory recovery values are as follows, 103% with a standard deviation of 1.9% for air filters, 117% with a standard deviation of 7.7% for gauze pads, 116% with a standard deviation of 1.5% for low-level hand rinse and 122% with a standard deviation of 3.8% for high-level hand rinse. Average field recovery values are as follows, 95% with a standard deviation of 4.4% for air filters, 105% with a standard deviation of 2.9% for gauze pads (outside clothing), 90% with a standard deviation of 4.5% for gauze pads (outside clothing), 103% with a standard deviation of 3.5% for gauze pads (inside clothing), and 102% with a standard deviation of 1.4% for hand rinses.

Table B-21: MRID 41054704 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-22: MRID 41054704 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	0.0288	1.40	0.0017	49	0.0590
A	0.0425	4.31	0.0017	101	0.0400
A	0.0106	3.17	0.0017	299	0.1604
A	0.01	5.33	0.0017	533	0.1700
B	0.0125	1.65	0.0017	132	0.1360
B	0.0088	0.74	0.0017	84	0.1932
B	0.0125	4.31	0.0016	345	0.1280
B	0.0169	8.51	0.0016	503	0.0947
B	0.0119	4.74	0.0016	398	0.1345
B	0.015	14.89	0.0016	992	0.1067
C	0.0075	1.40	0.0016	186	0.2133
C	0.0088	6.03	0.0015	685	0.1705
C	0.0081	2.22	0.0016	274	0.1975
C	0.0069	3.48	0.0016	504	0.2319
C	0.0138	0.78	0.0016	56	0.1159
C	0.0081	1.50	0.0016	186	0.1975

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of granule pesticide formulations using a belly grinder, the following limitations are noted:

- The individuals monitored in the study wore chemical-resistant gloves. Because residential handler exposure assessments representative of individuals wearing chemical-resistant gloves are not typically conducted, a back-calculation (i.e., increasing hand exposures by 90%) to represent “bare hand” exposure was necessary, adding uncertainty to the unit exposures.
- All inhalation samples were non-detects. One-half the limit of detection (0.2 ug) was used in exposure calculations.

Table B-23: Exposure Study Identification Information	
Citation	Shurdut, B.A. and Murphy, P.G. (1993). Evaluation of Flurprimidol Exposures during Mixing/Loading and Application of CUTLESS .33G Growth Regulator
EPA MRID	46807004
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: A total of 9 application events were monitored while loading and applying flurprimidol granules using a “hand cyclone spreader” to approximately 0.9 acres (six 0.15 acre plots) of turf in Michigan over the course of a 4 hour period. Each individual handled a total of approximately 400 lbs of formulation (1.4 lbs flurprimidol), equivalent to approximately 1.5 lb ai per acre. Dermal exposure was monitored using gauze patches, though the placement only allows for representation of individuals wearing a long-sleeve shirt, long pants, shoes and socks. Chemical-resistant gloves were not worn. Inhalation exposure was measured using standard pumps (set at 1 liter per minute), cassettes, and tubing. Average laboratory recoveries were as follows: 99.0 ± 10.2% for air filters and 98.0 ± 9.9% for tubes; 118.4 ± 6.5%. for hand washes; and 100.3 ± 6.9% for the gauze patches. Travel spike average recoveries for the tube, filter, hand rinse, and gauze patch travel spikes were 104%, 112%, 101%, and 112%, respectively. Since the results were all equal to or greater than 100%, no corrections to the data were applied based on these spikes. Field fortification recoveries for the filter, hand rinse, and gauze patch field spikes were 104%, 98%, and 90%, respectively.

Table B-24: MRID 46807004 – Checklist and Use Recommendation

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only inhalation exposure data are included since the dermal exposure data are not recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-25: MRID 46807004 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
DS	1.33	--	0.009	--	0.007
DV	0.82	--	0.006	--	0.008
IC	1.29	--	0.006	--	0.005
JC	1.00	--	0.011	--	0.011
JJ	1.26	--	0.012	--	0.009
JM	1.24	--	0.009	--	0.007
MD	1.36	--	0.007	--	0.005
MS	1.28	--	0.012	--	0.010
NB	1.37	--	0.010	--	0.007

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of granule pesticide formulations using a belly grinder, the following limitations are noted:

- Based on the amount of product applied and the application duration, the study was meant to simulate a professional lawn care operator, so using this study for residential assessments introduces uncertainty.

Table B-26: Exposure Study Identification Information	
Citation	Spencer, et al. (1997). Exposure of Hand Applicators to Granular Hexazinone in Forest Settings, 1993-1995.
EPA MRID	none
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Twenty-nine workers were monitored on 11 days at 4 different sites over the course of 3 years, totaling 129 monitored worker-days, while applying 10% hexazinone granules to forestry areas using a belly grinder. Applying approximately 3-4 lbs/acre, each worker handled from 15 – 35 lbs of hexazinone per workday (150 – 350 lbs formulation). Dermal exposure was monitored using whole body dosimetry underneath normal work clothing and hand wipes used at various intervals throughout the workday. Workers wore various types of clothing and personal protective equipment. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Recoveries from field fortifications of exposure sampling matrices were generally above 90%.

Table B-27: Spencer, et al. (1997) – Checklist and Use Recommendation

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Scenario Summary

Table B-28: Scenario Description and Available Exposure Studies	
Formulation	Granules
Equipment/Application Method	Spoon
Application Site(s)	outdoors (lawn, gardens, trees/bushes, perimeter, mounds/nest)
Available Exposure Studies	Pontal, P.G. (1996); MRID 45250702

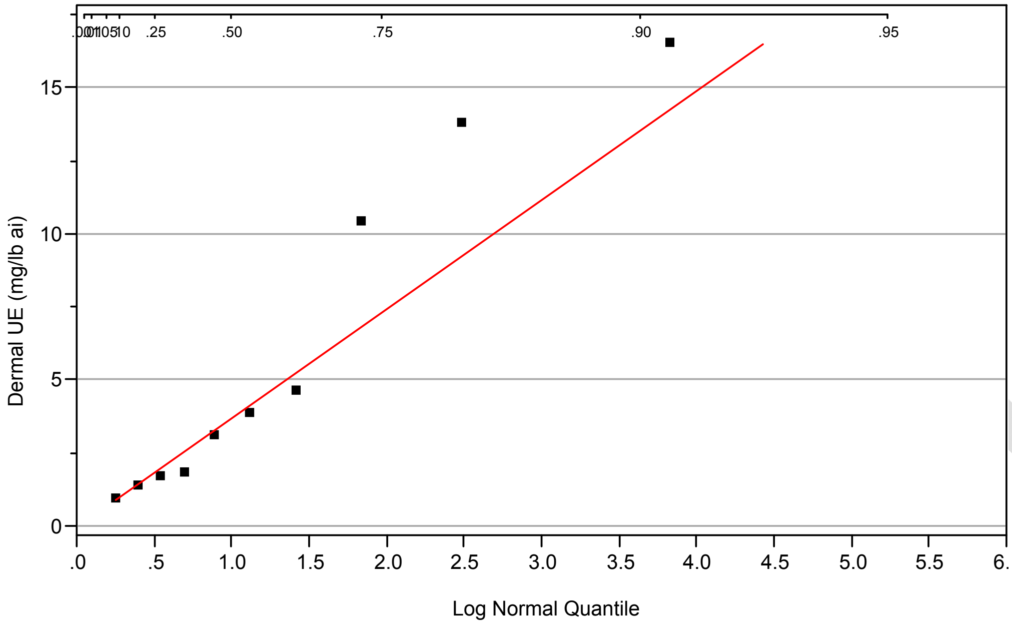
Table B-29: Unit Exposures (mg/lb ai) – Granule Spoon Applications		
Statistic	Dermal	Inhalation
50^{th} percentile	3.7	0.024
75^{th} percentile	7.3	0.071
95^{th} percentile	20	0.34
99^{th} percentile	39	1.0
99.9^{th} percentile	83	3.4
AM (SD)	6.2 (8.2)	0.087 (0.30)
GM (GSD)	3.7 (2.7)	0.024 (5.0)
Range	1 – 16	0.0024 – 0.33
N	10	10

Dermal Unit Exposure Data Summary: The recommended dermal unit exposures for applications of granule pesticide formulations using a spoon is based on a lognormal distribution fit with exposure monitoring data from Pontal, P.G. (1996) [EPA MRID 45250702]. Pontal, P.G. (1996) monitored 10 applications of a granule formulation to a 1 acre banana plantation in Cameroon using a spoon.

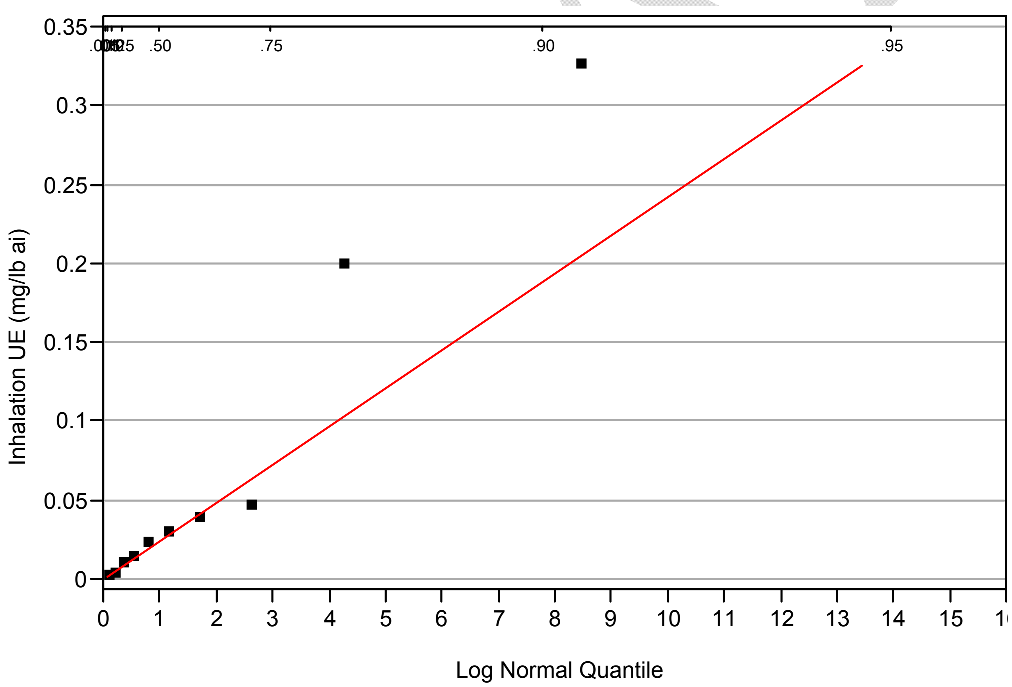
Inhalation Unit Exposure Data Summary: The recommended inhalation unit exposures for applications of granule pesticide formulations using a spoon is based on a lognormal distribution fit with exposure monitoring data from Pontal, P.G. (1996) [EPA MRID 45250702]. Pontal, P.G. (1996) monitored 10 applications of a granule formulation to a 1 acre banana plantation in Cameroon using a spoon.

Log-normal Probability Plots

Legend: ■ = Pontal, P.G. (1996)



Legend: ■ = Pontal, P.G. (1996)



Available Handler Exposure Studies:

Table B-30: Exposure Study Identification Information	
Citation	Pontal, P.G. (1996). Worker Exposure Study During Application Of Regent 20GR In Banana Plantation, (RP Study 94/136 - Amended)
EPA MRID	45250702
ORETF Code	NA
EPA Review	D270065
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: A total of 10 applications were monitored on two days for workers applying a granule formulation of fipronil with a spoon in banana plantations in Cameroon. The workers covered approximately 1 acre per application-event, applying granules to approximately 800 plants at a rate of 0.15 gms active ingredient per plant (13 lbs product; 0.26 lbs fipronil). Dermal exposure was monitored using whole body dosimetry – which served as the workers normal clothing (i.e., measurements would be representative of workers without clothing). Clothing protection factors were required to estimate exposure for workers while wearing clothing. Workers wore chemical-resistant gloves with cotton gloves underneath serving as the hand exposure measurement method. Inhalation exposure was measured using standard pumps (set at 1 liter per minute), cassettes, and tubing. Overall recovery levels from field spiked samples were between 64% and 99% (average 87%) with only one recovery below 80%. Overall recovery levels from samples spiked in the laboratory were between 92 and 117.5%.

Table B-31: MRID 45250702 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-32: MRID 45250702 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
1	0.368	1.13	0.0010	3.06	0.0027
2	0.368	3.84	0.0009	10.42	0.0024
3	0.368	5.06	0.1198	13.76	0.3255

4	0.368	1.71	0.0731	4.64	0.1986
5	0.368	0.62	0.0037	1.70	0.0101
6	0.368	6.07	0.0109	16.50	0.0296
7	--	--	--	--	--
8	0.247	0.94	0.0114	3.82	0.0462
9	0.247	0.45	0.0057	1.83	0.0231
10	0.247	0.23	0.0034	0.94	0.0138
11	0.247	0.33	0.0094	1.36	0.0381

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of granule pesticide formulations using a spoon, the following limitations are noted:

- Dermal exposure was measured using clothing the individuals wore, thus representing applicators not wearing any clothing. To estimate exposure representative of applicators wearing shorts, short-sleeve shirt, shoes, and socks, a penetration factor of 50% was used for exposure measurements to the torso, upper arms, and upper legs.
- For hand exposure, since chemical-resistant gloves were worn, a protection factor of 90% was used to back-calculate "bare" hand exposure.

Scenario Summary

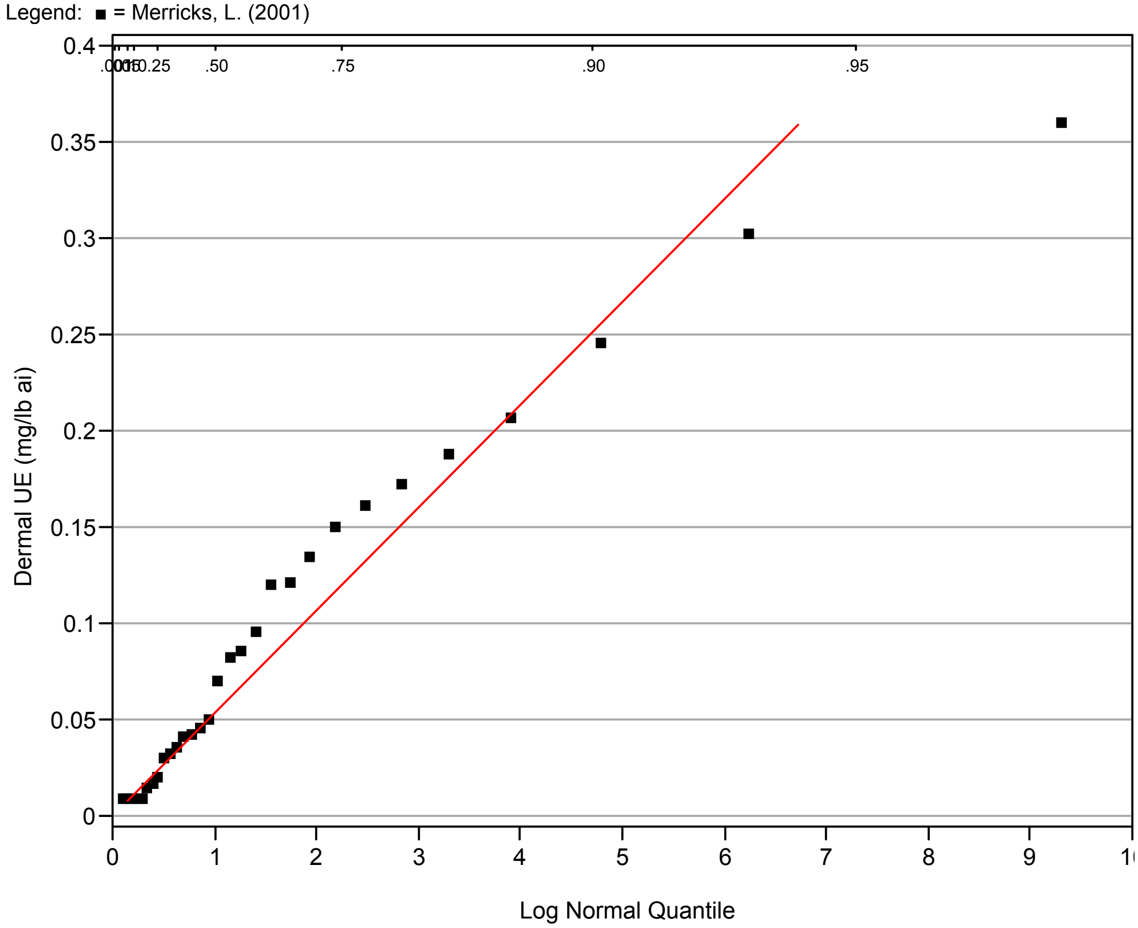
Table B-33: Scenario Description and Available Exposure Studies	
Formulation	Granules
Equipment/Application Method	Cup
Application Site(s)	outdoors (lawn, gardens, trees/bushes, perimeter, mounds/nest)
Available Exposure Studies	Merricks, L. (2001); MRID 45333401

Table B-34: Unit Exposures (mg/lb ai) – Granule Cup Applications		
Statistic	Dermal	Inhalation
50^{th} percentile	0.05	0.013
75^{th} percentile	0.12	0.013
95^{th} percentile	0.40	0.013
99^{th} percentile	0.91	0.013
99.9^{th} percentile	2.3	0.013
AM (SD)	0.11 (0.21)	0.013 (0)
GM (GSD)	0.05 (3.4)	0.013 (1)
Range	0.0075 – 0.36	0.013 – 0.013
N	30	30

Dermal Unit Exposure Data Summary: The recommended dermal unit exposures for applications of granule pesticide formulations using a cup is based on a lognormal distribution fit with exposure monitoring data from Merricks, L. (2001) [EPA MRID 45333401]. Merricks, L. (2001) monitored 60 applications of a granule formulation for approximately 20-40 minutes to shrubs and flower beds using a cup.

Inhalation Unit Exposure Data Summary: The recommended inhalation unit exposures for applications of granule pesticide formulations using a cup is based on a lognormal distribution fit with exposure monitoring data from Merricks, L. (2001) [EPA MRID 45333401]. Merricks, L. (2001) monitored 60 applications of a granule formulation for approximately 20-40 minutes to shrubs and flower beds using a cup.

Log-normal Probability Plots



Note: Inhalation unit exposure lognormal probability plot not shown as all unit exposures were identical – all inhalation samples were non-detects and all individuals handled the same amount of active ingredient.

Available Handler Exposure Studies

Table B-35: Exposure Study Identification Information	
Citation	Merricks, L. (2001) Determination of Dermal (Hand and Forearm) and Inhalation Exposure to Disulfoton Resulting from Residential Application of Bayer Advanced Garden 2-in-1 Systematic Rose and Flower Care to Shrubs and Flower Beds: Lab Project Number: 4201. Unpublished study prepared by Agrisearch Inc. 178 p.
EPA MRID	45333401
ORETF Code	NA
EPA Review	D273144
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Fifteen individuals were monitored during 4 applications (for a total of 60 application-events) of 1.04% disulfoton granules to shrubs and flower beds using a cup. An application consisted of pouring the product into the measuring cup/lid attached to the product package, then distributing the granules onto the soil around the base of the shrub or flower bed. Each application lasted between 20 and 40 minutes to apply approximately 10 pounds of formulation (0.1 lbs of disulfoton). Dermal exposure was measured for the hands and forearms only using detergent washes. Half of the applications were with chemical-resistant gloves and half were without (i.e., 30 applications with and 30 applications without chemical-resistant gloves). Inhalation exposure was measured using standard pumps (set at 1 liter per minute), cassettes, and tubing. All inhalation samples were non-detects. The overall mean percent recovery of concurrent laboratory fortifications from air sampling tubes was 99.9 ± 6.42%. The overall mean percent recovery from hand/forearm wash solution was 99.5 ± 9.15%. For air samples, the overall average fortified field recovery was 98.2 ± 6.32% with no apparent differences in mean recoveries between days or fortification levels. Overall field fortified recovery for hand/forearm wash samples collected from volunteers who did not wear gloves was 99.4 ± 7.95% with no apparent differences in recovery values between days.

Table B-36: MRID 45333401 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-37: MRID 45333401 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
1	0.1	0.013	0.0013	0.13	0.013
2	0.1	0.030	0.0013	0.30	0.013
3	0.1	0.019	0.0013	0.19	0.013
4	0.1	0.015	0.0013	0.15	0.013
5	0.1	0.004	0.0013	0.04	0.013
6	0.1	0.017	0.0013	0.17	0.013
7	0.1	0.005	0.0013	0.05	0.013
8	0.1	0.002	0.0013	0.02	0.013
9	0.1	0.009	0.0013	0.09	0.013
10	0.1	0.036	0.0013	0.36	0.013
11	0.1	0.004	0.0013	0.04	0.013
12	0.1	0.025	0.0013	0.25	0.013
13	0.1	0.001	0.0013	0.01	0.013
14	0.1	0.007	0.0013	0.07	0.013
15	0.1	0.016	0.0013	0.16	0.013
1	0.1	0.001	0.0013	0.01	0.013
2	0.1	0.003	0.0013	0.03	0.013
3	0.1	0.002	0.0013	0.02	0.013
4	0.1	0.021	0.0013	0.21	0.013
5	0.1	0.008	0.0013	0.08	0.013
6	0.1	0.001	0.0013	0.01	0.013
7	0.1	0.001	0.0013	0.01	0.013
8	0.1	0.001	0.0013	0.01	0.013
9	0.1	0.004	0.0013	0.04	0.013
10	0.1	0.005	0.0013	0.05	0.013
11	0.1	0.012	0.0013	0.12	0.013
12	0.1	0.003	0.0013	0.03	0.013
13	0.1	0.012	0.0013	0.12	0.013
14	0.1	0.001	0.0013	0.01	0.013
15	0.1	0.008	0.0013	0.08	0.013

1 Amount of active ingredient Handled
2 Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
3 Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
4 Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of granule pesticide formulations using a cup, the following limitations are noted:

- Dermal exposure was measured only on the hands and forearms. To the extent that this type of application would result in significant exposure to the lower body, the use of this data may underestimate exposure.
- Each individual handled the same amount of active ingredient making analysis of the relationship between exposure and the amount of active ingredient handled (the underlying basis of unit exposures) difficult.
- All inhalation samples were non-detects. One-half the limit of quantification (0.30) was used.

Scenario Summary

Table B-38: Scenario Description and Available Exposure Studies	
Formulation	Granules
Equipment/Application Method	Hand dispersal
Application Site(s)	outdoors (lawn, gardens, trees/bushes, perimeter, mounds/nest)
Available Exposure Studies	Dean, V.C. (1991); MRID 41896401

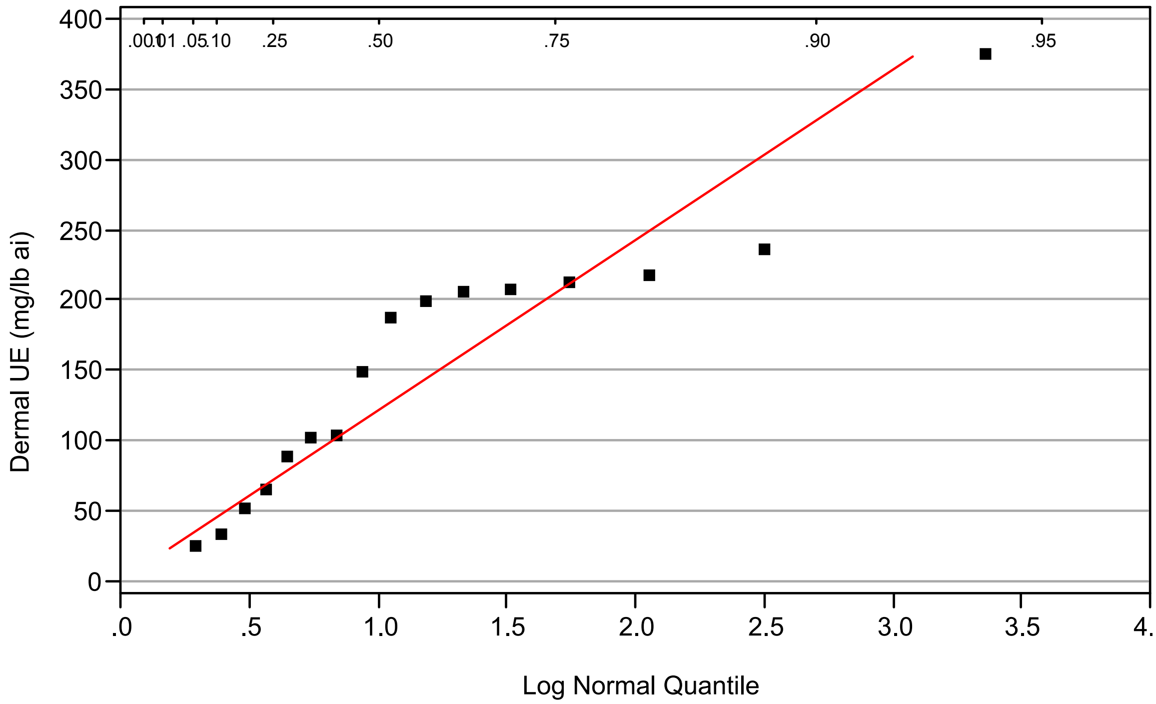
Table B-39: Unit Exposures (mg/lb ai) – Granule Applications by Hand		
Statistic	Dermal	Inhalation
50^{th} percentile	120	0.28
75^{th} percentile	205	0.47
95^{th} percentile	430	1.0
99^{th} percentile	740	1.7
99.9^{th} percentile	1300	3.1
AM (SD)	160 (150)	0.38 (0.35)
GM (GSD)	120 (2.2)	0.28 (2.2)
Range	24 – 370	0.064 – 0.95
N	16	16

Dermal Unit Exposure Data Summary: The recommended dermal unit exposures for applications of granule pesticide formulations by hand is based on a lognormal distribution fit with exposure monitoring data from Dean, V.C. (1991) [EPA MRID 41896401]. Dean, V.C. (1991) monitored 16 applications of a granule formulation to driveways, sidewalks, patios, foundations, and flower beds around private residences in Florida.

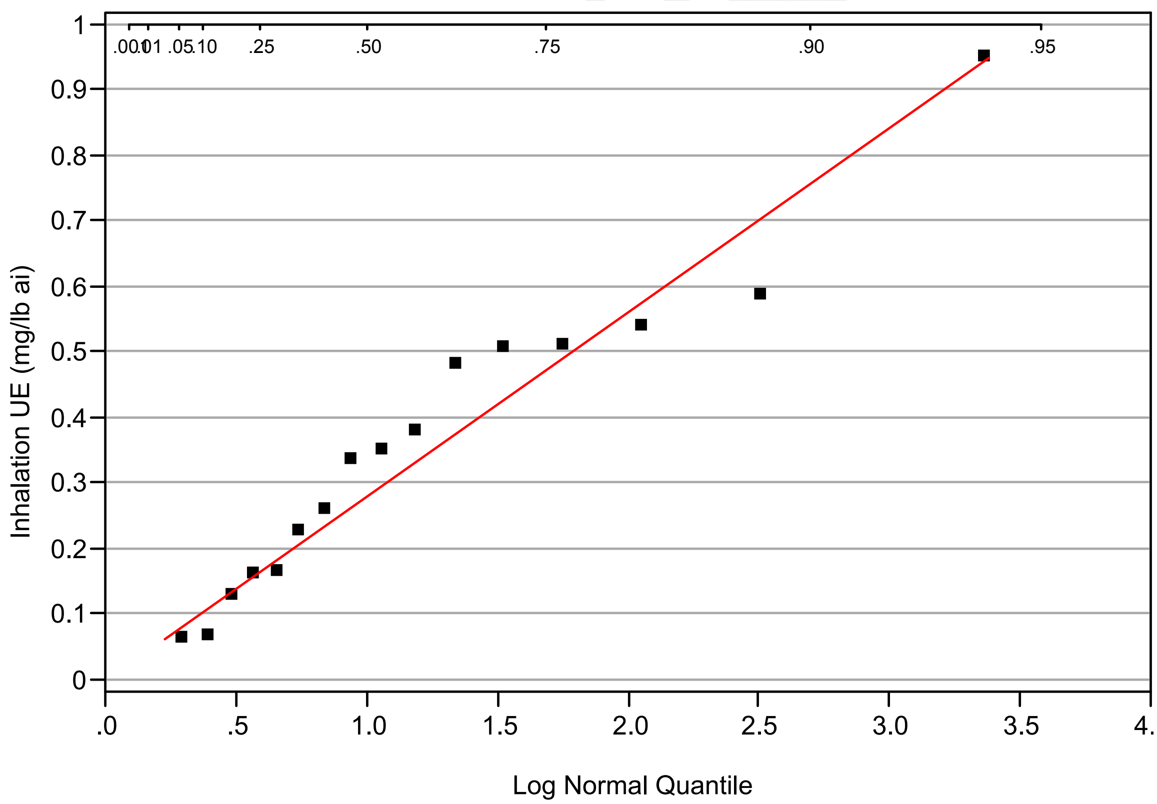
Inhalation Unit Exposure Data Summary: The recommended inhalation unit exposures for applications of granule pesticide formulations by hand is based on a lognormal distribution fit with exposure monitoring data from Dean, V.C. (1991) [EPA MRID 41896401]. Dean, V.C. (1991) monitored 16 applications of a granule formulation to driveways, sidewalks, patios, foundations, and flower beds around private residences in Florida.

Log-normal Probability Plots

Legend: ■ = Dean, V.C. (1991)



Legend: ■ = Dean, V.C. (1991)



Available Handler Exposure Studies

Table B-40: Exposure Study Identification Information	
Citation	Dean, V.C. (1991). Exposure of applicators to Propoxur during application of Baygon 2% bait insecticide around foundations, patios, driveways, or sidewalks
EPA MRID	41896401
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Three commercial applicators were each monitored 5 times (for a total of 16 application-events) while applying 2% propoxur granules by hand to driveways, sidewalks, patios, foundations, and flower beds around private residences in Florida. Each application consisted of treating one residences using less than 1 lb of product with gloved hands at a rate of approximately 4 ounces per 1000 ft^2 (0.005 lb ai/1000 ft^2). Dermal exposure was measured using gauze patches both inside and outside the normal work clothing (long-sleeve shirt, long pants, shoes, socks) as well as hand washes to measure exposure to hands underneath chemical-resistant gloves. Inhalation exposure was measured using standard pumps (set at 1 liter per minute), cassettes, and tubing. Recoveries from field fortifications of exposure sampling matrices were generally above 90%.

Table B-41: MRID 41896401 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-42: MRID 41896401 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	0.026	0.635	0.0017	24	0.0654
A	0.003	0.635	0.0016	205	0.5333
A	0.003	0.635	0.0016	235	0.5333
A	0.005	0.970	0.0016	206	0.3200
A	0.005	0.970	0.0016	216	0.3200

B	0.013	0.635	0.0016	51	0.1231
B	0.003	0.635	0.0016	212	0.5333
B	0.002	0.635	0.0016	374	0.8000
B	0.003	0.635	0.0016	199	0.5333
B	0.006	0.635	0.0016	102	0.2667
C	0.010	0.635	0.0016	64	0.1600
C	0.007	0.635	0.0016	88	0.2286
C	0.003	0.635	0.0016	187	0.5333
C	0.004	0.635	0.0016	148	0.4000
C	0.010	1.034	0.0016	103	0.1600
C	0.024	0.780	0.0016	33	0.0667

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of granule pesticide formulations by hand, the following limitations are noted:

- The individuals monitored in the study wore chemical-resistant gloves and nearly all dermal measurements (hands and body) were non-detects. Exposure was therefore calculated using ½ of the limit of quantification (0.41 ug for body exposure; 41 ug for hand exposure) and hand measurements required a back-calculation using a 90% protection factor to represent "bare" hand exposure.
- All inhalation samples were non-detects. One-half the limit of detection (0.2 ug) was used.

Scenario Summary

Table B-43: Scenario Description and Available Exposure Studies	
Formulation	Dusts/Powders
Equipment/Application Method	Plunger duster
Application Site(s)	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests), indoors (general broadcast treatments)
Available Exposure Studies	Merricks, D.L. (1997); MRID 44459801

Table B-44: Unit Exposures (mg/lb ai) – Dust/Powder Plunger Duster Applications

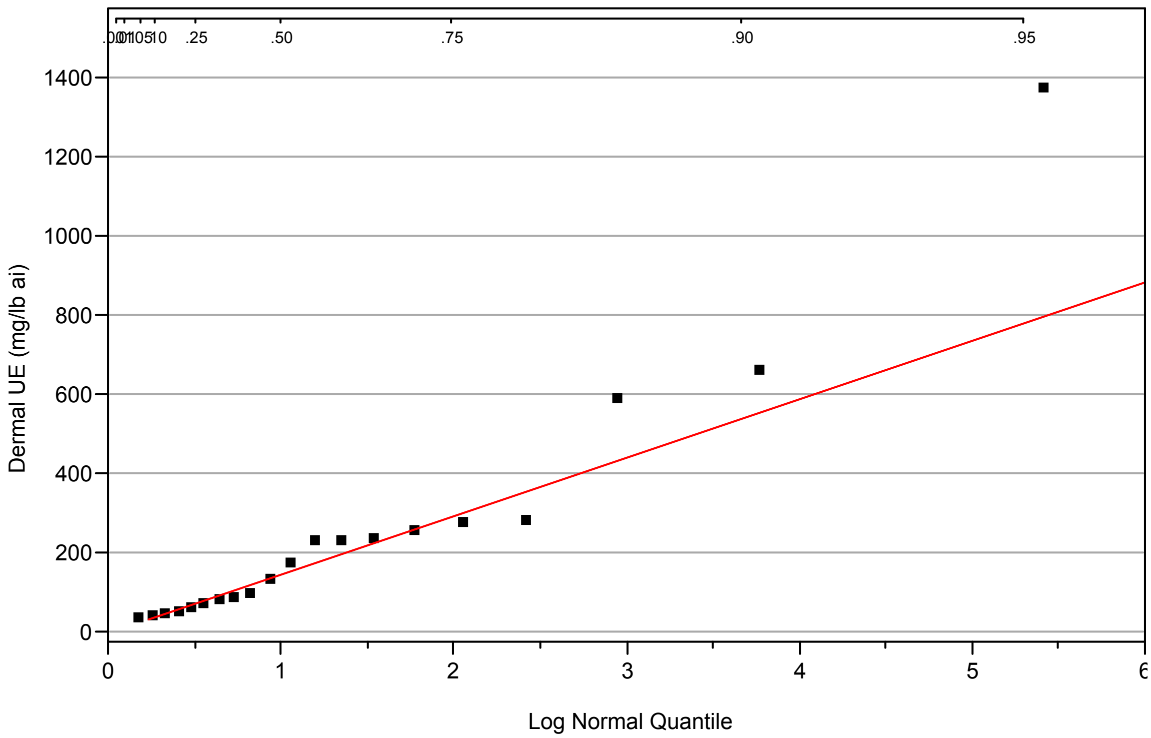
Statistic	Dermal	Inhalation
50^{th} percentile	150	0.50
75^{th} percentile	290	1.4
95^{th} percentile	790	6.5
99^{th} percentile	1600	19
99.9^{th} percentile	3400	62
AM (SD)	250 (330)	1.7 (5.4)
GM (GSD)	150 (2.8)	0.50 (4.8)
Range	36 – 1400	0.0045 – 8.2
N	20	20

Dermal Unit Exposure Data Summary: The recommended dermal unit exposures for applications of dust or powder pesticide formulations using a plunger duster is based on a lognormal distribution fit with exposure monitoring data from Merricks, D.L. (1997) [EPA MRID 44459801]. Merricks, D.L. (1997) monitored 20 applications of a dust formulation for approximately 20 minutes to garden plants using a hand-operated plunger duster.

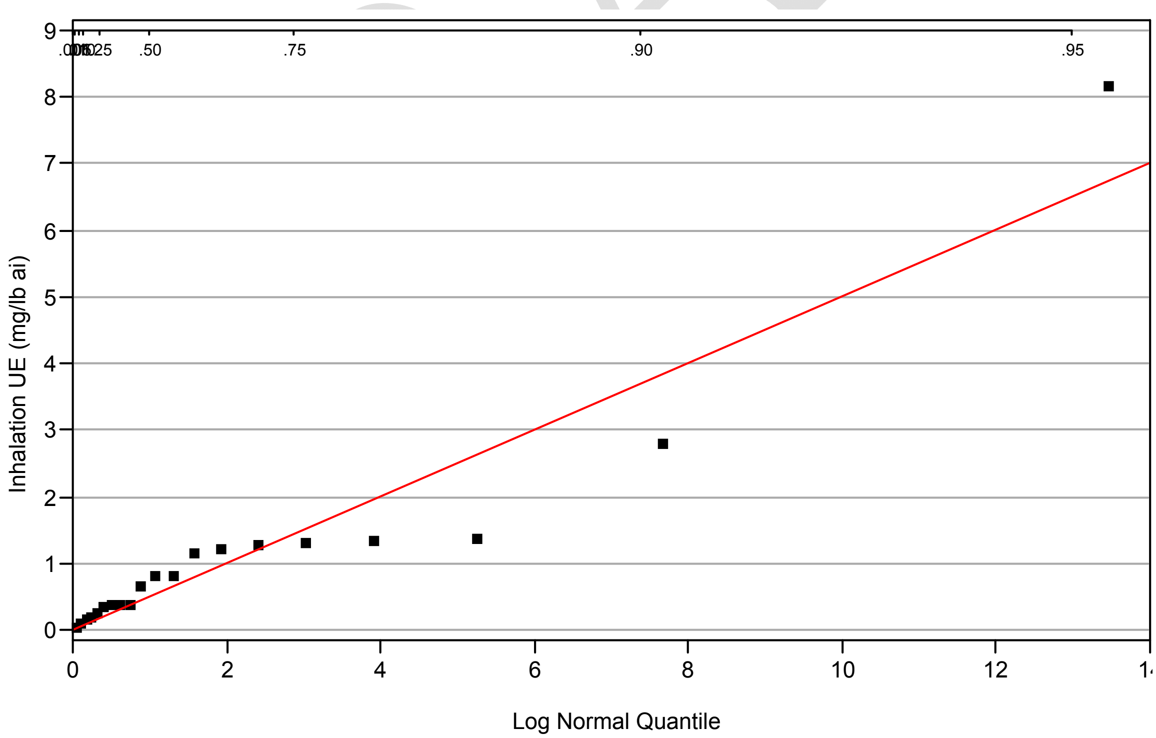
Inhalation Unit Exposure Data Summary: The recommended inhalation unit exposures for applications of dust or powder pesticide formulations using a plunger duster is based on a lognormal distribution fit with exposure monitoring data from Merricks, D.L. (1997) [EPA MRID 44459801]. Merricks, D.L. (1997) monitored 20 applications of a dust formulation for approximately 20 minutes to garden plants using a hand-operated plunger duster.

Lognormal Probability Plots

Legend: ■ = Merricks, D.L. (1997)



Legend: ■ = Merricks, D.L. (1997)



Available Handler Exposure Studies

Table B-45: Exposure Study Identification Information	
Citation	Merricks, D.L. (1997). 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
EPA MRID	44459801
ORETF Code	OMA006
EPA Review	EPA Memo from G. Bangs to D. Fuller (3/5/03)
	D287251
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Twenty individuals were monitored while applying a dust formulation (10% carbaryl) to gardens using a hand-operated plunger duster (The Spritzer™). Each application was approximately 20 minutes and consisted of loading the duster and applying approximately 0.16 lbs formulation (0.017 lbs carbaryl) to garden plants. Dermal exposure was measured using inner and outer whole body dosimetry and hand washes (without chemical-resistant gloves worn). Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Field fortification recoveries for passive dosimeters averaged 84.3% for inner dosimeters and 77.7% for outer dosimeters. Face and neck wipe field fortifications averaged 84.8%. Both handwash and inhalation tube field fortification averaged >90%. Laboratory method validation for each matrix fell within the acceptable range of 70 to 120%. 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.

Table B-46: MRID 44459801 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-47: MRID 44459801 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation

E	0.003	2.22	0.0043	661	1.43
F	0.025	14.70	0.0087	590	0.35
I	0.007	1.99	0.0058	275	0.83
H	0.012	1.55	0.0154	132	1.28
K	0.012	2.11	0.0021	172	0.18
L	0.013	1.22	0.0046	97	0.35
O	0.005	1.06	0.0126	234	2.52
P	0.009	2.13	0.0000	228	0.00
S	0.013	1.09	0.0158	82	1.22
T	0.015	1.03	0.0033	70	0.22
W	0.019	1.55	0.0235	84	1.24
X	0.012	3.10	0.0045	252	0.38
A2	0.029	1.48	0.0332	51	1.14
B2	0.003	3.61	0.0214	1375	7.13
E2	0.020	0.80	0.0014	40	0.07
F2	0.009	2.41	0.0053	280	0.59
I2	0.030	1.28	0.0242	42	0.81
J2	0.044	1.58	0.0144	36	0.33
M2	0.013	2.85	0.0171	227	1.32
O2	0.026	1.54	0.0039	60	0.15

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of dust/powder formulations using a plunger duster, the following limitations are noted:

- Though the study was strictly conducted outdoors, it is recommended for indoor use as well since no indoor plunger duster study is available. Such use introduces uncertainty.

Scenario Summary

Table B-48: Scenario Description and Available Exposure Studies	
Formulation	Dusts/Powders
Equipment/Application Method	Shaker can
Application Site(s)	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests), indoors (general broadcast treatments), pets/animals
Available Exposure Studies	Merricks, D. (1997); MRID 44439901
	McKeown, K. (2001); MRID 45519601

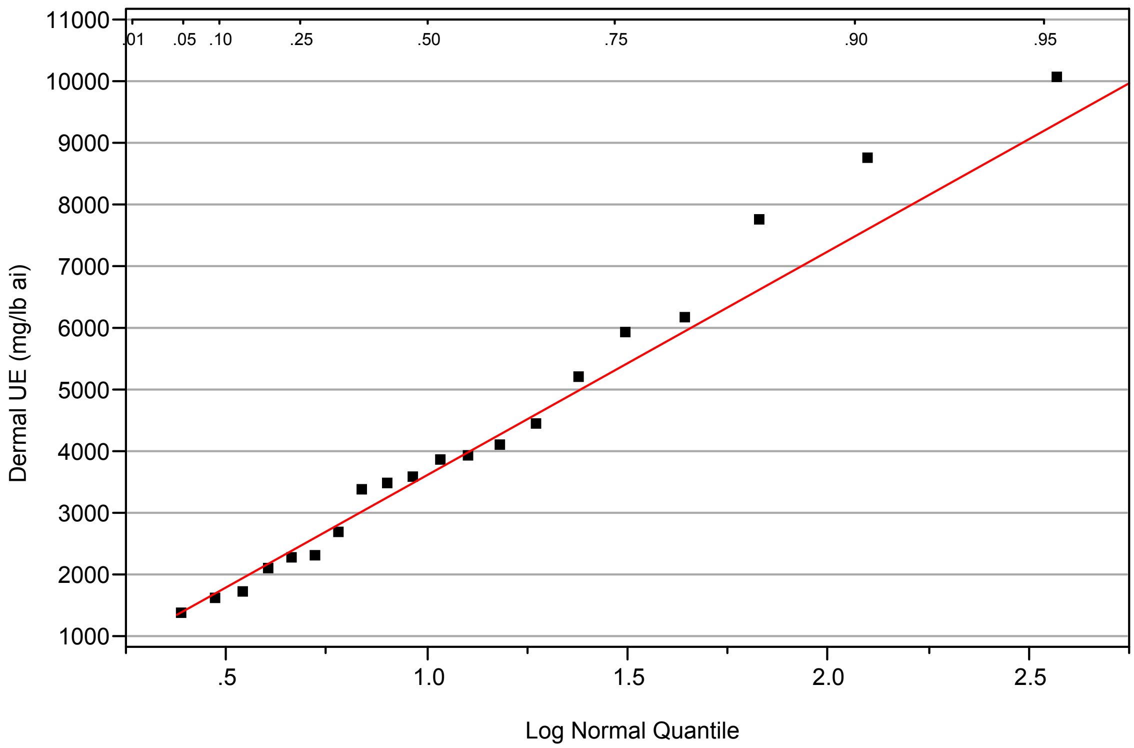
Table B-49: Unit Exposures (mg/lb ai) – Dust/Powder Shaker can Applications		
Statistic	Dermal	Inhalation
50th percentile	3600	9.4
75th percentile	5300	20
95th percentile	9200	59
99th percentile	14000	130
99.9th percentile	21000	290
AM (SD)	4300 (2600)	18 (28)
GM (GSD)	3600 (1.8)	9.4 (3.1)
Range	1400 – 10000	0.36 – 74
N	20	55

<u>Dermal Unit Exposure Data Summary:</u> The recommended dermal unit exposures for applications of dust or powder pesticide formulations using a shaker can is based on a lognormal distribution fit with exposure monitoring data from Merricks, D. (1997) [EPA MRID 44439901]. Merricks, D. (1997) monitored 40 applications of a dust formulation to dogs for approximately 7 minutes using a 1 lb shaker can.

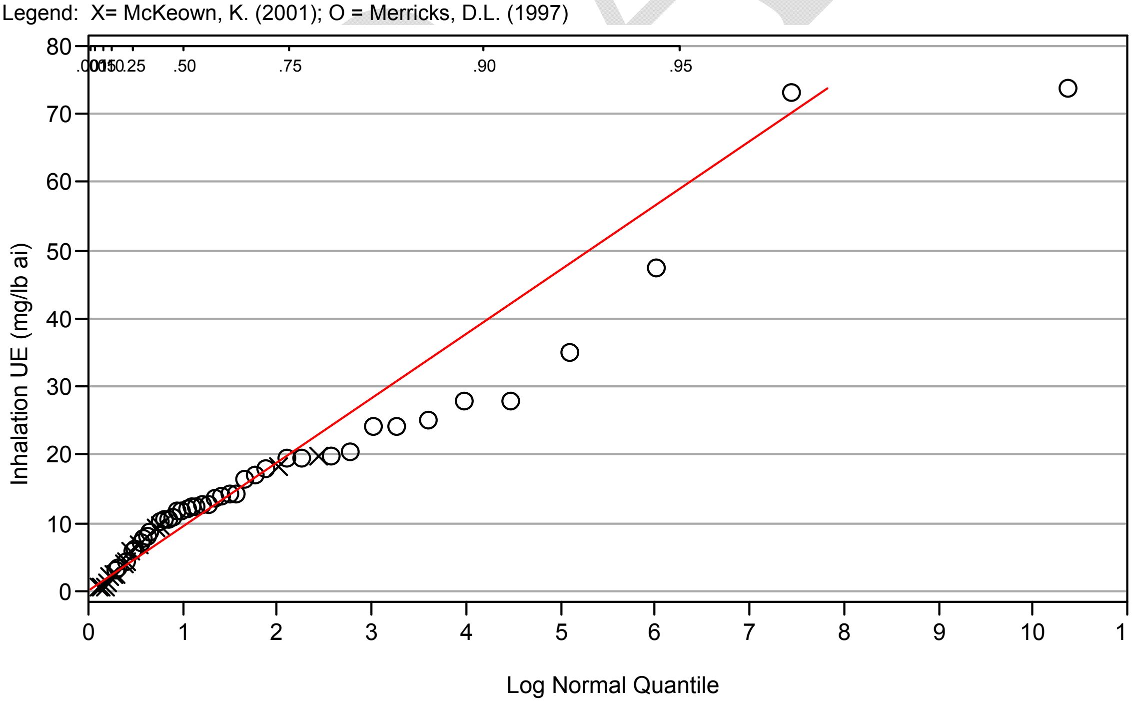
<u>Inhalation Unit Exposure Data Summary:</u> The recommended inhalation unit exposures for applications of dust or powder pesticide formulations using a shaker can is based on a lognormal distribution fit with exposure monitoring data from Merricks, D. (1997) [EPA MRID 44439901] and McKeown, K. (2001) [MRID 45519601]. Merricks, D. (1997) monitored 40 applications of a dust formulation to dogs for approximately 7 minutes using a 1 lb shaker can. McKeown, K. (2001) monitored 15 applications of approximately 1 ounce of a dust formulation for approximately 2-3 minutes to dogs using a shaker can.

Lognormal Probability Plots

Legend: ■ = Merricks, D.L. (1997)



Legend: X= McKeown, K. (2001); O = Merricks, D.L. (1997)



Available Handler Exposure Studies

Table B-50: Exposure Study Identification Information	
Citation	Merricks, D. (1997) Carbaryl Applicator Exposure Study During Application of Sevin 5 Dust to Dogs by the Non Professional: Lab Project Number: 1517: 10565: ML96 0662 RHP. Unpublished study prepared by Agrisearch Inc., Rhone Poulenc Ag Co. and Morse Laboratories, Inc. 212 p.
EPA MRID	44439901
ORETF Code	NA
EPA Review	D287251
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: A total of 40 individuals – 20 with and 20 without chemical-resistant gloves – were monitored while applying a dust formulation (5% carbaryl) to dogs. Each application, lasting approximately 7 minutes, consisted of an individual using a 1 lb shaker can to apply an average of 0.15 lbs of dust (0.008 lbs carbaryl) to 3 dogs, then rubbing the dust into the dog's coat. Dermal exposure was measured using inner and outer whole body dosimetry and hand washes. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Field fortification recoveries for passive dosimeters averaged >90% for inner and outer dosimeters. Face and neck wipe field fortifications average 87.6%. Inhalation tube field fortification averaged 100. Laboratory method validation for each matrix fell within the acceptable range of 70 to 120%.

Table B-51: MRID 44439901 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal (individuals without chemical-resistant gloves only) and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-52: MRID 44439901 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
1	0.005	--	0.036	--	7.20
2	0.015	--	0.307	--	20.47

3	0.0034	34.15	0.220	10044	64.71
4	0.016	82.94	0.134	5184	8.38
5	0.005	--	0.016	--	3.20
6	0.008	--	0.100	--	12.50
7	0.0079	10.84	0.145	1372	18.35
8	0.0042	25.84	0.140	6152	33.33
9	0.01	--	0.120	--	12.00
10	0.0083	64.13	0.086	7726	10.36
11	0.002	--	0.029	--	14.50
12	0.007	--	0.137	--	19.57
13	0.0025	10.19	0.022	4076	8.80
14	0.003	10.76	0.038	3586	12.67
15	0.008	--	0.062	--	7.75
16	0.0068	18.19	0.098	2676	14.41
17	0.009	--	0.094	--	10.44
18	0.011	--	0.221	--	20.09
19	0.0068	15.49	0.091	2278	13.38
20	0.012	104.75	0.302	8729	25.17
21	0.008	--	0.225	--	28.13
22	0.017	--	0.280	--	16.47
23	0.0047	20.82	0.140	4431	29.79
24	0.022	84.35	0.280	3834	12.73
25	0.004	--	0.048	--	12.00
26	0.009	15.91	0.099	1711	11.00
27	0.002	--	0.024	--	12.00
28	0.008	--	0.591	--	73.88
29	0.0014	8.28	0.048	5914	34.29
30	0.0093	13.59	0.124	1599	13.33
31	0.005	--	0.072	--	14.40
32	0.005	--	0.044	--	8.80
33	0.014	29.36	0.293	2097	20.93
34	0.0069	23.17	0.120	3359	17.39
35	0.007	--	0.043	--	6.14
36	0.0064	24.96	0.039	3900	6.09
37	0.006	--	0.027	--	4.50
38	0.011	--	0.269	--	24.45
39	0.006	13.65	0.021	2275	3.50
40	0.004	13.86	0.098	3465	24.50

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of dust/powder formulations using a shaker can, the following limitations are noted:

- Though the study was strictly conducted on dogs, it is recommended for all other uses as well since studies measuring exposure during shaker can applications of dust/powders to other sites are available. Such use introduces uncertainty.

Table B-53: Exposure Study Identification Information

Citation	McKeown, K. (2001). Determination of Dermal and Inhalation Exposures to Tetrachlorvinphos (TCVP) During the Application of an Insecticide Powder to a Dog: Lab Project Number: 1556. Unpublished study prepared by The Hartz Mountain Corp. 215 p.
EPA MRID	45519601
ORETF Code	NA
EPA Review	D278626
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Five different applicators applied insecticidal powder (3.29% TCVP) using a shaker can to 3 different dogs for a total of 15 application events. Each application of approximately 1 ounce of product (approximately 0.0017 lbs TCVP) ranged between 2 and 3 minutes. Dermal exposure was measured using inner dosimetry underneath shorts and a short-sleeve shirt and hand washes (face/neck exposure was not measured). Inhalation exposure was measured using standard pumps (set at 15 liters per minute), cassettes, and tubing. Recoveries from field fortifications of exposure sampling matrices were variable. Field fortification recoveries averaged 96.9% ± 12.1 for handwipes, 82.12% ± 2.3 for inhalation samples, and 64.1% ± 12.4 for whole body dosimeters. For the whole body dosimeters, recoveries were low (48% ± 2 at the low fortification level of 10 µg and 72.2% ± 3.2 at the higher fortification levels of 500 and 3000 µg). Laboratory recoveries averaged 104.8% ± 7.1 for handwipes, 100.2% ± 9.3 for inhalation samples for the air filter/PUF plug, and 97.9% ± 9.2 whole body dosimeters.

Table B-54: MRID 45519601 – Checklist and Use Recommendation

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	No	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only inhalation exposure data are presented as the dermal exposure data are not recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-55: MRID 45519601 Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	0.0017	--	0.0040	--	2.35
A	0.0015	--	0.0105	--	7.00
A	0.0016	--	0.0008	--	0.50

B	0.0019	--	0.0105	--	5.53
B	0.0019	--	0.0076	--	4.00
B	0.0017	--	0.0340	--	20.00
C	0.0019	--	0.0177	--	9.32
C	0.0018	--	0.0036	--	2.00
C	0.0019	--	0.0082	--	4.32
D	0.0019	--	0.0168	--	8.84
D	0.0017	--	0.0037	--	2.18
D	0.0019	--	0.0354	--	18.63
E	0.0017	--	0.0018	--	1.06
E	0.0019	--	0.0007	--	0.37
E	0.0018	--	0.0011	--	0.61

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations:

- Each individual handled the same amount of active ingredient making analysis of the relationship between exposure and the amount of active ingredient handled (the underlying basis of unit exposures) difficult.
- The use of 15 liters per minute is much higher than the standard setting of 1- 2 liters per minute and could complicate air sampling.

Scenario Summary

Table B-56: Scenario Description and Available Exposure Studies	
Formulation	Paints and Stains
Equipment/Application Method	Airless sprayer
Application Site(s)	outdoors and indoors (general paint and stain applications)
Available Exposure Studies	Formella, T. (1995); MRID 43600102
	Merricks, L. (1990); MRID 41411802

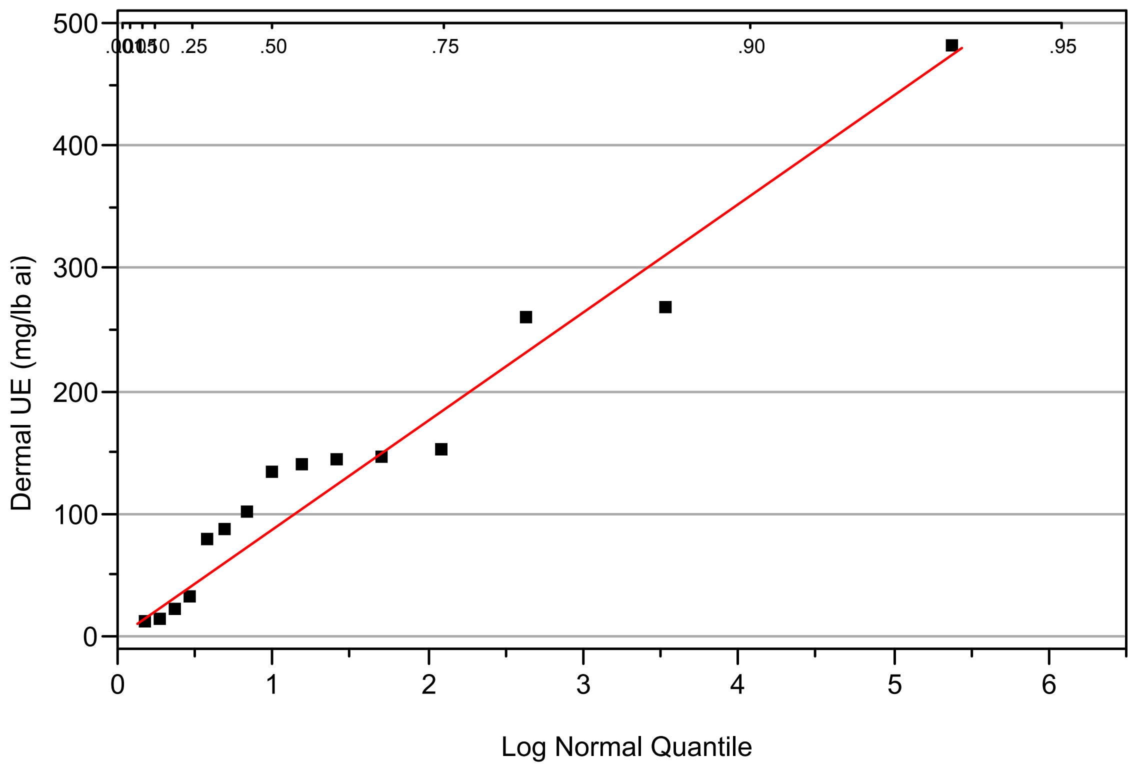
Table B-57: Unit Exposures (mg/lb ai) – Paint/Stain Airless Sprayer Applications		
Statistic	Dermal	Inhalation
50th percentile	88	0.38
75th percentile	190	0.69
95th percentile	540	1.6
99th percentile	1100	2.9
99.9th percentile	2700	5.7
AM (SD)	160 (250)	0.56 (0.60)
GM (GSD)	88 (3.01)	0.38 (2.4)
Range	12 – 480	0.078 – 1.6
N	15	51

Dermal Unit Exposure Data Summary: The recommended dermal unit exposures for applications of pesticide-containing paints or stains using an airless sprayer is based on a lognormal distribution fit with exposure monitoring data from Formella, T. (1995) [EPA MRID 43600102]. Formella, T. (1995) monitored 36 applications of approximately 5 gallons of pesticide-containing paint inside and outside houses for approximately 22-81 minutes using an airless sprayer.

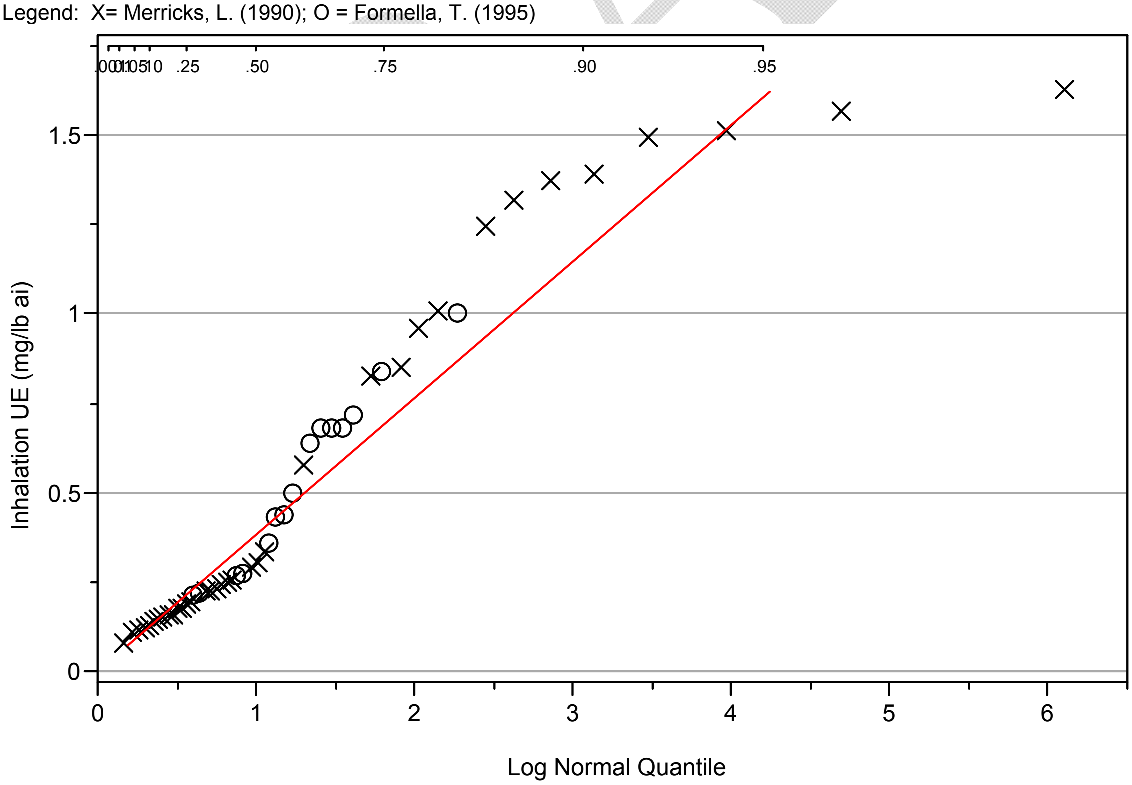
Inhalation Unit Exposure Data Summary: The recommended inhalation unit exposures for applications of pesticide-containing paints or stains using an airless sprayer is based on a lognormal distribution fit with exposure monitoring data from Formella, T. (1995) [EPA MRID 43600102] and Merricks, L. (1990) [EPA MRID 41411802]. Formella, T. (1995) monitored 36 applications of approximately 5 gallons of pesticide-containing paint inside and outside houses for approximately 22-81 minutes using an airless sprayer. Merricks, L. (1990) monitored 15 applications of approximately 5 gallons of pesticide-containing stain with an airless sprayer.

Lognormal Probability Plots

Legend: ■ = Formella, T. (1995)



Legend: X= Merricks, L. (1990); O = Formella, T. (1995)



Available Handler Exposure Studies

Table B-58: Exposure Study Identification Information	
Citation	Formella, T. (1995) Potential Exposure of Workers to Chlorothalonil when Handling and Applying Paint Containing Chlorothalonil: Lab Project Number: 94 0204: ISKB 1894 002 02: 5227 94 0204 CR 001. Unpublished study prepared by Ricerca, Inc. 272 p.
EPA MRID	43600102
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Four individuals were monitored while applying chlorothalonil-containing paint with an airless sprayer. Each individual was monitored 3 times for each of 3 paint-types (interior latex-based, exterior latex-based, and exterior alkyd-based) – for a total of 36 application-events – while spraying 5 gallons of paint (< 1 lb chlorothalonil). Each application-event ranged from 22 to 81 minutes. Dermal exposure was measured using whole body dosimetry underneath a long-sleeve shirt, long pants, socks, and shoes. Hand exposure was measured using inner and outer gloves. Inhalation exposure was measured using standard pumps (set at 1.5 liters per minute), cassettes, and tubing. Field fortification samples fortified with exterior latex paint containing had a mean recovery of 96% with a standard deviation of 10.1%. Those samples fortified with interior latex paint had a mean recovery of 96% with a standard deviation of 6.5% and those fortified with exterior alkyd paint had a mean recovery of 97% with a standard deviation of 10.4%. Overall laboratory concurrent recovery samples had a mean recovery of 101% with a standard deviation of 11%.

Table B-59: MRID 43600102 – Checklist and Use Recommendation for		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only inhalation exposure data are presented as the dermal exposure data are not recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-60: MRID 43600102 Data Summary			
Person ID	AaiH[1]	Exposure (mg)	Unit Exposure (mg/lb ai)[4]

	(lbs)	Dermal[2]	Inhalation[3]	Dermal	Inhalation
1	0.54	--	0.178	--	0.33
2	0.49	--	0.142	--	0.29
3	0.52	--	0.101	--	0.19
4	0.52	--	0.079	--	0.15
5	0.51	--	0.089	--	0.17
6	0.51	--	0.129	--	0.25
7	0.53	--	0.062	--	0.12
8	0.50	--	0.111	--	0.22
9	0.42	--	0.240	--	0.57
10	0.49	--	0.062	--	0.13
11	0.50	--	0.087	--	0.17
12	0.53	--	0.161	--	0.30
1	0.19	--	0.154	--	0.81
2	0.19	--	0.238	--	1.25
3	0.18	--	0.178	--	0.99
4	0.17	--	0.240	--	1.41
5	0.16	--	0.139	--	0.87
6	0.18	--	0.243	--	1.35
7	0.17	--	0.252	--	1.48
8	0.18	--	0.175	--	0.97
9	0.19	--	0.246	--	1.29
10	0.17	--	0.279	--	1.64
11	0.19	--	0.293	--	1.54
12	0.15	--	0.230	--	1.53
1	0.29	--	0.073	--	0.25
2	0.30	--	0.023	--	0.08
3	0.30	--	0.043	--	0.14
4	0.27	--	0.030	--	0.11
5	0.28	--	0.062	--	0.22
6	0.27	--	0.050	--	0.19
7	0.32	--	0.073	--	0.23
8	0.29	--	0.043	--	0.15
9	0.28	--	0.030	--	0.11
10	0.29	--	0.039	--	0.13
11	0.29	--	0.071	--	0.24
12	0.28	--	0.044	--	0.16

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: No limitations are identified for this study.

Table B-61: Available Exposure Study Identification Information	
Citation	Merricks, L. (1990) Folpet Worker Exposure Study Using Commercial House Stain Containing Folpet Exterior Application by Airless Sprayer: Lab Project Number: 2207. Unpublished study prepared by Agrisearch Inc. 105 p.
EPA MRID	41411802
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification	

ORETF = Outdoor Residential Exposure Task Force

Study Description: Eight different individuals were monitored at 3 different sites (for a total of 15 application-events) while apply folpet-containing stain with an airless sprayer. Each application consisted of an individual applying a 5 gallon container of stain to approximately 1000 ft^2. Dermal exposure was measured using gauze patches outside and inside standard cotton clothing. Hand exposure was measured using cotton gloves on the outside of protective latex gloves. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Field fortification recoveries averaged 80.3% for the patches, 90.7% for the filters, and 82.4% for the cotton gloves. The average recovery from laboratory fortified control samples that were analyzed with each set of test samples was 90.0% for white cotton gloves and 108.2% for polyurethane foam filters.

Table B-62: MRID 41411802 – Checklist and Use Recommendation

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-63: MRID 41411802 Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	0.1667	80.16	0.073	481	0.441
A	0.1667	22.17	0.168	133	1.007
B	0.1667	5.15	0.036	31	0.215
C	0.1667	23.31	0.140	140	0.842
B	0.1667	25.11	0.114	151	0.681
D	0.1667	1.95	0.045	12	0.270
C	0.1667	16.88	0.084	101	0.501
D	0.1667	2.27	0.046	14	0.275
E	0.1667	43.29	0.120	260	0.721
E	0.1667	14.45	0.107	87	0.641
F	0.1667	24.01	0.114	144	0.686
G	0.1667	24.23	0.060	145	0.361
F	0.1667	44.72	0.037	268	0.220
G	0.1667	3.72	0.073	22	0.436
H	0.1667	12.94	0.114	78	0.686

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of paint/stain applications using an airless sprayer, the following limitations are noted:

- Cotton gloves were used to measure hand exposure which, though used in the past as a frequent collection method for hand exposure may result in an overestimate.

Scenario Summary

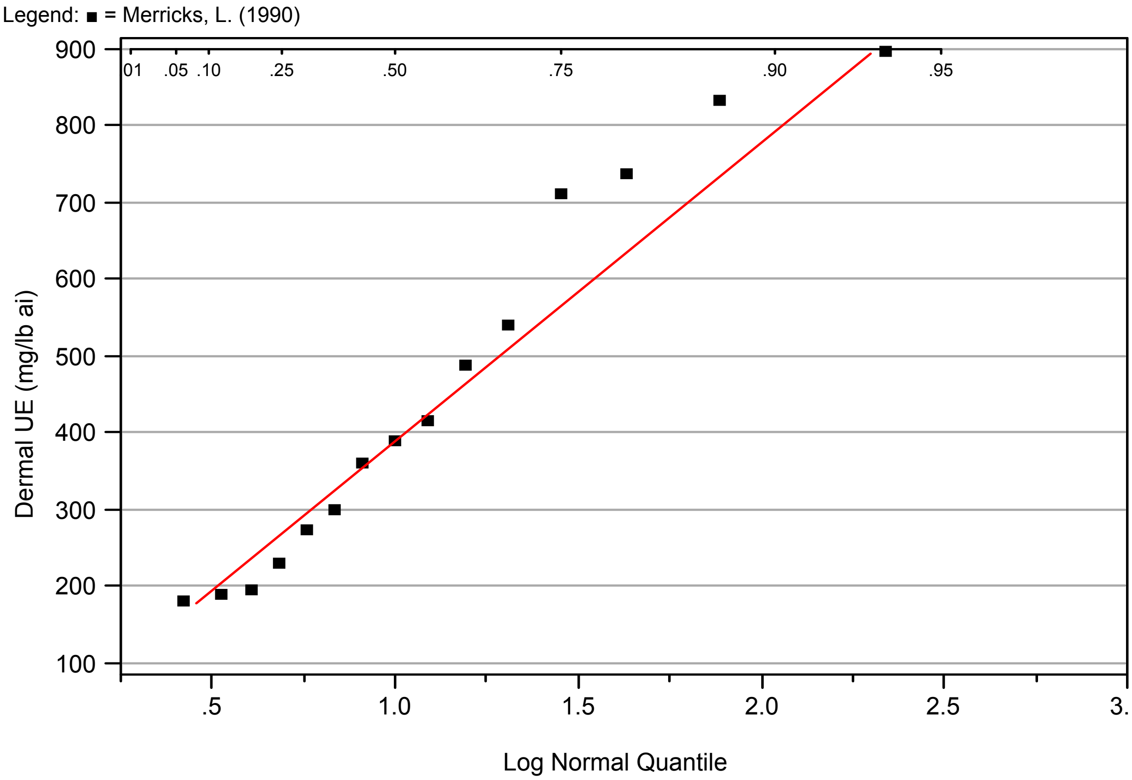
Table B-64: Scenario Description and Available Exposure Studies	
Formulation	Paints and Stains
Equipment/Application Method	Brush
Application Site(s)	outdoors and indoors (general paint and stain applications)
Available Exposure Studies	Merricks, L. (1990); MRID 41411801

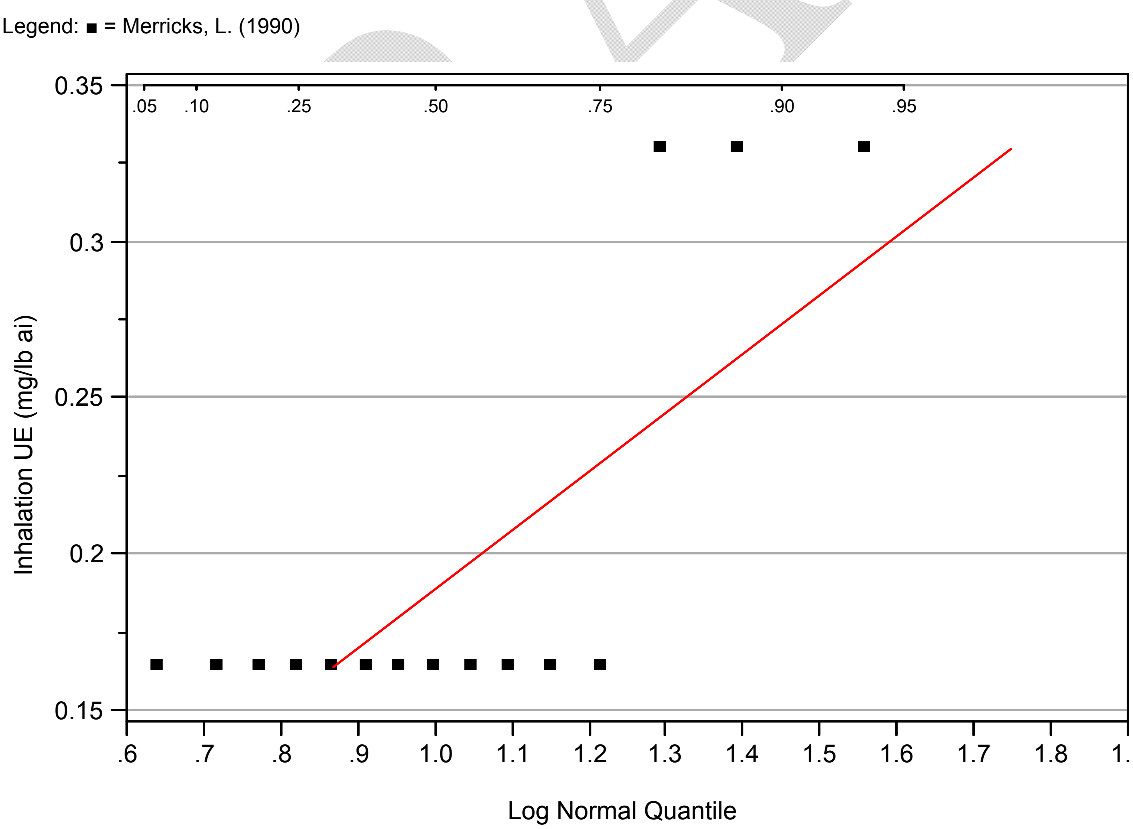
Table B-65: Unit Exposures (mg/lb ai) – Paint/Stain Brush Applications		
Statistic	Dermal	Inhalation
50th percentile	390	0.19
75th percentile	570	0.23
95th percentile	970	0.30
99th percentile	1400	0.37
99.9th percentile	2200	0.46
AM (SD)	450 (270)	0.20 (0.058)
GM (GSD)	390 (1.7)	0.19 (1.3)
Range	180 – 900	0.16 – 0.33
N	15	15

Dermal Unit Exposure Data Summary: The recommended dermal unit exposures for applications of pesticide-containing paints or stains using a brush is based on a lognormal distribution fit with exposure monitoring data from Merricks, L. (1990) [EPA MRID 41411801]. Merricks, L. (1990) monitored 15 applications of approximately 1 gallon of pesticide-containing paint to an interior bathroom for approximately 34-94 minutes with 2- or 4-inch brushes.

Inhalation Unit Exposure Data Summary: The recommended inhalation unit exposures for applications of pesticide-containing paints or stains using a brush is based on a lognormal distribution fit with exposure monitoring data from Merricks, L. (1990) [EPA MRID 41411801]. Merricks, L. (1990) monitored 15 applications of approximately 1 gallon of pesticide-containing paint to an interior bathroom for approximately 34-94 minutes with 2- or 4-inch brushes.

Lognormal Probability Plots





Available Exposure Studies

Table B-66: Exposure Study Identification Information	
Citation	Merricks, D. (1990) Folpet Worker Exposure Study Using a Paint Containing Folpet Interior Application in Bathrooms Using a Paint Brush: Lab Project Number: 2206. Unpublished study pre- pared by Agrisearch Inc. 95 p.
EPA MRID	41411801
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Ten different individuals were monitored at 3 different sites (for a total of 15 application-events) while applying approximately 1 gallon of folpet-containing paint with 2- or 4-inch brushes to an interior bathroom. Each application ranged from 34-94 minutes. Dermal exposure was measured using gauze patches outside and inside standard cotton clothing. Hand exposure was measured using cotton gloves on the outside of protective latex gloves. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Field fortification recoveries average 82.5% for patches, 87.5% for filters, and 74.7% for gloves. A laboratory storage stability study was initiated with each type of matrix. Patch samples had a recovery of 75.6%, gloves had 81.5%, and filters had a recovery of 94.6% after 89 days storage. The average recovery from laboratory fortified control samples averaged 87.5% for white cotton gloves and 99.0% for polyurethane foam air filters.

Table B-67: MRID 41411801 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-68: MRID 41411801 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
AA	0.0253	5.82	0.00835	230	0.330
BB	0.0253	4.87	0.00835	193	0.330
CC	0.051	18.32	0.00835	359	0.164

DD	0.051	12.35	0.00835	488	0.164
EE	0.051	4.75	0.00835	188	0.164
FF	0.051	10.50	0.00835	415	0.164
GG	0.051	21.05	0.00835	832	0.164
HH	0.051	7.59	0.00835	300	0.164
II	0.0253	13.67	0.00835	540	0.330
JJ	0.051	6.90	0.00835	273	0.164
KK	0.051	4.52	0.00835	179	0.164
LL	0.051	18.62	0.00835	736	0.164
MM	0.051	22.70	0.00835	897	0.164
NN	0.051	17.95	0.00835	710	0.164
OO	0.051	19.74	0.00835	387	0.164

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of paint/stain applications using a brush, the following limitations are noted:

- All inhalation samples were non-detects. One-half the limit of detection (2 ug) was used.

