HUMAN EXPOSURE ASSESSMENT FOR ACEPHATE

HS-1832

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INDEX OF ABBREVIATIONS AND SOME DEFINITIONS

A	Applicator
AADD	Annual Average Daily Dosage (SADD x exposure months/year ÷ 12 months)
ADD	Absorbed Daily Dosage (Short-term exposrues x absorption rate ÷ body weight)
AI	Active Ingredient
AM	Arithmetic Mean
BSA	Body Surface Area
CAC	County Agricultural Commissioner
CDFA	California Department of Food and Agriculture
CFWAP	California Farm Worker Activity Profile
DF	Dry Flowable
DFR	Dislodgeable Foliar Residue
DPR	(California) Department of Pesticide Regulation
DMPT	Dimethyl Phosphorothioate
ET	Exposure Time
F	Flagger
FC	Flowable concentrate
FM	Formulation
CFR	U.S. Code of Federal Regulations, the categorized set of regulation that implements federal statutes. Regulations pertaining to pesticides are in Title 40 of the CFR.
G	Granular
GLC	Gas-Liquid Chromatography
HSA	Hand Surface Area
IR	Ingestion Rate
L	Liquid
L/A	Loader/Applicator
LADD	Lifetime Average Daily Dosage (AADD x Lifetime of exposure (years) ÷ 75 years)
LPM	Liter per Minute
L/T	Loader/Treater
L/T/P	Loader/Treater/Planter
M/L	Mixer/Loader
M/L/A	Mixer/Loader/Applicator
MDL	Minimal Detection Limit
MIBK	Methyl Isobutyl Ketone
MSHA	Mine Safety and Health Administration

NIOSH	National Institute of Occupational Safety and Health
NOEL	No-Observed-Effect Level
OSHA	Occupational Safety and Health Administration
OVS	OSHA Versatile Sampler
P	Pellet
PCO	Pest Control Operator (PCO)
PHED	Pesticide Handler Exposure Database
PHI	Preharvest Interval
PPE	Personal Protective Equipment
PUR	Pesticide Use Report
RCD	Risk Characterization Document
RED	Reregistration Eligibility Decision
REI	Restricted Entry Interval
SADD	Seasonal Average Daily Dosage (Intermediate-term exposure x absorption rate ÷ body weight)
SD	Standard Deviation
SOP	Standard Operating Procedure
SP	Soluble Powder
TF	Transfer Factor (cm^2/hour - exposure transfer rate of, e.g., DFR to human)
TTR	Turf Transferable Residue
UCL	Upper Confidence Limit
U.S. EPA	United States Environmental Protection Agency
WBD	Whole-Body Dosimeters (Dosimeter that covers torso, arms and legs, except head, hands and feet)
WHS	Worker Health and Safety Branch
WP	Water-Soluble Pellet

I. ABSTRACT

Acephate (O,S-dimethyl acetylphosphoramidothioate) is currently registered in California as a systemic insecticide/miticide in agricultural and non-agricultural settings. There were 12 illness/injury cases associated with exposure to acephate, alone and in combination with other pesticides, in California from 2002 through 2006 The majority of the dermally absorbed acephate was excreted in the urine with most of the remaining activity found in the breath and feces. A toxic metabolite of acephate, methamidophos, was found to occur in plants, soil, and in mammals. However, it was found that this biotransformation in the rat is limited due to the inhibition of the carboxyamidases by its end-product, methamidophos. The dermal absorption of acephate in humans was determined to be 7.60%. The acute average absorbed daily dosage (acute ADD) for agricultural workers handling acephate is estimated to range from 3.60 μg/kg/day for groundboom applicators treating pasture to 7,570.0 μg/kg/day for mixer/loaders for aerial agricultural applications. The acute ADD for field workers is estimated to range from 0.800 μg/kg/day for succulent bean harvesters to 162 μg/kg/day for citrus tree pruners. The acute ADD for golf course pesticide handlers is estimated to be 191.0 μg/kg/day for mixer/loaders to 56.4 μg/kg/day for applicators. The acute ADD for residential users is estimated to range from 1.30 μg/kg/day for loader/applicators using a shaker can for treating roses to 170.0 μg/kg/day for handlers using hose-end sprayers. The acute ADD for pest control operators (PCO) is estimated to range from 57.8 μg/kg/day for handlers using low pressure hand wands at residential sites to 515.0 μg/kg/day for handlers using backpack sprayers. The seasonal average daily dosage (SADD) for agricultural handlers is estimated to range from 0.900 μg/kg/day for groundboom applicators treating pasture to 1,680.0 μg/kg/day for aerial mixer/loaders for agricultural applications. SADD for field workers is estimated to range from 0.100 μg/kg/day for succulent bean harvesters to 68.3 μg/kg/day for citrus tree pruners. The annual average daily dosage (AADD) for agricultural handlers is estimated to range from 0.5 μg/kg/day for groundboom applicators treating pasture to 701.0 μg/kg/day for mixer/loaders for aerial agricultural applications. AADD for field workers is estimated to range from 0.01 μg/kg/day for succulent bean harvesters to 28.5 for citrus tree pruners. The lifetime average daily dosage (LADD) for agricultural handlers is estimated to range from 0.3 μg/kg/day for groundboom applicators treating pasture to 374.0 μg/kg/day for mixer/loaders for aerial agricultural applications. LADD for field workers is estimated to range from 0.005 μg/kg/day for succulent bean harvesters to 15.2 for citrus tree pruners.

II. INTRODUCTION

Acephate (O,S-dimethyl acetylphosphoramidothioate) was first registered with the United States Environmental Protection Agency (U.S. EPA) in 1973, and a registration standard was published in 1987. It is an organophosphate pesticide that is applied as a systemic insecticide/miticide in agricultural and non-agricultural settings.

Acephate is a cholinesterase inhibitor in acute toxicity category II by the oral route and acute toxicity category IV by the dermal and inhalation routes. Acephate has the potential for exposure from both agricultural (handlers and post-application field workers) and residential uses. In addition, the general public may be exposed to acephate following treatment of golf courses.

Another registered pesticide, methamidophos (O,S-dimethyl phosphoramidothioate), is a metabolite of acephate and is a potent cholinesterase inhibitor in acute toxicity category I by all routes of exposure. Therefore, the potential exposure to methamidophos, resulting from acephate use, is also assessed in this document. Since methamidophos is anticipated to be present in plants and soil following the application of acephate, the agricultural and non-agricultural handler assessments only consider potential acephate exposures, while the agricultural, residential and recreational post-application assessments address both potential acephate and methamidophos exposures (U.S. EPA, 2000a).

U.S. EPA published acephate product cancellations and use deletions, that were requested to reduce certain residential risks, including risks to children, which exceeded the Agency's level of concern. The effective date of the cancellations is March 6, 2002, the date of publication. However, there are still some actively registered products in California that allow these uses. In this document, the exposure will be estimated based on scenarios from all active product labels.

A risk characterization document (RCD) for acephate is currently being prepared by the Department of Pesticide Regulation (DPR) due to its low no-observed-effect level (NOEL) values and possible adverse effects in chronic, oncogenicity and mutagenicity studies. The human exposure assessment for acephate provides essential information for the risk assessment of this pesticide. This document will be an integral part of the RCD. It will also serve as a basis for developing mitigation strategies if exposure to acephate is found to cause excessive risk.

III. FACTORS DEFINING EXPOSURE SCENARIOS

1. Physical and Chemical Properties

Physical and chemical properties of acephate as mentioned below were obtained from the Chevron Chemical Company (Pack, 1983; Thornberry, 1987), the Merck Index (Budavari *et al.,* 1989), and U.S. EPA (U.S. EPA, 2000a).

Acephate is the common name for O,S-dimethyl acetylphosphoramidothioate. Its empirical formula is $C_4H_{10}NO_3PS$. Its trade names include Orthene®, Address®, Isotox®, Orthenex®, Lancer®, Pinpoint®, Velocity®, and Payload®. Acephate is a white powder with a strong mercaptan-like odor and a melting point of 86.9 – 91.0 °C. Its molecular weight is 183.16. Acephate is soluble in water (70% w/v); moderately soluble in alcohol (10% w/v); slightly to moderately soluble in aromatic solvents (< 5% w/v). Its pH value is 4.67 (1% solution) or 4.05 (10% solution). Acephate technical displays excellent storage stability, and showed no significant change in methylthioacetate concentrations when stored at ambient conditions. It has a vapor pressure of 1.7 x 10^{-6} mmHg at 25°C. The octanol/water partition coefficient (K_{ow}) for acephate is 0.13 at 25°C. The chemical structure of acephate is shown in Figure 1.

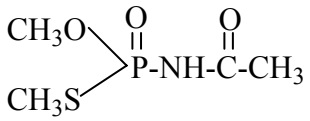


Figure 1. Chemical Structure of O,S-Dimethyl Acetylphosphoramidothioate.

2. Formulations and Registered Uses

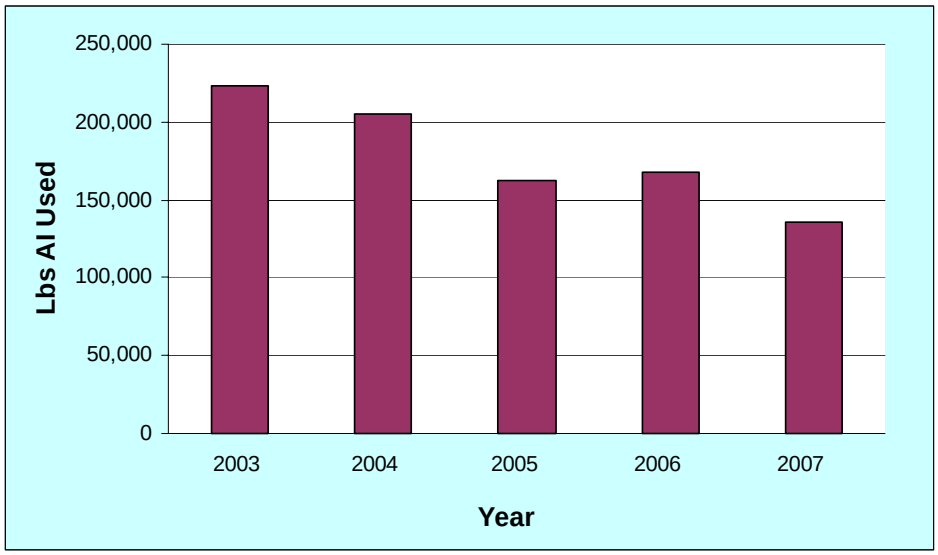
As of December 2008, there were 63 acephate-containing products registered in California. Among them, 36 products are registered for agriculture with some also having institutional and industrial uses, 25 products registered primarily for outdoor use around homes, 15 products for industrial and institutional use, two products are for use as tree implants (cartridges are pressed into pre-drilled holes in tree trunks) and 1 product is for manufacture use. Many of the end uses overlap with products registered primarily for agricultural having limited use in domestic residences such as outdoor perimeters around a home. Industrial and institutional use products may also have limited use in agricultural and residential settings like the treating of ant mounds. Acephate formulations include: granular (1.5, 4 and 15% active ingredient [AI]), emulsifiable concentrate or flowable concentrate (4 and 8% AI), wettable powder or soluble powder (75, 80, 90, and 96% AI), pelleted (97% AI), pressurized liquid (aerosols) (0.25 and 8% AI), aqueous concentrate (9.4% AI), and dust (50% AI).

Acephate is a broad spectrum systemic insecticide registered for use on various crops, including almonds, apples, apricots, beans (snap, dry and lima), Brussels sprouts, cauliflower, celery, non-bearing citrus, cotton, cranberries, grapefruit, grapes, kiwi, plums, head lettuce, oranges, peanuts, peppers (non-bell and sweet), peppermint/spearmint, potatoes, tobacco, walnuts and seed. Special Local Need (Section 24c) uses have been registered in California for greenhouse grown seed potato tubers, onions grown for seed (research purposes only) and bermudagrass (seed crop). It is also used on field-grown ornamentals (i.e., trees, shrubs, bedding plants, cut flowers and foliage), pasture, rangeland, sod, golf course turf and other non-crop areas. In addition, acephate is registered for indoor and outdoor residential uses.

3. Pesticide Use in California

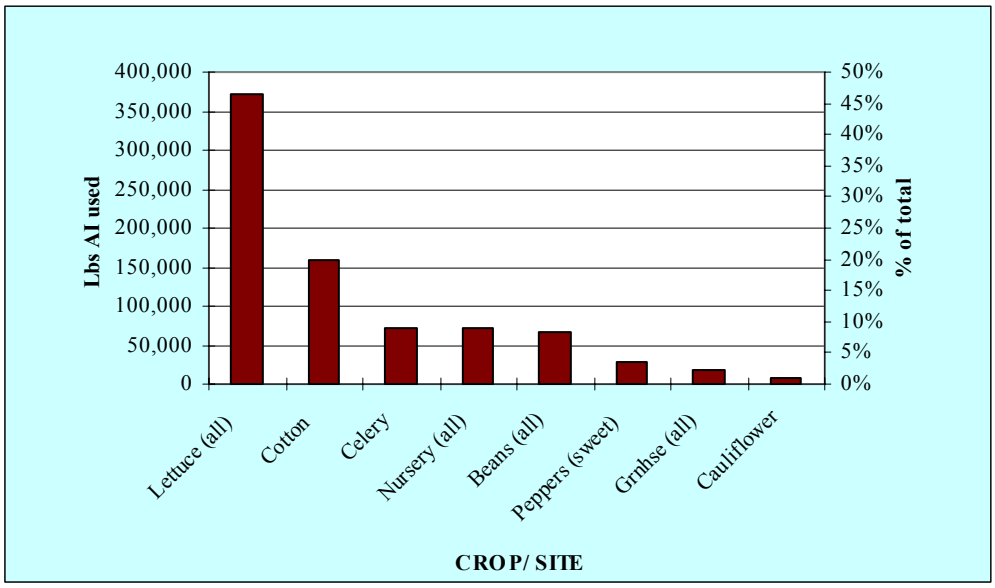
Based upon the data provided by the annual pesticide use reports (DPR, 2005, 2006a, 2008), the total annual usage of acephate in California was approximately 200,000 to 300,000 pounds AI per year during 2003 to 2007. The pounds AI used have gradually decreased in recent years (Figure 2). The major uses (> 1% of total amount) of acephate in California, as reported by the 2003 to 2007 pesticide use reports (PUR), are shown in Figure 3. The major uses of acephate include: lettuce (44%), cotton (17%), beans (13%), celery (12%), nursery crops (7%), peppers (3%), greenhouse crops (2%), cauliflower (1%) and other sites. The amount and relative percentage of seasonal use are shown in Figure 4. The top usage months (over 140,000 pounds AI and above 10% of total annual usage) are March, June, July, August and September.

Figure 2. Total Pounds Acephate (AI) Used per Year in California During 2003 – 2007 [a].



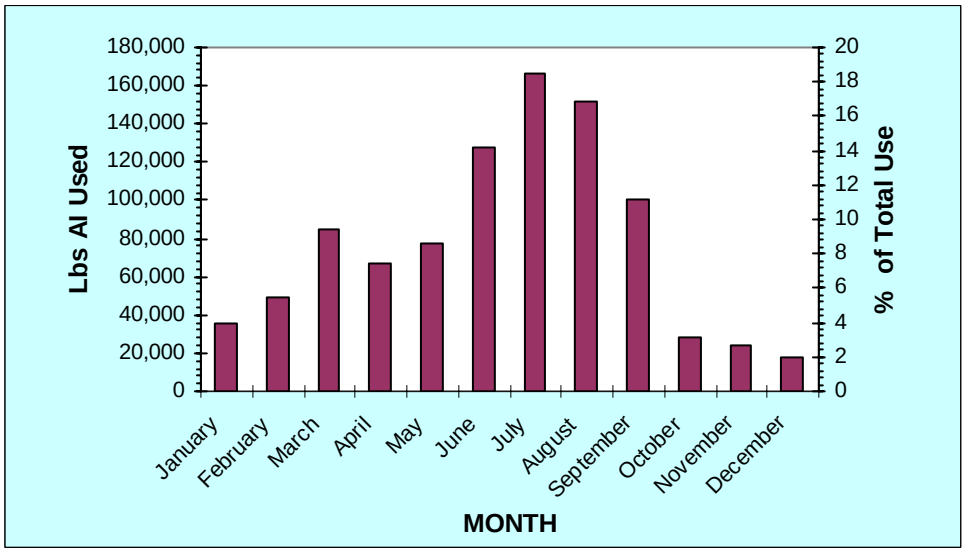
a Data from California pesticide use summaries (DPR, 2005, 2006a, 2008).

Figure 3. Pounds Acephate and Relative Percentage of Uses for the Top Crops/Sites in California During 2003-2007 [a].



a Data from California Pesticide Use Summaries Database (DPR, 2006b; queried March 21, 2006; 2009, queried January 29, 2009).

Figure 4. Pounds and Relative Percentage of Seasonal Uses of Acephate in California During 2003-2007.



a Pounds applied by all methods to all crops in Tulare County (DPR 2006b, queried March 22, 2006; DPR 2008, queried December 23, 2008).

The application methods for acephate include ground application, aerial application, hand application and seed treatment. Table 1 summarizes application rates for various uses, as stated on product labels.

Table 1. Application Rates for Acephate [a].

