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TOXIC SUBSTANCES

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MEMORANDUM

SUBJECT: Occupational and Residential Exposure Assessment And Recommendations For
The Reregistration Eligibility Decision (RED) for Resmethrin

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This document provides an assessment of occupational and residential exposure and risk
for Resmethrin.

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1.0 Executive Summary

1.1 Background and Purpose

This occupational and residential exposure and risk assessment is being conducted as part of EPA's human health risk assessment for the Resmethrin Reregistration Eligibility Decision (RED) Document. This document addresses the exposures and risks associated with the both occupational and residential exposure to resmethrin based on label prescribed uses.

1.2 Use Patterns and Formulations

Based on data from the Office of Pesticide Programs Information Network (OPPIN), there are currently 274 actively registered labels for resmethrin. Resmethrin is a broad spectrum insecticide effective against a wide range of flying and crawling insects. It is used for control of insects on ornamental plants, pets and their dwellings, and in outdoor and indoor areas of residential, agricultural, recreational, commercial and industrial sites. It is available primarily as ready-to-use, pressurized liquid, and emulsifiable concentrate formulation. It is applied by commercial and residential applicators with application methods and equipment typically used for liquid formulations.

1.3 Hazard Identification

The following toxicological endpoints of concern for occupational and residential exposure pathways have been identified for resmethrin. (B. Dykstra, D304864, 7/05, Section 4.0). Incidental oral, dermal, and inhalation non-cancer exposures cannot be combined due to lack of a common toxic effect via these exposure routes.

For short- and intermediate-term incidental oral exposure, the toxicology endpoint was selected from a developmental toxicity study in rats based on a maternal toxicity NOAEL of 40 mg/kg/day and a LOAEL of 80 mg/kg/day at which decreased body weight gain and food consumption were observed.

An endpoint of 30 mg/kg/day (NOAEL) was selected for short-, intermediate-, and long term dermal absorption exposure based on a developmental toxicity study in rabbits which showed increased incidence of skeletal variations and a possible marginal increase in resorbed litters at the LOAEL of 100 mg/kg/day. A dermal absorption factor of 2% was used for route-to-route extrapolation based on a recent dermal absorption study (2004) of pyrethrins in humans that indicated 0.22% dermal absorption. This study was further corroborated by other human dermal estimates with permethrin, (0.5%) and cypermethrin (0.3-1.8%).

Short-, intermediate-, and long- term inhalation exposure endpoints were based on a 90-day inhalation study in rats which indicated a LOAEL of 0.1 mg/L (28.2 mg/kg/day) based on clinical signs within the first month, decreased glucose levels in males, a decrease (-13%) in

body weight gain during weeks 1-4 and an increase in BUN (32%) at week 12 in females. A NOAEL was not established in the study.

The CARC (4/13/05) classified resmethrin as "likely to be carcinogenic to humans" and recommended a low-dose linear extrapolation of a Q_1^* for resmethrin based on the following studies. The unit risk, Q_1^* (mg/kg/day)⁻¹, of Resmethrin based upon male mouse liver combined adenoma and/or carcinoma tumor rates is 5.621×10^{-2} in human equivalents. (Lori L. Brunsmann, TXR No. 0053330, 6/8/05)

OPP's cancer risk level of concern (LOC) for occupational exposure is 1×10^{-4} . The target LOC or margin of exposure (MOE) for all occupational exposure routes is 100. The target MOE for occupational exposure is based on the conventional uncertainty factor of 100X (10X for intraspecies extrapolation and 10X for interspecies variation). OPP's cancer risk level of concern for residential exposure is 1×10^{-6} . The target MOE for all residential exposure routes is 1000. For residential exposure, the MOE is based on the conventional uncertainty factor of 100X (10X for intraspecies extrapolation and 10X for interspecies variation) plus an additional 10X for the database uncertainty factor due to the absence of subchronic and developmental neurotoxicity studies.

1.4 Occupational and Residential Exposure and Risk

Based on toxicological criteria, use patterns, and potential for exposure, HED has conducted inhalation, dermal, and incidental oral exposure assessments for a variety of occupational and residential scenarios. Occupational and residential exposure via inhalation and dermal routes can occur during mixing, loading, and application activities. Inhalation, dermal and incidental oral exposures can occur during residential post-application activities.

Twelve exposure scenarios were identified as representative of occupational exposure from resmethrin uses. These include seven scenarios for pesticide control operators, four scenarios for mosquito abatement applications, and one scenario for veterinary/pet grooming applications. Eleven exposure scenarios were assessed for residential exposure, two for residential handler activities, and nine for residential post-application activities.

Occupational and residential exposure and risk estimates were conducted using maximum and/or typical application rates and HED standard default assumptions for area of application and/or amount of product applied for most exposure scenarios. Available compound and scenario specific data were also used as appropriate for some scenarios.

Non-cancer exposure and risk estimates indicate no MOEs of concern at the maximum use rate for all occupational and residential exposure scenarios assessed. Occupational exposures were assessed with baseline or minimal personal protective equipment. Cancer exposure and risk estimates indicate cancer risks are below OPP's cancer risk level of concern ($\leq 1 \times 10^{-4}$) for all occupational exposure scenarios assessed. To characterize potential cancer risks for the

residential handler and/or post-application exposure scenarios assessed, HED estimated the number of days an individual adult or child could be exposed to resmethrin without presenting a cancer risk of concern (i.e., estimated cancer risk $\leq 1 \times 10^{-6}$).

2.0 Hazard Identification

2.1 Acute Toxicology Categories

Table 1 presents the acute toxicity categories as outlined in Section 4.0 of the risk assessment document.

Guideline No.	Study Type	MRID(s)	Results	Toxicity Category
870.1100	Acute oral [rat]	42076201	LD ₅₀ = 6091 mg/kg (males) 4639 mg/kg (females)	III
870.1200	Acute dermal [rabbit]	42076202	LD ₅₀ > 2000 mg/kg	III
870.1300	Acute inhalation [rat]	42153701	LC ₅₀ = 5.28 mg/L	IV
870.2400	Acute eye irritation [rabbit]	42076203	PIS = 2.3 at 1 hr. only	IV
870.2500	Acute dermal irritation [rabbit]	42076204	PIS = 0.0	IV
870.2600	Skin sensitization [guinea pig]	42153702	negative - Buehler	

2.2 Toxicological Endpoints

The HED resmethrin team toxicologist identified toxicological endpoints of concern for resmethrin. All calculations completed in this document are based on the most current toxicity information available for resmethrin. The endpoints and MOEs that were used to complete this assessment are summarized below in Tables 2 and 3.

Exposure Scenario	Dose Used in Risk Assessment, UF	Special FQPA SF* and Level of Concern for Risk Assessment	Study and Toxicological Effects
Incidental Oral Short- and Intermediate-Term (1 - 30 days, 1-6 months)	Maternal toxicity NOAEL = 40 mg/kg/day	Residential LOC for MOE = 1000 Occupational = NA	Rat Developmental Toxicity Study Maternal LOAEL = 80 mg/kg/day based on reduced weight gain and reduced food consumption during gestation
Dermal Short-, Intermediate-, Long-Term (1 - 30 days, 1-6 months, > 6 months)	Oral Developmental NOAEL = 30 mg/kg/day (dermal absorption rate = 2%)	Residential LOC for MOE = 1000 Occupational LOC for MOE = 100	Oral Rabbit Developmental Toxicity Study Developmental LOAEL = 100 mg/kg/day based on increased incidence of skeletal variations and a possible marginal increase in resorbed litters in the absence of maternal toxicity

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Table 2, Summary of Toxicological Doses and Endpoints for Resmethrin for Use in Human Risk Assessments

Exposure Scenario	Dose Used in Risk Assessment, UF	Special FQPA SF* and Level of Concern for Risk Assessment	Study and Toxicological Effects
Inhalation Short-, Intermediate-, Long-Term (1 - 30 days, 1-6 months, > 6 months)	Inhalation LOAEL = 0.1 mg/L (28.2 mg/kg/day)	Residential LOC for MOE = 1000 Occupational LOC for MOE = 100	90-Day Inhalation Toxicity Study Inhalation LOAEL = 0.1 mg/L (28.2 mg/kg/day) based on clinical signs within the first month, decreased glucose levels in males, a decrease (- 13%) in body weight gain during weeks 1-4 and an increase in BUN (32%) at week 12 in females.
Cancer (oral, dermal, inhalation)	Classification: "Likely to be carcinogenic to humans". Q1* = 5.62 x 10 ⁻² (mg/kg/day)-1		

UF = uncertainty factor, FQPA SF = Special FQPA safety factor, NOAEL = no observed adverse effect level, LOAEL = lowest observed adverse effect level, PAD = population adjusted dose (a = acute, c = chronic) RfD = reference dose, MOE = margin of exposure, LOC = level of concern. NA = Not Applicable

Table 3. Target Levels of Concern (i.e., Margins of Exposure) for Resmethrin Exposure Scenarios

Route/Duration	Short-Term (1-30 Days)	Intermediate-Term (1 - 6 Months)	Long-Term (> 6 Months)
Occupational (Worker) Exposure			
Dermal	100	100	100
Inhalation	100	100	100
Residential (Non-Dietary) Exposure			
Oral	1000	1000	N/A
Dermal	1000	1000	1000
Inhalation	1000	1000	1000

3.0 Summary of Use Patterns and Formulations

3.1 Target Pests

Resmethrin containing insecticides are used to control vast numbers and types of pests. Currently, based on EPA's OPPIN data base, resmethrin is used to control the following types of pests; ants, aphids, scab, scales, army worm, cockroach, cadelle, caterpillars, centipedes worms, bed bug, bees, billbugs, flies, spot, spiders, lice, box elder, ticks, skipper, moths, chiggers, cicadas, cutworms, mites, flying insects, crawling insects, grain insects, crickets, termites, earwigs, fleas, gnats, weevils, grasshoppers, hornets, lace bugs, leafhoppers, leafminers, borer, mealybugs, midges, millers, millipedes, mosquitoes, daubers, wasps, mildew, roaches, rust, slug, scorpions, silverfish, sow bugs, spittlebugs, thrips, waterbugs, and yellowjackets. General applications for which resmethrin is currently registered are as follows.