Scenario Summary

Table B-69: Scenario Description and Available Exposure Studies	
Formulation	Mothballs
Equipment/Application Method	Hand placement
Application Site(s)	Cabinets, sheds, closets
Available Exposure Studies	Waggoner, T. (1994); MRID 43716501

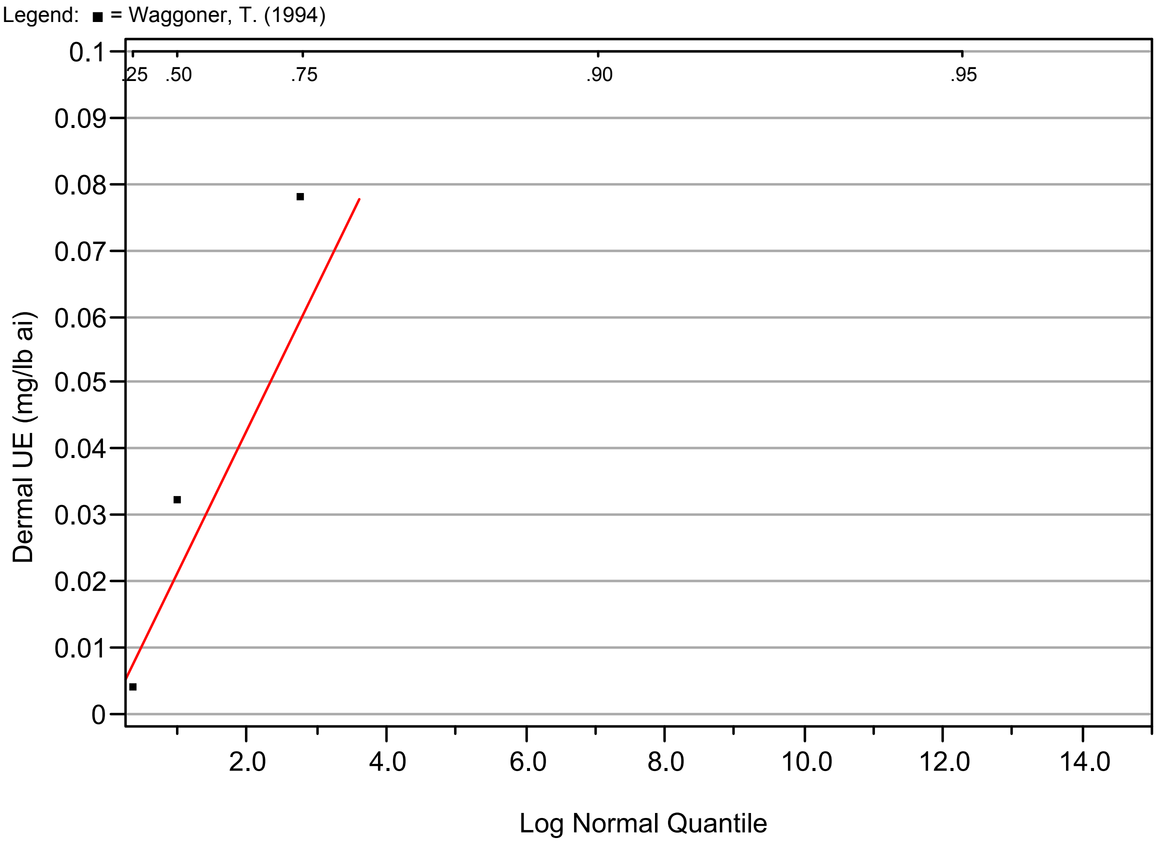
Table B-70: Unit Exposures (mg/lb ai) – Mothball Applications by Hand

Statistic	Dermal	Inhalation
50th percentile	0.021	Inhalation exposure while placing mothballs in cabinets, closets, etc. is assumed negligible. The post-application inhalation exposure assessment is considered protective of handler inhalation exposure.
75th percentile	0.060	
95th percentile	0.28	
99th percentile	0.81	
99.9th percentile	2.7	
AM (SD)	0.072 (0.24)	
GM (GSD)	0.021 (4.8)	
Range	0.032 – 0.078	
N	3	

Dermal Unit Exposure Data Summary: The recommended dermal unit exposures for applications of pesticide-containing mothballs by hand is based on a lognormal distribution fit with exposure monitoring data from Waggoner, T. (1990) [EPA MRID 43716501]. Waggoner, T. (1990) monitored 3 applications of mothballs in closets and dresser drawers in 3 residences in Georgia by hand.

Inhalation Unit Exposure Data Summary: Inhalation exposure while placing mothballs in cabinets, closets, etc. is assumed negligible.

Lognormal Probability Plots



Inhalation unit exposure probability plot is not shown. *See Table B-70.*

Available Exposure Studies

Table B-71: Exposure Study Identification Information	
Citation	Waggoner, T. (1994) Estimation of Homeowner Exposure to LX1298-01 (Napthalene) Resulting from Simulated Residential Use as an Insect Repellent: Final Report: Lab Project Number: 93-9083: 92-298-01-21H-02: 92-298-01-21H-03. Unpublished study prepared by Landis International, Inc. and Pharmaco LSR, Inc. 100 p.
EPA MRID	43716501
ORETF Code	NA
EPA Review	D340008
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Three individuals were monitored while placing mothballs in closets and dresser drawers in 3 residences in Georgia (1 person monitored in each residence for a total of 3 application-events). Each application consisted of weighing the mothballs (so as to place approximately 1.0 lb naphthalene per 50 ft^3 of space), placing mothballs in closets and/or dresser drawers and closing the closet or dresser drawer. The amount of naphthalene used ranged from 1.34 lbs to 2.2 lbs. Dermal exposure was monitored for hands only using cotton gloves. Inhalation exposure was monitored during the placement of the mothballs using standard pumps (set at 0.5 liter per minute), cassettes, and tubing – but the results were not reported. Recoveries from field fortifications of exposure sampling matrices were not reported.

Potential for Use in Residential Handler Exposure Assessments: The table below outlines relevant characteristics of the above referenced study with respect to its potential use in residential handler exposure assessments. The recommendation for use informs only the data that is ultimately used as a default and does not mean that a study not recommended for use cannot ever be used. Should a non-recommended study be deemed useful given a unique situation, the assessment should provide justification for its use and deviation from use of the recommended studies as default data.

Table B-72: MRID 43716501 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	No	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	No	No
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**No**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-73: MRID 43716501 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	2.2	0.0081	--	0.004	--
B	1.3	0.1040	--	0.078	--
C	1.5	0.0465	--	0.032	--

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm). Since "applicator" inhalation samples were not reported, the highest reported post-application inhalation exposures are shown.
[4] Unit Exposure = Exposure/AaiH

Limitations:

- The adequacy of the results is compromised due to the limited sample size.
- Inhalation exposure during application of mothballs was not reported.

Scenario Summary

Table B-74: Scenario Description and Available Exposure Studies	
Formulation	Liquids (emulsifiable concentrates, soluble concentrates, etc.)
Equipment/Application Method	Low-pressure handwand (LPHW) (also: handheld pump sprayer)
Application Site(s)	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests), indoors (general broadcast treatments, baseboards, cracks and crevices)
Available Exposure Studies	Merricks, D.L. (1997); MRID 44459801
	Merricks, D.L. (1998); MRID 44518501
	Merricks, L.D. (1988); MRID 42238702
	Contardi, J.S. et al. (1993); MRID 43017901
	Stewart, P., et al. (1999)
	Merricks, D.L. (1987); MRID 40462628

Table B-75: Unit Exposures (mg/lb ai) – Liquid LPHW Applications

Statistic	Indoor Uses		Outdoor Uses	
	Dermal	Inhalation	Dermal	Inhalation
50th percentile	Studies measuring exposure while mixing/loading/applying liquid formulations indoors using a low-pressure handwand are unavailable. The dataset for mixing/loading/applying wettable powder formulations indoors should be used as a surrogate.		46	0.0043
75th percentile			81	0.0068
95th percentile			180	0.013
99th percentile			310	0.021
99.9th percentile			580	0.035
AM (SD)			65 (63)	0.0054 (0.0041)
GM (GSD)			46 (2.3)	0.0043 (2.0)
Range			10 – 350	0.0021 – 0.020
N			40	60

Dermal Unit Exposure Data Summary

Outdoor Environments: The recommended dermal unit exposures for applications of liquid pesticide formulations using a low-pressure handwand in outdoor environments is based on a lognormal distribution fit with exposure monitoring data from Merricks, D.L. (1997) [EPA MRID 44459801] and Merricks, D.L. (1998) [EPA MRID 44518501]. Merricks, D.L. (1997) monitored 40 applications of a liquid pesticide formulation for approximately 20 minutes to tomato and cucumber gardens using a low-pressure handwand. Merricks, D.L. (1998) monitored 20 applications of a liquid pesticide formulation for approximately 20 minutes to citrus trees and shrubs using a low-pressure handwand.

Indoor Environments: Dermal exposure monitoring data for applications of liquid pesticide formulations using a low-pressure handwand in indoor environments is unavailable; dermal unit exposures for applications of wettable powder pesticide formulations using a low-pressure handwand in indoor environments are recommended as surrogate data.

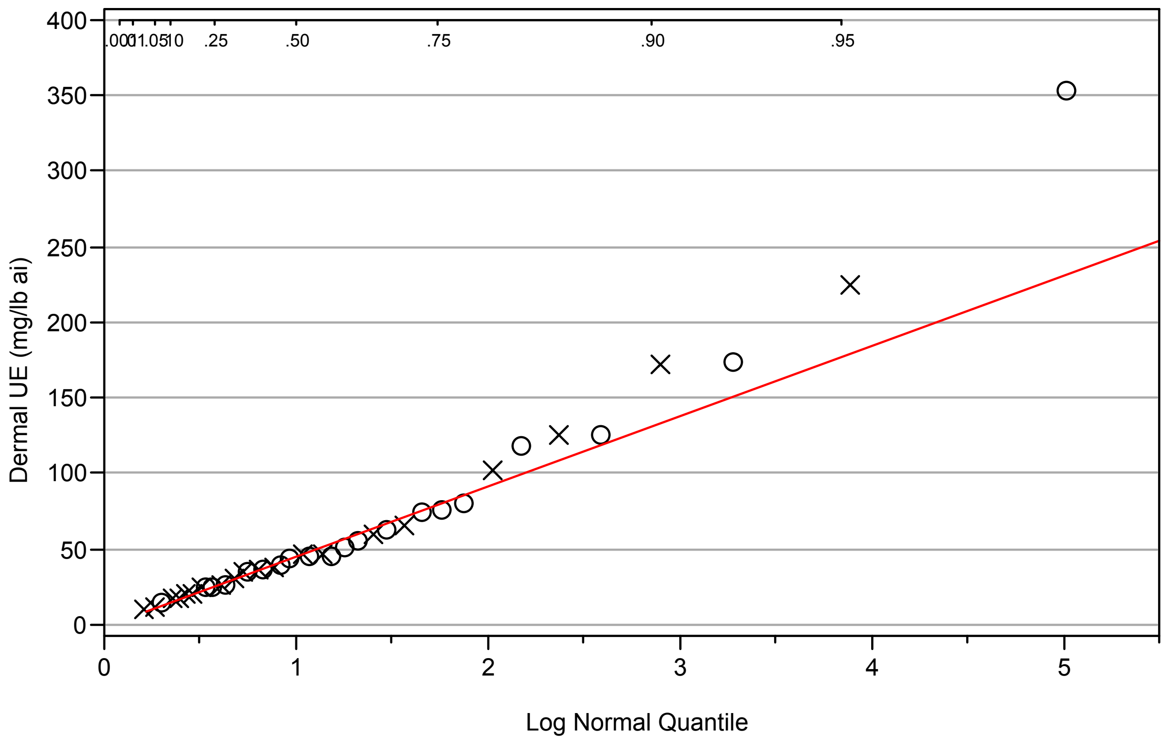
Inhalation Unit Exposure Data Summary

Outdoor Environments: The recommended inhalation unit exposures for applications of liquid pesticide formulations using a low-pressure handwand in outdoor environments is based on a lognormal distribution fit with exposure monitoring data from Merricks, D.L. (1997) [EPA MRID 44459801] and Merricks, D.L. (1998) [EPA MRID 44518501]. Merricks, D.L. (1997) monitored 40 applications of a liquid pesticide formulation for approximately 20 minutes to tomato and cucumber gardens using a low-pressure handwand. Merricks, D.L. (1998) monitored 20 applications of a liquid pesticide formulation for approximately 20 minutes to citrus trees and shrubs using a low-pressure handwand.

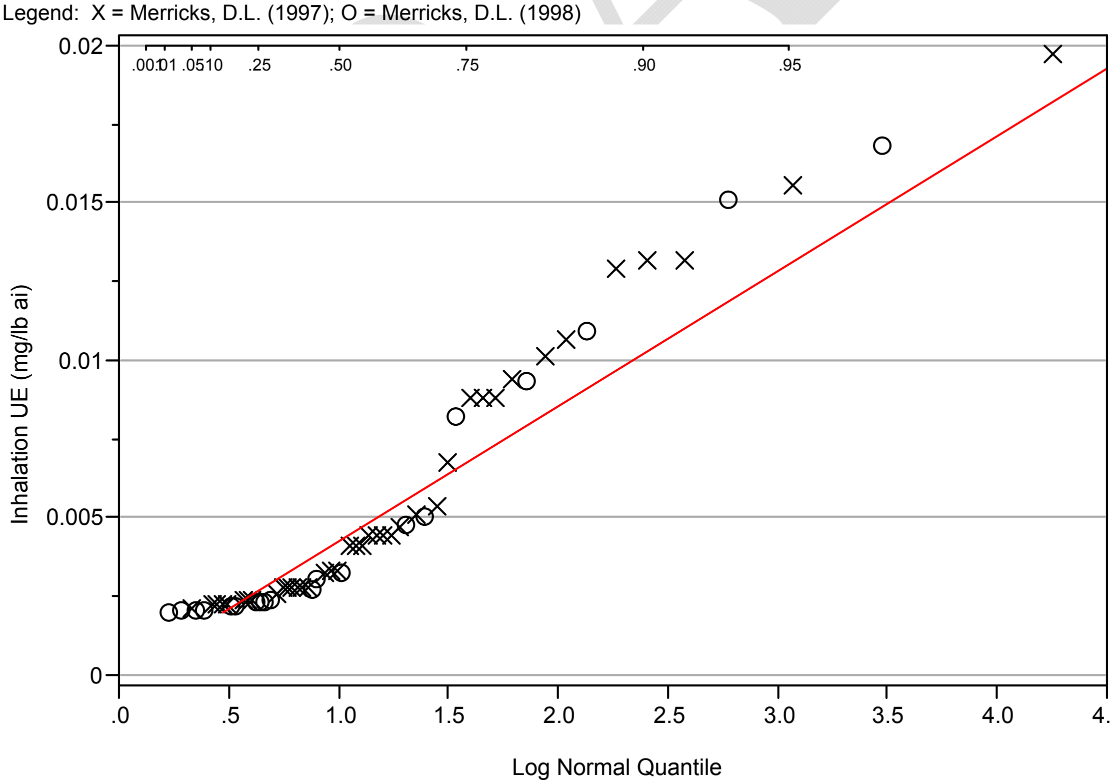
Indoor Environments: Inhalation exposure monitoring data for applications of liquid pesticide formulations using a low-pressure handwand in indoor environments is unavailable; inhalation unit exposures for applications of wettable powder pesticide formulations using a low-pressure handwand in indoor environments are recommended as surrogate data.

Lognormal Probability Plots

Legend: X = Merricks, D.L. (1997); O = Merricks, D.L. (1998)



Legend: X = Merricks, D.L. (1997); O = Merricks, D.L. (1998)



Available Exposure Studies

Table B-76: Exposure Study Identification Information	
Citation	Merricks, D.L. (1997). 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
EPA MRID	44459801
ORETF Code	OMA006
EPA Review	Memo from G. Bangs to D. Fuller (3/5/03)
	D287251
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Forty individuals were monitored while mixing, loading, and applying a liquid formulation (21% carbaryl) to tomato and cucumber gardens using a low-pressure handwand. Each application was approximately 20 minutes and consisted of loading the low-pressure handwand and applying approximately 0.07 lbs formulation (approximately 0.01 gallons; 0.02 lbs carbaryl) in 2 gallons of water to garden plants. Dermal exposure was measured using inner and outer whole body dosimetry and hand washes (20 individuals were monitored without gloves). Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Field fortification recoveries for passive dosimeters averaged 84.3% for inner dosimeters and 77.7% for outer dosimeters. Face and neck wipe field fortifications averaged 84.8%. Both handwash and inhalation tube field fortification averaged >90%. Laboratory method validation for each matrix fell within the acceptable range of 70 to 120%. 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.

Table B-77: MRID 44459801 – Checklist and Use Recommendation for		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate “residential” exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	Yes	Yes

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. Note that only dermal exposure data representative of individuals wearing short-sleeve shirt, shorts, shoes, socks, and no chemical-resistant gloves are presented. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-78: MRID 44459801 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
P2	0.018	--	0.00017	--	0.0094
Q2	0.019	--	0.00004	--	0.0023
R2	0.015	--	0.00009	--	0.0067
S2	0.017	--	0.00008	--	0.0041
V2	0.013	--	0.00004	--	0.0041
W2	0.017	--	0.00004	--	0.0041
X2	0.019	--	0.00004	--	0.0033
Y2	0.019	--	0.00004	--	0.0022
B3	0.017	--	0.00004	--	0.0032
C3	0.019	--	0.00008	--	0.0044
D3	0.019	--	0.00004	--	0.0021
E3	0.013	--	0.00004	--	0.0027
H3	0.018	--	0.00017	--	0.0131
I3	0.019	--	0.00025	--	0.0129
J3	0.019	--	0.00004	--	0.0023
K3	0.019	--	0.00004	--	0.0027
N3	0.015	--	0.00004	--	0.0027
O3	0.019	--	0.00004	--	0.0027
P3	0.015	--	0.00016	--	0.0107
Q3	0.019	--	0.00017	--	0.0101
A	0.018	1.16	0.00008	65	0.0047
B	0.018	0.88	0.00004	46	0.0022
G	0.013	0.30	0.00008	20	0.0053
C	0.020	2.84	0.00026	171	0.0155
J	0.010	0.21	0.00004	17	0.0033
D	0.010	3.71	0.00008	224	0.0050
M	0.013	0.33	0.00008	17	0.0044
N	0.019	1.14	0.00025	60	0.0131
Q	0.013	0.32	0.00004	19	0.0025
R	0.019	0.65	0.00017	34	0.0087
U	0.020	0.21	0.00004	11	0.0022
V	0.015	0.59	0.00025	46	0.0197
Y	0.013	1.81	0.00004	102	0.0023
Z	0.019	0.47	0.00004	25	0.0022
C2	0.018	2.39	0.00017	125	0.0087
D2	0.015	0.69	0.00008	36	0.0044
G2	0.015	0.45	0.00004	30	0.0027
H2	0.015	0.49	0.00017	26	0.0087
K2	0.015	0.16	0.00004	10	0.0027
L2	0.017	0.72	0.00008	38	0.0044

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of liquid concentrate formulations using a low-pressure handwand, the following limitations are noted:

- Each individual handled the same amount of active ingredient, making analysis of the relationship between exposure and the amount of active ingredient handled (the underlying basis of unit exposures) difficult.

Table B-79: Exposure Study Identification Information	
Citation	Merricks, D.L. (1998). Carbaryl Mixer/Loader/Applicator Exposure Study During Application of RP-2 Liquid (21%) to Fruit Trees and Ornamental Plants
EPA MRID	44518501
ORETF Code	OMA005
EPA Review	Memo from G. Bangs to D. Fuller (3/5/03)
	D287251
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Twenty individuals were monitored while loading and applying a liquid formulation (21% carbaryl) to citrus trees and shrubs using a low-pressure handwand. Each application consisted of pouring the formulation into the tank and spraying the trees – all lasting less than 20 minutes. The amount of carbaryl handled ranged from 0.02 to 0.09 lbs. Dermal exposure was measured using inner and outer whole body dosimetry and hand washes (individuals were monitored without gloves). Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Field fortification recoveries for passive dosimeters averaged

88.3% for inner and 76.2% for outer dosimeters. Face and neck wipe fortifications averaged 82.5%. Handwash fortifications averaged 93.6% and air sampler tube fortification was 91.8%. Laboratory method validation for each matrix fell within the acceptable range of 70 to 120%. 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.

Table B-80: MRID 44518501 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-81: MRID 44518501 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
2	0.018	0.45	0.000042	25	0.0023
4	0.015	0.79	0.000042	52	0.0027
6	0.020	2.57	0.000042	126	0.0021
8	0.019	0.51	0.000042	27	0.0022
10	0.013	4.52	0.000042	354	0.0033
12	0.014	0.78	0.000043	56	0.0031
14	0.018	2.12	0.000042	119	0.0023
16	0.020	3.52	0.000167	174	0.0083
18	0.017	0.75	0.000084	45	0.0050
20	0.015	0.61	0.000167	40	0.0109
22	0.019	0.88	0.000042	46	0.0022
24	0.018	0.27	0.000042	15	0.0023
26	0.018	0.64	0.000043	36	0.0024
28	0.020	1.66	0.000042	82	0.0021
30	0.015	1.17	0.000257	77	0.0168
32	0.018	1.34	0.000086	75	0.0048
34	0.020	0.92	0.000042	46	0.0021
36	0.017	0.61	0.000251	37	0.0151
38	0.020	0.50	0.000042	25	0.0021
40	0.018	1.13	0.000167	63	0.0094

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of liquid concentrate formulations using a low-pressure handwand, the following limitations are noted:

- Each individual handled the same amount of active ingredient, making analysis of the relationship between exposure and the amount of active ingredient handled (the underlying basis of unit exposures) difficult.

Table B-82: Exposure Study Identification Information	
Citation	Merricks, L.D. (1988). Exposure of workers to Cyromazine during the mixing, loading, and application of Larvadex 2SL in poultry houses.
EPA MRID	42238702
ORETF Code	NA
EPA Review	None

MRID = Master Record Identification
ORETF = Outdoor Residential Exposure Task Force

Study Description: Four workers at 4 different sites (for a total of 16 application events) were monitored while mixing, loading, and applying a liquid formulation of cyromazine to poultry litter using a low-pressure handwand. Each applicator mixed and applied 3, 2-gallon solutions (equal to approximately 0.052 lbs cyromazine); a task that lasted on average 53 minutes. Dermal exposure was measured using gauze patches (both inside and outside normal work clothing) and cotton gloves (underneath chemical-resistant gloves) for hand exposure. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. All inhalation samples were non-detects. An average of 84.9% ± 5.2 (n=18) was recovered from field fortified patches, 79.3% ± 7.3% from gloves and 84.0% ± 16.8% from foam air filters. The overall average recovery from laboratory fortified control samples was 87% ± 12.0% for alpha-cellulose gauze patches, 75% ± 11.6% for cotton gloves, and 89% ± 10.5% for foam air filters.

Table B-83: MRID 42238702 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Table B-84: Exposure Study Identification Information	
Citation	Contardi, J.S. et al. (1993). Evaluation of Chlorpyrifos exposures during mixing/loading and application of Empire 20 insecticide to ornamental plants in greenhouses.
EPA MRID	43017901
ORETF Code	NA
EPA Review	None
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Sixteen individuals were monitored while applying a liquid formulation of chlorpyrifos to greenhouse plants hanging overhead or on the floor or on benches using a low-pressure handwand. A wide range of solution was applied ranging from 5 gallons to 120 gallons per applicator, which corresponded to a range of 0.06 to 0.91 lbs of chlorpyrifos handled. Each application event generally lasted 1.5 hours. Dermal exposure was measured using gauze patches (both inside and outside normal work clothing) and hand rinses (underneath chemical-resistant gloves) for hand exposure. Inhalation exposure was measured using standard pumps (set at 1.5 liters per minute), cassettes, and tubing. Recoveries from field fortifications of exposure sampling matrices were generally above 90%.

Table B-85: MRID 43017901 – Checklist and Use Recommendation for		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Table B-86: Exposure Study Identification Information	
Citation	Stewart, P., T. Fears, H.F. Nicholson, B.C. Kross, L. K. Ogilvie, S.H. Zahm, M.H. Ward and A. Blair (1999) Exposure Received From Application Of Animal Insecticides. American Industrial Hygiene Association Journal. 60:208-212
EPA MRID	NA
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Three farmers were monitored while applying insecticides to animals using a low-pressure handwand. Each application ranged from approximately 1 to 200 liters of solution and varied among 6 active ingredients. Clothing worn varied between farmers. Dermal exposure was measured using a fluorescent dye video-imaging technique. Inhalation exposure was not measured.

Table B-87: Stewart, et al. (1999) – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	No	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory	Yes	NA

recovery samples adequate)?		
Should this study be recommended for use in residential handler exposure assessments?	**No**	**NA**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Table B-88: Exposure Study Identification Information	
Citation	Merricks, D.L. (1987). Assessment of Worker Exposure to Sumagic During Greenhouse Application Using Low Pressure Handheld Sprayers
EPA MRID	40462628
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Nine individuals were monitored on two days (4 on the 1st day, 5 on the 2nd day) while applying a plant growth regulator to ornamentals in a 2000 ft^2 greenhouse. Each worker was suited with sampling media separately for the mixing/loading portion of the task and the application portion. Each application consisted of spraying 2 gallons of spray solution for approximately 30 minutes at a rate of 1 gallon per 200 ft^2. The solution was 100 ppm (active ingredient unknown) so each applicator handled approximately 0.0017 lbs of active ingredient. Dermal exposure was measured using gauze patches (both inside and outside normal work clothing) and cotton gloves worn over chemical-resistant gloves for hand exposure. Inhalation exposure was measured using standard pumps (set at 1.5 liters per minute), cassettes, and tubing. All inhalation samples were non-detects. The overall recovery from samples fortified in the laboratory and analyzed with each set of field samples averaged 102% for alpha-cellulose, 106% for gloves, and 101% for foam filters.

Table B-89: MRID 40462628 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate “residential” exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Scenario Summary

Table B-90: Scenario Description and Available Exposure Studies	
Formulation	Liquids (emulsifiable concentrates, soluble concentrates, etc.)
Equipment/Application Method	Handheld Fogger
Application Site(s)	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests)
Available Exposure Studies	Nigg, et al (1987); MRID 40350501
	Bergman, J. (2003); MRID 45869301

<table>
<tr><th colspan="3">Table B-91: Unit Exposures (mg/lb ai) – Liquid Handheld Fogger Applications</th></tr>
<tr><th>Statistic</th><th>Dermal</th><th>Inhalation</th></tr>
<tr><td>50th percentile</td><td colspan="2" rowspan="9">Studies measuring exposure while mixing/loading/applying liquid formulations using a handheld fogger are available, but not recommended for residential handler exposure assessment. Therefore, the exposure studies recommended for applying an aerosol can should be used as a surrogate.</td></tr>
<tr><td>75th percentile</td></tr>
<tr><td>95th percentile</td></tr>
<tr><td>99th percentile</td></tr>
<tr><td>99.9th percentile</td></tr>
<tr><td>AM (SD)</td></tr>
<tr><td>GM (GSD)</td></tr>
<tr><td>Range</td></tr>
<tr><td>N</td></tr>
</table>

Available Handler Exposure Studies

Table B-92: Exposure Study Identification Information	
Citation	Nigg, et al (1987) Pesticide Exposure to Florida Greenhouse Applicators, Nigg, H.N., Stamper, J.H. and Mahon, W.D., University of Florida, 1987
EPA MRID	40350501
ORETF Code	NA
EPA Review	None
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Four different workers were monitored while using a pulse-fogging device in a Florida greenhouse. Four active ingredients were used at rates ranging from 0.03 lbs/hr to 0.2 lbs/hr. Dermal exposure was measured using gauze patches (both inside and outside normal work clothing) and hand rinses were used for hand exposure (hand exposure was measured only when gloves were not worn). Inhalation exposure was measured using standard pumps (set at 3 liters per minute), cassettes, and tubing. Recoveries from field fortifications of exposure sampling matrices were poor, ranging from 13% to 94% depending on the chemical and matrix. Mean recoveries (%) from 10 µg fortifications of fluvalinate on gauze pads was 75% ± 6%, for handwashes was 62% ± 6%, and for air sampler plugs was 51% ± 4%. Mean recoveries from 10 µg fortifications of the compound chlorpyrifos on gauze pads was 82% ± 3%, for handwashes was 79% ± 4%, and for air sampler plugs was 73% ± 4%. Mean recoveries from 10 µg fortifications of the compound ethazol on gauze pads was 51% ± 7%, for handwashes was 45% ± 10%, and for air sampler plugs was 68% ± 8%. Mean recoveries (%) from 10 µg fortifications of the compound dicofol on gauze pads was 89% ± 5%, for handwashes was 76% ± 4%, and for air sampler plugs was 90% ± 9%. Mean recoveries (%) from 10 µg fortifications of the compound captan on gauze pads was 61% ± 8%, for handwashes was 13% ± 2%, and for air sampler plugs was 63% ± 14%. Mean recoveries (%) from 10 µg fortifications of the compound chlorothalonil on gauze pads was 94% ± 3%, for handwashes was 25% ± 14%, and for air sampler plugs was 67% ± 8%.

Table B-93: MRID 40350501 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Limitations: This study has been identified to have ethical concerns.

Table B-94: Exposure Study Identification Information	
Citation	Bergman, J. (2003) Applicator Exposure and Air Sampling Following Application of ETOC Fogging Concentrate 2764 by ULV Fogging: Lab Project Number: GLP-1648. Unpublished study prepared by McLaughlin Gormley King Company. 107 p. {OPPTS 875.1400 and 875.2500}
EPA MRID	45869301
ORETF Code	NA
EPA Review	D289337
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: One individual was monitored during 25 applications of a liquid concentrate (active ingredient prallethrin) to a 5500 ft^3 test chamber using a handheld ultra low-volume (ULV) fogger at the maximum application rate of 1 fl. oz. per 1000 ft^3 (equivalent to approximately 0.001 lb ai/1000 ft^3). Dermal exposure was not monitored in this study. Inhalation exposure was measured using standard pumps (set at 0.03 liter per minute), cassettes, and tubing. One set of recovery results were provided, however, the study author did not specify whether the recovery samples represented laboratory fortified samples or field fortified samples. The results for these fortification recoveries are discussed in the Field Recovery section of this study review. Three fortification samples were prepared at three concentrations (LOQ, 10 X LOQ, and 100 X LOQ) for each application. Sample preparation and storage were not discussed. Recoveries ranged from 76.8% to 147.3%. The average percent recovery for samples fortified at the LOQ, at 10X LOQ and at 100X LOQ were 119.6%, 113.1%, and 92.3%, respectively. The overall average percent recovery was 108.3 ± 14.3%.

Table B-95: MRID 45869301 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	No	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Limitations: This study has been identified to have ethical concerns.

Scenario Summary

Table B-96: Scenario Description and Available Exposure Studies	
Formulation	Liquids (emulsifiable concentrates, soluble concentrates, etc.)
Equipment/Application Method	Dipping
Application Site(s)	Pets/animals
Available Exposure Studies	McKeown, K. (2001); MRID 45528801

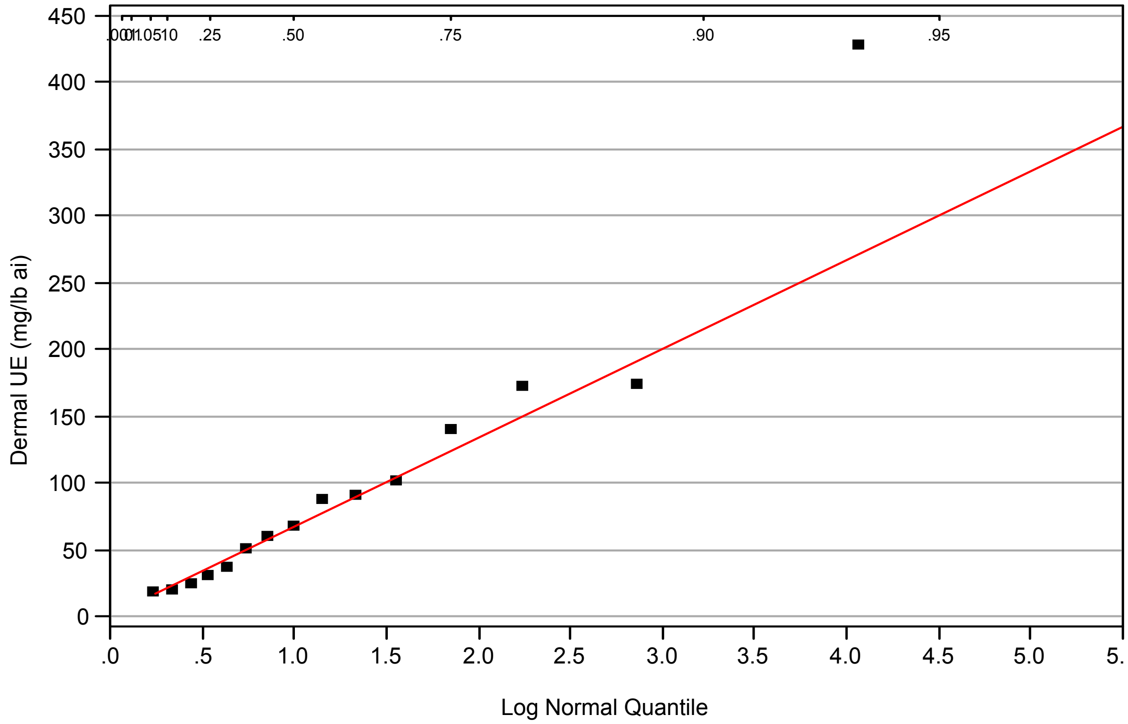
Table B-97: Unit Exposures (mg/lb ai) – Liquid Dipping Applications		
Statistic	Dermal	Inhalation
50th percentile	67	0.023
75th percentile	120	0.024
95th percentile	300	0.026
99th percentile	560	0.028
99.9th percentile	1100	0.030
AM (SD)	101 (120)	0.023 (0.0021
GM (GSD)	67 (2.5)	0.023 (1.1)
Range	17 – 430	0.019 – 0.027
N	15	15

<u>Dermal Unit Exposure Data Summary:</u> The recommended dermal unit exposures for dipping pets or animals in liquid pesticide formulations is based on a lognormal distribution fit with exposure monitoring data from McKeown, K. (2001) [EPA MRID 45528801]. McKeown, K. (2001) monitored 15 applications of dipping dogs in a tub containing a liquid pesticide solution for approximately 4 to 5 minutes.

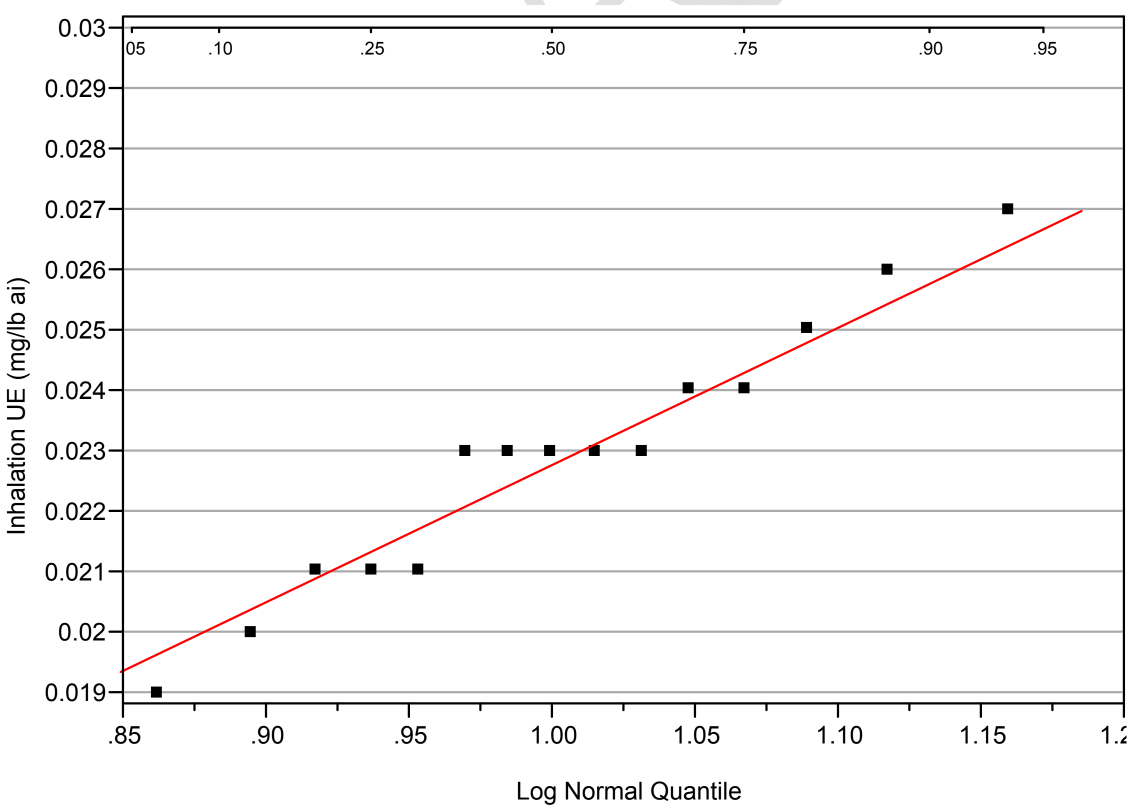
<u>Inhalation Unit Exposure Data Summary:</u> The recommended inhalation unit exposures for dipping pets or animals in liquid pesticide formulations is based on a lognormal distribution fit with exposure monitoring data from McKeown, K. (2001) [EPA MRID 45528801]. McKeown, K. (2001) monitored 15 applications of dipping dogs in a tub containing a liquid pesticide solution for approximately 4 to 5 minutes.

Lognormal Probability Plots

Legend: ■ = McKeown, K. (2001)



Legend: ■ = McKeown, K. (2001)



Available Handler Exposure Studies

Table B-98: Exposure Study Identification Information	
Citation	McKeown, K. (2001) Determination of Dermal and Inhalation Exposures to Tetrachlorvinphos (TCVP) During the Application of a Dipping Solution to a Dog: Lab Project Number: TX 76384: 1557: ML01-0925-HMT. Unpublished study prepared by The Hartz Mountain Corporation, Morse Laboratories, Inc. and Sharp Veterinary Research. 258 p.
EPA MRID	45528801
ORETF Code	NA
EPA Review	D279176
	Contractor (Versar, Inc.) review 1/7/02
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Five individuals were monitored while dipping 3 dogs (for a total of 15 application events) in a solution with the active ingredient TCVP. Each application event, lasting only 4 to 5 minutes, consisted of mixing the solution (8 oz of product per 4 gallons water; 3.29% TCVP) in a tub, dipping the dog in the solution and pouring the solution over those parts not submerged, then removing the dog from the tub. Dermal exposure was measured using a whole body dosimeter (underneath a short-sleeve shirt and shorts) and hand washes. Inhalation exposure was measured using standard pumps (set at 15 liters per minute), cassettes, and tubing. Hand wipes had field recoveries above 90% at all fortification levels. Cotton union suits had recoveries of 48% to 73% depending upon the fortification levels. The air sampling media had a recovery of 81% at 10X LOQ which was the lowest level tested. Laboratory recoveries were above 90% for all the types of dosimeters, at all levels tested, including the LOQ. For dermal dosimeters, handwipes, and air tubes, the limit of detection (LOD) was 0.5 µg, the limit of quantitation (LOQ) was 1.0 µg.

Table B-99: MRID 45528801 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	No	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-100: MRID 45528801 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	0.015	1.36	0.00037	90.7	0.024
A	0.015	2.09	0.00042	139.3	0.027
A	0.015	0.89	0.00038	59.3	0.025
B	0.015	2.59	0.00031	172.7	0.020
B	0.015	1.31	0.00033	87.3	0.021
B	0.015	1.01	0.00030	67.3	0.019
C	0.015	0.44	0.00039	29.3	0.026
C	0.015	0.29	0.00037	19.3	0.024
C	0.015	1.51	0.00035	100.7	0.023
D	0.015	0.37	0.00035	24.7	0.023
D	0.015	0.25	0.00034	16.7	0.023
D	0.015	0.74	0.00033	49.3	0.021
E	0.015	2.55	0.00035	170.0	0.023
E	0.015	6.35	0.00033	423.3	0.021
E	0.015	0.53	0.00034	35.3	0.023

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm). All samples were non-detects. Reported as ½ LOD (0.5 ug).
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of dipping pets or animals in a dilute liquid pesticide solution, the following limitations are noted:

- All inhalation samples were non-detects. One-half the limit of detection (0.5 ug) was used.
- Each individual handled the same amount of active ingredient making analysis of the relationship between exposure and the amount of active ingredient handled (the underlying basis of unit exposures) difficult.
- The use of 15 liters per minute is much higher than the standard setting of 1- 2 liters per minute and could complicate air sampling.

Scenario Summary

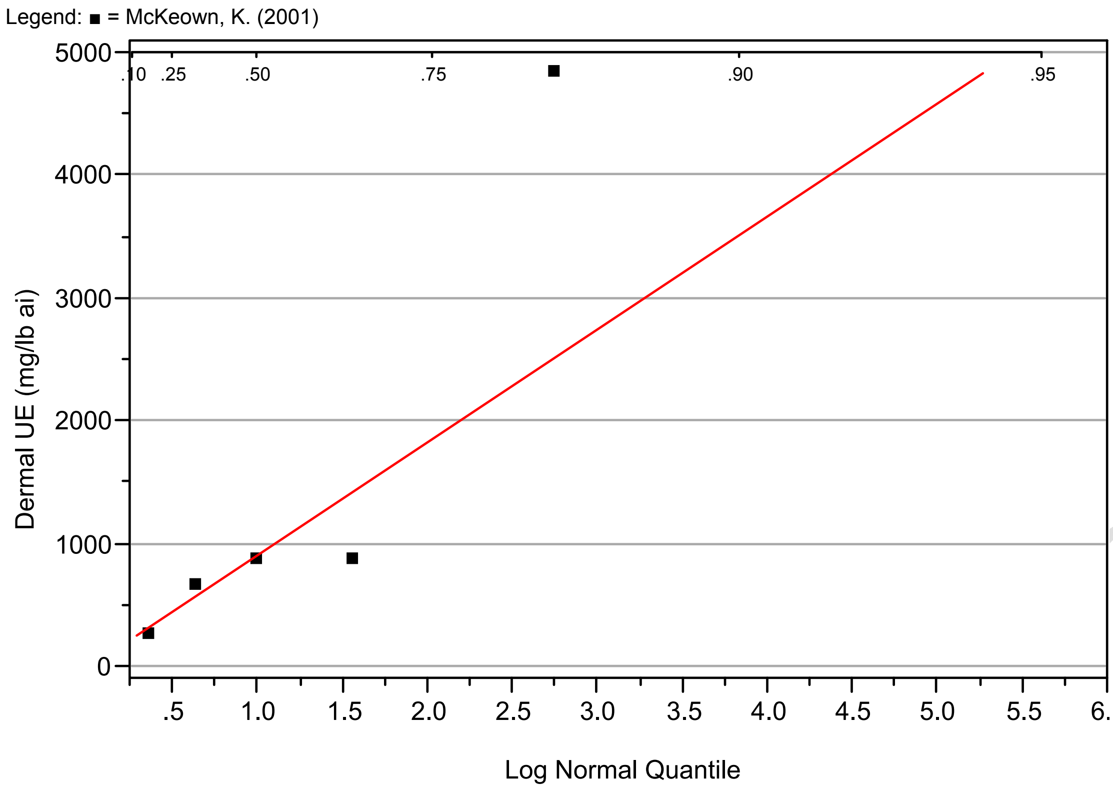
Table B-101: Scenario Description and Available Exposure Studies	
Formulation	Liquids (emulsifiable concentrates, soluble concentrates, etc.)
Equipment/Application Method	Sponge
Application Site(s)	Pets/animals
Available Exposure Studies	McKeown, K. (2001); MRID 45528801

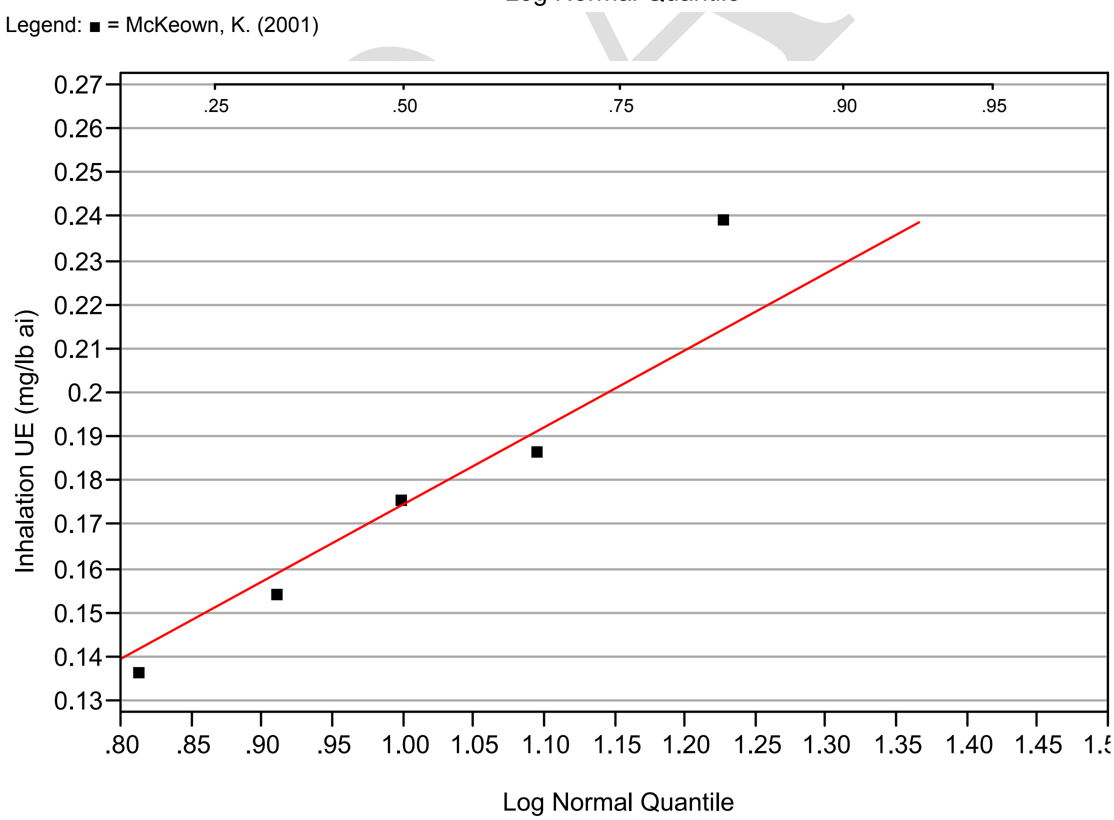
Table B-102: Unit Exposures (mg/lb ai) – Liquid Sponge Applications		
Statistic	Dermal	Inhalation
50^{th} percentile	920	0.18
75^{th} percentile	1900	0.20
95^{th} percentile	5100	0.25
99^{th} percentile	11000	0.29
99.9^{th} percentile	23000	0.34
AM (SD)	1600 (2200)	0.18 (0.038)
GM (GSD)	920 (2.9)	0.17 (1.2)
Range	270 – 4800	0.14 – 0.23
N	5	5

Dermal Unit Exposure Data Summary: The recommended dermal unit exposures for applications of liquid pesticide formulations using a sponge is based on a lognormal distribution fit with exposure monitoring data from McKeown, K. (2001) [EPA MRID 45528801]. McKeown, K. (2001) monitored 5 applications of a liquid pesticide solution for approximately 4 to 5 minutes using a sponge.

Inhalation Unit Exposure Data Summary: The recommended dermal unit exposures for applications of liquid pesticide formulations using a sponge is based on a lognormal distribution fit with exposure monitoring data from McKeown, K. (2001) [EPA MRID 45528801]. McKeown, K. (2001) monitored 5 applications of a liquid pesticide solution for approximately 4 to 5 minutes using a sponge.

Lognormal Probability Plots





Available Handler Exposure Studies

Table B-103: Exposure Study Identification Information	
Citation	McKeown, K. (2001) Determination of Dermal and Inhalation Exposures to Tetrachlorvinphos (TCVP) During the Application of a Dipping Solution to a Dog: Lab Project Number: TX 76384: 1557: ML01-0925-HMT. Unpublished study prepared by The Hartz Mountain Corporation, Morse Laboratories, Inc. and Sharp Veterinary Research. 258 p.
EPA MRID	45528801
ORETF Code	NA
EPA Review	D279176
	Contractor (Versar, Inc.) review 1/7/02
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Five individuals were monitored while applying a liquid solution (active ingredient TCVP) using a sponge to 5 dogs (for a total of 5 application events). Each application event, lasting only 4 to 5 minutes, consisted of mixing the solution (2 oz of product in a 1 gallon container; 3.29% TCVP), placing the dog in a tub, applying the solution to the dog with a sponge, then removing the dog from the tub. Dermal exposure was measured using a whole body dosimeter (underneath a short-sleeve shirt and shorts) and hand washes. Inhalation exposure was measured using standard pumps (set at 15 liters per minute), cassettes, and tubing. Hand wipes had field recoveries above 90% at all fortification levels. Cotton union suits had recoveries of 48% to 73% depending upon the fortification levels. The air sampling media had a recovery of 81% at 10X LOQ which was the lowest level tested. Laboratory recoveries were above 90% for all the types of dosimeters, at all levels tested, including the LOQ. For dermal dosimeters, handwipes, and air tubes, the limit of detection (LOD) was 0.5 µg, the limit of quantitation (LOQ) was 1.0 µg.

Table B-104: MRID 45528801 – Checklist and Use Recommendation for

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	No	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-105: MRID 45528801 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	0.0024	0.63	0.00037	262.5	0.154
B	0.0019	1.26	0.00035	663.2	0.186
C	0.0016	7.69	0.00038	4806.3	0.239
D	0.0024	2.08	0.00033	866.7	0.136
E	0.0019	1.61	0.00033	847.4	0.175

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of applying dilute liquid pesticide solutions to pets or animals with a sponge, the following limitations are noted:

- All inhalation samples were non-detects. One-half the limit of detection (0.5 ug) was used.
- Each individual handled approximately the same amount of active ingredient making analysis of the relationship between exposure and the amount of active ingredient handled (the underlying basis of unit exposures) difficult.
- The use of 15 liters per minute is much higher than the standard setting of 1- 2 liters per minute and could complicate air sampling.

Scenario Summary

Table B-106: Scenario Description and Available Exposure Studies	
Formulation	Liquids (emulsifiable concentrates, soluble concentrates, etc.)
Equipment/Application Method	Hose-end sprayer
Application Site(s)	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests)
Available Exposure Studies	Solomon, K. R., Harris, S. A, Stephenson, G. R. (1993).
	Klonne, D. 1999; MRID 44972201
	Merricks, D.L. (1998); MRID 44518501
	Merricks, D.L. (1997); MRID 44459801

Table B-107: Unit Exposures (mg/lb ai) – Liquid Hose-end Sprayer Applications

Statistic	Lawns / Mounds / Nests		Gardens / Trees / Perimeter	
	Dermal	Inhalation	Dermal	Inhalation
50th percentile	11	0.016	37	0.0012
75th percentile	18	0.029	69	0.0017
95th percentile	39	0.068	180	0.0029
99th percentile	65	0.12	340	0.0043
99.9th percentile	120	0.23	710	0.0065
AM (SD)	15 (13)	0.024 (0.025)	58 (71)	0.0014 (0.00082)
GM (GSD)	11 (2.1)	0.016 (2.4)	37 (2.6)	0.0012 (1.7)
Range	2.6 – 49	0.003 – 0.082	5.0 – 280	0.0004 – 0.0062
N	30	29	40	60

<u>Dermal Unit Exposure Data Summary</u>

Gardens, Trees, and Perimeter Treatments: The recommended dermal unit exposures for applications of liquid pesticide formulations using a dial-type hose-end sprayer to gardens, trees, and perimeters of houses is based on a lognormal distribution fit with exposure monitoring data from Merricks, D.L. (1998) [EPA MRID 44518501] and Merricks, D.L. (1997) [EPA MRID 44459801]. Merricks, D.L. (1998) monitored 20 applications of a liquid formulation for approximately 20 minutes to citrus trees and shrubs using a dial-type hose-end sprayer. Merricks, D.L. (1997) monitored 40 applications of a liquid formulation for approximately 20 minutes to tomato and cucumber gardens using a dial-type hose-end sprayer.

Lawns and Insect Mounds and Nests: The recommended dermal unit exposures for applications of liquid pesticide formulations using a dial-type hose-end sprayer to lawns and insect mounds and nests is based on a lognormal distribution fit with exposure monitoring data from Klonne, D. (1999) [EPA MRID 44972201]. Klonne, D. (1999) monitored 30 applications of a liquid pesticide formulation for approximately 75 minutes to approximately 5000 ft^2 of residential lawns using a dial-type hose-end sprayer.

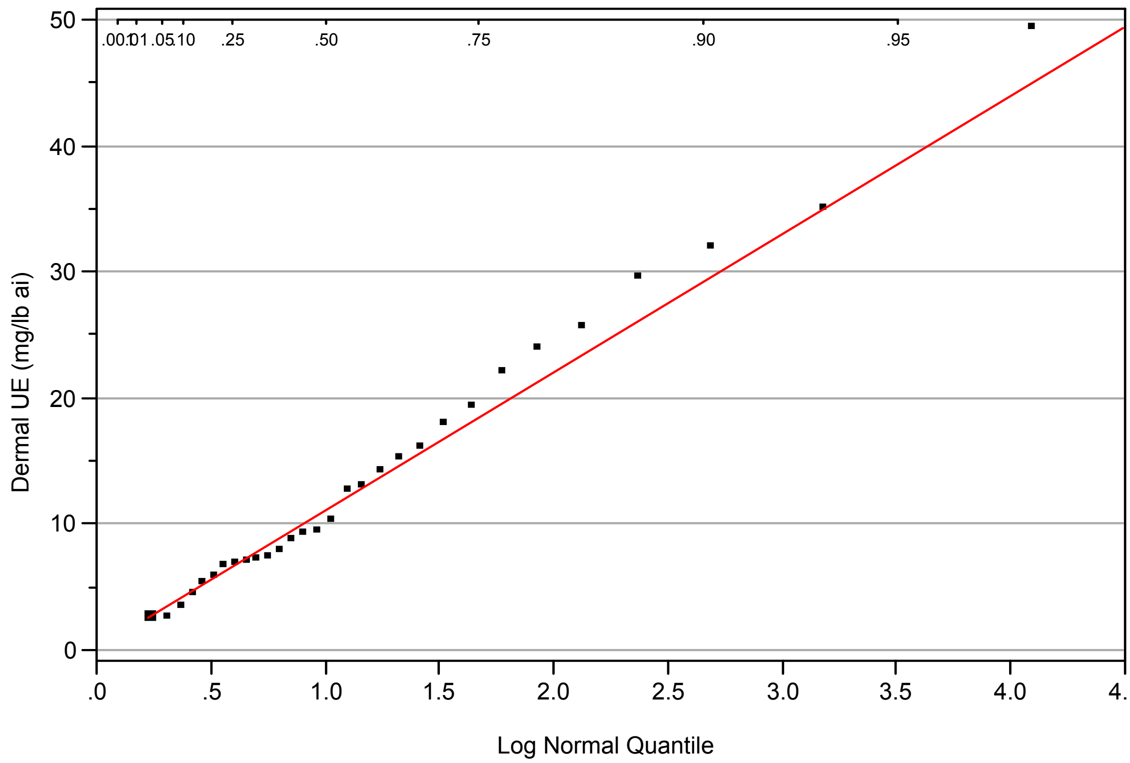
<u>Inhalation Unit Exposure Data Summary</u>

Gardens, Trees, and Perimeter Treatments: The recommended inhalation unit exposures for applications of liquid pesticide formulations using a dial-type hose-end sprayer to gardens, trees, and perimeters of houses is based on a lognormal distribution fit with exposure monitoring data from Merricks, D.L. (1998) [EPA MRID 44518501] and Merricks, D.L. (1997) [EPA MRID 44459801]. Merricks, D.L. (1998) monitored 20 applications of a liquid formulation for approximately 20 minutes to citrus trees and shrubs using a dial-type hose-end sprayer. Merricks, D.L. (1997) monitored 40 applications of a liquid formulation for approximately 20 minutes to tomato and cucumber gardens using a dial-type hose-end sprayer.

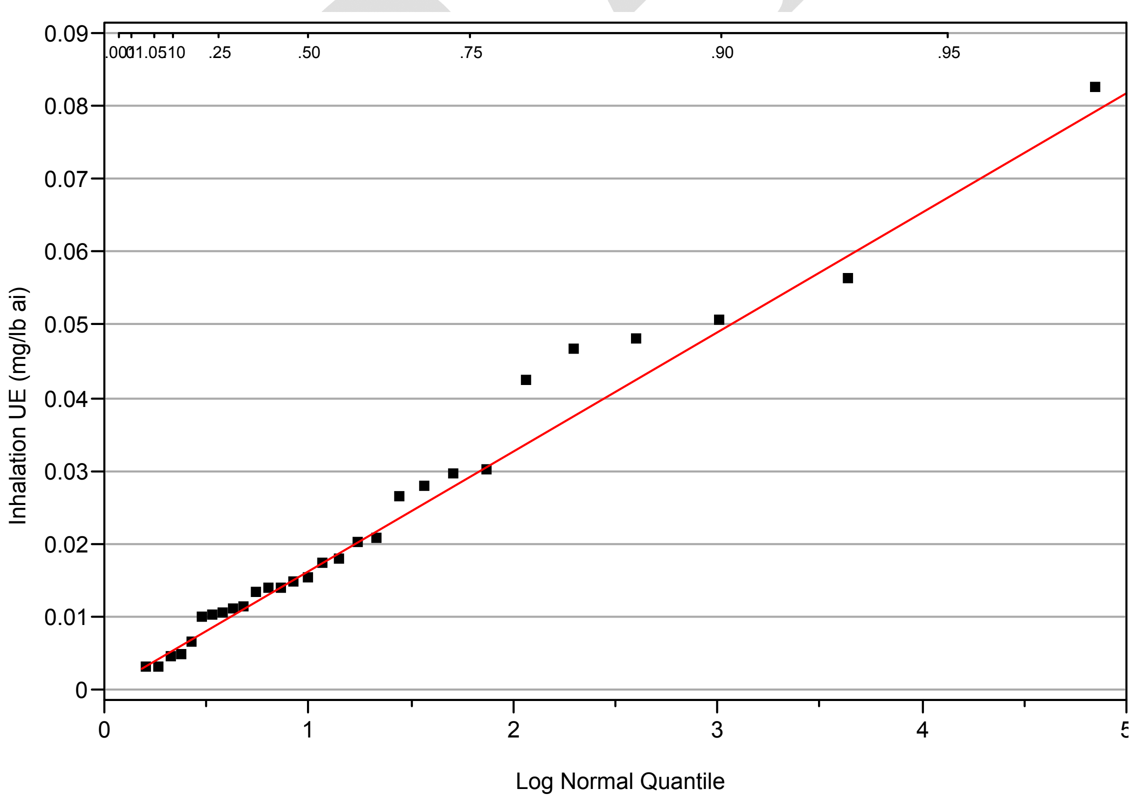
Lawns and Insect Mounds and Nests: The recommended inhalation unit exposures for applications of liquid pesticide formulations using a dial-type hose-end sprayer to lawns and insect mounds and nests is based on a lognormal distribution fit with exposure monitoring data from Klonne, D. (1999) [EPA MRID 44972201]. Klonne, D. (1999) monitored 30 applications of a liquid pesticide formulation for approximately 75 minutes to approximately 5000 ft^2 of residential lawns using a dial-type hose-end sprayer.

Lognormal Probability Plots

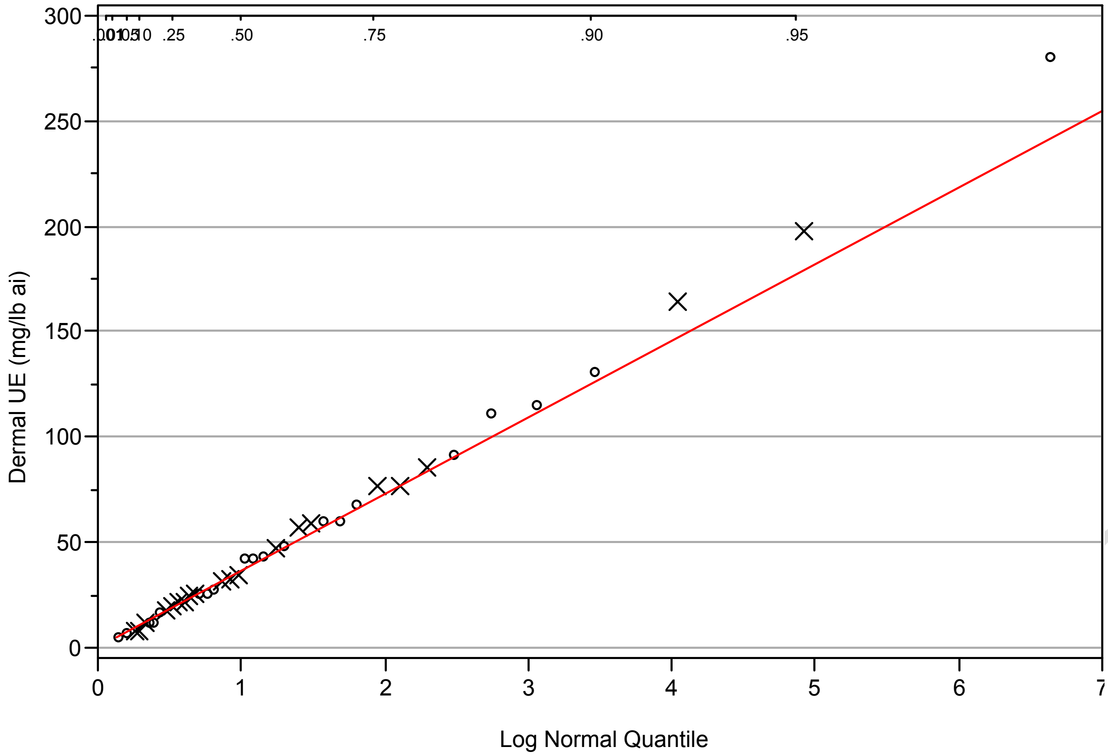
Turf/Mounds/Nests Legend: ■ = Klonne, D. (1999)



Turf/Mounds/Nests Legend: ■ = Klonne, D. (1999)



Gardens & Trees/Perimeter Legend: X = Merricks, D.L. (1997); O = Merricks, D.L. (1998)



Gardens & Trees/Perimeter Legend: X = Merricks, D.L. (1997); O = Merricks, D.L. (1998)

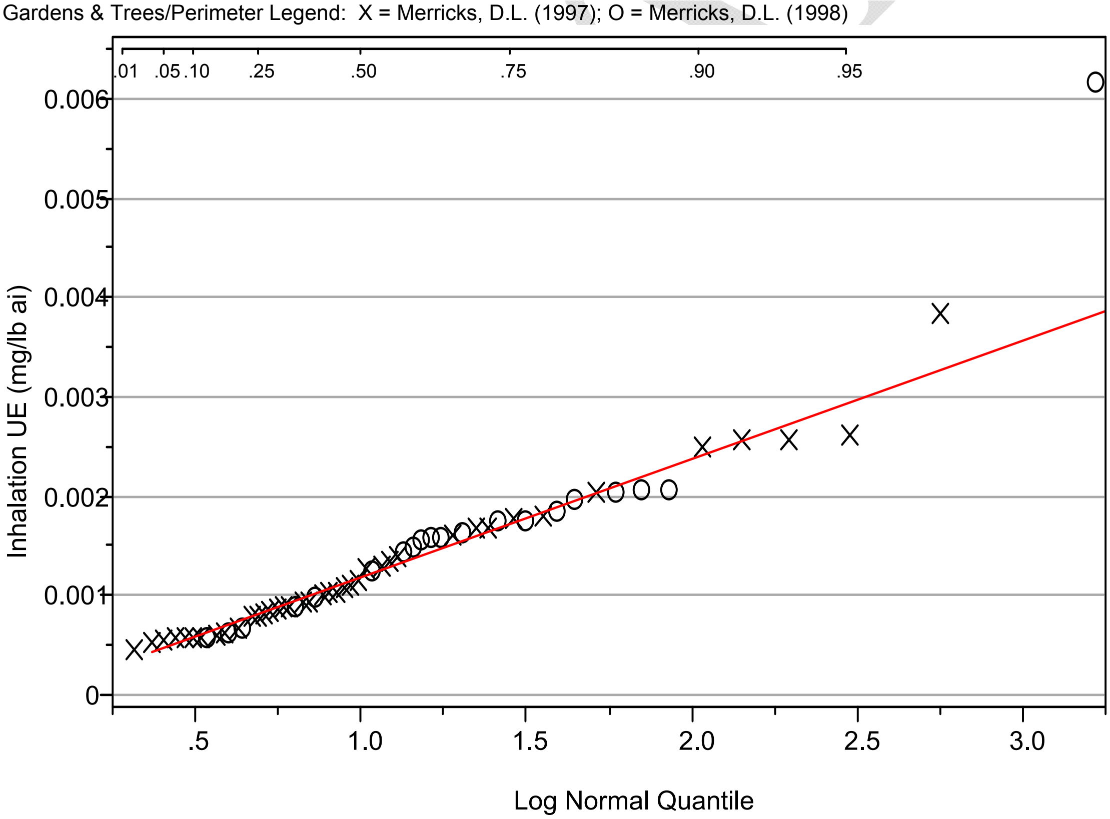


Table B-108: Available Exposure Study Identification Information	
Citation	Solomon, K. R., Harris, S. A, Stephenson, G. R. (1993). Applicator And Bystander Exposure To Home Garden And Landscape Pesticides. American Chemical Society, 1993, pp. 262-273
EPA MRID	none
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: A total 20 application events were monitored while loading and applying a liquid concentrate formulation (active ingredient 2, 4-D) using a hose-end sprayer. Eleven of the applications were conducted while wearing "protective" clothing, while 9 applications were conducted while wearing "normal" clothing. The exact nature of the clothing worn was not provided. Each individual handled approximately 0.08 – 3 lbs of 2, 4-D per application. Exposure was measured using biomonitoring with passive monitoring only conducted for inhalation exposure using standard pumps (set at 1 liter per minute), cassettes, and tubing. Recoveries from field fortifications of exposure sampling matrices were generally above 85%.

Table B-109: Solomon, et al. (1993) – Checklist and Use Recommendation for		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Table B-110: Exposure Study Identification Information	
Citation	Klonne, D. 1999. Integrated Report on Evaluation of Potential Exposure to Homeowners and Professional Lawn Care Operators Mixing, Loading, and Applying Granular and Liquid Pesticides to Residential Lawns. Sponsor/Submitter: Outdoor Residential Exposure Task Force
EPA MRID	44972201
ORETF Code	OMA004
EPA Review	Memo from G. Bangs to D. Fuller (3/5/03)

	D261948
	D287251
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: A total of 30 application events were collected from 30 individuals using passive dosimetry (inner and outer whole body dosimeters, hand washes, face/neck wipes, and personal inhalation monitors). Each test subject poured a 32 fl. oz. plastic container into a dial-type sprayer (DTS), which was then screwed onto the end of the hose. Each application consisted of treating approximately 5000 ft^2 of residential lawns and handling approximately 0.5 lb active ingredient (diazinon) over the course of 75 minutes. Dermal exposure was measured using inner and outer whole body dosimeters, hand washes, and face/neck washes, such that exposure can be constructed for various clothing scenarios (including a short-sleeve shirt, shorts, and no chemical-resistant gloves). Inhalation exposure was measured using standard personal air monitoring devices set at 1.5 liters per minute. 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. Lab spike recoveries for all matrices were in the range of 87-103%. Mean field fortification recoveries ranged from 79 to 104%.

Table B-111: MRID 44972201 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-112: MRID 44972201 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
3	0.5	1.29	0.007	2.58	0.014
4	0.5	9.01	--	18.03	--
7	0.5	12.80	0.025	25.60	0.050
8	0.5	7.60	0.015	15.21	0.030
10	0.5	5.20	0.005	10.40	0.010
14	0.5	3.52	0.008	7.04	0.016
15	0.5	2.97	0.021	5.94	0.042
16	0.5	6.56	0.015	13.12	0.030

18	0.5	3.60	0.014	7.19	0.028
20	0.5	4.65	0.007	9.30	0.014
24	0.5	2.25	0.010	4.49	0.020
25	0.5	24.72	0.041	49.44	0.082
27	0.5	4.70	0.028	9.40	0.056
28	0.5	8.04	0.023	16.07	0.046
30	0.5	14.78	0.005	29.57	0.010
34	0.5	4.39	0.005	8.77	0.010
35	0.5	17.55	0.002	35.10	0.004
36	0.5	11.98	0.002	23.96	0.004
39	0.5	3.40	0.007	6.81	0.014
40	0.5	7.14	0.006	14.28	0.012
43	0.5	1.74	0.002	3.48	0.004
44	0.5	3.72	0.003	7.44	0.006
47	0.5	6.32	0.007	12.65	0.014
49	0.5	11.05	0.024	22.09	0.048
50	0.5	3.94	0.013	7.88	0.026
54	0.5	9.73	0.009	19.45	0.018
55	0.5	2.65	0.002	5.29	0.004
56	0.5	1.31	0.005	2.62	0.010
59	0.5	16.03	0.010	32.06	0.020
60	0.5	3.49	0.009	6.99	0.018

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of liquid concentrate formulations using a hose-end sprayer, the following limitations are noted:

- Each individual handled the same amount of active ingredient, making analysis of the relationship between exposure and the amount of active ingredient handled (the underlying basis of unit exposures) difficult.

Table B-113: Exposure Study Identification Information	
Citation	Merricks, D.L. (1998). Carbaryl Mixer/Loader/Applicator Exposure Study During Application of RP-2 Liquid (21%) to Fruit Trees and Ornamental Plants
EPA MRID	44518501
ORETF Code	OMA005
EPA Review	Memo from G. Bangs to D. Fuller (3/5/03)
	D287251
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Twenty individuals were monitored while loading and applying a liquid formulation (21% carbaryl) to citrus trees and shrubs using a hose-end sprayer. Each application consisted of pouring the formulation into a dial-type sprayer (DTS), screwing it onto the garden hose and spraying the trees and shrubs. The activity lasted less than 20 minutes and the amount of carbaryl handled ranged from 0.02 to 0.09 lbs. Dermal exposure was measured using inner and outer whole body dosimetry and hand washes (individuals were monitored without gloves). Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Field fortification recoveries for passive dosimeters averaged 88.3% for inner and 76.2% for outer dosimeters. Face and neck wipe fortifications averaged 82.5%. Handwash fortifications averaged 93.6% and air sampler tube fortification was 91.8%. Laboratory method validation for each matrix fell within the acceptable range of 70 to 120%. 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.

Table B-114: MRID 44518501 – Checklist and Use Recommendation

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-115: MRID 44518501 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	0.026	0.19	0.000042	7.3	0.0016
B	0.020	2.25	0.000042	112.5	0.0021
C	0.066	8.71	0.000042	132.0	0.0006
D	0.052	14.65	0.000084	281.7	0.0016
E	0.027	1.64	0.000167	60.7	0.0062
F	0.025	0.31	0.000042	12.4	0.0017
G	0.020	1.38	0.000042	69.0	0.0021
H	0.022	0.99	0.000042	45.0	0.0019
I	0.021	0.90	0.000042	42.9	0.0020
J	0.020	0.99	0.000042	49.5	0.0021
K	0.035	0.42	0.000044	12.0	0.0013
L	0.046	0.23	0.000042	5.0	0.0009
M	0.042	2.51	0.000042	59.8	0.0010
N	0.090	3.80	0.000134	42.2	0.0015
O	0.029	0.75	0.000042	25.9	0.0015
P	0.027	3.08	0.000042	114.1	0.0016
Q	0.062	1.60	0.000042	25.8	0.0007
R	0.024	2.20	0.000042	91.7	0.0018

S	0.073	1.22	0.000043	16.7	0.0006
T	0.024	0.66	0.000042	27.5	0.0018

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of liquid concentrate formulations using a hose-end sprayer, the following limitations are noted:

- Seventeen of 20 inhalation exposure measurements were non-detects. Use of ½ the limit of detection (0.01 ug) was necessary, thus introducing uncertainty.

Table B-116: Exposure Study Identification Information	
Citation	Merricks, D.L. (1997). 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
EPA MRID	44459801
ORETF Code	OMA006
EPA Review	Memo from G. Bangs to D. Fuller (3/5/03)
	D287251

MRID = Master Record Identification
ORETF = Outdoor Residential Exposure Task Force

Study Description: Forty individuals were monitored while mixing, loading, and applying a liquid formulation (21% carbaryl) to tomato and cucumber gardens using a hose-end sprayer. Each application consisted of pouring the formulation into a dial-type sprayer (DTS), screwing it onto the garden hose and spraying the garden. The activity lasted less than 20 minutes and the amount of carbaryl handled ranged from 0.02 to 0.11 lbs. Dermal exposure was measured using inner and outer whole body dosimetry and hand washes (20 individuals were monitored without gloves). Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Field fortification recoveries for passive dosimeters averaged 84.3% for inner dosimeters and 77.7% for outer dosimeters. Face and neck wipe field fortifications averaged 84.8%. Both handwash and inhalation tube field fortification averaged >90%. Laboratory method validation for each matrix fell within the acceptable range of 70 to 120%. 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.

Potential for Use in Residential Handler Exposure Assessments: The table below outlines relevant characteristics of the above referenced study with respect to its potential use in residential handler exposure assessments. The recommendation for use informs only the data that is ultimately used as a default and does not mean that a study not recommended for use cannot ever be used. Should a non-recommended study be deemed useful given a unique situation, the assessment should provide justification for its use and deviation from use of the recommended studies as default data.

Table B-117: MRID 44459801 – Checklist and Use Recommendation for		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. Note that only dermal exposure data representative of individuals wearing short-sleeve shirt, shorts, shoes, socks, and no chemical-resistant gloves are presented. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-118: MRID 44459801 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
P2	0.11	3.43	0.000142	31.2	0.0013
Q2	0.08	3.59	0.000042	44.9	0.0005
T2	0.05	0.96	0.000042	19.2	0.0009
U2	0.03	1.92	0.000042	64.0	0.0017
V2	0.05	2.90	0.000043	58.0	0.0009
W2	0.08	6.30	0.000146	78.8	0.0018
Z2	0.05	1.18	0.000084	23.6	0.0018
A3	0.05	1.63	0.000134	32.6	0.0026
B3	0.04	0.79	0.000041	19.8	0.0010
C3	0.05	0.92	0.000042	18.4	0.0008
F3	0.07	2.34	0.000042	33.4	0.0006
G3	0.05	4.30	0.000125	86.0	0.0025
H3	0.03	0.73	0.000043	24.3	0.0014
I3	0.07	4.21	0.000042	60.1	0.0006
M3	0.03	0.20	0.000042	6.7	0.0016
L3	0.04	7.16	0.000094	179.0	0.0026
N3	0.05	8.33	0.000042	166.6	0.0008
O3	0.1	1.06	0.000042	10.6	0.0004
R3	0.05	1.09	0.000134	21.8	0.0025
S3	0.02	0.18	0.000042	9.0	0.0017
A	0.05	--	0.000042	--	0.0008
B	0.04	--	0.000042	--	0.0011
G	0.04	--	0.000042	--	0.0011
C	0.05	--	0.000042	--	0.0008
J	0.04	--	0.000042	--	0.0011
D	0.07	--	0.000042	--	0.0006
M	0.02	--	0.000042	--	0.0020

N	0.08	--	0.000042	--	0.0005
Q	0.03	--	0.000042	--	0.0013
R	0.04	--	0.000042	--	0.0010
U	0.04	--	0.000043	--	0.0010
V	0.07	--	0.000042	--	0.0006
Y	0.05	--	0.000042	--	0.0009
Z	0.04	--	0.000042	--	0.0009
C2	0.05	--	0.000042	--	0.0009
D2	0.07	--	0.000041	--	0.0006
G2	0.01	--	0.000042	--	0.0038
H2	0.07	--	0.000042	--	0.0006
K2	0.03	--	0.000042	--	0.0013
L2	0.06	--	0.000042	--	0.0006

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of liquid concentrate formulations using a hose-end sprayer, the following limitations are noted:

- Thirty-six of 40 inhalation exposure measurements were non-detects. Use of ½ the limit of detection (0.01 ug) was necessary, thus introducing uncertainty.