Site/Crop	Label Rates (lbs AI/acre)[b]
Food Crops	1 - 6
Commercial Turf	0.75 - 5
Fruit Trees	0.975
Cotton Seed Treatment	0.1875
Non Crop Areas	0.125
Evergreens in Large Stands	0.5 – 1.0
Commercial Ornamentals	0.3 – 1.3

a Data from product labels and U.S. EPA (U.S. EPA, 2000d).
b lb = pound; AI = active ingredient.

Granular and liquid acephate formulations can be applied using numerous types of application equipment. Granular acephate applications can be made by belly grinder, hand, tractor-drawn spreader, push-type spreader, and shaker can. Liquid acephate can be applied by aircraft, airblast sprayer, backpack sprayer, chemigation, groundboom equipment, hand/handtool, handgun (hydraulic sprayer), high-pressure sprayer, hopper box (seed treatment), low-pressure hand wand, seed slurry treatment, and sprinkler can.

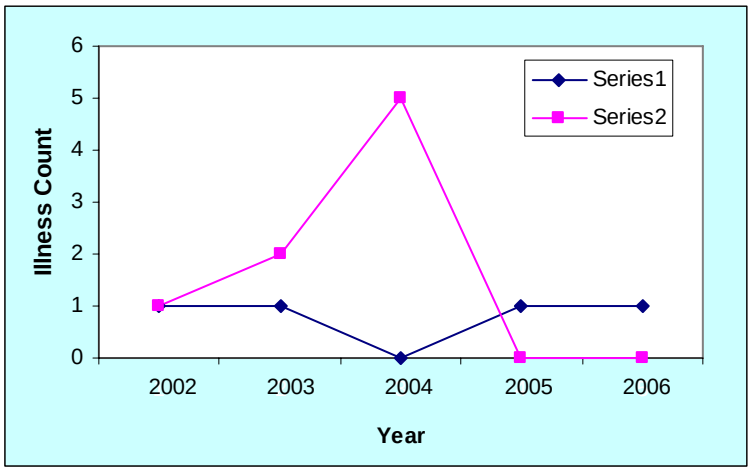
Acephate applications to residential settings can also be made by several methods. Applications can be made by aerosol can, shaker can, backpack sprayer, hand/handtool/shaker can, hose-end sprayer, low-pressure hand wand, and sprinkler can.

4. Reported Illnesses

When both Poison Control Center and California illness data were considered, acephate was generally considered less hazardous than other organophosphates and carbamates. Outdoor agricultural use was associated with lower risks of illness and poisoning than most other organophosphate and carbamate insecticides (U.S. EPA, 2000a).

The California Pesticide Illness Surveillance Program database maintained by the Worker Health and Safety Branch (WHS) indicated that from 2002 through 2006, there are 12 illnesses/injuries associated with exposure to acephate (Mehler, 2009). Among these 12 cases, 2 involved acephate exposure alone, while the remaining 10 were exposures to acephate in combination with other pesticides. Most of the illnesses were systemic in nature (9 systemic cases accounting for 75% of the total). One eye injury and 2 skin effects constitute the balance of the illnesses. No deaths occurred, but one of the exposed was hospitalized for five days during this period. Generally, there were more illness cases involving field work (residue and drift) than illness cases involving handlers (Figure 5).

Figure 5: Reported Illnesses Related to Handler and Non-Handler Exposures to Acephate in California During 2002-2006[a].



a Data from the illness report (Mehler, 2009).

5. Label Precautions

Among 63 acephate products registered in California (as of January 23, 2009), 5 products are classified as toxicity category I (with the signal word DANGER), 7 products are classified as toxicity category II (with the signal word WARNING), and 51 products are classified as toxicity category III/IV (with the signal word CAUTION).

Product labels state that acephate can be harmful if swallowed and that it may cause eye irritation. Hazards of and treatments for ingestion, inhalation, and dermal or eye contact have been indicated on the product labels. Applicators and other handlers must wear the following protective clothing and equipment:

- For toxicity category I (Danger) products:

  - Residential/home & garden: Handler must wear chemical-resistant gloves, long pants, and a long-sleeved shirt. When using outdoors, spray with the wind to your back and do not use when wind speeds are 10 mph or more. Handlers must wear goggles also when using a toxicity category I product.

- For toxicity category II (Warning) products:

  - Agriculture use: Wear goggles, face shield or safety glasses. Applicators and other handlers must wear a long-sleeved shirt and long pants, chemical-resistant gloves, shoes plus socks, protective eyewear, and a respirator with either an organic vapor-removing cartridge with a prefilter approved for pesticides (U.S. Mine Safety and Health Administration (MSHA)/National Institute of Occupational Safety and Health (NIOSH) approval number prefix TC-23C), or a canister approved for pesticides (MSHA/NIOSH approval number prefix TC-14G). Chemical-resistant headgear is required for overhead exposure.

- Residential/home & garden use: Handlers must wear chemical-resistant gloves, long pants, and a long-sleeved shirt. When using outdoors, spray with the wind to your back and do not use when wind speeds are 10 mph or more.

- For toxicity category III/IV products:

  - Agriculture use: Applicators and other handlers must wear chemical-resistant headgear for overhead exposure, long pants, long-sleeved shirt, and shoes plus socks. Mixers and loaders must also wear waterproof gloves. Early entry field workers must wear coveralls, waterproof gloves, shoes plus socks, and chemical-resistant headgear for overhead exposure.

    These PPE and clothing requirements are based on labels of some products that contain acephate at a concentration of 75% or lower. However, applicators and other handlers are required to wear waterproof gloves when they use products containing acephate at a concentration of 80% or greater, or some other products containing a lower percentage of acephate such as Pinpoint 15 Granular (15% AI) or Acephate 75SP AG (75% AI). Therefore, exposures were estimated for applicators and other handlers with and without the use of waterproof gloves (see Exposure Assessment section).

  - Industrial/commercial use: Handlers must wear chemical-resistant gloves, long-legged pants, a long-sleeved shirt, and shoes plus socks.

  - Residential/home & garden use: Mixer/loaders, applicators, repairers and cleaners of pesticide equipment must wear chemical-resistant gloves, long-pants, and a long-sleeved shirt. When using outdoors, spray with the wind to your back and do not use when wind speeds are 10 mph or more.

6. Restricted Entry Intervals

For most field crops, vegetables, tree crops, greenhouse and nursery ornamentals, pasture, grassland, forests, rangeland, parks, paths, greens, golf-courses, cemeteries and abatement districts, and quarantine areas the restricted entry interval (REI) is 24 hours. Some granular formulations have a 12-hour REI for nursery or greenhouse ornamentals (azalea, holly, pyracantha, photinia and crape myrtle) and some non-crop sites. For some residential, institutional and industrial uses, the REI is when sprays have dried or dust has settled. The preharvest intervals (PHI) are various, depending on different uses (see exposure section).

7. California Requirements

California regulations require eye protection and gloves to be used for nearly all handling activities. Under California regulations, employees must wear protective eyewear when required by pesticide product labeling or when employees are engaged in mixing or loading, maintaining or cleaning application equipment, application with hand-held

equipment, application with some ground equipment and flagging (except when using an enclosed cab) (Title 3 California Code of Regulations [3 CCR] 6738(b)(1)). Also, employees must wear gloves when required by the pesticide product labeling or when employees are engaged in mixing or loading, maintaining or cleaning application equipment and application with hand-held equipment (3 CCR 6738(c)(1)).

8. Significant Exposure Scenarios

8.1 Handler Exposure

Eighteen occupational handler exposure scenarios for acephate were identified in this document. Sixteen of these exposure scenarios were identified in the U.S. EPA Reregistration Eligibility Decision (RED) for Acephate (U.S. EPA, 2001a). The scenarios identified by DPR include agricultural, institutional and recreational area uses, and they serve as the basis for quantitative exposure assessments. The occupational handler exposure scenarios are listed in Table 2.

Table 2: Occupational Handler Exposure Scenarios for Acephate[a].

Activity[b]	Formulation	Application Method
1.a. M/L	Soluble Powder	Aerial
1.b. M/L	Soluble Powder	Groundboom
1.c. M/L	Soluble Powder	Airblast
1.d. M/L	Soluble Powder	Handgun (hydraulic sprayer)
1.e. M/L	Soluble Powder	Slurry Seed Treatment
1.f. L/T	Soluble Powder	Hopper Box
1.g. L/T/P	Soluble Powder	Hopper Box
1.h. M/L	Soluble Powder	Chemigation
2. M/L	Dry Flowable	Slurry Seed Treatment
3. L	Granular	Tractor-Drawn Drop-Type Spreader
4. A	Soluble Powder	Fixed-Wing Aircraft
5. A	Soluble Powder	Groundboom Sprayer
6. A	Soluble Powder	Airblast Sprayer
7. A	Soluble Powder	Handgun Sprayer
8. A	Granular	Tractor-Drawn Drop-Type Spreader
9. M/L/A	Soluble Powder	Low-Pressure Hand Wand
10. M/L/A	Soluble Powder	Backpack Sprayer
11. M/L/A	Soluble Powder	High-Pressure Sprayer
12. M/L/A	Soluble Powder	Sprinkler Can
13. M/L/A	Wettable Powder[c]	Backpack Sprayer
14. A	Water-Soluble Pellet	Paintbrush[c]
15. A	Granular	Shaker Can
16. L/A	Granular	Belly Grinder
17. L/A	Granular	Hand
18. Flagging	Liquid, Soluble Powder	Aerial Spray

a The occupational handler exposure scenarios are identified based upon the product labels and U.S. EPA (U.S. EPA, 2001a).

b M/L = mixer/loader; L = loader; A = applicator; M/L/A = mixer/loader/applicator; L/A = loader/applicator; L/T = loader/treater; L/T/P = loader/treater/planters.

c These scenarios were not covered by U.S. EPA, they were added by DPR based on the product labels.

Residential pesticide applicators are also likely to be exposed during acephate use. The anticipated use patterns and current labeling indicate several exposure scenarios based upon the types of equipment that potentially can be used to make acephate applications in the residential environment. There are 9 residential exposure scenarios identified in this document (Table 3), including 7 residential exposure scenarios identified by U.S. EPA (U.S. EPA, 2001a).

As mentioned before, although U.S. EPA published acephate product cancellations and use deletions for home and garden uses in 2002, some products still are actively registered in California. Therefore, for the purposes of this document, exposure was estimated based on actively registered products in CA.

Table 3: Residential Handler Exposure Scenarios for Acephate[a].

Activity [b]		Formulation	Application Method
1.	M/L/A	Wettable Powder	Low Pressure Hand Wand
2.	M/L/A	Wettable Powder	Backpack Sprayer
3.	M/L/A	Wettable Powder	Hose-End Sprayer
4.	M/L/A	Wettable Powder	Sprinkler Can
5.	L/A	Flowable Concentrate, Liquid	Hose-End Sprayer
6.	L/A	Soluble Powder	Handtool/Shaker Can
7.	L/A	Granular	Shaker Cup
8.	A	Water-Soluble Pellet	Paintbrush
9.	A	Liquid	Aerosol Can

a The residential exposure scenarios are identified based upon the product labels and U.S. EPA (U.S. EPA, 2001a). As mentioned before, although U.S. EPA published acephate product cancellations and use deletions for resident home and garden uses in 2002, the scenarios in this document were based on actively registered products labels in California.

b M/L/A = mixer/loader/applicator; L/A = loader/applicator; A = applicator.

8.2 Post-Application Exposure

In addition to handler exposure, the potential for post-application (reentry) occupational and residential exposures to acephate and its metabolite, methamidophos, also exist. All of the identified agricultural reentry scenarios are shown in Appendix A. These reentry scenarios represent activities allowed by acephate product labels registered for use in the state of California. Appendix A lists agricultural use sites, reentry activities, the shortest REI and PHI.

Due to absence of adequate information and data for each scenario, representative scenarios will be used in the actual assessment of these reentry exposures. Exposure estimates generated for representative scenarios are anticipated to be the best available for the other scenarios (listed as "crops represented") indicated in Table 4. While scenarios classified as representative are not expected to have exposures identical to the scenarios they represent, their use as a surrogate is anticipated to be health protective. In other words, the objective used while selecting representative activities is to choose scenarios that provide the best estimate of exposure, without underestimating the exposure for any of the scenarios in that category. Table 4 summarized representative and represented exposure scenarios for field workers who enter an area previously treated with acephate to perform specific work activities. These scenarios are based on the product labels, the RED document (U.S. EPA, 2001a) and acephate use situations in California (See section III-3).

The public may be exposed to acephate and methamidophos upon entering residential areas previously treated with acephate. The post-application residential exposures (Table 4) were assessed for both acephate and methamidophos.

Another post-application exposure scenario is post-application recreational exposure, including golf course mower, golfers, golf course maintenance workers, tennis players, tennis court maintenance workers, park maintenance workers, and players in parks. These activities were also summarized in Table 4.

Table 4: Representative and Represented Post-Application Agricultural, Residential, and Recreational Area Activities with Potential Exposure to Acephate[a].

Site	Activity	Crops/Activities Represented
Agricultural Post-Application		
1. Cotton[b]	Scouting	Tobacco
2. Cauliflower[b]	Harvesting	Lettuce, Celery, Peppers, Brussels Sprouts, Mint
3. Succulent Beans[b]	Harvesting	Dry Beans, Potatoes, Peanuts, Onions, Tomatoes
4. Greenhouse Roses[b]	Pruning & Harvesting	Greenhouse Crops
5. Nursery Ornamentals	Pruning & Harvesting	Nursery Crops
6. Citrus[b,c]	Pruning & Thinning	Oranges, Grapefruit, Lemons, Almonds, Walnuts, Pistachio
7. Stone Fruit (Apricots, Cherries, Plums, Prunes)	Pruning & Thinning[d]	Apples, Pears
8. Grapes[b]	Scouting, Thinning & Harvesting (hand)	Cranberries, Kiwi Fruit
9. Turf[b]	Mowing (with tractor or push)	Pasture, Rangeland
10. Turf[b]	Harvesting	
Residential Post-Application		
1. Adult Dermal[b]	Entering for recreation, yard-work, or other homeowner activities on turf grass	Player in Park (adult), Non-Crop Areas (Field borders, Fencerows, Roadside, Ditchbanks, Borrow Pits, Wasteland)
2. Toddlers Dermal[b]	Entering and playing on turf grass	Player in Park (children)
3. Toddlers Hand-to-Mouth[b]	Entering and playing on turf grass	Player in Park (children)
4. Toddlers Grass Ingestion[b]	Turf grass	Player in Park (children)
5 Indoor Pest Control	Reentering into building	
Recreational Areas Post-Application		
1. Golf Course Mower[b]	Mowing turfgrass of golf course	Park Turf Mower
2. Golfers[b]	Playing on golf course	Tennis Player
3. Maintenance Worker[b]	Cleaning holes, etc.	Tennis Court Maintenance Worker, Park Maintenance Worker
4. Indoor (Hard Surface and Carpet)	Reentry into treated building	

a The post-application agricultural activities exposure scenarios are identified based upon the product labels, U.S. EPA (U.S. EPA, 2001a) and WHS guidance. As mentioned before, although U.S. EPA published acephate product cancellations and use deletions for home and garden uses in 2002, these products are still actively registered in California. Therefore, potential exposures for these uses were assessed in this document.

b The scenarios with enough information/data to estimate the exposure.

c The applications are for non-bearing citrus, or as the product labels indicate: "Do not harvest citrus for one year after treatment." Therefore, the exposures to harvesters are not anticipated.

d The product labels indicate that acephate applications are limited to non-bearing fruit trees, nut trees or orchards. Therefore, the exposures to harvesters are not anticipated.

IV. PHARMACOKINETICS

1. Dermal/Inhalation Absorption

A percutaneous absorption study of acephate was conducted by Chevron Chemical Company (Carey, 1985). Dermal absorption was determined by topically applying single doses of either 0.5 mg/rat (42 μg/cm^2 for low dose) or 5.0 mg/rat (428 μg/cm^2 for high dose) of the test material (Table 5) onto an unabraded 12-cm^2 application site on the shaved dorsal trunk of groups of four adult male rats (weight: 498 – 608 grams; age: 144 – 151 days). The test material was labeled with ^{14}C and suspended in distilled water with 0.5% (w/w) Tween® 80. The rats were placed individually into Metrap® restraining metabolism chambers for 2, 8, or 24 hours. After each exposure period, the treated skin site was washed with acetone and the animals were sacrificed. The skin from the application site, blood, carcass, and excreta were collected and analyzed for radioactivity.

Table 5. Administered Doses of Acephate Technical on Rats[a].

Group	Dose [b] (μg/cm^2)	No. of Rats [c]	Exposure Time [d] (Hr After Application)
A	42	16	0, 2, 8, 24
B	428	16	0, 2, 8, 24

a Data were provided by Chevron Chemical Company (Carey, 1985).
b ^{14}C-acephate in water with Tween 80® (0.5% w/w).
c Four rats per exposure time.
d Animals were sacrificed at the end of each exposure time.

The average percentage of the administered dose of ^{14}C-acephate equivalent recovered in each specimen from each individual animal is presented in Table 6. The average total recovery of the administered dose ranged from 78.3% to 87.5% in the low dose group and 90.6% to 93.7% in high dose group. For all animals, the largest percentage of the administered dose was recovered in the acetone skin wash from the application site, and less than 0.1% of the administered dose was recovered in the blood.

Table 6. Mean Total Recovery of ^{14}C-Acephate Equivalent (% of Administered Dose)[a].