- Outdoor Non-food Plants (domestic and commercial): ornamentals, lawns, groundcover, greenhouse non-food plants

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- Commercial/Industrial/Agricultural Indoor and Outdoor Structures, Premises, and Equipment (includes eating establishments, food processing plants and equipment, and grain storage facilities)
- Indoor Domestic Dwellings
- Outdoor Domestic Buildings and Premises
- Farm Animals: beef and dairy cattle, hogs/pigs/swine, goat, sheep, rabbits, game, and poultry, donkeys, horses, ponies, mules
- Pets: cats, dogs, and all other domestic animals

3.2 Formulations

Based on EPA's pesticide registration database resmethrin is available as a technical manufacturing product, formulation intermediate, emulsifiable concentrate (EC), ready-to-use (RTU) liquids and pressurized liquids (PrL). End use products of resmethrin formulated as EC, RTU, and PrL liquids contain resmethrin at concentrations of 0.1-40.0% a.i.

3.3 Registered Use Sites and Application Rates

Maximum application rates for various application categories are provided in Table 4. Maximum rates are based primarily on information provided in the LUIS data base and a review of active labels.

Table 4. Summary of Resmethrin Commercial and Residential Uses	
Site Category	Maximum Application Rate
Professional Agricultural & Commercial Uses	
Non-food Crops - Greenhouses	0.004 lb ai/gal
Indoor Food Handling/Processing/Eating Establishments; Commercial and Domestic Structures Premises and Equipment - Surface and Crack and Crevice Application	0.242 lb ai/ 1000 ft ²
Indoor Food Handling/Processing/Eating Establishments; Commercial and Domestic Structures Premises and Equipment - Space Application	0.001 lb ai/1000 ft ³
Outdoor Commercial, Recreational and Domestic Outdoor Sites, Agricultural/Farm Structures, Premises and Equipment	0.25 lb ai/A
Public Health - Mosquito Abatement/Adulticide - Commercial, Recreational and Domestic Outdoor Sites	0.007 lb ai/A
Direct Application to Animals (Livestock, Farm Animals, Pets)	0.35%
Residential Uses	
Domestic Dwellings - Surface Crack and Crevice Application	0.242 lb ai/ 1000 ft ²
Domestic Dwellings - Space Application	0.001 lb ai/1000 ft ³

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Site Category	Maximum Application Rate
Out Door Premises (back yard/patios/ornamentals)	0.25 lb ai/A
Direct Application to Pets	0.35%

3.4 Application Methods and Equipment

Resmethrin is applied with the following types of equipment; aerosol can, non-aerosol pump sprayer, total release aerosol, aerial, truck-mounted and portable ultra low volume (ULV) equipment, cold aerosol generators, conventional mechanical compressed air equipment and conventional hydraulic sprayers (e.g., high and/or low pressure handwand, backpack sprayer), thermal fogging equipment.

4.0 Incident Report

The following data bases were consulted for poisoning incident data on the active ingredient resmethrin; OPP Incident Data System (IDS), Poison Control Centers (PCC), California Department of Pesticide Regulation, National Pesticide Information Center (NPIC), National Institute of Occupational Safety and Health's (NIOSH) Sentinel Event Notification System for Occupational Risks (SENSOR). The IDS review showed 34 incidents reported since 1992. Reports submitted to the IDS typically represent anecdotal reports or allegations only; therefore no conclusions can be drawn implicating the pesticide as a cause of any the reported health effects. A total of 1800 occupational and non-occupational exposure cases were reported to PCC for the nine year period from 1993-2001; 215 of the cases were seen in a health care facility. A total of 96 cases in which resmethrin was used alone or was judged to be responsible for health effects were submitted to the California Pesticide Illness Surveillance Program (1982-2003). On the list of the top 200 chemicals for which NPIC received calls from 1984-1991 inclusively, resmethrin was ranked 27th with 130 incidents in humans reported and 22 in animals (mostly pets). Based on the NIOSH SENSOR data there were there were a total of 118 occupationally related cases from 1998-2002. No scientific literature was found concerning human poisoning or other adverse effects from exposure to resmethrin.

According to the IDS and California data, the majority of cases involved systemic and respiratory effects such as headache, nausea, coughing, dizziness, and shortness of breath. The PCC and NIOSH data revealed that the majority of cases involved moderate effects such as nausea, dizziness, sore throat, eye irritation, dizziness, shortness of breath, and headache. Measures to limit systemic and respiratory exposure are recommended for this pesticide. Appropriate protective respiratory equipment is recommended for individuals who are likely to have substantial contact with resmethrin. Consideration should be given to warning the public that inhalation could provoke a reaction, especially with individuals with chronic respiratory illnesses.

5.0 Occupational Exposure and Risk

Based on data provided by the registrant and review of active labels, 12 primary occupational exposure scenarios have been assessed for this RED. Both inhalation and dermal exposures have been assessed for each of the occupational scenarios based on usage and toxicity data. For non-cancer risk assessment, short, intermediate, and long-term exposures are expected/assessed for occupational exposure scenarios based on use patterns.

5.1 Occupational Exposure Scenarios

Only occupational handler scenarios were assessed for the resmethrin RED. The term "handler" applies to individuals who mix, load, and apply the pesticide product. Occupational post-application scenarios were not assessed because based on the use patterns, worker re-entry exposure is considered unlikely, i.e., resmethrin is not used on agricultural field crops and worker re-entry exposures to treated food handling establishments, warehouse, ornamentals, and outdoor premises (e.g., recreational areas) are not expected to occur routinely for Pest Control Operators's (PCOs). Based primarily on active label uses, HED assessed the following scenarios for professional pest control operator and mosquito control applications for the resmethrin RED.

5.1.1 Pesticide Control Operator Handler Scenarios

- 1) mixing, loading and applying liquids with high pressure hand wand for non-food green house
- 2) mixing, loading and applying liquids with low pressure hand wand for non-food green house
- 3) mixing, loading and applying liquids with fogger for green house
- 4) mixing, loading and applying liquids with fogger for general outdoor sites
- 5) mixing, loading and applying liquids with low pressure handwand indoors (e.g., domestic dwellings) for surface and crack and crevice treatment
- 6) mixing, loading and applying liquids with low pressure handwand to food handling/processing/eating establishments and warehouses for surface and crack and crevice treatment
- 7) mixing, loading and applying liquids with low pressure handwand to grain storage units

5.1.2 Mosquito Abatement Scenarios

- 1) mixing, loading liquids for aerial application
- 2) mixing, loading liquids for ULV truck mounted spray application
- 3) applying liquids with truck mounted ULV ground spray (airblast sprayer unit exposure used as surrogate)
- 4) mixing, loading, applying liquids with low pressure handwand

5.1.3 Direct Application to Pets and Farm Animals (by veterinarians and groomers)

- spray application

5.2 Occupational Exposure Data and Assumptions

5.2.1 Exposure Data

5.2.1.1 Application Parameters

Maximum and typical/average application rates for all of the exposure scenarios assessed are based on information provided in the active resmethrin labels. Application methods and equipment are based on labels, information provided by the registrant, and HED data bases.

5.2.1.2 Occupational Handler Exposure Data

HED Occupational Exposure SOPs

It is HED's policy to use data from the Pesticide Handlers Exposure Database (PHED) or Outdoor Residential Exposure Task Force (ORETF) data to assess handler exposures for regulatory actions when chemical-specific monitoring data or other handler-specific data are not available. PHED was designed by a task force of representatives from the US, EPA, Health Canada, the California Department of Pesticide Regulation, and members of the American Crop Protection Association. PHED is a software system consisting of two parts; 1) a database of measured exposures for workers involved in the handling of pesticides under actual field conditions, and 2) a set of computer algorithms used to subset and statistically summarize the selected data. Currently, the database contains values for over 1,700 monitored individuals (i.e., replicates). The ORETF completed four studies which were designed to provide representative, or "generic" surrogate exposure data for residential risk assessment. The studies were designed by the Task Force, which included input from representatives of the crop protection field, regulatory agencies, and commercial applicators. The studies monitored professionals applying granular formulation by push spreader and various formulations by pressurized hose-end "handgun" or spray gun; and volunteers representing non-professional consumers applying granular formulation by push spreader and liquid formulations by garden hose-end sprays. Overall, the four ORETF studies were well-conducted and the data for all scenarios is considered of better quality and quantity than what is currently contained in PHED. Default application assumptions regarding areas treated or amounts applied for greenhouse and mosquito abatement handler exposure scenarios are documented in the HED Science Advisory Committee on Exposure's SOP 9, "Standard Values for Daily Acres Treated in Agriculture" (7/5/2000).