Scenario Summary

Table B-119: Scenario Description and Available Exposure Studies	
Formulation	Liquids (emulsifiable concentrates, soluble concentrates, etc.)
Equipment/Application Method	Backpack sprayer
Application Site(s)	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests)
Available Exposure Studies	Merricks, L.D. (1988); MRID 42238702
	Contardi, J.S. et al. (1993); MRID 43017901
	Beard, K.K. (1997); MRID 44339801
	Chester, G. et al. (1985); MRID 46807007
	Chester, G.; Woollen, B.H. (1980); MRID 00059714
	Scott, R.C. et al. (1983); MRID 00131455
	Chester, G.; Jones, N.; Woolen, B.H. (1989); MRID 46807005
	Schneider et al (1999)
	King, C.; Prince, P. (1995); MRID 43623202
	Spencer et al (2000); MRID 46852112
	Stewart, P., et al. (1999)
	Chester, G.; Woollen, B.H. (1980); MRID 00096364

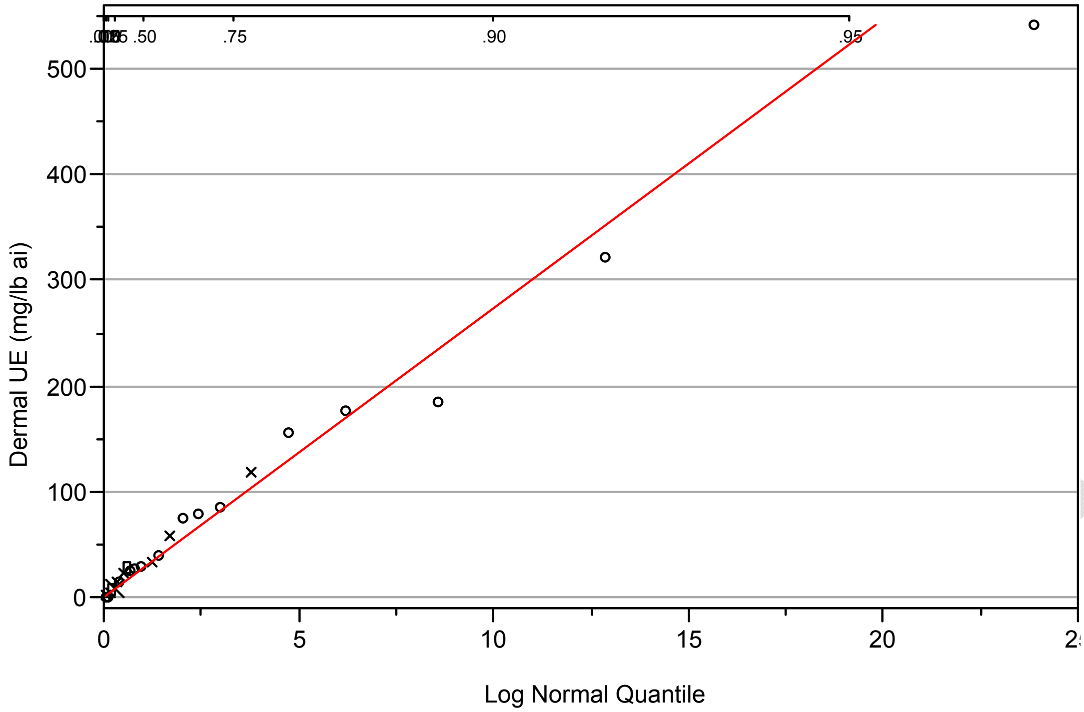
Table B-120: Unit Exposures (mg/lb ai) – Liquid Backpack Sprayer Applications		
Statistic	Dermal	Inhalation
50^{th} percentile	25	0.064
75^{th} percentile	85	0.14
95^{th} percentile	490	0.40
99^{th} percentile	1700	0.85
99.9^{th} percentile	6600	2.0
AM (SD)	130 (630)	0.120 (0.19)
GM (GSD)	25 (6.04)	0.064 (3.04)
Range	0.72 – 540	0.0071 – 0.21
N	26	16

<u>Dermal Unit Exposure Summary:</u> The recommended dermal unit exposures for applications of liquid pesticide formulations using a backpack sprayer is based on a lognormal distribution fit with exposure monitoring data from Merricks, D.L. (1988) [EPA MRID 42238702], Contardi, J.S., et al (1993) [EPA MRID 43017901], and Beard, K.K. (1997) [EPA MRID 44339801]. Merricks, D.L. (1988) monitored 9 applications of 3, 2-gallon liquid pesticide solutions for approximately 47 minutes to poultry litter using a backpack sprayer. Contardi, J.S. et al (1993) monitored 2 applications of a liquid pesticide formulation to greenhouse plants hanging overhead, on the floor, or on benches for approximately 1.5 hours using a backpack sprayer. Beard, K.K. (1997) monitored 15 applications of a liquid pesticide formulation to approximately 6000 ft^2 of Christmas tree farms in Michigan, Pennsylvania, and Connecticut for approximately 4 hours using a backpack sprayer.

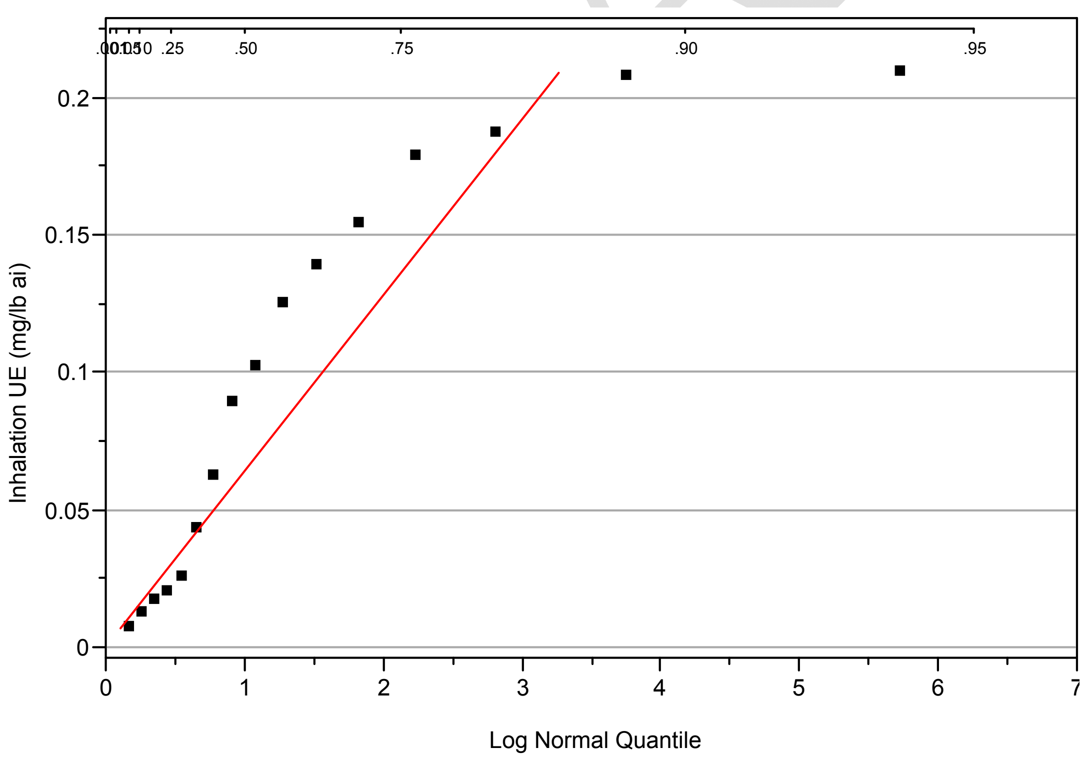
<u>Inhalation Unit Exposure Summary:</u> The recommended inhalation unit exposures for applications of liquid pesticide formulations using a backpack sprayer is based on a lognormal distribution fit with exposure monitoring data from King, C.; Prince, P. (1995) [EPA MRID 43623202]. King, C.; Prince, P. (1995) monitored 16 applications of a liquid pesticide formulation for approximately 63-94 minutes to greenhouse ornamentals in Florida, Maryland, and California.

Lognormal Probability Plots

Legend: O = Beard, K.K. (1997); X = Merricks, L.D. (1998); ■ = Contardi, J.S. (1993)



Legend: ■ = King, C., Prince, P., (1995)



Available Handler Exposure Studies

Table B-121: Exposure Study Identification Information	
Citation	Merricks, L.D. (1988). Exposure of workers to Cyromazine during the mixing, loading, and application of Larvadex 2SL in poultry houses.
EPA MRID	42238702
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Nine individuals were monitored while applying a liquid formulation of cyromazine to poultry litter using a backpack sprayer. Each applicator mixed and applied 3, 2-gallon solutions (equal to approximately 0.052 lbs cyromazine); a task that lasted on average 47 minutes. Dermal exposure was measured using gauze patches (both inside and outside normal work clothing) and cotton gloves (underneath chemical-resistant gloves) for hand exposure. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. An average of 84.9% ± 5.2 (n=18) was recovered from field fortified patches, 79.3% ± 7.3% from gloves and 84.0% ± 16.8% from foam air filters. The overall average recovery from laboratory fortified control samples was 87% ± 12.0% for alpha-cellulose gauze patches, 75% ± 11.6% for cotton gloves, and 89% ± 10.5% for foam air filters.

Table B-122: MRID 42238702 – Checklist and Use Recommendation for		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**No**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only dermal exposure data are presented as inhalation exposure data from this study is not recommended for the purposes of residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-123: MRID 42238702 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
CC	0.048	0.362	--	7.54	--
DD	0.048	0.035	--	0.73	--
EE	0.048	0.109	--	2.27	--
FF	0.048	2.69	--	56.04	--

GG	0.048	5.65	--	117.71	--
HH	0.048	1.58	--	32.92	--
II	0.048	0.68	--	14.17	--
JJ	0.048	1.08	--	22.50	--
KK	0.048	0.18	--	3.75	--

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm). All samples were non-detects.
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of liquid concentrate formulations using a backpack sprayer, the following limitations are noted:

- All monitored individuals wore chemical-resistant gloves, thus a back-calculation using a 90% protection factor to "bare hands" exposure was necessary.
- The study was conducted using workers in a poultry house, so use for residential handler exposure assessments introduces uncertainty.

Table B-124: Exposure Study Identification Information	
Citation	Contardi, J.S. et al. (1993). Evaluation of Chlorpyrifos exposures during mixing/loading and application of Empire 20 insecticide to ornamental plants in greenhouses.
EPA MRID	43017901
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Two individuals were monitored while applying a liquid formulation of chlorpyrifos to greenhouse plants hanging overhead or on the floor or on benches using a backpack sprayer. Each applicator sprayed over 100 gallons of solution, corresponding to 0.13 lbs of chlorpyrifos handled. Each application event generally lasted 1.5 hours. Dermal exposure was measured using gauze patches (both inside and outside normal work clothing) and hand rinses (underneath chemical-resistant gloves) for hand exposure. Inhalation exposure was measured using standard pumps (set at 1.5 liters per minute), cassettes, and tubing. Recoveries from field fortifications of exposure sampling matrices were generally above 90%.

Table B-125: MRID 43017901 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	

Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**No**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only dermal exposure data are presented as inhalation exposure data from this study is not recommended for the purposes of residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-126: MRID 43017901 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
L	0.13	0.56	--	4.30	--
N	0.13	3.39	--	26.10	--

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of liquid concentrate formulations using a backpack sprayer, the following limitations are noted:

- All monitored individuals wore chemical-resistant gloves, thus a back-calculation using a 90% protection factor to "bare hands" exposure was necessary.
- The study was conducted using workers in a greenhouse, so use for residential handler exposure assessments introduces uncertainty.

Table B-127: Exposure Study Identification Information

Citation	Beard, K.K. (1997). Evaluation of Applicator Exposures to SURFLAN® A.S. During Mixing, Loading, and Application with Backpack Sprayers
EPA MRID	44339801
ORETF Code	NA
EPA Review	D284121
	D242325

MRID = Master Record Identification
ORETF = Outdoor Residential Exposure Task Force

Study Description: Fifteen individuals (14 loader/applicators, 1 mixer/loader/applicator) were monitored while applying a liquid formulation of oryzalin to Christmas tree farms in Michigan, Pennsylvania, and Connecticut using a backpack sprayer. Each application was at least 4 hours and each worker treated an area of at least 6000 ft^2 handling from 5 to 70 lbs of oryzalin. Dermal exposure was measured using whole body dosimetry (both outside and underneath normal work clothing) and hand exposure was measured using wipes. Inhalation exposure was measured using standard pumps (set at 1 liter per minute), cassettes, and tubing. The average recoveries for spikes prepared with the filter/tube combinations, denim, long underwear, socks and hand wipes were 106 ± 5.1%, 113 ± 4.7%, 102 ± 7.2%, 93.3 ± 56%, and 84 ± 8.3%, respectively. The average recovery for spikes prepared with coverall portions was 85 ± 15%, for spikes prepared with long underwear portions was 104 ± 22%, for spikes prepared with pairs of socks was 87 ± 17%.

Table B-128: MRID 44339801 – Checklist and Use Recommendation

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**No**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only dermal exposure data are presented as inhalation exposure data from this study is not recommended for the purposes of residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-129: MRID 44339801 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
1	8.3	226	--	27.21	--
2	8.3	222	--	26.80	--
3	68.6	63	--	0.92	--
4	8.3	245	--	29.57	--
5	8.3	12	--	1.41	--
7	16	2957	--	184.82	--
8	16	8673	--	542.06	--
9	16	1285	--	80.32	--
10	16	2841	--	177.54	--
11	16	5171	--	323.16	--
13	4.9	770	--	157.11	--
14	4.9	419	--	85.57	--
15	4.9	376	--	76.71	--
16	4.9	203	--	41.44	--
17	23.3	359	--	15.40	--

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of liquid concentrate formulations using a backpack sprayer, the following limitations are noted:

- All monitored individuals wore chemical-resistant gloves, thus a back-calculation using a 90% protection factor to "bare hands" exposure was necessary.
- The study was conducted using workers at a Christmas tree farm, so use for residential handler exposure assessments introduces uncertainty.

Table B-130: Exposure Study Identification Information	
Citation	Chester, G.; Hart, T.B.; Sabapathy, N.N.; Woolen, B.H.; Atreya, N. (1985). Fluazifop-butyl: spray operator exposure on Malaysian plantation.
EPA MRID	46807007
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Eight workers were monitored on 5 separate days (for a total of 40 monitored application events) while applying fluazifop-butyl to grass cover in a Malaysian plantation. Each application was approximately 3 – 4 hours and each applicator handled approximately 1 lb of active ingredient. Dermal exposure was measured using whole body dosimetry (outside normal work clothing only) and hand exposure was measured using wipes. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Field recovery from all sampling materials ranged from 79% to 92%.

Table B-131: MRID 46807007 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Table B-132: Exposure Study Identification Information	
Citation	Chester, G.; Woollen, B.H. (1980) A Study of the Occupational Exposure of Malaysian Plantation Workers to Paraquat. (Unpublished study received Nov 24, 1980 under 239-2186; submitted by Chevron Chemical Co., Richmond, Calif.; CDL:243840-A)
EPA MRID	00059714
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Five workers were monitored during 4 applications of paraquat to grass cover in a Malaysian plantation using backpack sprayers. The application time and amount of active ingredient handled were unclear based on the study report. Dermal exposure was measured using gauze patches (most placed outside normal work clothing only). Hand exposure was not measured. Inhalation exposure was measured for only 9 of the 20 application events using standard pumps (set at 2 liters per minute), cassettes, and tubing. Only laboratory recoveries were reported which averaged 59%.

Table B-133: MRID 00059714 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	No	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	No	No
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Table B-134: Exposure Study Identification Information	
Citation	Scott, R.C.; Chester, G.; Hart, T.B.; Woolen, B.H.; Ward, R.J.; Laird, W.J.D. (1983). Fluazifop-butyl: a spray trial to assess knapsack spraying.
EPA MRID	00131455
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Six workers were monitored for a total of 12 application events during applications of fluazifop-butyl to grassland in England using a backpack sprayer. Each application consisted of spraying 3, 16 liter tanks over the course of 1 day. The amount of active ingredient handled ranged from 0.5 to 5 lbs per application. The application time was not reported in the study report. Dermal exposure was measured for 9 of the 12 applications using whole body dosimetry (outside normal work clothing only) and cotton gloves. Inhalation exposure was measured for 3 of the 12 applications using standard pumps (set at 3 liters per minute), cassettes, and tubing. Laboratory recoveries were generally above 85%, although field recoveries were not reported.

Table B-135: MRID 00131455 – Checklist and Use Recommendation

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	No	No
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Table B-136: Exposure Study Identification Information	
Citation	Chester, G.; Jones, N.; Woolen, B.H. (1989). Dermal exposure of, and absorption by, Sri Lankan tea plantation workers
EPA MRID	46807005
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Ten workers were monitored during 2 applications of paraquat to weeds in a Sri Lankan tea plantation using a backpack sprayer. Each application consisted of spraying 4 tank loads over the course of approximately 1 hour. Each worker handled approximately 0.05 lbs of paraquat per application. Dermal exposure was measured using whole body dosimetry (outside normal work clothing only) and cotton gloves. Inhalation exposure was not measured. Field recovery summary from the light procedural recoveries are for sock 90% and for glove 110%, and for dark procedural recoveries are for sock 94% and for glove 85%.

Table B-137: MRID 46807005 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	No	No
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Table B-138: Exposure Study Identification Information	
Citation	Schneider et al (1999). Exposure of Hand Applicators to Glyphosate in Forest Settings, 1995
EPA MRID	none
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Ten individuals were monitored during 2 days of glyphosate applications in forests using backpack sprayers. Each day of applications was approximately 6 to 8 hours (with each worker applying at least 20 tank loads) and each individual handled between 2 and 3 lbs of glyphosate per day. Dermal exposure was measured using a long-sleeve t-shirt and knee-length socks (underneath normal work clothing only) and hand wipes. All workers wore chemical-resistant gloves. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Field recoveries were generally above 75%.

Table B-139: Schneider, et al (1999) – Checklist and Use Recommendation

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Table B-140: Exposure Study Identification Information

Citation	King, C.; Prince, P. (1995) Chlorothalonil Worker Exposure During Application of Daconil 2787 Flowable Fungicide in Greenhouses: Lab Project Number: 5968-94-0104-CR-001: 94-0104: SDS-2787. Unpublished study prepared by Ricerca, Inc.
EPA MRID	43623202
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Sixteen backpack applications in greenhouses – 6 workers in Florida, and 5 each in Maryland and California – were monitored. Each application was approximately 63 to 94 minutes and consisted of each individual mixing, loading, and applying 3 tank loads (approximately 0.1 lbs chlorothalonil) to ornamental plants. Dermal exposure was measured using inner whole body dosimetry (underneath normal work clothing) and hand rinses. All workers wore chemical-resistant gloves. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Field fortified travel spikes had mean recoveries greater than or equal to 77% for each site and matrix. Weathered samples had recoveries greater than or equal to 75% at higher fortification levels. Recoveries ranged between 30 to 70% for alpha-cellulose patches, dosimeter patches, and air monitoring samples. Analytical laboratory generated recovery samples were analyzed concurrently with the worker exposure samples as a check on losses due to the extraction procedure. These samples had a mean recovery of 100% with a standard deviation of 9.7%.

Table B-141: Checklist and Use Recommendation for MRID 43623202

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only inhalation exposure data are presented as the dermal exposure data are not recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-142: MRID 43623202 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
1	0.086	--	0.0088	--	0.102
1A	0.098	--	0.0123	--	0.125
2	0.065	--	0.0040	--	0.062
3	0.081	--	0.0124	--	0.154
4	0.092	--	0.0191	--	0.208
5	0.085	--	0.0159	--	0.187
6	0.106	--	0.0008	--	0.007
7A	0.063	--	0.0008	--	0.013
8	0.064	--	0.0017	--	0.026
9	0.094	--	0.0019	--	0.020
10	0.065	--	0.0011	--	0.017
11	0.071	--	0.0127	--	0.179
12	0.057	--	0.0119	--	0.209
13	0.053	--	0.0073	--	0.139
14	0.099	--	0.0088	--	0.089
15	0.076	--	0.0033	--	0.043

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of liquid concentrate formulations using a backpack sprayer, the following limitations are noted:

- The study was conducted using workers in a greenhouse, so use for residential handler exposure assessments introduces uncertainty.

Table B-143: Exposure Study Identification Information	
Citation	Spencer et al (2000). HS-1769. Exposure of Hand Applicators to Triclopyr in Forest Settings, 1995
EPA MRID	46852112
ORETF Code	NA
EPA Review	Contractor (Versar, Inc.) review 9/30/03
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Ten individuals were monitored during 2 applications of triclopyr in forests using backpack sprayers. Each application consisted of loading and applying 3 tank loads over the course of approximately 6 hours with each individual handling approximately 3 lbs of triclopyr per application. Dermal exposure was measured using a long-sleeve t-shirt and knee-length socks (underneath normal work clothing only) and hand wipes. All workers wore chemical-resistant gloves. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. The average field fortification recoveries from air filters was 58.98% with a standard deviation of 20.95%, from wipes was 95.90% with a standard deviation of 8.67%, from socks was 85.62% with a standard deviation of 7.98%, and from T-shirt was 98.23% with a standard deviation of 5.06%.

Table B-144: MRID 46852112 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	No
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Table B-145: Exposure Study Identification Information	
Citation	Stewart, P., T. Fears, H.F. Nicholson, B.C. Kross, L. K. Ogilvie, S.H. Zahm, M.H. Ward and A. Blair (1999) Exposure Received From Application Of Animal Insecticides. American Industrial Hygiene Association Journal. 60:208-212
EPA MRID	none
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Two farmers were monitored while applying insecticides to animals using a backpack sprayer. Each application ranged from approximately 1 to 200 liters of solution and varied among 6 active ingredients. Clothing worn varied between farmers. Dermal exposure was measured using a fluorescent dye video-imaging technique. Inhalation exposure was not measured.

Table B-146: Stewart, et al (1999) – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	No
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Table B-147: Exposure Study Identification Information	
Citation	Chester, G.; Woollen, B.H. (1980) A Study of the Occupational Exposure of Malaysian Plantation Workers to Paraquat: Report No. CTL/P/580. (Unpublished study received Jan 29, 1981 under 239-2186; prepared by Imperial Chemical Industries, Ltd., England, submitted by Chevron Chemical Co., Richmond, Calif.; CDL:244280-A)
EPA MRID	00096364
ORETF Code	NA

EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Four workers were monitored during 5 applications of paraquat to grass cover in a Malaysian plantation using backpack sprayers. The application time and amount of active ingredient handled were unclear based on the study report. Dermal exposure was measured using gauze patches (most placed outside normal work clothing only). Hand exposure was not measured. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Only laboratory recoveries were reported (59%). [Note: This data comes from the same study as MRID 00059714 – monitoring conducted at different times.]

Table B-148: MRID 00096364 – Checklist and Use Recommendation

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	No	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	No	No
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Scenario Summary

Table B-149: Scenario Description and Available Exposure Studies	
Formulation	Ready-to-use (RTU)
Equipment/Application Method	Hose-end sprayer
Application Site(s)	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests)
Available Exposure Studies	Klonne, D. (1999); MRID 44972201

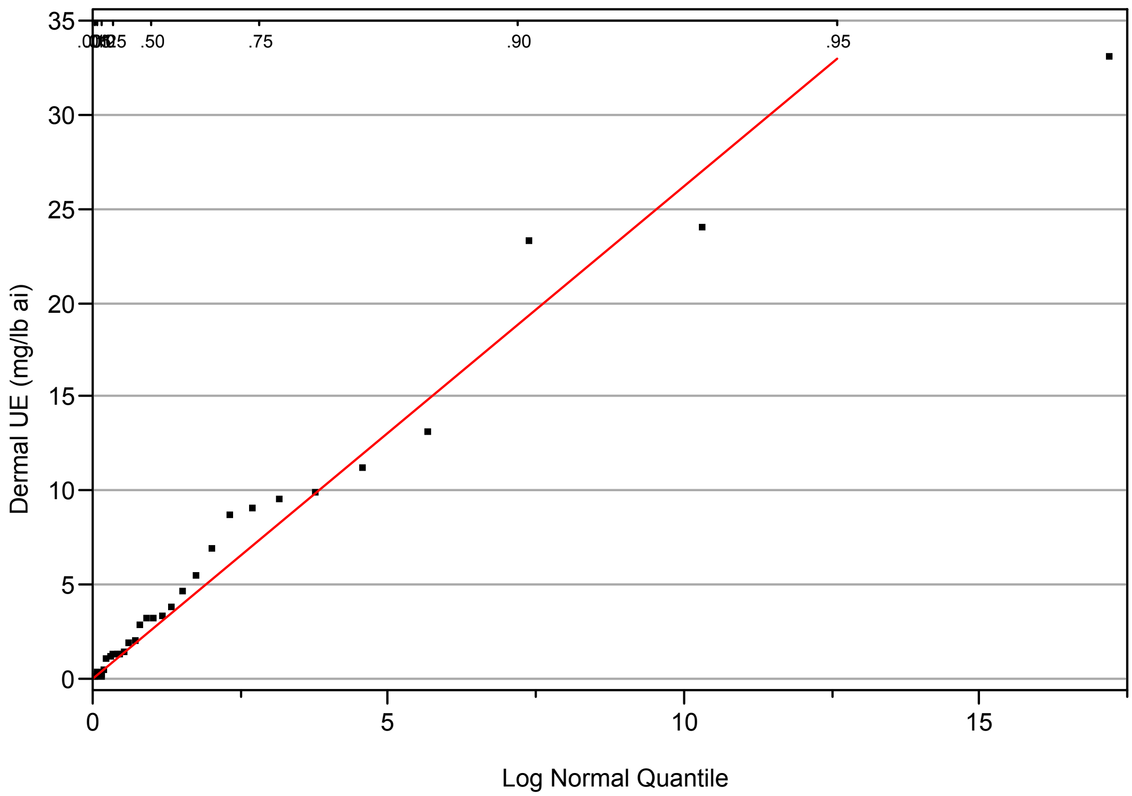
Table B-150: Unit Exposures (mg/lb ai) – RTU Hose-end Sprayer Applications		
Statistic	Dermal	Inhalation
50th percentile	2.6	0.010
75th percentile	7.4	0.023
95th percentile	33	0.071
99th percentile	94	0.16
99.9th percentile	304	0.39
AM (SD)	8.6 (27)	0.020 (0.036)
GM (GSD)	2.6 (4.7)	0.010 (3.3)
Range	0.078 – 33.0	0.00067 – 0.061
N	30	30

Dermal Unit Exposure Summary: The recommended dermal unit exposures for applications using a RTU hose-end sprayer is based on a lognormal distribution fit with exposure monitoring data from Klonne, D. (1999) [EPA MRID 44972201]. Klonne, D. (1999) monitored 30 applications of pesticide formulations to approximately 5000 ft^2 of residential lawns for approximately 75 minutes using a RTU hose-end sprayer.

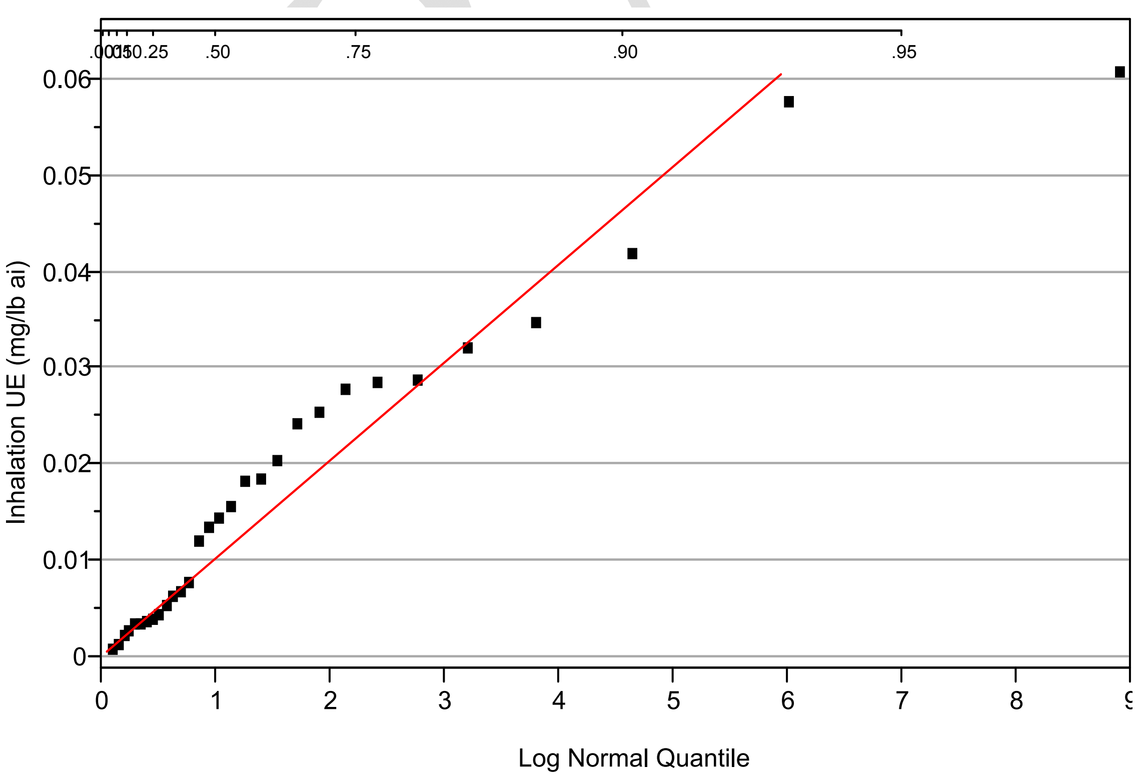
Inhalation Unit Exposure Summary: The recommended inhalation unit exposures for applications using a RTU hose-end sprayer is based on a lognormal distribution fit with exposure monitoring data from Klonne, D. (1999) [EPA MRID 44972201]. Klonne, D. (1999) monitored 30 applications of pesticide formulations to approximately 5000 ft^2 of residential lawns for approximately 75 minutes using a RTU hose-end sprayer.

Lognormal Probability Plots

Legend: ■ = Klonne, D. (1999)



Legend: ■ = Klonne, D. (1999)



Available Handler Exposure Studies

Table B-151: Exposure Study Identification Information	
Citation	Klonne, D. 1999. Integrated Report on Evaluation of Potential Exposure to Homeowners and Professional Lawn Care Operators Mixing, Loading, and Applying Granular and Liquid Pesticides to Residential Lawns. Sponsor/Submitter: Outdoor Residential Exposure Task Force.
EPA MRID	44972201
ORETF Code	OMA004
EPA Review	D261948
	EPA Memo from G. Bangs to D. Fuller (3/5/03)
	D287251
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: A total of 30 application events were monitored for 30 different volunteers using passive dosimetry (inner and outer whole body dosimeters, hand washes, face/neck wipes, and personal inhalation monitors). Each test subject screwed a ready-to-use (RTU) 32 fl. oz. plastic container onto the end of the hose and treated approximately 5000 ft^2 of residential lawns. Each applicator handled approximately 0.5 lb active ingredient (diazinon) over the course of 75 minutes. Dermal exposure was measured using inner and outer whole body dosimeters, hand washes, and face/neck washes, such that exposure can be constructed for various clothing scenarios (including a short-sleeve shirt, shorts, and no chemical-resistant gloves). Inhalation exposure was measured using standard personal air monitoring devices set at 1.5 liters per minute. 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. Concurrent lab spikes produced mean recoveries in the range of 78-125% for the various matrices. Mean field fortification recoveries ranged from 76% to 110% for all matrices. Mean percent field fortification recovery for outer dosimeter with a spike level of 50 μg was 80.6% with a standard deviation of 7.95%, of 500 μg was 79.4% with a standard deviation of 19.3%, and of 5000 μg was 75.5% with a standard deviation of 5.81%. Mean percent field fortification recovery for inner dosimeter with a spike level of 5 μg was 99.3% with a standard deviation of 10.7%, and of 50 μg was 89.5% with a standard deviation of 8.33%. Mean percent field fortification recovery for hand wash with a spike level of 5 μg was 83.7% with a standard deviation of 9.13%, of 25 μg was 83.9% with a standard deviation of 10.0%, and of 100 μg was 85.6% with a standard deviation of 11.1%. Mean percent field fortification recovery for neck/face wash with a spike level of 5 μg was 102% with a standard deviation of 2.81, of 10 μg was 101% with a standard deviation of 13.9%, and of 25 μg was 93.0% with a standard deviation of 2.93%.

Table B-152: MRID 44972201 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted	Yes	

activity, amount of active ingredient handled, volunteers used, or the setting?		
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-153: MRID 44972201 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
1	0.5	0.11	0.0090	0.21	0.0180
2	0.5	3.42	0.0120	6.84	0.0240
5	0.5	16.50	0.0303	33.00	0.0606
6	0.5	0.93	0.0059	1.86	0.0117
9	0.5	1.56	0.0142	3.12	0.0285
11	0.5	1.60	0.0173	3.20	0.0346
12	0.5	0.62	0.0126	1.23	0.0252
13	0.5	0.69	0.0141	1.37	0.0282
17	0.5	0.65	0.0016	1.30	0.0033
19	0.5	0.50	0.0091	1.00	0.0183
21	0.5	4.75	0.0159	9.49	0.0318
22	0.5	0.58	0.0030	1.17	0.0061
23	0.5	1.62	0.0101	3.23	0.0201
26	0.5	4.90	0.0209	9.80	0.0418
29	0.5	2.74	0.0288	5.49	0.0575
31	0.5	6.52	0.0026	13.05	0.0053
32	0.5	0.97	0.0010	1.94	0.0019
33	0.5	4.52	0.0019	9.04	0.0038
37	0.5	1.86	0.0077	3.72	0.0155
38	0.5	5.59	0.0037	11.17	0.0074
41	0.5	0.04	0.0003	0.08	0.0007
42	0.5	11.63	0.0006	23.26	0.0011
45	0.5	2.28	0.0016	4.56	0.0032
46	0.5	0.11	0.0071	0.22	0.0142
48	0.5	1.43	0.0138	2.86	0.0276
51	0.5	0.61	0.0017	1.22	0.0034
52	0.5	4.35	0.0033	8.71	0.0067
53	0.5	0.21	0.0013	0.41	0.0026
57	0.5	11.97	0.0066	23.94	0.0132
58	0.5	0.09	0.0021	0.17	0.0043

1 Amount of active ingredient Handled
2 Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
3 Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
4 Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of residential applications of ready-to-use formulations using a hose-end sprayer, the following limitations are noted:

- Each individual handled the same amount of active ingredient, making analysis of the relationship between exposure and the amount of active ingredient handled (the underlying basis of unit exposures) difficult.

Scenario Summary

Table B-154: Scenario Description and Available Exposure Studies	
Formulation	Ready-to-use (RTU)
Equipment/Application Method	Trigger-pump sprayer
Application Site(s)	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests), indoors (plants, cracks and crevices), pets/animals
Available Exposure Studies	Merricks, D.L. (1997); MRID 44459801
	Meo, N.; Gonzalez, C.; Mester, T. (1997); MRID 44433302
	Knarr, R.D. (1988); MRID 41054701
	Barnekow, D.E.; Cook, W.L.; Meitl, T.J.; Shurdut, B.A. (1999); MRID 44739301

Table B-155: Unit Exposures (mg/lb ai) – Liquid Trigger-pump sprayer Applications				
Statistic	Outdoors / Indoors		Pets/Animals	
	Dermal	Inhalation	Dermal	Inhalation
50th percentile	54	0.046	510	2.2
75th percentile	103	0.077	990	4.0
95th percentile	260	0.16	2600	9.6
99th percentile	490	0.26	5000	18
99.9th percentile	1020	0.46	10500	36
AM (SD)	85.1 (103)	0.061 (0.053)	820 (1040)	3.3 (3.7)
GM (GSD)	54.2 (2.56)	0.046 (2.10)	510 (2.7)	2.2 (2.5)
Range	11.0 – 253	0.016 – 0.21	101 – 2400	0.30 – 8.4
N	20	70	16	16

<u>Dermal Unit Exposure Summary</u>

Outdoor and Indoor Environments: The recommended dermal unit exposures for applications of liquid pesticide formulations using a trigger-pump sprayer to outdoor and indoor environments is based on a lognormal distribution fit with exposure monitoring data from Merricks, D.L. (1997) [EPA MRID 44459801]. Merricks, D.L. (1997) monitored 40 applications to tomatoes and cucumbers using a ready-to-use (RTU) trigger-spray bottle.

Pets and Animals: The recommended dermal unit exposures for applications of liquid pesticide formulations using a trigger-pump sprayer to pets or animals is based on a lognormal distribution fit with exposure monitoring data from Meo, N. et al (1997) [EPA MRID 44433302]. Meo, N. et al (1997) monitored 16 applications by commercial pet groomers treating 8 dogs for approximately 38-72 minutes using a read-to-use (RTU) trigger-spray bottle.

<u>Inhalation Unit Exposure Summary</u>

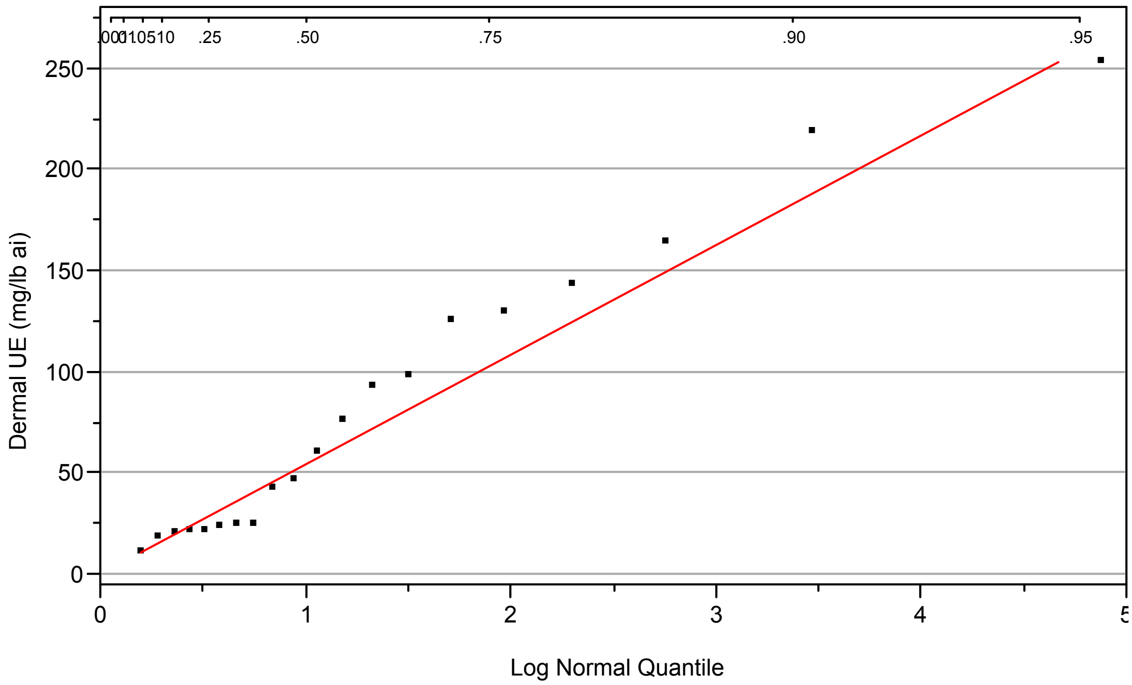
Outdoor and Indoor Environments: The recommended inhalation unit exposures for applications of liquid pesticide formulations using a trigger-pump sprayer to outdoor and indoor environments is based on a lognormal distribution fit with exposure monitoring data from Merricks, D.L. (1997) [EPA MRID 44459801], Knarr, R.D. (1998) [EPA

MRID 41054701], and Barnekow, D.E., et al (1999) [EPA MRID 47739301]. Merricks, D.L. (1997) monitored 40 applications to tomatoes and cucumbers using a ready-to-use (RTU) trigger-spray bottle. Knarr, R.D. (1998) monitored 5 applications of a liquid pesticide formulation to door frames, screens, patios, and stoops for approximately 9-21 minutes using a trigger sprayer attached to a ½ gallon container with an 18-inch hose. Barnekow, D.E., et al (1999) monitored 15 applications of a liquid pesticide formulation to outdoor foundations, perimeters, and flower beds for approximately 1 hour using a 24 oz. ready-to-use trigger spray bottle.

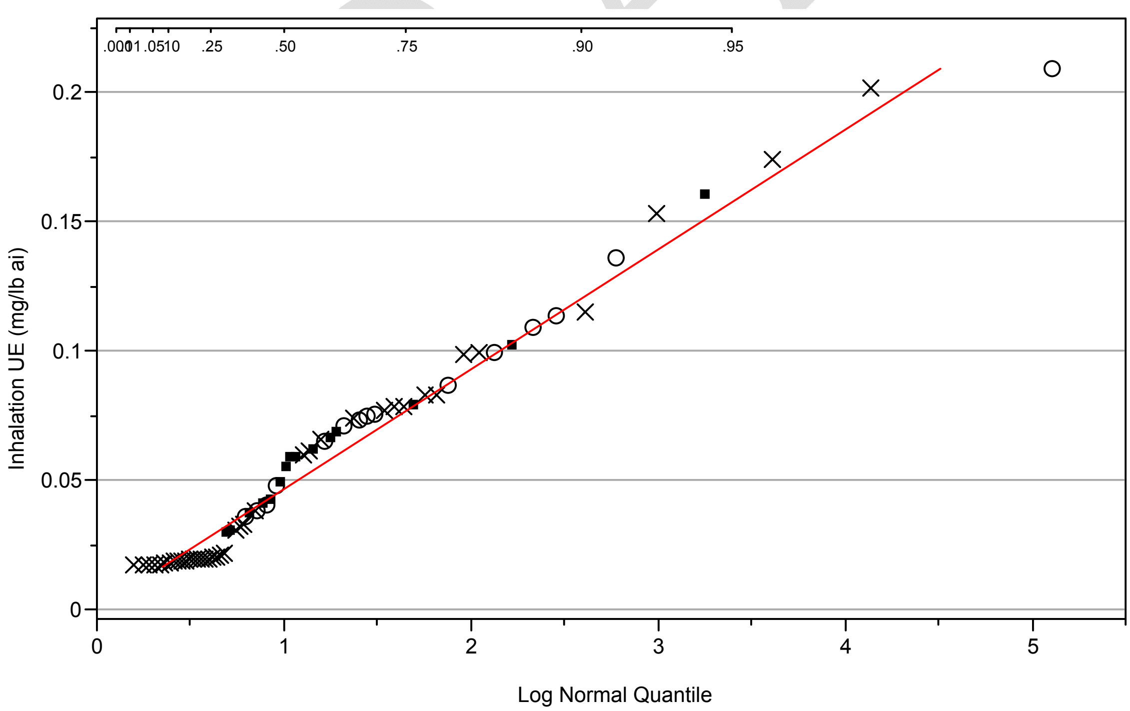
Pets and Animals: The recommended inhalation unit exposures for applications of liquid pesticide formulations using a trigger-pump sprayer to pets or animals is based on a lognormal distribution fit with exposure monitoring data from Meo, N. et al (1997) [EPA MRID 44433302]. Meo, N. et al (1997) monitored 16 applications by commercial pet groomers treating 8 dogs for approximately 38-72 minutes using a read-to-use (RTU) trigger-spray bottle.

Lognormal Probability Plots

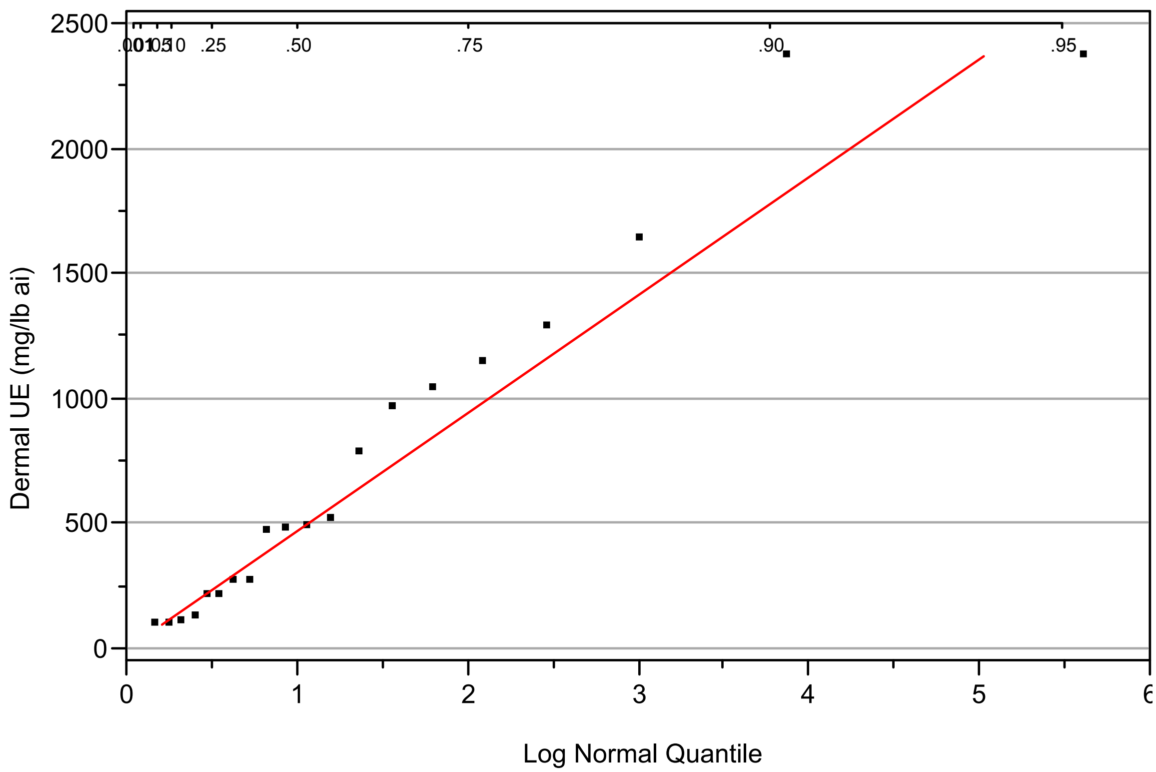
Outdoor/Indoor Environments Legend: ■ = Merricks, D.L. (1997)



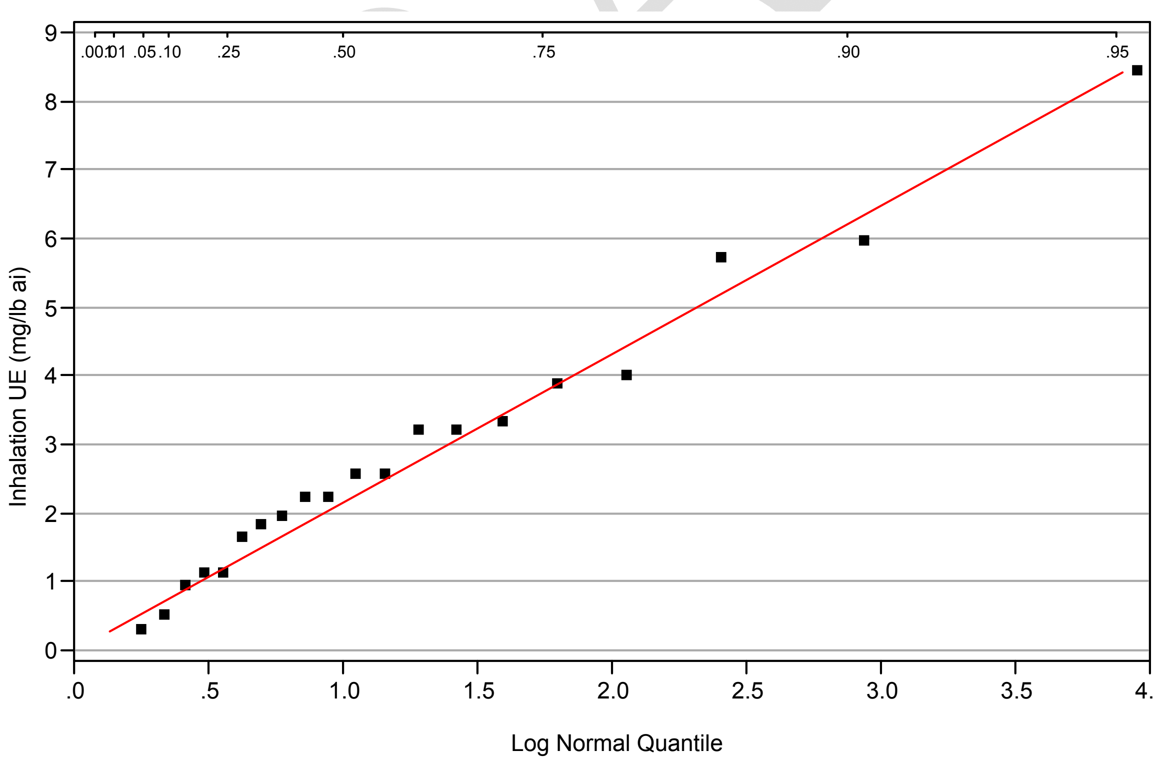
Outdoor/Indoor Environments Legend: ■ = Barnekow, D.E. et al (1997); O = Knarr, R.D. (1998); X = Merricks, D.L. (1997)



Pets/Animals Legend: ■ = Meo, N. et al (1997)



Pets/Animals Legend: ■ = Meo, N. et al (1997)



Available Handler Exposure Studies

Table B-156: Exposure Study Identification Information	
Citation	Merricks, D.L. (1997). 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
EPA MRID	44459801
ORETF Code	OMA006
EPA Review	EPA Memo from G. Bangs to D. Fuller (3/5/03)
	D287251
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Forty individuals were monitored while spraying tomatoes and cucumbers using a ready-to-use (RTU) trigger-spray bottle (i.e., no mixing was necessary). Each application was approximately 20 minutes and consisted of approximately 2 lbs formulation (approximately 0.24 gallons; 0.002 lbs carbaryl) to garden plants. Dermal exposure was measured using inner and outer whole body dosimetry and hand washes (20 individuals were monitored without gloves). Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Field fortification recoveries for passive dosimeters averaged 84.3% for inner dosimeters and 77.7% for outer dosimeters. Face and neck wipe field fortifications averaged 84.8%. Both handwash and inhalation tube field fortification averaged >90%. Laboratory method validation for each matrix fell within the acceptable range of 70 to 120%. 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.

Potential for Use in Residential Handler Exposure Assessments: The table below outlines relevant characteristics of the above referenced study with respect to its potential use in residential handler exposure assessments. The recommendation for use informs only the data that is ultimately used as a default and does not mean that a study not recommended for use cannot ever be used. Should a non-recommended study be deemed useful given a unique situation, the assessment should provide justification for its use and deviation from use of the recommended studies as default data.

Table B-157: MRID 44459801 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate “residential” exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. Note that only dermal exposure data representative of individuals wearing short-sleeve shirt, shorts, shoes, socks, and no chemical-resistant gloves are presented. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-158: MRID 44459801 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
R2	0.0024	0.30	0.000418	126	0.1739
S2	0.0022	0.13	0.000334	61	0.1532
T2	0.0028	0.70	0.000163	253	0.0592
U2	0.0025	0.33	0.000251	129	0.0989
X2	0.0020	0.29	0.000167	143	0.0824
Y2	0.0022	0.20	0.000042	93	0.0191
Z2	0.0020	0.33	0.000167	165	0.0824
A3	0.0022	0.17	0.000251	76	0.1149
D3	0.0021	0.05	0.000042	24	0.0202
E3	0.0022	0.10	0.000042	47	0.0188
F3	0.0021	0.05	0.000042	24	0.0195
G3	0.0022	0.22	0.000084	98	0.0375
J3	0.0022	0.05	0.000042	25	0.0191
K3	0.0021	0.05	0.000167	21	0.0782
M3	0.0020	0.04	0.000042	20	0.0208
L3	0.0022	0.48	0.000042	219	0.0191
P3	0.0022	0.02	0.000042	11	0.0193
Q3	0.0022	0.04	0.000042	18	0.0186
R3	0.0022	0.09	0.000041	43	0.0189
S3	0.0022	0.05	0.000041	22	0.0187
E	0.0025	--	0.000042	--	0.0166
F	0.0025	--	0.000042	--	0.0169
I	0.0022	--	0.000042	--	0.0186
H	0.0028	--	0.000084	--	0.0301
K	0.0025	--	0.000042	--	0.0165
L	0.0024	--	0.000042	--	0.0177
O	0.0024	--	0.000043	--	0.0180
P	0.0020	--	0.000042	--	0.0213
S	0.0025	--	0.000042	--	0.0168
T	0.0025	--	0.000042	--	0.0165
W	0.0026	--	0.000167	--	0.0654
X	0.0025	--	0.000501	--	0.2013
A2	0.0024	--	0.000042	--	0.0177
B2	0.0026	--	0.000251	--	0.0980
E2	0.0023	--	0.000167	--	0.0736
F2	0.0022	--	0.000167	--	0.0766
I2	0.0027	--	0.000086	--	0.0319
J2	0.0026	--	0.000084	--	0.0327
M2	0.0027	--	0.000167	--	0.0611
N2	0.0021	--	0.000167	--	0.0782

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant

gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of exposure during use of ready-to-use trigger sprayers, the following limitations are noted:

- An estimated 90% of all dermal exposure samples (underneath the individuals clothing) were non-detects. One-half the limit of detection (1.0 ug) was used.
- Nineteen of 40 inhalation samples were non-detects. One-half the limit of detection (0.01 ug) was used.

Table B-159: Available Exposure Study Identification Information	
Citation	Meo, N.; Gonzalez, C.; Mester, T. (1997) Dermal and Inhalation Exposure of Commercial Pet Groomers During Application of Frontline Spray Treatment: Final Report: Lab Project Number: MERIAL 445 SAFXT046: SAFX046: PDA9705. Unpublished study prepared by ABC Labs., California and Animal Appeal Grooming Shop & Case Veterinary Hospital. 1066 p.
EPA MRID	44433302
ORETF Code	OMA006
EPA Review	Contractor (Versar, Inc.) review; 4/27/98
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Sixteen different commercial pet groomers were monitored while treating dogs with fipronil, an active ingredient used to control fleas and ticks, using a read-to-use (RTU) trigger-spray bottle. Each application consisted of treating 8 dogs by holding the dog with one hand and spraying with the other, including rubbing the spray into the dog's fur. Application times ranged from 38 to 72 minutes and the amount of fipronil applied ranged from approximately 0.002 to 0.007 lbs. Dermal exposure was measured using inner whole body dosimetry (underneath pants, a short-sleeved shirt, and a smock) and cotton gloves underneath household latex gloves. Inhalation exposure was measured using standard pumps (set at 1.5 liters per minute), cassettes, and tubing. Field fortification samples of each matrix were fortified with diluted formulated product at the test site and subjected to the same conditions as the replicate samples. Average recoveries (triplicate samples) at each fortification level (low, medium, high) for each matrix ranged from 81.6% to 105.9%.

Table B-160: MRID 44433302 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure	**Yes**	**Yes**

assessments?		

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-161: MRID 44433302 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
1	0.0033	0.72	0.007	218.18	2.12
2	0.0024	5.64	0.003	2350.00	1.25
3	0.0033	0.33	0.008	100.00	2.42
4	0.0035	0.94	0.011	268.57	3.14
5	0.0047	2.17	0.039	461.70	8.30
6	0.0064	3.31	0.026	517.19	4.06
7	0.0037	5.97	0.003	1613.51	0.81
8	0.0025	0.29	0.010	116.00	4.00
9	0.0036	1.74	0.001	483.33	0.28
10	0.0065	7.48	0.012	1150.8	1.8
11	0.0038	3.95	0.022	1039.5	5.8
12	0.0025	0.31	0.001	124.0	0.4
13	0.0033	1.59	0.011	481.8	3.3
14	0.0053	5.07	0.009	956.6	1.7
15	0.0019	1.49	0.011	784.2	5.8
16	0.0060	7.78	0.012	1296.7	2.0

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of exposure during use of ready-to-use trigger sprayers, the following limitations are noted:

- The study monitored professional/commercial pet groomers and may not be representative of the exposure an individual at home would experience while treating their pets.
- The individuals monitored wore long pants, long-sleeve shirts, and chemical-resistant gloves. Therefore, back-calculations using standard penetration factors to represent exposure to people wearing shorts, a short-sleeve shirt and no chemical-resistant gloves were necessary.

Table B-162: Exposure Study Identification Information

Citation	Knarr, R.D. (1988). Exposure of Applicators to Propoxur During Trigger-Pump Spray Applications of a Liquid Product
EPA MRID	41054701
ORETF Code	NA
EPA Review	D287251
	Contractor (Versar, Inc.) review; 9/29/89

MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force

Study Description: Three individuals were monitored for each of 5 applications using a trigger sprayer attached to a ½ gallon container with an 18-inch hose to treat the outside of homes (door frames, screens, patios, stoops, etc.). Applications ranged from 9 to 21 minutes and the amount of active ingredient (propoxur) handled ranged from 0.01 to 0.025 lbs. Dermal exposure was measured using gauze patches (underneath normal work clothing) and hand washes. All individuals wore chemical-resistant gloves. Inhalation exposure was measured using standard pumps (set at 1 liter per minute), cassettes, and tubing. Average laboratory recovery for all media ranged from 99.2% to 109%. 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%. 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.

Table B-163: MRID 41054701 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-164: MRID 41054701 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	0.0188	0.72	0.0026	38.30	0.136
A	0.0188	5.64	0.0016	300.00	0.087
A	0.0250	0.33	0.0016	13.20	0.065
A	0.0250	0.94	0.0019	37.60	0.075
A	0.0250	2.17	0.0052	86.80	0.210
B	0.0188	3.31	0.0019	176.06	0.100
B	0.0188	5.97	0.0013	317.55	0.071
B	0.0250	0.29	0.0029	11.60	0.114
B	0.0250	1.74	0.0019	69.60	0.076
B	0.0206	7.48	0.0015	363.1	0.074
C	0.0100	3.95	0.0004	395.0	0.038
C	0.0188	0.31	0.0008	16.5	0.041

C	0.0188	1.59	0.0009	84.6	0.048
C	0.0131	5.07	0.0014	387.0	0.109
C	0.0250	1.49	0.0009	59.6	0.036

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations:

- All individuals wore gloves; therefore a "back-calculation" was necessary to calculate bare hand exposure.
- The use of gauze patches rather than whole body dosimetry increases the uncertainty with respect to the extent of exposure received by the individual (i.e., exposure is evident only if the pesticide settled on the patch).

Table B-165: Exposure Study Identification Information	
Citation	Barnekow, D.E.; Cook, W.L.; Meitl, T.J.; Shurdut, B.A. (1999). Exposure to Chlorpyrifos While Applying a Ready to Use Formulation. January 14, 1999. Laboratory Project Study ID: HEA 976046.
EPA MRID	44739301
ORETF Code	NA
EPA Review	D252733
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Fifteen individuals were monitored during applications to outdoor areas of houses (foundations, perimeters, flower beds) using a ready-to-use trigger spray bottle (24 oz.; 0.5% chlorpyrifos). Applications lasted 1 hour or until 5 bottles were exhausted, whichever was longer. Dermal exposure was measured using whole body dosimetry (underneath long pants, short-sleeve shirt) and hand washes (no chemical-resistant gloves were worn). Inhalation exposure was measured using standard pumps (set at 1.5 liters per minute), cassettes, and tubing. Laboratory recoveries for coveralls resulted in a mean percent recovery of 94.3% and RSD of 5.1%, while recoveries for handwash had a mean percent recovery of 107.6% and RSD of 3.9%. Field recoveries for coveralls resulted in a mean percent recovery of 99.1 and RSD of 4.7%, while recoveries for handwash had a mean percent recovery of 93.6% and RSD of 5.1%.

Table B-166: MRID 44739301 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes

Should this study be recommended for use in residential handler exposure assessments?	**No**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only inhalation exposure data are presented as the dermal exposure data are not recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-167: MRID 41054701 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
1	0.036	--	0.0024	--	0.066
2	0.030	--	0.0012	--	0.041
3	0.030	--	0.0016	--	0.055
4	0.036	--	0.0022	--	0.062
5	0.038	--	0.0022	--	0.059
6	0.037	--	0.0029	--	0.079
7	0.015	--	0.0024	--	0.161
8	0.030	--	0.0018	--	0.058
9	0.035	--	0.0036	--	0.102
10	0.037	--	0.0011	--	0.030
11	0.038	--	0.0011	--	0.030
12	0.023	--	0.0016	--	0.069
13	0.038	--	0.0016	--	0.042
14	0.038	--	0.0014	--	0.037
15	0.037	--	0.0018	--	0.049

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: No limitations were identified in this study.

Scenario Summary

Table B-168: Scenario Description and Available Exposure Studies	
Formulation	Ready-to-use (RTU)
Equipment/Application Method	Shampoo
Application Site(s)	Pets/animals, children
Available Exposure Studies	Mester, T.C. (1998); MRID 46658401
	Selim, S. (2005); MRID 46601001

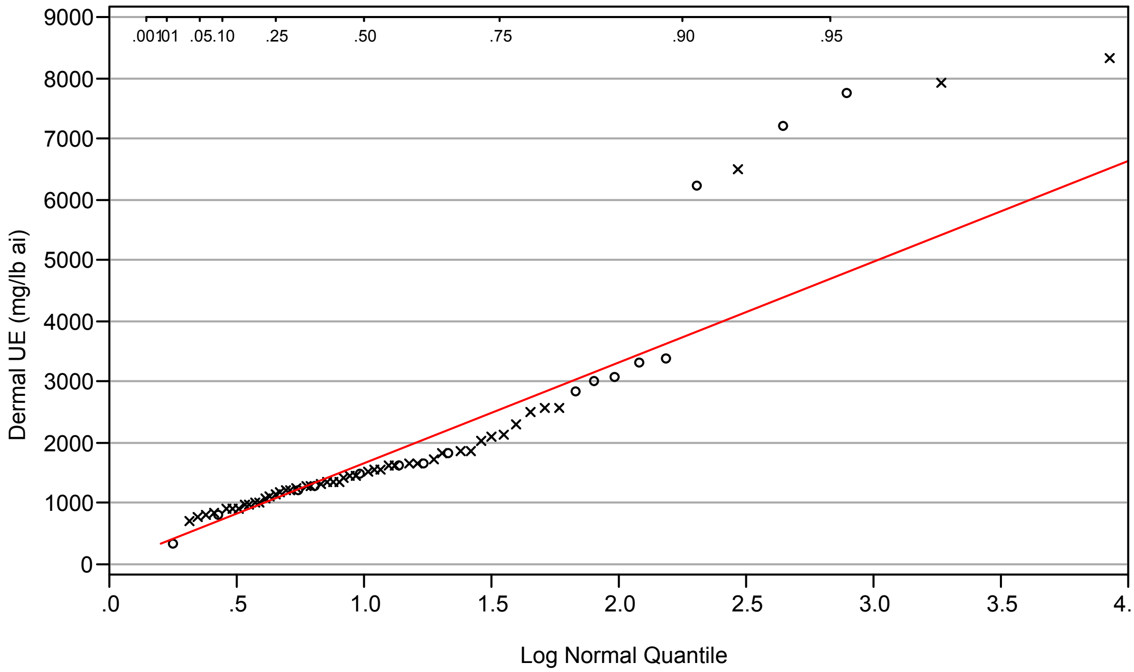
Table B-169: Unit Exposures (mg/lb ai) – RTU Shampoo Applications		
Statistic	Dermal	Inhalation
50th percentile	1700	2.1
75th percentile	2500	4.3
95th percentile	4700	12
99th percentile	7200	24
99.9th percentile	12000	54
AM (SD)	2000 (1400)	3.7 (5.2)
GM (GSD)	1700 (1.9)	2.1 (2.8)
Range	340 – 8300	0.25 – 6.2
N	64	16

Dermal Unit Exposure Summary: The recommended dermal unit exposures for shampoo applications of liquid pesticide formulations to pets, animals, or children is based on a lognormal distribution fit with exposure monitoring data from Mester, T.C. (1998) [EPA MRID 46658401] and Selim, S. (2005) [EPA MRID 46601001]. Mester, T.C. (1998) monitored 16 applications by commercial pet groomers of shampoo to 8 dogs for approximately 149-295 minutes. Selim, S. (2005) monitored 16 shampoo applications to one dog each for approximately 30 minutes.

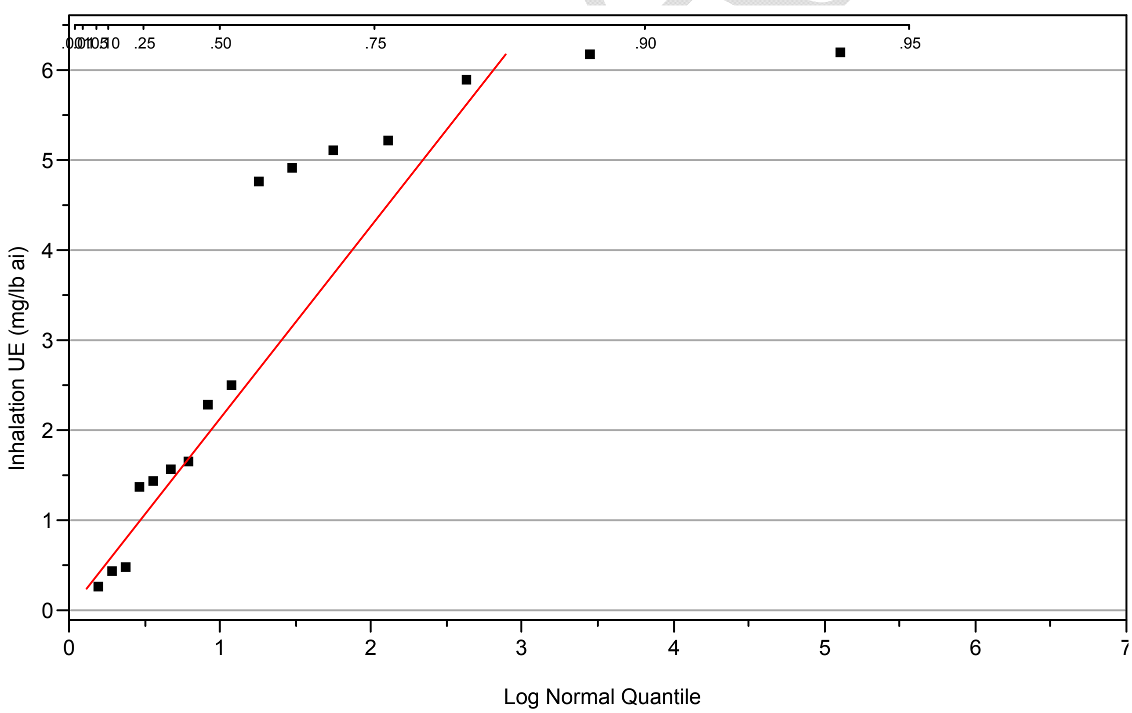
Inhalation Unit Exposure Summary: The recommended inhalation unit exposures for shampoo applications of liquid pesticide formulations to pets, animals, or children is based on a lognormal distribution fit with exposure monitoring data from Mester, T.C. (1998) [EPA MRID 46658401]. Mester, T.C. (1998) monitored 16 applications by commercial pet groomers of shampoo to 8 dogs for approximately 149-295 minutes.

Lognormal Probability Plots

Legend: O = Mester, T.C. (1998); X = Selim, S. (2005)



Legend: ■ = Mester, T.C. (1998)



Available Handler Exposure Studies

Table B-170: Exposure Study Identification Information	
Citation	Mester, T.C. (1998). Dermal Exposure and Inhalation Exposure to Carbaryl by Commercial Pet Groomers During Applications of Adams ™ Carbaryl Shampoo
EPA MRID	44658401
ORETF Code	NA
EPA Review	D287251
	Contractor (Versar, Inc.) review 12/4/98
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Sixteen different commercial pet groomers were monitored while treating dogs with carbaryl, an active ingredient used to control fleas and ticks, using a read-to-use (RTU) disposable shampoo bottle. Each application consisted of treating 8 dogs by soaking (2-3 minutes), treating with the shampoo, letting the shampoo sit for 5 minutes, then rinsing, drying and combing the dog. Application times for treating all 8 dogs ranged from 149 to 295 minutes and the amount of carbaryl applied ranged from approximately 0.0008 to 0.008 lbs. Dermal exposure was measured using inner whole body dosimetry (underneath pants, a short-sleeved shirt and a smock) and hand washes (no chemical-resistant gloves were worn). Inhalation exposure was measured using standard pumps (set at 1.5 liters per minute), cassettes, and tubing. Laboratory control samples for hand wash solutions were fortified with carbaryl with four rates of concurrent recovery determination, which ranged in percent recovery from 88% to 120%, with a mean percent recovery of 104% and a standard deviation of 8.7%. Field fortifications for hand wash solutions were prepared at three spiking levels, with a mean of all three spiking levels at 100% and a standard deviation of 5.9%. Laboratory control samples for whole body dosimeters were fortified with carbaryl with two rates for concurrent recovery determination, which ranged in percent recovery from 91% to 119%, with a mean percent recovery of 107% and a standard deviation of 6.9%. Field fortification samples for whole body dosimeters were prepared at three spiking levels with a mean of all three spiking levels at 83% and a standard deviation of 5.0%.

Table B-171: MRID 44658401 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-172: MRID 44658401 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
1	0.0050	15.36	0.025	3072	5.00
2	0.0015	11.72	0.001	7813	0.67
3	0.0020	2.61	0.011	1305	5.50
4	0.0044	5.51	0.007	1252	1.59
5	0.0036	10.40	0.008	2889	2.22
6	0.0027	3.99	0.007	1478	2.59
7	0.0015	4.49	0.007	2993	4.67
8	0.0008	5.13	0.005	6413	6.25
9	0.0013	2.20	0.001	1692	0.77
10	0.0039	27.88	0.018	7149	4.62
11	0.0021	1.76	0.003	838	1.43
12	0.0082	15.00	0.013	1829	1.59
13	0.0025	8.29	0.015	3316	6.00
14	0.0025	8.60	0.001	3440	0.40
15	0.0016	2.54	0.010	1588	6.25
16	0.0043	1.44	0.006	335	1.40

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of exposure during shampoo applications, the following limitations are noted:

- The study monitored professional/commercial pet groomers and may not be representative of the exposure an individual at home would experience while treating their pets.
- The individuals monitored wore long pants, long-sleeve shirts, a smock and chemical-resistant gloves. Therefore, back-calculations using standard penetration factors to represent exposure to people wearing shorts, a short-sleeve shirt and no chemical-resistant gloves were necessary.

Table B-173: Exposure Study Identification Information	
Citation	Selim, S. (2005) Human Exposure During and Following Use of a Pyrethrins/Piperonyl Butoxide/MGK-264 Shampoo Formulation on Dogs: Final Report. Project Number: 040154. Unpublished study prepared by Young Veterinary Research Services and Golden Pacific Laboratories, LLC (GPL). 466 p.
EPA MRID	46601001
ORETF Code	NA
EPA Review	D319806

MRID = Master Record Identification
ORETF = Outdoor Residential Exposure Task Force

Study Description: Sixteen individuals were monitored while treating dogs with a shampoo containing the active ingredients pyrethrins, piperonyl butoxide (PBO), and MGK-264. Each application took approximately 30 minutes and consisted of shampooing, rinsing, and drying a single dog. The amount of active ingredient ranged from 12 mg (pyrethrins) to 663 mg (PBO). Dermal exposure was measured using a t-shirt (no inner dosimeter, so exposure represents bare upper body) and hand washes or wipes (no chemical-resistant gloves were worn) both immediately following the treatment and 4 hours after. Lower body exposure was not measured. Inhalation exposure was not measured. Overall average laboratory recoveries for PYI (pyrethrins) ranged from 83.5% (shampoo rinse) to 98.0% (paper towels), for PBO (piperonyl butoxide) ranged from 84.2% (dog hair) to 98.6% (shampoo rinse), for MGK 264 ranged from 86.3% (hand washes) to 98.2% (paper towels). For CDCA, the overall average recovery was 92.1%. Field fortification samples were not discussed in the Study Report.

Table B-174: MRID 46601001 – Checklist and Use Recommendation

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	Yes	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	No
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**No**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only dermal exposure data are presented as inhalation exposure was not measured. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-175: MRID 46601001 – Data Summary

Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A1 (PY)	0.000056	0.063	--	1125	--
A2 (PY)	0.000049	0.063	--	1286	--
A3 (PY)	0.000063	0.080	--	1270	--
A4 (PY)	0.000060	0.058	--	967	--
A5 (PY)	0.000027	0.031	--	1148	--
A6 (PY)	0.000039	0.063	--	1615	--
A7 (PY)	0.000039	0.255	--	6538	--
A8 (PY)	0.000048	0.048	--	1000	--
A9 (PY)	0.000049	0.124	--	2531	--
A10 (PY)	0.000052	0.105	--	2019	--
A11 (PY)	0.000051	0.051	--	1000	--
A12 (PY)	0.000040	0.064	--	1600	--
A13 (PY)	0.000080	0.114	--	1425	--
A14 (PY)	0.000047	0.062	--	1319	--

A15 (PY)	0.000051	0.045	--	882	--
A16 (PY)	0.000056	0.042	--	750	--
A1 (PBO)	0.00103	1.25	--	1214	--
A2 (PBO)	0.00089	1.20	--	1348	--
A3 (PBO)	0.00116	1.41	--	1216	--
A4 (PBO)	0.00109	1.16	--	1064	--
A5 (PBO)	0.00049	0.74	--	1510	--
A6 (PBO)	0.00071	1.48	--	2085	--
A7 (PBO)	0.00072	5.67	--	7875	--
A8 (PBO)	0.00088	1.86	--	2114	--
A9 (PBO)	0.00090	2.24	--	2489	--
A10 (PBO)	0.00095	1.74	--	1832	--
A11 (PBO)	0.00094	0.83	--	883	--
A12 (PBO)	0.00073	1.12	--	1534	--
A13 (PBO)	0.00146	2.07	--	1418	--
A14 (PBO)	0.00086	1.08	--	1256	--
A15 (PBO)	0.00092	0.90	--	978	--
A16 (PBO)	0.00101	0.80	--	792	--
A1 (MGK-264)	0.00035	0.646	--	1846	--
A2 (MGK-264)	0.00030	0.493	--	1643	--
A3 (MGK-264)	0.00040	0.678	--	1695	--
A4 (MGK-264)	0.00037	0.450	--	1216	--
A5 (MGK-264)	0.00017	0.273	--	1606	--
A6 (MGK-264)	0.00024	0.552	--	2300	--
A7 (MGK-264)	0.00025	2.055	--	8220	--
A8 (MGK-264)	0.00030	0.461	--	1537	--
A9 (MGK-264)	0.00031	0.786	--	2535	--
A10 (MGK-264)	0.00033	0.596	--	1806	--
A11 (MGK-264)	0.00032	0.288	--	900	--
A12 (MGK-264)	0.00025	0.338	--	1352	--
A13 (MGK-264)	0.00050	0.725	--	1450	--
A14 (MGK-264)	0.00029	0.331	--	1141	--
A15 (MGK-264)	0.00032	0.266	--	831	--
A16 (MGK-264)	0.00035	0.244	--	697	--

1 Amount of active ingredient Handled
2 Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
3 Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
4 Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of exposure during shampoo applications, the following limitations are noted:

- Dermal exposure was measured using the t-shirt that the individuals were wearing, thus exposure to the torso would be representative of a bare upper body.
- Dermal exposure to the legs was not measured.