Time After Dosing (Hr)	Acetone Skin Wash	Methanol: Water Skin Wash	Skin Residue	Methanol Template Wash	Blood	Urine	Feces	Carcass	Methanol Cage Wash	CO_2 Trap	Total Recovery
0.5 mg/rat dose group (42 µg/cm^2):											
0	82.7	0.4	0.5	<0.1	NE [b]	NE	NE	NE	NE	NE	83.1±15.4
2	81.7	1.6	1.6	<0.2	<0.1	0.7	<0.1	1.0	<0.1	<0.1	86.9±1.6
8	80.8	2.1	2.2	<0.1	<0.1	1.4	<0.1	0.9	<0.1	0.4	87.5±0.7
24	55.8	9.4	4.8	<0.2	<0.1	4.7	<0.3	1.4	0.4	1.5	78.3±3.1
5.0 mg/rat dose group (428 µg/cm^2):											
0	87.5	0.6	0.7	<2.9	NE	NE	NE	NE	NE	NE	91.6±3.7
2	90.3	0.7	0.9	<0.2	<0.1	<0.5	<0.1	0.9	<0.1	<0.1	93.5±1.3
8	87.6	1.0	1.6	<0.1	<0.1	2.1	<0.1	0.9	<0.1	0.4	93.7±3.1
24	79.8	2.3	1.7	<0.2	<0.1	3.9	0.2	1.5	0.5	0.7	90.6±2.2

a Data were provided by Chevron Chemical Company (Carey, 1985).
b NE = not examined.

The values in Table 6 were adjusted by total recovery rates to reflect 100% recovery and summarized in Table 7. Almost all of the material that was not absorbed (92.3% of the applied dose in the low dose group and 93.6% of the applied dose in the high dose group at 8 hours) remained on the surface of the skin at the application site.

Table 7. Mean Normalized Recovery of ^{14}C-Acephate Equivalent (% of Administered Dose)[a,b].

Time After Dosing (Hr)	Acetone Skin Wash	Methanol: Water Skin Wash	Skin Residue	Methanol Template Wash	Blood	Urine	Feces	Carcass	Methanol Cage Wash	CO_2 Trap
0.5 mg/rat dose group (42 µg/cm^2):										
0	99.0±0.1	0.4	0.5	0.1	NE [c]	NE	NE	NE	NE	NE
2	94.0±1.8	1.9	1.8	0.2	<0.1	0.8	<0.1	1.2	0.1	0.1
8	92.3±0.9	2.4	2.2	0.1	<0.1	1.5	<0.1	1.0	0.1	0.4
24	71.5±10.2	11.9	6.0	0.2	<0.1	6.0	0.3	1.8	0.5	1.9
5.0 mg/rat dose group (428 µg/cm^2):										
0	95.4±5.9	0.6	0.8	3.3	NE	NE	NE	NE	NE	NE
2	96.6±1.5	0.8	1.0	0.1	0.1	0.5	<0.1	1.0	<0.1	0.1
8	93.6±6.6	1.0	1.7	<0.1	<0.1	2.2	<0.1	1.0	0.1	0.4
24	88.0±6.5	2.5	1.9	0.1	<0.1	4.4	0.2	1.6	0.5	0.8

a Data were provided by Chevron Chemical Company (Carey, 1985).
b The recovery of various sites was normalized to reflect 100% recovery.
c NE = not examined.

Mean dermal absorption for each time point at each dose level was summarized in Table 8. The amount of the test material found in the intradermal compartment increased with time and ranged from 0.9% of the administered dose at 0 hours to 17.9% at 24 hours in the low dose group and 1.4% of the administered dose at 0 hours to 4.4% at 24 hours in the high dose group. The amount of ^{14}C-acephate equivalent that was systemically absorbed and increased slowly with time; most of the absorbed material was recovered in the urine (6.0% of the administered dose in the low dose group and 4.4% in the high dose

group at 24 hours). The results indicated that acephate was slowly absorbed when applied dermally to adult male rats.

Table 8. Mean Distribution of Normalized ^{14}C-Acephate Equivalent (% of Administered Dose)[a].

Compartment	Time After Dosing (Hr) 0	2	8	24
0.5 mg/rat dose group (42 µg/cm^2):				
Skin Surface [b]	99.0 ± 0.1	94.2 ± 1.7	92.4 ± 0.8	71.6 ± 10.2
Intradermal [c]	0.9 ± 0.2	3.7 ± 1.4	4.6 ± 0.8	17.9 ± 7.5
Systemic Absorption [d]	NE [e]	2.1 ± 1.1	3.0 ± 1.5	10.5 ± 4.3
Dermal Absorption [f]	NE	5.8	7.6	28.4
5.0 mg/rat dose group (428 µg/cm^2):				
Skin Surface [b]	98.7 ± 0.6	96.7 ± 1.5	93.6 ± 6.6	88.1 ± 6.4
Intradermal [c]	1.4 ± 0.7	1.8 ± 0.5	2.7 ± 1.5	4.4 ± 0.9
Systemic Absorption [d]	NE	1.6 ± 1.4	3.6 ± 5.2	7.6 ± 6.0
Dermal Absorption [e]	NE	3.4	6.3	12.0

a Data were provided by Chevron Chemical Company (Carey, 1985).
b Acetone skin wash + methanol template wash.
c Methanol:water (1:1, v/v) skin wash + skin residue (combusted for ^{14}C determination), which is assumed equivalent to "bound skin residue".
d Carcass + blood + urine + feces + methanol cage wash + CO_2 trap.
e NE = Not examined.
f Assumed dermal absorption = systemic absorption + intradermal residues.

The results showed that in the low dose group, 7.6% of the administered dose was absorbed in 8 hours and 28.4% was absorbed in 24 hours. In the high dose group, 6.3% of the administered dose was absorbed in 8 hours and 12.0% was absorbed in 24 hours. Comparative studies between the rats and humans conducted by Bartek *et al.* (1972) have shown that rat skin is more permeable than human skin, but the differences are not large. This may be due to the small structural differences between rat and human skin; the stratum corneum of the two species is similar in thickness, but the whole skin of the rat is only two-thirds as thick as that of humans (Bronaugh *et al.*, 1982). Therefore, it is reasonable to apply the rat dermal absorption rate to assess human dermal exposure to acephate. The dermal absorption rate of 7.6% calculated for the dosage of 0.5 mg/rat (42 µg/cm^2) for the 8-hour exposure time is comparable to the human exposure period in a typical workday. Therefore, it was selected as estimated dermal absorption rate to assess human exposure to acephate.

Another available acephate dermal absorption study was conducted by Chevron Chemical Company (Tucker, 1974). However, this study was considered unacceptable because the study used only two rats. There was no attempt made to quantify the total radioactivity of the dosage given. This opinion is consistent with Wang (1986).

No inhalation absorption studies are available. In the absence of these data, the current default inhalation absorption value of 100% is used for calculations of doses absorbed via inhalation.

2. Metabolism/Pharmacokinetics

Chevron Chemical Company (Lee, 1972) investigated the metabolism of acephate in male and female rats using S-methyl-^{14}C-acephate. All doses were given by intubation of an aqueous solution. The excretion of radioactivity was rapid and complete. Total accountability was 88-100% of the applied dose. Most excretion occurred within the 12-hour period following dosing and only a low level elimination was observed thereafter. Urine accounted for about 95% of total radioactivity recovered. Most of the remaining radioactivity was found in the breath and feces, with a total of about 0.4% of applied dose detected in the organs and tissues (brain, heart, kidney, muscle, liver, fat, gut and skin) 72 hours after dosing. Among these tissues, liver had the highest total activity, followed by skin, gut and kidney. The radioactivity in urine was shown by co-chromatography to be acephate (73-77%), dimethyl phosphorothioate (DMPT) (3-6%) and S-methyl acetylphosphoramidothioate (3-4%). No O,S-dimethyl phosphoramidothioate (methamidophos), a plant and soil metabolite, was detected. There was no difference in the excretion patterns of male and female rats.

Chevron Chemical Company also conducted a metabolism study in Japanese quails (Warnock, 1973). Four Japanese quails were dosed orally with S-methyl-^{14}C-acephate and the fate of the insecticide was followed by radiotracer techniques. Within the first 6 hours after dosing, 70% of the ^{14}C was recovered from the excreta, and 4.7% from expired air. The balance was retained by the birds and was found rather uniformly distributed in the various tissues. When the birds were caged so that excreta was quickly frozen after being voided, only 75% of the ^{14}C in excreta was accountable as acephate. Small but significant amounts of methamidophos, S-methyl acetylphosphoramidothioate and DMPT were found.

An oral-human study was also conducted. Various concentrations of acephate (from 0.35 – 1.25 mg/kg/day) were given to groups of human volunteers in oral capsule form (Freestone & McFarlane, 2001). The study involved monitoring urine and blood at time intervals of 0, 1, 2, 4, 8, 12, 24, 48 and 72 h, since dosing. A small amount of the acephate was isolated as methamidophos in blood or urine (1 - 2%). Blood plasma concentrations of acephate peaked at 2 to 2.7 h after dosing and clearance from the blood had a relatively short $t_{1/2}$ of 4.3 to 6.6 h (Tozer, 2000).

Based on the results of the studies mentioned above, it appears that in rats, acephate is excreted almost entirely in urine (95%) and primarily (73-77%) as the parent compound. No methamidophos was found in milk. In quails, it showed that there was a small amount of methamidophos in feces and traces in eggs. Neither acephate nor its metabolite methamidophos bioconcentrated in any organism tested from simple organisms to mammals and birds. In the human study, acephate was absorbed, metabolized and excreted in a similar way to the rat, with little opportunity to bioaccumulate.

V. ENVIRONMENTAL CONCENTRATIONS

Acephate is not persistent in the environment such as in soil (half-life ranged from 0.5 to 3 days) and in plants (half-life is approximately 5 to 10 days). The environmental fate of this insecticide was reviewed and summarized in the research reports by Downing (2000) and Cook (2003).

1. Air

An air monitoring study was conducted by Chevron Chemical Company (Pack, 1975) in an orange orchard near Fresno, California in August, 1973 to determine air concentrations after application of Orthene® 75 S, a soluble powder containing 75% acephate. The application rate was 1 lb AI/100 gallons and the trees were sprayed to run-off at the rate of about 3.5 gallons of diluted spray per tree. The weather was hot (85°F at 6 A.M., the time of spraying) and clear and there was no wind.

The concentrations of acephate and its metabolites in the air within the canopy of the trees were measured 3, 8 and 26 hours after spraying. The results are shown in Table 9. The tree canopies started about 5-6 feet above the ground level. Monitoring was accomplished by pulling the air through 10 ml methyl isobutyl ketone (MIBK) in a midget impinger. The sampling time was 1 hour and the air flow rate was about 2 L/min. Air samples were analyzed by direct gas-liquid chromatography (GLC) assay of the MIBK solutions. An average concentration of 0.1 mg/m^3 acephate was detected at 3 hours, but none at 8 and 26 hours after application. No methamidophos was detected at any of the sampling intervals.

Table 9. Concentrations of Acephate and Methamidophos in Air in Canopy of Orange Trees Treated with Acephate at Various Times after Application[a].

Interval Hours	Air Concentration (mg/m^3) Acephate	Methamidophos
3	0.12	ND[b]
	0.07	ND
8	ND	ND
	ND	ND
26	ND	ND

a The data were provided by Chevron Chemical Company (Pack, 1975).
b ND = Not detectable.

No data on ambient air concentrations of acephate were available to WH&S. On January 2, 2002, DPR requested the California Air Resources Board to conduct application site and ambient monitoring for acephate (Helliker, 2002). The monitoring study should coincide with areas and times of peak acephate use. Based on a preliminary assessment of the toxicology data, DPR indicated these quantitation limits for acephate: 5 ng/m^3 for ambient monitoring and 0.1 µg/m^3 for application site monitoring.

2. Dislodgeable Foliar Residue (DFR)

The term DFR is defined as the amount of pesticide residue that can be removed from both sides of treated foliage surfaces using an aqueous surfactant. DFR residues could be transferred to humans when contact is made with treated foliage. DFR, along with an appropriate transfer factor (TF), can be used to estimate the pesticide amount transferred to humans who enter into a previously treated field. A number of DFR studies are available in the open literature (Gunther *et al.*, 1973a and 1973b). Generally, the leaf disc samples were rinsed and dislodgeable residues were analyzed by gas-liquid chromatography. The DFR is reported as residue per leaf surface area ($\mu g/cm^2$). Based on WHS policy (Andrews, 2000), a general equation for calculating DFR and half-life ($t_{½}$) at a given time is:

$$DFR_t = DFR_0 * exp(-kt)$$

In which DFR_0 represents initial DFR level, t represents the number of days since treatment, and k is the constant derived from regression. In subsequent discussions, the data were analyzed by completing an exponential regression and the first-order rate kinetics (in which the rate is proportional to the amount of DFR removed from treated foliage) calculation of half-life.

2.1 Cotton

Since acephate DFR data were not available for California, we used DFR data from a study conducted in Marana, Arizona as surrogate (Ware *et al.*, 1980). The study began on July 9, 1980 and ended July 14, 1980. Orthene® 75S (75% soluble powder) was applied at a rate of 1.1 kg AI/ha (equivalent to 0.98 lb AI/acre). Triplicate samples were collected in each treated plot at 0, 24, 48, 72, and 96 hours after treatment. These data were analyzed by completing an exponential regression and a first-order rate kinetics calculation of half-life as shown in Table 10. Methamidophos measurements were not conducted.

2.2 Cauliflower

Two acephate DFR studies following applications to cauliflower were evaluated. In one acephate DFR study, the result was obtained from the RED document (U.S. EPA, 2000a). The study was conducted in Santa Cruz County, California. Two applications of Orthene® 75 SP were made, 10 days apart, using 1.0 lb AI/acre with a tractor-mounted boom sprayer. The study was conducted between July 10, 1998 and August 24, 1998. The leaf punch samples were collected at the following intervals: prior to application #1, just after application #1 when the spray had dried, just before application #2, just after application #2, and on day 1, 2, 3, 5, 7, 10, 14, 21, 28, and 35 after the second application. The DFR data of acephate and methamidophos were analyzed by completing an exponential regression and a first-order rate kinetics calculation of half-life as shown in Table 10.

Another acephate DFR study was performed near Fresno, California by Chevron Chemical Company (Lai, 1987). The product used in the trial was Orthene® 75 S. Six foliar applications of Orthene® 75 S were made using a ground rig sprayer. Treatments at 1.0 lb AI/acre were made at 7-day intervals beginning April 28, 1987 and ending June 2, 1987. Sampling intervals were immediately after each application and 2, 3, 7, 10, 14, 21, 28 and 35 days after the last application. These results were analyzed by completing an exponential regression and a first-order rate kinetics calculation of half-life. The initial DFR of the last application (0.054 $\mu g/cm^2$) is much lower than the initial DFR of the first application (0.28 $\mu g/cm^2$) and the initial DFR of other previous applications (average 0.197 $\mu g/cm^2$). The document did not mention the phenomenon or possible reasons. Without adequate explanation, however, this study is considered unacceptable and was not shown in Table 10.

2.3 Citrus

Two DFR studies were conducted following acephate use on citrus trees. In the first study, the Orthene® 75 S was applied to two sites in Fresno County, CA (Pack, 1975). Navel orange trees were ground sprayed on August 20, 1973 at a dilution of 1.0 lb AI/100 gal. The trees were sprayed to run-off with about 3.5 gallons of diluted spray per tree. Generally, one acre has 90 orange trees (22 feet between two trees), so the equivalent application rate would be 3.15 lbs AI/acre. One application was made. The samples were collected at 3.5 hours, 1, 2, 4, 7, 14, and 21 days after the application and analyzed. These results were analyzed by completing an exponential regression and a first-order rate kinetics calculation of half-life. The calculated initial (Day 0) DFR was 7.02 $\mu g/cm^2$. DFR decreased to 1.10 $\mu g/cm^2$ by Day 15. The estimated half-life was 5.6 days (Table 10).

In the second study, Orthene® 75 S was applied to California grapefruit trees at 2.0 lbs AI/acre using an orchard sprayer (Lai, 1985). The trial was performed in Fresno, California. Two applications at 2.0 lb AI/acre were made on May 8 and May 22, 1984. Sampling intervals were 1, 8, 15, 22, and 29 days after last application. The calculated initial (Day 0) DFR was 1.31 $\mu g/cm^2$. The average DFR values from two treatments indicate that DFR decreased to 0.12 $\mu g/cm^2$ by Day 15. The estimated half-life was 5.9 days (Table 10).

In these two studies, half-life estimates are 5.6 and 5.9 days, which are very similar. However, the residue levels for these two studies were quite different (Table 10). The higher application rate and higher initial DFR, i.e., the first study (Navel orange), was used as citrus DFR in this document. There was no methamidophos measurement conducted in these two studies.

2.4 Greenhouse Roses

DFR of acephate and its degradate, methamidophos, were quantified from rose foliage in one greenhouse study in Monterey County, California (U.S. EPA, 2000a). Two applications of Orthene® Turf, Tree and Ornamental Spray were made by a backpack

sprayer with a handheld wand, seven days apart, using 2.15 lb AI/acre (maximum label rate) in 214 to 215 gallons of water/acre. The trial was conducted in a glass commercial greenhouse between June 15, 1998 and September 17, 1998 (last DFR sampling date). Leaf punch samples were collected at the following intervals: just prior to application #1, just after application #1 when the spray had dried, 1 day before application #2, just after application #2, and on day 1, 2, 3, 5, 7, 10, 14, 21, 28, and 35 after the second application. At each interval, three replicate samples were collected from the treated plot and one sample was collected from the control plot. The data were analyzed by completing an exponential regression and a first-order rate kinetics calculation of half-life with the results shown in Table 10.