National Pest Management Association Survey

Information on how pest control operators use pesticide products was obtained from a survey conducted by the National Pest Management Association (NPMA). NPMA sponsored a "Pest Control Operators (PCO) Product Use and Usage Information Survey". Using a retrospective telephone survey method, the enumerator (Dr. Richard Patterson of the University of Florida) contacted 148 PCO firms and was able to complete 67 surveys. The survey was national in scope and included 12-23 responses from each of four regions. The survey collected information on where PCOs apply their products, product brands that are used for wood destroying insects and general pest control, and the amount of time PCOs spend on application, travel, equipment set up, mixing/loading products, administrative and other activities.

OPP's Biological and Economic Analysis Division (BEAD) conducted a review of the NPMA survey. BEAD drew the following conclusions regarding the robustness and validity of the survey data. Given that there are approximately 19,000 PCO firms in the U.S., it is highly unlikely that a sample size of 67 represents a statistically valid sample. The use of a retrospective survey methodology may have introduced errors in the data. Pesticide survey firms like Doane use a prospective survey instrument sent to growers in advance thus allowing them to keep detailed accounts of their pesticide usage in real time throughout the year. Despite its small size and retrospective methodology, however, the information collected is far more robust than BEAD typically gets when asking questions of this nature. BEAD typically contacts 1-5 PCO's and asks chemical specific questions which may bias the responses if PCO's value the chemical under review. BEAD believes that the NPMA Survey should be a useful tool for conducting ORE assessments on upcoming RED chemicals. (D. Brassard, D305276, 7/19/04)

5.2.2 Exposure Assumptions

The following assumptions were used in estimating risks to occupational handlers from exposure to resmethrin:

- Average body weight of an adult handler is 70 kg
- For non-cancer assessment, exposure duration is short-term, intermediate-, and potentially long-term for PCOs and mosquito control applicators
- For cancer assessment exposure duration for PCO and mosquito control applicators is assumed to be 240 days per year for 35 years (this is a highly conservative assumption)
- For non-cancer assessment, maximum application rates as determined by a label review were used for all types and methods of application.
- For cancer assessment, typical or average application rates were used
- Daily volumes handled and/or area treated used for the scenarios assessed are as follows
 - Aerial application - 7500 acres treated per day for mosquito control
 - ULV truck mounted sprayer - 3000 acres treated per day for mosquito control (airblast used as surrogate)
 - pet groomer/veterinary applications

- non-cancer 8 pets/animals are treated per day
- cancer 1 pet/animal are treated per day
- one half of a 16 oz spray container used to treat each animal
- high pressure handwand application for greenhouse - 10 acres treated or 1000 gallons of spray solution used per day
- low pressure handwand or backpack sprayer applications
 - 2 acres treated per day for mosquito control/general outdoor site applications
 - non-cancer 5 grain storage bins treated per day with cross-sectional area of 1000 square feet per bin
 - cancer 1 grain storage bins treated per day with cross-sectional area of 1000 square feet per bin
 - non-cancer 5 food handling establishment/non-food storage warehouses treated per day. area treated per warehouse is 10,000 square feet
 - cancer 1 food handling establishment/non-food storage warehouses treated per day. area treated per warehouse is 10,000 square feet
- pest control operator applications
 - non-cancer a maximum of 7 commercial offices or residential homes treated per day for general pest control management activities
 - cancer 1 commercial offices or residential home treated per day for general pest control management activities
 - average area treated per building is 1600 square feet for surface spray and crack and crevice treatment (EPA Exposure Factors Handbook)

Non-Standard Exposure Assumptions

- Assumptions used for veterinary applications and grain storage treatments are not included in the Occupational Exposure SOPs but represent values that have been used by the Agency in previous assessments (e.g., carbaryl, cyfluthrin).
- Assumptions used for daily area treated for food handling establishments and warehouses are based on best professional judgement.
- Assumptions used for general pest control applicators are based on data from the NPMA survey. Based on BEAD's review of the NPMA survey, PCOs conducting general pest control activities would treat an average of between 6 and 7 buildings per day, assuming an 8-hour work day. According to the EPA Exposure Factors Handbook, a central tendency estimate of the average residential house is 369 m³ (12800 ft³). Given a typical ceiling height of 8 feet, the typical house has about 1,600 ft² of surface area. Given that NPMA survey data indicate that PCOs spend approximately the same amount of time applying general pest control formulations to residential and commercial buildings (68 minutes for residential buildings, 70 minutes for day care buildings, and 79 minutes for commercial/institutional buildings), it is assumed that approximately the same area is treated for residential and commercial structures.

- Airblast application unit exposure data was used to assess exposure resulting from truck mounted ULV application of mosquito adulticide. In the absence of more equipment specific data, airblast unit exposure data is thought to provide reasonable surrogate exposure information based on the similarity of the two application methods and has been used for this purpose in previous HED occupational exposure assessments (e.g., carbaryl).
- There are no data in the Pesticide Handler Exposure Database (PHED) addressing the use of a hand held fogger, and no chemical specific data. The exposures for the hand held fogger application were based on surrogate data from a pulse fogger application in a greenhouse. The applicators were wearing chemical resistant protective clothing (coveralls) over long sleeve shirt and long pants, gloves, boots, goggles, and a respirator (Nigg, H. N., J. H. Stamper, W. D. Mahon. 1987. Pesticide Exposure to Florida Greenhouse Applicators. Grant No. CR-810743. Sponsored by EPA). These data has been used for this purpose in previous HED occupational exposure assessments (i.e., DDVP).

5.3 Occupational Exposure and Risk Estimates

A target LOC or MOE of 100 is considered adequate for short-, intermediate-, and long-term inhalation and dermal occupational exposure and risk. Pesticide control operator exposures are assessed as short-, intermediate- and long-term. Mosquito abatement worker exposures are assessed as short- and intermediate-term for aerial and backpack spray applications and short-, intermediate-, and long-term for truck mounted ULV spray applications. OPP's cancer risk level of concern for occupational exposure is 1×10^{-4} . Non-cancer exposure and risk estimates indicate no MOEs of concern (MOEs > 100) at the maximum use rate for all occupational exposure scenarios assessed. Cancer exposure and risk estimates are also not of concern at the maximum use rate for all occupational exposure scenarios assessed (i.e., estimated cancer risk is $\leq 1 \times 10^{-4}$). Exposure and risk estimates for each scenario are summarized below and a more detailed summary of exposure and risk calculations, critical assumptions, and results is provided in Tables 5 and 6 below.

Table 5. Estimated Resmethrin Exposure & MOEs for Pesticide Control Operator & Mosquito Abatement Activities									
Non-Cancer Risk - Target Short Intermediate and Long Term MOE = 100									
Exp Scenario ¹	Dermal Unit Exposure (mg/lb ai)	Inhalation Unit Exposure (ug/lb ai)	Use ²	Maximum Application Rate ³	Daily Area Treated ⁴	Dermal Dose (mg/kg/day) ⁵	Dermal MOE ⁶	Inhalation Dose (mg/kg/day) ⁷	Inhalation MOE ⁸
Green House - Non Food Mix/Load/Apply Liquid Formulation									
High Pressure Handwand Baseline PPE	2.5	120	Greenhouse	0.004 lb/ai gal	1000 gal/day	0.0029	11000	0.0069	4100
Low Pressure Handwand Baseline PPE	100	30	Greenhouse	0.004 lb/ai gal	10 gal/day	0.05719	530	1.714E-05	1650000
Handheld Fogger PPE*	14	190	Greenhouse	0.004 lb/ai gal	10 gal/day	0.008	3800	0.0001	260000
Out Door Sites Mix/Load/Apply Liquid Formulation									

Table 5. Estimated Resmethrin Exposure & MOEs for Pesticide Control Operator & Mosquito Abatement Activities Non-Cancer Risk - Target Short Intermediate and Long Term MOE = 100									
Exp Scenario ¹	Dermal Unit Exposure (mg/lb ai)	Inhalation Unit Exposure (ug/lb ai)	Use ²	Maximum Application Rate ³	Daily Area Treated ⁴	Dermal Dose (mg/kg/day) ⁵	Dermal MOE ⁶	Inhalation Dose (mg/kg/day) ⁷	Inhalation MOE ⁸
Handheld Fogger PPE*	14	190	Patio/Yards/Recreational Areas	0.25 lb ai/acre	2 acre/day	0.002	15000	0.0014	21000
Indoor Homes/Buildings Mix/Load/Apply Liquid Formulation									
Low Pressure Handwand Baseline PPE	100	30	Contact Spray/Crack & Crevice	0.242 lbs/1000 ft ²	7 buildings per day avg area treated - 1600 ft ²	0.0775	390	0.0012	24000
Indoor Food Handling/Processing/Eating Establishments/Non-Food Warehouses Mix/Load/Apply Liquid Formulation									
Low Pressure Handwand Baseline PPE	100	30	Contact Spray/Crack & Crevice	0.242 lbs/1000 ft ²	5 facilities per day 10000 ft ² per facility	0.3458	90	0.0052	5400
Low Pressure Handwand Dermal PPE	0.43	30	Contact Spray/Crack & Crevice	0.242 lbs/1000 ft ²	5 facilities per day 10000 ft ² per facility	0.0015	20000	0.0052	5400
Indoor Grain Storage Units Mix/Load/Apply Liquid Formulation									
Low Pressure Handwand Baseline PPE	100	30	Contact Spray/Crack & Crevice	0.242 lbs/1000 ft ²	5 bins per day 1000 ft ² per bin	0.0346	870	0.0005	54000
Mosquito Abatement Mix/Load Liquid Formulation									
ULV Truck Mounted Spray Baseline PPE	2.9	1.2	Adulticide	0.007 lb ai/acre	3000 acre/day	0.0174	1700	0.0004	78000
ULV Aerial Baseline PPE	2.9	1.2	Adulticide	0.007 lb ai/acre	7500 acre/day	0.0435	690	0.0009	31000
Mosquito Abatement Apply Liquid Formulation									
ULV Truck Mounted Spray (Open Cab)	0.36	4.5	Adulticide	0.007 lb ai/acre	3000 acre/day	0.0022	14000	0.00135	21000
Mosquito Abatement Mix/Load/Apply Liquid Formulation									
Low Pressure Handwand Baseline PPE	100	30	Adulticide	0.007 lb ai/acre	2 acre/day	0.0004	75000	0.000006	4700000
Pet Groomer and Veterinarian Apply Aerosol									
Aerosol Baseline PPE	190	1300	Pet Spray	0.003 lb ai per 16 oz can	8 pets treated per day 1/2 can of spray per pet	0.0007	46000	0.0002	130000