Scenario Summary

Table B-176: Scenario Description and Available Exposure Studies	
Formulation	Ready-to-use (RTU)
Equipment/Application Method	Spot-on
Application Site(s)	Pets/animals
Available Exposure Studies	Meo, N.; Gonzalez, C.; Belcher, T. (1997); MRID 44433303

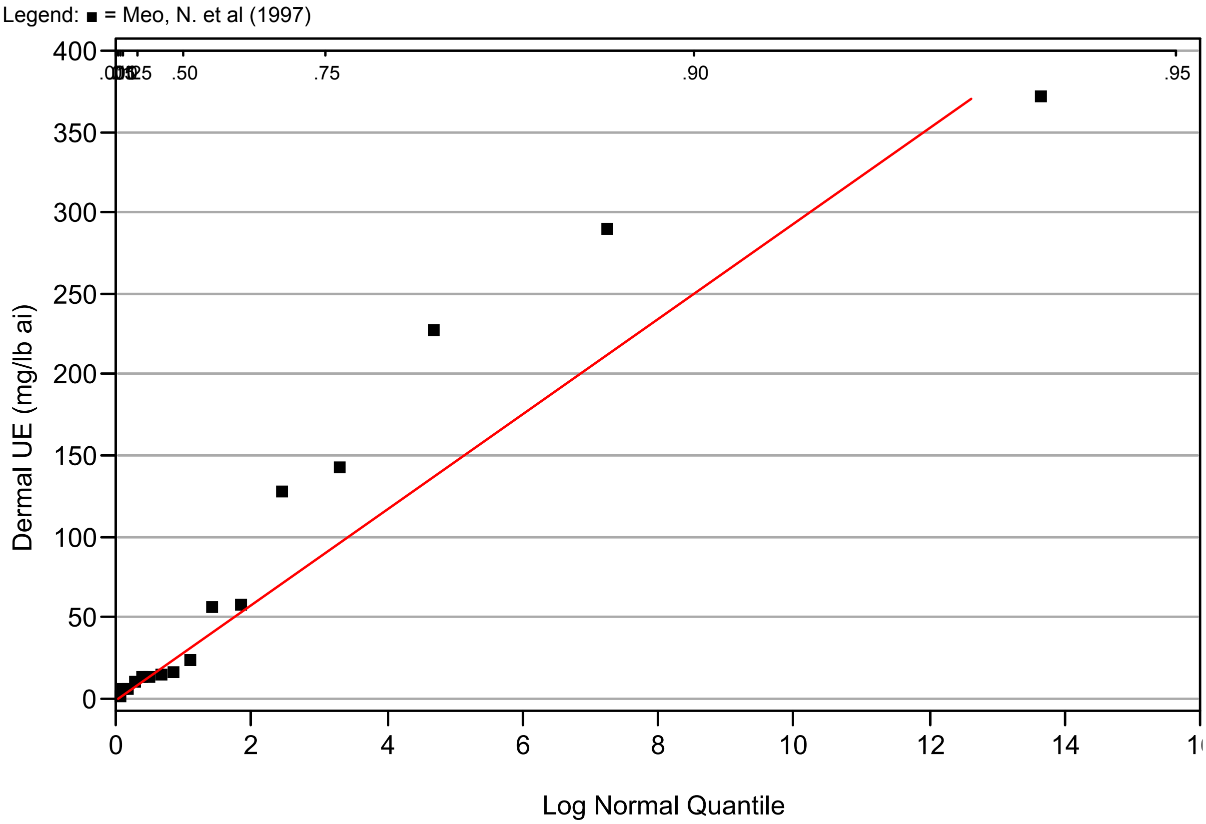
Table B-177: Unit Exposures (mg/lb ai) – RTU Spot-on Applications

Statistic	Dermal	Inhalation
50^{th} percentile	29	Inhalation exposure data during application of spot-on treatments is unavailable, however is considered negligible.
75^{th} percentile	91	
95^{th} percentile	460	
99^{th} percentile	1400	
99.9^{th} percentile	5100	
AM (SD)	120 (470)	
GM (GSD)	29 (5.3)	
Range	1.1 – 370	
N	16	

Dermal Unit Exposure Summary: The recommended dermal unit exposures for spot-on applications to pets or animals is based on a lognormal distribution fit with exposure monitoring data from Meo, N., et al (1997) [EPA MRID 44433303]. Meo, N., et al (1997) monitored 16 applications by commercial pet groomers to 8 dogs for approximately 14-32 minutes using a read-to-use (RTU), disposable, snap-top, plastic-backed pipette.

Inhalation Unit Exposure Summary: Inhalation exposure data during application of spot-on treatments is unavailable, however is considered negligible.

Lognormal Probability Plots



Inhalation unit exposure probability plot is not shown. *See Table B-177***.**

Available Handler Exposure Studies

Table B-178: Exposure Study Identification Information	
Citation	Meo, N.; Gonzalez, C.; Belcher, T. (1997) Dermal Exposure of Commercial Pet Groomers During Application of Frontline Top Spot: Final Report: Lab Project Number: MERIAL 445 SAFXT047: SAFXT047: EC 97 390. Unpublished study prepared by ABC Labs., California and Animal Appeal Grooming Shop & Case Veterinary Hospital. 925 p.
EPA MRID	44433303
ORETF Code	NA
EPA Review	DER by W. Britton (EPA); no barcode
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Sixteen different commercial pet groomers were monitored while treating dogs with fipronil, an active ingredient used to control fleas and ticks, using a ready-to-use (RTU), disposable, snap-top, plastic-backed pipette. Each application consisted of applying 2 or 3 pre-measured unit doses with a pipette to the neck area of each of 8 dogs with some groomers rubbing the material into the dogs' fur. Application times ranged from 14 to 32 minutes and the amount of fipronil applied ranged from approximately 0.001 to 0.004 lbs. Dermal exposure was measured using inner whole body dosimetry (underneath pants, a short-sleeved shirt and a smock) and cotton gloves underneath household latex gloves. Inhalation exposure was not measured. Data generated in the frozen stability phase of the study indicated that fipronil was stable in two dermal matrices after mean recoveries from field fortification samples which fell between 79% and 103% of theoretical concentration.

Table B-179: MRID 44433303 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	No
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**No**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only dermal exposure data are presented as inhalation exposure was not measured. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-180: MRID 44433303 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
1	0.00236	0.033	--	13.93	--

2	0.00207	0.032	--	15.59	--
3	0.00251	0.727	--	289.35	--
4	0.00162	0.090	--	55.40	--
5	0.00325	0.031	--	9.67	--
6	0.00162	0.037	--	23.03	--
7	0.00399	0.004	--	1.12	--
8	0.00177	0.252	--	142.25	--
9	0.00251	0.013	--	5.20	--
10	0.00148	0.084	--	56.94	--
11	0.00207	0.767	--	370.84	--
12	0.00192	0.024	--	12.56	--
13	0.00192	0.009	--	4.82	--
14	0.00266	0.337	--	126.71	--
15	0.00251	0.031	--	12.50	--
16	0.00266	0.603	--	226.66	--

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of exposure during spot-on pet treatments, the following limitations are noted:

- The study monitored professional/commercial pet groomers and may not be representative of the exposure an individual at home would experience while treating their pets.
- The individuals monitored wore long pants, long-sleeve shirts, a smock and chemical-resistant gloves. Therefore, back-calculations using standard penetration factors to represent exposure to people wearing shorts, a short-sleeve shirt and no chemical-resistant gloves were necessary.

Scenario Summary

Table B-181: Scenario Description and Available Exposure Studies	
Formulation	Ready-to-use (RTU)
Equipment/Application Method	Aerosol can
Application Site(s)	outdoors (gardens, trees/bushes, perimeter, mounds/nests), indoors (general broadcast treatments, baseboards, cracks and crevices), pets/animals
Available Exposure Studies	Knarr R.D. (1991); MRID 41858201
	Knarr, R. (1988); MRID 41054705
	Selim, S. (2002); MRID 46188618

Table B-182: Unit Exposures (mg/lb ai) – RTU Aerosol can Applications				
Statistic	Outdoors/Indoors		Pets/Animals	
	Dermal	Inhalation	Dermal	Inhalation
50th percentile	330	2.3	Studies measuring exposure while treating pets or animals using an aerosol can are unavailable. Therefore, the exposure studies recommended for use for treating pets or animals using RTU trigger-pump sprayers should be used as a surrogate.	
75th percentile	450	3.7		
95th percentile	720	7.4		
99th percentile	990	11		
99.9th percentile	1400	20		
AM (SD)	370 (180)	3.0 (2.4)		
GM (GSD)	330 (1.6)	2.3 (2.0)		
Range	140 – 1000	0.38 – 4.9		
N	15	15		

Dermal Unit Exposure Summary

Outdoor and Indoor Environments: The recommended dermal unit exposures for aerosol can applications to outdoor and indoor environments is based on a lognormal distribution fit with exposure monitoring data from Knarr, R.D. (1991) [EPA MRID 41858201]. Knarr, R.D. (1991) monitored 15 applications to cracks, crevices, baseboards, under sinks, and behind appliances in 15 separate houses using an entire 16 oz. aerosol can.

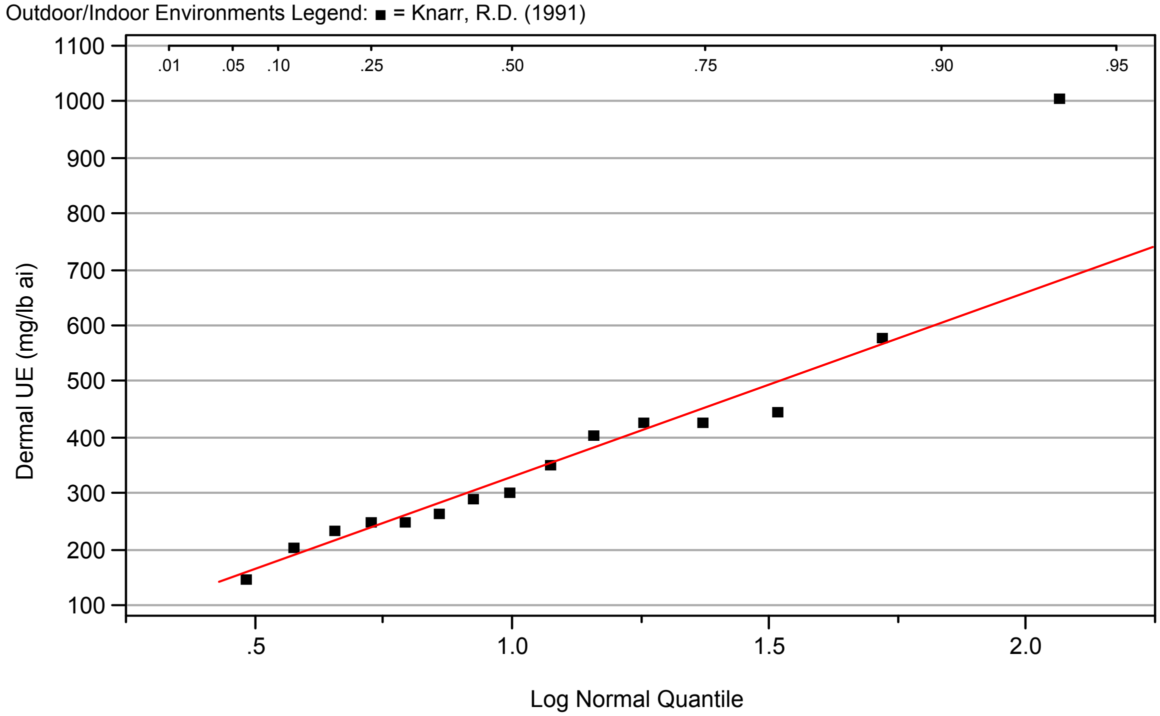
Pets and Animals: Dermal exposure monitoring data for aerosol can applications to pets and animals is unavailable; dermal unit exposures for trigger-sprayers applications to pets and animals is recommended as surrogate data.

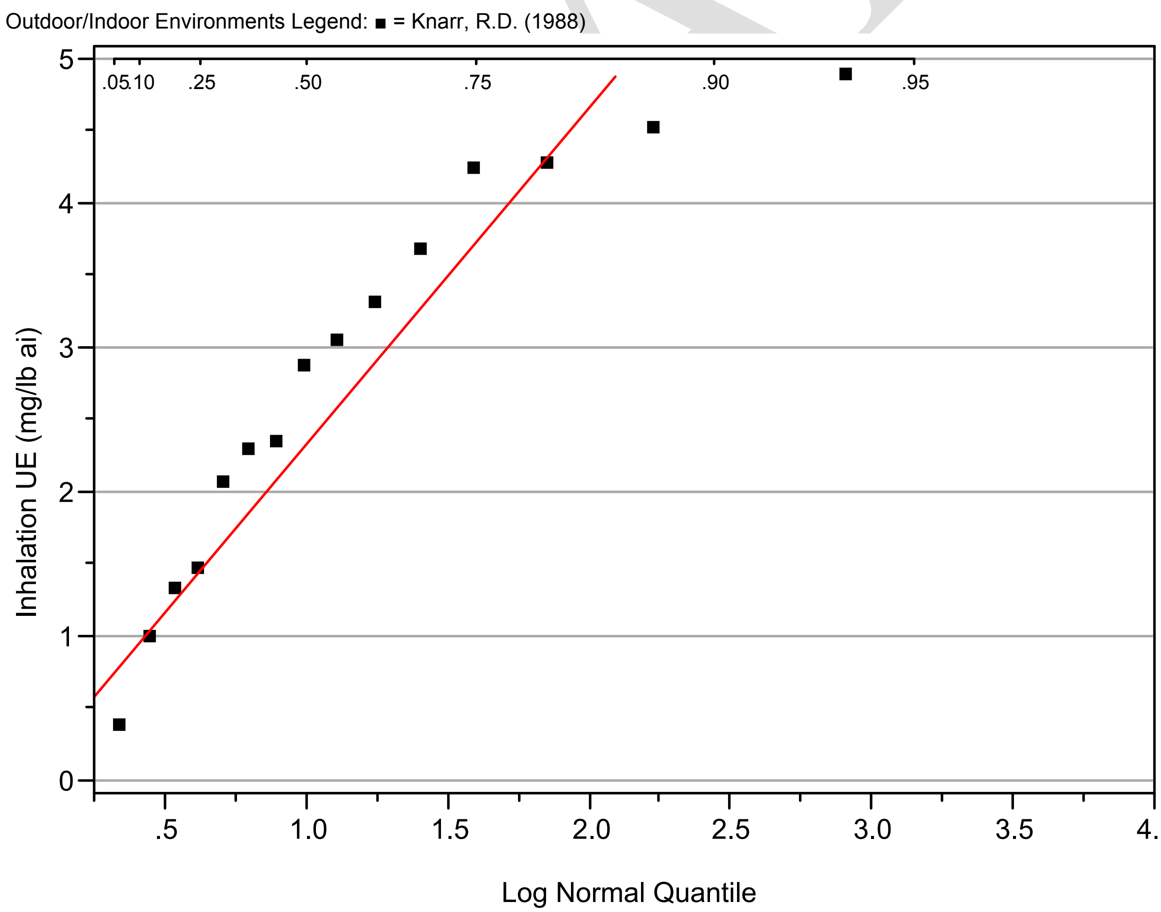
Inhalation Unit Exposure Summary

Outdoor and Indoor Environments: The recommended inhalation unit exposures for aerosol can applications to outdoor and indoor environments is based on a lognormal distribution fit with exposure monitoring data from Knarr, R.D. (1988) [EPA MRID 41054705]. Knarr, R.D. (1988) monitored 15 applications to cracks, crevices, baseboards, under sinks, and behind appliances in 15 separate houses using an entire 16 oz. aerosol can.

Pets and Animals: Inhalation exposure monitoring data for aerosol can applications to pets and animals is unavailable; inhalation unit exposures for trigger-sprayers applications to pets and animals is recommended as surrogate data.

Lognormal Probability Plots





Available Handler Exposure Studies

Table B-183: Available Exposure Study Identification Information	
Citation	Knarr R.D. 1991. Exposure of applicators to Propoxur during residential application of an aerosol spray containing 1% Propoxur
EPA MRID	41858201
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Five different individuals were monitored on 3 consecutive days while spraying an entire 16 oz. aerosol can (1% propoxur) to cracks, crevices, baseboards, under sinks, and behind appliances in 15 separate houses. Dermal exposure was measured using gauze patches (both inside and outside normal work clothing) and hand rinses (without chemical-resistant gloves). Inhalation exposure was measured using standard pumps (set at 1 liter per minute), cassettes, and tubing. Thirteen of 15 inhalation samples were non-detects (limit of detection = 1 ug per sample). Recoveries from field fortifications of exposure sampling matrices were generally above 90%.

Table B-184: MRID 41858201 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**No**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only dermal exposure data are presented as inhalation exposure data from this study is not recommended for the purposes of residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-185: MRID 41858201 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	0.01	4.25	--	425	--
A	0.01	2.99	--	299	--
A	0.01	2.88	--	288	--
B	0.01	2.61	--	261	--
B	0.01	4.43	--	443	--
B	0.01	1.42	--	142	--

C	0.01	5.77	--	577	--
C	0.01	4.01	--	401	--
C	0.01	10.02	--	1002	--
D	0.01	4.24	--	424	--
D	0.01	2.47	--	247	--
D	0.01	2.48	--	248	--
E	0.01	3.47	--	347	--
E	0.01	2.29	--	229	--
E	0.01	2.01	--	201	--
[1] Amount of active ingredient Handled [2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves. [3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm) [4] Unit Exposure = Exposure/AaiH					

Limitations: Though the above referenced study is useful for assessment of exposure during applications using aerosol cans, the following limitations are noted:

- The study monitored individuals during applications to indoor locations which introduces uncertainty when using the data to assess applications outdoors.

Table B-186: Exposure Study Identification Information	
Citation	Knarr, R. (1988) Exposure of Applicators to Propoxur During Residential Application of an Aerosol Spray Containing 1% Propoxur
EPA MRID	41054705
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Three different individuals were monitored during 5 applications while spraying an entire 16 oz. aerosol can (1% propoxur) to cracks, crevices, baseboards, under sinks, and behind appliances in homes. Each application lasted approximately 30 minutes. Dermal exposure was measured using gauze patches (both inside and outside normal work clothing) and hand rinses (underneath chemical-resistant gloves). Inhalation exposure was measured using standard pumps (set at 1 liter per minute), cassettes, and tubing. The average laboratory recovery values are as follows, 101% with a standard deviation of 3.1% for air filters, 98.8% with a standard deviation of 3.5% for gauze pads, 103% with a standard deviation of 0.9% for hand washes (200 μg) and 101% with a standard deviation of 3.5% for hand washes (1000 μg). Field recoveries of Baygon technical are reported for two separate sets of gauze pads in another propoxur exposure study for method validation. In that study, gauze pads were spiked with Baygon technical at a fortification level of 1.0 μg. The spiked pads were exposed to unspecified field conditions for 5 hours. The results of these field recoveries are as follows: the average recovery for the first set of gauze pads is 101% with a standard deviation of 3.5%, while for the second set of gauze pads is 84.5% with a standard deviation of 3.6%.

Potential for Use in Residential Handler Exposure Assessments: The table below outlines relevant characteristics of the above referenced study with respect to its potential use in residential handler exposure assessments. The recommendation for use informs only the data that is ultimately used as a default and does not mean that a study not recommended for use cannot ever be used. Should a non-recommended study be deemed useful given a unique situation, the assessment should provide justification for its use and deviation from use of the recommended studies as default data.

Table B-187: MRID 41054705 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only inhalation exposure data are presented as dermal exposure data from this study is not recommended for the purposes of residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-188: MRID 41054705 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	0.0094	--	0.042	--	4.52
A	0.0094	--	0.031	--	3.31
A	0.0094	--	0.040	--	4.24
A	0.0094	--	0.027	--	2.88
A	0.0094	--	0.003	--	0.37
B	0.0094	--	0.040	--	4.27
B	0.0094	--	0.034	--	3.67
B	0.0094	--	0.029	--	3.05
B	0.0094	--	0.046	--	4.89
B	0.0094	--	0.021	--	2.29
C	0.0094	--	0.014	--	1.46
C	0.0094	--	0.019	--	2.06
C	0.0094	--	0.022	--	2.34
C	0.0094	--	0.009	--	0.99
C	0.0094	--	0.013	--	1.33

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of exposure during applications using aerosol cans, the following limitations are noted:

- The study monitored individuals during applications to indoor locations which introduces uncertainty when using the data to assess applications outdoors.

Table B-189: Exposure Study Identification Information	
Citation	Selim, S. (2002) Measurement of Air Concentration, Dermal Exposure, and Deposition of Pyrethrin and Piperonyl Butoxide Following the Use of an Aerosol Spray
EPA MRID	46188618
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: One individual performed a total of 4 applications (2 per day) using an aerosol can to treat a 16 ft. x 16 ft. x 8 ft. room. Each application consisted of holding the can upright and spraying for approximately 10 seconds in a sweeping motion. It was unclear from the study report the amount of active ingredient handled per application. Dermal exposure was measured for hands only, using cotton gloves. Inhalation exposure was measured using standard pumps (set at 1 liter per minute), cassettes, and tubing. The overall average recoveries ± standard deviation of laboratory fortified controls for air sampling tubes were 83.5 ± 11.8% and 93.5 ± 12.1 % for PYI (pyrethrin) and PBO (piperonyl butoxide) respectively. The overall average recoveries ± standard deviation of laboratory fortified controls for cotton gloves were 83.0% ± 12.1% and 87.3 ± 9.52% for PYI (pyrethrin) and PBO (piperonyl butoxide) respectively. The overall average recoveries ± standard deviation of field fortified controls for air sampling tubes were 84.9% ± 8.87% for PYI (pyrethrin) and 93.6% ± 6.04% for PBO (piperonyl butoxide), and 79.6% ± 3.07% for PYI (pyrethrin) and 83.3% ± 6.64% for PBO (piperonyl butoxide) for cotton gloves.

Table B-190: MRID 46186618 – Checklist and Use Recommendation

Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	No	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Scenario Summary

Table B-191: Scenario Description and Available Exposure Studies	
Formulation	Wettable Powder (WP)
Equipment/Application Method	Low-pressure handwand (LPHW) (also: pump sprayer)
Application Site(s)	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests), indoors (general broadcast treatments, baseboards, cracks and crevices)
Available Exposure Studies	Merricks, L. (1987); MRID 40504823
	Dean, V. (1988); MRID 41054702
	Meikle, S.; Baugher, D. (1992); MRID 42622301/44202701/44202702
	Belcher, T. (2002); MRID 45773201

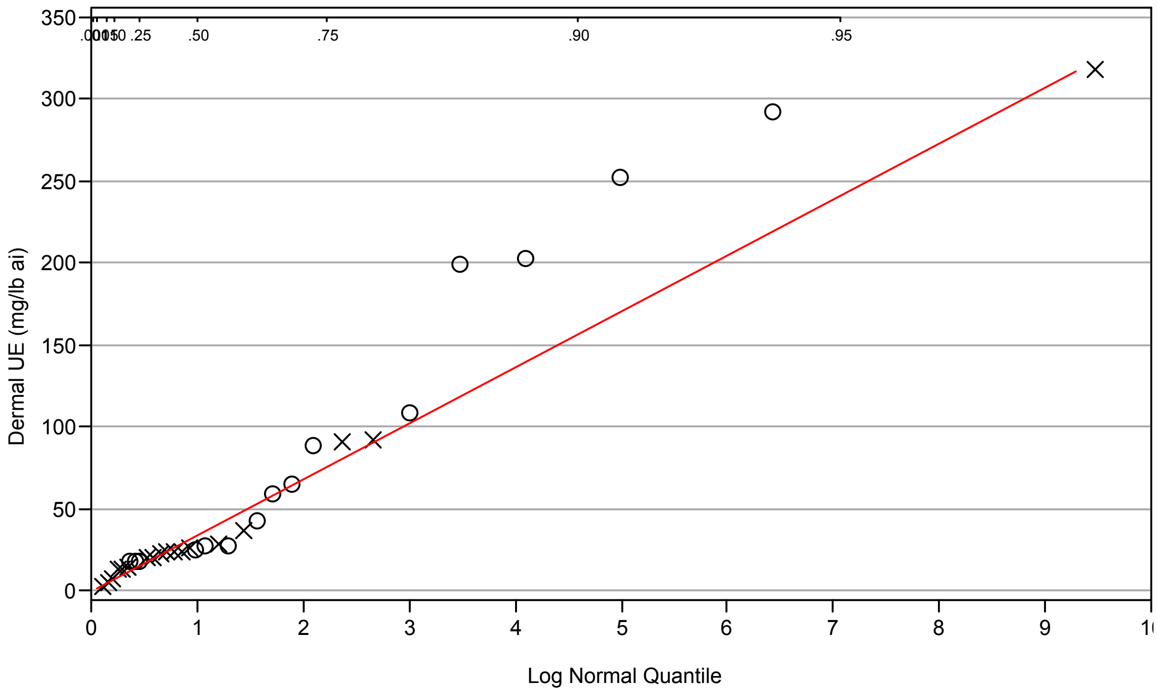
Table B-192: Unit Exposures (mg/lb ai) – WP LPHW Applications		
Statistic	Dermal	Inhalation
50th percentile	34	0.63
75th percentile	76	1.3
95th percentile	240	3.7
99th percentile	540	7.7
99.9th percentile	1300	18
AM (SD)	69 (120)	1.1 (1.67)
GM (GSD)	34 (3.30)	0.63 (2.9)
Range	2 – 320	0.17 – 5.1
N	33	16

Dermal Unit Exposure Summary: The recommended dermal unit exposures for applications of wettable powder pesticide formulations using a low-pressure handwand to outdoor and indoor environments is based on a lognormal distribution fit with exposure monitoring data from Merricks, L. (1987) [EPA MRID 40504823] and Dean, V. (1988) [EPA MRID 41054702]. Merricks, L. (1987) monitored 18 applications of a wettable powder formulation in homes and commercial buildings with 2, 1-gallon "B&G stainless steel PCO sprayers" (i.e., a low pressure handwand). Dean, V. (1988) monitored 16 applications of a wettable powder formulation in homes for approximately 1-2.5 hours using a 1-gallon hand compression sprayer.

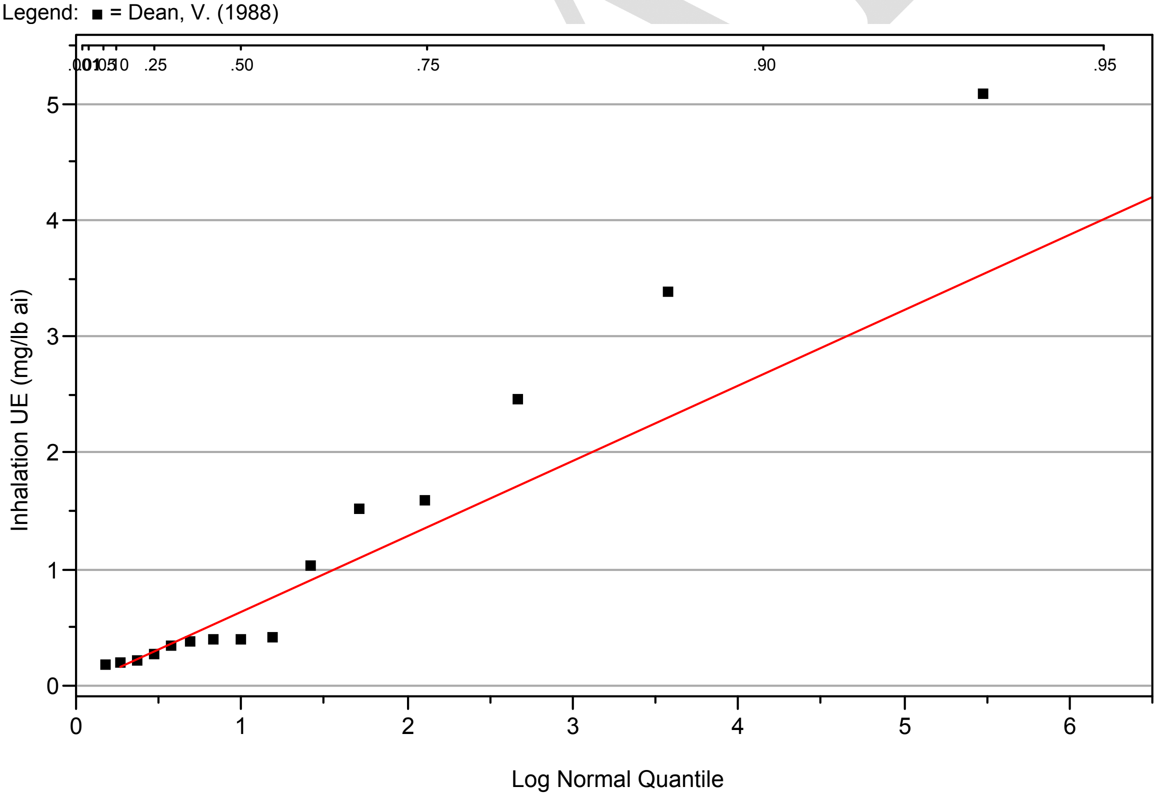
Inhalation Unit Exposure Summary: The recommended inhalation unit exposures for applications of wettable powder pesticide formulations using a low-pressure handwand to outdoor and indoor environments is based on a lognormal distribution fit with exposure monitoring data from Dean, V. (1988) [EPA MRID 41054702]. Dean, V. (1988) monitored 16 applications of a wettable powder formulation in homes for approximately 1-2.5 hours using a 1-gallon hand compression sprayer.

Lognormal Probability Plot

Legend: O = Dean, V. (1988); X = Merricks, L. (1987)



Legend: ■ = Dean, V. (1988)



Available Handler Exposure Studies

Table B-193: Exposure Study Identification Information	
Citation	Merricks, L. (1987). Potential Exposure to Acephate During and After Application of Orthene PCO Spray Concentrate by Commercial Pest Control Operators
EPA MRID	40504823
ORETF Code	NA
EPA Review	D270363
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Nine different individuals were monitored each at a home and in a commercial building (for a total of 18 application events) while mixing and applying a liquid solution (mixed from an acephate wettable powder formulation) using a “B&G stainless steel PCO sprayer” (i.e., a low pressure handwand). Each applicator mixed 2, 1-gallon solutions and applied 1 quart to baseboards and cracks and crevices, handling approximately 80 gms of acephate (0.176 lbs). Dermal exposure was measured using gauze patches (both inside and outside normal work clothing) and cotton gloves for hand exposure. Inhalation exposure was measured using standard pumps (set at 1 liter per minute), cassettes, and tubing. The overall acephate recovery from control samples fortified in the laboratory and analyzed with field samples was 103% for alpha-cellulose, 101% for gloves, and 96% for polyurethane foam plugs. Overall recovery from laboratory fortified samples was 107% for gloves, 103% for alpha-cellulose, and 83% for polyurethane foam plugs.

Table B-194: MRID 40504823 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	Yes	NA
Was the study intended to simulate “residential” exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**No**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Note that only the dermal exposure data are presented as the inhalation exposure data are not recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-195: MRID 40504823 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	0.176	4.88	--	27.7	--
B	0.176	0.39	--	2.2	--

C	0.176	2.15	--	12.2	--
D	0.176	3.37	--	19.1	--
E	0.176	2.10	--	12.0	--
F	0.176	15.87	--	90.2	--
G	0.176	16.00	--	90.9	--
H	0.176	3.47	--	19.7	--
I	0.176	3.83	--	21.7	--
A	0.176	55.91	--	317.7	--
B	0.176	0.80	--	4.6	--
C	0.176	3.97	--	22.6	--
D	0.176	4.42	--	25.1	--
E	0.176	1.06	--	6.0	--
F	0.176	6.28	--	35.7	--
G	0.176	3.99	--	22.6	--
H	0.176	2.45	--	13.9	--
I	0.176	4.00	--	22.7	--

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of exposure during applications using a low-pressure handwand to mix, load, and apply wettable powder formulations, the following limitations are noted:

- The study monitored individuals during applications to indoor locations which introduces uncertainty when using the data to assess applications outdoors.
- An estimated 90% of (non-hand) dermal exposure measurements were non-detects (1/2 the limit of detection, 0.01 ug per sample was used).

Table B-196: Exposure Study Identification Information	
Citation	Dean, V. 1988. Exposure of mixer/loader-applicators to propoxur during mixing/loading and application of Baygon 70 WP insecticide as a crack/crevice and limited surface treatment in residences
EPA MRID	41054702
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Three separate individuals were monitored in multiple houses for a total of 16 application events while mixing, loading, and applying a wettable powder formulation (70% propoxur) in homes using a 1-gallon hand compression sprayer. Each application ranged from 1 to 2.5 hours and the applicators handled from 0.1 to 0.25 lbs of propoxur. Dermal exposure was measured using gauze patches (both inside and outside normal work clothing) and hand rinses to measure hand exposure. Inhalation exposure was measured using standard pumps (set at 1 liter per minute), cassettes, and tubing. Average laboratory recovery values for air filters were 92.5% with a 5.4% standard deviation, for gauze pads 108% with a 3.6% standard deviation, for hand washes (200μg) 99.2% with a 0.5% standard deviation, and for hand washes (1,000μg) 97.3%

with a 0.8% standard deviation. Field recovery experiments were not performed for this specific study. The registrant assumed that the indoor laboratory conditions were similar to the indoor environmental conditions of the study houses. However, temperature and humidity were not reported for the laboratory or the study houses to allow comparison of the indoor environments. Furthermore, the study report does not specify the length of time the gauze pads and hand rinse solutions were exposed to the laboratory conditions.

Table B-197: MRID 41054702 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	No	Yes
Should this study be recommended for use in residential handler exposure assessments?	**Yes**	**Yes**

Data Summary: The following table summarizes pertinent exposure information from the above referenced study. Both dermal and inhalation exposure are included since both are recommended for use in residential handler exposure assessment. The submitted study itself or corresponding analytical spreadsheets should be reviewed for further information.

Table B-198: MRID 41054702 – Data Summary					
Person ID	AaiH[1] (lbs)	Exposure (mg)		Unit Exposure (mg/lb ai)[4]	
		Dermal[2]	Inhalation[3]	Dermal	Inhalation
A	0.09	17.78	0.296	198	3.29
A	0.08	23.82	0.413	298	5.16
A	0.13	31.63	0.306	243	2.35
A	0.09	17.75	0.035	197	0.39
B	0.16	14.09	0.251	88	1.57
B	0.09	5.17	0.132	57	1.47
B	0.22	5.94	0.083	27	0.38
B	0.22	9.49	0.071	43	0.32
B	0.24	26.21	0.095	109	0.40
B	0.13	8.52	0.135	66	1.04
C	0.11	1.94	0.022	18	0.20
C	0.09	2.39	0.038	27	0.42
C	0.13	3.48	0.032	27	0.25
C	0.11	2.02	0.022	18	0.20
C	0.13	2.35	0.023	18	0.18

[1] Amount of active ingredient Handled
[2] Representative of individuals wearing a short-sleeve shirt, shorts, shoes, socks and no chemical-resistant gloves.
[3] Inhalation exposure (mg) = mg collected/pump flow rate (Lpm) * Breathing Rate (16.7 Lpm)
[4] Unit Exposure = Exposure/AaiH

Limitations: Though the above referenced study is useful for assessment of exposure during applications using a low-pressure handwand to mix, load, and apply wettable powder formulations, the following limitations are noted:

- The study monitored individuals during applications to indoor locations which introduces uncertainty when using the data to assess applications outdoors.
- The individuals monitored wore chemical-resistant gloves, therefore back-calculation using a standard penetration factor of 90% was required.

Table B-199: Exposure Study Identification Information	
Citation	Meikle, S.; Baugher, D. (1992) Monitoring Exposure of Mixer/Loaders and Applicators Treating Agricultural Premises with Tetrachlorvinphos (Rabon 50WP Insecticide) in Handheld Wand-type Sprayers: Lab Project Number: 31189: 562: 62-RAB/92099. Unpublished study prepared by Orius Associates, Inc. and PTRL East, Inc. 207 p.
EPA MRID	42622301 / 44202701 / 44202702
ORETF Code	NA
EPA Review	D233254
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Four workers were monitored during 4 separate applications (for a total of 16 application events) while spraying the interior of poultry houses using a handwand sprayer attached with a 30 meter hose to a 2000 gallon tank (mixing and loading of the wettable powder formulation was monitored separately). Each application consisted of spraying from 385 to 1,372 liters of spray, handling from approximately 8 to 32 lbs of active ingredient (TCVP), with times ranging from 4 to 30 minutes. Dermal exposure was measured using whole body dosimetry and hand washes underneath their normal work clothing consisting of a long-sleeved/long pants coverall and chemical-resistant gloves. Inhalation exposure was measured using standard pumps (set at 1 liter per minute), cassettes, and tubing. Mean percent recoveries from laboratory fortifications were 75.2% with a standard deviation of 26.2% for union suits (whole) (10-50,000 μg/suit), 95.9% with a standard deviation of 9.3% for union suits (whole) (2,500-50,000 μg/suit only), 96.2% with a standard deviation of 9.9% for dosimeters (gloves), 89.6% with a standard deviation of 14.0% for handwash, 89.5% with a standard deviation of 9.8% for inhalation tubes with ambient conditions, 20% R.M., and 93.4% with a 10.3% standard deviation for inhalation tubes with >89% R.H.; 0.1-5.0 μg/tube. Mean percent recoveries from field fortifications were 84.3% with a standard deviation of 24% for union suits, 89.8% with a standard deviation of 9.8% for dosimeters (gloves), 82.9% with a standard deviation of 16.8% for handwash, and 84.2% with a standard deviation of 39.4% for inhalation monitoring tubes.

Table B-200: MRID 42622301 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate “residential” exposure via the scripted	No	

activity, amount of active ingredient handled, volunteers used, or the setting?		
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Table B-201: Exposure Study Identification Information	
Citation	Belcher, T. (2002) Dermal and Inhalation Exposure to Greenhouse Handlers While Mixing, Loading, and Applying Terrazole 35% Wettable Powder: Lab Project Number: RP-01011: ERS21047: 990085. Unpublished study prepared by Excel Research Services, Inc. 343 p. {OPPTS 875.1200, 875.1400}
EPA MRID	45773201
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Eleven different workers were monitored for a total of 15 application events while spraying greenhouse ornamentals with a handwand sprayer attached to a hose fed through a slurry tank. Each application consisted of spraying approximately 500 gallons of solution, equivalent to approximately 3 lbs of active ingredient (etridiazole), over the course of approximately 2 hours. Dermal exposure was measured using whole body dosimetry and hand washes underneath their normal work clothing consisting of a long-sleeved/long pants coverall and chemical-resistant gloves. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Mean recoveries for laboratory fortifications was 96.0% ± 7.64 with a range of 80.6% to 106% for dermal dosimeters, 65.9% ± 3.64 with a range of 62.5% to 70.8% for face/neck wipes, 90.7% ± 10.0 with a range of 81.7% to 105% for hand washes, and 89.1% ± 2.57 with a range of 85.7% to 94.6% for inhalation tubes. Mean recoveries for field fortifications across both levels were 90.2% ± 8.48 with a range of 79.0% to 102% for dermal dosimeters, 82.8% ± 7.85 with a range of 70.5% to 92.0% for face/neck wipes, 111% ± 6.05 with a range of 104% to 119% for handwashes, and 94.5% ± 1.97 with a range of 90.9% to 96.2% for inhalation tubes.

Table B-202: MRID 45773201 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA

Was the study intended to simulate "residential" exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Scenario Summary

Table B-203: Scenario Description and Available Exposure Studies	
Formulation	Wettable Powder (WP)
Equipment/Application Method	Backpack sprayer
Application Site(s)	outdoors (lawns, gardens, trees/bushes, perimeter, mounds/nests), indoors (general broadcast treatments, baseboards, cracks and crevices)
Available Exposure Studies	Fenske, R.A. (1985); MRID 40350602
	Findlay, M.L. (1998); MRID 44493001

Table B-204: Unit Exposures (mg/lb ai) – WP Backpack Sprayer Applications

Statistic	Dermal	Inhalation
50th percentile	Studies measuring exposure while mixing/loading/applying wettable powder formulations using a backpack sprayer are available, but not recommended for residential handler exposure assessment. Therefore, the exposure studies recommended for mixing/loading/applying wettable powder formulations using a low-pressure handwand should be used as a surrogate.	
75th percentile		
95th percentile		
99th percentile		
99.9th percentile		
AM (SD)		
GM (GSD)		
Range		
N		

Dermal Unit Exposure Summary: Dermal exposure monitoring data for applications of wettable powder formulations using backpack sprayer is available but not recommended for use in residential exposure assessments; dermal unit exposures for applications of wettable powder pesticide formulations using a low-pressure handwand are recommended as surrogate data.

Inhalation Unit Exposure Summary: Inhalation exposure monitoring data for applications of wettable powder formulations using backpack sprayer is available but not recommended for use in residential exposure assessments; inhalation unit exposures for applications of wettable powder pesticide formulations using a low-pressure handwand are recommended as surrogate data.

Available Handler Exposure Studies

Table B-205: Exposure Study Identification Information	
Citation	Fenske, R.A. (1985). Worker exposure to Aliette during greenhouse applications.
EPA MRID	40350602
ORETF Code	NA
EPA Review	none
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Four individuals were monitored while spraying greenhouse ornamentals using a backpack sprayer – the loading and mixing of the wettable powder formulation into the backpack sprayer tank was monitored separately. Each application lasted approximately 1 hour and consisted of spraying approximately 12 tank loads (3 gallons each) and handling approximately 1.2 lbs of active ingredient (fosetyl-al). Dermal exposure was measured using gauze patches (outside and underneath long-sleeve shirt and long pants) and hand rinses. All workers wore chemical-resistant gloves. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Mean laboratory control and spiked samples for handwash solutions, gauze pads, and air filters are 85.4%, 97.7%, and 119.3%, respectively. The average recovery for field spike samples for handwash solutions, gauze pads, and air filters were 89.4%, 96.8%, and 104.5% respectively.

Potential for Use in Residential Handler Exposure Assessments: The table below outlines relevant characteristics of the above referenced study with respect to its potential use in residential handler exposure assessments. The recommendation for use informs only the data that is ultimately used as a default and does not mean that a study not recommended for use cannot ever be used. Should a non-recommended study be deemed useful given a unique situation, the assessment should provide justification for its use and deviation from use of the recommended studies as default data.

Table B-206: MRID 40350602 – Checklist and Use Recommendation for		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	Yes	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate “residential” exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	Yes	Yes
Should this study be recommended for use in residential handler exposure assessments?	**No**	**No**

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Table B-207: Exposure Study Identification Information	
Citation	Findlay, M.L. (1998). Diquat: Worker Exposure During Mixing, Loading and Application of Reglone® with Knapsack Sprayers
EPA MRID	44493001
ORETF Code	NA
EPA Review	D222970
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Study Description: Four different workers were monitored on 5 different days while mixing, loading, and applying a wettable powder formulation (36.4% diquat) to banana plantations in Guatemala using backpack sprayers. Each application was approximately 6 hours and consisted of handling approximately 0.77 lbs diquat. Dermal exposure was measured using whole body dosimetry (the dosimeter served as the workers actual clothing; exposure representative of “no clothing”) and hand washes underneath chemical-resistant gloves. Inhalation exposure was measured using standard pumps (set at 2 liters per minute), cassettes, and tubing. Laboratory fortified samples of cotton material with a fortification level of 25 μg/sample had a range of recovery (%) of 90-110, and a mean ± SD of recovery (%) of 99.4 ± 8.0; with a fortification level of 250 μg/sample had a range of recovery (%) of 70-99, and a mean ± SD of Recovery (%) of 89.8 ± 9.8. Samples of handwash solution with a fortification level of 10 μg/sample had a range of recovery (%) of 84-95, and a mean ± SD of recovery (%) of 90.7% ± 5.9; with a fortification level of 100 μg/sample had a range of recovery (%) of 82-105, and a mean ± SD of recovery (%) of 96.0 ± 9.4. Samples of air filters with a fortification level of 1.25 μg/sample had a range of recovery (%) of 98-98, and a mean ± SD of recovery (%) of 98.0 ±0; with a fortification level of 12.5 μg/sample had a range of recovery (%) of 90-104 and a mean ± SD of recovery (%) of 98.0 ± 7.2. The mean recovery of diquat from the clothing and handwash was 69% and 68%, respectively. On day one, the recovery of diquat from the clothing and handwash was 90% and 89%, and on day 2 the recovery was 80% and 125%, respectively. On days 3, 4, and 5, the recoveries were low at 59%, 56%, and 61%, respectively fro the clothing, and 54%, 45%, and 29%, respectively, for the handwash. The mean recovery of diquat from glass fibre filters prepared under field conditions was 77% and ranged from 70 – 81%.

Table B-208: MRID 44493001 – Checklist and Use Recommendation		
Study Criteria	Exposure Component	
	Dermal	Inhalation
Does the study provide detailed characteristics on the activity, equipment type, and amount of active ingredient handled?	Yes	
Does dermal exposure monitoring allow for construction of an exposure estimate for individuals wearing short-sleeve shirts, shorts, shoes, socks?	No	NA
Was exposure to the hands representative of bare hands?	No	NA
Was the study intended to simulate “residential” exposure via the scripted activity, amount of active ingredient handled, volunteers used, or the setting?	No	
Is the data of reasonable quality (i.e., are field fortification and laboratory recovery samples adequate)?	No	Yes
Should this study be recommended for use in residential handler exposure	**No**	**No**

assessments?		

Data Summary: A summary of the data from this study is not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

Limitations: Any data limitations associated with the exposure data in this study are not provided since it is not recommended for use in residential handler exposure assessment. The submitted study itself should be reviewed for further information.

B.2 Exposure Factors Used to Calculate Amount of Active Ingredient Handled

B.2.1 Gardens and Trees

Limited information is available for estimating the amount of active ingredient an individual will handle during a pesticide application. Additionally, this factor is likely highly chemical- and product-specific due to the both the application instructions and efficacy of the chemical. Nevertheless, in the absence of chemical- and/or product-specific information, generic information can be useful to enable an exposure assessment.

In the case of gardens and trees, both garden size and amount of volume sprayed can be used generically to estimate the amount of active ingredient handled.

B.2.1.1 Garden Size

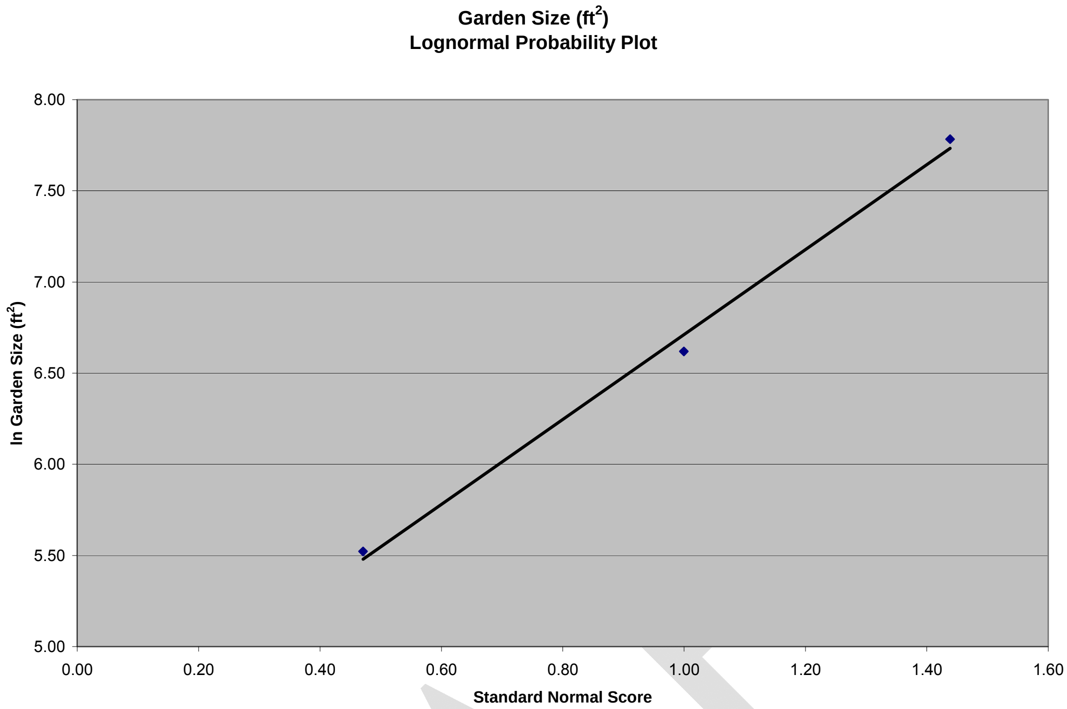
For application rates in terms of area (e.g., 2 lbs active ingredient per 1000 square feet), the size of a garden can be used to estimate the amount of active ingredient handled per application. The table below summarizes the results of a survey (Johnson, 1999) which included responses to a question regarding garden size.

Table B-209: Home Garden Size (ft^2)					
N	(% response)				
	< 250	250 – 749	750 – 2399	> 2400	DNK
364	56.2	13.2	6.9	6.2	17.5
DNK = did not know Source: Johnson, 1999. National Gardening Association Survey (EPA MRID 44972202)					

Because the actual responses are unavailable, the percent response values in the table above were adjusted based on the % "did not know" response (17.5%) and used as cumulative percentiles shown in the table below:

	Table B-210: Home Garden Size (ft^2)			
	(% response)			
	< 250	250 – 749	750 – 2399	> 2400
Reported % response	56.2	13.2	6.9	6.2
Adjusted % response[1]	68.1	16.0	8.4	7.5
Cumulative %tile	68.1	84.1	92.5	7.5
Standard Normal Score	0.471	0.999	1.44	NA
[1] Reported % response adjusted for 17.5% DNK response				

The data were then fit to a lognormal distribution shown in the probability plot below:



Summary statistics based on the above distribution area provided in the table below.

Table B-211: Statistical Summary – Garden Size (ft^2)	
50th percentile	80
75th percentile	385
90th percentile	1583
95th percentile	3690
99th percentile	18043
99.9th percentile	106887
AM (SD)	1205 (18109)
GM (GSD)	80 (10.3)
Range	unknown
N	364
AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

B.2.1.2 Hose-end Sprayer Application Volumes

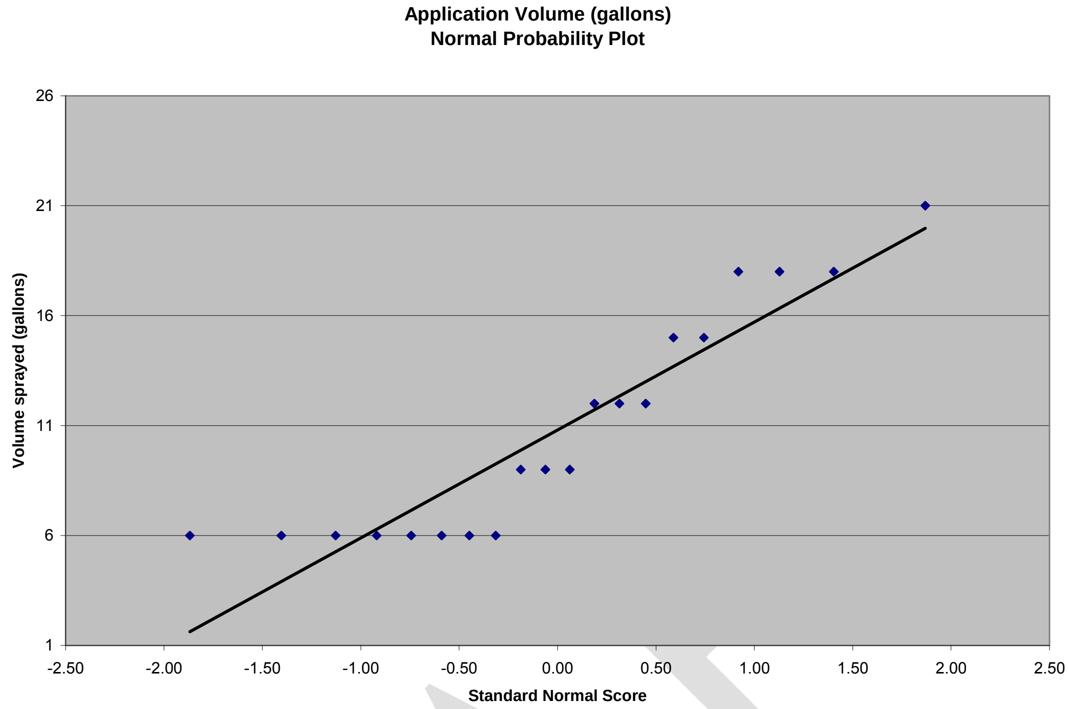
An estimate for the amount of spray solution volume sprayed is necessary if the application rate is used in terms of active ingredient per volume solution. Such a rate would be used for spraying trees where an "area-based" approach would not be appropriate or useful. However, this factor is likely application method-specific (i.e., one might apply more solution using a hose-end sprayer than a sprinkler can) and explicit information on volumes sprayed in home applications is unavailable.

For hose-end sprayers, application volume was derived from a study measuring exposure during applications of liquid formulations to fruit trees and ornamental shrubs using a hose-end sprayer

(Merricks, 1998). For application rates in terms of active ingredient per volume (e.g., 0.1 lbs active ingredient per gallon spray solution), typically appropriate for assessing spray applications to trees and shrubs, estimates for volume of solution sprayed are derived from EPA MRID 44518501 where individuals sprayed ornamental citrus trees and shrubs using a hose-end sprayer and low-pressure handwand. Volumes sprayed for the hose-end sprayer were calculated using the study-specified water flow rate of 3 gallons per minute. Each application ranged from 2 to 7 minutes resulting in a range of spray volumes from 6 to 21 gallons. The table below provides a summary of the relevant information.

Table B-212: Application Volume Summary from EPA MRID 44518501			
Applicator ID	**Application Time (minutes)**	**Flow rate (gallons/minute)**	**Application volume (gallons)**
A	3	3	9
B	4	3	12
C	6	3	18
D	5	3	15
E	2	3	6
F	3	3	9
G	2	3	6
H	2	3	6
I	2	3	6
J	2	3	6
K	2	3	6
L	4	3	12
M	4	3	12
N	7	3	21
O	6	3	18
P	2	3	6
Q	5	3	15
R	3	3	9
S	6	3	18
T	2	3	6

The data were fit to a normal distribution shown in the probability plot below.



Summary statistics for application volume are presented in the table below.

Table B-213: Statistical Summary – Hose-end Sprayer Application Volume (gallons)	
50th percentile	11
75th percentile	14
90th percentile	17
95th percentile	19
99th percentile	22
99.9th percentile	26
AM (SD)	11 (5.1)
GM (GSD)	10 (1.57)
Range	6 – 21
N	20
AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

For all other applications, reliable information on the amount of product used is unavailable. For low-pressure handwands, backpacks, and sprinkler cans a uniform distribution of 2 to 5 gallons is recommended. For aerosol cans and trigger-sprayers a uniform distribution of 0.5 to 2 cans/containers is recommended.

Appendix C Supporting Data Analysis and Documentation for Residential Post-Application Exposure Assessment

C.1 Indoor Fogger Settling Time

For indoor foggers, post-application inhalation exposure is not anticipated because the fogger labels typically require reentry restrictions. If necessary, the time needed for particle settling can be calculated using Stokes law and adjustments can be made for droplet evaporation (Matthews, 2000). Based on information provided by manufacturers, the particle distribution for a total release aerosol or fogger ranges from less than 15 micrometers (um) to 60 um. According to calculations of settling time versus droplet size, it will take 17 minutes for a 40 micron fog to settle from an eight-foot ceiling height if it is applied from a fogger that contains 1% non-volatile ingredients in a room with an air temperature of 22^{o}C and a relative humidity of 30%. This calculation is based on the assumption that a 40-micron droplet will decrease to a 9-micron nuclei due to evaporation.

Table C-1: Estimated settling time using Stokes Law

Drop Diameter (um)	Nuclei Diameter (um)	Settling Velocity (cm/sec)[a]	Settling Time (Release Height = 8 feet)		
			Hours	Minutes	Seconds
10	2	0.0	6	339	20320
15	3	0.0	3	151	9031
20	4	0.0	1	85	5080
30	6	0.1	1	38	2258
40	9	0.2	0.3	17	1003
50	11	0.4	0.2	11	672
60	13	0.5	0.1	8	481

C.2 Background on Multi- Chamber Concentration and Exposure Model (MCCEM)

Indoor air concentrations can be calculated using a computer model, Multi- Chamber Concentration and Exposure Model (*MCCEM). MCCEM* is a model that is capable of calculating indoor air concentrations for both acute and chronic scenarios. *MCCEM* contains a database of various default house data, such as air exchange rates, geographically based inter-room air flows, and house/room volumes. Unique house specifications may also be created according to the scenario being assessed.

Chemical source emission rates of pollutants are entered into the model and *MCCEM* can account for removal processes and the contribution of outdoor concentrations. The model is also capable of performing sensitivity analyses and Monte Carlo analyses. However, because this SOP is focused on high-end assessments, only the aspects of *MCCEM* determined to produce high end results are addressed herein. The essential aspects of *MCCEM* that must be defined to complete a high-end assessment include the following:

- type of house (selection based on number of stories and house volume),
- definition of zones for selected house (single or multi-zone up to 4 indoor zones),
- selection of model (run time and reporting intervals),
- selection/calculation of appropriate emission rate inputs for chemical/product, and
- selection of removal processes for the chemical/product (presence of sinks).

Input parameters can be adjusted according to scenarios unique to specific assessments, however, *Table C-2* includes *MCCEM* parameters that are appropriate for a high-end calculation. *MCCEM* requires further input to operate the model.

Table C-2: High-end Scenario Guidance for *MCCEM*

Use Scenario	House Selection (GN001)		Chamber Type (Number Zones)[b]	Duration[c] (days)			Emissions Parameters[d]		*MCCEM* Decay Rate[e]
	House Type/ Season	Air Exchange Rate[a] (xch/hr)		Run Time (days)	Time Steps (hours) Acute	Time Steps (hours) Chronic	Type	Rate	
Total Release Aerosol[f]	Generic/ Summer	0.18	Multi (2)	90	1	24	Instant Release	Total/hr	0
Indoor Space Sprays[f]	Generic/ Summer	0.18	Multi (2)	90	1	24	Instant Release	Total/h	0
Broadcast	Generic/ Summer	0.18	Multi (2)	90	1	24	Chinn Evaporation	Chinn Rate	0
Perimeter	Generic/ Summer	0.18	Multi (2)	90	1	24	Chinn Evaporation	Chinn Rate	0
Crack and Crevice	Generic/ Summer	0.18	Single (1)	90	1	24	Chinn Evaporation	Chinn Rate	0
Termiticides	Generic/ Summer	0.18	Single (1)	365			Chinn Evaporation	Chinn Rate	0
Carpet Dusting	Generic/ Summer	0.18	Multi (2)	90	1	24	Chinn Evaporation	Chinn Rate	0

a. The value of 0.18 ACH corresponds to the 10th percentile of the estimated national distribution for residential air exchange rates. (Koontz and Rector, 1995).

b. Chamber type is reflected in the house selection and must correlate with the Execution Mode (Step 8)
c. Duration refers to the length of time that the chemical exposure concentration is modeled, as well as the time steps for recording the calculated exposure concentration
d. Instant release represents when a chemical is "thrown up" in the air of a residence as an aerosol immediately -- less than 1 hour; Chinn Evaporation is when a pesticide offgasses from the treated surfaces for several weeks; See Step 3 and the associated *Figure C-1* below for details concerning the calculation of Chinn release emission rates.
e. Decay rate is chemical specific. For high-end estimates the chemical is considered non-reactive.
f. These two use scenarios include the use of aerosol sprays for which this model may be an overestimation of air concentrations

Step-by-step procedures for completing a high-end assessment using *MCCEM Version 1.2* are presented below.

Step 1: House Tab: Select the "Generic House" (House Code: GN001) option within the Residence Type section. This provides a conservative air exchange rate of 0.18 ACH.

Step 2: Run Time: The long-term model is appropriate for all high-end assessments. For the purposes of this SOP, 1-hour steps should used for an acute endpoint while a 24-hour step should be used for a chronic endpoint.

Step 3: Emission Rate & Exposure Zone Inputs: For the high-end assessment requirement, select "Constant" as the source model definition. Two emission mechanisms may be inputted for the constant emissions rate:

- For instant release scenarios, the emissions rate is calculated as the mass of product released per hour.
- For the Chinn type or long-term emission (e.g., offgassing from treated surfaces for several weeks), the emission rate is calculated based on an empirical relationship between evaporation time, vapor pressure, and molecular weight (Chinn, 1981). The equations used to calculate a Chinn Type emission rate and an example calculation are presented in *Figure C-1*.

Step 4: Sinks: No inputs are entered in this field. Unless information regarding the absorption rate and sink area for reversible and/or irreversible sinks are available to characterize the sink, the chemical is considered to be nonreactive.

Step 5: Activities: No contributions of occupant activities or breathing rates are entered.

Step 6: Dose: Dose is not calculated for high end estimates for the purposes of this SOP. No values are inputted.

Step 7: Monte Carlo Options: Ensure that "Apply Model Once" and "Randomly Select Seed" are selected. Monte Carlo Assessments are not conducted for the purpose of a high-end assessment.

Step 8: <u>Options:</u> Ensure that "Use Interzonal Airflow Rates Provided" ("Single Chamber Model" may be run if the application is throughout all rooms in the house) and the appropriate "Output Concentration Units" are selected. Unless initial concentration data exists, input parameters should be "0".

Step 9: <u>Execute the Model:</u> Run the model and save the output and data (.csv) files for review purposes.

Figure C-1: Calculation of Chinn Release Emission Rates

Calculate the mass of active ingredient applied (m) in grams during a single application event. Next calculate the Chinn Evaporation time using the following formula (Chinn, 1981):

$$d = \frac{145}{(mw * vp)^{0.9546}}$$

where:

d = Chinn evaporation time (hr)
mw = molecular weight of pesticide active ingredient (unitless)
vp = vapor pressure (torr)

Finally, calculate the emission rate (g/hr) using the following formula

$$er = \frac{mw}{d}$$

Example:

3 gallons of solution containing 500 grams of ai with a vapor pressure of $5x10^{-4}$ torr and a molecular weight of 500 are applied in a typical crack-and-crevice scenario, then:

$$d = \frac{145}{(500 * 5 * 10^{-4})^{0.9546}} = 545\, hours$$

and

$$er = \frac{500}{545} = 0.91 \frac{grams}{hour}$$

Selection of the proper air concentration value (AC_t) from *MCCEM* to be used in the exposure assessment depends on the inhalation toxicological endpoint (i.e., acute or chronic). The "average concentration in the zone 1" is selected for an acute endpoint. This value is used even if a multi-chamber model run is completed because zone 1 will have slightly higher concentration values as it will always be designated as the release zone. If the endpoint is chronic, the “Time-Weighted-Average (TWA)" value is selected for Zone 1.

C.3 Background on Well-Mixed Box Model

C.3.1 Outdoor Fogging/Misting Systems - Aerosol Spray Area Foggers

The well-mixed box (WMB) model was used to develop the exposure equation (*5.5*) for the aerosol spray area foggers post-application inhalation scenario. The WMB was used to model pesticide air concentrations within an enclosed, fixed volume (i.e. a box) over time after an initial aerosol spray application of an area fogger. The WMB model incorporates a number of simplifying assumptions: fresh air (having zero pesticide concentration) enters the box at a constant airflow rate, a turbulent internal airflow thoroughly mixes the fresh air with the pesticide-laden air resulting in a uniform pesticide air concentration within the box, and the perfectly mixed air exits the box at the same constant airflow rate (i.e. the inflow rate equals the outflow rate). Thus the outdoor area where the aerosol is being applied is assumed to be in an enclosed box, therefore, using the WMB model is conservative for estimation of exposures for an open patio or deck.

The removal of the aerosol from the box depends on airflow. For an outdoor scenario, the airflow, Q, is the product of the cross-sectional area and the wind velocity. The WMB model developed for this scenario models the pesticide air concentrations *after* an initial, instantaneous release of an aerosol spray area repellant. Only dissipation due to airflow into and out of the box is modeled. The mass balance within the box can be described by the following differential equation:

$$V\frac{dC}{dt} = -Q \cdot C$$

$$\frac{dC}{C} = -\frac{Q}{V}dt$$

where **C** is the air concentration, **Q** is the airflow (the product of the cross-sectional area of the box and the wind speed), and **V** is the volume of the box. Integrating the differential equation and simplifying and combining terms yields an equation describing the air concentration over time.

$$\int\frac{dC}{C} = -\int\frac{Q}{V}dt$$

$$\ln(C) = -\frac{Q}{V}t + a$$

$$e^{\ln(C)} = e^{-\frac{Q}{V}t+a}$$

$$C = A \cdot e^{-\frac{Q}{V}t}$$

where $A = e^a$ is a constant whose value is determined by the initial condition that at time t = 0, the pesticide air concentration is equal to initial air concentration, i.e. $C(0) = C_0$. Based on this initial constraint, the WMB model described above for modeling pesticide air concentrations over time can be written as follows:

$$C(t) = C_0 e^{-\frac{Q}{V}t} \qquad \text{(C.1.1)}$$

where **C(t)** is the air concentration at time **t**, $\mathbf{C_0}$ is the initial air concentration (i.e. concentration at time t=0), **Q** is the airflow (the product of the cross-sectional area of the box and the wind speed), and **V** is the volume of the box. The air concentration equation (1.1) is then used to calculate the exposure, E:

$$E = IR\int_0^{ET} C(t)dt \qquad \text{(C.1.2)}$$

The exposure, **E** is based on integrating equation (1.1) over the exposure time, **ET** which is then multiplied by an inhalation rate, **IR**. The final exposure equation is derived from equation (C.1.2) by performing the integration and simplifying terms.

$$E = IR\int_0^{ET} C_0 e^{-\frac{Q}{V}t} dt$$

$$E = IR \cdot C_0 \left(\frac{-1}{Q/V}\right)\left(e^{-\frac{Q}{V}(ET)} - e^{-\frac{Q}{V}(0)}\right)$$

$$E = \frac{IR \cdot C_0}{Q/V}\left(1 - e^{-\frac{Q}{V}(ET)}\right) \qquad \text{(C.1.3)}$$

The term $e^{-\frac{Q}{V}ET}$ in equation (C.1.3) represents the fraction of the initial concentration, $\mathbf{C_0}$ present in the treated area at the end of the exposure time, **ET**. To the extent that the pesticide rapidly dissipates, this term will rapidly approach zero. For this scenario, the assumed volume of the outdoor treated space is 20 × 20 × 8 ft^3 and the minimum flow rate is 52.5 ft^3/sec, which based on the minimum air velocity of 0.1 m/s and the cross sectional area of 20 × 8 ft^2 (~15 m^2) from Table 5-3. Given these values for **V** and **Q**, one can determine the time after which the term $e^{-\frac{Q}{V}t}$ would be less than 0.001 (i.e. the time after which less than 0.1% of the original concentration remains).

$$V = 20\,ft \times 20\,ft \times 8\,ft\,;\ Q = (20\,ft \times 8\,ft) \times 0.1\,m/s \times 3.28\,ft/m$$

$$e^{-\frac{Q}{V}t} = 0.001 \Rightarrow -\frac{Q}{V}t = \ln(0.001) \Rightarrow t = -\frac{\ln(0.001)\times V}{Q}$$

$$t = -\frac{\ln(0.001)\times(20\,ft\times 20\,ft\times 8\,ft)}{(20\,ft\times 8\,ft)\ \times 0.1\,{}^{m}\!/_{s}\times 3.28\,{}^{ft}\!/_{m}} = 421\sec = 7.02\min$$

The above calculation demonstrates that after an exposure time of about 7 minutes, less than 0.1% of the initial concentration would be left in the treated space. This implies that the released pesticide fog would be almost completely dissipated for any significant exposure time. Therefore the term $e^{-\frac{Q}{V}ET}$ in equation (C.1.3) approaches zero very quickly. Thus the exposure equation can be simplified to:

$$E = \frac{IR\cdot C_0}{Q/V} \qquad \text{(C.1.4)}$$

The initial concentration, $\mathbf{C_0}$, can be replaced by the term application rate, **AR** (which is specified to have units mg-AI/day for this scenario) divided by **V**, the volume of the treated space. Thus equation (C.1.4) can be rewritten as:

$$E = \frac{IR\cdot AR/V}{Q/V}$$

After canceling out the volume terms, the final exposure equation can be expressed as:

$$E = \frac{IR\cdot AR}{Q} \qquad \text{(C.1.5)}$$

C.3.2 Outdoor Fogging/Misting Systems - Candles, Coils, Torches, and Mats (CCTM)

The well-mixed box (WMB) model was used to develop exposure equation (5.12) for the candles, coils, torches, and mats (CCTM) post-application inhalation scenario. The CCTM scenario differs from the other exposure scenarios in this Outdoor Fogging/Misting System SOP section in that the WMB model includes a constant emission rate term during the exposure time and thus results in a more complicated exposure equation. The WMB was used to model pesticide air concentrations within an enclosed, fixed volume (i.e. a box) over time during the constant emission of a pesticide from a CCTM product. The WMB model incorporates a number of simplifying assumptions: fresh air (having zero pesticide concentration) enters the box at a constant airflow rate, a turbulent internal airflow thoroughly mixes the fresh air with the pesticide-laden air resulting in a uniform pesticide air concentration within the box, and the perfectly mixed air exits the box at the same constant airflow rate (i.e. the inflow rate equals the outflow rate). Thus the outdoor area where the aerosol is being applied is assumed to be in an enclosed box, therefore, using the WMB model is conservative for estimation of exposures for an open patio or deck.

The removal of the CCTM emission from the box depends on airflow. For an outdoor scenario, the airflow, Q is the product of the cross-sectional area and the wind velocity. The WMB model developed for this scenario models the pesticide air concentrations *during* a constant emission of pesticide from a CCTM product. Only constant emission and dissipation due to airflow into and out of the box is modeled. The mass balance within the box can be described by the following differential equation:

$$V\frac{dC}{dt} = V_E \cdot ER - Q \cdot C$$

$$\frac{dC}{dt} = \frac{V_E \cdot ER}{V} - \frac{Q}{V} \cdot C$$

where **C** is the air concentration, $\mathbf{V_E}$ is the vaporization efficiency, **ER** is the emission rate, **Q** is the airflow (the product of the cross-sectional area of the box and the wind speed), and **V** is the volume of the box. Based on the method of undetermined coefficients, the solution to this differential equation has the form:

$$C(t) = \frac{\frac{V_E \cdot ER}{V}}{\frac{Q}{V}} - A \cdot e^{-\frac{Q}{V}t}$$

$$C(t) = \frac{V_E \cdot ER}{Q} - A \cdot e^{-\frac{Q}{V}t}$$

where A is a constant whose value is determined by the initial condition that at time t = 0, the pesticide air concentration is equal to zero, i.e. C(0) = 0. Based on this initial constraint, the equation describing the air concentration over time can be written as:

$$C(t) = \frac{V_E \cdot ER}{Q} - \frac{V_E \cdot ER}{Q} e^{-\frac{Q}{V}t}$$

Based on the WMB model described above, which is very similar to the box model described by Fan and Zhang (2000), the equation for modeling pesticide air concentrations over time is as follows:

$$C(t) = \frac{V_E \cdot ER}{Q}\left(1 - e^{-\frac{Q}{V}t}\right) \qquad \text{(C.2.1)}$$

where **C(t)** is the air concentration at time **t**, $\mathbf{V_E}$ is the vaporization efficiency, **ER** is the emission rate, **Q** is the airflow (the product of the cross-sectional area of the box and the wind speed), and **V** is the volume of the box. The air concentration equation is then used to calculate the exposure, **E**, which is based on integrating equation (C.2.1) over the exposure time, **ET** which is then multiplied by an inhalation rate, **IR**:

$$E = IR \int_0^{ET} C(t)dt \qquad \text{(C.2.2)}$$

The final exposure equation is derived from equation (C.2.2) by performing the integration and simplifying terms.

$$E = IR \int_0^{ET} \frac{V_E \cdot ER}{Q}\left(1 - e^{-\frac{Q}{V}t}\right)dt$$

$$E = \frac{IR \cdot V_E \cdot ER}{Q} \int_0^{ET} \left(1 - e^{-\frac{Q}{V}t}\right)dt$$

$$E = \frac{IR \cdot V_E \cdot ER}{Q} \int_0^{ET} 1dt - \int_0^{ET} e^{-\frac{Q}{V}t}dt$$

$$E = \frac{IR \cdot V_E \cdot ER}{Q}\left[(ET - 0) - \left(-\frac{V}{Q}\right)\left(e^{-\frac{Q}{V}(ET)} - e^{-\frac{Q}{V}(0)}\right)\right]$$

$$E = \frac{IR \cdot V_E \cdot ER}{Q}\left[ET - \left(\frac{V}{Q}\right)\left(1 - e^{-\frac{Q}{V}(ET)}\right)\right] \qquad \text{(C.2.3)}$$

As in equation (C.1.3), the term $e^{-\frac{Q}{V}ET}$ in equation (C.2.3) is less than one and approaches zero as exposure time, **ET** increases. To the extent that the pesticide air concentration rapidly approaches steady state, this term will rapidly approach zero. For this scenario, the assumed volume of the outdoor treated space is 15 × 15 × 8 ft^3 and the minimum flow rate is 39.4 ft^3/sec, which based on the minimum air velocity of 0.1 m/s and the cross sectional area of 15 × 8 ft^2 (~11 m^2) from Table 5-4. Given these values for **V** and **Q**, one can determine the time after which the term $e^{-\frac{Q}{V}t}$ would be less than 0.001 (i.e. the time after which the air concentration is 99.9% of the steady-state value).

$$V = 15\,ft \times 15\,ft \times 8\,ft\,;\; Q = (15\,ft \times 8\,ft) \times 0.1\, {}^{m}\!/_{s} \times 3.28\, {}^{ft}\!/_{m}$$

$$e^{-\frac{Q}{V}t} = 0.001 \Rightarrow -\frac{Q}{V}t = \ln(0.001) \Rightarrow t = -\frac{\ln(0.001) \times V}{Q}$$

$$t = -\frac{\ln(0.001) \times (15\,ft \times 15\,ft \times 8\,ft)}{(15\,ft \times 8\,ft) \times 0.1\, {}^{m}\!/_{s} \times 3.28\, {}^{ft}\!/_{m}} = 316\sec = 5.27\min$$

The above calculation demonstrates that after an exposure time of less than 6 minutes, the air concentration would be more than 99.9% of the steady-state value in the treated space. This implies that the air flow would practically cease to dissipate the pesticide after any significant exposure time. Therefore the term $e^{-\frac{Q}{V}ET}$ in equation (C.2.3) approaches zero very quickly. Thus the final exposure equation can be simplified to:

$$E = \frac{IR \cdot V_E \cdot ER}{Q}\left(ET - \frac{V}{Q}\right) \qquad \text{(C.2.4)}$$

C.3.3 Outdoor Fogging/Misting Systems - Outdoor Residential Misting Systems (ORMS)

The well-mixed box (WMB) model was used to develop exposure equation (*5.19*) for the outdoor residential misting systems (ORMS) post-application inhalation scenario[17]. The WMB model incorporates a number of simplifying assumptions: fresh air (having zero pesticide concentration) enters the box at a constant airflow rate, a turbulent internal airflow thoroughly mixes the fresh air with the pesticide-laden air resulting in a uniform pesticide air concentration within the box, and the perfectly mixed air exits the box at the same constant airflow rate (i.e. the inflow rate equals the outflow rate). Thus the outdoor area where the aerosol is being applied is assumed to be in an enclosed box, therefore, using the WMB model is conservative for estimation of exposures for an open patio, deck, or yard. Also, this scenario assumes instantaneous spray releases, that is, the total amount of aerosol released at each spray event is modeled to occur instantaneously.

The removal of the pesticide from the box depends on airflow. For an outdoor scenario, the airflow, Q is the product of the cross-sectional area and the wind velocity. The WMB model developed for this scenario models the pesticide air concentrations *after* multiple instantaneous aerosol spray releases at regular time intervals[18]. Only dissipation due to airflow into and out of the box is modeled. The mass balance within the box can be described by the following differential equation:

$$V\frac{dC}{dt} = -Q \cdot C$$

$$\frac{dC}{C} = -\frac{Q}{V}dt$$

where **C** is the air concentration, **Q** is the airflow (the product of the cross-sectional area of the box and the wind speed), and **V** is the volume of the box. Integrating the differential equation and simplifying and combining terms yields an equation describing the air concentration over time.

$$\int \frac{dC}{C} = -\int \frac{Q}{V}dt$$

$$\ln(C) = -\frac{Q}{V}t + a$$

$$e^{\ln(C)} = e^{-\frac{Q}{V}t + a}$$

[17] For the ORMS and horse barn scenarios, the WMB models describing the air concentrations over time have the same form. The parameterization of these models is the only difference. For the ORMS scenario, the decay rate constant is specified by the ratio of the airflow rate and the volume of the treated space; whereas for the horse barn scenario, the decay rate constant is specified by the air changes per hour.