2.5 Succulent Beans

Since acephate DFR data were not available for California, we used succulent bean DFR data from Benton, Oregon as a surrogate (U.S. EPA, 2000a). DFR of acephate and one of its degradates, methamidophos, were quantified from succulent beans in Benton County, Oregon. Two applications of Orthene® 75 SP were made, seven days apart, at a rate of 1.0 lb AI/acre (maximum label rate) in 20 gallons/acre (minimum volume) with a tractor-mounted boom sprayer. Field studies were conducted between June 30 and August 4, 1998. Leaf punch samples were collected at the following intervals: just prior to application 1, just after application 1 when the spray had dried, 1 day before application 2, just after application 2, and day 1, 2, 3, 5, 7, 10, 14, 21, 28, and 35 after the second application. At each interval, three replicate samples were collected from the treated plot and one sample was collected from the control plot. The data were analyzed by completing an exponential regression and a first-order rate kinetics calculation of half-life with the results shown in Table 10.

2.6 Grapes

Two studies were conducted in grape vineyards in Fresno, California to determine the DFR after ground application of Orthene® 75 S by Chevron Chemical Company (Pack, 1976). The study with longer half-life was selected to estimate exposure of field workers in this document. The vines were sprayed three times at 4- to 8-week intervals with 1 lb AI/acre (maximum label rate). At intervals of 0 to 14 days after the last spraying, samples were collected and analyzed. At each interval, two replicate samples were collected. The DFR values were reported as ppm in the study. The ppm values were converted to $\mu g/cm^2$ based on the method generated by Dong *et al.* (1991). All leaves were weighed and the average weight was used to convert weight to surface area. The data were analyzed by completing an exponential regression and a first-order rate kinetics calculation of half-life with the results shown in Table 10.

3. Turf Surface Residues

Since acephate DFR data were not available for California, we used turf transferable residues (TTR) data from Putnam, Florida as surrogate (U.S. EPA, 2000a). TTR of acephate and methamidophos, were quantified from turfgrass. Two applications of

Orthene® 75 WSP were made, 14 days apart, using 5.0 lb AI/acre with a backpack sprayer and handheld wand. Samples were collected between August 26 and October 14, 1998 at the following intervals: just after application 1 when the spray had dried (20 to 35 minutes after application), 6 days after application 1, 1 day prior to application 2, just after application 2 when the spray had dried (20 to 35 minutes after application), 2 and 8 hours after application 2, and on day 1, 2, 3, 5, 7, 10, 14, 21, 28, and 35 after the second application. At each interval, three replicate samples were collected from the treated subplot and one sample was collected from the control plot. The samples were collected using the modified California roller technique (Fuller *et al.,* 2001). This technique involved attaching a cotton sheet to a sampling frame and securing the frame to the turf subplot area with large spikes. The surface area of the sheet exposed to the turf was 4,026 cm^2. The modified California roller was placed at one end of the frame on a plastic sheet covering the cotton sheet. The roller was guided back and forth inside the frame for five round trips over the sample area. Afterwards, the frame was lifted from the turf and the cotton sheet removed. Any debris on the sheet was removed before the sheet was folded with the exposed sides inward. The folded sheet was then placed in a pre-labeled plastic bag. The sample from the untreated plot was collected prior to the collection of the samples from the treated subplots. The data were analyzed by completing an exponential regression and a first-order rate kinetics calculation of half-life with the results shown in Table 10.

Table 10. Acephate Dislodgeable Foliar Residues on Various Crops.

	ACEPHATE				METHAMIDOPHOS						
Crop	DFR_0 [a] ($\mu g/cm^2$)	Calculation Equation	R^2	$t_{1/2}$ (days)	DFR_0 [a] ($\mu g/cm^2$)	Calculation Equation	R^2	$t_{1/2}$ (days)	Formulation[b]	Acephate Use Rate (lb AI/acre)	Location
Cotton[c]	4.8	$DFR_t = 5.009e^{-0.4082t}$	0.99	1.7	NA[d]	NA[d]	NA[d]	NA[d]	SP	0.98	Marana, AZ
Grapefruit[e]	1.31	$DFR_t = 1.3106e^{-0.1184t}$	0.91	5.9	NA[d]	NA[d]	NA[d]	NA[d]	SP	2.0	Fresno, CA
Oranges[f]	7.02	$DFR_t = 7.0223e^{-0.1237t}$	0.86	5.6	NA[d]	NA[d]	NA[d]	NA[d]	SP	1.0/100 gal	Fresno, CA
Cauliflower[g]	0.2003	$DFR_t = 0.2003e^{-0.1216t}$	0.88	5.7	0.0029	$DFR_t = 0.0029e^{-0.0578t}$	0.72	12	SP	1.0	Santa Cruz, CA
Greenhouse Roses[h]	1.517	$DFR_t = 1.517e^{-0.2297t}$	0.94	3.0	0.0315	$DFR_t = 0.0315e^{-0.1496t}$	0.73	4.6	SP	2.15/215 gal	Monterey, CA
Beans[i]	0.6063	$DFR_t = 0.6063e^{-0.2006t}$	0.83	3.4	0.0282	$DFR_t = 0.0282e^{-0.1108t}$	0.88	6.0	SP	1.0/20 gal	Benton, Oregon
Turf[j]	0.289	$DFR_t = 0.289e^{-0.5331t}$	0.89	1.3	0.0011	$DFR_t = 0.0011e^{-0.1386t}$	0.29	5.0	WSP	5.0	Putnam, FL
Grapes[k]	3.0382[k]	$DFR_t = 6.8732e^{-0..4019t}$	0.80	4.4[l]	NA[d]	NA[d]	NA[d]	NA[d]	SP	1.0	Fresno, CA

[a] DFR_0 = Calculated initial DFR.
[b] SP = soluble powder; WSP = wettable soluble powder.
[c] Data based on the study by Ware *et al.* (1980).
[d] NA = Not Available.
[e] Data based on the study by Lai (1985).
[f] Data based on the study by Pack (1975).
[g] Data based on U.S. EPA (2000a).
[h] Data based on U.S. EPA (2000a).
[i] Data based on U.S. EPA (2000a).
[j] Data based on U.S. EPA (2000a).
[k] Data based on the study by Pack (1976). Since the study used ppm as the unit of DFR, ppm values were convert to $\mu g/cm^2$ based on the method generated by Dong *et al.* (1991). All leafs were weighed and the average weight were used to convert weight to surface area.
[l] The half-life were calculated based on the initial ppm values.

VI. EXPOSURE ASSESSMENT

Private and professional pesticide applicators are likely to be exposed to acephate during acephate use. U.S. EPA determined that uses of acephate by private and professional pesticide applicators would result in short-term and intermediate-term exposures based on the frequency and duration of acephate uses (U.S. EPA, 2000a). The anticipated use patterns and current labeling indicate numerous exposure scenarios based on the types of equipment that could be used to make acephate applications. These scenarios serve as the basis for the quantitative exposure assessments. The major handler exposure scenarios for acephate are listed in Tables 2-4 in the Significant Exposure Scenarios section.

There is the potential for exposure from both agricultural and residential uses of acephate. In addition, the general public may be exposed to acephate while golfing on acephate-treated golf courses.

An acephate degradate, methamidophos, is a potent cholinesterase inhibitor in acute toxicity category I by all routes of exposure. The potential exposure to methamidophos is also assessed in this document. As methamidophos is anticipated to be present following the application of acephate, the occupational and residential handler assessments only consider potential acephate exposures while the occupational, residential and recreational post-application assessments address both potential acephate and methamidophos exposures.

1. Agricultural Use

1.1 Handlers

1.1.1 Exposure Monitoring

(A) Mixer/Loader for Cotton Aerial Application

Valent U.S.A Corporation (Bruce *et al.*, 2002) performed a study to monitor and quantify dermal and inhalation exposures to acephate. Bruce *et al.* monitored agricultural workers while mixing and loading a water-soluble pellet formulation of acephate, Orthene® 97.

Workers followed product label requirements to mix the pellet formulation in water and load the solution into aerial application equipment for spraying onto cotton. A total of 15 mixer/loaders were monitored on August 8, 9 and 10, 2001. Five replicates were monitored at each of three field sites, two sites in southern California and one site in western Arizona, to represent a variety of mixing facilities. Each worker mixed and loaded 100 pounds of product, enough product to treat 100 acres of cotton at the highest label rate of 1.0 lb product/acre. The fully diluted spray mixture was then pumped into a fixed-wing aircraft for application to cotton.

Dermal exposure was measured using whole-body dosimeters (100% cotton long underwear), detergent handwashes (0.01% v/v Triton-X), and 100% cotton gauze

face/neck wipes, moistened with 0.01% v/v Triton-X. The long underwear was worn under typical work clothing consisting of long pants and a long-sleeved shirt. Personal protective equipment consisted of chemical-resistant gloves, hat and eye protection. Air concentration was monitored using Occupational Safety and Health Administration (OSHA) Versatile Sampler (OVS) air-sampling tubes attached to the personal air-sampling pumps. The pump was placed on each worker's belt and Tygon® tubing attached the pump to the OVS tube. The OVS tube was enclosed in an open-ended plastic protective sleeve, which was clipped to the shirt collar, near the worker's breathing zone. Field fortifications of all matrices were performed during each day of monitoring.

The dermal exposure values for mixer/loaders at all sites are shown in Table 11. The total dermal exposure is the sum of inner dosimeters, face/neck, and hand exposure. Table 11 also shows the average contribution of total dermal exposure for each body part monitored, and percent of total dermal exposure by body part. The exposure data indicated that the lower arms and front torso are subject to the greatest exposure, accounting for approximately two-thirds of total dermal exposure. Hand exposure represents approximately 10% of total dermal exposure. In addition, hand exposure, although variable, was relatively small indicating that gloves are probably effective at limiting acephate exposure to the workers' hands.

Table 11. Adjusted Dermal Acephate Exposure of Mixer/Loaders for Cotton Aerial Application [a].

M/L [b]	Hand Wash [c] (µg)	Face/Neck Wipe [d] (µg)	Rear Torso [e] (µg)	Front Torso [e] (µg)	Upper Arm [e] (µg)	Lower Arm [e] (µg)	Upper Legs [e] (µg)	Lower Legs [e] (µg)	Total Dermal Exposure [f] (µg)	Dermal Exposure [g] (µg/lb AI)	Dermal ADD [h] (µg/kg/day)
Site 1											
1	7.65	3.27	2.67	24.9	3.9	51.4	5.1	2.0	101.0	1.0	1.28
2	32.30	8.39	8.86	105.0	18.6	161.0	18.2	15.8	368.2	3.6	4.67
3	2.64	7.34	52.40	292.0	31.1	297.0	37.3	8.0	727.8	7.1	9.23
4	8.46	2.52	13.90	78.0	9.3	172.0	10.2	6.2	300.6	2.9	3.81
5	5.99	5.72	66.80	547.0	43.2	535.0	55.2	73.1	1332.0	12.9	16.89
Site-mean	11.41 (2.0%)	5.45 (1.0%)	28.93 (5.1%)	209.4 (37.0%)	21.2 (3.8%)	243.3 (43.0%)	25.2 (4.5%)	21.0 (3.7%)	565.9	5.5	7.18
Site 2											
6	0.5	1.05	1.7	9.2	4.2	16.0	7.5	8.86	49.0	0.5	0.62
7	5.1	2.99	14.9	39.9	32.4	55.7	14.0	5.63	170.7	1.7	2.16
8	167.0	0.50	11.6	13.3	14.2	34.8	3.6	7.32	252.3	2.4	3.20
9	18.7	5.16	6.7	68.7	16.3	102.0	22.0	4.14	243.7	2.4	3.09
10	1.3	1.09	18.8	182.0	8.4	197.0	30.5	6.39	445.5	4.3	5.65
Site-mean	38.5 (16.6%)	2.16 (0.9%)	10.5 (4.6%)	62.6 (27.0%)	15.1 (6.5%)	81.1 (34.9%)	15.5 (6.7%)	6.47 (2.8%)	232.2	2.3	2.94
Site 3											
11	28.1	13.9	17.6	147.0	41.9	224.0	31.5	42.5	546.5	5.3	6.9
12	223.0	73.0	1110.0	4990.0	1080.0	9780.0	584.0	307.0	18147.0	175.8	230.1
13	3.6	89.7	24.2	91.7	30.9	127.0	14.0	16.1	397.2	3.8	5.0
14	188.0	14.1	26.9	118.0	22.6	431.0	30.1	22.0	852.7	8.3	10.8
15	136.0	6.6	14.9	24.2	52.6	234.0	30.5	27.2	526.0	5.1	6.7
Site-mean	115.7 (2.8%)	39.5 (1.0%)	238.7 (5.8%)	1074.2 (26.2%)	245.6 (6.0%)	2159.2 (52.7%)	138.0 (3.4%)	83.0 (2.0%)	4093.9	39.7	51.9
Overall-mean	55.22 (3.4%)	15.69 (1.0%)	92.79 (5.7%)	448.73 (27.5%)	93.98 (5.8%)	827.86 (50.8%)	59.58 (3.7%)	36.82 (2.3%)	1630.67	15.80	20.68
SD [i]	79.3	27.2	282.0	1264.0	273.2	2480.8	145.8	77.1	4580.9	44.4	58.08

a The data based on the study by Valent U.S.A Corporation (Bruce *et al.*, 2002).
The values in this table are adjusted by field recoveries, the adjusted value (µg) = matrix raw value (µg)/ matrix-specific and spike level-specific field recovery adjustment factor.
The values in the brackets are percent of total dermal exposure by body part.
Minimal detection limit (MDL) for the inner dosimeter = 1.00 µg/sample.
MDL for face/neck wipe solutions = 1.00 µg/sample; MDL for hand wash solutions = 1.00 µg/sample.

b M/L = mixer/loader; Site 1 = El Centro, California; Site 2 = Blythe, California; Site 3 = Stanfield, Arizona.

c Worker's hands were washed in a dilute detergent solution (0.01% v/v Triton-X) after removing gloves.

d Workers' faces and necks were wiped with 100% cotton gauze moistened with 0.01% v/v Triton-X.

e Inner dosimeters (long underwear) were removed and cut into six sections representing various body parts.

f Sum of adjusted values for all dosimeter sections, handwashes, and face/neck wipes.

g Dermal exposure (µg/lb active ingredient (AI)) = Total dermal exposure (µg)/100 lb mixed * 96.9% AI.

h Dermal ADD (Dermal Absorbed Daily Dosage) = Dermal exposure (µg/lb AI) * application rate/acre * treated acres/day * dermal absorption rate ÷ body weight. Calculation assumptions include:

- Application rate = 1.0 lb product/acre = 0.97 lb AI/A ≅ 1.0 lb AI/A.
- The maximum treated acres per day were 1200 acres according to RED (U.S. EPA, 2000c).
- Absorption rate = 7.6% (see dermal absorption section).
- Default body weight = 69.7 kg (U.S. EPA, 1997a).

i SD = Standard deviation.

Individual results indicate that dermal exposures were noticeably different at various sites. That may be due to the position of the tank's opening. The slurry tank opening at site 2 was located at ankle level, and the dermal exposures at site 2 were much lower than those at the other two sites. While the tank openings at site 1 and site 3 were located at waist and chest level, respectively, the dermal exposures at these two sites were higher. The data indicate the low tank opening may minimize contact between upper body parts and the pesticide packaging and/or spilled product.

It is noted that worker #12 had the highest exposure for every body part (except face/neck where worker #12 had the second highest exposure). There appears to be no specific body part or pathway accounting for worker #12's higher exposure. In the field phase report of the original study, the only unusual entries in the "observations during the work period" were that he "pulled up pants" seven times whereas this activity was not observed in any other worker. Therefore, his high exposure may due to his highly exposed hands contaminating other body parts.

The overall mean total dermal exposure of 1,630.67 μg/worker corresponds to 15.8 μg/lb AI handled since each worker handled 100 pounds of product containing 96.9% active ingredient. Dermal Absorbed Daily Dosage (dermal ADD) was estimated to be 20.68 μg/kg/day.

Table 12 shows calculated inhalation exposure of mixer/loaders. It is apparent that particulate acephate accounts for the majority of airborne residues generated during mixing and loading of Orthene® 97. The worker whose dermal exposure was extremely high also had the highest measured acephate air concentration.

The overall mean air concentration of 0.0101 μg/L corresponds to 0.047 μg/lb AI handled since each worker handled 100 pounds of product containing 96.9% active ingredient. A breathing rate of 14 L/minute for light activity was assumed in this calculation (Thongsinthusak, *et al.,* 1993; Thongsinthusak, 1998).

Table 12. Adjusted Inhalation Exposure to Acephate of Mixer/Loaders for Cotton Aerial Application [a].