¹Baseline inhalation unit exposures represent no respirator. Values are reported in the PHED Surrogate Exposure Guide dated August 1998 or are from data submitted by the Outdoor Residential Exposure Task Force dated May 2000.

Baseline dermal unit exposures represent long pants, long sleeved shirts, shoes, and socks. Dermal PPE represents single layer plus gloves. Values are reported in the PHED Surrogate Exposure Guide dated August 1998 or are from data submitted by the Outdoor Residential Exposure Task Force dated May 2000.

* Handheld fogger application. There are no data in the Pesticide Handler Exposure Database (PHED) addressing the use of a hand held fogger, and no chemical specific data. The exposures for the hand held fogger application were based on surrogate data from a pulse fogger application in a greenhouse. The applicators were wearing chemical resistant protective clothing (coveralls) over long sleeve shirt and long pants, gloves, boots, goggles, and a respirator. (Nigg, 1987).

² Use patterns are from the active labels

³ Application rates are based on maximum values provided in the master label. Most application rates upon which the analysis is based are presented as lb ai/A. In some cases, the application rate is based on applying a solution at concentrations specified by the label (i.e., presented as lb ai/gallon).

¹Amount treated is based on the area or gallons that can be reasonably applied in a single day for each exposure scenario of concern based on the application method and formulation/packaging type. (Standard EPA/OPP/HED values).

²Dermal dose (mg/kg/day) = [unit exposure (mg/lb ai) * Dermal absorption (2%) * Application rate (lb ai/acre or lb ai/gallon) * Daily area treated (acres or gallons)] / Body weight (70 kg).

³Dermal MOE = short-term endpoint for dermal - dermal NOAEL (mg/kg/day) / Daily Dermal Dose.

⁴Inhalation dose (mg/kg/day) = [unit exposure (ug/lb ai) * 0.001 mg/g unit conversion * Inhalation absorption (100%) * Application rate (lb ai/acre or lb ai/gallon) * Daily area treated (acres or gallons)] / Body weight (70 kg).

⁵Inhalation MOE = short-term and intermediate-term endpoint for inhalation: (inhalation LOAEL)/ Daily Inhalation Dose.

Table 6. Estimated Resmethrin Exposure & Cancer Risk Estimate for Pesticide Control Operator & Mosquito Abatement								
Exp Scenario ¹	Dermal Unit Exposure (mg/lb ai)	Inhalation Unit Exposure (ug/lb ai)	Use ²	Typical Application Rate ³	Daily Area Treated ⁴	Combined Inhalation and Dermal Daily Dose (mg/kg/day) ⁵	Lifetime Average Daily Dose ⁶	Cancer Risk ⁷
Green House - Non Food Mix/Load/Apply Liquid Formulation								
High Pressure Handwand Baseline PPE	2.5	120	Greenhouse	0.001 lb/ai gal	1000 gal/day	0.0024	0.0008	4.E-05
Low Pressure Handwand Baseline PPE	100	30	Greenhouse	0.001 lb/ai gal	10 gal/day	0.0143	0.0047	3.E-04
Low Pressure Handwand Dermal PPE	0.43	30	Greenhouse	0.001 lb/ai gal	10 gal/day	0.0001	0.0000	1.E-06
Handheld Fogger*	14	190	Greenhouse	0.001 lb/ai gal	10 gal/day	0.002	0.0007	4.E-05
Out Door Sites Mix/Load/Apply Liquid Formulation								
Handheld Fogger*	14	190	Patio/Yards/Recreational Areas	0.05 lb ai/acre	2 acre/day	0.0007	0.0002	1.E-05
Indoor Homes/Buildings Mix/Load/Apply Liquid Formulation								
Low Pressure Handwand Baseline PPE	100	30	Contact Spray/Crack & Crevice	0.02 lbs/1000 ft ²	1 building/day avg area - 1600 ft ²	0.0009	0.0003	2.E-05
Indoor Food Handling/Processing/Eating Establishments/Non-Food Warehouses Mix/Load/Apply Liquid Formulation								
Low Pressure Handwand Sprayer Baseline PPE	100	30	Contact Spray/Crack & Crevice	0.02 lbs/1000 ft ²	1 facility/ per day 10000 ft ² / facility	0.0058	0.0019	1.E-04
Indoor Grain Storage Units Mix/Load/Apply Liquid Formulation								
Low Pressure Handwand Baseline PPE	100	30	Contact Spray/Crack & Crevice	0.02 lbs/1000 ft ²	1 bin/day 1000 ft ² / bin	0.0006	0.0002	1.E-05
Mosquito Abatement Mix/Load Liquid Formulation								
ULV Truck Mounted Spray (Open Cab)	2.9	1.2	Adulticide	0.003 lb ai/acre	3000 acre/day	0.0076	0.0025	1.E-04
ULV Aerial Baseline PPE	2.9	1.2	Adulticide	0.003 lb ai/acre	7500 acre/day	0.0190	0.0063	4.E-04
ULV Aerial Dermal PPE	0.023	1.2	Adulticide	0.003 lb ai/acre	7500 acre/day	0.0005	0.0002	1.E-05
Mosquito Abatement Apply Liquid Formulation								
ULV Truck Mounted Spray (Open Cab)	0.36	4.5	Adulticide	0.003 lb ai/acre	3000 acre/day	0.0015	0.0005	3.E-05
Mosquito Abatement Mix/Load/Apply Liquid Formulation								
Low Pressure Handwand Baseline PPE	100	30	Adulticide	0.003 lb ai/acre	2 acre/day	0.0006	0.0001	3.E-06
Pet Groomer and Veterinarian Apply Aerosol								

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Table 6. Estimated Resmethrin Exposure & Cancer Risk Estimate for Pesticide Control Operator & Mosquito Abatement

Exp Scenario ¹	Dermal Unit Exposure (mg/lb ai)	Inhalation Unit Exposure (ug/lb ai)	Use ²	Typical Application Rate ³	Daily Area Treated ⁴	Combined Inhalation and Dermal Daily Dose (mg/kg/day) ⁵	Lifetime Average Daily Dose ⁶	Cancer Risk ⁷
Aerosol Baseline PPE	190	1300	Pet Spray	0.003 lb ai per 16 oz can	1 pet/day ½ can spray/pet	0.0001	0.00004	2.E-06

¹ Baseline inhalation unit exposures represent no respirator. Values are reported in the PHED Surrogate Exposure Guide dated August 1998 or are from data submitted by the Outdoor Residential Exposure Task Force dated May 2000.

Baseline dermal unit exposures represent long pants, long sleeved shirts, shoes, and socks. Values are reported in the PHED Surrogate Exposure Guide dated August 1998 or are from data submitted by the Outdoor Residential Exposure Task Force dated May 2000.

* Handheld fogger application. There are no data in the Pesticide Handler Exposure Database (PHED) addressing the use of a hand held fogger, and no chemical specific data. The exposures for the hand held fogger application were based on surrogate data from a pulse fogger application in a greenhouse. The applicators were wearing chemical resistant protective clothing (coveralls) over long sleeve shirt and long pants, gloves, boots, goggles, and a respirator. (Nigg, 1987).

² Use patterns are from the active labels

³ Application rates are based on maximum values provided in the master label. Most application rates upon which the analysis is based are presented as lb ai/A. In some cases, the application rate is based on applying a solution at concentrations specified by the label (i.e., presented as lb ai/gallon).

⁴ Amount treated is based on the area or gallons that can be reasonably applied in a single day for each exposure scenario of concern based on the application method and formulation/packaging type. (Standard EPA/OPP/HED values).

⁵ Dermal dose (mg/kg/day) = [unit exposure (mg/lb ai) * Dermal absorption (2%) * Application rate (lb ai/acre or lb ai/gallon) * Daily area treated (acres or gallons)] / Body weight (70 kg).

Inhalation dose (mg/kg/day) = [unit exposure (ug/lb ai) * 0.001 mg/g unit conversion * Inhalation absorption (100%) * Application rate (lb ai/acre or lb ai/gallon) * Daily area treated (acres or gallons)] / Body weight (70 kg).