[18] The regular spray applications are assumed to continue for the entire time spent outdoors.

$$C = A \cdot e^{-\frac{Q}{V}t}$$

where $A = e^a$ is a constant whose value is determined by the initial condition that at time $t = 0$, the pesticide air concentration is equal to initial air concentration, i.e. $C(0) = C_0$. Based on this initial constraint, A is set equal to C0. The WMB model described above for the ORMS scenario is similar to the model used for aerosol area fogger scenario. In fact, the equation for modeling pesticide air concentrations over time after the first spray event (but before the second spray) is exactly the same as equation (C.1.1) except for the subscript on the left-hand side denoting the number of applications:

$$C_1(t) = C_0 e^{-\frac{Q}{V}t} \qquad \text{(C.3.1)}$$

where **C(t)** is the air concentration at time **t** after the initial spray, $\mathbf{C_0}$ is the initial air concentration (i.e. concentration at time t=0), **Q** is the airflow (the product of the cross-sectional area of the box and the wind speed), and **V** is the volume of the box.

Assuming the same amount of pesticide is released at each spray event, the equation describing the air concentrations after the second spray event ($t \geq T_{BA}$), but before the third spray ($t < 2 \times T_{BA}$) is:

$$C_2(t) = \left(C_0 + C_0 e^{-\frac{Q}{V}T_{BA}} \right) e^{-\frac{Q}{V}(t - T_{BA})} \qquad T_{BA} \leq t < (2 \times T_{BA}) \qquad \text{(C.3.2)}$$

where $\mathbf{T_{BA}}$ is the time between application. The first $\mathbf{C_0}$ term represents the (entire) air concentration released at the second spray event; the $C_0\, e^{-\frac{Q}{V}T_{BA}}$ term represents the remaining air concentration from the first application at the time of the second spray event; and the $e^{-\frac{Q}{V}(t - T_{BA})}$ term specifies that the sum of the air concentrations (from the first and second spray events) will dissipate at the same decay rate constant, **Q/V**, but that the dissipation will begin at time $\mathbf{T_{BA}}$. The term $\mathbf{(t - T_{BA})}$ shifts the origin of dissipation process from zero to $\mathbf{T_{BA}}$.

The equation describing the air concentrations over time after a series of regularly-spaced spray events can be generalized for the **(n+1)th** spray event as follows:

$$C_{n+1}(t) = \left(1 + e^{-\frac{Q}{V}T_{BA}} + e^{-\frac{Q}{V}(2 \times T_{BA})} + e^{-\frac{Q}{V}(3 \times T_{BA})} + \ldots + e^{-\frac{Q}{V}((n-1) \times T_{BA})} + e^{-\frac{Q}{V}(n \times T_{BA})} \right) C_0 e^{-\frac{Q}{V}(t - n \times T_{BA})} \text{(C.3.3)}$$

when $\left(n \times T_{BA}\right) \leq t < \left((n+1) \times T_{BA}\right)$, that is from the time of the (n+1)th spray event to the time just prior to the (n+2)th spray event[19]. By specifying $R = e^{-\frac{Q}{V}T_{BA}}$, equation (C.3.3) can be rewritten as

$$C_{n+1}(t) = \left(1 + R + R^2 + R^3 + \ldots + R^{n-1} + R^n\right)C_0 e^{-\frac{Q}{V}(t - n \times T_{BA})} \qquad \text{(C.3.4)}$$

where the **R** term is the fraction of air concentration remaining from the previous spray event. The summation of these progressively higher order R terms is referred to as a geometric series. The resulting sum of which can be written as:

$$\left(1 + R + R^2 + R^3 + \ldots + R^{n-1} + R^n\right) = \frac{1 - R^{n+1}}{1 - R} \qquad \text{(C.3.5)}$$

By substituting equation (C.3.5) into (C.3.4), the general equation describing air concentrations after a series of **(n+1)** regularly-spaced spray events can be written as:

$$C_{n+1}(t) = \left(\frac{1 - R^{n+1}}{1 - R}\right)C_0 e^{-\frac{Q}{V}(t - n \times T_{BA})} \qquad \text{(C.3.6)}$$

After several spray events, the air concentration at the beginning of each dissipation period approaches a fixed value determined by the geometric series in equation (C.3.5). This value can be determined by allowing $n \to \infty$, which implies that $R^{n+1} \to 0$ since **R** < 1. Thus after a sufficient number of spray events, the general equation describing air concentrations after a series of **(n+1)** regularly-spaced spray events can be written as:

$$C_{n+1}(t) = \left(\frac{C_0}{1 - R}\right)e^{-\frac{Q}{V}(t - n \times T_{BA})} \qquad \text{(C.3.7)}$$

Since R < 1, the term $\frac{C_0}{1 - R} > C_0$. In other words, after a sufficient number of spray events, the (total) air concentration immediately after the spray event will approach a fixed value that is larger than the (initial) concentration released during the spray event (due to the remaining air concentration from previous spray events). Therefore, it is more health protective to calculate inhalation exposure after the total air concentration approaches this larger, fixed value (i.e. after a sufficient number of spray applications have occurred).

The air concentration equation (C.3.7) can be used to calculate the exposure, **E**, over the time period (n × T_{BA}) to ((n+1) ×T_{BA}), that is, the *entire* time period from the (n+1)th spray event until the time just prior to the (n+2)th spray event (i.e. the next spray event). The exposure equation is based on integrating equation (C.3.7) and multiplying by an inhalation rate, **IR**.

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[19] Note that the 1st spray event occurs at time t = 0 (or t = 0 × T_{BA}), the 2nd spray event at t = T_{BA} (or t = 1 × T_{BA}), the 3rd at t = 2 × T_{BA}, the nth at t = (n - 1) × T_{BA}, and the (n + 1)th at t = n × T_{BA}.

$$E = IR \int_{n \times T_{BA}}^{(n+1) \times T_{BA}} C_{n+1}(t) dt$$

$$E = IR \int_{n \times T_{BA}}^{(n+1) \times T_{BA}} \left(\frac{C_0}{1-R} \right) e^{-\frac{Q}{V}(t - n \times T_{BA})} dt$$

$$E = IR \left(\frac{C_0}{1-R} \right) \left(-\frac{V}{Q} \right) \left[e^{-\frac{Q}{V}(t - n \times T_{BA})} \right]_{n \times T_{BA}}^{(n+1) \times T_{BA}}$$

$$E = IR \left(\frac{C_0}{1-R} \right) \left(\frac{V}{Q} \right) \left[e^{-\frac{Q}{V}(n \times T_{BA} - n \times T_{BA})} - e^{-\frac{Q}{V}((n+1) \times T_{BA} - n \times T_{BA})} \right]$$

$$E = IR \left(\frac{C_0}{1-R} \right) \left(\frac{V}{Q} \right) \left[e^{-\frac{Q}{V}(0)} - e^{-\frac{Q}{V}(T_{BA})} \right]$$

$$E = IR \left(\frac{C_0}{1-R} \right) \left(\frac{V}{Q} \right) [1 - R]$$

$$E = \frac{IR \cdot C_0 \cdot V}{Q} \qquad \text{(C.3.8)}$$

Note that this exposure equation (C.3.8) is for an exposure time equal to the time between applications (T_{BA}), that is, exposure due to one spray event. If exposure is being calculated for an exposure time that is a whole number multiple of T_{BA}, that is, for multiple spray events, then a multiple of equation (C.3.8) can be used to calculate exposure over such an exposure time[20]. Thus to calculate exposure due to multiple spray events when the exposure time is a whole number multiple of the time between application, the following exposure equation can be used:

$$E = \frac{IR \cdot C_0 \cdot V \cdot N_s}{Q} \qquad \text{(C.3.9)}$$

where $\mathbf{N_s}$ is the number of spray events. The number of spray events could be calculated from the exposure time, **ET** and the time between applications ($\mathbf{T_{BA}}$):

$$N_s = \frac{ET}{T_{BA}}$$

[20] For example, if the time between applications is one hour (i.e. T_{BA} = 1) and the exposure time is exactly four hours (ET = 4), then exposure over the four-hour exposure time would be equal to four times the exposure due to one spray event as calculated by equation (3.8).

If $\mathbf{T_{BA}}$ is specified to have units hr/spray, then the inverse of this parameter could be termed the pulse rate (**PR**), which would have units spray/hr. Alternatively, N_s could be calculated from ET and PR as follows:

$$N_s = ET \cdot PR \tag{C.3.10}$$

Substituting equation (C.3.10) into equation (C.3.9), the exposure equation over an exposure time equal to a whole number multiple of the time between applications becomes:

$$E = \frac{IR \cdot C_0 \cdot V \cdot ET \cdot PR}{Q} \tag{C.3.11}$$

Now consider exposure over some exposure time *less than* the time between applications. Again, the air concentration equation (C.3.7) can be used to calculate the exposure, **E**, over the time period $(n \times T_{BA})$ to $((n+\rho) \times T_{BA})$, where $0 < \rho < 1$; that is, some *fraction* of the time period from the (n+1)th spray event until some time prior to the (n+2)th spray event (i.e. the next spray event). The exposure equation is based on integrating equation (C.3.7) and multiplying by an inhalation rate, **IR**.

$$E = IR \int_{n\times T_{BA}}^{(n+\rho)\times T_{BA}} C_{n+1}(t)dt$$

$$E = IR \int_{n\times T_{BA}}^{(n+\rho)\times T_{BA}} \left(\frac{C_0}{1-R}\right) e^{-\frac{Q}{V}(t-n\times T_{BA})} dt$$

$$E = IR\left(\frac{C_0}{1-R}\right)\left(-\frac{V}{Q}\right)\left[e^{-\frac{Q}{V}(t-n\times T_{BA})}\right]_{n\times T_{BA}}^{(n+\rho)\times T_{BA}}$$

$$E = IR\left(\frac{C_0}{1-R}\right)\left(\frac{V}{Q}\right)\left[e^{-\frac{Q}{V}(n\times T_{BA}-n\times T_{BA})} - e^{-\frac{Q}{V}((n+\rho)\times T_{BA}-n\times T_{BA})}\right]$$

$$E = IR\left(\frac{C_0}{1-R}\right)\left(\frac{V}{Q}\right)\left[e^{-\frac{Q}{V}(0)} - e^{-\frac{Q}{V}(\rho\times T_{BA})}\right]$$

$$E = IR\left(\frac{C_0}{1-R}\right)\left(\frac{V}{Q}\right)\left[1-R^{\rho}\right]$$

$$E = \frac{IR \cdot C_0 \cdot V}{Q} \cdot \frac{(1-R^{\rho})}{(1-R)} \tag{C.3.12}$$

Note that this exposure equation (C.3.12) is for an exposure time equal to some fraction of the time between applications, that is, ($\rho \times T_{BA}$). Combining equation (C.3.12) and equation (C.3.10), the exposure equation over an exposure time equal to a whole number multiple of T_{BA}, a general exposure equation for an exposure time of any duration can be expressed as:

$$E = \frac{IR \cdot C_0 \cdot V \cdot \text{int}(ET \cdot PR)}{Q} + \frac{IR \cdot C_0 \cdot V}{Q} \cdot \frac{(1 - R^{frac(ET \cdot PR)})}{(1 - R)}$$

$$E = \frac{IR \cdot C_0 \cdot V}{Q}\left[\text{int}(ET \cdot PR) + \frac{(1 - R^{frac(ET \cdot PR)})}{(1 - R)}\right] \qquad \text{(C.3.13)}$$

where $R = e^{-\frac{Q}{V}T_{BA}}$, **int(ET·PR)** is the integer (i.e. whole number) part of the product of the exposure time, ET and the pulse rate, PR (i.e. number of spray events per hour) and **frac(ET·PR)** is the fractional part of the product of the exposure time and the pulse rate21. Note that according to equation (C.3.10), the product of the exposure time and pulse rate is simply the numbers of spray events, Ns for which inhalation exposure is being estimated.

[21] For example, if the time between applications is 40 minutes or 2/3 hour (i.e. T_{BA} = 0.67) or equivalently, the pulse rate is 3/2 sprays/hour (i.e. PR = 1.5); and the exposure time is three hours (ET = 3), then int(ET·PR) = int(3 × 1.5) = int(4.5) = 4; and frac(ET·PR) = frac(4.5) = 0.5.

C.3.4 Outdoor Fogging/Misting Systems - Horse Barn Misting Systems

As with the ORMS scenario, the well-mixed box (WMB) model was used to develop exposure equation (*5.30*) for the horse barn misting systems post-application inhalation scenario[22]. The WMB model incorporates a number of simplifying assumptions: fresh air (having zero pesticide concentration) enters the box at a constant airflow rate (based on the number of air changes per hour), a turbulent internal airflow thoroughly mixes the fresh air with the pesticide-laden air resulting in a uniform pesticide air concentration within the box, and the perfectly mixed air exits the box at the same constant airflow rate (i.e. the inflow rate equals the outflow rate). Thus the indoor area where the aerosol is being applied (i.e. barn) is assumed to be in an enclosed box, which seems a reasonable assumption for a walled, indoor space. This scenario assumes instantaneous spray releases, that is, the total amount of aerosol released at each spray event is modeled to occur instantaneously.

The removal of the pesticide from the box depends on airflow. The WMB model developed for this scenario models the pesticide air concentrations *after* multiple instantaneous aerosol spray releases at regular time intervals[23]. Only dissipation due to airflow into and out of the box is modeled. The mass balance within the box can be described by the following differential equation:

$$V\frac{dC}{dt} = -Q \cdot C$$

$$\frac{dC}{C} = -\frac{Q}{V}dt$$

where **C** is the air concentration, **Q** is the airflow, and **V** is the volume of the box. Integrating the differential equation and simplifying and combining terms yields an equation describing the air concentration over time.

$$\int \frac{dC}{C} = -\int \frac{Q}{V}dt$$

$$\ln(C) = -\frac{Q}{V}t + a$$

$$e^{\ln(C)} = e^{-\frac{Q}{V}t + a}$$

[22] For the ORMS and horse barn scenarios, the WMB models describing the air concentrations over time have the same form. The parameterization of these models is the only difference. For the ORMS scenario, the decay rate constant is specified by the ratio of the airflow rate and the volume of the treated space; whereas for the horse barn scenario, the decay rate constant is specified by the air changes per hour.

[23] The regular spray applications are assumed to continue for the entire time spent inside the horse barn.

$$C = A \cdot e^{-\frac{Q}{V}t}$$

where $A = e^a$ is a constant whose value is determined by the initial condition that at time t = 0, the pesticide air concentration is equal to initial air concentration, i.e. $C(0) = C_0$. Based on this initial constraint, A is set equal to C_0.

For an indoor scenario, the ratio of the airflow, Q to the volume of the treated space, V is defined as the number of air changes per hour, ACH (i.e. ACH = Q/V). The WMB model described above for the horse barn misting system scenario is similar to the model used for aerosol area fogger scenario. In fact, the equation for modeling pesticide air concentrations over time after the first spray event (but before the second spray) is exactly the same as equation (C.1.1) except for the use of an air exchange rate (ACH) for the ratio of the airflow to the volume of the treated space and the subscript on the left-hand side denoting the number of applications:

$$C_1(t) = C_0 e^{-ACH \cdot t} \qquad \text{(C.4.1)}$$

where **C(t)** is the air concentration at time **t**, $\mathbf{C_0}$ is the initial air concentration (i.e. concentration at time t=0), and **ACH** is the air changes per hour.

Assuming the same amount of pesticide is released at each spray event, the equation describing the air concentrations after the second spray event (but before the third spray) is:

$$C_2(t) = \left(C_0 + C_0 e^{-ACH \cdot T_{BA}}\right) e^{-ACH \cdot (t - T_{BA})} \qquad \text{(C.4.2)}$$

where $\mathbf{T_{BA}}$ is the time between application. The first $\mathbf{C_0}$ term represents the (entire) air concentration released at the second spray event; the $C_0 \, e^{-ACH \cdot T_{BA}}$ term represents the remaining air concentration from the first application at the time of the second spray event; and the $e^{-ACH \cdot (t - T_{BA})}$ term specifies that the sum of the air concentrations (from the first and second spray events) will dissipate at the same decay rate constant, **ACH**, but that the dissipation will begin at time $\mathbf{T_{BA}}$. The term $\mathbf{(t - T_{BA})}$ shifts the origin of dissipation process from zero to $\mathbf{T_{BA}}$.

The equation describing the air concentrations over time after a series of regularly-spaced spray events can be generalized for the **(n+1)$^{\mathbf{th}}$** spray event as follows:

$$C_{n+1}(t) = \left(1 + e^{-ACH \cdot T_{BA}} + e^{-ACH \cdot (2 \times T_{BA})} + e^{-ACH \cdot (3 \times T_{BA})} + \ldots + e^{-ACH \cdot ((n-1) \times T_{BA})} + e^{-ACH \cdot (n \times T_{BA})}\right) C_0 e^{-ACH \cdot (t - n \times T_{BA})}$$

(C.4.3)

when $\left(n \times T_{BA}\right) \leq t < \left((n+1) \times T_{BA}\right)$, that is from the time of the (n+1)th spray event to the time just prior to the (n+2)th spray event[24]. By specifying $R = \mathrm{e}^{-ACH \cdot T_{BA}}$, equation (C.4.3) can be rewritten as

$$C_{n+1}(t) = \left(1 + R + R^2 + R^3 + \ldots + R^{n-1} + R^n\right) C_0 e^{-ACH \cdot \left(t - n \times T_{BA}\right)} \qquad \text{(C.4.4)}$$

where the term **R** is the fraction of air concentration remaining from the previous spray event. Since **R** <1 by definition, the sum of the **R** terms is a geometric series, which can be written as:

$$\left(1 + R + R^2 + R^3 + \ldots + R^{n-1} + R^n\right) = \frac{1 - R^{n-1}}{1 - R} \qquad \text{(C.4.5)}$$

By substituting equation (C.4.5) into (C.4.4), the general equation describing air concentrations after a series of **(n+1)** regularly-spaced spray events can be written as:

$$C_{n+1}(t) = \left(\frac{1 - R^{n-1}}{1 - R}\right) C_0 e^{-ACH \cdot \left(t - n \times T_{BA}\right)} \qquad \text{(C.4.6)}$$

After several spray events, the air concentration at the beginning of each dissipation period approaches a fixed value determined by the geometric series in equation (C.4.5). This value can be determined by allowing $n \to \infty$, which implies that $R^{n-1} \to 0$ since **R** < 1. Thus after a sufficient number of spray events, the general equation describing air concentrations after a series of **(n+1)** regularly-spaced spray events can be written as:

$$C_{n+1}(t) = \left(\frac{C_0}{1 - R}\right) e^{-ACH \cdot \left(t - n \times T_{BA}\right)} \qquad \text{(C.4.7)}$$

Since R < 1, the term $\frac{C_0}{1-R}$ > C_0. In other words, after a sufficient number of spray events, the (total) air concentration present immediately after the spray event will approach a fixed value that is larger than the (initial) concentration released during the spray event (due to the remaining air concentration from previous spray events). Therefore, it is more health protective to calculate inhalation exposure after the total air concentration approaches this larger, fixed value (i.e. after a sufficient number of spray applications have occurred).

The air concentration equation (C.4.7) can be used to calculate the exposure, **E**, over the time period $\left(n \times T_{BA}\right)$ to $\left((n+1) \times T_{BA}\right)$, that is, the *entire* time period from the (n+1)th spray event until the time just prior to the (n+2)th spray event (i.e. the next spray event). The exposure equation is based on integrating equation (C.4.7) and multiplying by an inhalation rate, **IR**.

[24] Note that the 1st spray event occurs at time t = 0 (or t = 0 × T_{BA}), the 2nd spray event at t = T_{BA} (or t = 1 × T_{BA}), the 3rd at t = 2 × T_{BA}, the nth at t = (n - 1) × T_{BA}, and the (n + 1)th at t = n × T_{BA}.

$$E = IR \int_{n \times T_{BA}}^{(n+1) \times T_{BA}} C_{n+1}(t) dt$$

$$E = IR \int_{n \times T_{BA}}^{(n+1) \times T_{BA}} \left(\frac{C_0}{1-R} \right) e^{-ACH \cdot (t - n \times T_{BA})} dt$$

$$E = IR \left(\frac{C_0}{1-R} \right) \left(-\frac{1}{ACH} \right) \left[e^{-ACH \cdot (t - n \times T_{BA})} \right]_{n \times T_{BA}}^{(n+1) \times T_{BA}}$$

$$E = IR \left(\frac{C_0}{1-R} \right) \left(\frac{1}{ACH} \right) \left[e^{-ACH \cdot (n \times T_{BA} - n \times T_{BA})} - e^{-ACH \cdot ((n+1) \times T_{BA} - n \times T_{BA})} \right]$$

$$E = IR \left(\frac{C_0}{1-R} \right) \left(\frac{1}{ACH} \right) \left[e^{-ACH \cdot (0)} - e^{-ACH \cdot (T_{BA})} \right]$$

$$E = IR \left(\frac{C_0}{1-R} \right) \left(\frac{1}{ACH} \right) [1 - R]$$

$$E = \frac{IR \cdot C_0}{ACH} \qquad \text{(C.4.8)}$$

Note that this exposure equation (C.4.8) is for an exposure time equal to the time between applications (T_{BA}), that is, exposure due to one spray event and is also same as Eqn. C.3.8 given earlier. If exposure is being calculated for an exposure time that is a whole number multiple of T_{BA}, that is, for multiple spray events, then a multiple of equation (C.4.8) can be used to calculate exposure over such an exposure time[25]. Thus to calculate exposure due to multiple spray events when the exposure time is a whole number multiple of the time between application [i.e. ET = 0 mod(T_{BA})], the following exposure equation can be used:

$$E = \frac{IR \cdot C_0 \cdot N_s}{ACH} \qquad \text{(C.4.9)}$$

where $\mathbf{N_s}$ is the number of spray events. The number of spray events could be calculated from the exposure time, **ET** and the time between applications **($\mathbf{T_{BA}}$)**:

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[25] For example, if the time between applications is one hour (i.e. T_{BA} = 1) and the exposure time is exactly four hours (ET = 4), then exposure over the four-hour exposure time would be equal to four times the exposure due to one spray event as calculated by equation (3.8).

$$N_s = \frac{ET}{T_{BA}}$$

If $\mathbf{T_{BA}}$ is specified to have units hr/spray, then the inverse of this parameter could be termed the pulse rate (**PR**), which would have units spray/hr. Alternatively, N_s could be calculated from ET and PR as follows:

$$N_s = ET \cdot PR \tag{C.4.10}$$

Substituting equation (C.4.10) into equation (C.4.9), the exposure equation over an exposure time equal to a whole number multiple of the time between applications becomes:

$$E = \frac{IR \cdot C_0 \cdot ET \cdot PR}{ACH} \tag{C.4.11}$$

Now consider exposure over some exposure time *less than* the time between applications. Again, the air concentration equation (C.4.7) can be used to calculate the exposure, **E**, over the time period $(n \times T_{BA})$ to $((n+\rho)\times T_{BA})$, where $0 < \rho < 1$; that is, some *fraction* of the time period from the (n+1)th spray event until some time prior to the (n+2)th spray event (i.e. the next spray event). The exposure equation is based on integrating equation (C.4.7) and multiplying by an inhalation rate, **IR**.

$$E = IR \int_{n\times T_{BA}}^{(n+\rho)\times T_{BA}} C_{n+1}(t)dt$$

$$E = IR \int_{n\times T_{BA}}^{(n+\rho)\times T_{BA}} \left(\frac{C_0}{1-R}\right) e^{-ACH\cdot(t-n\times T_{BA})}dt$$

$$E = IR\left(\frac{C_0}{1-R}\right)\left(-\frac{1}{ACH}\right)\left[e^{-ACH\cdot(t-n\times T_{BA})}\right]_{n\times T_{BA}}^{(n+1)\times T_{BA}}$$

$$E = IR\left(\frac{C_0}{1-R}\right)\left(\frac{1}{ACH}\right)\left[e^{-ACH\cdot(n\times T_{BA}-n\times T_{BA})} - e^{-ACH\cdot((n+\rho)\times T_{BA}-n\times T_{BA})}\right]$$

$$E = IR\left(\frac{C_0}{1-R}\right)\left(\frac{1}{ACH}\right)\left[e^{-ACH\cdot(0)} - e^{-ACH\cdot(\rho\times T_{BA})}\right]$$

$$E = IR\left(\frac{C_0}{1-R}\right)\left(\frac{1}{ACH}\right)\left[1-R^{\rho}\right]$$

$$E = \frac{IR \cdot C_0}{ACH} \cdot \frac{(1 - R^{\rho})}{(1 - R)} \qquad \text{(C.4.12)}$$

Note that this exposure equation (C.4.12) is for an exposure time equal to some fraction of the time between applications, that is, ($\rho \times T_{BA}$). Combining equation (C.4.12) and equation (C.4.10), the exposure equation over an exposure time equal to a whole number multiple of T_{BA}, a general exposure equation for an exposure time of any duration can be expressed as:

$$E = \frac{IR \cdot C_0 \cdot \mathrm{int}(ET \cdot PR)}{ACH} + \frac{IR \cdot C_0}{ACH} \cdot \frac{(1 - R^{frac(ET \cdot PR)})}{(1 - R)}$$

$$E = \frac{IR \cdot C_0}{ACH}\left[\mathrm{int}(ET \cdot PR) + \frac{(1 - R^{frac(ET \cdot PR)})}{(1 - R)}\right] \qquad \text{(C.4.13)}$$

where $R = e^{-ACH \cdot T_{BA}}$, **int(ET·PR)** is the integer (i.e. whole number) part of the product of the exposure time, ET and the pulse rate, PR (i.e. number of spray events per hour) and **frac(ET·PR)** is the fractional part of the product of the exposure time and the pulse rate[26]. Note that according to equation (C.4.10), the product of the exposure time and pulse rate is simply the numbers of spray events, N_s for which inhalation exposure is being estimated.

[26] For example, if the time between applications is 40 minutes or 2/3 hour (i.e. T_{BA} = 0.67) or equivalently, the pulse rate is 3/2 sprays/hour (i.e. PR = 1.5); and the exposure time is three hours (ET = 3), then int(ET·PR) = int(3 × 1.5) = int(4.5) = 4; and frac(ET·PR) = frac(4.5) = 0.5.

C.3.5 Indoor Environments - Instantaneous Release/Aerosol Applications

As with the *outdoor* aerosol spray area foggers scenario, the well-mixed box (WMB) model was used to develop exposure equation (*7.6*) for the *indoor* instantaneous release/aerosol application post-application inhalation scenario[27]. The WMB model incorporates a number of simplifying assumptions: fresh air (having zero pesticide concentration) enters the box at a constant airflow rate (based on the number of air changes per hour), a turbulent internal airflow thoroughly mixes the fresh air with the pesticide-laden air resulting in a uniform pesticide air concentration within the box, and the perfectly mixed air exits the box at the same constant airflow rate (i.e. the inflow rate equals the outflow rate). Thus the indoor area where the aerosol is being applied (e.g., living room) is assumed to be in an enclosed box, which seems a reasonable assumption for a walled, indoor space. This scenario assumes an instantaneous spray release, that is, the total amount of aerosol released during a spray event is modeled to occur instantaneously.

The removal of the pesticide from the box depends on airflow. The WMB model developed for this scenario models the pesticide air concentrations *after* an initial, instantaneous release of an aerosol spray. Only dissipation due to airflow into and out of the box is modeled. The mass balance within the box can be described by the following differential equation:

$$V\frac{dC}{dt} = -Q \cdot C$$

$$\frac{dC}{C} = -\frac{Q}{V}dt$$

where **C** is the air concentration, **Q** is the airflow, and **V** is the volume of the box. Integrating the differential equation and simplifying and combining terms yields an equation describing the air concentration over time.

$$\int \frac{dC}{C} = -\int \frac{Q}{V}dt$$

$$\ln(C) = -\frac{Q}{V}t + a$$

$$e^{\ln(C)} = e^{-\frac{Q}{V}t+a}$$

$$C = A \cdot e^{-\frac{Q}{V}t}$$

[27] For the *outdoor* aerosol spray area foggers and the *indoor* instantaneous release/aerosol application scenarios, the WMB models describing the air concentrations over time have the same form. The parameterization of these models is the only difference. For the outdoor aerosol spray area foggers scenario, the decay rate constant is specified by the ratio of the airflow rate and the volume of the treated space; whereas for the indoor instantaneous release/aerosol application scenario, the decay rate constant is specified by the air changes per hour.

where $A = e^a$ is a constant whose value is determined by the initial condition that at time t = 0, the pesticide air concentration is equal to initial air concentration, i.e. $C(0) = C_0$. Based on this initial constraint, A is set equal to C_0. Also, for an indoor scenario, the ratio of the airflow, Q to the volume of the treated space, V is defined as the number of air changes per hour, ACH (i.e. ACH = Q/V). Based on the initial constraint that $C(0) = C_0$ and that ACH = Q/V, the WMB model described above for modeling pesticide air concentrations over time can be written as follows:

$$C(t) = C_0 e^{-ACH \cdot t} \tag{C.5.1}$$

where **C(t)** is the air concentration at time **t**, $\mathbf{C_0}$ is the initial air concentration (i.e. concentration at time t=0), and **ACH** is the air changes per hour. The air concentration equation (5.1) is then used to calculate the exposure, E:

$$E = IR \int_0^{ET} C(t) dt \tag{C.5.2}$$

The exposure, **E** is based on integrating equation (C.5.1) over the exposure time, **ET** which is then multiplied by an inhalation rate, **IR**. The final exposure equation is derived from equation (C.5.2) by performing the integration and simplifying terms.

$$E = IR \int_0^{ET} C_0 e^{-ACH \cdot t} dt$$

$$E = IR \cdot C_0 \left(\frac{-1}{ACH} \right) \left(e^{-ACH(ET)} - e^{-\frac{Q}{V}(0)} \right)$$

$$E = \frac{IR \cdot C_0}{ACH} \left(1 - e^{-ACH(ET)} \right) \tag{C.5.3}$$

C.3.6 Indoor Environments - Vapor Emission for Surface Sprays

As with the *outdoor* candles, coils, torches, and mats scenario, the well-mixed box (WMB) model was used to develop exposure equation (*7.11*) for the *indoor* vapor emission for surface sprays post-application inhalation scenario[28]. The vapor emission for surface sprays scenario differs from the other exposure scenarios based on the WMB model because it includes a variable emission rate term and thus results in a more complicated exposure equation. The WMB was used to model pesticide air concentrations within an enclosed, fixed volume (i.e. a box) over time during the variable emission of a pesticide from a surface spray. The WMB model incorporates a number of simplifying assumptions: fresh air (having zero pesticide concentration) enters the box at a constant airflow rate, a turbulent internal airflow thoroughly mixes the fresh air with the pesticide-laden air resulting in a uniform pesticide air concentration within the box, and the perfectly mixed air exits the box at the same constant airflow rate (i.e. the inflow rate equals the outflow rate). Thus the indoor area where the aerosol is being applied (e.g., living room) is assumed to be in an enclosed box, which seems a reasonable assumption for a walled, indoor space.

The removal of the surface spray emission from the box depends on airflow. The WMB model developed for this scenario models the pesticide air concentrations *during* a variable emission of pesticide from a surface spray. Only emission and dissipation due to airflow into and out of the box is modeled. The mass balance within the box can be described by the following differential equation:

$$V\frac{dC}{dt} = ER - Q \cdot C + k \cdot V \cdot C$$

$$\frac{dC}{dt} = \frac{ER}{V} - \frac{Q}{V} \cdot C + k \cdot C$$

$$\frac{dC}{dt} = \frac{ER}{V} - \left(\frac{Q}{V} - k\right)C$$

where **C** is the air concentration, **ER** is the emission rate, **Q** is the airflow, **k** is the decay rate constant of the emission rate, and **V** is the volume of the box. Based on the method of undetermined coefficients, the solution to this differential equation has the form:

$$C(t) = \frac{\frac{ER}{V}}{\left(\frac{Q}{V} - k\right)} - A \cdot e^{-\left(\frac{Q}{V} - k\right)t}$$

[28] For the *outdoor* candles, coils, torches, and mats and the *indoor* vapor emission for surface sprays scenarios, the WMB models describing the air concentrations over time have a similar form. The parameterization of these models is one of the differences. For the outdoor candles, coils, torches, and mats scenario, the decay rate constant is specified by the ratio of the airflow rate and the volume of the treated space; whereas for the indoor vapor emission for surface sprays scenario, the decay rate constant is specified in part by the air changes per hour.

$$C(t) = \frac{ER}{V\left(\frac{Q}{V} - k\right)} - A \cdot e^{-\left(\frac{Q}{V} - k\right)t}$$

where A is a constant whose value is determined by the initial condition that at time t = 0, the pesticide air concentration is equal to zero, i.e. C(0) = 0. Based on this initial constraint, the equation describing the air concentration over time can be written as:

$$C(t) = \frac{ER}{V\left(\frac{Q}{V} - k\right)} - \frac{ER}{V\left(\frac{Q}{V} - k\right)} e^{-\left(\frac{Q}{V} - k\right)t}$$

Based on the WMB model described above, the equation for modeling pesticide air concentrations over time is as follows:

$$C(t) = \frac{ER}{V\left(\frac{Q}{V} - k\right)} \left[1 - e^{-\left(\frac{Q}{V} - k\right)t}\right] \qquad \text{(C.6.1)}$$

where **C(t)** is the air concentration at time **t**, **ER** is the emission rate, **Q** is the airflow, **k** is the decay rate constant of the emission rate, and **V** is the volume of the box. For an indoor scenario, the ratio of the airflow, Q to the volume of the treated space, V is defined as the number of air changes per hour, ACH:

$$ACH = \frac{Q}{V} \qquad \text{(C.6.2)}$$

For the indoor vapor emission for surface sprays scenario, the decreasing emission rate, ER is based on decay rate constant, k[29] which can be calculated from various physical and chemical properties of the pesticide.

$$ER = k \cdot M \cdot e^{-k \cdot t} \qquad \text{(C.6.3)}$$

where **M** is the amount (i.e. mass) of the surface spray application. Substituting equations (C.6.2) and (C.6.3) into equation (C.6.1) and yields the equation for modeling pesticide air concentrations over time following surface spray application base on a variable emission rate:

$$C(t) = \frac{k \cdot M \cdot e^{-k \cdot t}}{V(ACH - k)} \left[1 - e^{-(ACH - k)t}\right]$$

Which can be rewritten as:

$$C(t) = \frac{k \cdot M}{V(ACH - k)} \left[e^{-k \cdot t} - e^{-ACH \cdot t}\right]$$

[29] As discussed in Guo (2002), Evans (1994) proposed estimating the decay rate constant, k based on the 90% drying time which, in turn, is estimated by a method developed by Chinn (1981).

(C.6.4)

The air concentration equation is then used to calculate the exposure, **E**, which is based on integrating equation (C.6.4) over the exposure time, **ET** which is then multiplied by an inhalation rate, **IR**:

$$E = IR\int_0^{ET} C(t)dt \qquad \text{(C.6.5)}$$

The final exposure equation is derived from equation (6.5) by performing the integration and simplifying terms.

$$E = IR\int_0^{ET} \frac{k \cdot M}{V(ACH-k)}\left[e^{-k\cdot t} - e^{-ACH\cdot t}\right]dt$$

$$E = \frac{IR \cdot k \cdot M}{V(ACH-k)}\left[-\frac{1}{k}e^{-k\cdot t} + \frac{1}{ACH}e^{-ACH\cdot t}\right]_0^{ET}$$

$$E = \frac{IR \cdot k \cdot M}{V(ACH-k)}\left[\frac{1}{k}e^{-k\cdot t} - \frac{1}{ACH}e^{-ACH\cdot t}\right]_{ET}^{0}$$

$$E = \frac{IR \cdot k \cdot M}{V(ACH-k)}\left[\left(\frac{1}{k}e^{-k\cdot(0)} - \frac{1}{ACH}e^{-ACH\cdot(0)}\right) - \left(\frac{1}{k}e^{-k\cdot ET} - \frac{1}{ACH}e^{-ACH\cdot ET}\right)\right]$$

$$E = \frac{IR \cdot k \cdot M}{V(ACH-k)}\left[\left(\frac{1}{k} - \frac{1}{ACH}\right) - \left(\frac{1}{k}e^{-k\cdot ET} - \frac{1}{ACH}e^{-ACH\cdot ET}\right)\right]$$

$$E = \frac{IR \cdot k \cdot M}{V(ACH-k)}\left[\left(\frac{ACH-k}{k \cdot ACH}\right) - \left(\frac{ACH \cdot e^{-k\cdot ET} - k \cdot e^{-ACH\cdot ET}}{k \cdot ACH}\right)\right]$$

$$E = \frac{IR \cdot k \cdot M}{V \cdot k \cdot ACH}\left[\left(\frac{ACH-k}{ACH-k}\right) - \left(\frac{ACH \cdot e^{-k\cdot ET} - k \cdot e^{-ACH\cdot ET}}{ACH-k}\right)\right]$$

$$E = \frac{IR \cdot M}{V \cdot ACH}\left[1 - \left(\frac{ACH \cdot e^{-k\cdot ET} - k \cdot e^{-ACH\cdot ET}}{ACH-k}\right)\right] \qquad (6.6)$$

C.3.7 References

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Evans, W.C., 1994. Development of continuous-application source terms and analytical solution for one- and two-compartment systems. In: Tichenor, B.A. (Ed.), Characterizing Sources of Indoor Air Pollution and Related Sink Effects, ASTM STP 1287. American Society of Testing and Materials, Philadelphia, pp. 279–293.

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C.4 Selection of Air Velocity

Meteorological data from National Weather Service (NWS) and other appropriate meteorological monitoring stations was considered in this SOP. Such data have been widely used for dispersion modeling in the Agency's fumigant human health risk assessments. The six weather stations were located around the country and recorded wind velocity (i.e., meters/second or m/s) and other meteorological parameters. The meteorological conditions for these sites represent a broad range of situations, including inland and coastal sites in California and Florida as well as the Midwest and desert plain of the Pacific Northwest.

These types of weather stations typically use cup and vane anemometers to measure windspeed and typically do not record velocities below 1 m/s. Any meteorological monitor recording velocities less than 1 m/s are recorded as 0 m/s. *Table C-3* reports the results from each weather station considered and the percentage of hourly wind speed data that were recorded below 1 m/s and 1.5 m/s, respectively.

Both flying pest pressure and post-application inhalation exposure will likely be highest in the assessed scenarios for days when the air conditions are "calm" (>0.3 m/s) as defined on the Beaufort Wind Force Scale because less mixing will occur at lower windspeeds.

Table C-3: Wind Velocity from National Weather Stations (1999-2003)

City	Source	Percent of the hourly wind speed data below 1 m/s	Percent of the hourly wind speed data below 1.5 m/s
Bakersfield CA	ASOS or Automated Surface Observing System operated by the FAA	18%	18%
Ventura CA	CIMIS or California Irrigation Management	22%	29%

Table C-3: Wind Velocity from National Weather Stations (1999-2003)			
City	**Source**	**Percent of the hourly wind speed data below 1 m/s**	**Percent of the hourly wind speed data below 1.5 m/s**
	Information System		
Bradenton FL	FAWN or Florida Automated Weather Network	25%	42%
Tallahassee FL	NWS or National Weather Service	26%	42%
Flint MI	NWS or National Weather Service	4%	4%
Yakima WA	NWS or National Weather Service	9%	9%

C.5 Estimates of Deposited Residue (DepR)

For indoor environments, the deposited residue is the residue that is deposited onto carpets and hard surfaces following an application. It can be obtained either from (1) chemical-specific deposition data, (2) calculated from the application rate of the product, or (3) default values based on the percent spray of the product.

C.5.1 Indoor Surfaces

A) RESIDUE VALUES BASED ON APPLICATION RATE

If chemical-specific deposition data are not available, but the label provides an application rate in terms of mass per unit area, then residue values may be estimated using the application rate.

BROADCAST TREAMENT:
The deposited residue is assumed to be equivalent to the application rate.

PERIMETER AND SPOT TREATMENTS:
It is assumed that the deposited residue is equivalent to 50% of the deposited residue from a broadcast application (i.e., 50% of the application rate). This is based on studies that have examined deposited residues resulting from broadcast and perimeter treatments.

Sources considered in analysis:

Table C-4: Perimeter as a Percent of Broadcast	
Source: U.S. EPA (1993); Vaccaro (1991); Gurunathan et al (1998); Fenske et al (1990); Krieger et al (2001)	
Perimeter treatment residue (0.5% malathion)	9 ug/cm^2
Broadcast treatment residue (0.5% chlorpyrifos)	15 ug/cm^2
Percent of broadcast:	60%
Source: Selim (2008)	
Perimeter treatment residue (0.1% esfenvalerate)	0.9 ug/cm^2
Broadcast treatment residue (0.1% esfenvalerate)	2.901 ug/cm^2

Table C-4: Perimeter as a Percent of Broadcast	
Percent of broadcast:	32%

CRACK AND CREVICE TREATMENT (pin stream nozzle applications ONLY):
It is assumed that the deposited residue is equivalent to 10% of the deposited residue from a broadcast application (i.e., 10% of the application rate). This is based on a study that examined deposited residues resulting from broadcast and crack and crevice treatments.

Sources considered in analysis:

Table C-5: Crack and Crevice as a Percent of Broadcast	
Source: Selim (2008)	
Crack and crevice treatment residue (0.1% esfenvalerate)	0.2 ug/cm^2
Broadcast treatment residue (0.1% esfenvalerate)	2.901 ug/cm^2
Percent of broadcast:	7%

B) DEFAULT RESIDUE VALUES BASED ON PERCENT SPRAY OF PRODUCT

If chemical-specific deposition data are not available and the label does not provide an application rate in terms of mass per unit area, then default residue values may be used based on the percent spray of the product.

A summary of all sources and information considered in development of default residue values for broadcast, perimeter, and crack and crevice treatments is provided in the table below and more detailed analysis is provided after the table.

Table C-6: Summary of sources considered in development of default residue values for broadcast, perimeter, and crack and crevice treatments

Source	Approach to calculating residue	Type of Application		
		Broadcast	Perimeter	Crack and Crevice (pin stream nozzle applications ONLY):
Vaccaro (1991) Gurunathan *et al* (1998) Fenske *et al* (1990) Krieger *et al* (2001)	Average residue values from studies	*0.5% spray*	NA	*0.5% spray*
		High end of range: 15 ug/cm^2		High end of range: 0.25 ug/cm^2
		Range: 7.19 - 15 ug/cm^2		Range: 0.0003 - 0.256 ug/cm^2
U.S. EPA (1993)	Weighted average based on area	NA	*0.5% spray*	NA
			12 ug/cm^2	
	Weighted average based on 70% untreated / 30% treated		9 ug/cm^2	
Keenan (2007)	Average residue value	--	NA	*0.05% spray*
		4.1 ug/cm^2 (fogger application)	N/A	N/A

Table C-6: Summary of sources considered in development of default residue values for broadcast, perimeter, and crack and crevice treatments				
Source	**Approach to calculating residue**	**Type of Application**		
		Broadcast	**Perimeter**	**Crack and Crevice (pin stream nozzle applications ONLY):**
	Weighted average based on 90% untreated / 10% treated	N/A	N/A	1.5 ug/cm^2
	Weighted average based on 70% untreated / 30% treated	N/A	2.8 ug/cm^2	N/A
Selim (2008)	Average residue value	*0.1% spray*	*0.1% spray*	*0.1% spray*
		2.901 ug/cm^2	N/A	N/A
	Weighted average based on 90% untreated / 10% treated	N/A	N/A	0.2 ug/cm^2
	Weighted average based on 70% untreated / 30% treated	N/A	0.9 ug/cm^2	N/A

BROADCAST TREAMENT:
Recommended default residue value: 15 ug/cm^2 for a 0.5% spray (based on literature review)

Sources considered in analysis:

1) Vaccaro (1991). Evaluation of Dislodgeable Residues and Absorbed Doses of Chlorpyrifos to Crawling Infants following of a Chlorpyrifos Based Emulsifiable Concentrate Indoor Broadcast Applications. MRID 42008401. Reviewed by EPA: D168824 8/18/1995

   In this study, Dursban LO (0.5% chlorpyrifos) was applied to 4 rooms (no furniture) using a low-pressure handwand. The application rate was approximately 1 gallon per 1,600 ft^2. After completion of application, the surfaces were allowed to dry for a period of 2 hours using natural ventilation. At the end of the drying period, the rooms were closed for the duration of the testing period. At time 0, 4 gauze coupons (representing carpet) and 4 aluminum squares (representing hard surfaces) were collected to measure deposition. Tables 3 and 4 of the report provide coupon/square deposition values in terms of ug/# cm^2 (aluminum squares = 58.06 cm^2 and gauze coupons = 103.22 cm^2). The table below summarizes the results from the study.

Table C-7: Residue values from Tables 3 and 4 for Time 0							
House	Room	Rep #1	Rep #2	Rep #3	Rep #4	Average	Max
House #1	*Gauze coupons*						
	PC Room	9.01	9.05	10.66	4.65	8.34	14.19
	Activity Room	9.11	8.72	N/A	N/A	8.91	
		10.62	7.89			9.25	
		10.63	14.19			12.41	
		Average:				10.19	

Table C-7: Residue values from Tables 3 and 4 for Time 0							
House	Room	Rep #1	Rep #2	Rep #3	Rep #4	Average	Max
	Aluminum squares						
	PC Room	7.58	9.40	5.51	6.42	7.23	14.64
	Activity Room	8.37	8.22	N/A	N/A	8.29	
		8.18	7.65			7.91	
		14.64	4.77			9.71	
		Average:				8.64	
House #2	*Gauze coupons*						
	PC Room	4.43	3.37	5.75	7.87	5.35	14.76
	Activity Room	2.61	3.86	N/A	N/A	3.23	
		2.89	2.76			2.82	
		2.34	14.76			8.55	
		Average:				4.87	
	Aluminum squares						
	PC Room	2.27	6.54	6.73	5.30	5.21	10.97
	Activity Room	2.20	4.86	N/A	N/A	3.53	
		2.95	1.93			2.44	
		3.10	10.97			7.04	
		Average:				4.33	
Overall average:	7.19 ug/cm^2						

2) Gurunathan, S; Robson, M; Freeman, N; Buckley, B; Roy, A; Meyer, R; Bukowski, J; and Lioy, P. (1998). Accumulation of Chlorpyrifos on Residential Surfaces and Toys Accessible to Children. Environmental Health Perspectives. 106:9-16.

   In this study, a 0.5% chlorpyrifos solution was applied to furnished apartments (2 apartments with identical furnishings, layout, and living space of 860 ft^2) using a low-pressure handwand. The HVAC was operated during the study period and partial ventilation was used during the experiment. During the application and for 2 hours after, the windows were kept closed. For 4 hours, the windows were opened and a fan was operated near the window, and then the windows were shut and kept closed for the duration of the experiment. Air, surface and toy samples were taken as part of the study. Surface wipe samples were collected from the top of a dresser from 4 - 336 hours after the application. Plastic and plush toys were placed in the rooms 1 hr after application and removed for sampling at 8, 24, 72, 168, and 336 hrs after application. The results of the study showed that chlorpyrifos concentrations measured on the surfaces peaked at 36 hr post-application (0.043 ug/cm^2) and chlorpyrifos concentrations measured on the surface of toys peaked at 1 week after application (11.5 ug/cm^2).

3) Fenske, R.A.; Black, K.G.; Elkner, K.P.; Lee, C.; Methner, M.N.; Soto, R. (1990) Potential Exposure and Health Risks of Infants Following Indoor Residential Pesticide Applications. Amer. Jour. Publ. Health. 80:689-693.

   In this study, 3 rooms of unoccupied apartments were treated with 0.5% chlorpyrifos spray using a low-pressure handwand. All of the rooms were carpeted. Windows and doors were open in two of the rooms, but there was no ventilation in the 3rd room. Applications were performed by a licensed PCO. The formulation was applied ~40 cm above the carpet with a hand-held fan broadcast nozzle attached to a CO_2 pressurized tank. Aluminum foil squares were used to collect deposition measurements. Five squares were collected immediately following application. The average deposition was reported to be 13.6 ug/cm^2. There was no significant difference between the three rooms sampled and the measured deposition corresponded well with the 13 ug/cm^2 value calculated from the label recommendations.

4) Krieger, RI; Bernard, CE; Dinoff, TM; Ross, JH; and Williams, RL. (2001). Biomonitoring of persons exposed to insecticides used in residences. Annals of Occupational Hygiene. 45(1001):S143-S153.

   In this report, the results of four studies were presented, which examined exposure to chlorpyrifos (one experimental exposure study and three situational monitoring studies). The experimental exposure study involved 2 successive fogger applications in a 2000 ft^2 residence approximately one year apart. The three post-application situational monitoring studies were conducted upon interest and cooperation of the families, and their homes were treated by the residents themselves as part of their normal activity. The studies included: (1) a crack and crevice chlorpyrifos application by a commercial pest management firm, (2) a fogger application and (3) a broadcast application. In the broadcast study, applications were made using a handheld pressurized tank/wand. Six rooms were treated and foils were used in three of the six rooms to collect deposition measurements. The average measured residue was reported to be 15 ug/cm^2 (replicates: 13.5, 14.3, 17.3 ug/cm^2).

PERIMETER TREATMENT:
Recommended default residue values: 9 ug/cm^2 for 0.5% spray (based on weighted averages)

In order to determine the appropriate default value to use for perimeter treatments, two options were examined: (1) base the value on weighted averages or (2) base the value on a percentage of the default broadcast treatment (50%). In examining the data, it was determined that the more conservative approach would be to base the default residue value on weighted averages. The table below provides a summary.

Table C-8: Default residue values for broadcast and perimeter treatments.

Type of treatment	**Default residue value**				
Broadcast	For 0.5% spray: 15 ug/cm^2				
Perimeter	weighted residue (70/30)			50% of broadcast residue	
	U.S. EPA (1993) (0.5% spray)	Keenan (2007) (? % spray)	Selim (2008) (0.1% spray)	0.5% broadcast spray	1.0% broadcast spray
	9 ug/cm^2	2.8 ug/cm^2	0.9 ug/cm^2	7.5 ug/cm^2	15 ug/cm^2

Sources considered in analysis:

1) U.S. Environmental Protection Agency. (1993) Protocol for Dermal Exposure Assessment: A Technical Report. Environmental Monitoring Systems Laboratory. EPA/600/X-93/005.

   In this study, deposition measurements were taken after a perimeter treatment of 0.5% aqueous malathion suspension was made to a baseboard in an unfurnished room. A mean deposition rate of 28.9 µg/cm^2 was measured within 1 foot of the baseboard and 3 feet and greater from the baseboard were 12.07 µg/cm^2 and 0.13 µg/cm^2, respectively. The 1, 1 to 2, and greater than 3 feet areas were considered the hot, warm, and cold zones, respectively, and the respective surface areas were 44 ft^2, 36 ft^2, and 64 ft^2. The weighted average deposition rate for these zones is 12 $\mu g/cm^2$ or 41% of the hot zone deposition.

2) Keenan, J. (2007). Potential Exposures of Children and Adults to Cypermethrin and other Pyrethroid Insecticides Following Treatment and Control of Indoor Pests. (Doctoral Dissertation, University of California, Riverside, June 2007).

   In Chapter 3 of this dissertation (“Potential Exposures of Children and Adults to Cypermethrin and Other Pyrethroid Insecticides Following Treatment and Control of Indoor Pests”), several application scenarios (e.g., spot, crack and crevice, perimeter and fogger) were examined. Three pyrethroids (deltamethrin, cypermethrin, and cyfluthrin) as well as one organophosphate (chlorpyrifos) were included in the study. A licensed PCO applied the chemicals to a carpeted room in a house in Riverside, CA. Deposition was measured using chromatography paper attached to foam board as well as Water and Oil Sensitive Papers located in a corner, under a large window and along a wall. Results were presented for the different locations in the room (0-8 cm from the wall and 32-40 cm from the wall) as well as for the whole room (residues collected 0-40 cm from the wall and then adjusted for surface area).

3) Selim, S. (2008). Determination of Floor Residues of Esfenvalerate Following a Crack and Crevice or Broadcast Application of EVERCIDE® Residual Ant and Roach Spray 27523. MRID: 47647701

   This study was designed to determine the dissipation pattern of esfenvalerate in a room following application of an aerosol product containing 0.1% esfenvalerate. Three application scenarios were conducted which included: 1) broadcast treatment applied using a typical aerosol nozzle, 2) crack and crevice treatment applied using a typical aerosol nozzle, and 3) void and crack treatment applied using an injection tube attached to the aerosol container. Deposition samples were collected using alpha-cellulose coupons, which were placed on the floor and one wall of the environmental exposure room prior to application. The samples were removed from the room 30 minutes after application for all scenarios. Another set of samples was removed 7 days after application for the crack and crevice treatment scenario and the void and crevice treatment scenario. At each sampling time, samples were collected from 61 locations on the floor and 17 locations on the wall. All sampling coupons measured 25 cm^2, except for the coupons along the perimeter of the floor in the void and crevice scenario, which measured 75 cm^2; however, these coupons were separated into three 25 cm^2 pieces prior to analysis.

Table C-9: Summary of Residue Values for Perimeter Applications	
Location in room	**Residue (ug/cm^2)**
<u>Source</u>: U.S. EPA (1993) 0.5% malathion	
1 ft of baseboard (30 cm) (treated)	28.9
1-3 feet (30-90 cm)	12.07
greater than 3 ft (>90 cm) (untreated)	0.13
Weighted average: 70% untreated / 30% treated	9**
<u>Source</u>: Keenan (2007) ?? (0.17% chlorpyrifos; 0.03% deltamethrin; 0.015% cyfluthrin)	

Table C-9: Summary of Residue Values for Perimeter Applications	
Location in room	**Residue (ug/cm^2)**
0-8 cm ("treated")	7.1
32-40 cm ("untreated")	0.9
Weighted average: 70% untreated / 30% treated	2.8
<u>Source</u>: Selim (2008) 0.1% esfenvalerate	
treated	3.097
untreated	0.0031
Weighted average: 70% untreated / 30% treated	0.9

CRACK AND CREVICE TREATMENT (pin stream nozzle applications ONLY):
Recommended default residue value: 3 ug/cm^2 (based on 10% of broadcast treatment)

In order to determine the appropriate default value to use for crack and crevice treatments, two options were examined: (1) base the value on weighted averages or (2) base the value on a percentage of the default broadcast treatment (10%). In examining the data, it was determined that the more conservative approach would be to base the default residue value on a percentage of the default broadcast residue. The table below provides a summary.

Table C-10: Summary residue values for crack and crevice treatments.				
Type of treatment	**Default residue value**			
Broadcast	For 0.5% spray: 15 ug/cm^2			
Crack and crevice	weighted residue (90/10)		10% of broadcast AR	
	Keenan (2007) (0.05% spray)	Selim (2008) (0.1% spray)	0.5% broadcast spray	1.0% broadcast spray
	1.5 ug/cm^2	0.2 ug/cm^2	1.5 ug/cm^2	3 ug/cm^2

Sources considered in analysis:

1) Keenan, J. (2007). Potential Exposures of Children and Adults to Cypermethrin and other Pyrethroid Insecticides Following Treatment and Control of Indoor Pests. (Doctoral Dissertation, University of California, Riverside, June 2007).

   In Chapter 3 of this dissertation ("Potential Exposures of Children and Adults to Cypermethrin and Other Pyrethroid Insecticides Following Treatment and Control of Indoor Pests"), several application scenarios (e.g., spot, crack and crevice, perimeter and fogger) were examined. Three pyrethroids (deltamethrin, cypermethrin, and cyfluthrin) as well as one organophosphate (chlorpyrifos) were included in the study. A licensed PCO applied the chemicals to a carpeted room in a house in Riverside, CA. Deposition was measured using chromatography paper attached to foam board as well as Water and Oil Sensitive Papers located in a corner, under a large window and along a wall. Results were presented for the different locations in the room (0-8 cm from the wall and 32-40 cm from the wall) as well as for the whole room (residues collected 0-40 cm from the wall and then adjusted for surface area).

2) Selim, S. (2008). Determination of Floor Residues of Esfenvalerate Following a Crack and Crevice or Broadcast Application of EVERCIDE® Residual Ant and Roach Spray 27523. MRID: 47647701

   This study was designed to determine the dissipation pattern of esfenvalerate in a room following application of an aerosol product containing 0.1% esfenvalerate. Three application scenarios were conducted which included: 1) broadcast treatment applied using a typical aerosol nozzle, 2) crack and crevice treatment applied using a typical aerosol nozzle, and 3) void and crack treatment applied using an injection tube attached to the aerosol container. Deposition samples were collected using alpha-cellulose coupons which were placed on the floor and one wall of the environmental exposure room prior to application. The samples were removed from the room 30 minutes after application for all scenarios. Another set of samples was removed 7 days after application for the crack and crevice treatment scenario and the void and crevice treatment scenario. At each sampling time, samples were collected from 61 locations on the floor and 17 locations on the wall. All sampling coupons measured 25 cm^2, except for the coupons along the perimeter of the floor in the void and crevice scenario, which measured 75 cm^2; however, these coupons were separated into three 25 cm^2 pieces prior to analysis.

Table C-11: Summary of Residue Values for Crack and Crevice Applications.

Location in room	Residue (ug/cm^2)
Source: Keenan (2007) 0.05% deltamethrin	
0-8 cm ("treated")	14.6
32-40 cm ("untreated")	0.02
Weighted average: 90% untreated / 10% treated	1.5
Source: Selim (2008) 0.1% esfenvalerate	
treated	1.97
untreated	0.0035
Weighted average: 90% untreated / 10% treated	0.2

C.6 Generic Estimates of Transferable Residue

Following an application, pesticide residue that remains on target surfaces (e.g., carpets, leaves, turf, etc.) and thus available for surface-to-skin transfer is referred to as transferable residue. Examples of non-transferable residue would be residue that evaporates, adheres to carpet fibers, or absorbs into plant surfaces. Typically, chemical-specific studies are submitted quantifying transferable residue using standardized and replicable methodologies on the day of application (i.e., “day 0”) and subsequent days (i.e., 1, 3, 5, 7 days) following application. This data can then be directly used in mathematical models to estimate daily residue.

When a chemical-specific study is unavailable, however, transferable residue on the day of application (i.e., “day 0”) can be estimated as a fraction of the application rate (e.g., 10% of the application rate as transferable residue on the day of application) and transferable residue on subsequent days can be calculated using a daily dissipation rate (e.g., 15% of the transferable residue on the day of application is present on the day after application).

Existing transferable residue studies for a variety of chemicals can provide a basis for generic approximations of the "day 0" transferable residue and daily dissipation when chemical-specific studies are unavailable to assess post-application exposure in outdoor and indoor residential settings. "Day 0" transferable residue, as a fraction of the application rate, is derived as the ratio of the application rate as a mass per area target surface concentration (e.g., lbs active ingredient per acre) to the measured mass per area "day 0" concentration. Converting each value to the same units provides a unitless ratio which can also be considered as a percentage (i.e., 10% of the application is transferable residue on the day of application). Daily residue dissipation is typically derived using a first-order exponential decay model. Each day's measured transferable residue is log-transformed and regressed against the day of application using ordinary least squares (OLS). The resulting slope represents a constant fraction, or percentage, of residue that dissipates per day. The following sections present analyses of existing studies for various residential settings.

C.6.1 Turf

Transferable residue on turf has historically been referred to as transferable turf residue (TTR), and can be measured using a number of different techniques. The industry-based Occupational and Residential Exposure Task Force (ORETF) tested five techniques in 1996: the California roller method, the shoe method, the polyurethane foam (PUF) roller method, the drag sled method, and the foliar wash method. A follow-up study was conducted on a turf farm in 1997 using three modified techniques: the modified California roller method, the modified shoe method, and the ORETF roller method. The data from both of these studies is summarized and analyzed in a 1999 ORETF report (J. Cowell and D. Johnson, MRID 44972203). Ultimately – based on the information provided by ORETF and working in conjunction with the California Department of Pesticide Regulation (DPR) and Canada's Pest Management Regulatory Agency (PMRA) – a TTR collection method (the Modified California Roller Method) was agreed upon for all future TTR studies. The Modified California Roller was selected because it produced the most consistent results across individuals, active ingredients, formulation types, and time than the other techniques. It also was sensitive enough to detect low levels of residues and was one of the easier techniques to use.

In a typical TTR study, triplicate samples are collected using the Modified California Roller Method before the day of application, on the day of application, and for several days following the application (e.g., 1, 3, 5, 7 days after application). Each sample is then extracted in solution to yield a mass of chemical which can be expressed as a turf residue concentration (e.g., [X] ug per [X] cm^2). This data can then be directly used in mathematical models to estimate daily residue.

TTR studies can also be used as surrogates in the event chemical-specific information is unavailable for a particular pesticide. The Agency analyzed 36 TTR studies using liquid formulations, 11 TTR studies using wettable powders/water dispersible granular (WP/WDG) formulations, and 12 studies using granular formulations for the purposes of establishing generic transferable residue factors. Since they are applied as sprays, residue data resulting from applications with the liquid/wettable powder/water dispersible granular formulation were combined while residues from applications of granular formulations were treated separately.

Table C-12 and *Table C-13* present the "day 0" transferable residue as a fraction of the application rate (F) for each of the 47 liquid/wettable powder/water dispersible granular studies and each of the 12 granular studies, respectively.

Table C-12: Residential Turf – Liquid/WP/WDG Transferable Residue Data

MRID Number	Active Ingredient	Site	Formulation	Fraction of Application Rate Available for Transfer (F)
45040701	Isoxaban	CA	DF	0.015
		IN	DF	0.011
		MS	DF	0.0070
44901001	Chlorothalonil	GA	DF	0.010
		NY	DF	0.0042
		OR	DF	0.006
44955501	Permethrin	GA	EC	0.0064
		CA	EC	0.0085
		PA	EC	0.0061
45288601	Propiconazole	IN	EC	0.0016
		CA	EC	0.0097
		PA	EC	0.0045
45361602	Fluroxypyr	CA	EC	0.0043
		MS	EC	0.0035
		PA	EC	0.0074
45118725	Pyraclostrobin	NC	EC	0.0018
		CA	EC	0.0062
		PA	EC	0.0022
46684102	Pendimethalin	PA	EC	0.0019
		GA	EC	0.0016
		CA	EC	0.0021
45260201	Trinexapac-methyl	GA	EC	0.0047
		CA	EC	0.0031
		IN	EC	0.0069
44958501	Mancozeb	NC	F	0.00077
		PA	F	0.00041
		CA	F	0.00097
44958701	Simazine	CA	L	0.0027
		FL	L	0.0032
44958901	Monosodium Methanearsonate	NY	L	0.0029
		NC	L	0.0014
		CA	L	0.015
45067201	Trichlorfon	GA	L	0.00015
		MO	L	0.000033
		NY	L	0.0000050
44687101	Pentachloronitrobenzene	CA	L	0.011
		OR	L	0.0081
		MO	L	0.0067
45251501	Propamocarb	CA	L	0.0043

Table C-12: Residential Turf – Liquid/WP/WDG Transferable Residue Data				
MRID Number	**Active Ingredient**	**Site**	**Formulation**	**Fraction of Application Rate Available for Transfer (F)**
		MO	L	0.0035
		VA	L	0.0090
45894314	Propamocarb hydrochloride	CA	L	0.013
		PA	L	0.011
45249601	Triclopyr (Amine)	CA	L	0.0050
		IN	L	0.0046
		MS	L	0.0036
	Triclopyr (Ester)	CA	L	0.0031
		IN	L	0.0037
		MS	L	0.0050
45250001	Fenarimol	CA	L	0.061
		IN	L	0.0084
		MS	L	0.0058
45214201	Paclobutrazol	CA	L	0.010
		NY	L	0.0029
		NC	L	0.0053
45114301	Carbaryl	CA	L	0.030
		GA	L	0.015
		PA	L	0.011
44799001	Bensulide	NY	L	0.0040
44828401	Spinosad	CA	L	0.013
		MS	L	0.023
		PA	L	0.0087
44951901	Siduron	NY	L	0.0051
44959101	Diazinon	GA	L	0.00012
		CA	L	0.00050
		PA	L	0.00035
44968001	Iprodion	GA	L	0.0068
		CA	L	0.0094
		NY	L	0.0073
45111501	Cypermethrin	CA	L	0.0053
		MO	L	0.0014
		PA	L	0.0051
	Chlorothalonil	CA	L	0.013
		GA	L	0.0081
		NY	L	0.014
45033101	2,4-D	CA	L	0.013
		WI	L	0.011
45251401	Glufosinate-Ammonium	NY	LC	0.0040
		CA	LC	0.0070
		GA	LC	0.0028
4507150	Oryzalin	CA	SC	0.0049
		IN	SC	0.0046
		MS	SC	0.010

Table C-12: Residential Turf – Liquid/WP/WDG Transferable Residue Data				
MRID Number	**Active Ingredient**	**Site**	**Formulation**	**Fraction of Application Rate Available for Transfer (F)**
44959001	Dicamba	FL	SC	0.0078
		CA	SC	0.012
		PA	SC	0.010
46571104	Cyanzofamid	NC	SC	0.0037
45576801	Triticonazole	GA	SC	0.0060
		CA	SC	0.0032
		NY	SC	0.0017
46703508	Penoxsulam	GA	SC	0.043
		FL	SC	0.0068
47172301	Mesotrione	NY	SC	0.00096
		CA	SC	0.0032
		GA	SC	0.0017
45251201	Deltamethrin	NY	SC	0.0058
		GA	SC	0.0086
		CA	SC	0.014
	Oryzalin	CA	SC	0.061
		IN	SC	0.011
		MS	SC	0.013
45640010	Dinotefuran	CA	SG	0.0061
		PA	SG	0.0066
		GA	SG	0.0047
44969901	Pendimethalin	CA	WDG	0.030
45071501	Chlorothalonil (Daconil, Ultrex)	CA	WDG	0.0049
		GA	WDG	0.0046
		NY	WDG	0.010
45405301	Nicotinamide	PA	WDG	0.011
		GA	WDG	0.0044
		CA	WDG	0.0090
45102911	methyl 2,4-[o-(methylphenoxymethyl)phenyl]-2-methoxyimino) acetamide	NC	WDG	0.0043
		CA	WDG	0.014
		PA	WDG	0.017
45260401	Prodimaine	GA	WDG	0.0098
		CA	WDG	0.0012
		PA	WDG	0.00091
45149001	Cyfluthrin	GA	WP	0.011
		MS	WP	0.015
		NY	WP	0.0034
		CA	WP	0.012
		MO	WP	0.0069
		PA	WP	0.017
44952501	Pronamide	NC	WP	0.027
44952901	Myclobutanil	NC	WP	0.012
		CA	WP	0.024

Table C-12: Residential Turf – Liquid/WP/WDG Transferable Residue Data				
MRID Number	**Active Ingredient**	**Site**	**Formulation**	**Fraction of Application Rate Available for Transfer (F)**
44806401	Acephate	Fl	WSP	0.0052
44995502	Oxadiazon	GA	WSP	0.026
F = Fraction of residue available on day 0				

Table C-13: Residential Turf – Granular Transferable Residue Data				
MRID Number	**Active Ingredient**	**Site**	**Formulation**	**Fraction of Application Rate Available for Transfer (F)**
44958801	Atrazine	GA	G	0.0021
		FL	G	0.0069
45260401	Prodimaine	GA	G	0.00021
		CA	G	0.00022
		PA	G	0.00039
44829601	Chlorpyrifos	CA	G	0.0013
		IN	G	0.00075
		MS	G	0.00075
44959101	Diazinon	GA	G	0.000039
		CA	G	0.000012
		PA	G	0.000028
45067201	Trichlorfon	GA	G	0.000006
		MO	G	0.000032
44998301	Benefin	CA	G	0.000109
		IN	G	0.000087
		MS	G	0.000047
	Trifluralin	CA	G	0.00012
		IN	G	0.000094
		MS	G	0.000067
46673901	Carbaryl	FL	G	0.0062
		KS	G	0.0019
		CA	G	0.0051
47172301	Mesotrione	NY	G	0.00077
		CA	G	0.0016
		GA	G	0.0017
45249601	Triclopyr, Clopyralid	CA	G	0.0051
		IN	G	0.0025
		MS	G	0.0023
45040701	Isoxaben (Gallery)	CA	G	0.00080
		IN	G	0.0020
		MS	G	0.00030
	Isoxaben (Gallery plus Surflan)	CA	G	0.0059
		IN	G	0.0027
		MS	G	0.00030

Table C-13: Residential Turf – Granular Transferable Residue Data				
MRID Number	**Active Ingredient**	**Site**	**Formulation**	**Fraction of Application Rate Available for Transfer (F)**
	Oryzalin (Gallery plus Surflan)	CA	G	0.0060
		IN	G	0.0030
		MS	G	0.00020
F = Fraction of residue available on day 0				

Historically, environmental data such as turf residues typically follow a lognormal distribution. Lognormal probability plots for the transferable residue factors in *Figure C-2* (liquid/wettable powder/water dispersible granular) and *Figure C-3* (granules), respectively.

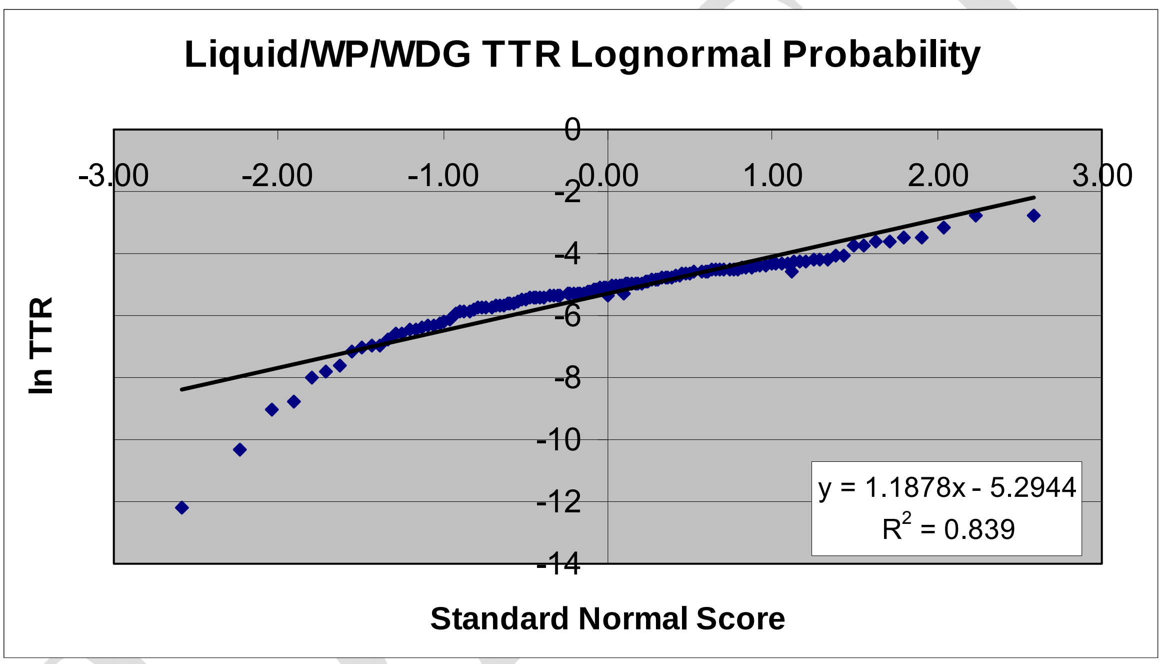

Figure C-2: Liquid, Wettable Powder, and Water Dispersible Granular Transferable Turf Residue Lognormal Probability Plot

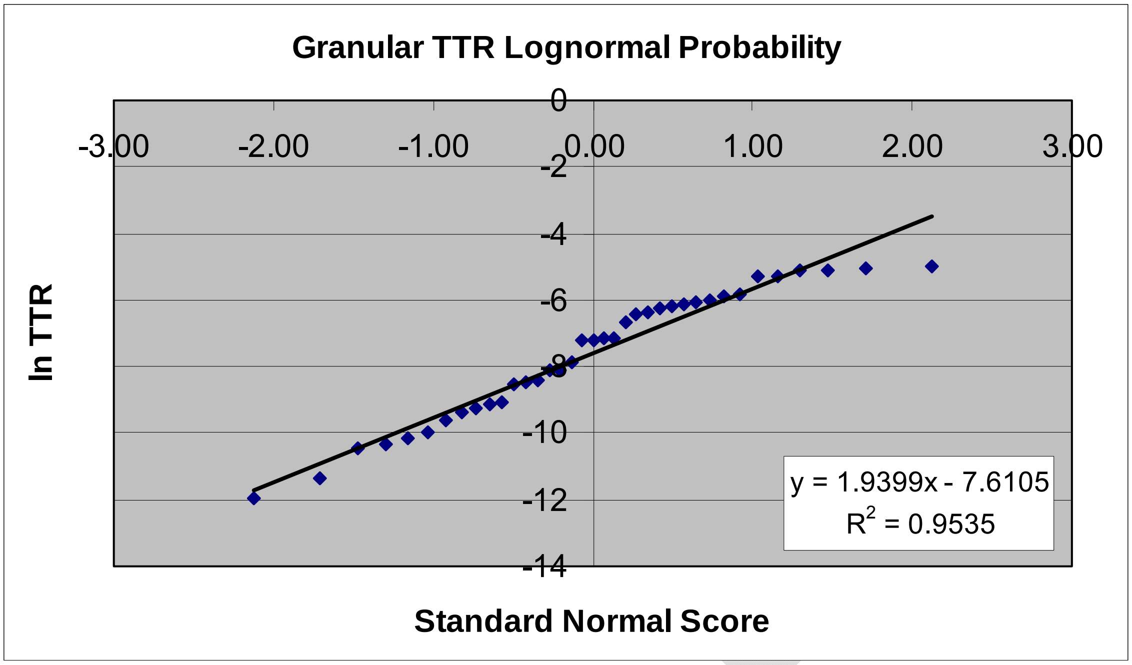

Figure C-3: Granular Transferable Turf Residue Lognormal Probability Plot

Because both datasets reasonably fit lognormal distributions, statistics, such as standard deviations and percentiles can be estimated based on characteristics of the lognormal distribution. The table below presents select summary statistics for turf residue.

Table C-14: Turfgrass Statistical Summary – Transferable Residue Factor (F)		
Statistic	**Liquids/WPs/WDGs**	**Granules**
50th percentile	0.0050	0.0005
75th percentile	0.011	0.002
95th percentile	0.035	0.02
99th percentile	0.080	0.045
99.9th percentile	0.20	0.20
Arithmetic Mean	0.0086	0.0017
Standard Deviation	0.0094	0.0021
Geometric Mean	0.0051	0.00050
Geometric Standard Deviation	3.6	6.9
Range	0.000005 – 0.061	0.0000064 – 0.0069
N	131	37

C.6.2 Gardens, Trees, and "Pick-your-own" Farms

Transferable residue in vegetable gardens, flower gardens, trees, shrubs, bushes, and "pick-your-own" farms has historically been referred to as dislodgeable foliar residue (DFR). In chemical-specific studies, DFR is measured using a "leaf-punch" technique. Three (3) samples, each containing 40 leaf punches equal to approximately 400 square centimeters (cm^2) of 2-sided foliar surface area, are collected on the day of application and for several days following the application (e.g., 1, 3, 5, 7 days after application). Each of the 3 samples is then "dislodged" in solution to yield a mass of chemical which can be expressed as a foliar concentration (e.g., [X] ug per 400 cm^2).

DFR studies can also be used as surrogates in the event chemical-specific information is unavailable for a particular pesticide. Nineteen (19) studies conducted by the Agricultural Reentry Task Force (ARTF) were analyzed for the purposes of establishing generic transferable residue factors. *Table C-15* below presents the "day 0" transferable residue as a fraction of the application rate (F_{AR}) and the fraction per day daily dissipation (F_D) for each of the 19 studies.