M/L[b]	Filter[c] (µg)	Resin[d] (µg)	Total OVS Tube[e] (µg)	Flow Rate (L/min)	Duration (min)	Volume (L)[f]	Particulate Conc.[g] (µg/L)	Vapor Conc.[h] (µg/L)	Total Air Conc.[i] (µg/L)	Inhalation Exposure[j] (µg /lb AI)	Inhalation ADD[k] (µg/kg/day)
Site 1:											
1	0.021	<0.02	0.0310	1.469	52.0	76.4	0.0003	0.0001	0.0004	0.0029	0.049
2	0.102	<0.02	0.1120	1.478	48.0	70.9	0.0014	0.0001	0.0016	0.0103	0.177
3	0.040	<0.02	0.0495	1.477	51.0	75.3	0.0005	0.0001	0.0007	0.0046	0.078
4	0.169	<0.02	0.1790	1.480	37.0	54.8	0.0031	0.0002	0.0033	0.0164	0.282
5	0.301	<0.02	0.3110	1.485	54.0	80.2	0.0038	0.0001	0.0039	0.0284	0.489
Site-mean	0.127	0.01	0.1365	1.478	48.4	71.5	0.0018	0.0001	0.0020	0.0125	0.215
Site 2:											
6	0.025	<0.02	0.0351	1.492	48.0	71.6	0.0004	0.0001	0.0005	0.0032	0.055
7	0.639	<0.02	0.6490	1.492	81.0	121.0	0.0053	0.0001	0.0054	0.0589	1.015
8	0.068	<0.02	0.0776	1.501	59.0	88.6	0.0008	0.0001	0.0009	0.0070	0.121
9	0.405	<0.02	0.4150	1.497	89.0	133.0	0.0031	0.0001	0.0031	0.0377	0.650
10	0.255	<0.02	0.2650	1.512	73.0	110.0	0.0023	0.0001	0.0024	0.0239	0.411
Site-mean	0.278	0.01	0.2883	1.499	70.0	104.8	0.0024	0.0001	0.0025	0.0261	0.450
Site 3:											
11	1.040	0.219	1.2590	1.501	27.0	40.5	0.0257	0.0054	0.0311	0.1140	1.962
12	2.350	0.893	3.2430	1.495	31.0	46.3	0.0508	0.0193	0.0701	0.2948	5.076
13	0.384	0.050	0.4336	1.513	23.0	34.8	0.0110	0.0014	0.0125	0.0388	0.668
14	0.461	<0.02	0.4710	1.494	31.0	46.3	0.0100	0.0002	0.0102	0.0428	0.737
15	0.202	0.029	0.2306	1.499	29.0	43.5	0.0046	0.0007	0.0053	0.0208	0.359
Site-mean	0.887	0.240	1.1274	1.500	28.2	42.3	0.0204	0.0054	0.0258	0.1022	1.760
Overall -mean	0.431	0.087	0.5174	1.492	48.9	72.9	0.0082	0.0019	0.0101	0.0470	0.808
SD[l]	0.565	0.216	0.7722	0.012	19.5	29.3	0.0128	0.0047	0.0174	0.0702	1.279

a The data based on the study by Valent U.S.A Corporation (Bruce *et al.*, 2002).
The values in this table are adjusted by field recoveries. The adjusted value (µg) = matrix raw value (µg) / matrix-specific and spike level-specific field recovery adjustment factor.
The minimal detection limit (MDL) for quartz filter and resin from OSHA Versatile Sampler (OVS) tube = 0.0200 µg/sample.

b M/L = mixer/loader.
Site 1 = El Centro, California; Site 2 = Blythe, California; Site 3 = Stanfield, Arizona.

c Particulates trapped on the filter.

d Vapors trapped on adsorbent. For those values less than MDL, half of test limits are used as defaults.

e Total OVS tube adjusted value = sum of filter + resin adjusted values.

f Sample volume (L) = sample flow rate (L/min) * sample duration (min).

g Particulate concentration (µg/L) = Filter adjusted value (µg) / sample volume (L).

h Vapor concentration (µg/L) = Resin adjusted value (µg) / sample volume (L).

i Total air concentration (µg/lb AI) = OVS tube adjusted value (µg) / sample volume (L).

j Inhalation exposure = Total air concentration * sampling time x 14 liters/minute breathing rate / 100 lbs. handled * 96.9% AI.

k Inhalation ADD (Absorbed Daily Dosage) = Inhalation exposure (µg/lb AI) * application rate/acre * treated acres/day * inhalation absorption rate ÷ body weight.
Calculation assumptions include:
- Application rate = 1.0 lb product/acre = 0.97 lb AI/A ≅ 1.0 lb AI/A.
- The maximum treated acres per day were 1200 acres according to RED (U.S. EPA, 2000a).
- Absorption rate is assumed to be 100%.
- Default body weight = 69.7 kg (U.S. EPA, 1997a).

l SD = Standard deviation.

Table 13 shows the total ADD (combined the dermal and inhalation ADD), and the standard deviation.

Table 13. Total Absorbed Daily Dosage (ADD) of Mixer/Loaders for Cotton Aerial Application to Acephate.

Workers[a] (M/L)	Dermal ADD[b] (µg/kg/day)	Inhalation ADD[c] (µg/kg/day)	Total ADD[d] (µg/kg/day)
1	1.28	0.049	1.33
2	4.67	0.177	4.85
3	9.23	0.078	9.31
4	3.81	0.282	4.09
5	16.90	0.489	17.40
6	0.62	0.055	0.68
7	2.16	1.020	3.18
8	3.20	0.121	3.32
9	3.09	0.650	3.74
10	5.65	0.411	6.06
11	6.93	1.960	8.89
12	230.00	5.080	235.00
13	5.04	0.668	5.70
14	10.80	0.737	11.60
15	6.67	0.359	7.03
Mean	20.70	0.808	21.50
SD[e]	58.08	1.279	59.30

a M/L = Mixer/loader.
b Dermal ADD data from Table 11.
c Inhalation ADD data from Table 12.
d Total ADD are combined dermal ADD and inhalation ADD.
e SD = Standard deviation.

Table 14 calculations are based on the above data and estimates of acephate exposure durations of mixer/loader for aerial cotton applications. The duration periods are: short- (seven days or less), intermediate- (seven days to one year) and long-term (greater than one year).

For calculating short-term (up to 7 days in duration) exposures, the estimated 95th percentile of the ADD is used (Powell, 2006). The 95th percentile can be calculated by finding the arithmetic mean (AM) and standard deviation (ASD) of the log-transformed data, then calculating: 95th percentile = $\exp\left\{\hat{\mu} + 1.645 \cdot \hat{\sigma}\right\}$. Where $\hat{\mu}$ and $\hat{\sigma}$ stand for the arithmetic mean and standard deviation of the logarithms of exposure, and 1.645 is the value corresponding to the 95th percentile of the standard normal distribution

To estimate intermediate- and longer-term exposures, the average daily exposure is of interest because over these periods of time, a worker is expected to encounter a range of daily exposures (i.e., WHS assumes that with increased exposure duration, repeated daily exposure at the upper-bound level is unlikely). To estimate the average, WHS uses the arithmetic mean of daily exposure. Thus the seasonal absorbed daily dosage (SADD) is the upper confidence limit (UCL 90) for the mean ADD (Powell, 2002), which can be calculated by finding the arithmetic mean (AM) and standard deviation

(ASD) of the log-transformed data, then calculating: UCL90 = antilog {AM + ($t_{(0.90;\ n-1)}$ * ASD/√n)}.

Table 14. Estimated Short-, Intermediate- and Long-Term Exposure of Mixer/loaders to Acephate for Aerial Application to Cotton.

Workers[a]	Acute ADD[b] (µg/kg/day)	SADD[c] (µg/kg/day)	Exposure Months [d]	AADD[e] (µg/kg/day)	LADD[f] (µg/kg/day)
M/L	52.0	9.64	6	4.82	2.57

a M/L = Mixer/loader.

b Acute ADD (absorbed daily dosage) = Dermal Acute ADD + Inhalation Acute ADD.
Acute ADD is an upper-bound estimate (95th percentile estimate, Powell, 2006); the 95th percentile can be calculated by finding the arithmetic mean (AM) and standard deviation (ASD) of the log-transformed data, then calculating: 95th percentile = $\exp\left\{\hat{\mu} + 1.645 \cdot \hat{\sigma}\right\}$. Where $\hat{\mu}$ and $\hat{\sigma}$ stand for the arithmetic mean and standard deviation of the logarithms of exposure, and 1.645 is the value corresponding to the 95th percentile of the standard.

c Seasonal Average Daily Dosage (SADD) is an upper confidence limit (UCL90) for the mean ADD (Powell, 2002), by finding the arithmetic mean (AM) and standard deviation (SD) of the log-transformed data, then calculating: UCL90 = antilog {AM + ($t_{(0.90;\ n-1)}$ * SD/$\sqrt{n}$)}.

d Annual exposure months are assumed to be six months based on California Pesticide Use Report Database (DPR, 2006b, see text in section VI(1.1)(B) and Figure 6).

e Annual Average Daily Dosage (AADD) = SADD * annual exposure months/12 months in a year.

f Lifetime Annual Daily Dosage = AADD * (40 years of work in a lifetime) ÷ (75 years in a lifetime).

(B) Loader/Treater/Planter Using Hopper Box

The study (Klonne, 2005) was conducted to determine the dermal and inhalation exposure of experienced agricultural workers loading seed into hopper boxes, then treating the seed within the hopper box with a powdered pesticide, and finally planting the treated seed.

Acephate, formulated as Orthene® 90S Soluble Powder, was mixed with seed just prior to planting. The powdered formulation was added to the hopper box according to label directions and based on the approximate number of acres to be planted. Each planter consisted of 8 or 12 hopper boxes and the boxes were filled 1, 2, or 3 times per work period. The treated seed (640 to 1,480 lbs per work period) was then planted until the hopper boxes were essentially empty.

Sixteen male workers were monitored for exposure while loading seed into hopper boxes, treating the seed within the hopper box with a powdered pesticide, and finally planting the treated seed. A total of 16 replicates were completed. Each worker was monitored for a "typical" day of work. The work periods lasted approximately 4.5 to 10 hours. Total pounds of AI handled across the replicates ranged from 11.5 to 34.9 pounds. Total area planted ranged from 64 to 213 acres.

Workers wore personal protective equipment (PPE) prescribed by the label, including long-sleeved shirt and long pants, and shoes plus socks while loading/treating and

planting, and waterproof gloves during loading/treating of seed. Workers also wore work boots (required by the protocol).

The potential for dermal exposure was assessed by measuring residues on or in 100% cotton inner whole-body dosimeters (WBD), inner socks, face/neck wipes, and hand washes. Workers wore one layer of outer work clothing over the WBD. The foot dosimeters, inner socks, were worn under the worker's socks. Potential inhalation exposure was monitored using a personal air sampling pump and an OVS tube (containing a glass fiber filter and XAD-2 sorbent) attached to an air sampling pump calibrated to an air flow rate of approximately 2 liters per minute (LPM).

Field fortifications (using formulated product diluted in water) were performed in the field for all matrices except OVS tubes, which were fortified with AI in the laboratory. Field fortification samples were collected on two days at each of the two sites (AR and TX). With the exception of socks, mean field fortification recoveries were acceptable for all matrices, ranging from 83.6% to 112%.

The field phase of the study was conducted in April and May of 2004 at commercial cotton fields located in Arkansas and Texas.

The dermal exposure values for workers are summarized in Table 15. The total dermal exposure is the sum of inner dosimeter, face/neck, and hand exposure.

Table 15. Adjusted Dermal Acephate Exposure of Loader/Treater/Planters While Using Dry Hopper Box Application [a].

L/T/P [b]	Hands Wash [c] (µg)	Face/Neck Wipe [d] (µg)	Whole Body Dosimeter [e] (µg)	Total Dermal Exposure [f] (µg)	Dermal Monitoring Time [g] (min)	Time for Loading/Treating [h] (min)	Dermal ADD [i] (µg/kg/day)
1	15,059	4,356	31,615	51,030	578	55	46.2
2	8,516	16,609	14,204	39,329	495	48	41.6
3	34,590	10,772	35,375	80,737	456	29	92.7
4	6,103	3,005	62,655	71,763	475	66	79.1
5	1,069	3,812	7,436	12,317	485	36	13.3
6	58,038	2,149	36,975	97,162	328	40	155.0
7	20,681	3,768	47,182	71,631	304	13	123.3
8	3,378	1,218	25,455	30,051	403	21	39.0
9	616	234	1,546	2,396	374	33	3.4
10	2,548	2,752	37,434	42,734	439	80	51.0
11	5,007	2,208	10,920	18,135	550	62	17.3
12	37,392	9,851	56,762	104,005	589	94	92.4
13	14,116	42,574	194,030	250,720	388	40	338.2
14	8,418	10,495	139,924	158,837	523	42	159.0
15	21,176	6,460	122,374	150,010	473	20	166.0
16	33,432	33,119	215,892	282,443	599	40	247.0
Average	16,884	9,586	64,986	91,456	466	45	104.0
SD [j]	16,426	11,987	66,663	82,042	90	22	91.7

a The values in this table were adjusted to reflect field fortification recoveries; the adjusted value (µg) = matrix raw value (µg) x 100 / matrix-specific and spike level-specific field recovery adjustment factor.
Minimal detection limit (MDL) for the inner dosimeter = 0.5 µg/section.
MDL for face/neck wipe solutions = 0.5 µg/sample.
MDL for hand wash solutions 0.2 µg/sample.
MDL for sock samples = 0.25 µg/sample, where one sample was equivalent to two socks.

b L/T/P: loader/treater/planters.

c Worker's hands were washed in a dilute detergent solution (0.01% Aeroso® OT solution) after removing gloves.

d Worker's faces and necks were wiped with gauze pads that were sequentially wetted with 0.01% Aeroso® OT solution.

e Inner dosimeters (long underwear) were removed and cut into six sections representing various body parts. In this study, workers also wore work boots (required by the protocol). However, exposure to lower legs and feet were not adjusted to reflect a worker wearing shoes and socks required by the product label because of inadequate information.

f Sum of adjusted values for all dosimeter sections, hand washes, and face/neck wipes.

g Dermal monitoring time was calculated from seed treatment start time to inner dosimeter sampling time.

h Time used for only during loading and treating of seed.

i Dermal ADD (Dermal Absorbed Daily Dosage) = Total dermal exposure (µg) x default work hours per day x dermal absorption rate ÷ (dermal monitoring time for L/T/P (hr) x body weight).
Calculation assumptions include:
- The default work hours per day = 8 hours.
- Dermal absorption rate = 7.6% (see dermal absorption section of the draft of the exposure assessment document for acephate).
- Default body weight = 69.7 kg (U.S. EPA, 1997).

j SD = Standard deviation.

The inhalation exposure values for workers and air concentrations within the worker's breathing zone are summarized in Table 16.

Table 16. Adjusted Inhalation Exposure of Loader/Treater/Planters While Using Dry Hopper Box Application [a].

L/T/P [b]	Adjusted Residue [c] (µg/sample)	Exposure Time [d] (min)	Time for Loading/Treatment [e] (min)	Inhalation ADD [e] (µg/kg/day)	Breathing Zone Air Concentrations [f] (µg/L)
1	350	560	55	4.30	0.313
2	285	480	48	4.09	0.297
3	1,160	443	29	18.03	1.31
4	999	459	66	14.99	1.09
5	219	472	36	3.20	0.232
6 [g]	-	-	-	-	-
7	1,046	291	13	24.75	1.80
8	202	395	30	3.52	0.256
9	31.1	375	47	0.57	0.042
10	534	435	82	8.45	0.614
11	174	544	68	2.20	0.160
12	3,787	585	100	44.58	3.24
13	1,922	378	45	35.02	2.54
14	1,717	517	45	22.87	1.66
15	781	472	30	11.40	0.827
16	7,426	595	46	85.95	6.22
Average	1,376	467	49	18.93	1.37
SD [h]	1,935	85	22	22.64	1.64

a The values in this table are residues of acephate in OVS tubes during the entire work period. The flow rate = 2.0 L/min.
MDL for OVS air sampling tubes = 0.01 µg/tube.

b L/T/P: loader/treater/planters.

c The values in this table were adjusted to reflect field fortification recoveries, the adjusted value (µg) = matrix raw value (µg) x 100 / matrix-specific and spike level-specific field recovery adjustment factor.

d Exposure time is throughout the entire work period (loading + treating + planting).

e Inhalation ADD (Inhalation Absorbed Daily Dosage) = Total Inhalation Exposure (µg) x default work hours per day x inhalation absorption rate ÷ (Inhalation monitoring time (hr) x body weight).
Calculation assumptions include:
- The default work hours per day = 8 hours.
- Inhalation absorption rate = 100%.
- Default body weight = 69.7 kg (U.S. EPA, 1997).

f Air concentration indicates the air concentration within the worker's breathing zone. The data were provided by the study (Klonne, 2005).

g Sample was lost after collection.

h SD = standard deviation.

Although the times used for entire work period (loading + treating + planting) and for just loading/treating of seed were measured in this study, residues were only measured after the entire workday, rather than separate work periods. Thus, exposure of the loader/treaters could not be estimated. However, in practice, a worker may be involved either in loading/treating seed or planting seed, or both. When a worker loads and treats seed, he/she loads the pesticide dust into a hopper box and stirs the pesticide and seeds to mix them. Thus, the loader/treater usually has higher pesticide exposure. In this study, the planters drove tractors with enclosed cabs and planting involved release of seeds from the hopper into the ground, resulting in minimal pesticide exposure. Therefore, the exposure of a loader/treater was assumed to be equivalent to the exposure

of a worker doing loading/treating/planting. Because the time used for loading/treating was much shorter than planting (about 1/10 of the time used for the entire work period as shown in Table 15 and 16), their exposure is expected to be much greater than a loader/treater/planter if they did same work for whole day. It may be inaccurate that a loader/treater would load/treat for 8 hours, but when there is no data available, the worst case scenario is estimated. The exposure for loader/treater and loader/treater/planter were estimated as shown in Table 17.