⁶ LADD = Total Daily Dose (mg/kg/day) * Handler Activity Days/365 days/yr * Years Handler Activity/70 years

⁷ Cancer Risk = LADD * Q₁

6.0 Residential Exposure and Risk

Based on a review of active labels, 12 residential exposure scenarios have been assessed for this RED. Inhalation, dermal, and incidental ingestion exposure assessments have been conducted for the residential scenarios. Short- and intermediate-term exposures are expected/assessed for residential handler and post-application exposure scenarios based on use and exposure patterns.

6.1 Residential Exposure Scenarios

The residential exposure assessment includes two handler and ten post-application residential exposure scenarios. The term "handler" applies to individuals who mix, load, and apply the pesticide product. The term "post-application" describes individuals who are exposed to pesticides after entering areas previously treated with pesticides. Based on a review of active labels and information provided by the registrant, HED assessed the following residential exposure scenarios for the resmethrin RED.

6.1.1 Handler Exposure Scenarios

- 1) Mixing, loading, and applying liquid spray formulation by low-pressure handwand for indoor surface spray and crack and crevice treatment application
- 2) Mixing, loading, and applying liquid formulation by fogger for general outdoor application.

6.1.2 Post Application Exposure Scenarios

- 1) Inhalation exposure from application of mosquito adulticide from fixed wing aircraft and/or helicopter
- 2) Inhalation exposure from application of mosquito adulticide from ULV truck mounted sprayer
- 3) Toddler incidental ingestion of residue from exposed turf grass via hand-to-mouth activities
- 4) Toddler incidental ingestion of residue via object-to-mouth activity while on exposed turf grass
- 5) Toddler incidental ingestion of soil from treated area
- 6) Toddler incidental ingestion of residues deposited on carpet via hand-to-mouth activities after use of total release foggers
- 7) Toddler incidental ingestion of residues deposited on vinyl flooring via hand-to-mouth activities after use of total release foggers
- 8) Toddler incidental ingestion of residues on pets via hand-to-mouth activities and dermal exposure after pet treatment
- 9) Inhalation exposure to by adult applicator to aerosol spray during and after space spray application; post-application inhalation exposure to aerosol spray by child
- 10) Dermal Exposure to adults and children reentering treated lawns

6.2 Residential Exposure Data and Assumptions

6.2.1 Handler Exposure Data

Application rates for all of the exposure scenarios assessed are based on information provided by a review of active labels. Data from the PHED or ORETF data bases were used to assess residential handler exposures. Default application assumptions regarding areas treated or amounts applied for residential handler scenarios are documented in the HED Science Advisory Committee on Exposure SOP 12: "Recommended Revisions To The Standard Operating Procedures For Residential Exposure Assessment" (2/22/2001).

6.2.2 Post-application Exposure Data

HED Residential Exposure SOPs

The default factors used for the assessment are taken from the Exposure Science Advisory Committee SOP 12. SOP 12 provides values to assess post application inhalation and non-dietary ingestion exposure to lawn care pesticides, and indoor broadcast and crack and crevice treatments.

Non-Dietary Exposure Task Force Exposure Data

Primary assumptions for assessing post-application exposure to use of foggers and aerosols in indoor residential settings were based on data provided by the Non-Dietary Exposure Task Force (NDETF). The NDETF was formed in 1996 by members of the Pyrethrin Joint Venture (PJV) and Piperonyl Butoxide Task Force II (PBOTFII), Task Forces set up in the 1980s

by producers, formulators, and marketers of the AIs to respond to reregistration needs. NDETF includes; Bayer CropSciences, Botanical Resources Australia, Endura S.p.A, McLaughlin Gormley King Company, Pyrethrum Board of Kenya Prentiss Inc., S.C. Johnson and Son, Inc., and Valent BioSciences Corporation. NDETF's purpose is to produce scientifically sound data on non-dietary exposures to pyrethrin, the pyrethroids, piperonyl butoxide, and MGK-264.

The NDETF conducted studies to examine the deposition of residues from total release foggers. The studies conducted with formulations of pyrethrin/piperonyl butoxide and permethrin/piperonyl butoxide were submitted to EPA in January 2004. The studies simulated the use of a fogger and aerosol products indoors to provide data on air dispersion and deposition on surfaces (walls, floor). Carpet and vinyl were selected as the flooring surfaces of interest because of their different physical and chemical properties and because they represent a significant amount of the floor coverings used in homes in North America. While the focus of the NDETF efforts was on total release foggers, a study was also conducted to determine both dispersion (air levels) and deposition (on flooring) of pyrethrin/piperonyl butoxide resulting from the use of a hand held aerosol spray can. Potential direct exposure of the aerosol spray applicator was also measured; air sampling from the breathing zone was performed. A more detailed evaluation of the NDETF Study data used for the resmethrin residential exposure assessment is provided in a separate review (D302120, B. Daiss, 5/11/04).

Spray Drift Task Force Exposure Data

HED used the AgDRIFT model to calculate airborne concentrations from aerial ULV applications. The model was developed by the Spray Drift Task Force, a coalition of pesticide registrants whose primary objective was to develop a comprehensive data base of off-target spray drift information along with an appropriate modeling system. The model has been peer reviewed by EPA's Science Advisory Panel and has been used in previous mosquito adulticide exposure assessments (e.g. carbaryl, malathion). AgDRIFT predicts the motion of spray material released from an aircraft, including the mean position of the material and the variance about the mean resulting from turbulent fluctuations. The model provides information on what percentage of the application volume remains aloft and what percentage of the resulting droplets is deposited on surfaces in the treated area and downwind. AgDRIFT allows for estimation of air concentration in breathing zones and residues deposited on turf. For this assessment, however, only breathing zone concentrations were estimated using AgDRIFT. Estimates of turf deposition used for assessing incidental ingestion were based more conservatively on direct application of resmethrin to turf grass. Turf grass application involves a higher application rate and a more direct application pathway.

6.2.2 Exposure Assumptions

The following assumptions were used in estimating risks from residential exposure to resmethrin:

- Average body weight of an adult is 70 kg
- Average body weight of a toddler is 15 kg
- Exposure is assessed on day of application (i.e., day zero)

- For non-cancer assessment exposure duration is short- and intermediate-term
- For cancer assessment exposure duration for adults is 50 years for handler and 70 years for non-handler exposure
- For non-cancer assessment maximum application rates as determined by the label review were used for all types and methods of application
- For cancer assessment typical or average application rates were used
- Maximum daily volumes handled and/or area treated are as follows
 - 0.5 acre is used to represent the surface area treated for broadcast applications to outdoor sites using fogger equipment
 - average home treated with surface spray or crack and crevice treatment has 1600 square feet of surface area
- Mosquito Abatement Scenario
 - for aerial application
 - fixed wing aircraft release height is 100 feet
 - rotary aircraft release height is 30 feet
 - average droplet size is 50 microns (per label and/or Public Health Pesticide Applicator Manual (25-50 microns))
 - wind speed is 2 mph (per label and/or Applicator Manual (<10 mph))
 - temperature is 86° F (per label and/or pesticide Applicator Manual (50-95° F))
 - for truck mounted ULV spray application a dilution factor of 0.01 is applied to the airborne concentration at the maximum application rate (i.e., 1% of product released is available for exposure)
 - breathing zone airborne concentration is estimated to be approximately 4-6 ft from the ground
 - adult breathing rate is 1.0 m³ per hour; child breathing rate is 0.8 m³ per hour (NAFTA breathing rates for light activity)
 - exposure duration is ≤ 2 hours
- Dermal exposure to treated lawn areas - adults and children
 - exposure duration is ≤ 2 hours
 - turf transferable residue is 5% of application rate
- Toddler Outdoor (turf) and Indoor Fogger (carpet and vinyl) Hand to Mouth Scenario
 - estimated turf transferable residue is assumed to be 5% of the maximum application rate for sprays
 - indoor surface residue is 10 µg/cm² based on NDETF study data and a maximum application rate of 0.033 lbs ai/1000 ft³ for indoor foggers
 - hand transfer efficiency is 13% for carpet; 8% for vinyl based on NDETF data
 - saliva extraction factor is 50 percent
 - surface portion of hand put in mouth is 20 cm²
 - hand-to-mouth exposure frequency is 20 times per hour
 - saliva extraction factor is 50 percent
 - Exposure duration is 2 hours
- Toddler Object to Mouth Scenario
 - object to mouth transfer efficiency is equal to 20% of the application rate
 - ingestion rate of residues from mouthing turf or a small object is 25 cm²
- Toddler Incidental Soil Ingestion Scenario
 - soil ingestion rate is 100 mg/day

- fraction of ai available in uppermost cm of soil (fraction/cm) is 100 percent based on soil incorporation into top 1 cm of soil after application
- Toddler Pet Treatment Hand to Mouth and Dermal Scenario
 - one half of a 16 oz spray container is used to treat each animal
 - transferable residue from a treated pet is assumed to be 20% of the maximum application rate for sprays
 - surface area of a treated (30 lb) dog is 6000 cm² (EPA 1993 Wildlife Exposure Factors Handbook - carbaryl)
 - for hand to mouth
 - saliva extraction factor is 50 percent
 - surface portion of hand put in mouth is 20 cm²
 - for dermal exposure
 - transferable residue from pet is 10 percent
 - frequency of hand-to-mouth/dermal events is one per day (frequency modified to reflect transferable residue assumption which is based on a 5 minute heavy rubbing/petting technique that would lead to significantly higher concentrations than would result from a single contact)
- Inhalation during and after aerosol space spray application
 - one 10 oz spray can containing maximum of 0.2% ai is used per application
 - one application per home
 - adult breathing rate is 1.0 m³ per hour; child breathing rate is 0.8 m³ per hour
 - exposure duration is ≤2 hours