Table C-15: Gardens, Trees, and "Pick-your-own" Farms – Transferable Residue Data

Study Reference		Crop	Chemical	Application Rate (lb ai/acre)	Day 0 DFR (measured; ug ai/cm^2)	Transferable Residue as fraction of Application Rate (F_{AR})	Fraction per Day Daily Dissipation (F_D)
ARTF #	MRID						
ARF025	45138202	Apple	Malathion	1.25	2.45	0.17	0.09
					2.18	0.16	
					2.33	0.17	
ARF028	45175101	Orange	Cyfluthrin	0.10	0.03	0.02	0.03
					0.04	0.04	
					0.04	0.03	
ARF044	45469502	Nursery Citrus	Malathion	1.20	1.38	0.10	0.47
					1.77	0.13	
					1.26	0.09	
ARF009	45005904	Sweet Corn	Chlorothalonil	1.40	1.82	0.12	0.19
					4.43	0.28	
					4.80	0.31	
ARF021	45005908	Dry Bean/Pea	Chlorothalonil	1.40	1.78	0.11	0.07
					1.57	0.10	
					1.45	0.09	
ARF041	45432301	Orange	Carbaryl	7.07	24.20	0.31	0.04
					24.60	0.31	
					30.00	0.38	
ARF010	45005905	Sweet Corn	Chlorothalonil	1.40	3.83	0.24	0.32
					2.31	0.15	
					2.27	0.14	
ARF022	45005909	Sunflower	Carbaryl	1.50	4.93	0.29	0.13
					6.05	0.36	
					4.78	0.28	
ARF048	45491901	Wine Grapes	Malathion	0.93	0.44	0.04	0.32
					0.69	0.07	
					0.78	0.07	
ARF023	45005910	Raisin Grapes	Malathion	0.94	1.37	0.13	0.10
					1.24	0.12	
					1.37	0.13	
ARF042	45432302	Grapefruit	Carbaryl	7.70	24.20	0.31	0.34
					24.60	0.31	
					30.00	0.38	
ARF012	45005907	Cauliflower	Chlorothalonil	1.10	0.94	0.08	0.19
					0.99	0.08	
					0.93	0.08	

Table C-15: Gardens, Trees, and "Pick-your-own" Farms – Transferable Residue Data							
Study Reference		Crop	Chemical	Application Rate (lb ai/acre)	Day 0 DFR (measured; ug ai/cm^2)	Transferable Residue as fraction of Application Rate (F_{AR})	Fraction per Day Daily Dissipation (F_D)
ARTF #	MRID						
ARF011	45005906	Cauliflower	Chlorothalonil	1.12	4.38	0.35	0.12
					4.43	0.35	
					4.70	0.37	
ARF024	45005911	Tobacco	Carbaryl	2.00	4.83	0.22	0.24
					4.68	0.21	
					5.45	0.24	
ARF037	45191701	Cabbage	Carbaryl	2.00	3.95	0.18	0.17
					1.27	0.06	
					1.74	0.08	
ARF051	45530103	Tomato	Chlorothalonil	2.70	5.58	0.18	0.40
					5.65	0.19	
					4.88	0.16	
ARF049	45491902	Squash	Malathion	0.95	3.28	0.31	0.10
					5.05	0.47	
					3.55	0.33	
ARF039	45344501	Chrysanthemum	Diazinon	0.66	5.63	0.76	0.45
					6.58	0.89	
					3.60	0.49	
					5.90	0.80	
					4.95	0.67	
					3.40	0.46	
ARF043	45469501	Nursery Citrus	Malathion	1.30	2.46	0.17	0.11
					2.89	0.20	
					2.55	0.18	
F_{AR} = "Day 0" DFR, expressed as a fraction of Application Rate F_D = daily dissipation, expressed as a fraction per day							

Though F_{AR} values are intended to be applied when chemical-specific data are unavailable, there may be systematic differences such that different F_{AR} values could be used for specific circumstances. For example, if it were the case that apples typically demonstrated higher F_{AR} values than other crops, one would want to utilize apple-specific F_{AR} values in order not to underestimate potential exposure while conducting activities associated with apples. The same could apply for chemical class (i.e., insecticides, fungicides, etc.). To investigate such trends, F_{AR} data from *Table C-15* are plotted separately against crop and chemicals in *Figure C-4* and *Figure C-5*, respectively. A lognormal probability plot of the composite dataset coded for crop-chemical combination is also presented in *Figure C-6*.

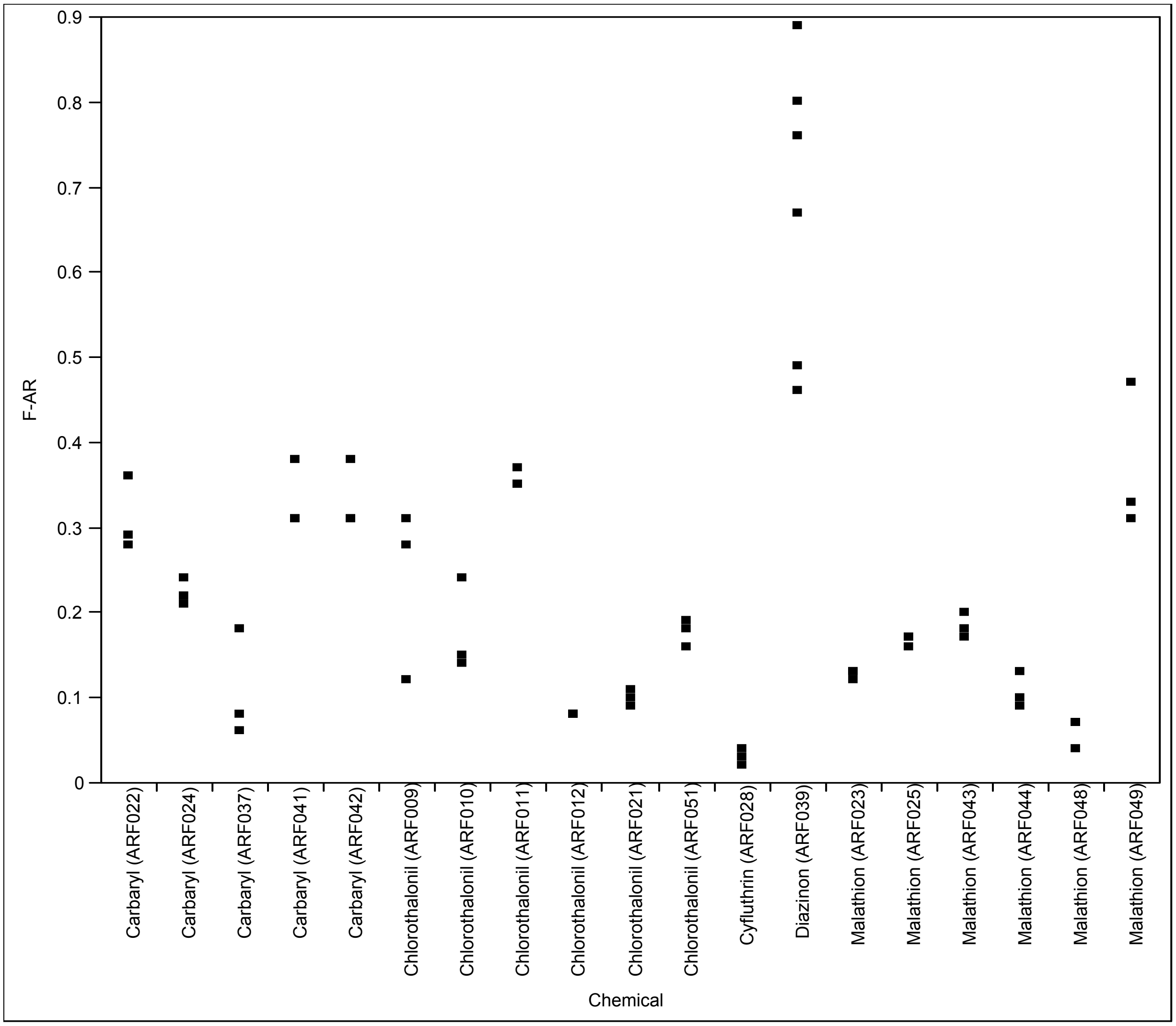

Figure C-4: Fraction of Transferable Residue, By Chemical

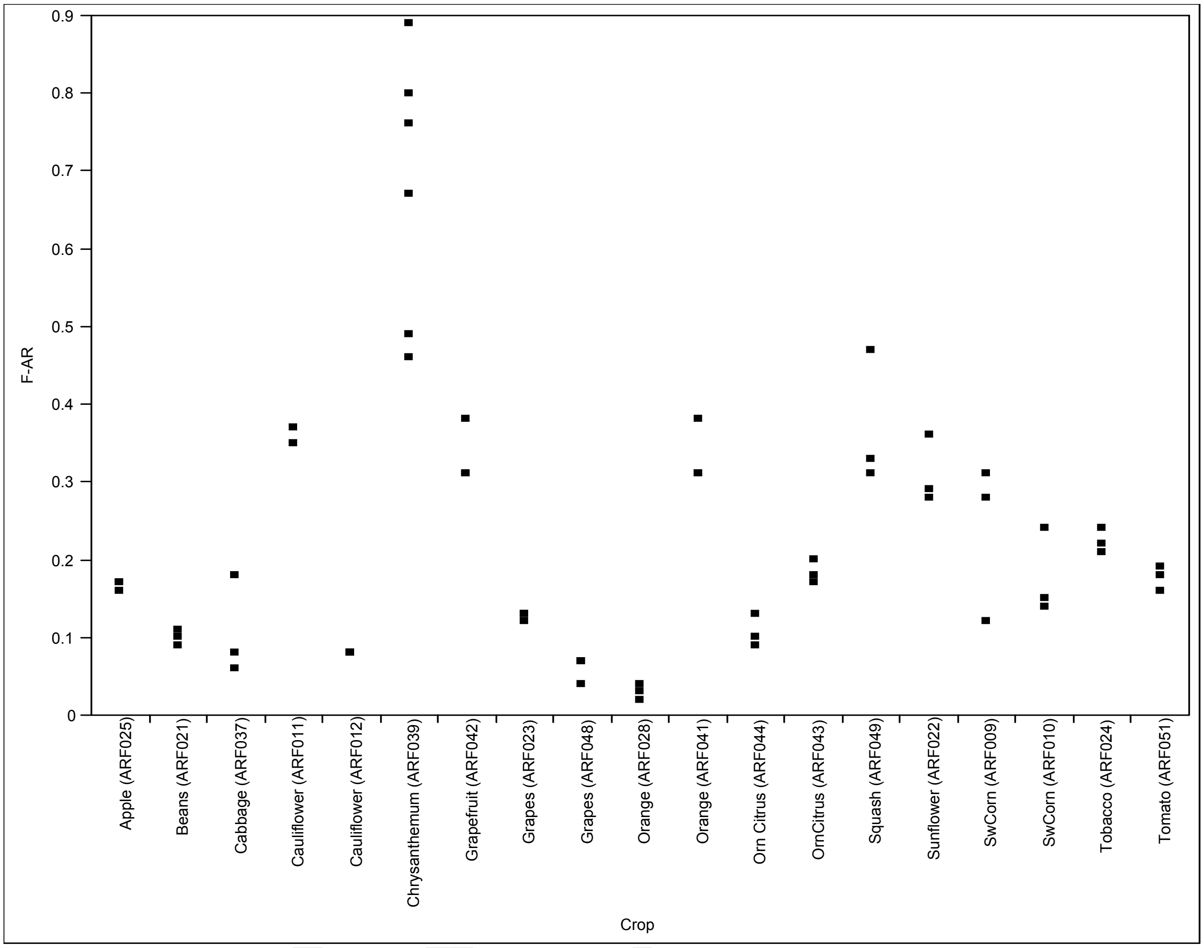

Figure C-5: Fraction of Transferable Residue, By Crop Type

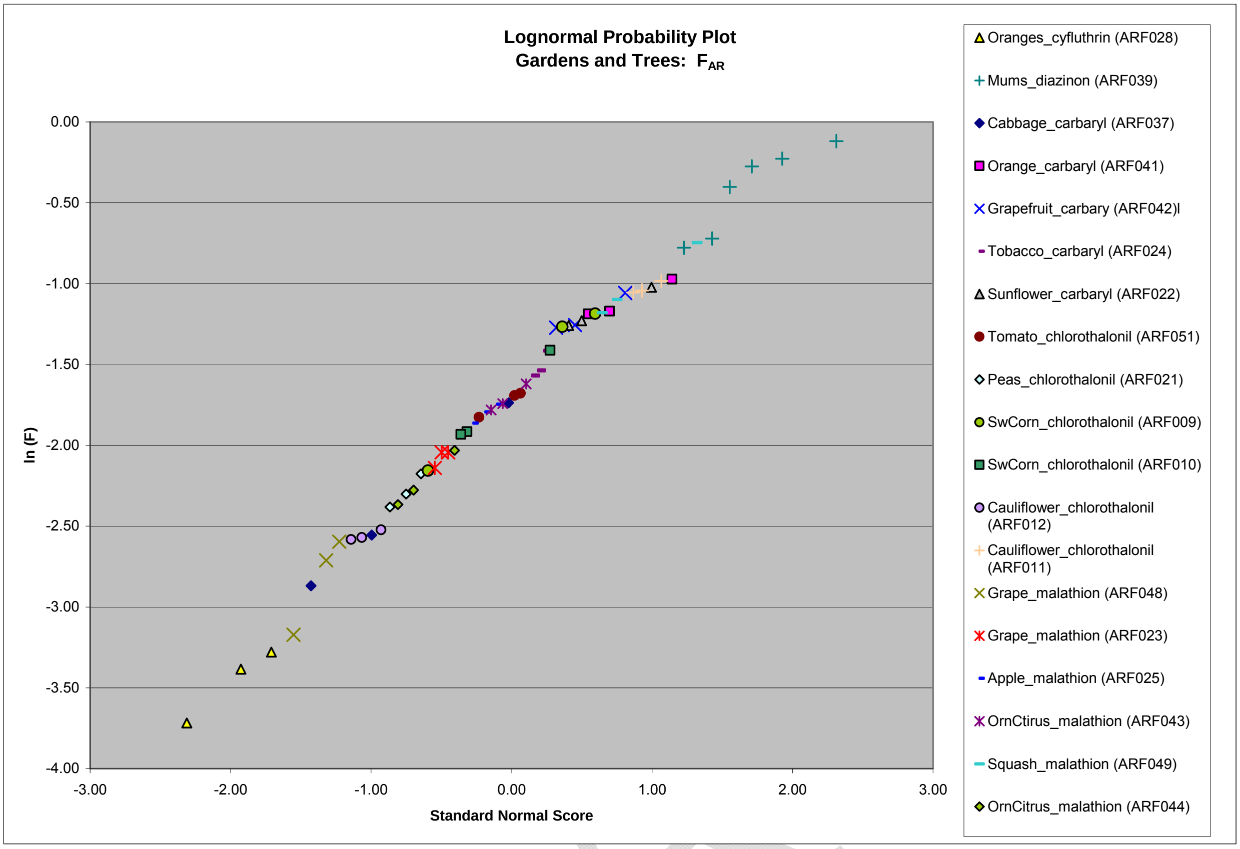

Figure C-6: Gardens and Trees – Fraction of Available Residue Lognormal Probability Plot

It is not clear from the data whether any broad categories can be defined for F_{AR} values. For example, *Figure C-6* shows that while malathion demonstrates relatively high F_{AR} values (0.31 – 0.47; ARF049) it also demonstrates some of the lowest (0.04 – 0.07; ARF048). The same appears to be the case for specific crops with oranges, as one example, demonstrating fairly high F_{AR} values (0.31 – 0.38; ARF041) and low F_{AR} values (0.02 – 0.04; ARF028).

Due to the inability to observe meaningful trends in these datasets, the F_{AR} values (as well as residue dissipation values) are pooled into composite datasets for the purposes of providing generic transferable residue factors for exposure assessment. Lognormal probability plots for these composite datasets are presented below in *Figure C-7* and *Figure C-8*.

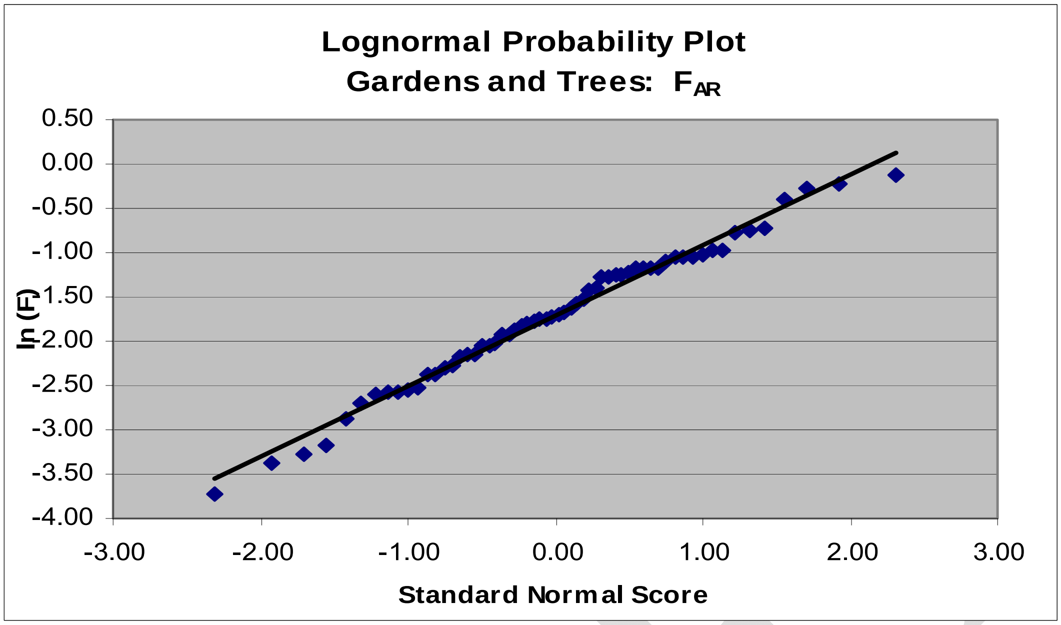

Figure C-7: Gardens and Trees – Fraction of Available Residue Lognormal Probability Plot

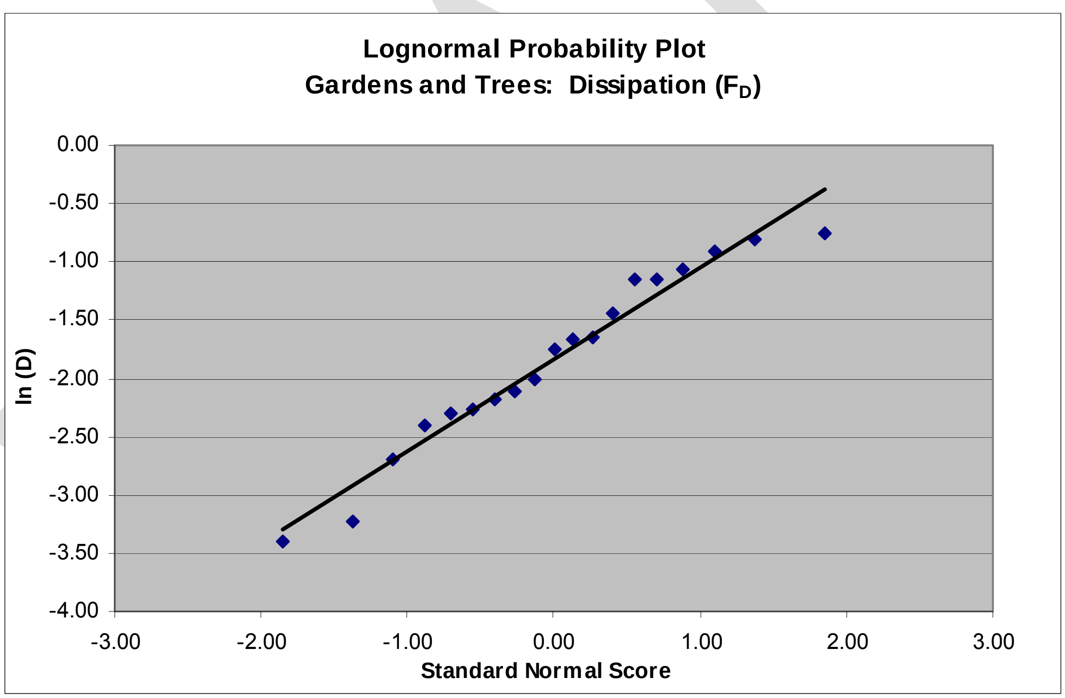

Figure C-8: Gardens and Trees – Residue Dissipation Lognormal Probability Plot

Because both datasets reasonably fit lognormal distributions, statistics, such as standard deviations and percentiles can be estimated based on characteristics of the lognormal distribution. *Table C-16* and *Table C-17* below present select summary statistics for each factor. [Note: it is recognized that treating each data point independently is technically incorrect due to the "nested" structure of the data set (i.e., F_{AR} values within crops, which are within chemicals, etc.), however, resulting statistics are nonetheless reasonable and useful for exposure assessment purposes.]

Table C-16: Gardens, Trees, and "Pick-your-own" Farms Statistical Summary	
Statistic	**Transferable Residue as Fraction of Application Rate (F_{AR})**
50th percentile	0.18
75th percentile	0.31
90th percentile	0.50
95th percentile	0.66
99th percentile	> 1.0
99.9th percentile	> 1.0
AM (SD)	0.25 (0.23)
GM (GSD)	0.18 (2.2)
Range	0.02 – 0.89
N	60
Statistics based on a lognormal distribution. AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

Table C-17: Gardens, Trees, and "Pick-your-own" Farms Statistical Summary	
Statistic	**Fraction per Day Daily Dissipation (F_D)**
50th percentile	0.16
25th percentile	0.09
5th percentile	0.04
1st percentile	0.03
0.1st percentile	0.01
AM (SD)	0.22 (0.20)
GM (GSD)	0.16 (2.2)
Range	0.03 – 0.47
N	19
Statistics based on a lognormal distribution. AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

C.6.3 Indoor Surfaces

The values for fraction transferred are based on two sources which examined transferability of chemicals from carpets and hard surfaces.

1) Beamer, P; Canales, R; and Leckie, J. (2008) Developing probability distributions for transfer efficiencies for dermal exposure. Journal of Exposure Science and Environmental Epidemiology. 1-10.

Beamer *et. al* (2008) analyzed numerous transfer efficiency studies, which covered various methods including the cloth roller, drag sled, PUF roller, and bare hand press. A literature search was conducted, which identified 35 studies and included 25 different sampling methods, 25 chemicals, and 10 surface types. According to Beamer *et al*., the majority of these studies only reported mean values and were not included in the analysis. Thirteen studies provided full data sets, but four of those provided little data on four different chemicals and were excluded from the analysis. Therefore, out of a total of 35 studies identified, only nine studies were used to fit transfer efficiency distributions for three chemicals (chlorpyrifos, pyrethrins and piperonyl butoxide) on 4 different surfaces with 8 different methods. Most of the transfer efficiencies were measured relatively soon after application (i.e., within 24 hours). Data sets were compared using a non-parametric analysis of variance method and the Kruskal-Wallis test to determine whether different combinations of data sets arise from the same distribution. The data sets were initially separated by chemical and surface type. The Kruskall-Wallis test was used to determine whether data sets from different sampling methods, but for the same chemical and surface could be combined. All data sets for a specific chemical and surface type were evaluated and data sets were eliminated one by one, with the attempt being to maximize the number of data points until the *p*-value was greater than 0.05. The experimental methods of the combined data sets were assessed to determine whether there were any consistent trends related to the inclusion/exclusion of data sets. No consistent trends were observed with respect to different transfer efficiency methods, dry versus wet hand presses, different application concentrations and formulations and different sampling time points after application. The combined data set was assessed to determine which distribution was a best fit and it was determined to be the lognormal distribution. The Kruskal-Wallis *p*-value for all surface and chemical combinations was less than 0.0001, indicating that distributions are statistically different. A trend for pesticide transfer was observed for surface type with transfer from vinyl being higher than from carpet.

2) In addition to the Beamer et. al paper, an analysis of data provided by the Non-Dietary Exposure Task Force (NDETF) was conducted. This analysis included data for bare hand presses on carpets and vinyl surfaces for deltamethrin, permethrin, piperonyl butoxide and pyrethrin.

2a) MRID 46188605: Measurement of Transfer of Pyrethrin and Piperonyl Butoxide Residues from Vinyl Flooring Treated with a Fogger Formulation

The purpose of the study was to determine the degree of transfer of pyrethrin (PY) and piperonyl butoxide (PBO) residue from treated vinyl flooring to dry bare hands after a single application of a fogger formulation containing 0.778% PY and 1.55% PBO. A total release aerosol fogger product was applied using a sprayboom apparatus in the center of four 16 ft. x 16 ft. x 8 ft. test rooms. Additionally, the study compared residue transfer from bare hands using alternate methods (indoor roller and drag sled) for measuring residue transfer from the application of an indoor aerosol fogger. Total deposition was measured using coupons, collected after the product application and drying period, respectively. During the application, and for three hours thereafter, the ventilation system in the room was turned off with the dampers closed to allow for deposition of the spray onto the test surfaces. After the three hours, the dampers were opened for a 30 minute drying period and then the flooring sections were transferred to a hand press test room. Residues remaining on bare and gloved hands, percale from indoor roller, and denium from a drag sled following contact with treated vinyl surfaces were determined. The analysis of the alpha cellulose deposition coupons for the roller, drag samples and first and second hand presses (bare and gloved) show that the mean deposition rate of PY and PBO is consistent from application to application and is reproducible. A comparison of the percent transfer of PY and PBO residues from the roller, drag sled, bare and gloved hands shows that for all procedures the percent transferability of PY is higher than that of PBO.

2b) MRID 46188614: Determination of Pyrethrin (PY) and Piperonyl Butoxide (PBO) Residue on the Hand from Treated Vinyl Flooring Sections Following Hand Press on Untreated Surfaces

The purpose of the study was to determine the amount of residue left on a hand exposed to vinyl flooring treated with a formulation containing pyrethrin (PY) and piperonyl butoxide (PBO) following hand contact with untreated vinyl flooring surfaces. In this study, three test rooms were used, with one containing the application equipment (the sprayboom). Sixty-six vinyl flooring sections were pinned onto a sheet of plastic-covered plywood attached to the top of six 40 in x 40 in wooden platforms. Total deposition was measured using deposition coupons, which were collected after application of the test material, followed by a drying period. After collection of the deposition coupons, four vinyl flooring sections were removed and moved to a hand press room. Two male test subjects performed one hand press on the treated surface and 4 separate hand presses on untreated pieces of vinyl flooring. Each subject performed hand presses with each hand, for a total of four replicates. The subjects' hands were then cleaned with isopropyl alcohol dressing sponges to remove any remaining residues. Hand residues averaged 34.3 ng/cm^2 for PY and 38.4 ng/cm^2 for PBO. Corrected deposition coupon residues averaged 5.91 ± 1.68 µg/cm^2 for PY and 14.52 ± 3.54 µg/cm^2 for PBO. PY and PBO residues on the hand were estimated to be 0.58% and 0.26% of the PY and PBO applied to the vinyl flooring, as determined from the deposition coupons.

2c) MRID 46297602: Measurement of Transfer of Deltamethrin Residue from Vinyl and Carpet Flooring Treated with a Fogger Formulation Following a Single Hand Press

The purpose of the study was two-fold. The first objective was to determine the amount of deltamethrin residue transferred from treated vinyl and carpet flooring to dry hands using both a hand press and roller technique. The second objective was to compare the degree of residue transferred for each collection methodology: isopropyl alcohol (IPA) hand wipes and cotton gloves used for the hand press technique and cotton percale cloth used for the modified California indoor roller technique. The test formulation contained a target weight percentage of 0.15% deltamethrin (DTM) (wt/wt). It was applied via a sprayboom that was meant to simulate a fogger spray. Total deposition was monitored using alpha cellulose deposition coupons placed at various randomly selected locations on the platforms. Residues resulting from a single, dry hand press approximately 3.5 hours following application were measured on vinyl and carpet flooring using the following sampling techniques and collection methodologies: IPA hand wipes and cotton gloves for the hand press, and percale cloth for the indoor modified California roller. Calculation of the percent transferability is a function of the measured hand residue and the DTM deposition on the corresponding flooring. Residue transfer using the modified indoor California roller appears to be higher for carpets than vinyl (2.8% to 1.5%, respectively). Residue transfer using cotton gloves appears to be higher for carpets than vinyl (2.7% to 1.9%, respectively). Residue transfer using IPA wipes appears to be higher for vinyl flooring than carpet (4.7% to 1.4%, respectively). Overall, after combining % transferability across residue collection methodologies, transfer from vinyl flooring appears to be higher than carpet (2.6% to 2.1%, respectively). It should be noted that this is likely because of the relatively high % transferability from vinyl measured using IPA wipes (4.7%) compared with all the other methodologies (range of 1.4% to 2.8%).

2d) MRID 46188625: Measurement of Transfer of Permethrin and Piperonyl Butoxide Residues from Vinyl and Carpet Flooring Treated with a Fogger Formulation Following a Single Hand Press

The purpose of the study was twofold. The first objective was to determine the amount of permethrin (PER) and piperonyl butoxide (PBO) residue transferred from treated vinyl and carpet flooring to bare and gloved adult hands utilizing a single hand press collection technique. The second objective was to compare the degree of residue transferred via two sampling strategies, i.e., (1) transfer from the single hand press technique versus (2) transfer to cotton percale cloth using the modified California indoor roller method. The test formulation contained a target weight percentage of 0.77% permethrin (PER) (wt/wt) and 0.77% piperonyl butoxide (PBO) (wt/wt). It was applied via a sprayboom that was meant to simulate the use of a ready-to-use fogger. Total deposition was monitored using alpha cellulose deposition coupons placed at various randomly selected locations on the platforms. Residues resulting from a single, dry hand press approximately 3.5 hours following application were measured on vinyl and carpet flooring using the following sampling techniques and collection methodologies: IPA hand wipes and cotton gloves for the hand press, and percale cloth for the indoor modified California roller. Calculation of the percent transferability is a function of the measured hand residue and the DTM deposition on the corresponding flooring. For the indoor California roller, the findings illustrate that the percentage of PBO and PER residue transferred from carpet flooring sections to percale was higher than the percentage transferred from vinyl flooring sections. Also, the percentage of PBO transferred from vinyl to percale was less than half the percentage of PER transferred, while for carpet flooring surfaces, the percentage of PBO and PER transferred was similar. For treated vinyl surfaces, the percent of PER transferred to the percale, gloved or bare hands, was always higher than the percent of PBO transferred. For carpet treated samples, the percent of PER and PBO residues transferred onto bare or gloved hands, are similar.

2e) MRID 46188628: Determination of Permethrin (PER) and Piperonyl Butoxide (PBO) Residue on the Hand Following Hand Press on Treated and Untreated Vinyl and Carpet

The purpose of the study was to determine residue concentrations of permethrin (PER) and piperonyl butoxide (PBO) on bare hands following: 1) contact with either a treated vinyl tile or carpet swatch and then 2) contact with respective untreated vinyl tiles or carpet swatches. The study was conducted in two climate controlled test rooms. One room was outfitted with a fixed overhead sprayboom system. The carpet swatches and vinyl tiles were arranged beneath the spray boom for treatment in the first room while the hand procedures were performed in the second room. The formulation applied was meant to simulate a single application of a total release fogger product containing 0.77% PER and 0.77% PBO. During the spray application, and for three hours thereafter, the ventilation system in the room was turned off with the dampers closed to allow for deposition of the spray onto the test surfaces. After the three hours, the dampers were opened for a 30 minute drying period and then the carpet swatches and vinyl tiles were transferred to the second room to perform the hand press procedures. For the bare hand presses, two subjects were recruited to press their hands on a single treated swatch or vinyl tile followed by four separate presses (one each) on untreated carpet swatches or vinyl tiles respectively. Four samples were collected (two subjects times two hands). The residues remaining on the hands following this procedure were collected via isopropanol moistened dressing sponges. The mean percent of the application rate (deposition) collected from the hands was 0.83 percent (PER) and 0.48% (PBO) for the vinyl tiles and 1.55% (PER) and 1.49% (PBO) for the carpet swatches.

2f) MRID 46188620: Determination of Pyrethrin (PY) and Piperonyl Butoxide (PBO) Residue on the Hand Following Hand Press on Treated and Untreated Carpet

The purpose of the study was to determine residue concentrations of pyrethrin (PY) and piperonyl butoxide (PBO) on bare hands following: 1) contact with a treated carpet swatch and then 2) contact with untreated carpet swatches. The study was conducted in two climate controlled test rooms. One room was outfitted with a fixed overhead sprayboom system. The carpet swatches were arranged beneath the spray boom for treatment in the first room while the hand procedures were performed in the second room. The formulation applied was meant to simulate a single application of a total release fogger product containing 0.77% PY and 1.55% PBO. During the spray application, and for three hours thereafter, the ventilation system in the room was turned off with the dampers closed to allow for deposition of the spray onto the test surfaces. After the three hours, the dampers were opened for a 30 minute drying period and then the carpet swatches were transferred to the second room to perform the hand press procedures. For the bare hand presses, two subjects were recruited to press their hands on a single treated swatch and then to make an additional four separate presses (one each) on untreated carpet swatches. Four samples were collected (two subjects times two hands). The residues remaining on the hands following this procedure were collected via isopropanol moistened dressing sponges. The mean percent of the application rate (deposition) collected from the hands was 4.43 percent (PY) and 4.57 percent (PBO).

For the purposes of the residential indoor SOP, the Beamer and NDETF datasets were combined for the two types of surfaces (carpet and vinyl/hard surfaces). The combined datasets were fit to a lognormal distribution with a geometric mean of 0.02 and 0.03 for carpets and hard surfaces, respectively, and geometric standard deviations of 1.97 and 2.53, respectively.

A review of transfer efficiency studies from the literature for a variety of chemicals (e.g., chlorpyrifos, piperonyl butoxide, pyrethrin, and methoprene) provided a ranges for carpets (0.03% to 7.5%) and for hard surfaces (0.7% to 23.5%) (Camaan et al, 1995; Lu and Fenske, 1999; Vaccaro, 1996; Krieger et al, 2000; Ross et al, 1991; Vaccaro, 1990).

Carpets

Table C-18: Residential Indoor Areas – Transferable Residue Data for Carpets

Study	N	MRID No.	Replicate	Transferable Residue as Fraction of Application Rate
NDETF Data				
Deltamethrin Study 1	10	46297602	1R	0.0204
			1L	0.0167
			2R	0.0204
			2L	0.0185
			3R	0.0130
			3L	0.0139
			4R	0.0130
			4L	0.0046
			5R	0.0093
			5L	0.0157
			Average:	0.0145
Permethrin Study 1	10	46188625	1R	0.0170
			1L	0.0312
			2R	0.0188
			2L	0.0098
			3R	0.0186
			3L	0.0146
			4R	0.0158
			4L	0.0172
			5R	0.0230
			5L	0.0324
			Average:	0.0198
Permethrin Study 2	4	46188628	1L	0.0188
			1R	0.0137
			2L	0.0167
			2R	0.0128
			Average:	0.0155
Overall N:	14	46188625 46188628	Overall Average:	0.0186
PBO Study 1	10	46188625	1R	0.0192
			1L	0.0359
			2R	0.0205
			2L	0.0107
			3R	0.0214
			3L	0.0178
			4R	0.0180
			4L	0.0234
			5R	0.0285
			5L	0.0432
			Average:	0.0239
PBO Study 2	4	46188628	1L	0.0188
			1R	0.0128
			2L	0.0154
			2R	0.0124
			Average:	0.0149
PBO Study 3	4	46188620	1L	0.0569
			1R	0.0606
			2L	0.0509

Table C-18: Residential Indoor Areas – Transferable Residue Data for Carpets				
Study	**N**	**MRID No.**	**Replicate**	**Transferable Residue as Fraction of Application Rate**
			2R	0.0368
			Average:	0.0513
Overall N:	18	46188625 46188628 46188620	Average:	0.0513
Pyrethrin Study 1	4	46188620	1L	0.0591
			1R	0.0615
			2L	0.0568
			2R	0.0418
			Average:	0.0548

Table C-19: Summary Data for Transferable Residue for Carpets						
Source	Chemical	N	Mu	Sigma	Geomean	GSD
Beamer et al, 2008	chlorpyrifos	95	-4.26	0.54	0.01	1.70
	Pyrethrins I	66	-3.86	0.68	0.02	1.97
	PBO	60	-4.00	0.51	0.02	1.67
NDETF	deltamethrin	10	-4.30	0.45	0.01	1.56
	permethrin	14	-4.03	0.32	0.02	1.38
	PBO	18	-3.72	0.54	0.02	1.71
	pyrethrin	4	-2.92	0.18	0.05	1.19

Historically, environmental data such as surface residue typically follow a lognormal distribution. Lognormal probability plots for the fraction transferred for carpets in *Table C-18* are presented below in *Figure C-9* and *Figure C-10*.

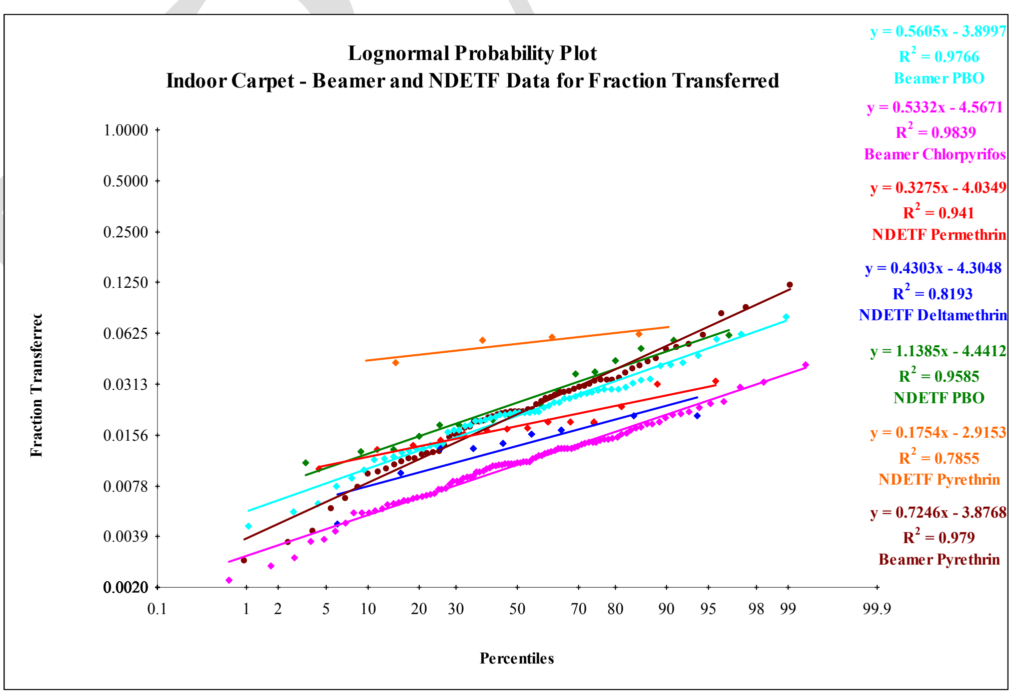

Figure C-9: Indoor Carpets – Fraction of Transferable Residue, By Study (Beamer et al., 2008 and NDETF) and Chemical

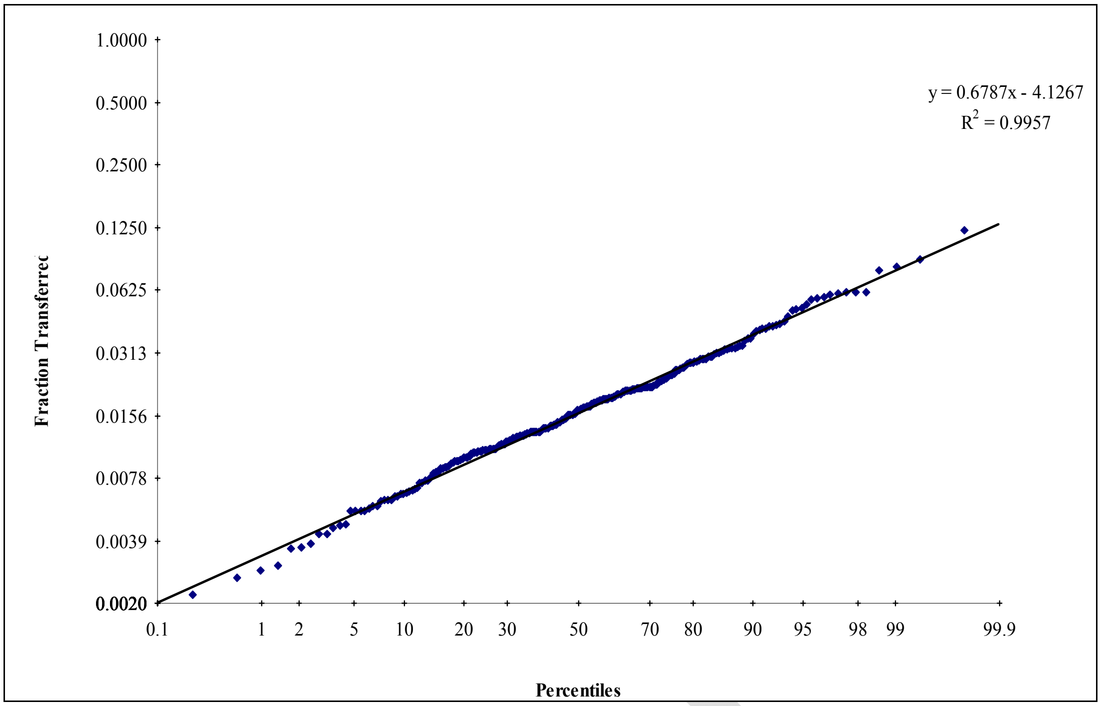

Figure C-10: Indoor Carpets – Fraction of Transferable Residue Combined Data (Beamer et al., 2008, NDETF) Lognormal Probability Plot

Table C-20: Residential Indoor Areas Statistical Summary – Fraction Transferred (F) for Carpets	
Statistic	**Fraction Transferred**
50th percentile	0.02
75th percentile	0.03
95th percentile	0.05
99th percentile	0.08
99.9th percentile	0.13
Arithmetic Mean	0.02
Standard Deviation	0.09
Geometric Mean	0.02
Geometric Standard Deviation	1.97
Range	0.002 - 0.121
N	267

Hard Surfaces

Table C-21: Residential Indoor Areas – Transferable Residue Data for Hard Surfaces				
Study	**N**	**MRID No.**	**Replicate**	**Fraction Transferred**
Deltamethrin Study 1	10	46297602	1R	0.0673
			1L	0.1242
			2R	0.0445
			2L	0.0352
			3R	0.0280
			3L	0.0331
			4R	0.0611
			4L	0.0228
			5R	0.0311

Table C-21: Residential Indoor Areas – Transferable Residue Data for Hard Surfaces				
Study	**N**	**MRID No.**	**Replicate**	**Fraction Transferred**
			5L	0.0166
Overall N:			Average:	0.0464
Permethrin Study 1	10	46188625	1R	0.0259
			1L	0.0320
			2R	0.0491
			2L	0.0368
			3R	0.0304
			3L	0.0123
			4R	0.0177
			4L	0.0382
			5R	0.0390
			5L	0.0452
			Average:	0.0327
Permethrin Study 2	4	46188628	1L	0.0071
			1R	0.0089
			2L	0.0112
			2R	0.0064
			Average:	0.0084
Overall N:	14	46188625 46188628	Average:	0.0257
PBO Study 1	10	46188625	1R	0.0175
			1L	0.0196
			2R	0.0331
			2L	0.0255
			3R	0.0208
			3L	0.0086
			4R	0.0139
			4L	0.0269
			5R	0.0259
			5L	0.0291
			Average:	0.0221
PBO Study 2	32	46188605	1-1L	0.0078
			1-1R	0.0185
			1-2L	0.0183
			1-2R	0.0206
			1-3L	0.0083
			1-3R	0.0411
			1-4L	0.0800
			1-4R	0.0368
			2-1L	0.0330
			2-1R	0.0348
			2-2L	0.0116
			2-2R	0.0128
			2-3L	0.0346
			2-3R	0.0881
			2-4L	0.0369
			2-4R	0.0297
			3-1L	0.0372
			3-1R	0.0174
			3-2L	0.0153
			3-2R	0.0108
			3-3L	0.0327

Table C-21: Residential Indoor Areas – Transferable Residue Data for Hard Surfaces				
Study	**N**	**MRID No.**	**Replicate**	**Fraction Transferred**
			3-3R	0.0184
			3-4L	0.0373
			3-4R	0.0192
			4-1L	0.0094
			4-1R	0.0069
			4-2L	0.0240
			4-2R	0.0269
			4-3L	0.0290
			4-3R	0.0277
			4-4L	0.0180
			4-4R	0.0522
			Average:	0.0280
PBO Study 3	4	46188628	1L	0.0043
			1R	0.0051
			2L	0.0064
			2R	0.0043
			Average:	0.0050
PBO Study 4	4	46188614	1L	0.0037
			1R	0.0047
			2L	0.0046
			2R	0.0039
			Average:	0.0042
Overall N:	50	46188625 46188605 46188628 46188614	Average:	0.0231
Pyrethrins Study 1	32	46188605	1-1L	0.0140
			1-1R	0.0316
			1-2L	0.0365
			1-2R	0.0411
			1-3L	0.0134
			1-3R	0.0776
			1-4L	0.1509
			1-4R	0.0657
			2-1L	0.0640
			2-1R	0.0684
			2-2L	0.0186
			2-2R	0.0258
			2-3L	0.0664
			2-3R	0.1610
			2-4L	0.0597
			2-4R	0.0496
			3-1L	0.0739
			3-1R	0.0336
			3-2L	0.0336
			3-2R	0.0217
			3-3L	0.0453
			3-3R	0.0313
			3-4L	0.0623
			3-4R	0.0306
			4-1L	0.0080
			4-1R	0.0109

Table C-21: Residential Indoor Areas – Transferable Residue Data for Hard Surfaces				
Study	**N**	**MRID No.**	**Replicate**	**Fraction Transferred**
			4-2L	0.0386
			4-2R	0.0440
			4-3L	0.0526
			4-3R	0.0526
			4-4L	0.0351
			4-4R	0.0912
			Average:	0.0503
Pyrethrins Study 2	4	46188614	1L	0.0075
			1R	0.0097
			2L	0.0092
			2R	0.0067
			Average:	0.0083
Overall N:	36	46188605 46188614	Average:	0.0083

Table C-22: Summary Data for Transferable Residue for Hard Surfaces						
Source	**Chemical**	**N**	**Mu**	**Sigma**	**Geomean**	**GSD**
Beamer et al, 2008	chlorpyrifos	42	-3.30	0.85	0.04	2.34
	Pyrethrins I	30	-3.66	0.96	0.03	2.61
	PBO	42	-3.63	0.81	0.03	2.25
NDETF data	deltamethrin	10	-3.24	0.59	0.04	1.80
	permethrin	14	-3.87	0.72	0.02	2.06
	PBO	50	-4.05	0.80	0.02	2.22
	pyrethrin	36	-3.38	0.83	0.03	2.29

Historically, environmental data such as surface residue typically follow a lognormal distribution. Lognormal probability plots for the fraction transferred for indoor hard surfaces in *Table C-21* are presented below in *Figure C-11* and *Figure C-12*.

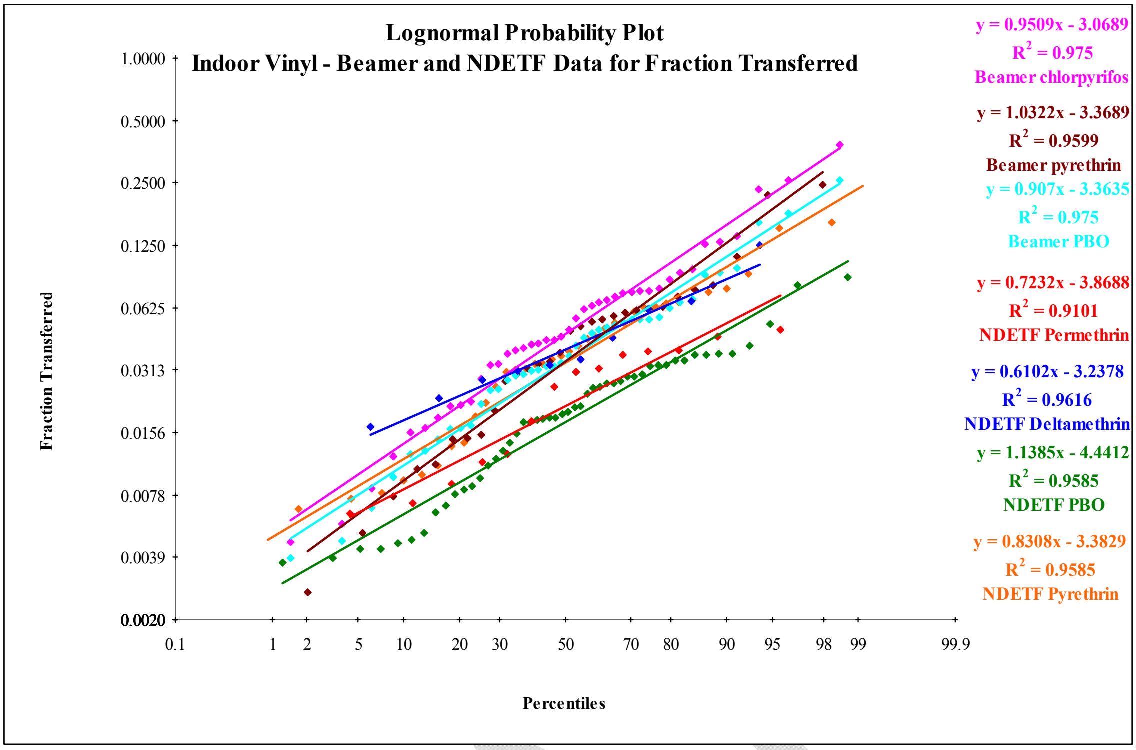

Figure C-11: Indoor Vinyl – Fraction of Transferable Residue, By Study (Beamer et al., 2008 and NDETF) and Chemical

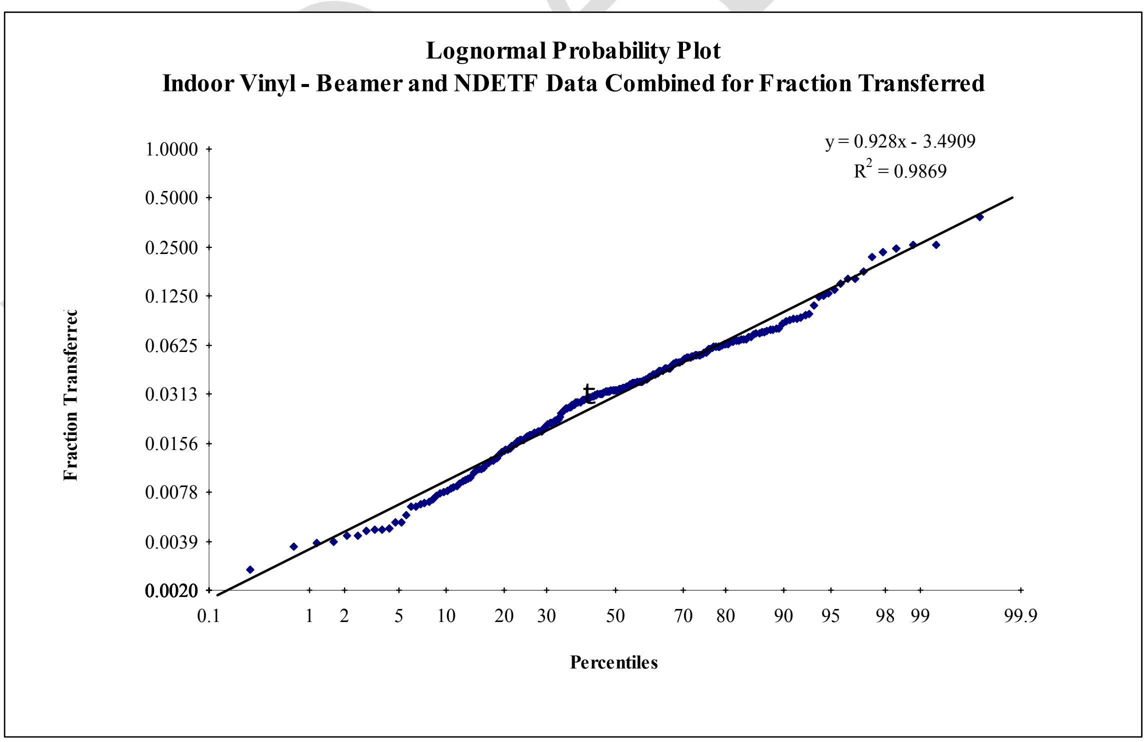

Figure C-12: Indoor Vinyl – Fraction of Transferable Residue Combined Data (Beamer et al., 2008, NDETF) Lognormal Probability Plot

Table C-23: Residential Indoor Areas Statistical Summary – Fraction Transferred (F) for Hard Surfaces	
Statistic	Fraction Transferred
50th percentile	0.03
75th percentile	0.06
95th percentile	0.14
99th percentile	0.26
99.9th percentile	0.54
Arithmetic Mean	0.047
Standard Deviation	0.30
Geometric Mean	0.03
Geometric Standard Deviation	2.53
Range	0.003 - 0.382
N	224

C.6.4 Pets

If chemical specific TR measurements are not available, then a generic value for the fraction of active ingredient available for transfer is used. In this SOP, a default F_{AR} was selected based on the review of 5 petting studies submitted to the Agency. Measurements of residue availability were derived by taking the ratio of the amount of active ingredient on a bare or gloved hand (on the day of application) to the amount of active ingredient applied. Petting studies were performed by means of volunteers "petting" or "stroking" animals treated with a known amount of active ingredient and determining the amount of residue transferred to the hands. F_{AR} studies varied in the number, location and intensity of petting and stroking actions. All 5 petting studies were reviewed for ethical conduct and no barriers were identified in law or regulation for their being relied upon by the Agency. *Table C-24* provides a statistical summary of F_{AR} data available for transfer distribution.

All but one petting studies used in the selection of F_{AR} were conducted with a liquid formulation application method (i.e., aerosol and pump sprays, dip, shampoo and spot-on). The study, "Determination of the Dislodgeability of Tetrachlorvinphos (TCVP) from the Fur of Dogs Following the Application of an Insecticide Powder, Pump Spray or Aerosol (MRID 45485501)" includes a segment which was conducted to analyze a solid formulation application method, powder. While these data are the only identified by the Agency which are specific to solid formulations, several issues preclude their use. The data resulting from the powder dislodgeability study segment consist of a sample size of 5 (N = 5). In contrast, the data available for all liquid formulation application methods combined consist of a sample size of 91 (N = 91). Furthermore, the mean F_{AR} values resulting for the solid and combined liquid formulations are 0.00031 and 0.0054, respectively. The Agency recognizes that the physical differences between the solid and liquid formulations may account for the observed comparison; however, the small sample size of the solid formulation data and the large difference observed in anticipated F_{AR} (order of magnitude), limit the reliability of the data set. Therefore, the Agency has identified the liquid formulation F_{AR} data set as the most reliable for the assessment of post-application exposure from treated pets for all formulations assessed.

Note: The F_{AR} distribution is only meant as a basis for selecting a generic estimate for the TR on the day of application as a fraction of the application rate and they are inappropriate for probabilistic use. Because the data are comprised of a variety of chemicals, under a variety of conditions; this distribution represents the variability of many different situations. Within each particular TR study, the distribution of the TR on the day of application as a fraction of the application rate is much less variable; for a given chemical the range may be only 0.1-0.7%; not 0.06 to 3.1%. Furthermore, because the chemical-specific variability of this fraction is small, a distribution for probabilistic use is unnecessary (i.e., it will not have much effect on the outcome) and a point estimate is appropriate for use in both deterministic and probabilistic assessments.

Table C-24: Dermal Exposure Fraction of Application Rate (F_{AR})

Statistic	Dermal Exposure Fraction of Application Rate
50th Percentile	0.0045
75th Percentile	0.0069
95th Percentile	0.012
99th Percentile	0.022
99.9th Percentile	0.030
Arithmetic Mean	0.0054
SD	0.0043
Range	0.0006 – 0.0312

Description of Available Studies Used for Dermal Exposure Fraction of Application Rate (F_{AR})

Below is a description of the available studies used to determine the input values for F_{AR}.

Table C-25: Available Exposure Study Identification Information

Citation	Hughes, D.L. (1997). Dislodgeable Residues of Fipronil Following Application of Frontline® Spray Treatment to Dogs
EPA MRID	44433306
EPA Review	Contractor (Versar, Inc.) review 4/30/98
MRID = Master Record Identification ORETF = Outdoor Residential Exposure Task Force	

Table C-26: Available Exposure Study Identification Information

Citation	Hughes, D.L. (1997). Dislodgeable Residues of Fipronil Following Application of Frontline® Spray Treatment to Cats
EPA MRID	44433307
EPA Review	Contractor (Versar, Inc.) review 4/30/98
MRID = Master Record Identification	

Two post-application studies, the "Dislodgeable Residues of Fipronil Following Application of Frontline Spray Treatment to Dogs" (MRID 44433306), and the "Dislodgeable Residues of Fipronil Following Application of Frontline Spray Treatment to Cats" (MRID 44433307) were conducted to examine dislodgeable residues of fipronil, the active ingredient of Frontline®, on the hair coats of dogs and cats, respectively, following their treatment with the pesticide.

The dislodgeability residues of fipronil was studied in 10 female dogs (5 short-haired dogs and 5 long-haired dogs) weighing 9.5 to 19.2 kg and 5 female cats (varying hair lengths) weighing 2.8 to 3.5 kg after a topical application of Frontline® Spray Treatment. Dogs and cats were topically treated with the Frontline® spray treatment. Each animal received one treatment on Day 1 with the maximum label rate of 6 mL of product per kg of body weight.

Dye free 100 percent cotton gloves were used for collecting residues at the following sampling time intervals: before dosing; 2, 4, and 12 hours after dosing; and 2, 3, 5, 8, 15, 22, and 29 days after dosing. A total of five strokes were applied which uniform medium pressure to each dog and a total of four strokes were applied to each cat to cover the whole body surface at each sampling interval. One glove was used for each test animal at each of the sampling intervals.

The residue levels of fipronil in each glove were reported and used for calculating the percent of dislodgeable residues. The percent of dislodgeable residues was calculated based on the total residues levels divided by the actual amount of fipronil sprayed for each treatment. Most of the laboratory recoveries for both studies fell within the range of 70 -120 %.

Table C-27: Available Exposure Study Identification Information	
Citation	McKeown, K. (2001). Determination of the Dislodgeability of Tetrachlorvinphos (TCVP) from the Fur of Dogs Following the Application of an Insecticide Powder, Pump Spray or Aerosol
EPA MRID	45485501
EPA Review	D277543
	Contractor (Versar, Inc.) review 11/19/2001
MRID = Master Record Identification	

The study, "Determination of the Dislodgeability of Tetrachlorvinphos (TCVP) from the Fur of Dogs Following the Application of an Insecticide Powder, Pump Spray or Aerosol," was conducted to determine the potential for TCVP to become dislodged from an animal and be available for human exposure. This study provides data on the amount of TCVP dislodged by the human hand when stroking a dog following the application onto the dog of an aerosol, spray, or powder product.

The study determined the total amount of TCVP on the fur of 5 dogs after a single treatment by one of three types of product (aerosol, powder and pump spray) applied according to label direction. The study concurrently determined the amount of TCVP which was dislodged onto the hand from 5 strokes of the full length of the animals' body. Both of these parameters were measured at baseline and at 4 hours, 1 day, 2 days, 4 days, 8 days, 16 days and 32 days after treatment (DAT). The study used three types of products, each with different delivery systems, the application by 5 different applicators, and the use of 5 different dogs.

The study used a "split-back" methodology. In this methodology, one side of the dog's back is stroked by a human hand to determine dislodgeability residues of TCVP, and samples of fur are taken from the opposite side of the dog's back to determine total residues of TCVP. This study uses the bare human hand to model the dislodgeability rather than a cotton glove. Fortified sample recoveries were in an acceptable range and no significant QA/QC problems were identified. The study results are similar or lower to the findings found in the earlier study where a cotton glove was used.

Table C-28: Available Exposure Study Identification Information	
Citation	Brickel, P. et al. (1997). Dislodgeable Residues of Fipronil Following Topical

Table C-28: Available Exposure Study Identification Information	
	Application of Frontline® Spot-on Treatment to Dogs
EPA MRID	44531203
EPA Review	Contractor (Versar, Inc.) review 1/9/2008
MRID = Master Record Identification	

The study, "Dislodgeable Residues of Fipronil Following Topical Application of Frontline® Spot-on Treatment to Dogs, was conducted to measure the dislodgeability of the test substance, Frontline®", over time from the haircoat of dogs treated with a spot-on formulation containing fipronil as the active ingredient. The test substance was administered to six Beagle dogs by topical application to the back (between the shoulders) using ready-to-use pipettes intended for commercial application. Each dog received a maximum label specified application dose of 1.34 mL (131,722 µg ai) of the test product on Day 0. The subsequent field sampling consisted of stroking the entire body surface of the dog by taking 5 strokes along the body of the dog using the palmar surface of one hand, while wearing cotton gloves to collect the residues. Glove samples were collected from each dog prior to treatment and at 10 intervals following treatment (1 hr to 28 days).

The cotton gloves were analyzed for fipronil and the results were reported as µg/glove fipronil per glove. None of the residues were corrected since average recoveries of fipronil were greater than 90%. In addition, the Registrant reported the percent of the applied dose that was dislodgeable at each sampling period after application.

Table C-29: Available Exposure Study Identification Information	
Citation	Bach, T. (2002). Stroking Test in Dogs After Topical Application of Imidacloprid 10% (w/v) + Permethrin 50% (w/v) Spot-On
EPA MRID	46594103
EPA Review	Contractor (Versar, Inc.) review
MRID = Master Record Identification	

The purpose of this study was to measure the dislodgeability of the test substance (imidacloprid and permethrin) from the haircoat of dogs treated with a spot-on formulation. The substance was applied to beagle dogs by topical application to the back (spine) using pipettes intended for commercial application. The test substance was applied in a quantity of 2.5 ml to each animal in the study, with each receiving a dose equivalent to 250 mg imidacloprid and 1250 mg permethrin. Residues were collected to assess post-application exposure to the treated dogs by stroking the dogs 3 times from head to tail over the application areas while wearing absorbent cotton gloves. "Medium" pressure was applied for each stroking procedure. Samples were collected at intervals of 30 minutes, 2 hours, 12 hours, and 24 hours after application. Four groups of 5 beagle dogs were established, and each group was sampled for one of the 4 sampling intervals only. Dog weights ranged between 10 and 25 kg. The limit of quantitation (LOQ) for imidacloprid was determined to be 0.25 mg/glove and 1.25 mg/glove for permethrin. If individual sample results were below the LOQ, 1/2 the LOQ for the chemical was used for quantitative purposes.

Data Summary for Available Studies for F_{AR}

Summary: *Table C-30* summarizes pertinent exposure information from the above referenced petting/transfer studies *Table C-13* and *Table C-14* are graphical representations of lognormal probability plots for all study data sets identified for use in development of the F_{AR} input presented individually and combined, respectively.

Table C-30: Fraction Application Rate (F_{AR}) Transferred

Study	MRID	N	Fraction Application Rate Transferred
Dislodgeable Residues of Fipronil Following Application of Frontline® Spray Treatment to Dogs	44433306	30	0.0041
			0.0052
			0.0053
			0.0088
			0.011
			0.012
			0.0067
			0.0076
			0.0081
			0.0043
			0.0049
			0.0047
			0.0076
			0.0099
			0.015
			0.0061
			0.0069
			0.0047
			0.0070
			0.0072
			0.0058
			0.0045
			0.0038
			0.0045
			0.0055
			0.0077
			0.0071
			0.0056
			0.0088
			0.0076
Average			*0.0069*
Dislodgeable Residues of Fipronil Following Application of Frontline® Spray Treatment to Cats	44433307	15	0.0021
			0.0036
			0.0030
			0.0034
			0.0047
			0.0021
			0.0046
			0.0055
			0.0044
			0.0056
			0.0020
			0.0036
			0.0049
			0.0028

Table C-30: Fraction Application Rate (F_{AR}) Transferred			
			0.0059
		Average	0.0039
Determination of the Dislodgeability of Tetrachlorvinphos (TCVP) from the Fur of Dogs Following the Application of an Insecticide Powder, Pump Spray or Aerosol	45485501	10	Aerosol/ Pump Spray
			0.0056
			0.0029
			0.0035
			0.0084
			0.0035
			0.0034
			0.0038
			0.0028
			0.0025
			0.0022
Average			0.0030
Dislodgeable Residues of Fipronil Following Topical Application of Frontline® Spot-on Treatment to Dogs	44531203	18	0.0018
			0.0068
			0.0044
			0.0021
			0.0061
			0.0047
			0.0010
			0.0039
			0.0022
			0.031
			0.021
			0.0069
			0.0092
			0.011
			0.0046
			0.0032
			0.013
			0.0043
Average			*0.0076*
Stroking Test in Dogs After Topical Application of Imidacloprid 10% (w/v) + Permethrin 50% (w/v) Spot-On	46594103	18	0.0016
			0.0016
			0.0010
			0.0062
			0.0010
			0.0018
			0.0040
			0.0033
			0.0024
			0.0042
			0.0013
			0.0015
			0.0070
			0.0016
			0.0032
			0.0023
			0.0024
			0.0026
Average			*0.0027*

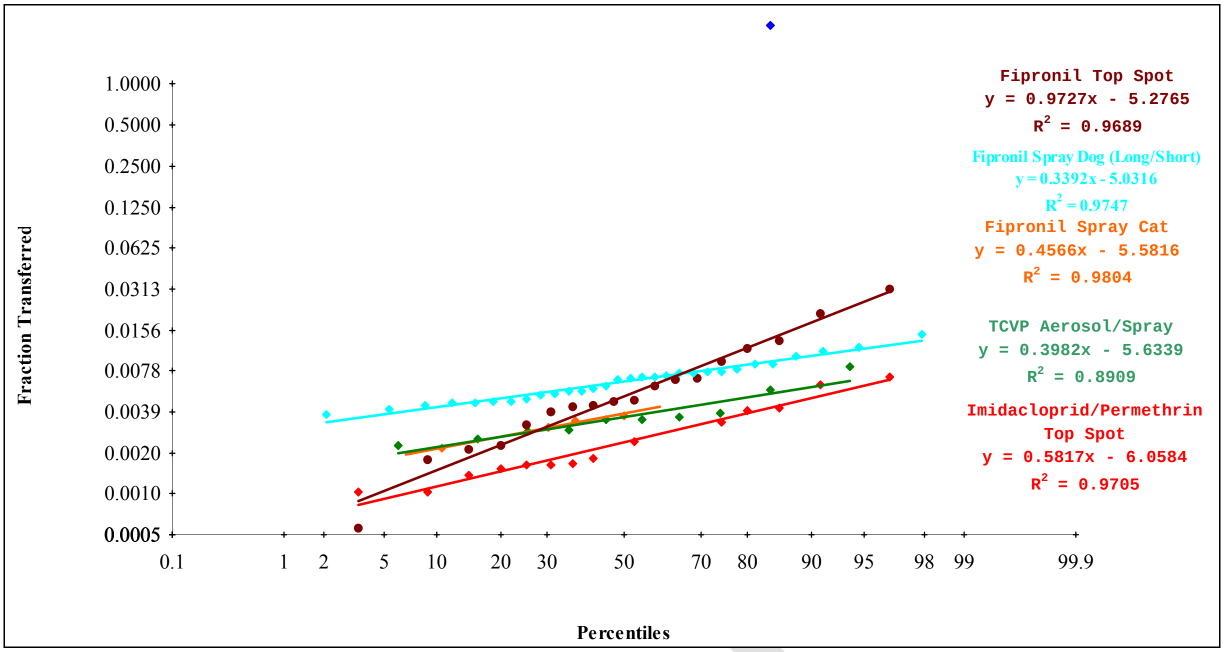

Figure C-13: Lognormal Probability Plots for Fraction of Application Rate Transferred from Separate Petting Data Sets

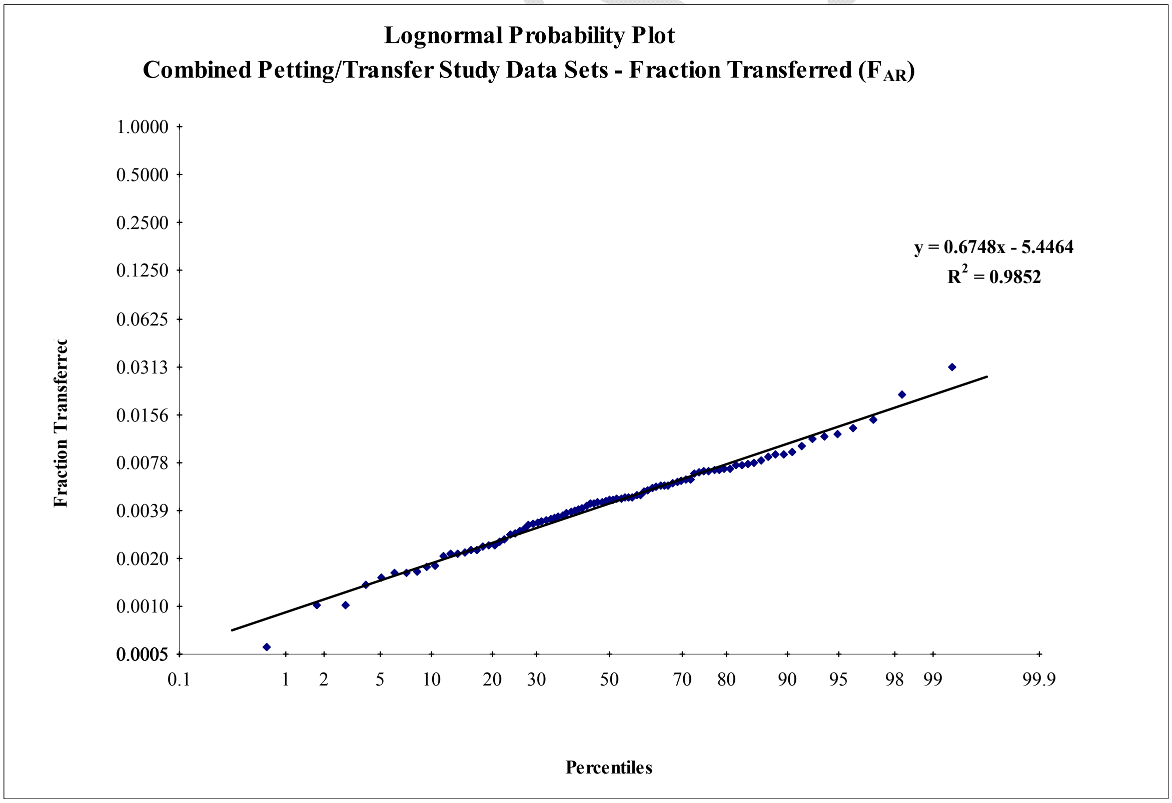

Figure C-14: Lognormal Probability Plots for Fraction of Application Rate Transferred from Combined Petting Data Sets

Development of Input Value for Dissipation

Short-term post-application exposure is typically assessed on the same day the pesticide is applied (day 0) since it is assumed that individuals could be exposed to pets immediately after application. Exposure is also likely to occur for longer (intermediate-/long-term) durations. In these cases, it is necessary to use a pesticide dissipation rate (d) to estimate a range of anticipated risk for the treatment period. If no chemical-specific dissipation data are available, a default value should be used. A default of 14% (0.014) dissipation per day was determined based upon the review of the same dermal post-application exposure studies identified to determine F_{AR}.

The study, "Stroking Test in Dogs After Topical Application of Imidacloprid 10% (w/v) + Permethrin 50% (w/v) Spot-On (MRID 46594103)" was not included, however, since the sampling period did not exceed one day and, therefore, is not an adequate period of time to fully analyze dissipation. All other studies measured pesticide residues from 16 to 32 days after application. A description of each study is included in the previous section, Fraction of Application Rate (F_{AR}). *Table C-31* below provides a statistical summary of d data resulting from data analysis.

No studies were identified for collars for which dissipation data could be derived. Unlike the other pet product application methods which have shorter treatment intervals and dissipate rapidly, collars are intended to be affective for longer intervals and, likewise, emit at a more constant rate. Therefore, dissipation is not anticipated for collars and should not be accounted for when assessing longer term durations of exposure.

In order to estimate the daily dissipation rate for residue values resulting from each study, an average value was derived from all data points for each time point sampled. A regression analysis was then performed resulting in a prediction of daily percent dissipation.

Table C-31: Pet Insecticide Daily Dissipation Rate (d)

Statistic	Pet Insecticide Daily Dissipation Rate (d)
50th Percentile	0.14
75th Percentile	0.17
95th Percentile	0.18
99th Percentile	0.18
99.9th Percentile	0.18
Arithmetic Mean	0.14
SD	0.034
Range	0.098 – 0.18

Table C-32: Daily Dissipation Rate (d) – Pet Products

Study	MRID	Time (days)	Average Residue (mg)	Daily Dissipation Rate
Dislodgeable Residues of Fipronil Following Application of Frontline® Spray Treatment to Dogs - Short Hair	44433306	0.083	0.92	0.10
		0.167	1.1	
		0.5	1.3	
		2	0.98	
		3	0.71	
		5	0.43	

Table C-32: Daily Dissipation Rate (d) – Pet Products				
Study	**MRID**	**Time (days)**	**Average Residue (mg)**	**Daily Dissipation Rate**
		8	0.29	
		15	0.24	
		22	0.093	
		29	0.049	
Dislodgeable Residues of Fipronil Following Application of Frontline® Spray Treatment to Dogs - Long Hair	44433306	0.083	1.4	0.098
		0.167	1.7	
		0.5	1.5	
		2	1.3	
		3	0.87	
		5	0.67	
		8	0.36	
		15	0.17	
		22	0.075	
		29	0.039	
Dislodgeable Residues of Fipronil Following Application of Frontline® Spray Treatment to Cats	44433307	0.083	0.17	0.13
		0.167	0.23	
		0.5	0.20	
		2	0.19	
		3	0.082	
		5	0.030	
		8	0.010	
		15	0.0057	
		22	0.0057	
		29	0.0057	
Determination of the Dislodgeability of Tetrachlorvinphos (TCVP) from the Fur of Dogs Following the Application of an Insecticide Powder, Pump Spray or Aerosol – Pump Spray	45485501	0.17	1.7	0.19
		1	0.87	
		2	0.32	
		4	0.071	
		8	0.019	
		16	0.002	
		32	0.002	
Determination of the Dislodgeability of Tetrachlorvinphos (TCVP) from the Fur of Dogs Following the Application of an Insecticide Powder, Pump Spray or Aerosol – Aerosol	45485501	0.17	1.3	0.18
		1	0.83	
		2	0.70	
		4	0.19	
		8	0.026	
		16	0.038	
		32	0.033	
Dislodgeable Residues of Fipronil Following Topical Application of Frontline® Spot-on Treatment to Dogs	44531203	0.04	1.1	0.17
		1.17	1.4	
		0.33	0.60	
		1	0.63	
		2	0.59	
		4	0.29	
		7	0.21	
		14	0.047	

Table C-32: Daily Dissipation Rate (d) – Pet Products				
Study	**MRID**	**Time (days)**	**Average Residue (mg)**	**Daily Dissipation Rate**
		21	0.021	
		28	0.0047	

C.7 Generic Estimates of Residential Transfer Coefficients

A transfer coefficient is a measure of surface-to-skin residue transfer dependent on factors such as surface type and contact intensity. It is derived from concurrent measurements of exposure and foliar residue, and is the ratio of exposure, measured in mass of chemical per time (e.g., ug/hr), to residue, measured in mass of chemical per foliar surface area (e.g., ug/cm2), with resulting units cm^2/hr. It follows that the use of this ratio precludes the necessity to measure exposure because it can be reasonably predicted from measured residue using a scenario-specific transfer coefficient. Additionally, based on analysis of various studies, it is apparent that transfer coefficients differ based on different activities and scenarios. For example, the transfer of residues while harvesting apples is different than while weeding cabbage; or a child playing on a treated carpet experiences a different level of residue transfer than a child playing on a treated lawn.

Chemical- and scenario-specific exposure measurements are preferable to predicting exposure using residue and transfer coefficients. However, in the event chemical- and scenario-specific exposure data are unavailable, generic transfer coefficients have been derived for use in specific residential situations.

C.7.1 Turf

Residential Turf Exposure

Data to adequately characterize exposure for individuals who contact previously treated residential turf are scarce. However, a residential re-entry exposure study is available to establish reliable transfer coefficients for representative activities in residential settings. This study (D. Klonne and D. Johnson, MRID 47292001) was conducted by the Outdoor Residential Exposure Task Force (ORETF) to determine dermal exposure to residents re-entering a treated turf plot after granular and liquid applications.