Table 17. Estimated Dermal and Inhalation Exposure of Loaders/Treater and Loader/Treater/Planter While Using Dry Hopper Box Application.

Job Category [a]	Mean Dermal Exposure Time [b] (min)	Total Dermal Exposure [c] (µg)	Dermal ADD [d] (µg/kg/day)	Mean Inhalation Exposure Time [b] (min)	Breathing Zone Air Concentrations [e] (µg/L)	Inhalation ADD [f] (µg/kg/day)
L/T	45	91,456.3	1370.0	49	13.9	219.0
L/T/P	466	91,456.3	104.0	467	1.4	18.9

a L/T: loader/treater; L/T/P: loader/treater/planter.

b The mean dermal exposure time for L/T and L/T/P are from Table 15. The mean inhalation exposure time for L/T and L/T/P are from Table 16.

c The total dermal exposure for L/T/P is from Table 15; the total dermal exposure for L/T is assumed to be equivalent to that of L/T/P (see text).

d The dermal ADD for L/T/P is from Table 15.
The dermal ADD for L/T = Total dermal exposure (µg) x default work hours per day x dermal absorption rate ÷ (Dermal monitoring time for L/T (hr) x body weight).
Calculation assumptions include:
- The default work hours per day = 8 hours.
- Dermal absorption rate = 7.6% (see dermal absorption section of the draft of the exposure assessment document for acephate).
- Default body weight = 69.7 kg (U.S. EPA, 1997).

e The breathing zone air concentration for L/T/P is from Table 16.
The breathing zone air concentrations for L/T = Residues in OVS tubes/Exposure time for L/T (min)/Flow rate (L/min).

f The inhalation ADD for L/T/P is from Table 16.
The inhalation ADD for L/T = Total inhalation exposure (µg) x default work hours per day x inhalation absorption rate ÷ (Inhalation monitoring time for L/T (hr) x body weight).
Calculation assumptions include:
- The default work hours per day = 8 hours.
- Inhalation absorption rate = 100%.
- Default body weight = 69.7 kg (U.S. EPA, 1997).

For calculating short-term (up to 7 days in duration) exposures, the estimated 95th percentile of the ADD is used (Powell, 2006). The 95th percentile can be calculated by finding the arithmetic mean (AM) and standard deviation (ASD) of the log-transformed data, then calculating: 95th percentile = $\exp\left\{\hat{\mu} + 1.645 \cdot \hat{\sigma}\right\}$. Where $\hat{\mu}$ and $\hat{\sigma}$ stand for the arithmetic mean and standard deviation of the logarithms of exposure, and 1.645 is the value corresponding to the 95th percentile of the standard normal distribution

To estimate intermediate- and longer-term exposures, the average daily exposure is of interest because over these periods of time, a worker is expected to encounter a range of daily exposures (i.e., WHS assumes that with increased exposure duration, repeated daily

exposure at the upper-bound level is unlikely). To estimate the average, WHS uses the arithmetic mean of daily exposure. Thus the seasonal absorbed daily dosage (SADD) is the upper confidence limit (UCL 90) for the mean ADD (Powell, 2002), which can be calculated by finding the arithmetic mean (AM) and standard deviation (ASD) of the log-transformed data, then calculating: UCL90 = antilog $\{AM + (t_{(0.90;\, n-1)} * ASD/\sqrt{n})\}$.

Table 18. Estimated Short-, Intermediate- and Long-Term Exposure of Loader/Treaters and Loader/Treater/Planters to Acephate Using Dry Hopper Box.

Workers[a]	Acute ADD[b] (µg/kg/day)	SADD[c] (µg/kg/day)	Exposure Months [d]	AADD[e] (µg/kg/day)	LADD[f] (µg/kg/day)
L/T	7490.0	1310.0	8	762.0	406.0
L/T/P	542.0	111.0	8	64.6	34.4

a L/T = loader/treater; L/T/P = loader/treater/planter.

b Acute ADD (absorbed daily dosage) = Dermal Acute ADD + Inhalation Acute ADD.
Acute ADD is an upper-bound estimate (95th percentile estimate, Powell, 2006); the 95th percentile can be calculated: 95th percentile = $\exp\left\{\hat{\mu} + 1.645 \cdot \hat{\sigma}\right\}$. Where $\hat{\mu}$ and $\hat{\sigma}$ stand for the arithmetic mean and standard deviation of the logarithms of exposure, and 1.645 is the value corresponding to the 95th percentile of the standard.

c Seasonal Average Daily Dosage (SADD) is an upper confidence limit (UCL90) for the mean ADD (Powell, 2002), determined by finding the arithmetic mean (AM) and standard deviation (SD) of the log-transformed data, then calculating: UCL90 = antilog $\{AM + (t_{(0.90;\, n-1)} * SD/\sqrt{n})\}$.

d Annual exposure months are assumed to be 8 months based on California Pesticide Use Report Database (DPR, 2006b, see text in section VI(1.1)(B) and Figure 6).

e Annual Average Daily Dosage (AADD) = SADD * annual exposure months/12 months in a year.

f Lifetime Annual Daily Dosage = AADD * (40 years of work in a lifetime) ÷ (75 years in a lifetime).

1.1.2 Exposure estimates using surrogate data

Since no other acceptable chemical-specific studies are available for assessment of agricultural handler exposure, estimates were derived using the Pesticide Handler Exposure Database (PHED, 1995). PHED was developed by the U.S. EPA, Health Canada and the American Crop Protection Association to provide non-chemical-specific pesticide handler exposure estimates for specific handler scenarios. It combines exposure data from multiple field monitoring studies of different AIs. The user selects a subset of the data having the same or a similar application method and formulation type as the target scenario. The use of non-chemical-specific exposure estimates is based on two assumptions (Versar, 1992): (1) that exposure is primarily a function of the pesticide application method/equipment and formulation type and not of the physical-chemical properties of the specific AI; and (2) that exposure is proportional to the amount of AI handled.

The data grading in PHED is an indicator of data quality of the studies in the database. These grades are based on Quality Assurance/Quality Control data provided as part of the exposure studies. Grades A and B are high-quality grades, with lab recoveries of 90-110% and 80-100%, respectively (field recoveries range 70-120% and 50-120%); grade C represents moderate quality, with lab and field recoveries of 70-120% and 30-120%; D and E are the lowest quality grades, and are assigned to PHED data that do not meet basic

quality assurance (U.S. EPA, 1998). A total of 15 observations or more were considered as a sufficient number of records, as recommended by the U.S. EPA (U.S. EPA, 1987).

U.S. EPA's (2000a) identified job categories were used as the basis of exposure scenarios assessed in this document. Handler exposure scenarios and related exposure data are given in the PHED reports (Appendices 1-18), and statements of assumptions used and conditions applied to PHED calculations are summarized in Table 19.

Table 19. Pesticide Handler Exposure Database (PHED) Exposure Estimates for Handlers of Acephate.

Exposure Scenarios[a]			Application Rate[d] (lb AI/A or lb AI/gal as noted)	Area/Day[e] (A/day)	Average Exposure[f] (µg/lb AI)		Absorbed Daily Dosage[g] (µg/kg/day)			N[h]	Appendix Number
Task[b]	FM[c]	Method			Dermal	Inhalation	Dermal	Inhalation	Total		
1a. M/L	SP	Aerial	Ag=1.0	1200	635.2	49.4	831.1	850.50	1681.6	17-28	1
			Turf=5.0	350	635.2	49.4	1212.1	1240.32	2452.4	17-28	1
			Pasture=0.125	350	635.2	49.4	30.3	31.01	61.3	17-28	1
1b. M/L	SP	Groundboom	Ag=1.0	200	635.2	49.4	138.5	141.75	280.3	17-28	1
			Pasture=0.125	80	635.2	49.4	6.9	7.09	14.0	17-28	1
			Turf=5.0	Turf=80	635.2	49.4	277.0	283.50	560.5	17-28	1
			Turf=5.0	Golf course=40	635.2	49.4	138.5	141.75	280.3	17-28	1
1c. M/L	SP	Airblast	Non-bearing citrus=0.5	40	635.2	49.4	13.9	14.18	28.0	17-28	1
			Trees/Shrubs=1.0 lb/100 gal	1000 gal/day	635.2	49.4	6.9	7.09	14.0	17-28	1
			Outdoor Floral=0.5 lb/100 gal	1000 gal/day	635.2	49.4	3.5	3.54	7.1	17-28	1
1d. M/L	SP	Handgun	Trees, Shrubs, Outdoor Floral Crops=1.0 lb/100 gal	1000 gal/day	635.2	49.4	6.9	7.09	14.0	17-28	1
			Turf=5.0	5	635.2	49.4	17.3	17.72	35.0	17-28	1
1e. M/L	SP	Slurry seed treatment	Cotton seed =0.04 lb/100 lb seed	200,000 lb seed	635.2	49.4	55.4	56.70	112.1	17-28	1
1f. M/L	SP	Chemigation	Cranberries = 1.0	30	635.2	49.4	20.8	21.26	42.0	17-28	1
2. M/L	DF	Slurry seed treatment	Cotton seed=0.04 lb/100 lb seed	200,000 lb seed	173.7	0.66	15.2	0.76	15.9	21-23	2
3. L	G	Tractor-Drawn Drop-Type Spreader	Cotton=1.0	200	9.1	3.45	1.5	9.90	11.9	33-58	4
			Turf=5.0	80	9.1	3.45	4.0	19.80	23.8	33-58	4
			Golf Course Turf=5.0	40	9.1	3.45	2.0	9.90	11.9	33-58	4
4. A	SP,L	Aerial	Ag=1.0	1200	148.5	0.57	194.3	9.81	204.1	9-14	5
			Turf=5.0	350	148.5	0.57	283.4	14.31	297.7	9-14	5
			Pasture=0.125	350	148.5	0.57	7.1	0.36	7.4	9-14	5
			Forest=0.75	1200	148.5	0.57	145.7	7.36	153.1	9-14	5
5. A	SP	Groundboom	Ag=1.0	200	66.5	1.18	14.5	3.39	17.9	22-33	6
			Pasture=0.125	80	66.5	1.18	0.7	0.17	0.9	22-33	6
			Turf=5.0	Turf=80	66.5	1.18	29.0	6.77	35.8	22-33	6
			Turf=5.0	Golf course=40	66.5	1.18	14.5	3.39	17.9	22-33	6
6. A	SP	Airblast	Non-bearing citrus=0.5	40	1560.3	5.4	34.0	1.55	35.6	18-49	7
			Trees & Shrubs=1.0 lb/100 gal	2400 gal/day	1560.3	5.4	40.8	1.86	42.7	18-49	7
			Outdoor Floral=0.5 lb/100 gal	2400 gal/day	1560.3	5.4	20.4	0.93	21.3	18-49	7

Table 19. Pesticide Handler Exposure Database (PHED) Exposure Estimates for Handlers of Acephate (continued).

Exposure Scenarios[a]			Application Rate[d] (lb AI/A or lb AI/gal as noted)	Area/Day[e] (A/day)	Average Exposure[f] (µg/lb AI)		Absorbed Daily Dosage[g] (µg/kg/day)			N[h]	Appendix Number
Task[b]	FM[c]	Method			Dermal	Inhalation	Dermal	Inhalation	Total		
7. A	SP	Handgun [i]	Trees, Shrubs, Outdoor Floral Crops=1.0 lb/100 gal	1000 gal/day	6600.4	151.0	72.0	21.66	93.6	13	11
			Turf=5.0	5	6600.4	151.0	179.9	54.16	234.1	13	11
8. A	G	Tractor-Drawn Drop-Type Spreader	Cotton=1.0	200	2.4	0.22	0.5	0.63	1.2	17-37	8
			Turf=5.0	80	2.4	0.22	1.0	1.26	2.3	17-37	8
			Golf Course Turf=5.0	40	2.4	0.22	0.5	0.63	1.2	17-37	8
9. M/L/A	SP	Low Pressure Hand Wand	Trees, Shrubs, Roses, Ground Cover, Floral Crops=1.0 lb/100 gal	40 gal/day	12525.8	1040.0	5.5	5.97	11.4	15-16	10
			Wasps=0.075 lb/l gal	5 gal/day	12525.8	1040.0	5.1	5.60	10.7	15-16	10
			Fire Ant (non-crop)=0.47 lb/5 gal	5 gal/day	12525.8	1040.0	6.4	7.01	13.4	15-16	10
10. M/L/A	SP/ WP	Backpack Sprayer	Trees/Shrubs/Roses/Ground Cover/Floral Crops=1.0 lb/100 gal	40 gal/day	22309.7	17.5	9.7	0.10	9.8	11	9
			Wasps=0.075 lb/l gal	5 gal/day	22309.7	17.5	9.1	0.02	9.1	11	9
11. M/L/A	SP	High Pressure Sprayer	Trees, Shrubs, Roses, Ground Cover, Floral Crops=1.0 lb/100 gal	1000 gal/day	6600.4	151.0	72.0	21.66	93.6	13	11
12. A	G	Shaker Can [j]	Fire ants=2 tsp/mound (0.00694 lb/5 gal)	10 mounds/acre; 1 acre	26334.0	80.7	2.0	0.08	2.1	23-45	15
			Tree, Shrubs, Ornamentals=0.1125 lb/1000	10,000 sq ft	26334.0	80.7	7.8	0.02	7.8	23-45	15
13. A	WP	Paintbrush	Window Frame etc. = 0.083 lb/gal,	2 gal/event	68500.0	308.0	62.0	0.73	62.7	15	18
14. M/L/A	SP	Sprinkler Can	Fire ants=0.047 oz/5 gal (0.0029 lb/5 gal)	1 gal/mound; 10 mounds/acre; 1 acre	No Data	No Data	NA	NA	NA	NA	NA
15. L/A	G	Belly Grinder	Trees, Shrubs, Ornamentals=0.1125 lb/1000 sq ft	87,000 sq ft	26334.0	80.7	281.0	11.33	292.4	23-45	15
16. L/A	G	By Hand	0.00099 lb per pot up to 12 in diameter	1000 pots	96660.0	350.0	104.3	4.97	109.3	15-16	12
			Fire ants=2 tsp/mound (0.008 lb/mound)	1 acre; 10 mounds per acre	96660.0	350.0	8.4	0.40	8.8	15-16	12
			Trees, Shrubs, Ornamentals=0.1125 lb/1000 sq ft	1,000 sq ft	96660.0	350.0	11.9	0.56	12.4	15-16	12
17. F	PS,L	Flagging	Ag=1.0	1200	32.6	0.2	42.7	3.44	46.1	26-30	16
			Turf=5.0	350	32.6	0.2	62.2	5.02	67.2	26-30	16
			Pasture=0.125	350	32.6	0.2	1.6	0.13	1.7	26-30	16
			Forest=0.75	1200	32.6	0.2	32.0	2.58	34.6	26-30	16

a The exposure scenarios based on RED document (U.S. EPA, 2001a).

Table 19. Pesticide Handler Exposure Database (PHED) Exposure Estimates for Handlers of Acephate (continued).

b M/L = mixer/loader; A = applicator; L = loader; M/L/A = mixer/loader/applicator; L/A = loader/applicator; F = Flagger.
Protective clothing and equipment for various scenarios based on product label and California regulations (see "Label precaution" section).
For agricultural applicators, some products require wearing waterproof gloves, while others do not require. For those non-hand-held equipment application, the least protected conditions, without gloves, were listed in this table. Either gloves or no-gloves values are listed in corresponding appendixes.

c FM = Formulation; SP = Soluble powder; DF = Dry flowable; L = Liquids; G = Granular; WP = Water-soluble pellet.

d Maximum application rates are values found on currently registered labels. AI = active ingredient; A = Acre.

e Maximum daily acres and volumes to be treated in each scenario based on default (U.S. EPA, 1997b, 2001a).

f The exposure data are from PHED (PHED, 1995). Dermal values are sum of dermal (non-hand) and hand (see Appendices). Appropriate protection factors were applied depending on label precaution and listed in Appendices.

g Absorbed Daily Dosage = exposure * absorption rate * application rate * acres(or volume)/day ÷ body weight. Calculation assumptions include:

- The maximum label rate based on currently registered labels for all scenarios;
- Dermal absorption rate = 7.6% (see Dermal Absorption section);
- Inhalation absorption is assumed to be100%;
- Body weight = 69.7 kg for both male and female (U.S. EPA, 1997a).
- NA = Not applicable.

h N = Median number of observations for dermal (non-hand), hand and inhalation in PHED data set.

i No PHED data were available for this scenario; therefore, used the PHED data for the high pressure sprayer.

j No PHED data were available for this scenario; therefore, PHED data for the Belly Grinder scenario were used.