Non-Standard Exposure Assumptions

- Scenario specific data on pyrethrin from the NDETF study was used to determine deposition of resmethrin on vinyl and carpet flooring following use of a total release indoor fogger. NDETF data on permethrin were used to determine transfer of resmethrin residues from fogger treated vinyl and carpet flooring to the hands of a playing toddler. Given the close structural similarity of pyrethrin, permethrin, and resmethrin and the similarity of use patterns for these chemicals, HED believes that the NDETF pyrethrin and /or permethrin data provide appropriate surrogate data for resmethrin. A more detailed evaluation of the NDETF Study data used for the resmethrin residential exposure assessment is provided in a separate review (D302120, B. Daiss, 5/11/04).
- Post-fogger/aerosol floor concentration of resmethrin was assumed to be 3 µg/cm². This is based on data from NDETF Study Volume 2, "Post-Application Deposition Measurements for Pyrethrins & Piperonyl Butoxide Following Use of a Total Release Indoor Fogger". The measured mean floor concentration of pyrethrin was 2.2 µg/cm² following fogger application at the rate of 0.00075 lb ai per 1000 ft³. The measured deposition of resmethrin was adjusted to reflect a maximum application rate of 0.001 lb ai per 1000 ft³. HED used the mean measured deposition which excluded the concentration on the floor center coupon because the coupon under the total release canister appeared to be an outlying data point. The maximum pyrethrin concentration measured on the coupon under the total release canister was 121 µg/cm². The next highest concentration was 6.7 µg/cm² on a coupon at a distance of two feet from the canister. This deposition pattern was not

repeated in findings from NDETF Study Volume 23, "Post-Application Deposition Measurements for Permethrin and Piperonyl Butoxide Following Use of a Total Release Indoor Fogger". The mean floor concentration including the floor center coupon was 5.8 $\mu\text{g}/\text{cm}^2$.

- Transfer of resmethrin from fogger treated carpet was assumed to be 13% of deposition based on data from Volume 29 of the NDETF Study, "Measurement of Transfer of Permethrin and Piperonyl Butoxide Residues from Vinyl and Carpet Flooring Treated with a Fogger Formulation to DSS Wetted Hands Following a Single Hand Press". Transfer of resmethrin from fogger treated vinyl flooring was assumed to be 7% of deposition also based on data from Volume 29 of the NDETF Study. Again, given the close structural similarity between permethrin and resmethrin and the similarity of use patterns. HED believes that the NDETF permethrin data provide an appropriate surrogate for resmethrin.
- Indoor air concentration for the period during and after aerosol space spray application was based on data from Volume 18 of the NDETF Study, "Measurement of Air Concentration, Dermal Exposure, and Deposition of Pyrethrin and Piperonyl Butoxide Following the Use of an Aerosol Spray". The measured time weighted average air concentration over a two hour period was 0.05 $\mu\text{g}/\text{L}$ following aerosol application of small amount of a 1% ai formulation (1/20th of a can or 9.3 grams of a 170 gram container) to a simulated residential room measuring of 2048 ft^3 . The measured air concentration was adjusted to reflect a likely maximum application rate of 0.002 lbs ai per application of a 16 oz can of aerosol spray in a similar size area. Maximum rate is based on a review of active labels. Inhalation following release of an aerosol fogger was not modeled separately because the aerosol spray application scenario is likely to provide a more conservative exposure estimate and therefore be protective of exposures following fogger release. The aerosol spray application involves more direct and immediate exposure and application rates for total release foggers, while higher, do not significantly exceed those of aerosol sprays. Labels for use of total release foggers require that the room be closed and vacated during release of the fogger and that the room be opened and air for a period of time (e.g. 30 minutes, 1 hour) prior to reentry.
- The approach for estimating air concentrations from truck-mounted ULV spray applications is based on the SOP for residential exposure assessment for inhalation exposure from use of an outdoor space spray for pest control. The approach was modified to assume that 1% of the highest application rate for a truck mounted ULV sprayer is available in the breathing zone of the resident. It is assumed that the full application rates for a truck-mounted ULV sprayer (with a one percent dilution factor) is available in the breathing zone of the residential bystander, i.e., an application rate expressed as lbs. ai/ ft^2 is converted into a concentration expressed in a per cubic foot (ft^3) basis.
- There are no data in ORETF or PHED addressing the use of a hand held fogger for outdoor applications, and no chemical specific data. The exposures for the hand held fogger application were based on surrogate data from a pulse fogger application in a greenhouse. The applicators were wearing chemical resistant protective clothing (coveralls) over long sleeve shirt and long pants, gloves, boots, goggles, and a respirator.

(Nigg, 1987). Dermal unit exposure was adjusted to reflect estimated exposure at baseline personal protective equipment (i.e., no gloves and single layer clothing). Based on PHED SOPs, gloves are assumed to provide a protection factor (PF) of 90%; coveralls, long sleeve shirt, pants, and boots are assumed to provide a PF of 50%. Assumptions regarding the proportional area of hands and body are from Volume I of the Exposure Factors Handbook.

6.3 Residential Exposure and Risk Estimates

A target LOC or MOE of 1000 is considered adequate for inhalation, dermal and incidental oral residential exposure and risk. OPP's cancer risk level of concern for occupational exposure is 1×10^{-6} . Non-cancer exposure and risk estimates indicate that all residential scenarios result in exposures below the level of concern (i.e., MOEs ≥ 1000). To characterize potential cancer risks for the residential handler and/or post-application exposure scenarios assessed, HED estimated the number of days an individual adult or child could be exposed to resmethrin without presenting a cancer risk of concern. Exposure and risk estimates for each scenario are summarized below and a more detailed summary of risk calculations, critical assumptions, and results is provided in Tables 7-16. Estimated exposure and MOEs for the non-cancer assessment are provided in tables 7-13. Cancer risk exposure and characterization for each residential scenario is provided in tables 14-16.

**Table 7. Estimated Resmethrin Exposure & MOEs for Residential Handler Activities.
Non-Cancer Risk - Target Short Intermediate and Long Term MOE = 1000**

Exposure Scenario ¹	Dermal Unit Exposure (mg/lb ai)	Inhalation Unit Exposure (ug/lb ai)	Use ²	Maximum Application Rate ³	Daily Area Treated ⁴	Dermal Dose (mg/kg/day)	Dermal MOE ⁵	Inhalation Dose (mg/kg/day)	Inhalation MOE ⁵
Out Door Sites Mix/Load/Apply Liquid Formulation									
Handheld fogger	21	190	Outdoor Areas e.g., Patio/Yards	0.25 lb ai/acre	0.5 acre/day	0.0008	40000	0.0003	83000
Indoors Mix/Load/Apply Liquid Formulation									
Low Pressure Handwand	100	30	Contact Spray/Crack & Crevice	0.242 lbs/1000 ft ²	1 home avg area treated - 1600 ft ²	0.0111	2700	0.0002	170000

¹ Handheld fogger application. There are no data in the Pesticide Handler Exposure Database (PHED) addressing the use of a hand held fogger, and no chemical specific data. The exposures for the hand held fogger application were based on surrogate data from a pulse fogger application in a greenhouse. The applicators were wearing chemical resistant protective clothing (coveralls) over long sleeve shirt and long pants, gloves, boots, goggles, and a respirator (Nigg, 1987). Dermal Unit Exposure was estimated to assume baseline exposure (i.e., assumes gloves provide PF of 90%, full body PPE provides PF of 50%); Assumptions re: proportional area of hands (5.2%) and body (87%) are from EFH Vol I.

² Use patterns are from the active labels

³ Application rates are based on maximum values provided in the master label. Most application rates upon which the analysis is based are presented as lb ai/A. In some cases, the application rate is based on applying a solution at concentrations specified by the label (i.e., presented as lb ai/gallon).

⁴ Amount treated is based on the area or gallons that can be reasonably applied in a single day for each exposure scenario of concern based on the application method and formulation/packaging type. (Standard EPA/OPP/HED values).

⁵ Dermal dose (mg/kg/day) = [unit exposure (mg/lb ai) * Dermal absorption (2%) * Application rate (lb ai/acre or lb ai/gallon) * Daily area treated (acres or gallons)] / Body weight (70 kg).

⁶ Dermal MOE = short-term endpoint for dermal - dermal NOAEL (mg/kg/day) / Daily Dermal Dose.

⁷ Inhalation dose (mg/kg/day) = [unit exposure (ug/lb ai) * 0.001 mg/g unit conversion * Inhalation absorption (100%) * Application rate (lb ai/acre or lb ai/gallon) * Daily area treated (acres or gallons)] / Body weight (70 kg).

⁸ Inhalation MOE = short-term and intermediate-term endpoint for inhalation; (inhalation LOAEL) / Daily Inhalation-Dose.