Two types of re-entry activities were monitored in the study. The first activity was an approximate 20-minute Jazzercise routine (represented by JAZZ) and the second activity was an approximate 2-hour composite routine consisting of many typical children's activities (represented by CHAPS). The Jazzercise routine is a highly choreographed routine of exercises performed to music. The CHAPS routine is a series of 12 sequential activities that simulated activities in which children routinely engage on residential turf. The activities were selected from activities listed in the National Human Activity Pattern Survey (NHAPS) for children aged 1 to 12 years (Klepeis, et. al., 2001). *Table C-33* summarizes the activities and the time allotted for each activity.

Table C-33: Summary of the Activities and the Duration for Each Activity		
Activity Group	**Activity**	**Duration (minutes)**
Passive	Walking/Jogging	12
	Playing catch	12
	Crawling	12
	Picnicking	12
	Resting	12

Active	Playing with toys	8
	Playing Frisbee	8
	Playing soccer	8
	Playing games (spud)	8
	Playing tag (steal the bacon)	8
Hard Direct	Football	10
	Tumbling	10

A total of 40 participants were used in this study. For each formulation, 20 participants (10 participants each during a morning and afternoon session) performed the JAZZ routine and 20 participants (10 participants each during a morning and afternoon session) performed the CHAPS routine. A two hour duration was chosen for the CHAPS routine because the NHAPS indicated that the upper-bound estimate of time children spend playing on turf is two hours per day. The potential dermal exposure during re-entry was assessed by using whole-body dosimetry (inner and outer dosimeters), socks (JAZZ only), foot washes (CHAPS only), hand washes, and face/neck wipes.

There were decreases in the residue levels between the morning and afternoon sessions for both the JAZZ and CHAPS routines for the liquid formulation. The data obtained on the first part of the day are more robust because turf residues during the second part of the day were artificially altered using a helicopter. Therefore, only measurements from the first part of the day were used in the transfer coefficient calculations.

Dermal transfer coefficients in cm^2/hr were calculated by dividing the corrected residue value (µg) by the replicate duration (hr) and by the formulation-specific turf transferable residue value (µg/cm^2). Within a given activity, total dermal dose (µg) was always lower for the granular formulation than the liquid formulation. Across each formulation, the normalized transfer coefficients (µg/hr) for the CHAPS routine were consistently higher than the JAZZ routine. *Table C-34* presents the raw transfer coefficient data for both the liquid and granular formulation.

Table C-34: Liquid and Granular Formulation TC Data Used for Dermal Scenarios (shoes)				
Population	**Formulation**	**TC Values (cm^2/hr)**	**Formulation**	**TC Values (cm^2/hr)**
Adult	Liquid	112,133	Granular	137,245
		138,525		150,510
		139,625		157,653
		148,625		162,245
		174,375		174,490
		195,858		190,561
		219,742		191,071
		220,767		197,959
		224,417		198,724
		261,175		246,684

All transfer coefficient values are expressed as square centimeters per hour (cm^2/hr). Each adult transfer coefficient was log-transformed and plotted to evaluate its fit to a lognormal distribution. The data appears to reasonably fit a lognormal distribution as shown in the figure below. This analysis also allowed for the assessment of the statistical differences between the transfer coefficients calculated using the liquid data vs. the granular data. It was determined that these two distributions should not be combined because the upper percentile values were 25% higher for the granular transfer coefficients vs. the liquid transfer coefficients even though the central tendency values of the two distributions were similar.

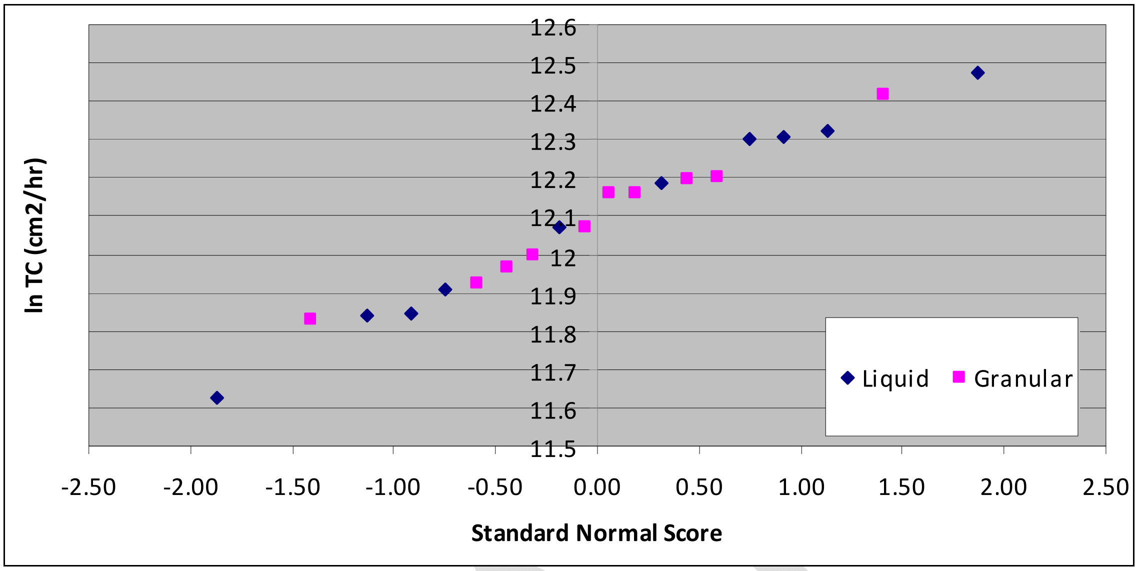

Figure C-15: Residential Turf Transfer Coefficient Lognormal Probability Plot

Statistics such as standard deviations and select percentiles are presented in *Table C-35* below. The transfer coefficients presented above represent adults only. For toddlers, the Agency adjusted the transfer coefficient for body surface area. This calculation uses the value of 0.76 m^2 for the 3 to <6 age group (mean surface area) from the Child-Specific Exposure Factors Handbook (USEPA, 2008) and the value of 1.815 m^2 (the average of mean total surface area for males of 1.94 m^2 and for females 1.69 m^2) from the Exposure Factors Handbook (USEPA, 1997). This results in a 58% reduction factor (0.76 m^2/1.815 m^2). *Table C-35* provides some summary statistical information about the turf dermal transfer coefficients for both adults and toddlers.

Table C-35: Dermal Exposure Transfer Coefficients (T-shirt and Shorts) for Individuals Performing CHAPS Activities				
Statistic	Liquid Transfer Coefficient (cm^2/hr) [1]		Granular Transfer Coefficient (cm^2/hr) [2]	
	Toddler [3]	Adult	Toddler [3]	Adult
50th percentile	75,000	180,000	74,000	180,000
75th percentile	84,000	200,000	90,000	220,000
90th percentile	94,000	220,000	110,000	260,000
95th percentile	100,000	240,000	120,000	280,000
99th percentile	110,000	270,000	140,000	340,000
99.9th percentile	130,000	310,000	180,000	430,000
Arithmetic Mean	77,000	180,000	76,000	180,000
Arithmetic Mean Standard Deviation	NA	31,000	NA	48,000
Geometric Mean	74,000	180,000	75,000	180,000
Geometric Mean Standard Deviation	NA	1.2	NA	1.3
Range	NA	112,133–261,175	NA	137,245–246,684

1 The liquid transfer coefficient distribution consists of 10 observations.
2 The granular transfer coefficient distribution consists of 10 observations.
3 A 58% reduction in the adult transfer coefficient is recommended to justify the differences of body surface areas between adults and toddlers (3 to <6 years old).

Golf Course Exposure

Data to adequately characterize exposure for individuals who contact previously treated turf while golfing are unavailable. However, an occupational re-entry exposure study is available to establish reliable transfer coefficients for representative golfing activities. This study (D. Klonne and E. Bruce, MRID 46734001) was conducted by the Agricultural Reentry Task Force (ARTF) to determine dermal exposure to golf course maintenance workers re-entering a treated turf plot after liquid applications. The cup changing component of this study was used to represent dermal exposure to previously treated turf while golfing.

The cup changing activity consisted of using a hand operated cup cutter to make a new hole, taking the plastic cup liner from the old hole and putting it into the new hole, and filling the old hole with sand and the plug from the new hole. A total of 6 participants were used in this study. Most workers performed the cup changing while bending over and not contacting the turf with anything, but their shoes and hands; however, one worker routinely kneeled on one knee and two other workers kneeled for a few holes. Some cup changers also repaired ball marks on the greens with a hand tool similar to those used by golfers but only one individual performed significant ball mark repair (79 instances). Cup changing occurred first thing in the morning and a monitoring replicate consisted of changing 18 cups. This task took approximately 1.5 to 2.5 hours, including 33 to 110 minutes changing the cups, 43 to 52 minutes traveling between holes, and 0 to 20 minutes spent resting, talking to other workers, or performing tasks other than cup changing.

Dermal transfer coefficients in cm^2/hr were calculated by dividing the corrected residue value (µg) by the replicate duration (hr) and by the worker-specific turf transferable residue value (µg/cm^2). Total dermal transfer coefficients were calculated for three clothing scenarios: (1) wearing long pants and a long sleeved shirt, (2) wearing long pants and a t-shirt, and (3) wearing shorts and a t-shirt. *Table C-36* presents the transfer coefficient data for the shorts and t-shirt clothing scenario.

Table C-36: Dermal Exposure Transfer Coefficients (T-shirt and Shorts) for Individuals Golfing

Population	TC Values (cm^2/hr)
Adult	988
	1,097
	1,253
	2,667
	7,165
	18,863

All transfer coefficient values are expressed as square centimeters per hour (cm^2/hr). Each adult transfer coefficient was log-transformed and plotted to evaluate its fit to a lognormal distribution. The data appears to reasonably fit a lognormal distribution as shown in the figure below.

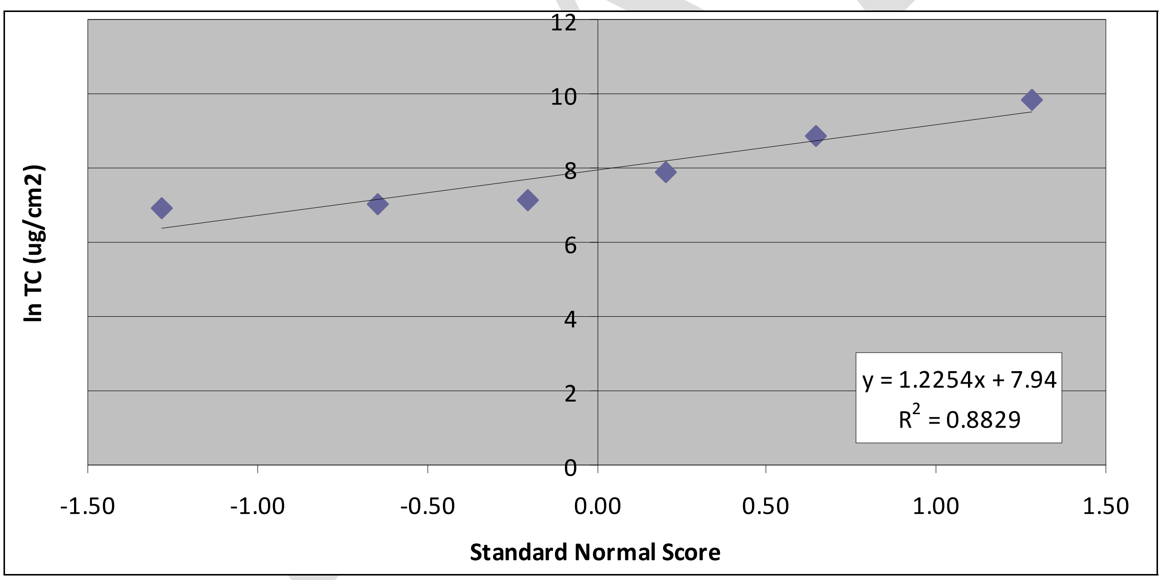

Figure C-16: Golfing Turf Transfer Coefficient Lognormal Probability Plot

Statistics such as standard deviations and select percentiles are presented in *Table C-37* below.

Table C-37: Dermal Exposure Transfer Coefficients (T-shirt and Shorts) for Individuals Golfing

Statistic	Transfer Coefficient (cm^2/hr) [1]
50th percentile	2,800
75th percentile	6,400
95th percentile	21,000
99th percentile	49,000
99.9th percentile	120,000
Arithmetic Mean	5,300
Arithmetic Standard Deviation	7,000
Geometric Mean	2,800
Geometric Mean Standard Deviation	3.3
Range	988–18,863

Lawn Mowers Exposure

Data to adequately characterize exposure for individuals who contact previously treated turf while mowing are unavailable. However, an occupational re-entry exposure study is available to establish reliable transfer coefficients for representative mowing activities. This study (D. Klonne and E. Bruce, MRID 46734001) was conducted by the Agricultural Reentry Task Force (ARTF) to determine dermal exposure to golf course maintenance workers re-entering a treated turf plot after liquid applications. The mowing component of this study was used to represent dermal exposure to previously treated turf while mowing a residential lawn. The mowing activity consisted of two distinct types of mowing: mowing greens and mowing fairways.

The mowing greens activity consisted of using a walk-behind reel mower with a grass catcher to make two perpendicular passes to cut the green to 7/32-inch height. A total of 8 participants performed this activity in the study. This activity included emptying the grass catchers and spreading clippings in the rough areas around the golf course as well as hosing off the mower with water at the conclusion of mowing. Greens mowing occurred in the morning (after cups had been changed) and a monitoring replicate consisted of mowing 4 to 5 greens. This task took approximately 2 to 3 hours, including 89 to 140 minutes mowing or emptying baskets, 23 to 43 minutes traveling between holes, and 0 to 29 minutes spent resting, talking to other workers, or performing tasks other than mowing. When the mower was engaged, the workers walked briskly behind the mower to keep up. At the end of each pass, the worker pushed down on the mower handle to the lift the reel off the ground and quickly turned the mower around to make the next pass adjacent to the previous pass. Workers generally mowed in one direction, then the other, and then made a pass around the perimeter of the green to finish off the mowing process.

The mowing fairways activity consisted of using either a 5-reel riding mower to mow fairways to ¾ inch height or a 3-reel riding mower to mow tee boxes and surrounds (areas around the greens) to ½-inch height. A total of 8 participants performed these activities in the study. This activity included emptying the grass catchers of the mower and spreading clippings in the rough areas around the golf course as well as hosing off the mower with water at the conclusion of mowing. Fairway mowing occurred in the morning and a monitoring replicate consisted of mowing either 5 to 6 fairways or surrounds for 9 holes. This task took approximately 2 to 4.5 hours, including 96 to 253 minutes mowing fairway or surrounds, 11 to 30 minutes traveling, and 0 to 4 minutes talking to other workers or repairing motor. The workers generally mowed the fairways and surrounds in one of two patterns: 1) mow the perimeter, then back-and-forth or 2) in a "spiral" pattern, from the outside to inside. The mowers were operated at a low speed (3.5 miles per hour) since it was found that moist grass clippings were not efficiently "thrown" into the grass catchers if the speed was higher. When the grass was wet, the 5-reel mower would frequently get clumps of turf caught in the reel mechanisms, which would require the operator to lift the reels, stop the mower, get off, and clear the clipping from the reels with his hands and/or a stick. The workers would also occasionally dismount to remove debris or to move 150-yard markers.

Dermal transfer coefficients in cm^2/hr were calculated by dividing the corrected residue value (µg) by the replicate duration (hr) and by the worker-specific turf transferable residue value ($\mu g/cm^2$). Total dermal transfer coefficients were calculated for three clothing scenarios: (1) wearing long pants and a long sleeved shirt, (2) wearing long pants and a t-shirt, and (3) wearing shorts and a t-shirt. *Table C-38* presents the transfer coefficient data for the shorts and t-shirt clothing scenario.

Table C-38: Dermal Exposure Transfer Coefficients (T-shirt and Shorts) for Individuals Mowing

Population	Activity	TC Values (cm^2/hr)
Adult	Mowing Greens	661
		1,035
		2,245
		6,913
		1,982
		319
		25,860
		18,875
	Mowing Fairways	648
		6,616
		1,874
		2,369
		2,951
		1,109
		11,387
		3,031

All transfer coefficient values are expressed as square centimeters per hour (cm^2/hr). Each adult transfer coefficient was log-transformed and plotted to evaluate its fit to a lognormal distribution. The data appears to reasonably fit a lognormal distribution as shown in the figure below. This analysis also allowed for the assessment of the statistical differences between the transfer coefficients calculated using the mowing greens data vs. the mowing fairways data. Based on this analysis, it was determined that there was no statistical difference between these datasets and thus, in calculating the adult dermal mowing transfer coefficient the data were combined.

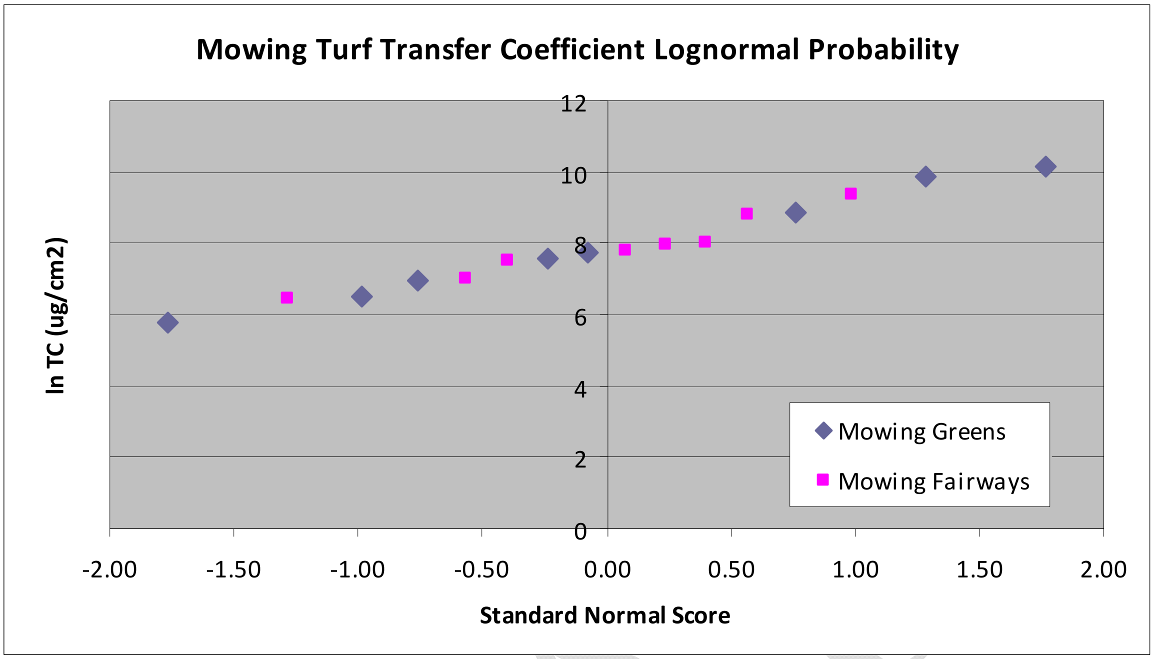

Figure C-17: Mowing Turf Transfer Coefficient Lognormal Probability Plot

Statistics such as standard deviations and select percentiles are presented in *Table C-39* below. The transfer coefficients presented above represent adults only. For youths/teens, the transfer coefficient is adjusted for body surface area by a factor of 0.87 (i.e., a 13% TC reduction) as outlined in Section 2.3. *Table C-39* provides some summary statistical information about the turf dermal transfer coefficients for both adults and toddlers.

Table C-39: Dermal Exposure Transfer Coefficients (T-shirt and Shorts) for Individuals Performing Mowing Activities

Statistic	Adult Transfer Coefficient (cm^2/hr) [1]	Youth/Teen Transfer Coefficient (cm^2/hr) [2]
50^{th} percentile	2,700	2,300
75^{th} percentile	6,300	5,600
95^{th} percentile	22,000	19,000
99^{th} percentile	54,000	47,000
99.9^{th} percentile	140,000	120,000
Arithmetic Mean	5,500 ± 7,300	4,800
Arithmetic Standard Deviation	7,300	NA
Geometric Mean	2,700	2,300
Geometric Mean Standard Deviation	3.5	NA
Range	319–25,860	NA

C.7.2 Gardens, Trees, and "Pick-your-own" Farms

Data to adequately characterize exposure for individuals who contact previously treated residential gardens and trees and in "pick-your-own" farms is unavailable. Therefore, occupational re-entry exposure studies, all conducted by the Agricultural Reentry Task Force (ARTF), were used to establish transfer coefficients for representative crops and activities in residential settings.

Unlike occupational settings where individuals generally perform one task (or, at most a few tasks) on a single crop throughout the day (e.g., harvesting apples), individuals in residential settings are likely to conduct various activities. Therefore, transfer coefficients from occupational reentry studies were used to establish composite transfer coefficients for distinct activities likely to occur in residential settings. Additionally, also unlike occupational settings, the transfer coefficients represent individuals wearing shorts and short-sleeve shirts, a standard assumption in residential exposure assessment.

Activities are divided between those that would occur in gardens (vegetable and flower), those that would occur with trees (fruit and nut trees and ornamental shrubs and bushes), and those that would occur for indoor plants. Transfer coefficients for each category are then derived from select occupational reentry exposure studies considered to be representative of "residential-like" activities. *Table C-40* below lists the occupational field reentry studies used to derive transfer coefficients for each of these scenarios.

Table C-40: Gardens, Trees, and "Pick-your-own" Farms – Transfer Coefficient Studies

Residential Post-application Activity	Representative Crop/Activity Combinations	Study Code	
		MRID	ARTF #
Gardens (vegetables and flowers)	Cabbage weeding	45191701	ARF037
	Tomato tying	45530103	ARF051
	Squash harvesting	45491902	ARF049
	Chrysanthemum pinching	45344501	ARF039
Trees and Retail Plants (fruits, nuts, ornamentals, shrubs, bushes)	Ornamental citrus tree pruning	45469501	ARF043
	Apple harvesting	45138202	ARF025
	Orange harvesting	45432302	ARF041
	Grapefruit harvesting	45432302	ARF042
Indoor Plants	Ornamental citrus tree pruning	45469501	ARF043

Despite the uncertainty of using occupational reentry monitoring studies, where workers likely conduct activities in a much different fashion than those in residential settings, the transfer coefficients outlined are considered reasonable for use in risk assessment. Note that use of these transfer coefficients for youths should be used in combination with an adjustment factor of 0.6 for body surface area.

Vegetable and Flower Gardening Activities at Home and at "Pick-your-own" Farms

Transfer coefficients for residential gardening and picking vegetables and flowers at "pick-your-own" farms were derived using studies considered adequately representative of activities in these settings such as weeding and picking vegetables and flowers. The studies used measured exposure for workers during four different studies: cabbage weeding, tomato tying, squash harvesting, and chrysanthemum pinching. *Table C-41* below presents the raw data for these studies.

Table C-41: Gardening at Home and at "Pick-your-own" Vegetable Farms: Transfer Coefficient Data

Study Reference		Crop	Activity	Person ID	DAA	Transfer Coefficient
ARTF #	MRID					
ARF037	45191701	Cabbage	Weeding	A	1	29,612
					2	41,329
					3	31,947
				B	1	19,910
					2	28,428
					3	24,226
				C	1	21,134
				D	1	24,149
					2	28,601
				E	2	16,482
					3	23,976
				F	2	29,683
					3	20,604
ARF051	45530103	Tomato	Tying	A	2	1,812
					3	3,999
				B	2	2,807
					3	5,040
					4	3,161
				C	2	2,349
					3	4,425
					4	2,292
				D	2	3,236
					3	6,810
					4	4,506
				E	2	2,448
					3	6,132
					4	3,479
				F	4	4,431
ARF049	45491902	Squash	Harvesting	A	2	1,395
					3	4,747
					4	3,043
				B	2	1,426
					3	6,800
					4	3,178
				C	2	1,121
					3	5,130
					4	3,195
				D	2	1,546
					3	5,042
					4	3,897
				E	2	887
					3	3,846
					4	2,550
				F	2	1,163
					3	7,411
					4	2,667
				G	2	1,326

Table C-41: Gardening at Home and at "Pick-your-own" Vegetable Farms: Transfer Coefficient Data						
Study Reference		Crop	Activity	Person ID	DAA	Transfer Coefficient
ARTF #	MRID					
					3	4,686
					4	3,642
				H	2	1,298
					3	5,466
					4	3,864
				D	2	424
					3	214
					4	177
				E	2	328
					3	299
					4	134
ARF039	45344501	Chrysanthemum	Pinching	A	1	164
					2	253
					3	223
				B	1	264
					2	422
					3	314
				C	1	250
					2	218
					3	241
				D	1	321
					2	492
					3	301
				E	1	218
					2	436
					3	201

Tree Activities at Home and at "Pick-your-own" Farms

Transfer coefficients for activities associated with fruit and nut trees and ornamental shrubs and bushes (including potential exposure from those purchased at retail locations) were derived using exposure studies for workers during four different studies: apple harvesting, orange harvesting, grapefruit harvesting, and ornamental citrus tree pruning. *Table C-42* below presents the raw data for these studies.

Table C-42: Tree Activities at Home and at "Pick-your-own" Farms: Transfer Coefficient Data						
Study Reference		Crop	Activity	Person ID	DAA	Transfer Coefficient
ARTF #	MRID					
ARF025	45138202	Apple	Harvesting	A	1	3132
					2	3207
					3	3033
				B	1	2596
					2	2741
					3	1931
				C	1	2547
					2	3323
					3	1927
				D	1	2865
					2	3161
					3	1873

Table C-42: Tree Activities at Home and at "Pick-your-own" Farms: Transfer Coefficient Data						
Study Reference		**Crop**	**Activity**	**Person ID**	**DAA**	**Transfer Coefficient**
ARTF #	**MRID**					
				E	1	2343
					2	3078
					3	1905
ARF041	45432301	Orange	Harvesting	A	5	1143
					6	1189
					7	1228
				B	5	1087
					6	1545
					7	1430
				C	5	1192
					6	1691
					7	1873
				D	5	1010
					6	2091
					7	1883
				E	5	978
					6	1983
					7	2026
ARF043	45469501	Nursery Citrus	Pruning	A	2	181
					3	146
					4	144
				B	2	505
					3	222
					4	113
				C	2	205
					3	150
					4	85
				D	2	424
					3	214
					4	177
				E	2	328
					3	299
					4	134
ARF042	45432302	Grapefruit	Harvesting	A	5	1960
					6	2008
					7	2177
				B	5	2044
					6	1822
					7	2530
				C	5	2832
					6	3188
					7	2609
				D	5	2690
					6	2579
					7	3312
				E	5	2706
					6	3358
					7	2539

Indoor Plant Activities

Transfer coefficients from the study measuring exposure while pruning ornamental citrus trees are recommended for use for activities associated with indoor plants. The data for this study is presented above in *Table C-42*.

Transfer Coefficient Data Analysis

Each transfer coefficient was log-transformed and plotted to evaluate its fit to a lognormal distribution. Each study appears to reasonably fit a lognormal distribution as shown in the figure below.

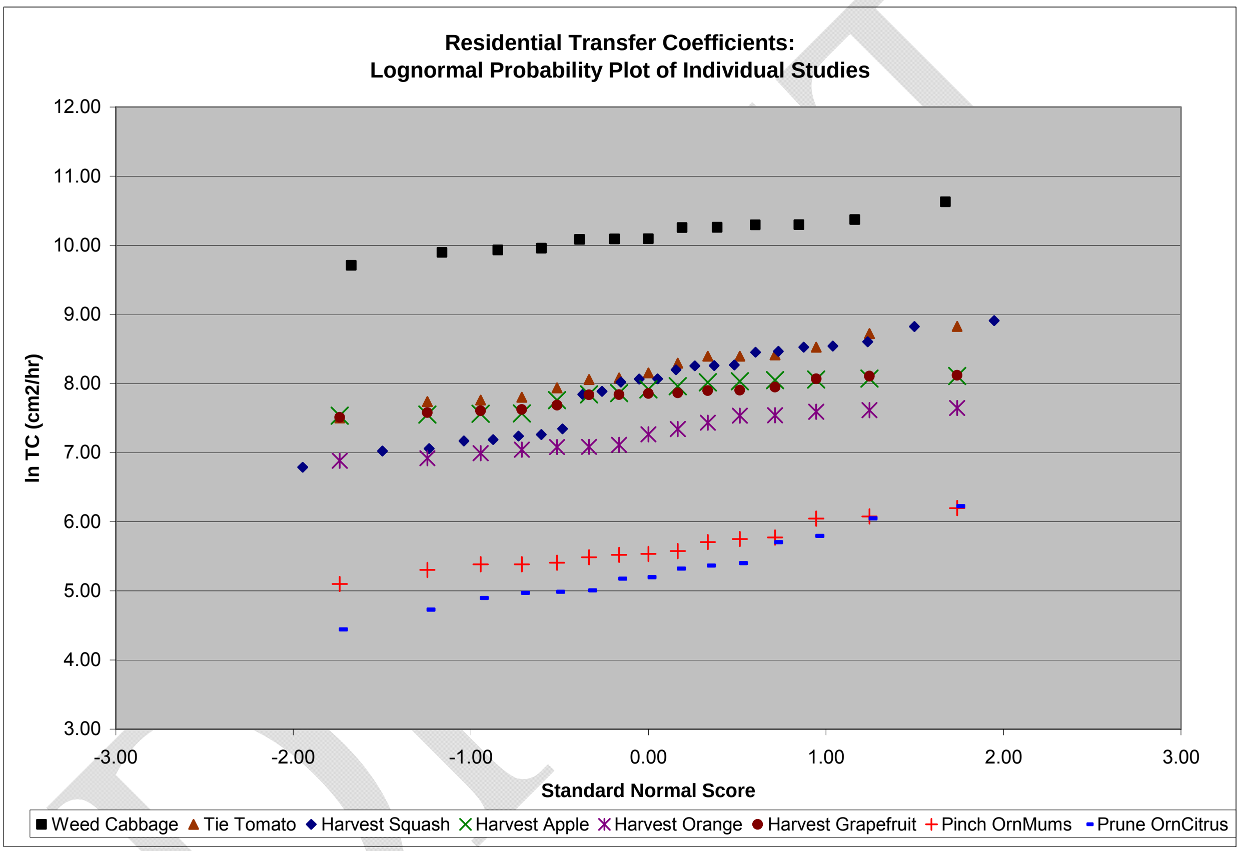

Figure C-18: Residential Transfer Coefficients: Lognormal Probability Plot of Individual Studies

As previously stated, unlike these occupational studies where workers conducted a single activity for the duration of their workday, homeowners tending to their outdoor gardens and trees and individuals attending "pick-your-own" are likely to conduct various activities. For example, it is likely that individuals would weed both their vegetable and flower gardens on the same day or trim their bushes and apple trees on the same day. In fact, it is likely that individuals would conduct some configuration of all outdoor activities on the same day. Note that in the case of indoor plants these activities are reasonably represented by ornamental citrus tree pruning alone.

For the purposes of pesticide assessment, however, where certain chemicals may only be used on gardens and trees, respectively, composite transfer coefficient distributions have been developed to represent activities in gardens and trees. These were derived by constructing, via a 5000 trial Monte Carlo simulation using Crystal Ball 4.0 (Microsoft Excel add-on), custom distributions using the lognormal distributions for each individual activity (*See Figure C-18*), but assigning equal probabilities for each activity. Essentially just a weighting mechanism, it assumes, for example while gardening, that an individual conducts "cabbage weeding-like," "squash harvesting-like," "tomato tying-like," and "chrysanthemum pinching-like" activities in equal proportions (i.e., 25% of the time spent conducting each). Additional data on specific gardening activities (or an exposure study representing actual homeowner gardening work) could confirm this assumption or inform a more accurate weight to each activity. Thus, absent exposure studies specific for activities in residential settings (e.g., a study in which individuals perform various activities following pesticides applications in various locations on their property), the approach outlined is considered reasonable.

Parameters for each lognormal distribution are outlined in *Table C-43* below.

Table C-43: Gardens, Trees, and "Pick-your-own" Farms – Transfer Coefficient Studies

Residential Post-application Activity	Representative Crop/Activity Combinations	Lognormal TC Distribution Parameters	
		GM	GSD
Gardening (vegetables and flowers)	Cabbage weeding	25,463	1.27
	Tomato tying	3,547	1.47
	Squash harvesting	2,774	1.89
	Chrysanthemum pinching	275	1.36
Tree maintenance (fruits, nuts, shrubs, bushes)	Ornamental citrus tree pruning	197	1.63
	Apple harvesting	2,591	1.24
	Orange harvesting	1,440	1.31
	Grapefruit harvesting	2,513	1.21

As previously stated, a composite distribution for activities in gardens and trees was simulated by assigning equal probabilities (i.e., 25% for each representative activity) to each single activity's distribution. The figures below present probability and cumulative density function for each of the resulting simulated distributions.

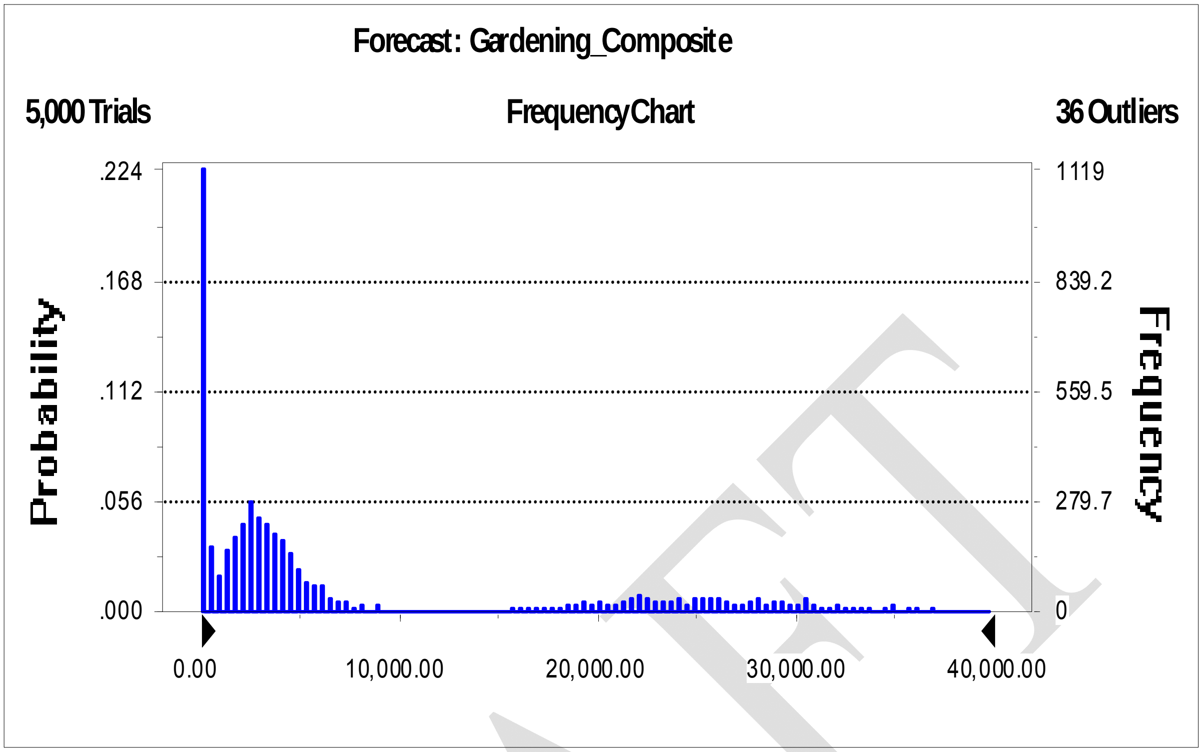

Figure C-19: Gardening Transfer Coefficient– Composite Probability Density Function Simulation

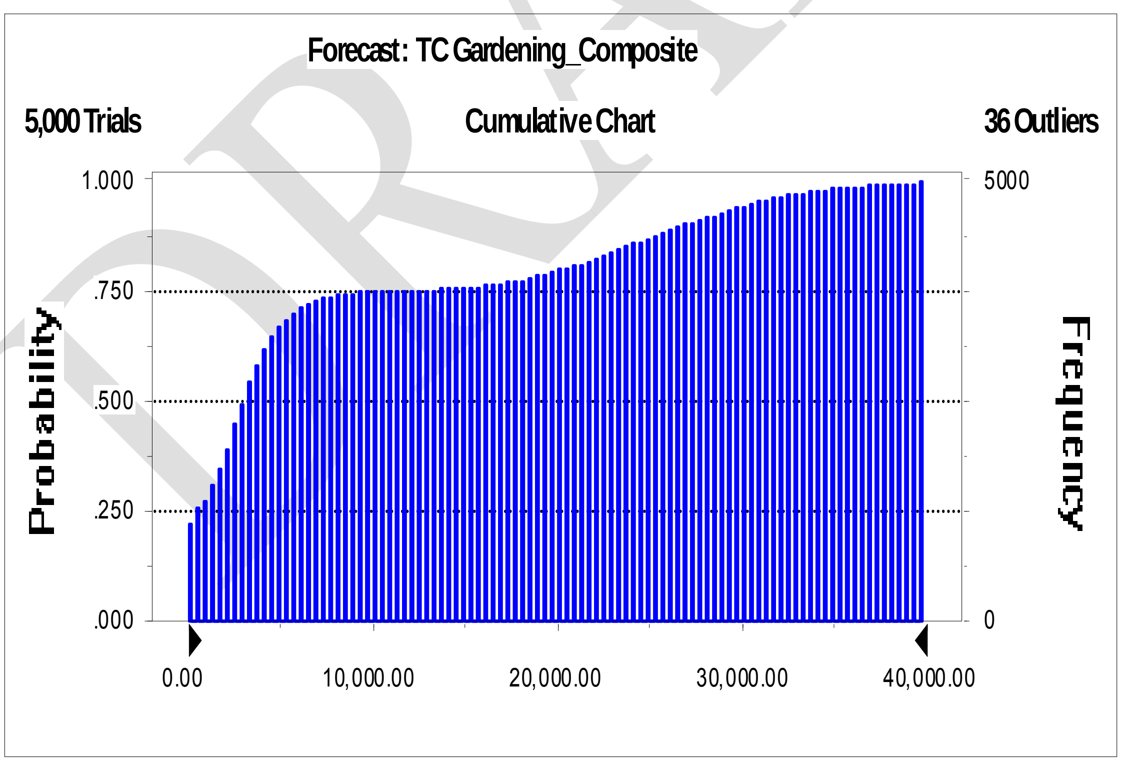

Figure C-20: Gardening Transfer Coefficient – Composite Cumulative Distribution Function Simulation

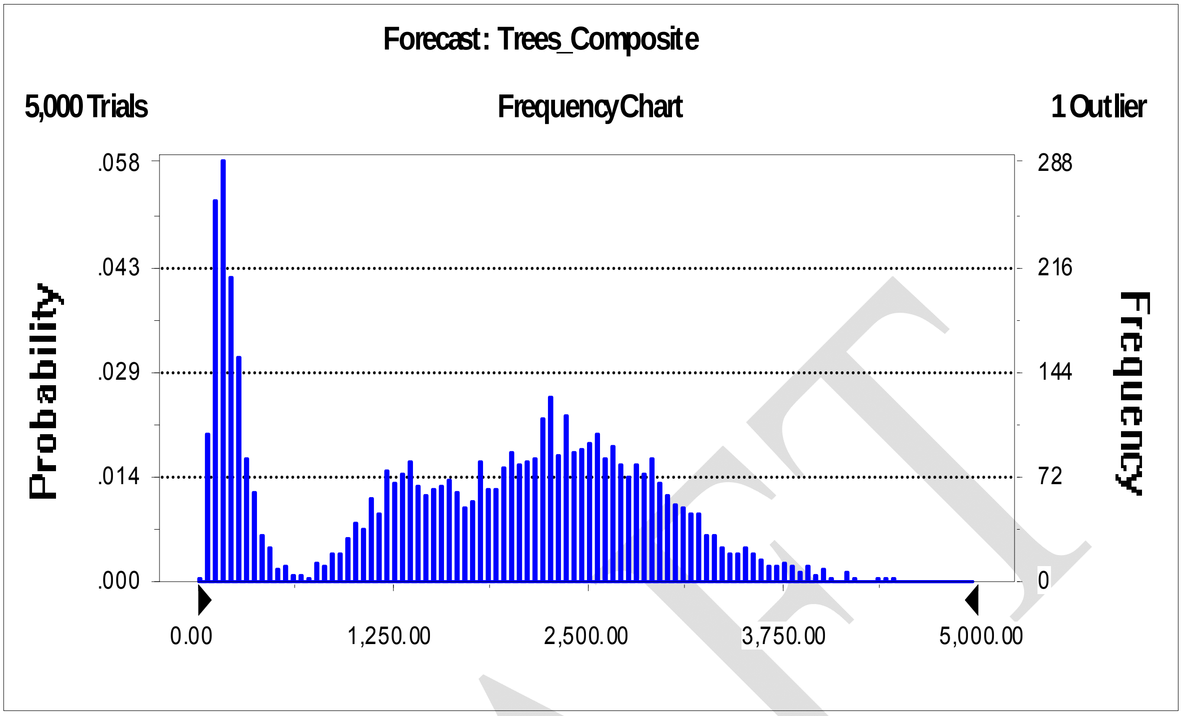

Figure C-21: Trees Transfer Coefficient – Composite Probability Density Function Simulation

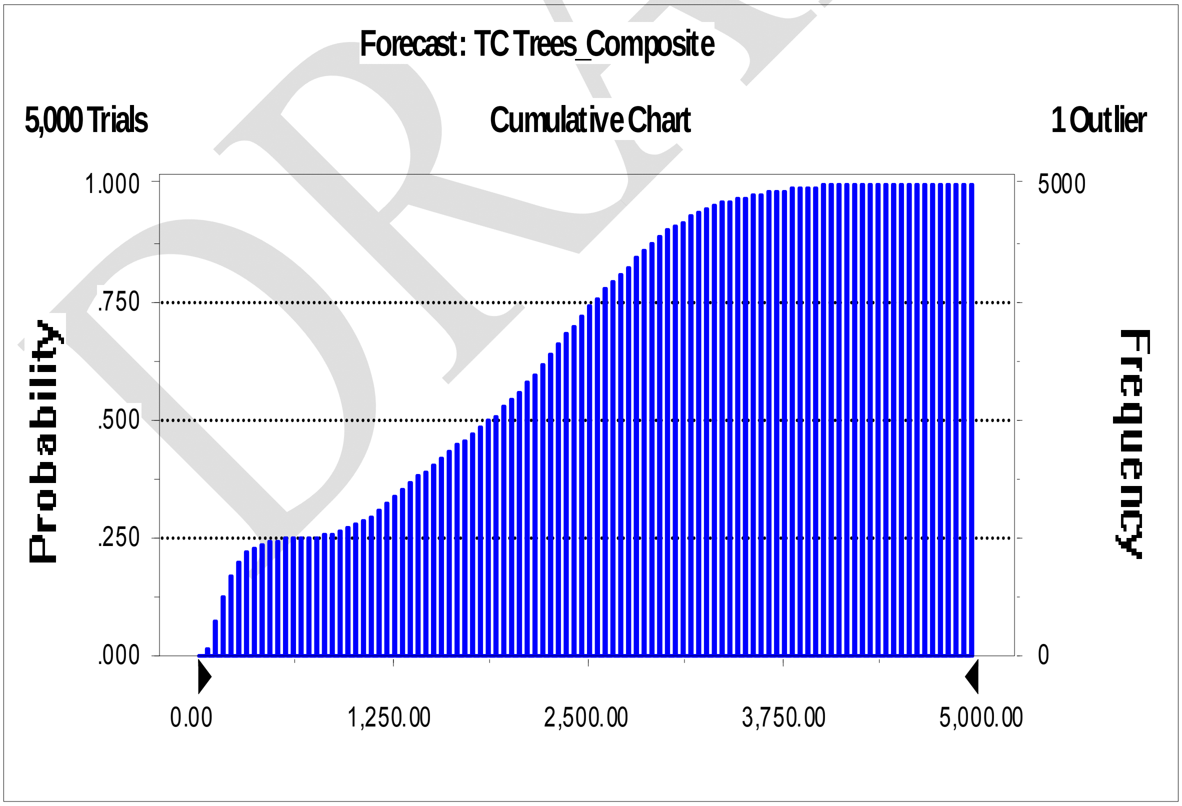

Figure C-22: Trees Transfer Coefficient – Composite Cumulative Distribution Function Simulation

Summary statistics for each composite distribution are provided below in *Table C-44*. [Note: it is recognized that treating each data point independently is technically incorrect due to the "nested" structure of the data set (i.e., transfer coefficients "within" workers, "within" crops, "within" chemicals, etc.), however, resulting statistics are nonetheless reasonable and useful for exposure assessment purposes.]

Table C-44: Statistical Summary – Residential Transfer Coefficients (cm^2/hr)

Statistic	Gardens	Trees	Indoor Plants
Mean	8413	1741	223
50th percentile	3243	1911	197
75th percentile	13035	2583	274
90th percentile	27367	3056	370
95th percentile	31082	3332	443
99th percentile	37777	3949	617
99.9th percentile	47087	4575	901
Range	164 – 41329	85 – 3357	85 – 505
N	67	60	15

C.7.3 Indoor Areas

There are no studies available that measure both exposure and surface residue while subjects are performing typical indoor activities. Therefore, the transfer coefficients used for indoor scenarios are derived from information provided in two different studies: (1) a study which measured exposure and surface residues while subjects performed a Jazzercise™ routine (Krieger, 2000) and (2) a study which measured biomonitoring doses while adults performed scripted activities for 4 hours on carpet (Vaccaro, 1991). In the Krieger study, a Jazzercise™ routine was performed to achieve maximum contact of the entire body with a surface using low impact aerobic movements. All body surfaces (dorsal, ventral, and lateral) contact the treated surface. The potential dermal exposure was measured by using whole-body dosimetry. The dosimeters were expected to normalize differences in surface contact and to increase the total sample area relative to patches. The assumption is that the dosimeter represents the skin and that the dose retained by the dosimeter is equivalent to dermal exposure. In the Krieger study, adult males performed two 20-minute Jazzercise routines, which yielded a transfer coefficient of 50,953 cm^2/0.67 hr.

Table C-45: Transfer coefficients based on Jazzercise[a]

Subject	Total exposure (ug/40 min)	Average transferable residue from study (ug/cm^2)	Transfer Coefficient (cm^2/40 min)
1	2,524	0.27	9,348
2	1,466	0.27	5,430
3	28,980	0.27	107,333
4	3,294	0.27	12,200
5	52,590	0.27	194,778
6	22,950	0.27	85,000
7	2,081	0.27	7,707
8	14,730	0.27	54,556
9	4,541	0.27	16,819

Table C-45: Transfer coefficients based on Jazzercise[a]			
Subject	**Total exposure (ug/40 min)**	**Average transferable residue from study (ug/cm^2)**	**Transfer Coefficient (cm^2/40 min)**
10	5,012	0.27	18,563
11	1,328	0.27	4,919
12	1,579	0.27	5,848
13	37,770	0.27	139,889
Arithmetic Mean			50,953
Standard Deviation			62,242
Geometric Mean			23,254

a. From table 2 of Krieger (2000)

In the Vaccaro study, adult males, dressed in bathing suits only, performed different activities over a 4 hour activity period. These activities included: sitting-playing with blocks, on hands and knees crawling, walking on carpet, laying on back, and laying on abdomen. Although activity was minimal during the last 2 activities, considerable surface area was in contact with the carpets during these times. An estimated dermal dose from the Vaccaro (1991) biomonitoring study was estimated to be 10.02 ug/kg (based on biomonitoring and inhalation monitoring results reported in study).

Substituting the transfer coefficient from the Jazzercise study in the exposure algorithm for Post-application dermal exposure and using the deposition value from the Vaccaro (1991) study yields an estimate of dermal exposure comparable to that measured using biomonitoring (See *Figure C-23* below). In addition, if the biomonitoring doses from both studies are normalized to the activity time, the values are similar. In the Krieger study, the average biomonitoring dose was 3.3 ug/kg for 40 minutes of activity, or 0.08 ug/kg-min. In the Vaccaro study, the average biomonitoring dose was 12 ug/kg for 4 hours of activity, or 0.05 ug/kg-min. Therefore, it is assumed that the shorter duration of high contact activity (i.e., Jazzercise) can be used to estimate exposure during longer durations of low contact activity (in this case, 4 hours of activity) and the Jazzercise transfer coefficient can be applied to 4 hours of typical indoor activity.

Figure C-23: Calculation of indoor dermal transfer coefficient using Krieger (2000) and Vaccaro (1991) studies

Chemical: Chlorpyrifos
Residue deposition value from Vaccaro (1991) study: 7.19 ug/cm^2
Transfer coefficient (TC) from Krieger study: 50,953 cm^2/day[a]
Chemical-specific dermal absorption (DA): 3%
Body weight (BW): 70 kg
Fraction transferred: 0.05 (95th percentile)

Dermal exposure equation:

(Residue) * (fraction transferred) * (TC) * (DA) / BW

(7.19 ug/cm^2) * (0.05) * (50,953 cm^2/day) * (3%) / (70 kg) = 7.85 ug/kg compared to 10.02 ug/kg from Vaccaro study

[a]. assumed to be per day for purposes of comparing typical indoor activities to Jazzercise

Table C-46: Transfer coefficients calculated based on comparison of Krieger (2000) and Vaccaro (1991)

Jazzercise Adult TC (cm2/40 min)		Adults	Toddlers	Infants
		Jazzercise TC applied to 4 hours of typical indoor activity (cm2/hr)	Jazzercise TC applied to 4 hours of typical indoor activity and adjusted for surface area,b (cm2/hr)	
9,348		2,337	979	286
5,430		1,357	568	166
107,333		26,833	11236	3,281
12,200		3,050	1277	373
194,778		48,694	20390	5,954
85,000		21,250	8898	2,598
7,707		1,927	807	236
54,556		13,639	5711	1,668
16,819		4,205	1761	514
18,563		4,641	1943	567
4,919		1,230	515	150
5,848		1,462	612	179
139,889		34,972	14644	4,276
Arithmetic mean	50,953	5,194	5,334	1,558
Standard Deviation	62,242	6,344	6,516	1,903
Geometric mean	23,254	2,370	2,434	711

a. 58% reduction factor (0.76 m^2 / 1.815 m^2)
b. 71% reduction factor (0.53m^2 / 1.815 m^2).

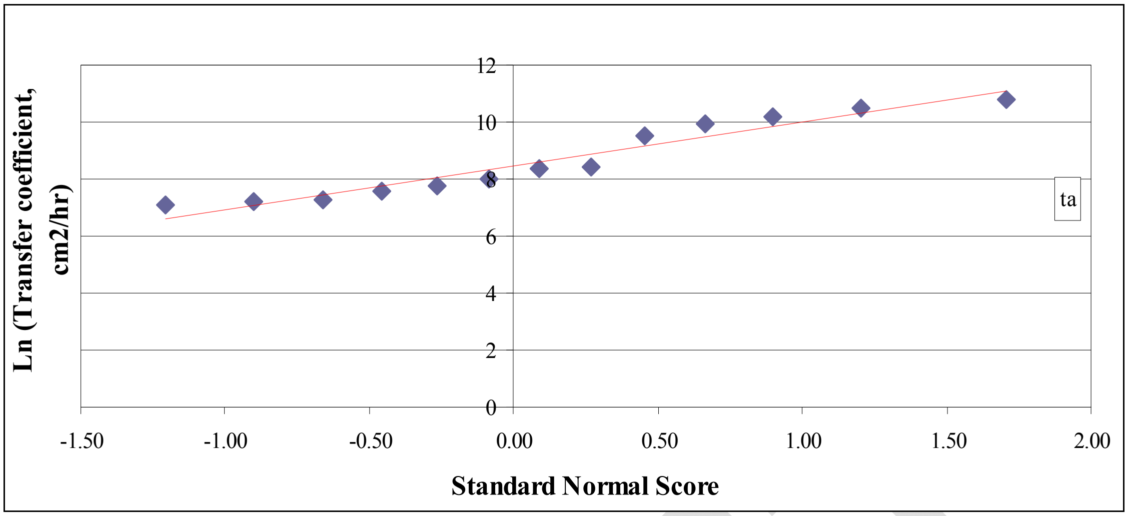

Figure C-24: Indoor Areas – Adult Transfer Coefficient Lognormal Probability Plot

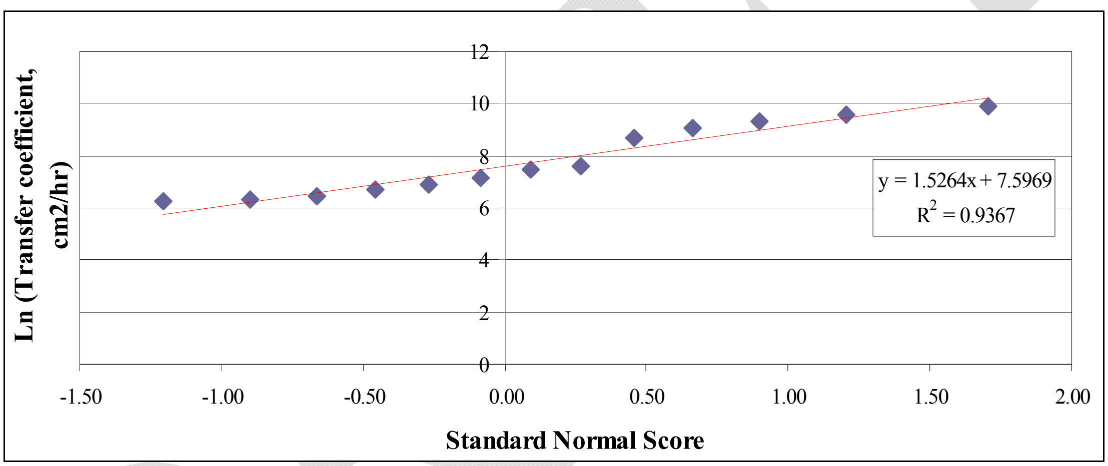

Figure C-25: Indoor Areas – Toddler Transfer Coefficient Lognormal Probability Plot

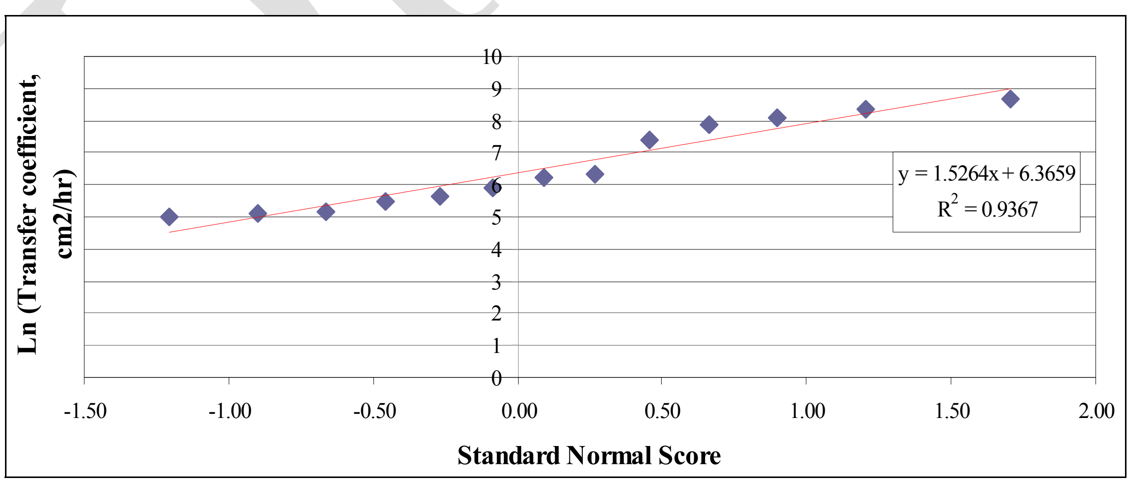

Figure C-26: Indoor Areas – Infant Transfer Coefficient Lognormal Probability Plot

Table C-47: Residential Indoor Areas Statistical Summary – Transfer Coefficient			
Statistic	**Adult Transfer coefficient (cm^2/hr)**	**Toddler Transfer coefficient (cm^2/hr)**	**Infant Transfer coefficient (cm^2/hr)**
50th percentile	4,800	2,000	580
75th percentile	13,000	5,500	1,600
95th percentile	59,000	25,000	7,200
99th percentile	170,000	70,000	20,000
99.9th percentile	530,000	220,000	65,000
Arithmetic mean	13,000	5,300	1,600
Standard Deviation	16,000	6,500	1,900
Geometric Mean	5,800	2,400	710
Geometric Standard Deviation	3.8	3.8	3.8
Range	1,200 – 49,000	500 – 20,000	150 – 6,000

C.7.4 Pets

Post-application dermal exposure can be predicted using estimates for residue transfer to individuals contacting treated pets during certain activities and exposure durations. Residue transfer from a given formulation and activity is an empirical value, known as the transfer coefficient (TC). Dermal TCs were developed for liquid and solid pet product formulations. The following is a summary of the exposure studies used in the quantification of pet treatment TCs and the corresponding data sets of each exposure study.

The Agency did not identify any studies which were conducted to observe homeowner activities with a treated pet. While studies were conducted to determine the fraction of application rate transferred from the treated pet to a human hand, these data are limited in that the scripted activity patterns employed (i.e., a pre-determined number of wipes to the animal's coat) and hand only exposure measurements, limit their utility for the estimation of actual activities, contact and resulting exposure to the whole body of exposed individuals. Applicator and groomer studies were, therefore, identified as a data source for reasonable upper bound estimates of contact with an animal. These activities are likely to result in higher, as well as, more consistent and reliable contact factors than petting, hugging or sleeping with a pet and, therefore, are an appropriate source from which to derive a TC.

The TCs used to assess dermal post-application pet exposure were developed from two studies representing application and grooming activities with dogs, one using carbaryl shampoo and the other using carbaryl dust; which represent TCs liquid and solid formulations, respectively. Data were gathered while human volunteers applied pesticide products to various dogs of differing sizes and fur lengths. Volunteers in the carbaryl shampoo study groomed the animals as well as applying the product. Pet exposure TCs can be defined as animal surface area contact per unit time (cm^2/hr), or the ratio of exposure rate, measured in mass of chemical per time (e.g., ug/hr), to residue, measured in mass of active ingredient per surface area of the animal (e.g., ug/cm^2).

The mass of active ingredient per surface area of the animal (ug/cm^2) used to determine the TCs were adjusted for the dust and shampoo studies. The applicator/groomer studies were not performed in a manner which measured active ingredient per surface area of the animal. Therefore, the residue available on the animal for transfer was predicted by multiplying the arithmetic mean fraction of application rate (F_{AR}) value (0.0054) by the active ingredient per surface area (ug/cm^2) estimated from the studies. This adjustment has the effect of increasing TC estimates, thus resulting in value which is more protective of human health. Furthermore, the selection of the arithmetic mean F_{AR} value (0.0054), in lieu of the 95th percentile value (0.022), further increases TC estimates for the dust and shampoo studies. A full description of the F_{AR} input is detailed in the next section.

Since TCs were established from studies using adult volunteers, they have been scaled to adjust for assessment of toddler exposure. The Agency assumes that the surface area of an average toddler 58.1% less than that of an average adult. The adjustment is based upon a ratio of the mean surface area of 3 to < 6 year age group, 0.76 m², from the Child-Specific Exposure Factors Handbook (USEPA, 2008) and the value of the average of mean total surface area for males (1.94 m²) and females (1.69 m²), 1.82 m², from the Exposure Factors Handbook (USEPA, 1997).

Formulation: Liquid

Application Method: Aerosols, Collars, Dips, Pump Sprays, Shampoos, Sponges and Top-Spots

Table C-48: Adult and Toddler Transfer Coefficients for Liquid Formulations

Statistic	Transfer Coefficent (cm^2/hour)	
	Adult	Toddler
50th percentile	6,500	2,700
75th percentile	11,000	4,800
95th percentile	26,000	11,000
99th percentile	46,000	19,000
99.9th percentile	88,000	37,000
GM	6,500	2,700
GSD	2.3	2.33
Range	928 – 22,866	390 – 9,607
N	16	16

Notes:
- Represents individuals wearing short-sleeve shirts, shorts, and no chemical-resistant gloves

Each adult transfer coefficient was log-transformed and plotted to evaluate its fit to a lognormal distribution. The data appears to reasonably fit a lognormal distribution as shown in the figure below.

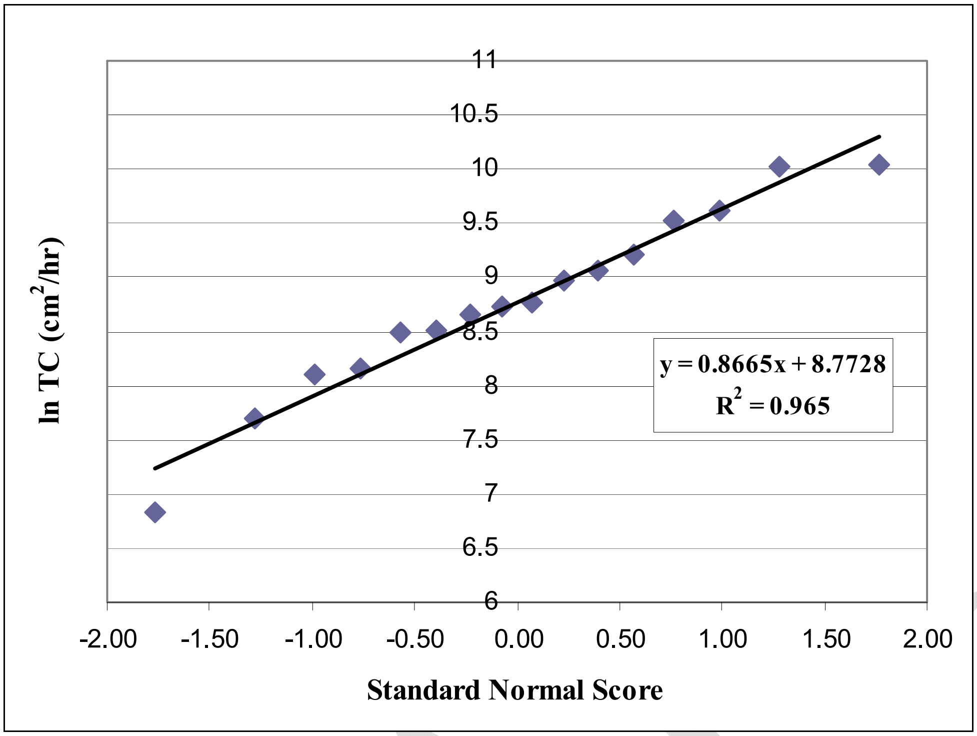

Figure C-27: Liquid Formulation Transfer Coefficient Lognormal Probability Plot

Table C-49: Available Exposure Study Identification Information	
Citation	Mester, T.C. (1998). Dermal Exposure and Inhalation Exposure to Carbaryl by Commercial Pet Groomers During Applications of Adams ™ Carbaryl Shampoo
EPA MRID	44658401
EPA Review	D287251
	Contractor (Versar, Inc.) review 12/4/98
MRID = Master Record Identification	

Study Description: 16 different commercial pet groomers were monitored while treating dogs with carbaryl, an active ingredient used to control fleas and ticks, using a read-to-use (RTU) disposable shampoo bottle. Each application consisted of treating 8 dogs by soaking (2-3 minutes), treating with the shampoo, letting the shampoo sit for 5 minutes, then rinsing, drying and combing the dog. Application times for treating all 8 dogs ranged from 149 to 295 minutes and the amount of carbaryl applied ranged from approximately 0.0008 to 0.008 lbs. Dermal exposure was measured using inner whole body dosimetry (underneath pants, a short-sleeved shirt and a smock) and hand washes (no chemical-resistant gloves were worn). Inhalation exposure was measured using standard pumps (set at 1.5 liter per minute), cassettes, and tubing. Recoveries from field fortifications of exposure sampling matrices were generally above 80%.

Table C-50: MRID 44658401 TC Data Summary

Person ID	AaiH[1] (mg)	Total Dermal Exposure (mg)	Duration (hr)	Animal Surface Area (cm^2)	ai on Dog Available for Transfer[2] (mg/cm^2)	TC Adult[3] (cm^2/hr)	TC Toddler[4] (cm^2/hr)
1	2,290	15.4	2.88	31,603	0.00039	13,601	5,719
2	684	11.7	2.58	12,313	0.00030	15,125	6,355

3	916	2.6	3.07	28,726	0.00017	4,940	2,076
4	2,004	5.5	2.48	17,002	0.00064	3,487	1,465
5	1,641	10.4	3.08	26,067	0.00034	9,922	4,169
6	1,205	4.0	3.18	25,148	0.00026	4,844	2,035
7	659	4.5	2.93	19,937	0.00018	8,562	3,597
8	373	5.1	2.72	24,210	0.00008	22,693	9,535
9	600	2.2	4.03	19,665	0.00016	3,313	1,392
10	1,747	27.9	3.88	30,047	0.00031	22,866	9,607
11	945	1.8	3.17	20,140	0.00025	2,190	920
12	3,720	15.0	4.05	31,231	0.00064	5,757	2,419
13	1,132	8.3	4.92	22,305	0.00027	6,152	2,584
14	1,148	8.6	3.45	15,911	0.00039	6,397	2,688
15	706	2.5	3.03	35,946	0.00011	7,885	3,313
16	1,929	1.4	3.00	20,140	0.00052	929	390

[1] Amount of active ingredient Handled
[2] The total ai deposited on the dog (mg/cm^2) = AaiH (mg)/ Surface Area Animals (cm^2) * 0.0054 (0.54% is the arithmetic mean F_{AR} value which is applied to adjust the total amount of ai per surface area (mg/cm2) on the dog to an amount estimated to be available for transfer)
[3] Adult TC = Total Dermal Exposure (mg) / (Duration (hr) * (ai on Dog Available for Transfer (mg/cm^2))
[4] Toddler TC = Adult TC adjusted by 58% for reduction from adult to toddler mean surface areas.

Formulation: Solids

Application Method: Dusts and Powders

Table C-51: Adult and Toddler Transfer Coefficients for Solid Formulations

Statistic	Transfer Coefficent (cm^2/hour)	
	Adult	**Toddler**
50th percentile	210,000	87,000
75th percentile	310,000	130,000
95th percentile	560,000	230,000
99th percentile	840,000	350,000
99.9th percentile	1,300,000	560,000
GM	210,000	87,000
GSD	1.8	1.8
Range	51,180 – 566,918	21,504 – 238,200
N	20	20

Notes:
- Represents individuals wearing short-sleeve shirts, shorts, and no chemical-resistant gloves
- Dermal liquid formulation TC based on a lognormal distribution fit with data from MRID 44439901.

Each adult transfer coefficient was log-transformed and plotted to evaluate its fit to a lognormal distribution. The data appears to reasonably fit a lognormal distribution as shown in the figure below.

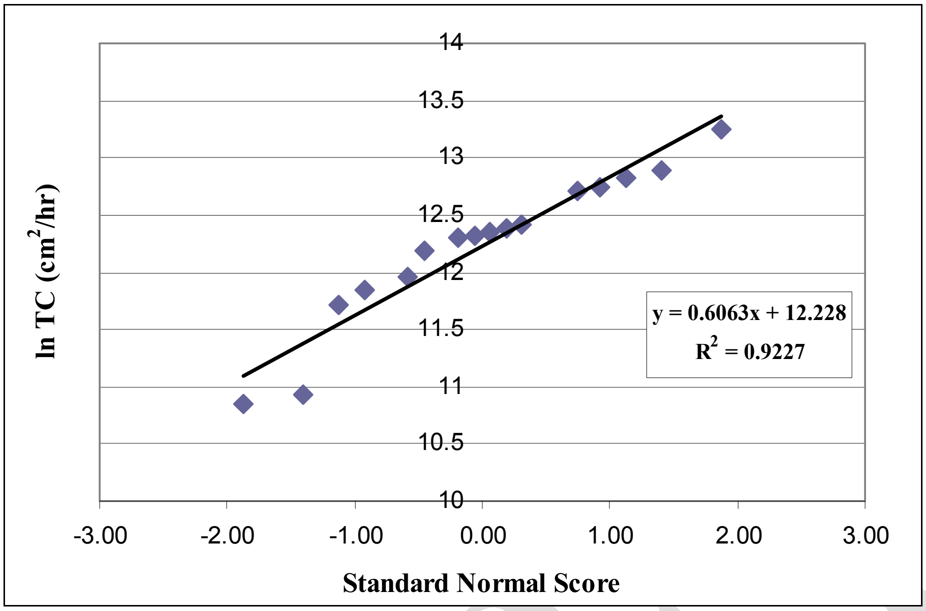

Figure C-28: Solid Formulation Transfer Coefficient Probability Plot

Table C-52: Available Exposure Study Identification Information	
Citation	Merricks, D. (1997) Carbaryl Applicator Exposure Study During Application of Sevin 5 Dust to Dogs by the Non Professional: Lab Project Number: 1517: 10565: ML96 0662 RHP. Unpublished study prepared by Agrisearch Inc., Rhone Poulenc Ag Co. and Morse Laboratories, Inc. 212 p.
EPA MRID	44439901
EPA Review	Contractor (Versar, Inc.) review
MRID = Master Record Identification	

Study Description: A total of 40 individuals – 20 with and 20 without chemical-resistant gloves – were monitored while applying a dust formulation (5% carbaryl) to dogs. Each application, lasting approximately 7 minutes, consisted of an individual using a 1 lb shaker can to apply an average of 0.15 lbs of dust (0.008 lbs carbaryl) to 3 dogs, then rubbing the dust into the dog's coat. Dermal exposure was measured using inner and outer whole body dosimetry and hand washes. Inhalation exposure was measured using standard pumps (set at 2 liter per minute), cassettes, and tubing. Recoveries from field fortifications of exposure sampling matrices were generally above 90%.

Table C-53: MRID 44439901 TC Data Summary

Person ID	AaiH[1] (mg)	Total Dermal Exposure (mg)	Duration (hr)	Animal Surface Area (cm^2)	ai on Dog Available for Transfer[2] (mg/cm^2)	TC Adult[3] (cm^2/hr)	TC Toddler[4] (cm^2/hr)
3	1,361	30.1	0.13	12,921	0.00057	397,358	166,957
4	7,257	82.9	0.12	12,313	0.0032	223,368	93,852
7	3,629	10.9	0.22	19,801	0.00099	51,180	21,504
8	1,814	24.6	0.12	10,670	0.00092	223,368	96,507
10	3,629	61.8	0.08	14,977	0.0013	566,918	238,201

13	907	8.15	0.12	15,526	0.00032	221,470	93,054
14	1,361	10.76	0.10	16,443	0.00045	240,714	101,140
16	3,175	18.73	0.13	19,044	0.00090	156,016	65,553
19	3,175	15.95	0.13	20,005	0.00086	139,552	58,636
20	5,443	104.8	0.17	11,598	0.0025	248,009	104,206
23	2,268	22.2	0.08	17,113	0.00072	371,459	156,075
24	9,979	84.4	0.08	18,342	0.0029	344,533	144,762
26	4,082	15.4	0.12	20,275	0.0011	121,406	51,011
29	454	5.9	0.08	11,416	0.00022	330,735	138,964
30	4,082	14.4	0.13	11,324	0.0019	55,442	23,295
33	6,804	31.5	0.12	26,680	0.0014	195,767	82,255
34	3,175	23.5	0.13	20,743	0.00083	213,322	89,631
36	2,722	23.4	0.08	14,255	0.0010	272,397	114,453
39	2,722	13.6	0.12	17,841	0.00082	142,029	59,676
40	1,814	13.9	0.08	15,911	0.00062	270,080	113,479

[1] Amount of active ingredient Handled
[2] The total ai deposited on the dog (mg/cm^2) = AaiH (mg)/ Surface Area Animals (cm^2) * 0.0054 (0.54% is the arithmetic mean F_{AR} value which is applied to adjust the total amount of ai per surface area (mg/cm2) on the dog to an amount estimated to be available for transfer)
[3] Adult TC = Total Dermal Exposure (mg) / (Duration (hr) * (ai on Dog Available for Transfer (mg/cm^2))
[4] Toddler TC = Adult TC adjusted by 58% for reduction from adult to toddler mean surface areas.

Fraction of TC from Hands ($F_{aihands}$)

The TCs used to estimate post-application dermal exposure were developed using data from two studies representing application and grooming activities with dogs, as described in Sections 8.2.2 of the Treated Pet Section. The TCs for solid and liquid pet pesticide formulations represent are based upon whole body exposure (mg a.i.) of the volunteers involved in the studies. In order to adjust dermal exposure (DE) to a value which is more representative of that anticipated for the toddlers hands, a ratio of hand exposure to total body exposure (as measured in both studies) was performed. In addition, since toddler surface area is less than adults, hand surface area was adjusted using the method described in Sections 2.3. The resulting values represent the fraction of a.i. from hands for solid and liquid formulations. *Table C-56* and *Table C-57* provide a statistical summary $F_{ai\ hands}$ liquid and solid formulation data values for use in toddler post-application incidental ingestion exposure assessment, respectively.

Table C-54: MRID 44658401 $F_{AI\ hands}$ Data Summary – Liquid Formulation

Person ID	AaiH[1] (mg)	Total Dermal Exposure (mg)	Hand Exposure (mg)	Fraction Total Dermal Exposure from Hands[2] ($F_{AI\ hands}$)
12	3,720	15.0	0.15	0.0097
13	1,132	8.3	0.12	0.014
14	1,148	8.6	0.14	0.016
15	706	2.5	0.24	0.094
16	2,929	15.4	0.29	0.019
1	1,990	1.4	0.11	0.074
2	684	11.7	0.18	0.015
3	916	2.6	0.13	0.051
4	2,004	5.5	0.25	0.045
5	1,641	10.4	0.12	0.012
6	1,205	4.0	0.16	0.041
7	659	4.5	0.082	0.018
8	373	5.1	0.11	0.020
9	600	2.2	0.062	0.028
10	1,747	27.9	0.47	0.017
11	945	1.8	0.29	0.17

[1] Amount of active ingredient Handled
[2] Fraction Total Dermal Exposure from Hands ($F_{AI\ hands}$) = Hand Exposure/ Total Dermal Exposure

Table C-55: Toddler $F_{ai\ hands}$ for Liquid Formulations	
Statistic	$F_{TC\ hands}$ (cm^2/hour)
	Toddler
50th percentile	0.028
75th percentile	0.048
95th percentile	0.11
99th percentile	0.18
99.9th percentile	0.35
GM	0.028
GSD	2.3
Range	0.0097 – 0.17
N	16
Notes: Fraction of TC from hands based on a lognormal distribution fit with data from MRID 44658401.	

Table C-56: MRID 44439901 $F_{aihands}$ Data Summary – Solid Formulation				
Person ID	AaiH[1] (mg)	Total Dermal Exposure (mg)	Hand Exposure (mg)	Fraction Total Dermal Exposure from Hands[2] ($F_{TC\ hands}$)
3	1361	30.1	5.8	0.19
4	7257	82.9	12.5	0.15
7	3629	10.9	3.9	0.35
8	1814	24.6	5.4	0.22
10	3629	61.8	8.1	0.13
13	907	8.15	4.9	0.61
14	1361	10.76	4.5	0.42
16	3175	18.73	10.5	0.56
19	3175	15.95	11.6	0.73
20	5443	104.8	11.9	0.11
23	2268	22.2	7.3	0.33
24	9979	84.4	24.6	0.29
26	4082	15.4	4.4	0.28
29	454	5.9	3.9	0.65
30	4082	14.4	6.0	0.42
33	6804	31.5	5.1	0.16
34	3175	23.5	4.6	0.19
36	2722	23.4	6.8	0.29
39	2722	13.6	9.1	0.67
40	1814	13.9	7.7	0.55
[1] Amount of active ingredient Handled [2] Fraction Total Dermal Exposure from Hands ($F_{ai\ hands}$) = Hand Exposure/ Total Dermal Exposure				

Table C-57: Toddler $F_{ai\ hands}$ for Solid Formulations	
Statistic	$F_{TC\ hands}$ (cm^2/hour)
	Toddler
50th percentile	0.31
75th percentile	0.47
95th percentile	0.82
99th percentile	1.2
99.9th percentile	1.9
GM	0.31
GSD	1.8
Range	0.11 – 0.73
N	0.72
Note: Fraction of ai from hands based on a lognormal distribution fit with data from MRID 44439901.	

C.8 Estimates for Residential Activity Duration

C.8.1 Gardens, Trees, and "Pick-your-own" Farms

Based on analysis of a survey and the U.S. EPA's 1997 Exposure Factors Handbook, considered the best available data sources for this information, activity duration is presented below for similar activities conducted at home and at "pick-your-own" farms.