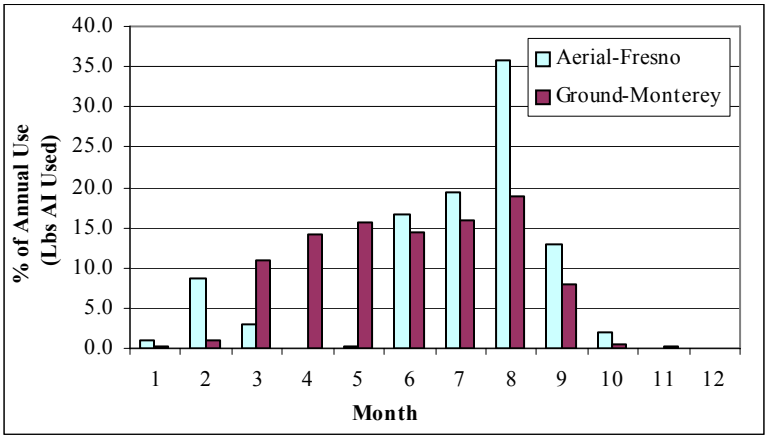
When data from the PHED are used to estimate exposure, an upper confidence limit on the percentile should be used in place of the percentile itself, in order to increase confidence in the estimate by accounting for some of the uncertainty in using surrogate data whose relevance to the target exposure scenario cannot be fully assessed. The 90% confidence level is used by statistical convention.

An approximation to the confidence limit for the 95th percentile must be used because PHED summary output for dermal exposure does not give sufficient information to calculate the statistic exactly. The approximation is described in Frank (2007). Briefly, the approximate confidence limit is obtained by multiplying arithmetic mean (dermal or inhalation) exposure from the PHED by specified multipliers (for detail, see Powell, 2002) that increased as the median number of observations decreased.

When the PHED is used to estimate seasonal exposure, an upper confidence limit on the arithmetic mean is used to increase confidence in the estimate by accounting for some of the uncertainty added by using surrogate data whose relevance to the target exposure scenario cannot be fully assessed. The 90% confidence level is used by statistical convention. The approximation is described in Powell (2002). The approximate confidence limit is obtained by multiplying arithmetic mean (dermal or inhalation) exposure from the PHED by the multipliers (for detail, see Powell, 2002) that increased as the median number of observations decreased.

The temporal patterns were investigated by plotting percent of annual use based on number of applications per month for 2000 - 2004 (DPR, 2006b) to estimate intermediate and long-term exposures of workers involved in applications of acephate. For the exposure assessment, data from the highest use county over the given-year period were used as surrogates. To estimate annual exposure, only those monthly uses greater than or equal to 5% of the annual applications over the five-year period were considered as crucial and counted. These county-based data were further limited to the application method at issue to screen highest use counties in various categories. The data from all counties in California indicates that Fresno County has the highest number of aerial applications, and Monterey County has the highest number of ground applications. Data showing aerial applications in Fresno County and ground applications in Monterey County are summarized in Figure 6.

Figure 6. Aerial and Ground Applications of Acephate in Highest Use County from 2000 – 2004 [a].



a Data from the California Pesticide Use Summaries Database. (DPR, 2006b).

The annual aerial use of acephate is estimated to occur in 5 months, February and June through September. The annual ground use of acephate is estimated to occur in 7 months, March to September. Table 20 summarizes the estimates of acute, seasonal, annual, and lifetime exposures for acephate handlers.

Table 20. Estimates of Short-, Intermediate- and Long-Term Exposure to Acephate of Pesticide Handlers.

Job Category[a]	FM[b]	Use Rate[c] (lb AI/A or gal)	Acute ADD[d] (µg/kg/day)	SADD[e] (µg/kg/day)	AADD[f] (µg/kg/day)	LADD[g] (µg/kg/day)	N[h]	Appendix Number
Aerial								
M/L	SP	Ag=1.0	7580.0	1680.0	701.0	374.0	17-28	1
	SP	Turf[i] =5.0	11100.0	-	-	-	17-28	1
	SP	Pasture=0.125	276.0	61.3	25.5	13.6	17-28	1
Applicator	SP	Ag=1.0	1220.0	408.0	170.0	90.8	9-14	5
		Turf[i] =5.0	1770.0	-	-	-	9-14	5
		Pasture=0.125	76.4	14.9	6.2	3.3	9-14	5
		Forest=0.75	458.0	306.0	128.0	68.1	9-14	5
Flagging	SP	Ag=1.0	185.0	46.2	19.3	10.3	26-30	16
		Turf[i] =5.0	270.0	-	-	-	26-30	16
		Pasture=0.125	6.7	1.7	0.7	0.4	26-30	16
		Forest=0.75	139.0	34.7	14.4	7.7	26-30	16
Ground M/L								
Groundboom	SP	Ag=1.0	1260.0	280.0	164.0	87.2	17-28	1
	SP	Pasture=0.125	63.1	14.0	8.2	4.4	17-28	1
	SP	Turf[i] =5.0	2530.0	-	-	-	17-28	1
	SP	Golf Course Turf[i] =5.0	1263.0	-	-	-	17-28	1
Airblast	SP	Non-bearing citrus=0.5	126.0	28.0	16.3	8.7	17-28	1
	SP	Trees/Shrubs=1.0 lb/100 gal	63.1	14.0	8.2	4.4	17-28	1
	SP	Outdoor Floral=0.5 lb/100 gal	31.6	7.0	4.1	2.2	17-28	1
Handgun	SP	Trees, Shrubs, Outdoor Floral Crops=1.0 lb/100 gal	63.1	14.0	8.2	4.4	17-28	1
	SP	Turf[i] =5.0	158.0	-	-	-	17-28	1
Slurry seed treatment	SP	Cotton seed =0.04 lb/100 lb seed	505.0	112.0	65.4	34.9	17-28	1
Hopper box	SP	Cotton seed =0.1875	114.0	25.2	14.7	7.8	17-28	1
Chemigation	SP	Cranberries =1.0	115.0	42.0	24.5	13.1	17-28	1
Slurry seed treatment	DF	Cotton seed=0.04 lb/100 lb seed	63.6	15.9	9.3	5.0	21-23	2
Tractor-Drawn Spreader	G	Cotton=1.0	47.5	11.9	6.9	3.7	33-58	4
	G	Turf[i] =5.0	95.0	-	-	-	33-58	4
	G	Golf Course Turf[i] =5.0	47.5	-	-	-	33-58	4

Table 20. Estimates of Short-, Intermediate- and Long-Term Exposure to Acephate of Pesticide Handlers (continued).

Job Category[a]	FM[b]	Use Rate[c] (lb AI/A or gal)	Acute ADD[d] (µg/kg/day)	SADD[e] (µg/kg/day)	AADD[f] (µg/kg/day)	LADD[g] (µg/kg/day)	N[h]	Appendix Number
Ground Application								
Groundboom	SP	Ag=1.0	71.6	17.9	10.4	5.6	22-33	6
		Pasture=0.125	3.6	0.9	0.5	0.3	22-33	6
		Turf[i] =5.0	143.0	-	-	-	22-33	6
		Golf Course Turf[i] =5.0	71.6	-	-	-	22-33	6
Airblast	SP	Non-bearing citrus=0.5	142.0	21.7	12.7	6.8	22-47	7
		Trees & Shrubs=1.0 lb/100 gal	171.0	26.0	15.2	8.1	22-47	7
		Outdoor Floral=0.5 lb/100 gal	85.4	13.0	7.6	4.1	22-47	7
Handgun	SP	Trees, Shrubs, Outdoor Floral Crops=1.0 lb/100 gal	468.0	187.0	109.0	58.3	13	11
		Turf[i] =5.0	1170.0	-	-	-	13	
Tractor-Drawn Drop-Type Spreader	G	Cotton=1.0	4.6	1.2	0.7	0.4	24-37	8
		Turf[i] =5.0	9.1	-	-	-	24-37	8
		Golf Course Turf[i] =5.0	4.6	-	-	-	24-37	8
Paintbrush	WP	Window Frame = 0.083 lb/gal, 2 gal/event	62.2	-	-	-	15	18
Ground M/L/A								
Low Pressure Hand Wand	SP	Trees, Shrubs, Roses, Ground Cover, Floral Crops=1.0 lb/100 gal	57.2	11.4	6.7	3.6	15-16	10
		Wasps=0.075 lb/l gal	53.6	10.7	6.3	3.3	15-16	10
		Fire Ant (non-crop)[j]=0.47 lb/5 gal	67.2	-	-	-	15-16	10
Backpack Sprayer	SP	Trees, Shrubs, Roses, Ground Cover, Floral Crops=1.0 lb/100 gal	59.0	19.7	11.5	6.1	11	9
		Wasps=0.075 lb/l gal	55.3	18.4	10.7	5.7	11	9
High Pressure Sprayer	SP	Trees, Shrubs, Roses, Ground Cover, Floral Crops=1.0 lb/100 gal	468.0	187.0	109.0	58.3	13	11
Belly Grinder	G	Trees, Shrubs, Ornamentals=0.1125 lb/1000 sq ft	1170.0	292.0	171.0	91.0	23-45	15
Shaker Can/Handtool	G	Trees, Shrubs, Ornamentals=0.1125 lb/1000 sq ft	134.0	34.0	19.6	10.5	23-45	15
		Fire ants[j]=2 tsp/mound (0.00694 lb/5 gal)	8.3	-	-	-	23-45	15
By Hand	G	0.00099 lb per pot up to 12 in diameter.	546.0	109.0	63.8	34.0	15-16	12
		Fire ants[j]=2 tsp/mound (0.008 lb/mound)	44.2	-	-	-	15-16	12
		Trees, Shrubs, Ornamentals=0.1125 lb/1000 sq ft	62.1	12.4	7.2	3.9	15-16	12

a The exposure scenarios are based on RED (U.S. EPA, 2001a) and U.S. EPA guidance (2001b).
b FM = formulation; SP = Soluble powder; DF = Dry flowable; G = Granular; WP = Water-soluble pellet.
c The use rates are based on RED (U.S. EPA, 2001a). AI = Active ingredient; A = Acre

d Acute Absorbed Daily Dosage (ADD) is 90% upper confidence limit for 95th percentile estimates from the Pesticide Handler Exposure Database (PHED); multipliers from Powell (2002). Acute ADD = Short-term exposure (sum of dermal and inhalation) * absorption rate * maximum application rate * maximum daily treated acres (or volume) ÷ body weight. Calculation assumptions include:

- Short-term exposures are shown in Appendices.
- Dermal absorption rate = 7.6 % (see Dermal Absorption section);
- Inhalation absorption is assumed to be 100%.

e Seasonal Average Daily Dosage (SADD) is a 90% upper confidence estimate of absorbed dose; multipliers from Powell (2002). Seasonal ADD = Long-term exposure (sum of dermal and inhalation) * absorption rate * maximum application rate * maximum daily treated acres (or volume) ÷ body weight. Calculation assumptions include:

- Long-term exposures are shown in Appendices.
- Dermal absorption rate = 7.6 % (see Dermal Absorption section);
- Inhalation absorption is assumed to be 100%.

f Annual Average Daily Dosage (AADD) = SADD * annual use months per year/12 months in a year. The estimated high-use season for handler was based on the California Pesticide Use Summaries Database (DPR, 2006b, see text and Figure 6).

g Lifetime Annual Daily Dosage = AADD * 40 years of work in a lifetime/75 years in a lifetime.

h N = Median number of observations in PHED data set (includes inhalation and all dermal body parts).

i Based on use history information (DPR, 2006b), acephate was minimally used for turf in California during 1996 to 2000 (less than 10 applications occurred in one year). Therefore, SADD, AADD and LADD were not estimated in this document.

j Since acephate is not a recommended chemical in the California Department of Food and Agriculture (CDFA) eradication program, it is minimally used to control the fire ants in California, and acephate is not allowed for treatment of ant mounds more than once per season based on product labels, only acute absorbed daily dosage was estimated in this document.

1.2 Field Workers

Harvesters and other field workers are subject to exposure to acephate and its metabolite, methamidophos, from contact with dislodgeable foliar residues on treated foliage. Data on reentry exposure to acephate and methamidophos for these workers were not available to WHS. For these field workers, it is thus necessary to extrapolate the dermal exposure from a dermal transfer factor, which is defined as the ratio of hourly dermal exposure in μg/hr to foliar residue (DFR) in $\mu g/cm^2$ and the DFR expected at the time of reentry. When multiplied with a proper dermal TF, the DFR may be converted to hourly dermal exposure of workers entering a treated field. TFs and DFR values are used to estimate potential human exposure of field workers performing different activity patterns (e.g., scouting, harvesting, pruning, etc.). Reentry workers are not required to wear protective clothing unless entering before expiration of the REI. Therefore, field worker exposure calculations were not corrected for any protection factors.

The inhalation component was not included in the reentry exposures since acephate is not considered a volatile compound. Studies of reentry worker exposure in crops treated with organophosphates (Ware *et al*., 1973, 1974, 1975), suggest that inhalation is a relatively minor exposure route for nonvolatile AIs. U.S. EPA also estimated that inhalation exposure would be negligible in reentry workers (U.S. EPA, 2000a). Only dermal exposure was considered for field workers.

Acute exposures were estimated using DFR at the expiration of REI or PHI since it is the earliest time workers could enter and results in the highest amount of DFR that workers would typically contact. For some activities including fresh-cut flowers and turf, the PHI is equal to REI. Table 21 summarizes the dissipation of DFR and dermal TFs used to estimate daily and acute acephate and methamidophos exposures of field workers, performing cultural activities on various treated crops.

For longer-term exposure estimates, it was assumed that workers would not always enter fields at the expiration of the REI. Seasonal, annual and lifetime exposures were estimated at an assumed average reentry at the expiration of the REI plus 7 days for all activities other than harvesting, and at PHI plus 7 – 10 days for harvesting. These assumed reentry times were not based on data; rather, they were based on the reasonable, conservative assumption that workers may enter fields an average of 7 – 10 days after expiration of the REI. For crops such as roses, which have intense activities close to the end of the PHI, seasonal, annual and lifetime exposures were estimated at an assumed average reentry at the expiration of the REI plus 1 day for all activities.

The annual exposure period is estimated based on the application data (DPR, 2006b) showed in Figure 7 – 11, and farm worker activity data (Edmiston *et al.,* 1999) showed in Table 22. The use was based on acres sprayed, not numbers of applications, per month. The focus here was on acreage sprayed because it was assumed that reentry frequency depends more on the size of the crop treated. In using treated acreage, DPR recognizes that the same acres may be treated with multiple applications of acephate.

Table 21. DFR Dissipation Data, Dermal Transfer Factors and Estimated Dermal Exposure of Field Workers to Acephate and Its Metabolite Methamidophos.

Crop and Task [a]	REI/PHI [b] (day)	TF[c] (cm^2/hr)	ACEPHATE DFR[d] (μg/cm^2)	ACEPHATE Daily Exposure[e] (μg/person/day)	ACEPHATE Acute ADD[f] (μg/kg/day)	METHAMIDOPHOS DFR[d] (μg/cm^2)	METHAMIDOPHOS Daily Exposure[e] (μg/kg/day)	METHAMIDOPHOS Acute ADD[f] (μg/kg/day)
Cotton								
Scouting	1	1500	3.33	29,970	32.7	0.0250[g]	225.0	0.25
Cauliflower								
Harvesting	14	5000	0.0365	1,460	1.6	0.0013	52.0	0.06
Succulent Beans								
Harvesting	14	2500	0.0366	732	0.8	0.0059	120.0	0.13
Greenhouse Roses [h]								
Pruning & Harvesting	1	700	1.206	6,754	7.4	0.0271	151.8	0.17
Nursery Ornamentals								
Harvesting	1	400	1.206	3,859	4.2	0.0271	86.7	0.09
Greenhouse Crops[i]								
Pruning & Harvesting	1	7000	1.206	67,536	73.6	0.0271	1517.6	1.65
Citrus[j,k]								
Pruning	1	3000	6.21	149,040	163.0	0.0250[g]	600.0	0.65
Stone Fruit[l]								
Thinning	1	8000	6.21	397440.0	433.0	0.0250	1600.0	1.74
Grapes								
Thinning & Harvesting	1	5000	2.0584	82,336	89.8	0.0250 [g]	1000.0	1.09
Turfgrass								
Mowing (tractor or push)	0.5	500	0.2214	886	1.0	0.0010	4.0	0.004
Harvesting	0.5	6670	0.2214	11,814	12.9	0.0010	53.4	0.06

a Workers were assumed to wear a long pants, long-sleeved shirt, without gloves.
b REI (restricted entry interval) and PHI (pre-harvest interval) were taken from the product label.
c TF (transfer factor) values are taken from the Agricultural Default Transfer Coefficients (U.S. EPA, 2000b). TF for turf harvester is from the Agriculture Reentry Task Force report (Merricks, 2000). TF for nursery ornamentals is from Klonne et al. (2000).
d DFR (dislodgeable foliar residues) values at the expiration of the REI or PHI, see Dislodgeable Foliar Residues section.
e Daily exposure (μg/person/day) = DFR * dermal transfer factor * work hours/day (8 hr/day except for cotton scouting, where the work hour was 6 hours/day based on Dong, 1994).
f Acute ADD (Absorbed Daily Dosage) = daily exposure * 7.6% dermal absorption (see Section IV-1) ÷ 69.7 kg body weight (U.S. EPA, 1997a).
g DFR data of Cotton, Grape and Citrus are not available, and their REI/PHI are 1 day, therefore, the DFR data with the highest percentage of methamidophos metabolized from acephate (bean, see Table 10) was used as a surrogate.
h Based on U.S. EPA (2000b), TF for cut flower pruning and harvesting is 7000. Since workers for roses need to wear gauntlet gloves to avoid being hurt by thorns, the TFs for greenhouse rose pruning and harvesting was adjusted to 700 (protection factor for glove is 90%).
i For other greenhouse crops, harvesting and pruning exposures were estimated using rose DFR data, but without wearing gloves.
j Orange and grapefruit are combined as category of "citrus", the higher DFR (orange) was used.
k The product label states "Do not harvest citrus for one year after treatment". So it is assumed there is no significant exposure to harvesters.
l Since DFR data for stone fruit is unavailable, thinning exposures for these fruit trees were estimated using citrus (orange) tree DFR data.