**Table 8. Estimated Resmethrin Post-application Inhalation Risks Mosquito Adulticide Application
Non-Cancer Risk - Target MOE = 1000**

Exposed Individual	Maximum Application Rate lb ai/acre	Breathing Zone Concentration (mg/m ³)	Inhalation Dose (mg/kg/day) ¹	MOE
Aerial Spray (Fixed Wing and Rotary Aircraft)				
Adult	0.007	0.003	0.00009	330000
Child	0.007	0.003	0.0003	88000
Truck Mounted ULV Sprayer				
Adult	0.007	0.0258	0.0007	38000
Child	0.007	0.0258	0.0028	10000

ID (mg/kg/day) = Inhalation Dose = PDR/ BW
 PDR_{in} (mg/day) = ((AR_i (lb ai/A)-BZC * BR * ED

where:

- PDR = Potential Dose Rate - inhalation dose in breathing zone after spray application (mg/m³)
- AR = maximum application rate lb/ai per acre converted to mg/m³ (0.007 lb ai/acre)
- BZC = Breathing Zone Concentration (mg/m³) - from Ag Drift Model for aerial spray application: 1% of application rate for truck mounted ULV sprayer application
- BR = Breathing rate for adult or child (m³/hr) (1.0 m³/hr adult, 0.8 m³/hr child)
- BW = 70 kg for adult; 15 kg for toddler
- ED = Exposure Duration (2 hr/day)
- MOE = Inhalation NOAEL/Inhalation Dose (mg/kg/day) MOEs are reported to two significant figures

**Table 9. Estimated Resmethrin Post-application Incidental Ingestion Risks to Toddlers Reentering Treated Lawns
Hand to Mouth (HTM), Object to Mouth (OTM), Incidental Soil Ingestion (SI), Aggregate - Short-Term Target MOE = 1000**

Inputs	Hand to Mouth			Object to Mouth			Soil Ingestion			Aggregate
	Hand Transfer (ug/cm ²)	Daily Oral Dose (mg/kg/day)	MOE	Dislodgeable Foliar Residue (ug/cm ²)	Daily Oral Dose (m/k/d)	MOE ³	Soil Residue (ug/g)	Daily Oral Dose (m/k/d)	MOE	Aggregate MOE
0.25	0.13	0.00075	11000	0.52	0.0009	45000	1.8	0.00001	3300000	8900

¹ DOD(mg/kg/day) = Daily Oral Dose (PDR/ BW)
 BW = 15 kg for toddler

Hand To Mouth Calculation

PDR_{in} (mg/day) = (HTF_{in} (ug/cm²) * SEF * SA * Freq * ED)/1000 (ug/mg)

where:

- PDR = Potential Dose Rate at time (t) attributable for activity in a previously treated area (mg/day)
- HTE_{in} = Hand Transfer Efficiency at time t = 5% of Application Rate (ug/cm²)
- SEF = Saliva Extraction Factor (50%)
- SA = Surface Area of Two Fingers (20 cm²)
- Freq = Frequency of Hand to Mouth Events (20)
- ED = Exposure Duration in hours (2 hr/day)
- t = Postapplication Day on which exposure is being assessed (day 0)
- MOE = Short Term Oral NOAEL /Daily Oral Dose (mg/kg/day)

Object to Mouth Calculation

PDR_{in} (mg/day) = (DFR_{in} (ug/cm²) * SA)/1000 (ug/mg)

where:

- PDR = Potential Dose Rate at time (t) attributable for activity in a previously treated area (mg/day)
- DFR_{in} = Dislodgeable Foliar Residue at time t = 20% of Application Rate (ug/cm²)
- SA = Surface Area of grass or toy mouthed-by toddler (25 cm² day)
- t = Postapplication day on which exposure is being assessed (day 0)
- MOE = Short Term Oral NOAEL /Daily Oral Dose (mg/kg/day) MOEs are reported to two significant figures

Soil Ingestion Calculation

PDR_{in} (mg/day) = (SR_i * Igr * CF1)

where:

- PDR = Potential Dose Rate - nondietary ingestion rate from contact with treated surface (mg/day)

SR_t = Soil Residue on day "t" (µg/g)
 IgR = Ingestion Rate of soil (mg/day): (100 mg/day)
 CFI = Weight unit conversion factor (1E-6 g/µg)

where:

SR_t = Application Rate (µg/cm²) * 1/cm * 0.67 cm³/g soil [1/cm is fraction of ai available in uppermost cm of soil]
 t = Postapplication Day on which exposure is being assessed. assumed to be day zero
 MOE = Short Term Oral NOAEL/[Daily Oral Dose (mg/kg/day) MOEs are reported to two significant figures
 AggMOE=1/(1/MOE HTM + 1/MOE OTM + 1/MOE SI)

Table 10. Estimated Resmethrin Post-application Incidental Ingestion Risks To Toddlers Playing on Vinyl Floor and Carpet after Treatment with Fogger Formulation - Short-Term Target MOE = 1000

Indoor Surface	Application Rate (lb ai/1000 ft ²)	Indoor Surface Residue (µg/cm ²)	Hand Transfer Efficiency (%)	Daily Oral Dose (mg/kg/day) ¹	MOE
carpet	0.001	3	13	0.0104	3800
vinyl	0.001	3	7	0.0056	7000

¹ DOD(mg/kg/day) = Daily Oral Dose = PDR/ BW
 PDR_{in} (mg/day) = (ISR_t (µg/cm²) * TE * SEF * SA * Freq * ED/1000 (µg/mg)

where:

PDR = Potential Dose Rate on day of application (mg/day)
 ISR = Indoor Surface Residue (µg/cm²) at maximum AR of 0.001 lbs ai/1000 ft²
 HTE = Hand Transfer Efficiency - transfer of (13% for carpet; 8% for vinyl)
 SEF = Saliva Extraction Factor (50%)
 SA = Surface Area of Two Fingers (20 cm²)
 Freq = Frequency of Hand to Mouth Events (20)
 ED = Exposure Duration in hours = 2 hr/day
 t = Postapplication Day on which exposure is being assessed (day 0)
 BW = 15 kg for toddler
 MOE = Short Term Oral NOAEL/Daily Oral Dose (mg/kg/day) MOEs are reported to two significant figures.

Table 11. Estimated Resmethrin Post-application Incidental Ingestion And Dermal Risks To Toddlers Playing with Pets after Treatment with Spray Formulation - Non-Cancer - Short-Term Target MOE = 100

Application Method	AR (mg ai/animal)	Transferable Residue (%)	Daily Oral Dose (mg/kg/day) ¹	Daily Dermal Dose (mg/kg/day) ¹	Inhalation MOE	Dermal MOE
Aerosol Spray	795	20	0.0177	0.000004	2300	8500000

¹ DOD(mg/kg/day) = Daily Oral Dose = PDR/ BW
 PDR_{in} (mg/day) = ((AR_t (mg ai/animal) * F)/SA_{pet}) * SEF * SA_{hands} * Freq

where:

PDR = Potential Dose Rate - nondietary ingestion dose from contact with treated pets (mg/day)
 AR = Application Rate or amount applied to animal in a single treatment (mg ai/animal) = 1/2 of 16 oz spray container with maximum of 0.35% ai per 6000 cm²/animal
 F_{sk} = Fraction of Application Rate available for dermal contact as transferable residue (20%)
 SA_{pet} = Surface Area of a treated dog (6000 cm²/animal)
 t = Time After Application (0 days)
 SEF = Saliva Extraction Factor (50%)
 SA_{hands} = Surface Area of the hands (20 cm²)
 Freq = Hand-to-Mouth Events (1 event/day)
 BW = 15 kg for toddler
 MOE = Short Term Oral NOAEL/Daily Oral Dose (mg/kg/day) MOEs are reported to two significant figures.

DDD(mg/kg/day) = Daily Dermal Dose = PDR/ BW
 PDR_{in} (mg/day) = ((AR_t (mg ai/animal) * F)/SA_{pet}) * ATR * SA_{hands} * Freq

where:

PDR = Potential Dose Rate - nondietary ingestion dose from contact with treated pets (mg/day)
 F_{AR} = Fraction of Application Rate available for dermal contact as transferable residue (20%)
 t = Time After Application (0 days)
 ATR = Available transferable residues (10%)
 Freq = Hand-to-Mouth Events (1 event/day)
 BW = 15 kg for toddler
 MOE = Short Term Dermal NOAEL/Daily Oral Dose (mg/kg/day) MOEs are reported to two significant figures.

Exposed Individual	Maximum AR (lb ai/A)	TTR (µg/cm ²)	DDD (mg/kg/day)	MOE
Adult	0.25	2.68	0.0011	27000
Child	0.25	2.68	0.0019	16000

DDD(mg/kg/day) = Daily Dermal Dose (DDE / BW)
 BW = 70 kg for adult; 15 kg for toddler

where

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

where:

- DDE = Daily Dermal Exposure at time (t) attributable for activity in a previously treated area (mg/day);
- TTR = 5% of AR (µg/cm²)
- TC = Transfer Coefficient (500 cm²/hour for adult golfer; 14,500 cm²/hour for adults; 5200 cm²/hour for toddler)
- Hr = Exposure duration in hours (2 hr/day for adult & toddler; 4 hr/day for adult golfer)
- TTR = TTR₀ * (Max AR/StudyAR) * e^(TTRslope * t)

where:

- AR = application rate (lbs ai/ft² or lb ai/acre)
- t = postapplication day on which exposure is being assessed = day 0
- Dermal MOE = Dermal NOAEL (1000 mg/kg/day)/(Daily Dermal Dose (mg/kg/day) x Dermal Absorption Value)

Application Method	Exposed Individual	Breathing Zone Concentration (mg/m ³)	Inhalation Dose (mg/kg/day) ¹	MOE
Aerosol Spray	Adult*	0.46	0.09	2100
	Child**	0.075	0.28	3500

Inhalation Dose (mg/kg/day) = PDR / BW
 $PDR_{(t)} (mg/day) = ((AR_{(t)} (lb ai/A) \cdot BZC \cdot BR \cdot ED)$

where:

- PDR = Potential Dose Rate - inhalation dose in breathing zone after spray application (mg/m³)
- AR = application rate - 1 16 oz can containing 0.2% ai applied to a 16 x 16 x 8 ft room
- BZC = Breathing Zone Concentration (mg/m³) - measured air concentration from NDETF study adjusted to reflect a likely maximum application rate
- *Adult = BZC during and after application
- **Child = BZC post-application
- BR = Breathing rate for adult or child (m³/hr) (1.0 m³/hr adult, 0.8 m³/hr child)
- BW = 70 kg for adult; 15 kg for toddler
- ED = Exposure Duration (2 hr/day)
- MOE = Inhalation NOAEL/Inhalation Dose (mg/kg/day) MOEs are reported to two significant figures.