Home Activities

Activity durations for activities associated with gardens and trees at home were derived from a survey (Johnson, 1999) and U.S. EPA's 1997 Exposure Factors Handbook. While the Exposure Factors Handbook includes information on "time spent working with soil in a garden or other circumstances working" for all age groups including youths (Vol. III, Table 15-62), the data are presented as hours/month, thus difficult to interpret daily exposure times necessary for exposure assessments of short duration. The survey, on the other hand, asked about specific types of residential landscaping and maintenance activities and the amount of time an individual spends conducting such activities quantified in "hours per week" and "days per week". However, because this survey only included individuals 18 years or older, the Exposure Factors Handbook information was used to adjust these results for those under 18 years.

Johnson, 1999 surveyed households regarding types of residential landscaping and maintenance activities and the amount of time an individual spends conducting such activities quantified in "hours per week" and "days per week". Though the survey did not ask for specific crop/activity durations (i.e., how long do you pick apples per day?) – which could potentially correspond to transfer coefficients from specific reentry exposure studies – the information on general activities can be used in conjunction with the composite transfer coefficients derived to represent broad categories of residential garden and tree activities. *Table C-58* and *Table C-59* below present a summary of the survey data.

Table C-58: Residential Gardens and Trees – Activity Duration (% response)

Activity	N	Hours per week										
		< 1	1	2	3	4-5	6-7	8-10	11-15	16-20	> 20	DNK
Vegetable Garden	364	0.1	15.1	13.5	11.9	14.7	8.8	6.7	4.2	2.6	2.1	20.2
Flower Garden	519	0.8	20.9	17.4	8.0	10.9	7.5	4.0	2.1	--	--	27.9
Roses	252	1.4	34.2	22.8	5.5	9.4	2.6	0.8	0.5	--	--	21.7
Shrubs/bushes	456	0.8	32.8	14.7	4.3	8.2	1.2	2.5	0.3	--	--	34.9
Fruit/Nut trees	123	0.8	24.9	6.5	3.8	12.7	3.0	3.4	1.3	--	--	41.9

Source: National Gardening Association Survey (1999).
DNK = did not know

Table C-59: Residential Gardens and Trees – Activity Duration (% response)

Activity	N	Days per week								
		< 1	1	2	3	4	5	6	7	DNK
Vegetable Garden	364	0.2	17.4	22.2	15.3	7.7	11.3	3.9	10.3	11.9
Flower Garden	519	1.2	26.7	17.1	15.5	5.5	6.9	3.1	8.2	15.5
Roses	252	1.6	28.5	17.5	10.9	2.9	4.4	1.9	10.0	21.0
Shrubs/bushes	456	2.8	35.8	16.8	5.2	0.7	1.1	0.1	3.9	32.2
Fruit/Nut trees	123	2.4	22.8	13.0	5.2	1.0	1.7	2.3	6.7	43.7

Source: National Gardening Association Survey (1999).
DNK = did not know

Exposure assessment values for "hours per day" had to be implicitly derived from the survey since responses were given only in "hours per week" and "days per week". To derive "hours per day", the "hours per week" values were divided by 2 (i.e., 2 days per week). The survey showed that greater than 60% of respondents for most activities reported 1 – 3 days performing that activity per week. Therefore, normalizing the "hours per week" responses by a factor of 2 is not an unreasonable assumption to derive daily exposure times for the purposes of exposure assessment. Additionally, the responses were adjusted proportionally to the fraction who responded "did not know" (i.e., 21% of "did not know" responses were distributed equally amongst the other responses). The results for "hours per day" are shown in *Table C-60* below:

Table C-60: Residential Gardens and Trees – Activity Duration (% response)[1]										
Activity	**Hours per day[2]**									
	< 0.5	**0.5**	**1**	**1.5**	**2-2.5**	**3-3.5**	**4-5**	**5.5-7.5**	**8-10**	**> 10**
Vegetable Garden	0.13	18.9	16.9	14.9	18.4	11.0	8.4	5.3	3.3	2.6
Flower Garden	1.1	29.2	24.3	11.2	15.2	10.5	5.6	2.9	--	--
Roses	1.8	44.3	29.5	7.1	12.2	3.4	1.0	0.65	--	--
Shrubs/bushes	1.2	50.6	22.7	6.6	12.7	1.9	3.9	0.46	--	--
Fruit/Nut trees	1.4	44.1	11.5	6.7	22.5	5.3	6.0	2.3	--	--

[1] Percent responses adjusted proportionally per activity's "did not know" percentage (see *Table C-58*).
[2] Hours per day derived by dividing "hours per week" values by 2.
Source: National Gardening Association Survey (1999).
DNK = did not know

After calculating "hours per day", the responses, given as percentages, were used in conjunction with the upper bound of each range to derive cumulative percentile distributions. The distributions were truncated at 16 hours per day to subtract for 8 hours of sleep. Also, note that vegetable gardening was the only activity with results reported for "8-10" and "> 10" hours per week (derived from 16-20 and > 20 hours per week). *Table C-61* below presents the cumulative percentiles for each activity.

Table C-61: Cumulative Percentile Distributions for Activity Durations for Gardens and Trees					
Activity Duration (hrs/day)	**Cumulative %tiles**				
	Vegetable Gardening	**Flower Gardening**	**Roses**	**Shrubs/Bushes**	**Fruit/Nut Trees**
0	0	0	0	0	0
0.5	19	30	46	52	46
1	36	55	76	75	57
1.5	51	66	83	81	64
2.5	69	81	95	94	86
3.5	80	91	98	96	92
5	89	97	99	99.5	97
7.5	94	99	99.5	99.9	99
10	97	--	--	--	--
16	100	100	100	100	100

Note: As shown in *Table C-58*, vegetable gardening was the only activity with results reported for "8-10" and "> 10" hours per week (derived from 16-20 and > 20 hours per week), thus the upper bound reported value for all activities except for vegetable gardening is 7.5 hours per day.

Next, custom cumulative distributions were constructed for gardens and trees, respectively. The distribution for activities in gardens was constructed by combining, via a 5000 trial Monte Carlo simulation, the cumulative distributions for each vegetable gardening and flower gardening in equal proportion (i.e., 50% each). The distribution for activities in trees was derived similarly with the cumulative distributions for each roses, shrubs/bushes, and fruit/nut trees used in equal 33% proportions.

Probability and cumulative density functions are provided in the figures below. A statistical summary follows in *Table C-63*.

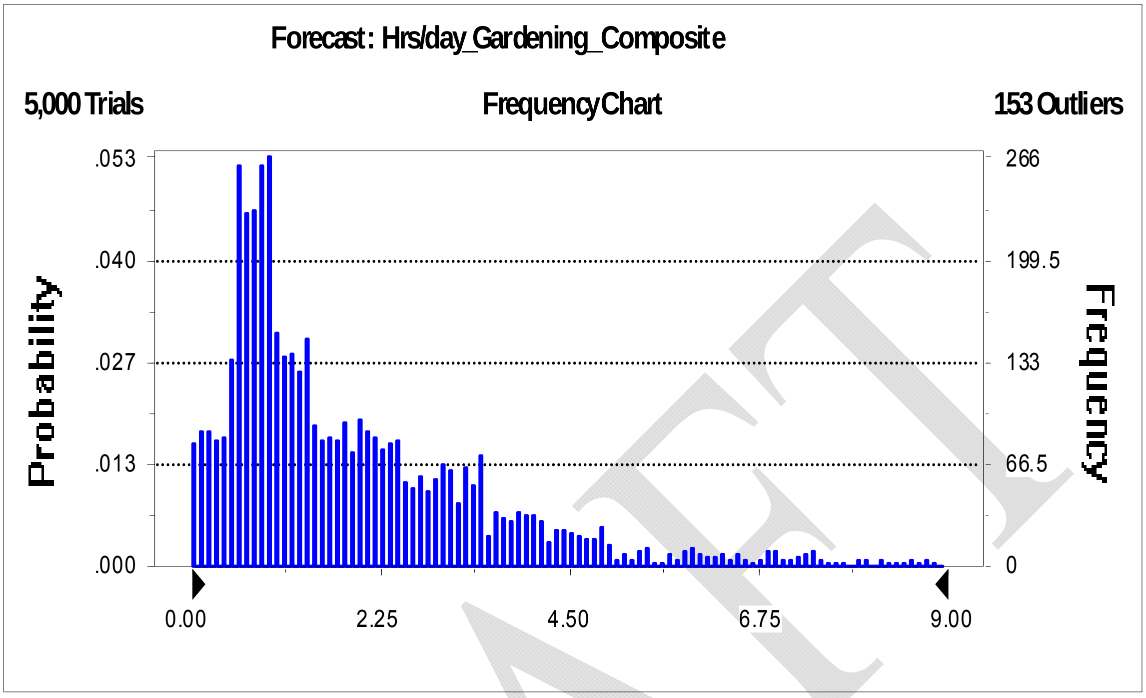

Figure C-29: Gardening Exposure Duration – Composite Probability Density Function Simulation

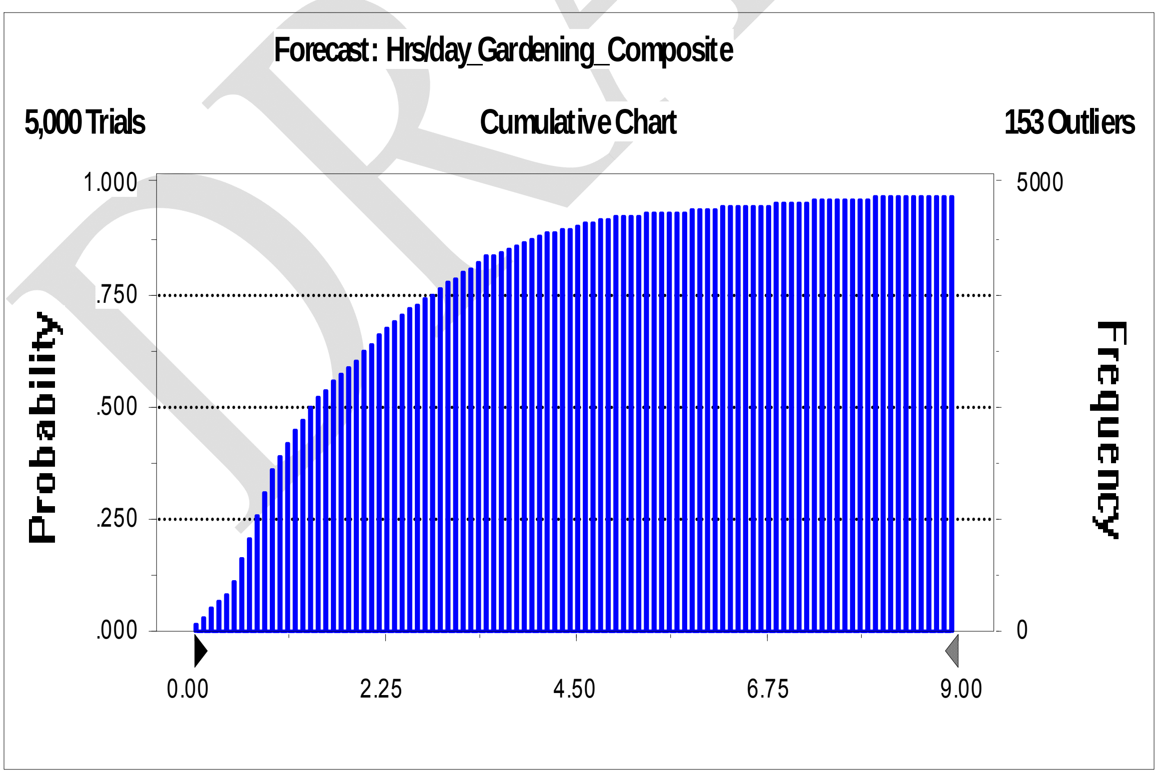

Figure C-30: Gardening Exposure Duration – Composite Cumulative Density Function Simulation

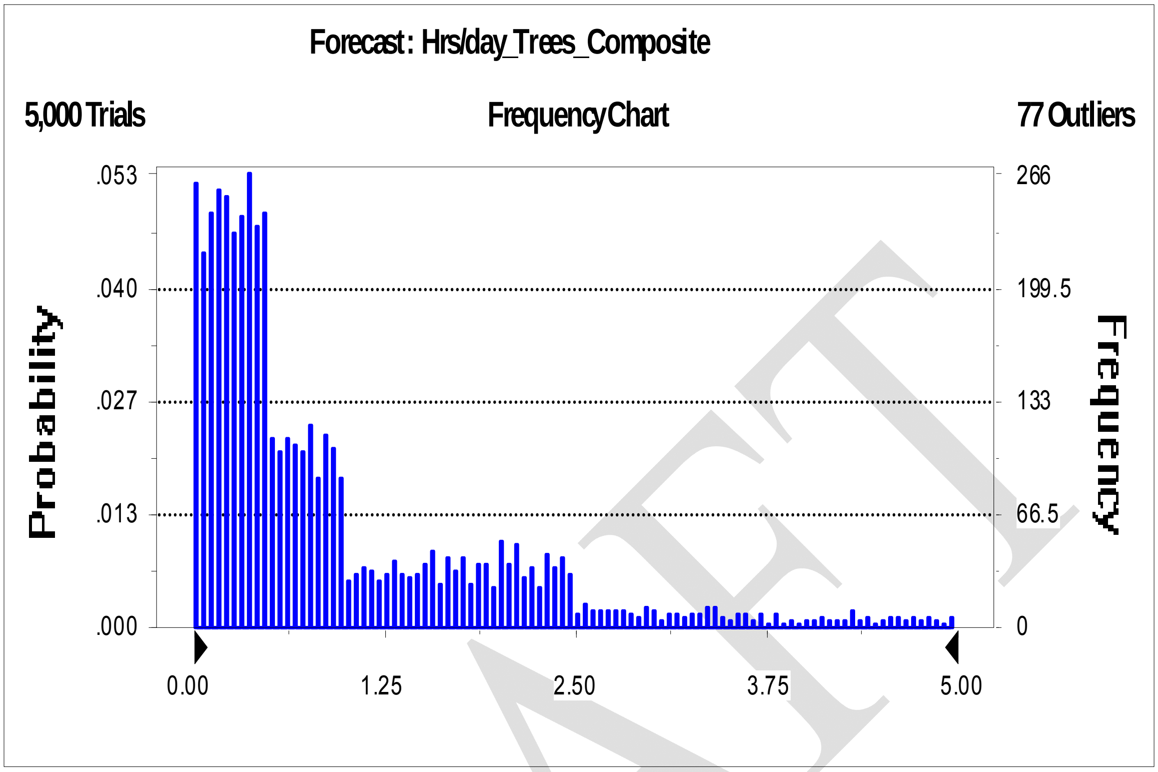

Figure C-31: Trees Exposure Duration – Composite Probability Density Function Simulation

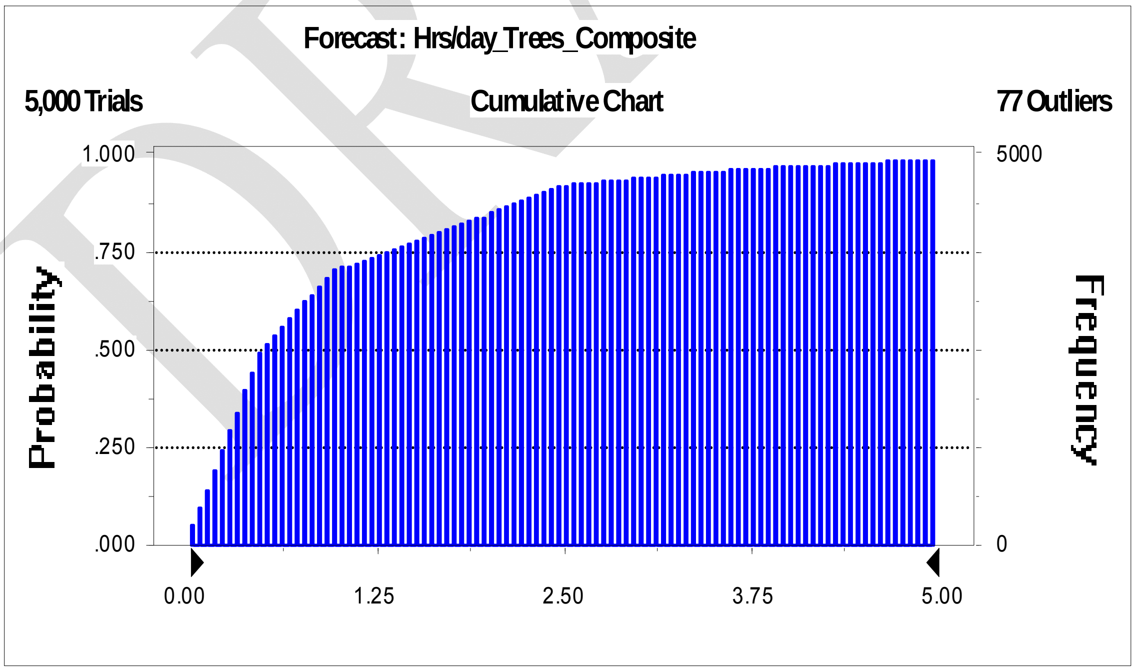

Figure C-32: Trees Exposure Duration – Composite Cumulative Density Function Simulation

Next, because the survey included only those older than 18, the Exposure Factors Handbook was used to adjust this data for youths conducting similar activities. The Exposure Factors handbook provides distributions for "time spent working with soil in a garden or other circumstances" in hours per month (Vol. III, Table 15-62). Comparing the distributions it is apparent that adults spend approximately twice the amount of time as youths for this scenario. *Table C-62* below presents these datasets.

Table C-62: Adult to Youth Activity Duration Ratios from Exposure Factors Handbook VIII, Table 15-62									
Percentile	**5**	**10**	**25**	**50**	**75**	**90**	**95**	**98**	**99**
Adults (18-64 yrs.)	0	0	0	0	3	16	40	90	200
Youths (5-11 yrs.)	0	0	0	0	2	10	20	50	60
Adult:Youth Ratio	NA	NA	NA	NA	1.5	1.6	2	1.8	3.3

Using the survey information from Johnson, 1999 and the Exposure Factors Handbook, a statistical summary of activity durations associated with gardens and trees at home are presented below.

Table C-63: Home Gardens and Trees – Activity Duration (hrs/day) Statistical Summary				
Statistic	**Vegetable and Flower Gardens**		**Fruit, Nut, and Ornamental Trees/Bushes/Shrubs and Indoor Plants**	
	Adults	**Youths**	**Adults**	**Youths**
Mean	2.2	1.1	1.0	0.5
50th percentile	1.4	0.7	0.5	0.25
75th percentile	2.9	1.5	1.4	0.7
90th percentile	4.5	2.3	2.4	1.2
95th percentile	6.9	3.5	3.4	1.7
99th percentile	13	6.5	6.3	3.2
99.9th percentile	16	8	15	7.5
Notes: - Distributions are truncated at 16 hours per day. - Durations for youths derived as ½ that of adult activity durations.				

"Pick-your-own" Farms

Activities at "pick-your-own" farms are likely to be similar to those conducted at home (e.g., picking fruits), however the duration of the activities are likely to be different since people and families are away from their home and likely at the farm for recreation. The U.S. EPA's 1997 Exposure Factors Handbook includes data for the amount of time "spent outdoors at a farm" and is considered a reasonable surrogate for time spent at a "pick-your-own" farm. The data indicates that adults ages 18-64 ranged from 5 minutes to 16 hours per day while youths aged 5-11 ranged from 25 minutes to 4.4 hours per day. Unlike the survey for home activities, it is possible to differentiate between adults and youths. The summary statistics are provided below in *Table C-64*.

Table C-64: Time Spent at "Pick-your-own" Farms (hrs/day) Statistical Summary				
Population	**Age (years)**	**Statistics**		
		N	**Mean**	**Summary Percentiles**

				5	25	50	75	90	95	98	99
Adults	18-64	91	5.0	0.3	1.3	3.8	8.3	10.6	13.0	15.6	15.9
Youths	5-11	7	1.9	0.4	0.8	1.7	2.2	4.4	4.4	4.4	4.4
Source: 1997 EPA Exposure Factors Handbook (Vol. III; Tables 15-112)											

C.8.2 Pets

The exposure time (ET) for adults and toddlers with treated pets is assumed to be 1.0 hours per day based on the results of an observational study (Freeman et al, 2001). It is not likely that infants will contact a treated pet for as long as toddlers due to their reduced activity patterns; however, contact may occur and must be accounted for regardless of the inherent conservatism of the assumption.

In the study, macroactivity and microactivity data were collected via questionnaires and videotaping of 19 children (aged 3 to 12) for a four hour period. The videotapes from the observational portion of this study were analyzed to determine frequency of contacts for several mouthing behaviors, as well as duration of time each child spent in various locations around the home. The results of this study include several measurements for the duration of time the observed children spent with their pets. Contact with pets (3 children, 30 contacts) had a median duration of 13 seconds (4 – 123 seconds). Based upon these results, the time spent in this activity followed a triangular distribution with a minimum value of 0.03 hours and a maximum value of 1.0 hours per day. In order to determine exposure times the maximum number of contacts, 30, was multiplied by the minimum, median and maximum durations of 4, 13, and 123 seconds, respectively.

Table C-65: Daily Continuous Exposure Time (ET) with Pet (Adults and Toddlers)

Statistic	ED (hours)
Minimum	0.03
Median	0.11
Maximum	1.0

No additional data sources were identified which were specific to the time that individuals spend in contact with their pets. US EPA's National Center for Environmental Assessment (NCEA) recommended data included in Table 15-77, *Statistics for 24-Hour Cumulative Number of Minutes Spent in Animal Care*, of the 1997 Exposure Factors Handbook for a potential resource of exposure time. The data identified the time spent with an animal while performing household activities as recorded in 24 hour diaries by study volunteers. Since the times recorded by volunteers is not specific to only that time spent in contact with household pets, the study data cannot be relied upon to inform the exposure time factor. Furthermore, information regarding what activities were considered to be and reported as animal care was unable to be defined.

C.9 Estimates of Hand-to-Mouth Events per Hour

Frequency of hand-to-mouth events is an important variable for hand-to-mouth Post-application exposure assessments. Data on the frequency of hand-to-mouth events are limited and difficult to collect. The generic estimates for frequency of hand-to-mouth events are based on the Xue et al. (2007) meta-analysis. This article examined hand-to-mouth frequency data from 9 available studies representing 429 subjects and more than 2,000 hours of behavior observation. Results of this analysis indicate that age and location are important for hand-to-mouth frequency, but study and gender are not. In fact, hand-to-mouth frequency is significantly greater indoors than outdoors. As a result, hand-to-mouth frequency for outdoor environments is presented in this Appendix separately from hand-to-mouth frequency for indoor environments.

C.9.1 Outdoors - Turf

The turf SOP utilizes hand-to-mouth frequency data for the 3 to <6 year old age grouping to represent toddlers. The estimates for frequency of hand-to-mouth events in outdoor environments are based on the Xue et al. (2007) meta-analysis. The turf SOP utilizes hand-to-mouth frequency data for the 3 to <6 year old age grouping to represent toddlers. The estimates of hand mouthing frequency (events/hour) for 3 to <6 year olds were derived from 4 studies representing 55 participants. Based on an analysis of the data, it was determined that a Weibull distribution (0.55, 5.53) best fits the observed data. *Table C-66* provides the raw data for the 4 studies.

Table C-66: Outdoor Hand-to-Mouth Frequency Data

ID	Study	Age (yrs)	HtM Frequency (events/hr)
317F03	Leckie et al., 2000 [1]	3	0
129M03		3	3.03
165M03		3	5.61
772F04		4	0
575F04		4	0
422F04		4	11.46
557F05		5	0
919F05		5	1.09
280M05		5	1.52
id375	Freeman et al., 2001 [2]	3	0
id359		3	1.22
id401		5	2.86
id521	Tulve et al., 2002 [3]	3.33	0
id511		3.33	2
id121		3.42	10
id107		3.42	11
id121		3.42	21
id121		3.42	23
id125		3.5	0
id125		3.5	3
id129		3.58	0
id129		3.58	7
id129		3.58	8
id179		3.58	16
id145		3.67	0
id133		3.67	8
id145		3.67	16

Table C-66: Outdoor Hand-to-Mouth Frequency Data			
ID	**Study**	**Age (yrs)**	**HtM Frequency (events/hr)**
id133		3.67	19
id140		3.75	16
id140		3.75	29
id140		3.75	38
id111		3.92	0
id137		3.92	0
id153		3.92	0
id137		3.92	3
id137		3.92	7
id153		3.92	7
id153		3.92	8
id127		4.33	6
id191		4.5	0
id191		4.5	3
id134		4.67	20
id288		4.75	6
id109		4.75	10
id149		4.75	36
id057		3	0
id056		3	4.86
id058		3	6.67
id059		3.08	0
id060		3.33	1.33
id061	Black et al., 2005 [4]	3.58	40.85
id064		3.75	0
id063		3.75	8.71
id067		4.08	7.06
id068		4.42	34.84

[1] Leckie, J. O., Naylor, K. A., Canales, R. A., Ferguson, A. C., Cabrera, N. L., Hurtado, A. L., Lee, K., Lin, A. Y., Ramirez, J.D.,& Vieira, V. M. (2000). *Quantifying Children's Microlevel Activity Data from Existing Videotapes*. Contract Report Submitted to U.S. EPA, ORD, NERL, Reference No. U2F112OT-RT.
[2] Freeman, N. C. G., Jimenez, M., Reed, K. J., Gurunathan, S., Edwards, R. D., & Lioy, P. J. (2001). Quantitative analysis of children's microactivity patterns: The Minnesota Children's Pesticide Exposure Study. *Journal of Exposure Analysis and Environmental Epidemiology*, *11*(6), 501–509.
[3] Tulve, N., Suggs, J., McCurdy, T., Cohen Hubal, E., & Moya, J. (2002). Frequency of mouthing behavior in young children. *Journal of Exposure Analysis and Environmental Epidemiology*, *12*(4), 259–264.
[4] Black, K., Shalat, S. L., Freeman, N. C. G., Jimenez, M., Donnelly, K. C., & Calvin, J. A. (2005). Children's mouthing and food handling behavior in an agricultural community on the U.S./Mexico border. *Journal of Exposure Analysis and EnvironmentalEpidemiology*, *15*, 244–251.

Statistics such as standard deviations and select percentiles are presented in *Table C-67* below.

Table C-67: Frequency of Hand-to-Mouth Events (events/hour)	
Statistic	**3 to <6 year olds**
50^{th} percentile	5.6
75^{th} percentile	11.0

95th percentile	36
AM (SD)	8.5 (10.7)
Range	0 - 48.9
N	55
AM (SD) = arithmetic mean (standard deviation)	

C.9.2 Indoor

The Indoor SOP utilizes hand-to-mouth frequency data for the 3 to <6 year old and 1 to <2 age groupings to represent toddlers and infants, respectively. Distributions for different sub-populations can be used if there is a need to assess a more specific exposure population. The estimates of hand mouthing frequency (events/hour) for 1 to <2 year olds were derived from 5 studies representing 243 participants. The estimates of hand mouthing frequency (events/hour) for 3 to <6 year olds were derived from 6 studies representing 160 participants. *Table C-68* provides the raw data.

Table C-68: Indoor Hand-to-Mouth Frequency Data

ID	Study	Age (years)	Hand-to-Mouth Frequency (events/hr)
Infants (1 to <2 year olds)			
315M12	Beamer et. al, in prep[1]	1	15
081F13		1	48
764M20		2	63
674F22		2	14
328F22		2	35
768M23		2	29
681M23		2	30
00201136	Greene, 2002[2]	1	50
00201136		1	82
00206446		1	13
00206446		1	20
TXK16769		1	20
TXK16769		1	31
00206443		1	4
TXK31661		1	15
00206443		1	17
TXK31661		1	31
ILK34447		1	24
ILK34447		1	24
ILK67031		1	5
ILK67031		1	13
ILK66422		1	36
ILK66422		1	63
TXK24860		1	7
TXK24860		1	22
ILK37758		1	10
ILK37758		1	40

Table C-68: Indoor Hand-to-Mouth Frequency Data			
ID	**Study**	**Age (years)**	**Hand-to-Mouth Frequency (events/hr)**
ILK51607		1	5
ILK51607		1	13
ILK92729		1	22
ILK92729		1	68
TXK37439		1	4
TXK37439		1	11
00204534		1	7
00204534		1	10
ILK98213		1	32
ILK98213		1	43
ILK83625		1	7
ILK83625		1	11
ILK93446		1	14
ILK93446		1	23
ILK44904		1	9
ILK44904		1	32
TXK12275		1	24
TXK12275		1	63
00203429		1	0
00203429		1	2
ILK63757		1	4
ILK63757		1	15
TXK10932		1	4
TXK10932		1	24
ILK92658		1	3
ILK92658		1	15
ILK64770		1	0
ILK64770		1	25
IL106650		1	3
IL106650		1	5
TXK47553		1	21
TXK47553		1	35
TXK15447		1	16
TXK15447		1	22
TXK57344		1	12
TXK57344		1	47
TXK39510		1	34
TXK39510		1	53
TXK03500		1	22
TXK03500		1	27
TXK15315		1	7
TXK15315		1	23
TXK34418		1	7
TXK34418		1	21
TXK14690		1	6
TXK14690		1	27

Table C-68: Indoor Hand-to-Mouth Frequency Data			
ID	Study	Age (years)	Hand-to-Mouth Frequency (events/hr)
ILK39523		1	5
ILK39523		1	10
ILK88461		1	4
ILK88461		1	5
ILK43787		1	12
ILK43787		1	28
ILK91233		1	0
ILK91233		1	0
TXK02791		1	12
TXK02791		1	43
00200973		2	1
00200973		2	6
TXK04568		2	39
TXK04568		2	78
TXK36066		2	14
TXK36066		2	17
IL105497		2	27
IL105497		2	65
ILK55650		2	4
ILK55650		2	6
TXK54694		2	18
TXK54694		2	33
ILK96974		2	6
ILK96974		2	17
ILK90093		2	4
ILK90093		2	9
ILK41454		2	2
ILK41454		2	8
TXK49183		2	4
TXK49183		2	8
ILK95130		2	3
ILK95130		2	29
ILK48848		2	1
ILK48848		2	3
TXK29304		2	17
TXK29304		2	31
ILK75432		2	0
ILK75432		2	0
ILK86318		2	11
ILK86318		2	36
ILK83808		2	107
ILK83808		2	113
IL104760		2	0
IL104760		2	8
ILK82433		2	3
ILK82433		2	21

Table C-68: Indoor Hand-to-Mouth Frequency Data			
ID	**Study**	**Age (years)**	**Hand-to-Mouth Frequency (events/hr)**
ILK87131		2	15
ILK87131		2	23
ILK81166		2	2
ILK81166		2	8
00200925		2	17
00200925		2	24
TXK57947		2	1
TXK57947		2	15
ILK52051		2	0
ILK52051		2	10
ILK49347		2	7
ILK49347		2	21
TXK36720		2	11
TXK36720		2	24
TXK28972		2	11
TXK28972		2	37
ILK52599		2	56
ILK52599		2	80
id890	Tulve et al., 2002[3]	1	0
id876		1	2
id876		1	3
id876		1	4
id932		1	5
id932		1	8
id187		1	9
id932		1	10
id975		1	10
id876		1	15
id890		1	18
id890		1	24
id932		1	24
id975		1	30
id975		1	30
id187		1	38
id975		1	41
id187		1	87
id126		1	5
id126		1	14
id126		1	19
id126		1	23
id167		1	0
id711		1	5
id104		1	7
id711		1	10
id711		1	18
id167		1	19

Table C-68: Indoor Hand-to-Mouth Frequency Data			
ID	**Study**	**Age (years)**	**Hand-to-Mouth Frequency (events/hr)**
id711		1	20
id167		1	32
id167		1	32
id705		1	10
id162		1	12
id705		1	14
id705		1	18
id705		1	20
id162		1	24
id194		1	28
id194		1	29
id162		1	32
id194		1	37
id162		1	72
id101		1	0
id101		1	0
id122		1	0
id101		1	2
id101		1	3
id837		1	3
id837		1	5
id723		1	6
id837		1	8
id723		1	11
id122		1	14
id122		1	16
id122		1	24
id837		1	24
id132		2	37
id132		2	54
id768		2	38
id768		2	62
id768		2	108
id108		2	2
id108		2	3
id108		2	4
id108		2	4
id190		2	9
id120		2	10
id190		2	11
id120		2	24
id150		2	0
id150		2	0
id103		2	12
id103		2	24

Table C-68: Indoor Hand-to-Mouth Frequency Data			
ID	**Study**	**Age (years)**	**Hand-to-Mouth Frequency (events/hr)**
id103		2	27
id150		2	27
id764		2	29
id103		2	30
id110		2	0
id748		2	0
id748		2	4
id748		2	6
id748		2	7
id110		2	16
id110		2	32
id012	Black et al., 2005[4]	1	5
id015		1	11
id013		1	21
id014		1	35
id018		1	4
id017		1	16
id016		1	29
id019		1	23
id020		1	26
id022		1	9
id021		1	13
id023		1	7
id024		1	21
id025		2	36
id026		2	14
id027		2	12
id028		2	8
id029		2	18
id030		2	24
id031		2	10
r208	Reed et al., 1999[5]	2	11
r201		2	0
Toddlers (3 to <6 year olds)			
TXK38194	Greene, 2002[2]	3	12
TXK38194		3	30
ILK41456		3	0
ILK41456		3	2
TXK40696		3	4
TXK40696		3	9
TXK01757		3	3
TXK01757		3	11
TXK07961		3	8
TXK07961		3	14
ILK42850		3	21

Table C-68: Indoor Hand-to-Mouth Frequency Data			
ID	**Study**	**Age (years)**	**Hand-to-Mouth Frequency (events/hr)**
ILK42850		3	27
id375	Freeman et al., 2001[6]	3	4
id362		3	5
id359		3	5
id401		5	4
id135	Tulve et al., 2002[3]	3	2
id135		3	2
id135		3	8
id521		3	0
id521		3	0
id529		3	0
id529		3	0
id529		3	5
id511		3	6
id511		3	8
id511		3	8
id107		3	2
id121		3	6
id107		3	9
id107		3	19
id142		4	1
id142		4	1
id142		4	5
id125		4	8
id142		4	23
id158		4	39
id158		4	62
id158		4	64
id158		4	88
id129		4	6
id179		4	22
id179		4	31
id179		4	45
id469		4	0
id469		4	0
id133		4	17
id133		4	20
id140		4	22
id192		4	2
id146		4	4
id146		4	4
id146		4	4
id192		4	4
id166		4	7
id166		4	11

Table C-68: Indoor Hand-to-Mouth Frequency Data			
ID	**Study**	**Age (years)**	**Hand-to-Mouth Frequency (events/hr)**
id166		4	13
id166		4	20
id192		4	23
id192		4	120
id111		4	0
id137		4	2
id111		4	24
id102		4	2
id102		4	20
id429		4	42
id429		4	44
id102		4	54
id177		4	2
id410		4	10
id410		4	13
id177		4	24
id410		4	24
id369		4	0
id369		4	0
id369		4	0
id369		4	0
id127		4	84
id375		4	1
id375		4	3
id321		5	0
id321		5	1
id321		5	3
id191		5	4
id321		5	4
id303		5	14
id303		5	15
id303		5	16
id303		5	65
id298		5	0
id298		5	2
id134		5	4
id298		5	4
id134		5	5
id298		5	5
id134		5	18
id149		5	5
id109		5	8
id149		5	12
id109		5	14
id183		5	14

Table C-68: Indoor Hand-to-Mouth Frequency Data			
ID	**Study**	**Age (years)**	**Hand-to-Mouth Frequency (events/hr)**
id149		5	24
id183		5	27
id109		5	31
id288		5	31
id288		5	33
id288		5	36
id183		5	59
id278		5	0
id278		5	0
id278		5	12
id278		5	22
id113		5	0
id113		5	0
id113		5	0
id265		5	1
id265		5	2
id265		5	5
id113		5	12
id265		5	12
id057		3	10
id058		3	10
id056		3	12
id059		3	12
id060		3	15
id061		4	84
id062	Black et al., 2005[4]	4	32
id064		4	5
id063		4	23
id066		4	10
id065		4	23
id067		4	17
id068		4	15
d119	Reed et al., 1999[5]	3	8
r202		3	11
r210		3	11
d107		3	3
d105		4	6
d114		4	15
r205		4	10
r203		4	21
d102		4	2
d113		4	9
d120		4	13
d106		4	7
d117		4	7

Table C-68: Indoor Hand-to-Mouth Frequency Data

ID	Study	Age (years)	Hand-to-Mouth Frequency (events/hr)
d101		5	5
d109		5	4
d116		5	26
d110		5	3
r207		5	10
r206		5	5
d112		5	25
d118		5	10
d115		5	16
r204		5	8
d111		6	15
d104		6	2
c_004	Zartarian et al., 1998[7]	4	2
c_003		4	4

[1] Beamer, P., Key, M. E., Ferguson, A. C., Canales, R. A., Auyeung, W., & Leckie, J. O. (in preparation). Time activity assessment of young farmworker children in California.
[2] Greene, M.A. (2002). Mouthing times among young children from observational data. U.S. Consumer Product Safety Commission, Bethesda, MD
[3] Tulve, N., Suggs, J., McCurdy, T., Cohen Hubal, E., & Moya, J. (2002). Frequency of mouthing behavior in young children. *Journal of Exposure Analysis and Environmental Epidemiology*, *12*(4), 259–264.
[4] Black, K., Shalat, S. L., Freeman, N. C. G., Jimenez, M., Donnelly, K. C., & Calvin, J. A. (2005). Children's mouthing and food handling behavior in an agricultural community on the U.S./Mexico border. *Journal of Exposure Analysis and EnvironmentalEpidemiology*, *15*, 244–251.
[5] Reed, K. J., Jimenez, M., Freeman, N. C. G., & Lioy, P. J. (1999). Quantification of children's hand and mouthing activities through a videotaping methodology. *Journal of Exposure Analysis and Environmental Epidemiology*, *9*, 513–520.
[6] Freeman, N. C. G., Jimenez, M., Reed, K. J., Gurunathan, S., Edwards, R. D., & Lioy, P. J. (2001). Quantitative analysis of children's microactivity patterns: The Minnesota Children's Pesticide Exposure Study. *Journal of Exposure Analysis and Environmental Epidemiology*, *11*(6), 501–509.
[7] Zartarian,V.G., Ferguson, A. C.,&Leckie, J.O. (1998). Quantified mouthing activity data from a four-child pilot field study. *Journal of Exposure Analysis and Environmental Epidemiology*, *8*, 543–554.

C.9.3 Pets

There are currently no data available that specifically address the number of hand-to-mouth events that occur relative to the amount of time a child spends with a pet. As a result, the estimates for frequency of hand-to-mouth events in indoor environments from the Xue et al. (2007) meta-analysis were used as a surrogate. This article examined hand-to-mouth frequency data from 9 available studies representing 429 subjects and more than 2,000 hours of behavior observation. Results of this analysis indicate that age and location are important for hand-to-mouth frequency, but study and gender are not. In fact, hand-to-mouth frequency is significantly greater indoors than outdoors. As a result, hand-to-mouth frequency for indoor environments was selected for risk analysis of toddler indoor ingestion from treated pets.

Since the indoor environment data used are not specific to the pet SOP, raw data from the studies and resulting statistical analysis can be found in C.9.2 of the Appendix.

C.10 Estimates of Object-to-Mouth Events per Hour

Frequency of object-to-mouth events is an important variable for object-to-mouth Post-application exposure assessments. Data on the frequency of object-to-mouth events are limited and difficult to collect. The generic estimates for frequency of hand-to-mouth events are based on the Xue et al. (in press) meta-analysis. This article examined object-to-mouth frequency data from 7 available studies representing 438 participants and ~1500 hours of behavior observation. Results of this analysis indicate that age and location are important for object-to-mouth frequency. In fact, object-to-mouth frequency is significantly greater indoors than outdoors. As a result, object-to-mouth frequency for outdoor environments is presented in this Appendix separately from object-to-mouth frequency for indoor environments.

C.10.1 Outdoors - Turf

The turf SOP utilizes object-to-mouth frequency data for the 3 to <6 year old age grouping to represent toddlers. The estimates for frequency of object-to-mouth events in outdoor environments are based on the Xue et al. (accepted for publication) meta-analysis. The turf SOP utilizes object-to-mouth frequency data for the 3 to <6 year old age grouping to represent toddlers. The estimates of object mouthing frequency (events/hour) for 3 to <6 year olds were derived from 3 studies representing 53 participants. Based on an analysis of the data, it was determined that a Weibull distribution (scale= 0.55, shape= 5.38) best fits the observed data.

Table C-69: Outdoor Object-to-Mouth Frequency Data

ID	Study	Age (yrs)	OtM Frequency (events/hr)
id003	AuYeung et al., 2004 [1]	3	5.1
id027		3	6.2
id002		3.4	0.8
id028		3.4	3.2
id007		3.7	0.5
id029		3.8	9.6
id011		4.4	30.3
id030		4.7	0.0
id031		4.7	16.9
id015		4.8	10.6
id018		4.8	15.0
id032		4.9	7.8
id017		5	2.0
id033		5.1	20.1
id034		5.4	1.5
id006		5.9	0.0
id035		5.9	6.1
id359	Freeman et al., 2001 [2]	3	0.0
id375		3	0.5

id401		5	0.0
521	Tulve et al., 2002 [3]	3.33	0.0
511		3.33	6.0
107		3.42	4.0
121		3.42	4.0
121		3.42	9.0
121		3.42	20.0
125		3.5	0.0
125		3.5	0.0
129		3.58	0.0
179		3.58	0.0
129		3.58	3.0
129		3.58	19.0
133		3.67	0.0
133		3.67	0.0
145		3.67	2.0
145		3.67	13.0
140		3.75	7.0
140		3.75	7.0
140		3.75	10.0
111		3.92	0.0
153		3.92	0.0
137		3.92	2.0
137		3.92	12.0
153		3.92	14.0
137		3.92	21.0
153		3.92	70.0
127		4.32	5.0
191		4.5	0.0
191		4.5	6.0
134		4.67	8.0
149		4.75	1.0
288		4.75	16.0
109		4.75	46.0

[1] AuYeung, W., Canales, R.A., Beamer, P., Ferguson, A.C., Leckie, J.O. (2004). Young Children's Mouthing Behavior: An Observational Study via Videotaping in a Primarily Outdoor Residential Setting. *Journal of Children's Health*, *2*(3-4), 271-295.
[2] Freeman, N.C.G., Jimenez, M., Reed, K.J., Gurunathan, S., Edwards, R.D., Lioy, P.J. (2001). Quantitative analysis of children's microactivity patterns: The Minnesota Children's Pesticide Exposure Study. *Journal of Exposure Analysis and Environmental Epidemiology, 11*(6), 501-509.
[3] Tulve, N., Suggs, J., McCurdy, T., Cohen Hubal, E., Moya, J. (2002). Frequency of Mouthing Behavior in Young Children. *Journal of Exposure Analysis and Environmental Epidemiology, 12*(4), 259-264.

Statistics such as standard deviations and select percentiles are presented in *Table C-70* below.

Table C-70: Frequency of Object-to-Mouth Events (events/hour)	
Statistic	**3 to <6 year olds**
50^{th} percentile	5.0

75th percentile	10.6
95th percentile	30.3
AM (SD)	8.3 (12.4)
Range	53
N	0 - 70
AM (SD) = arithmetic mean (standard deviation)	

C.10.2 Indoors

The Indoor SOP utilizes object-to-mouth frequency data for the 3 to <6 year old and 1 to < 2 year old age grouping to represent toddlers and infants, respectively. Distributions for different sub-populations can be used if there is a need to assess a more specific exposure population. The estimates of object mouthing frequency (events/hour) for 1 to <2 year olds were derived from 4 studies representing 137 participants. The estimates of object mouthing frequency (events/hour) for 3 to <6 year olds were derived from 5 studies representing 158 participants. *Table C-71* provides the raw data.

Table C-71: Indoor Object-to-Mouth Frequency Data

ID	Study	Age (years)	Object-to-Mouth Frequency (events/hr)
Infants (1 to <2 year olds)			
id001	AuYeung et al., 2004[1]	2	11
315M12	Beamer et al., 2008[2]	1	32
081F13		1	32
764M20		2	29
328F22		2	11
674F22		2	21
681M23		2	18
768M23		2	44
00501670	Green, 2002[3]	1	0
00501670		1	3
00206446		1	6
00206446		1	9
IL101540		1	11
TXK04115		1	18
00201136		1	19
ILK67044		1	21
ILK67044		1	25
00201136		1	25
TXK04115		1	26
IL101540		1	34
ILK54587		1	49
ILK54587		1	67
ILK67031		1	6
ILK66422		1	8
ILK92729		1	9
TXK31661		1	10

Table C-71: Indoor Object-to-Mouth Frequency Data			
ID	Study	Age (years)	Object-to-Mouth Frequency (events/hr)
TXK24860		1	10
TXK31661		1	11
ILK51607		1	12
TXK16769		1	14
ILK67031		1	14
ILK66422		1	16
ILK51607		1	16
ILK92729		1	18
TXK37439		1	18
00206443		1	19
TXK37439		1	19
TXK16769		1	22
ILK34447		1	22
ILK37758		1	25
TXK24860		1	26
ILK34447		1	33
00206443		1	38
ILK37758		1	41
00203429		1	6
ILK98213		1	6
00203429		1	6
ILK98213		1	7
ILK63757		1	8
ILK63757		1	8
00204534		1	11
TXK12275		1	11
00204534		1	14
ILK83625		1	16
ILK83625		1	16
ILK44904		1	17
ILK44904		1	19
TXK10932		1	19
ILK93446		1	21
TXK10932		1	21
ILK93446		1	27
TXK12275		1	32
ILK92658		1	2
TXK47553		1	3
ILK92658		1	5
IL106650		1	6
IL106650		1	6
TXK47553		1	7
TXK57344		1	11
TXK15447		1	12
TXK57344		1	12
ILK64770		1	12
TXK15447		1	13

Table C-71: Indoor Object-to-Mouth Frequency Data			
ID	Study	Age (years)	Object-to-Mouth Frequency (events/hr)
ILK64770		1	15
TXK39510		1	18
TXK39510		1	19
ILK88461		1	1
TXK15315		1	3
TXK15315		1	3
ILK88461		1	5
ILK39523		1	6
TXK34418		1	9
TXK03500		1	11
TXK14690		1	12
TXK34418		1	13
ILK39523		1	14
TXK14690		1	18
TXK03500		1	18
ILK43787		1	21
ILK43787		1	23
ILK91233		2	1
ILK91233		2	4
00200973		2	10
00200973		2	10
TXK04568		2	10
TXK02791		2	15
TXK04568		2	16
TXK02791		2	26
ILK90093		2	2
ILK95130		2	3
ILK95130		2	5
TXK49183		2	5
TXK49183		2	6
TXK36066		2	7
ILK96974		2	8
IL105497		2	8
ILK90093		2	9
ILK41454		2	10
ILK55650		2	12
TXK36066		2	12
ILK41454		2	14
ILK96974		2	14
TXK54694		2	16
TXK54694		2	17
IL105497		2	34
ILK55650		2	38
IL104760		2	1
ILK75432		2	2
ILK75432		2	2
IL104760		2	3

Table C-71: Indoor Object-to-Mouth Frequency Data

ID	Study	Age (years)	Object-to-Mouth Frequency (events/hr)
TXK29304		2	5
TXK29304		2	7
ILK86318		2	10
ILK48848		2	14
ILK83808		2	17
ILK48848		2	19
ILK83808		2	23
ILK86318		2	28
00200925		2	2
ILK81166		2	5
TXK57947		2	8
ILK82433		2	15
TXK57947		2	15
00200925		2	17
ILK87131		2	17
ILK82433		2	20
ILK81166		2	21
ILK87131		2	25
ILK52051		2	7
ILK52051		2	15
ILK49347		2	19
ILK49347		2	31
r208	Tulve et al., 2002[4]	2	2
r201		2	0
890		1	9
876		1	18
932		1	19
876		1	21
932		1	24
876		1	33
932		1	34
187		1	41
975		1	45
975		1	50
890		1	58
890		1	58
876		1	69
187		1	84
187		1	84
932		1	89
975		1	90
975		1	112
126		1	36
126		1	38
126		1	62
126		1	73

Table C-71: Indoor Object-to-Mouth Frequency Data			
ID	Study	Age (years)	Object-to-Mouth Frequency (events/hr)
711		1	12
104		1	17
711		1	32
167		1	37
167		1	51
711		1	54
167		1	67
167		1	72
711		1	87
705		1	17
194		1	24
705		1	30
194		1	31
162		1	43
162		1	45
194		1	47
705		1	48
705		1	72
162		1	98
162		1	204
101		1	0
101		1	0
122		1	0
101		1	10
837		1	10
101		1	24
837		1	27
122		1	28
837		1	36
723		1	38
122		1	50
837		1	54
122		1	62
723		1	72
132		2	32
132		2	59
768		2	22
768		2	24
768		2	53
108		2	7
190		2	18
108		2	19
108		2	20
190		2	31
108		2	40
120		2	41
120		2	120

Table C-71: Indoor Object-to-Mouth Frequency Data			
ID	Study	Age (years)	Object-to-Mouth Frequency (events/hr)
150		2	2
103		2	8
764		2	21
150		2	68
150		2	75
103		2	82
103		2	96
103		2	147
748		2	2
748		2	6
748		2	24
748		2	54
110		2	60
110		2	64
110		2	81
Toddlers (3 to <6 year olds)			
id018	AuYeung et al., 2004[1]	5	46
id032		5	13
id017		5	7
id033		5	0
id034		5	0
id375	Freeman et al., 2001[5]	3	2
id359		3	5
id362		3	12
id401		5	1
TXK38194	Green, 2002[3]	3	0
TXK38194		3	2
ILK41456		3	2
ILK85996		3	2
ILK85996		3	2
ILK41456		3	3
ILK88806		3	7
TXK40696		3	7
ILK88806		3	7
ILK63180		3	7
TXK40696		3	9
ILK63180		3	10
TXK26423		3	22
TXK26423		3	27
TXK07961		3	3
TXK07961		3	4
TXK01757		3	4
ILK42850		3	7
TXK01757		3	9
ILK42850		3	10

Table C-71: Indoor Object-to-Mouth Frequency Data			
ID	Study	Age (years)	Object-to-Mouth Frequency (events/hr)
d119	Reed et al., 1999[6]	3	6
r202		3	11
r210		3	4
d107		3	4
d105		4	6
d114		4	0
r203		4	5
r205		4	7
d120		4	0
d113		4	1
d102		4	4
d117		4	0
d106		4	3
d101		5	1
d109		5	6
d116		5	3
d110		5	1
r207		5	2
d112		5	0
r206		5	5
d118		5	1
d115		5	0
r204		5	2
d111		6	1
d104		6	0
135	Tulve et al., 2002[4]	3	0
135		3	2
135		3	5
511		3	0
521		3	0
529		3	0
529		3	0
511		3	1
521		3	3
511		3	5
529		3	7
121		3	5
107		3	9
107		3	14
107		3	19
142		4	3
142		4	4
142		4	8
142		4	10
158		4	15

Table C-71: Indoor Object-to-Mouth Frequency Data			
ID	Study	Age (years)	Object-to-Mouth Frequency (events/hr)
125		4	26
158		4	40
158		4	63
158		4	65
179		4	2
129		4	11
179		4	13
179		4	28
469		4	0
133		4	2
133		4	4
469		4	4
140		4	13
146		4	0
192		4	0
146		4	2
166		4	4
192		4	4
166		4	8
192		4	8
166		4	11
166		4	13
146		4	16
192		4	57
111		4	0
111		4	0
137		4	6
102		4	0
102		4	0
429		4	0
429		4	5
102		4	26
177		4	3
410		4	10
410		4	23
177		4	24
410		4	32
369		4	0
369		4	0
369		4	17
369		4	33
127		4	18
375		4	0
375		4	0
321		5	2

Table C-71: Indoor Object-to-Mouth Frequency Data

ID	Study	Age (years)	Object-to-Mouth Frequency (events/hr)
191		5	3
321		5	16
321		5	21
321		5	44
303		5	5
303		5	9
303		5	37
303		5	38
298		5	0
298		5	0
298		5	0
298		5	0
134		5	6
134		5	18
134		5	32
109		5	2
149		5	5
183		5	6
183		5	12
288		5	15
149		5	19
149		5	19
288		5	20
288		5	36
109		5	39
109		5	50
183		5	104
278		5	0
278		5	0
278		5	0
278		5	30
113		5	0
113		5	0
113		5	0
113		5	0
265		5	2
265		5	3
265		5	3
265		5	7

[1] AuYeung, W., Canales, R.A., Beamer, P., Ferguson, A.C., Leckie, J.O. (2004). Young Children's Mouthing Behavior: An Observational Study via Videotaping in a Primarily Outdoor Residential Setting. *Journal of Children's Health*, *2*(3-4), 271-295.
[2] Beamer, P., Key, M.E., Ferguson, A.C., Canales, R.A., Auyeung, W., Leckie, J.O. (2008). Time Activity Assessment of Young Farmworker Children in California. In revision, Journal of Environmental Research.
[3] Greene, M.A. (2002). Mouthing times among young children from observational data. U.S.

Table C-71: Indoor Object-to-Mouth Frequency Data			
ID	Study	Age (years)	Object-to-Mouth Frequency (events/hr)

Consumer Product Safety Commission, Bethesda, MD
[4] Tulve, N., Suggs, J., McCurdy, T., Cohen Hubal, E., Moya, J. (2002). Frequency of Mouthing Behavior in Young Children. *Journal of Exposure Analysis and Environmental Epidemiology, 12*(4), 259-264.
[5] Freeman, N.C.G., Jimenez, M., Reed, K.J., Gurunathan, S., Edwards, R.D., Lioy, P.J. (2001). Quantitative analysis of children's microactivity patterns: The Minnesota Children's Pesticide Exposure Study. *Journal of Exposure Analysis and Environmental Epidemiology, 11*(6), 501-509.
[6] Reed, K.J., Jimenez, M., Freeman, N.C.G., and Lioy, P.J. (1999). Quantification of children's hand and mouthing activities through a videotaping methodology. *Journal of Exposure Analysis and Environmental Epidemiology, 9*, 513-520.

C.11 Insect Repellent Application Rates

Background on Repellent Efficacy Studies

As part of the registration process for insect repellent products, efficacy studies are required. Efficacy studies with dosimetry determination are available for aerosols, pumps prays, lotions, and towelettes – formulations that comprise the vast majority of repellent products. To the extent that acceptable, appropriate studies are available, these studies are useful in determining an application rate estimate for some repellent exposure scenarios, and have been included in this SOP.

Some insect repellent efficacy studies incorporate "dosimetry determination" that can be used as application rates in the form "mass repellent product per square centimeter of skin". Rates in this form can then be extrapolated to the rest of the body for different application scenarios (e.g., weather, location, etc.) to estimate a total body application. "Dosimetry determination" in efficacy studies is used to determine the dosing rate of repellent products when tested for efficacy under laboratory and field conditions. For an insect repellent to perform as claimed on the label, a certain concentration of the chemical and thorough coverage of the exposed area is essential. Dosimetry is conducted using 10-12 adult subjects, both males and females. The process starts by designating an area to treat (cm^2) by measuring the length and circumference of the forearm and/or lower leg. Then the test subjects are given a copy of the instructions (part of the label of the proposed product) along with a product sample. After they become familiar with the instructions and the product's formulation and package they will practice treating themselves. During the practice session, a technician will show each test subject how to treat the forearm or leg with the test product to thoroughly and evenly cover the measured area without wasting the product and each test subject practices the treatment the way he/she would use the product under the actual use conditions. Then each subject performs three applications of the product which is measured and reported in mass product per skin surface area.

Because there is large variation in the applied rate of repellent products by the consumers, dosimetry is used to capture that variability and apply a standardized application rate in the efficacy trial. Besides determining a rate to use in an efficacy trial however, the dosimetry aspect provides an estimate of the actual amount of product applied to a treatment area and also lends itself to statistical analysis to capture the range of application rates individuals will apply for certain types of products. As previously stated, a product-specific estimate of the total amount of repellent applied to the entire body (e.g., total mass per application) would be the most accurate measure of repellent applications. However, absent this kind of information, an extrapolation to the whole body from the dosimetry estimates in these efficacy studies provide the most reliable available application estimates.

The following sections provide an analysis of the dosimetry determination components of various efficacy studies for the purposes of generating product-specific application rates for use in estimating exposure to insect repellents.

Variable AR_F: Formulation-specific application rate (mg product/cm^2 skin)

Several efficacy studies on insect repellents of different formulations have been submitted to the Agency and are available for analysis. These studies have been reviewed by OPP and the Human Studies Review Board. Each study used in the creation of this SOP has been found to be acceptable under both GLP and HSRB guidelines.

Aerosols

When aerosol (or pump spray) formulations are tested, the delivered quantity of spray is measured using dosimeter patches (i.e., four 1-inch wide strips of 3M Brand Nexcare Holdfast self adhesive roll gauze) placed strategically on the forearm or leg to intercept a portion of the spray applied which is then extrapolated to the rest of the treated area. Before each spray trial, a technician custom fits the four narrow rings of plastic-backed gauze patches around each person's forearm or leg. The dosimeters are narrow to minimize the extent to which the sensation of the spray falling on the bare skin is altered. For each treatment, there are 4 dosimeters per limb totaling 24 if both limbs are used.

The amount of product captured by each dosimeter patch is determined by the weight difference before and after application. The total captured by all 4 patches (1 inch wide) per trial is added and then any weight gain or loss in the paired control dosimeters is corrected to obtain a net total weight gain. The total weight of applied product per treated area was calculated by the following algorithm:

$$AR = \frac{\frac{DW}{SD} * LT}{AT}$$

where:

AR	= Application rate of spray product (g /cm^2)
AT	= Area treated, leg or forearm (cm^2)
DW	= Weight of product captured by 4 dosimeters (g)
LT	= Length of treated area, leg or forearm (cm)
SD	= Total width of 4 dosimeter patches (10.16 cm)

Application rate data from two efficacy studies (EPA MRID 47049501 and 47049502), both measuring IR 3535 which contains 20% ai in aerosol form, were available for analysis.

Application rates, as measured using the dosimetry determination outlined above, ranged from 0.17 to 3.5 mg aerosol per cm2 of skin. A lognormal probability plot is presented below.

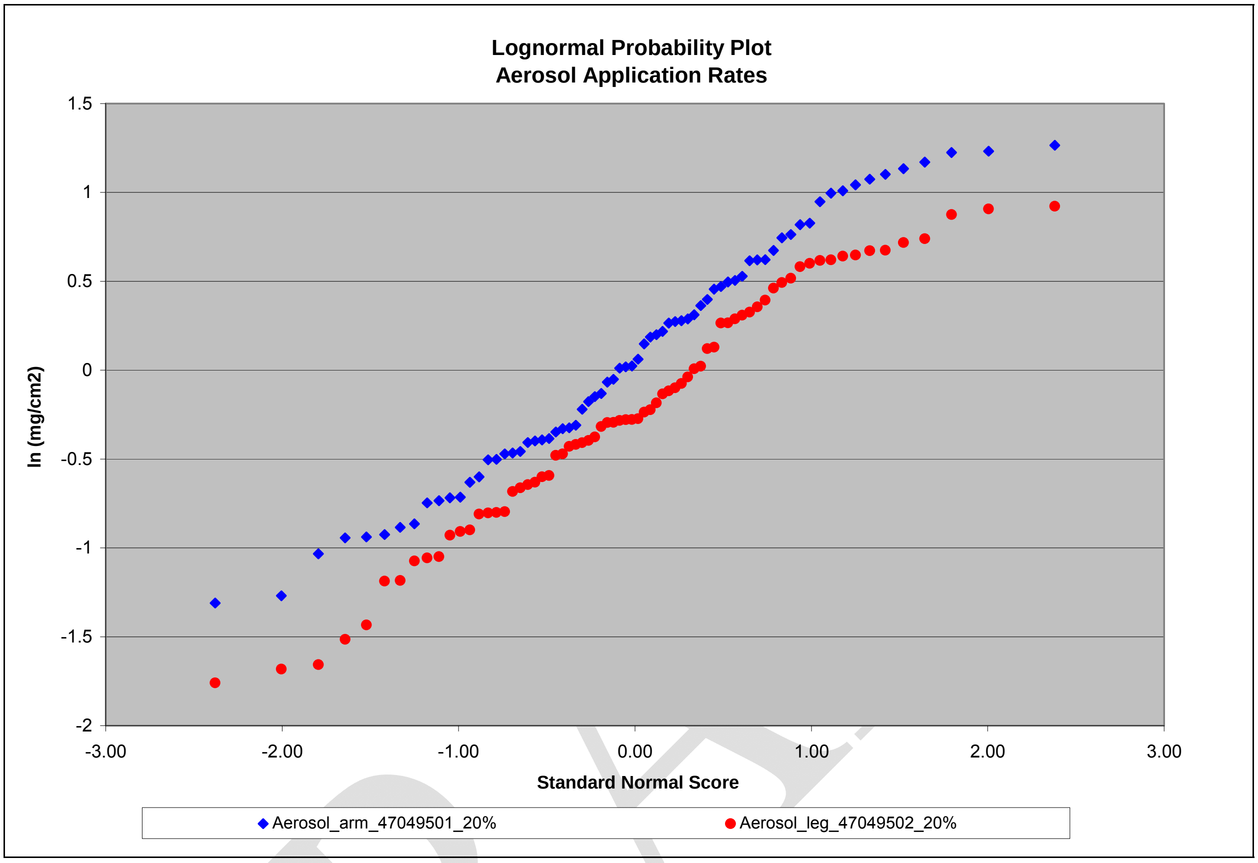

Figure C-33: Lognormal Probability Plot for Aerosol Application Rates

Statistics following combination of the two datasets and analysis as a lognormal distribution are presented in *Table C-72* below.

Table C-72: Statistical Summary – Repellent Aerosol Application Rate (mg product/cm2)	
Statistic	**Application Rate**
50th percentile	0.92
75th percentile	1.48
95th percentile	2.91
99th percentile	4.68
99.9th percentile	7.98
AM (SD)	1.12 (0.93)
GM (GSD)	0.92 (2.01)
Range	0.17 – 3.54
N	144
Based on MRID 47049501 and 47049502 AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

Pump Sprays

Similar to the studies for aerosols, efficacy studies for pump sprays were available from three MRIDs (47217601, 47535201, and 47535202). MRID 47217601 tested oil of lemon (30% pump spray) and MRIDs 47535201 and 47532502 both tested 7% and 15% picaridin pump sprays. A total of 5 sets of dosimetry samples, conducted as described above, were available from these three studies (two MRIDs each had two sets of dosimetry samples from two different products). Across all pump spray studies the application rates ranged from 0.06 to 2.3 mg spray per cm2 of skin. A lognormal probability plot showing the distribution of each study is presented below.

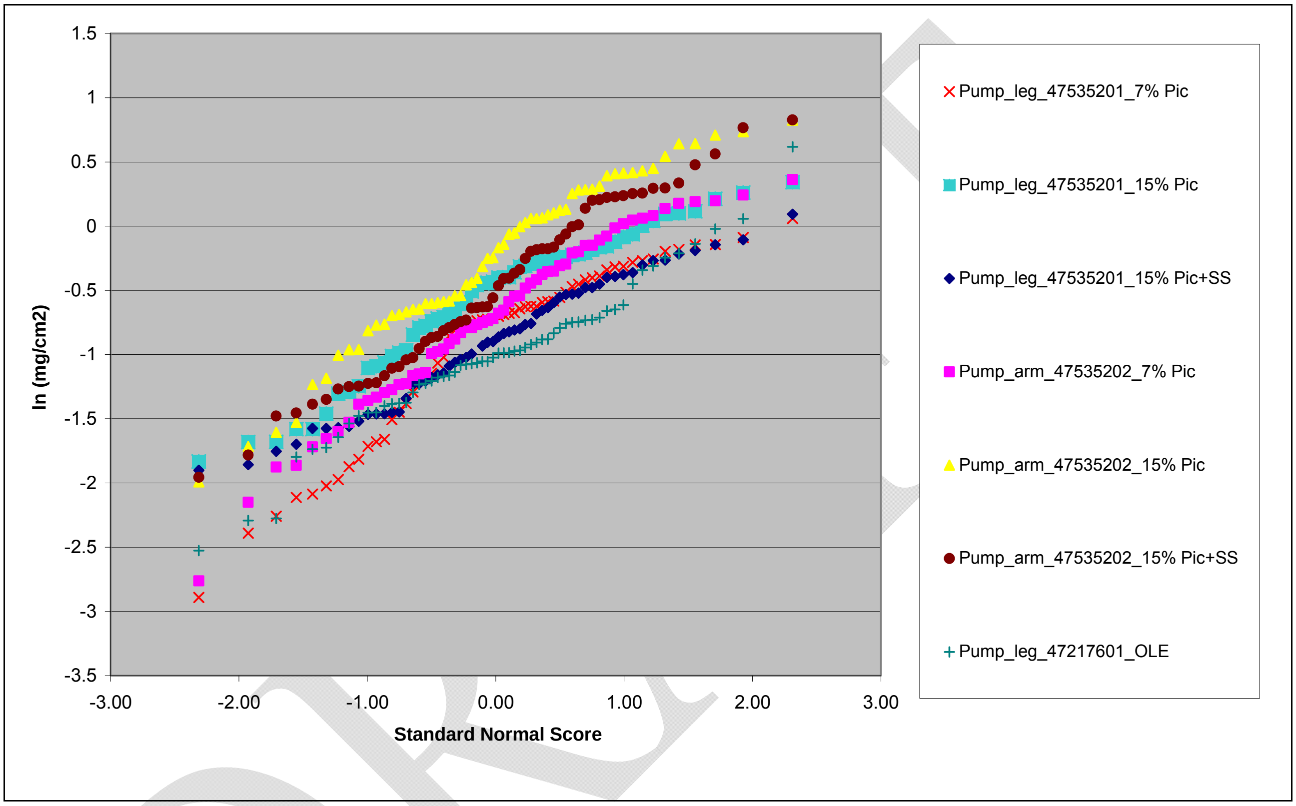

Figure C-34: Pump Spray Application Rate Lognormal Probability Plots

Statistics following combination of the datasets and analysis as a lognormal distribution are presented in *Table C-73* below.

Table C-73: Statistical Summary – Repellent Pump Spray Application Rate (mg product/cm2)	
Summary Statistic	**Application Rate**
50th percentile	0.50
75th percentile	0.78
95th percentile	1.47
99th percentile	2.29
99.9th percentile	3.78
AM (SD)	0.62 (0.45)
GM (GSD)	0.50 (1.93)
Range	0.06 – 2.29
N	420
Based on MRID 47535201, 47535202, and 47217601 AM (SD) = arithmetic mean (standard deviation)	

GM (GSD) = geometric mean (geometric standard deviation)

Lotions

Two studies (EPA MRID 47322401 and 47322501) measuring the efficacy of repellents formulated as lotions are available to estimate application rates based on dosimetry determination. The studies tested the efficacy of Coulston's Duranon Personal Insect Repellent (30% DEET) and Dermaegis Lipo DEET (20% DEET). As previously described, each test subject applied the lotions three times to designated areas on each of their forearms for a total of 120 applications. The application rate (in mg lotion per cm2 forearm) is determined simply by weighing the product (bottle) before and after each application and dividing by the surface area of the arm treated.

Overall the application rates in these studies ranged from 0.68 to 4.51 mg lotion per cm2 of skin. The application rates for each study were plotted on a lognormal probability plot, shown in the figure below, to evaluate the distributions of the datasets.

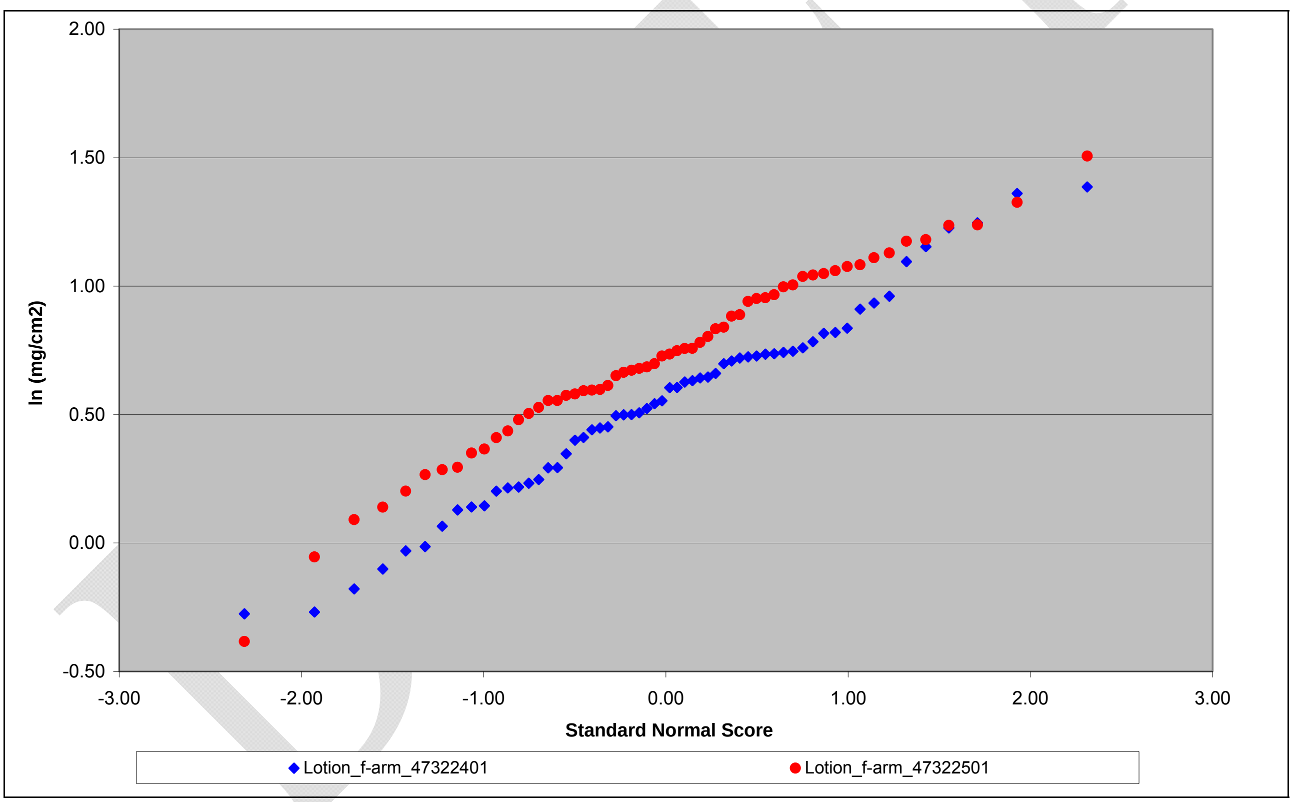

Figure C-35: Lotion Application Rate Lognormal Probability Plots

It is not unexpected that there are differences between the two applications, though at the upper end of each distribution they appear to be fairly similar. Because the intention of this exercise is to yield a distribution of application rates for a future lotion repellent, the datasets were combined. Statistics of this distribution are summarized in *Table C-74* below.

Table C-74: Statistical Summary – Repellent Lotion Application Rate (mg product/cm2)	
Statistic	**Application Rate**

50th percentile	1.89
75th percentile	2.43
95th percentile	3.52
99th percentile	4.55
99.9th percentile	6.08
AM (SD)	2.03 (0.80)
GM (GSD)	1.89 (1.46)
Range	0.68 – 4.51
N	120
Based on MRID 47322401 and 47322501 AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	

Towelettes

The amount of repellent applied for towelettes is similarly quantified in three replicates and like lotions, dosimeter patches are not required for determining the application – it is simply derived as the weight difference before and after application according to the label. An estimation of loss of active ingredient via evaporation is determined by a exposing a pre-weighed towelette to the air for the same duration the test subject takes to apply the repellent (i.e., a control towelette). Any weight difference of the towelette used for treatment is corrected for loss due to evaporation of the control towelette. The application rate was calculated based on the weight loss of towelette and the applied skin area.

Two available studies (MRIDs 47535201 and 47535202) testing the efficacy of 12% and 6% picaridin towelettes are available to determine towelette application rates. For both towelette studies the application rates ranged from 0.5 to 2.5 mg spray per cm2 of skin. A lognormal probability plot showing the distribution of each study is presented below.

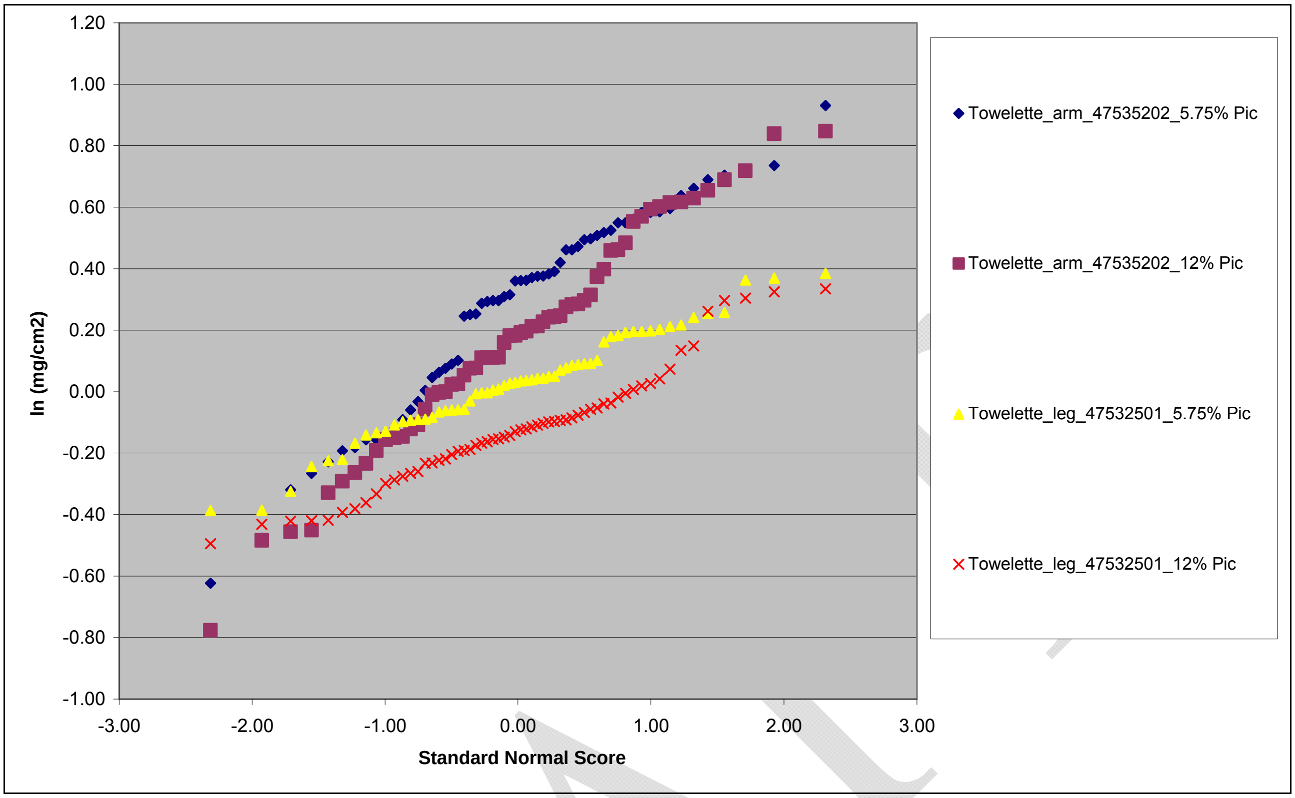

Figure C-36: Towelette Application Rate Lognormal Probability Plots

Statistics following combination of the datasets and analysis as a lognormal distribution are presented in *Table C-75* below.

Table C-75: Statistical Summary – Repellent Towelette Spray Application Rate (mg product/cm2)	
Statistic	**Application Rate**
50^{th} percentile	1.09
75^{th} percentile	1.34
95^{th} percentile	1.82
99^{th} percentile	2.25
99.9^{th} percentile	2.85
AM (SD)	1.14 (0.36)
GM (GSD)	1.09 (1.36)
Range	0.46 – 2.54
N	240
Based on MRID 47535201, 47535202 AM (SD) = arithmetic mean (standard deviation) GM (GSD) = geometric mean (geometric standard deviation)	