Exp Scenario ¹	Dermal Unit Exposure (mg/lb ai)	Inhalation Unit Exposure (ug/lb ai)	Use ²	Average Application Rate ³	Daily Area Treated ⁴	Combined Dermal and Inhalation Daily Dose (mg/kg/day) ⁵	LADD (mg/kg/day) ⁶	# Days Applied ⁷
Out Door Sites Mix/Load/Apply Liquid Formulation								
Handheld fogger	21	190	Outdoor Areas e.g., Patio/Yards	0.05 lb ai/acre	0.5 acre/day	0.0002	0.000018	30
Indoors Mix/Load/Apply Liquid Formulation								
Low Pressure Handwand	100	30	Contact Spray/Crack & Crevice	0.02 lbs/1000 ft ²	1 home avg area treated - 1600 ft ²	0.0111	0.000018	7

¹ Handheld fogger application. There are no data in the Pesticide Handler Exposure Database (PHED) addressing the use of a hand held fogger, and no chemical specific data. The exposures for the hand held fogger application were based on surrogate data from a pulse fogger application in a greenhouse. The applicators were wearing chemical resistant protective clothing (coveralls) over long sleeve shirt and long pants, gloves, boots.

goggles, and a respirator (Nigg, 1987). Dermal Unit Exposure was estimated to assume baseline exposure (i.e., assumes gloves provide PF of 90%, full body PPE provides PF of 50%); Assumptions re: proportional area of hands (5.2%) and body (87%) are from EFH.

² Use patterns are from the active labels

³ Application rates are based on maximum values provided in the master label. Most application rates upon which the analysis is based are presented as lb ai/A. In some cases, the application rate is based on applying a solution at concentrations specified by the label (i.e., presented as lb ai/gallon).

⁴ Amount treated is based on the area or gallons that can be reasonably applied in a single day for each exposure scenario of concern based on the application method and formulation/packaging type. (Standard EPA/OPP/HED values).

⁵ Dermal dose (mg/kg/day) = [unit exposure (mg/lb ai) * Dermal absorption (2%) * Application rate (lb ai/acre or lb ai/gallon) * Daily area treated (acres or gallons)] / Body weight (70 kg).

Inhalation dose (mg/kg/day) = [unit exposure (ug/lb ai) * 0.001 mg/g unit conversion * Inhalation absorption (100%) * Application rate (lb ai/acre or lb ai/gallon) * Daily area treated (acres or gallons)] / Body weight (70 kg).

Inhalation MOF = short-term and intermediate-term endpoint for inhalation: 4 mg/kg/day (inhalation LOAEL)/ Daily Inhalation Dose.

⁶ LADD = Total Daily Dose (mg/kg/day) * Handler Activity Days/365 days/yr * Years Handler Activity/70 years. Cancer Risk = LADD * Q₁

⁷ # Days of Handler Activity at which Cancer Risk ≤ 1x10⁻⁶ (i.e., LADD * Q₁ ≤ 1x10⁻⁶)

Table 15. Estimated Resmethrin Post-application Inhalation Cancer Risks - Mosquito Adulticide				
Estimated # of Exposure Days Per Year at which Cancer Risks are Not of Concern (Risk ≤ 1x10 ⁻⁶)				
Exposed Individual	Average Application Rate lb ai/acre	Breathing Zone Concentration (mg/m ³)	Inhalation Daily Dose (mg/kg/day) ¹	# Exposure Days
Aerial Spray (Fixed Wing and Rotary Aircraft)				
Adult	0.003	0.0015	0.00004	153
Truck Mounted ULV Sprayer				
Adult	0.003	0.0110	0.0003	21

ID (mg/kg/day) = Inhalation Dose = PDR/ BW

PDR_{in} (mg/day) = ((AR_n (lb ai/A)-BZC * BR * ED

where

PDR = Potential Dose Rate - inhalation dose in breathing zone after spray application (mg/m³)

AR = maximum application rate lb/ai per acre converted to mg/m³ (0.007 lb ai/acre)

BZC = Breathing Zone Concentration (mg/m³) - from Ag Drift Model for aerial spray application: 1% of application rate for truck mounted ULV sprayer application

BR = Breathing rate for adult or child (m³/hr) (1.0 m³/hr adult, 0.8 m³/hr child)

BW = 70 kg for adult; 15 kg for child

ED = Exposure Duration (2 hr/day)

LADD = Total Daily Dose (mg/kg/day) * Days Exposed/365 days/yr * Years Exposed/70

Exposure Days = # days exposure at which cancer risk ≤ 1x10⁻⁶

Table 16. Estimated Resmethrin Inhalation Cancer Risks To Adults During and After Indoor Space Spray Application -				
Estimated # of Exposure Days per Year at which Cancer Risks are Not of Concern (Risk ≤ 1x10 ⁻⁶)				
Application Method	Exposed Individual	Breathing Zone Concentration (mg/m ³)	Inhalation Dose (mg/kg/day) ¹	# Exposure Days
Aerosol Spray	Adult	0.29	0.09	1

Inhalation Dose (mg/kg/day) = PDR/ BW

PDR_{in} (mg/day) = ((AR_n (lb ai/A)- BZC * BR * ED

where:

PDR = Potential Dose Rate - inhalation dose in breathing zone after spray application (mg/m³)

AR = application rate - 1 10 oz can containing 0.2% ai applied to a 16 x 16 x 8 ft room

BZC = Breathing Zone Concentration (mg/m³) - measured air concentration from NDETF study adjusted to reflect a likely maximum application rate = BZC during and after application

BR = Breathing rate for adult or child (m³/hr) (1.0 m³/hr adult, 0.8 m³/hr child)

BW = 70 kg for adult; 15 kg for child

ED = Exposure Duration (2 hr/day)

Exposure Days = # days exposure at which cancer risk ≤ 1x10⁻⁶

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7.0 Uncertainties and Risk Characterization

Uncertainties identified by BEAD regarding the NPMA survey data used to determine potential exposures to PCO should also be noted. Regarding the robustness and validity of the NPMA survey data BEAD drew the following conclusions. Given that there are approximately 19,000 PCO firms in the U.S., it is highly unlikely that a sample size of 67 represents a statistically valid sample. The use of a retrospective survey methodology may have introduced errors in the data. Pesticide survey firms like Doane use a prospective survey instrument sent to growers in advance thus allowing them to keep detailed accounts of their pesticide usage in real time throughout the year. Despite its small size and retrospective methodology, however, the information collected is more robust than BEAD typically gets when asking questions of this nature. BEAD typically contacts 1-5 PCO's and asks chemical specific questions which may bias the responses if PCO's value the chemical under review. HED believes the NPMA survey provides reasonable estimates of average number of buildings treated per day by PCOs.

For pest control operator and mosquito abatement scenarios, assuming full day, long-term application for each application method may significantly overestimate total exposure. Based on data on usage of likely resmethrin containing pesticides presented in the NPMA survey, this assumption would result in significant overestimate of exposure for PCOs. Similarly, assuming continuous usage of resmethrin containing pesticides for mosquito abatement applications would also significantly overestimate total exposure based on personal communication with mosquito control district officials regarding current usage of these products. However, resmethrin is used to control a large number and a wide variety of pests and labels do not restrict or preclude repeated applications or long term use. Given the potential for multiple applications and long-term use for occupational handlers, inclusion of a repeated use/long-term exposure scenario for pest control operators and mosquito abatement is considered reasonable. Accordingly, the assumption for cancer risk assessment that workers are exposed for 240 days per year for 35 years should be considered highly conservative.

For the cancer risk estimate for residential exposure, the assumption that adult individuals are exposed annually for a lifetime (i.e., 70 years) should also be considered conservative.

Attachment. Default Unit Exposure Values

Table 19. PHED Inhalation and Dermal Unit Exposure Values Used In Resmethrin Occupational and Residential Exposure Assessment						
Scenario	Inhalation			Dermal		
	Unit Exposure (ug/lb ai)	Replicates	Grade/ Confidence	Unit Exposure (ug/lb ai)	Replicates	Grade/ Confidence
Mixing Loading Liquids	1.2	85	AB/High Confidence	2.9	72-122	AB/High Confidence
Airblast Application - Open Cab	4.5	47	AB/High Confidence	0.36	32-49	AB/High Confidence
Mix/Load/Apply Liquids High Pressure Handwand	120	13	A/Low Confidence	2.5	7-13	Low Confidence
Mix/Load/Apply Liquids Low Pressure Handwand	30	80	ABC/Medium Confidence	100	9-80	ABC/Low Confidence