Table 22. Reported Activity Periods for Field Workers on Various Crops. [a]

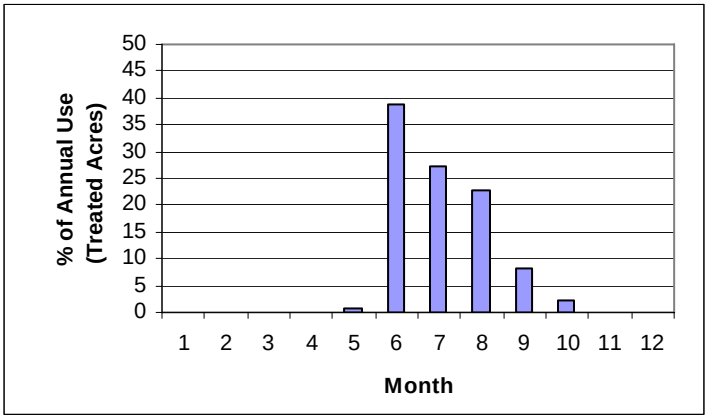
Crop	Activities	Location	Peak Activity Period [b]	Total Activity Period [b]
Cauliflower	Harvest	Monterey	Apr – Sept (6)	Jan – Dec (12)
		Imperial	Jan (1)	Dec – Mar (4)
		Riverside	mid-Dec – mid-Mar (3)	Dec – Mar (4)
		Stanislaus	Nov (1)	mid-Oct – mid-Dec (2)
		Tulare	Dec - Jan (2)	Dec – Feb (3)
		San Luis Obispo	May - Aug (4)	Jan – Dec (12)
		Santa Barbara	Jun – Jul (2)	Jan – Dec (12)
		Ventura	Feb – Mar (2)	Dec – Apr (5)
Orange	Prune	Tulare	May – Jun (2)	Mar – Jul (5)
			Oct – Dec (3)	Sep – Feb (6)

[a] Data from California Farm Worker Activity Profile database (Edmiston *et al.*, 1999).
[b] The number in parentheses is the number of months.

Cotton Scouting

Figure 7 shows the relative numbers of acres of cotton treated with acephate on a monthly basis in Fresno. The county was selected due to its highest numbers of treated acres with acephate for the five-year period 2000 to 2004 (DPR, 2006b). Scouting can occur during whole growing season. Therefore, the seasonal and annual exposures were estimated based on the high-use periods of acephate on cotton. High-use periods (>5% of annual use) occurred in a four-month interval, June to September (Figure 7). For seasonal and annual exposure estimates, it was assumed that scouts were exposed on each workday for the four months that account for 95% of annual applications. The estimated SADD, AADD, and LADD were summarized in Table 23.

Figure 7. Application of Acephate to Cotton in Fresno County During 2000 - 2004[a]



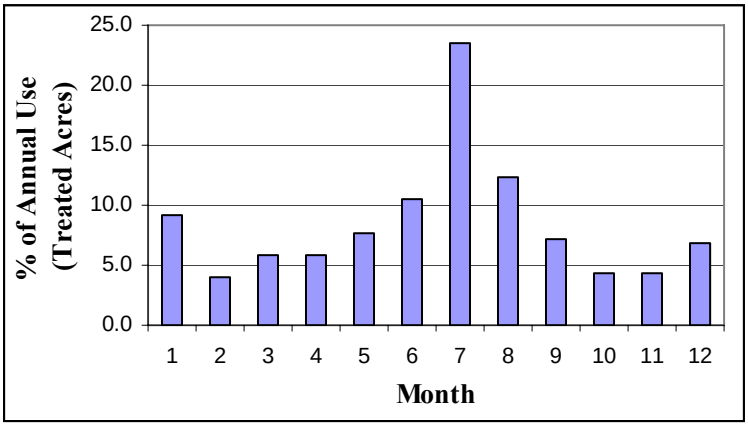
[a] Percent calculations based on acres treated (DPR, 2006b; queried April 11, 2006).

Cotton is mechanically harvested in California after defoliation, and the shortest PHI for cotton is 21 days. With a half-life of 1.7 days and the long PHI, residue levels are anticipated to be very low. Therefore, cotton harvest crew's exposure to acephate is assumed to be minimal.

Cauliflower Harvesting

Figure 8 shows the relative number of acres of cauliflower treated with acephate on a monthly basis in Santa Barbara County. The county was selected due to its highest number of acres treated with acephate in 2000 to 2004 (DPR, 2006b). High-use periods (>5% of annual use) occurred during most of the year, with the exception of three months, February (4.0%), October (4.3%) and November (4.4%). These data were compared to the task-specific data that are available in the California Farm Worker Activity Profile (CFWAP, Edmiston *et al.,* 1999). For cauliflower harvesting, the peak activity periods occur in June and July, and total activity periods occur in January through December in Santa Barbara County (Table 22). Considering Santa Barbara is only one county, workers can travel across county lines along the coast to work in cauliflower fields, the annual exposure to acephate by workers involved in cauliflower harvesting is estimated to occur year-round, January to December.

Figure 8. Application of Acephate to Cauliflower in Santa Barbara County During 2000 - 2004[a].



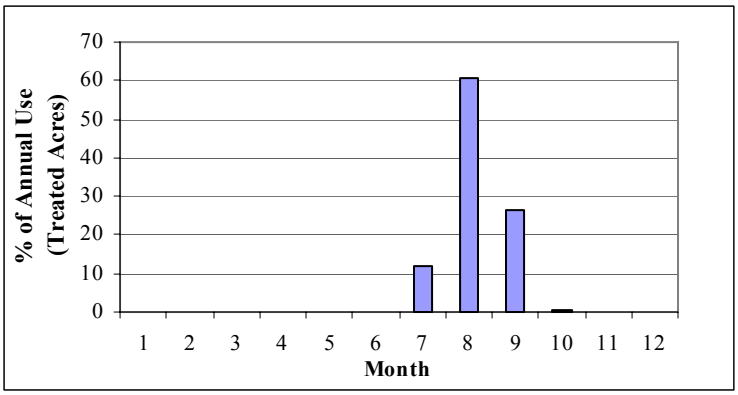
[a] Percent calculations based on acres treated (DPR, 2006b; queried April 11, 2006).

Succulent Bean Harvesting

Figure 9 summarizes the application of acephate to succulent beans on a monthly basis in Stanislaus County, the county with most acephate-treated bean acreage for the five-year period of 2004 to 2004 (DPR, 2006b). High-use periods (>5% of annual use) occurred in three months, July through September. There is no task-specific data on succulent bean harvesting available in the CFWAP database. From the County Agricultural Commissioners (CAC) harvested acreage data it looks like Stanislaus has by far the most acres of green beans. We contacted the farm advisor in Stanislaus County and were told that that succulent beans are usually harvested from the last week of August to last week

of October. Based on the information, we estimate that the succulent bean-harvesting period occurs in two months. Because less than 5% of the average annual applications (based on numbers of acres treated each month) occur in October, potential harvester exposure to acephate was considered to be insignificant during this month. The annual exposure to acephate by workers involved in succulent bean harvesting is estimated to occur in one month, September.

Figure 9. Application of Acephate to Succulent Beans in Stanislaus County During 2000 – 2004 [a].

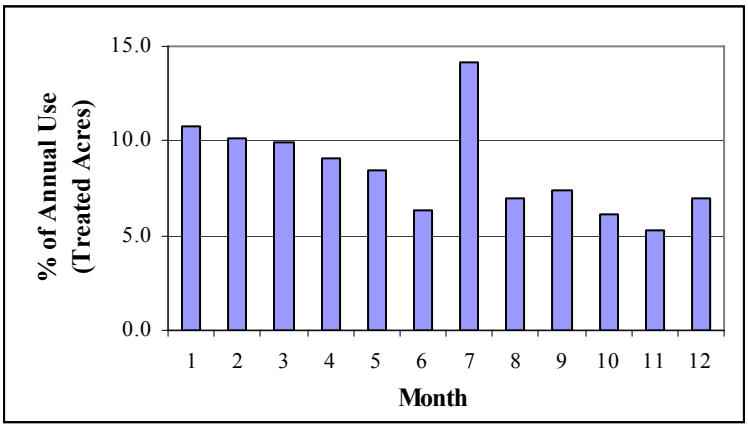


[a] Percent calculations based on acres treated (DPR, 2006b; queried April 11, 2006).

Greenhouse Rose Harvesting and Pruning

The controlled environment (air movement, light, temperature and humidity) of a greenhouse permits optimum growing conditions that allow rose production year-round. Figure 10 shows the distribution of acephate applications to greenhouse cut flowers and greens in California during 2000 to 2004. It indicates that applications distribute quite evenly during a year. There is no task-specific data on greenhouse rose pruning and harvesting available in the CFWAP database. Jarvis (1992) indicated that some large size greenhouses (greater than one acre) require continual work in some portion of the greenhouse on a daily basis. Based on these estimates, it is assumed that the annual exposure frequency for greenhouse workers pruning and harvesting is 12 months. Since workers for roses need to wear gauntlet (elbow-length) gloves to avoid being hurt by thorns, the TF (U.S. EPA, 2000b) for greenhouse rose pruning and harvesting was adjusted by reduction of 90% (Aprea *et al*., 1994)

Figure 10. Applications of Acephate to Nursery/Greenhouse Cut Flowers or Greens in California During 2000 - 2004[a]



[a] Percent calculations based on acres treated (DPR, 2006b; queried April 18, 2006).

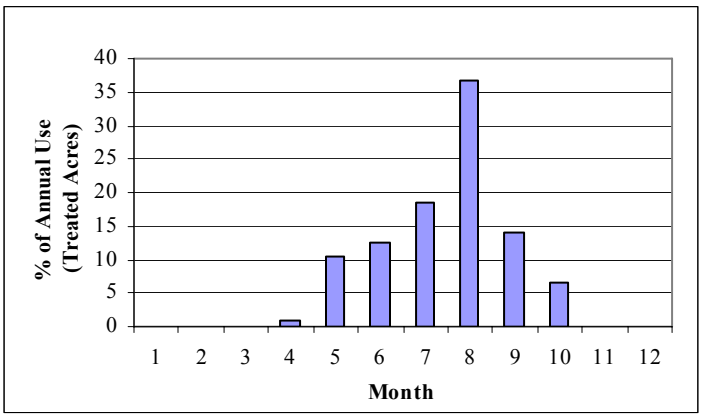
Nursery Ornamental Harvesting and Pruning

Since there is no available DFR data for nursery ornamentals, DFR on rose foliage was used as a surrogate. The TF value was taken from the study by Klonne et al. (2000), and the exposure was estimated assuming the workers do not wear gloves. The information provided by California Pesticide Information Portal (DPR, 2005) indicates that acephate was not used on nursery ornamentals during 1999 to 2003. Therefore, only acute exposure was estimated in this document.

Citrus Tree Pruning

As pruning involves high contact with foliage, its potential for exposure to DFR is high (Maddy, 1975). In the absence of adequate exposure data for workers entering treated fields, residue decay data and TFs were used to estimate worker exposure at the expiration of the REI (Table 21).

Figure 11. Application of Acephate to Grapefruit & Oranges in Tulare County During– 2000 - 2004[a]



[a] Percent calculations based on acres treated (DPR, 2006b; queried April 11, 2006).

Figure 11 summarizes the applications of acephate to grapefruit and oranges in Tulare County from 2000 through 2004 (DPR, 2006b). Tulare County was selected due to large amount of citrus acres treated with acephate (DPR, 2006b). High-use periods (>5% of annual use) occurred in six months, May to October. These data were compared to the task-specific data on pruning that were available in the CFWAP database (Edmiston *et al.*, 1999). Within the CFWAP database, data are available for orange pruning activities (Table 22). For orange pruning, the peak activity periods occur in two intervals, May to June and October to January; and the total activity periods occur in two intervals, March to July and September to February (Table 22). Based on these data, the annual exposure to acephate by workers involved in orange and grapefruit pruning is estimated to occur in 5 months, May to July, September and October. Although there are applications of acephate, August is not included because there is no pruning activity in this month.

Stone Fruit Thinning

Thinning involves high contact with foliage; therefore its potential for exposure to the residue is high. In the absence of adequate exposure data for workers entering treated fields, residue decay data and TFs were used to estimate worker exposure at the expiration of the REI (Table 21). Since stone fruit DFR data are unavailable, citrus (oranges) DFR was used as a surrogate. The information provided by California Pesticide Information Portal (DPR, 2007) indicates that acephate is minimally used on stone fruit trees. During 2001 to 2005, only 1 application to plums and 1 application to cherries occurred in 2002. There were no applications to apricots and prunes in the last five years. Therefore, only acute exposure was estimated in this document.

Grape Thinning and Harvesting

The information provided by California Pesticide Information Portal (DPR, 2006b) indicates that acephate is minimally used on grapes. During 1999 to 2003, only 1 application occurred in 2000. Therefore, only acute exposure was estimated in this document.

Turf Grass Mowing and Harvesting

The information provided by California Pesticide Information Portal (DPR, 2006b) indicates that acephate is minimally used on commercially grown turf. During 2000 to 2004, only a couple of applications occurred in each year. Acephate is applied on commercial turf mainly for fire ant control by thoroughly spraying the foliage and soil. To evaluate fire ant control in California, we contacted staff at the California Department of Food and Agriculture (CDFA) and professors at the University of California at Riverside. They mentioned that fire ants may be active year-round in southern California, and the fire ant eradication program of CDFA recommends three chemicals: pyriproxyfen (Distance®), hydramethylnon (Amdro®), and phenoxycarb. All uses of the above chemicals are in the form of baits, consisting of corncob grit in soybean oil. The effective

period can last from a few days to 90 days. Acephate is not one of the recommended chemicals in the CDFA eradication program. Besides fire ant, acephate is applied on turf to control other insects, e.g. armyworms, fleas, leafhoppers, and greenbugs. Summarizing the information from the use report, the fire ant experts and the product labels, we know that: (1) Acephate is minimally used on turf, and it is not the primary choice to control the fire ants in California. It is unlikely that PCOs will concentrate on using acephate. (2) Acephate can only be used to treat the ant mounds once per season. (3) Acephate may injure the grass. (4) Acephate was minimally applied (less than 10 times per year) during the last five years. Based on these, only acute exposure was estimated in this document.

Table 23 summarizes the estimates of intermediate and long-term exposure to acephate for field workers. Since the acute ADD of methamidophos is very low for most field activities (Table 21), the intermediate- and long-term exposure to methamidophos is assumed to be minimal and not estimated. However, the activities of succulent bean harvesting, and greenhouse rose pruning/harvesting have higher exposure (Table 21), so the intermediate- and long-term exposures to methamidophos are estimated for the workers on these crops (Table 24).

Table 23. Estimates of Field Workers' Exposure to Acephate.

Task [a]	Acute ADD [b] (µg/kg/day)	Ave. DFR [c] (µg/cm^2)	TF [d] (cm^2/hr)	SADD [e] (µg/kg/day)	Exposure Months [f]	AADD [g] (µg/kg/day)	LADD [h] (µg/kg/day)
Cotton							
Scout	32.7	0.1912	1500	1.88	4	0.63	0.33
Cauliflower							
Harvest	1.6	0.0108	5000	0.47	12	0.47	0.25
Succulent Beans							
Harvest	0.8	0.0049	2500	0.11	1	0.01	0.005
Greenhouse Roses [i]							
Pruning & Harvest	7.4	0.9580	700	5.85	12	5.85	3.12
Nursery Ornamentals [j]							
Pruning & Harvest	4.2	0.9580	400	3.34	-	-	-
Citrus							
Pruning	163.0	2.6104	3000	68.30	5	28.5	15.2
Stone Fruit [j,k]							
Thinning	433.0	2.6104	8000	-	-	-	-
Grapes [j]							
Tying & Pruning	89.8	-	5000	-	-	-	-
Turf [j]							
Mowing	1.0	-	500	-	-	-	-
Harvesting	12.9	-	6670	-	-	-	-

a The crops listed this table are those with enough information from available or surrogate data, and their exposure can be estimated based on these information.

b Acute Absorbed Daily Dosage (ADD) is from Table 21.

c Average DFRs, which are the DFR values at the average reentry interval (the average reentry interval was assumed to be the expiration of REI plus 7 days, or the expiration of PHI plus 10 days), are assumed to be the DFR values on 7th day after the REI or 10th day after the PHI. For crops such as roses and grapes, which have intense activities close to the end of the PHI, seasonal, annual and lifetime exposures were estimated at an assumed average reentry time of REI plus 1 day for all activities.

d TF (transfer factor) values are taken from Agricultural Default Transfer Coefficients (U.S. EPA, 2000b). TF for turf harvester were taken from the Agricultural Reentry Task Force report (Merricks, 2000).

e Seasonal Average Daily Dosage (SADD) = average DFR * TF * work hours/day (For cotton scouting, the work hour was 6 hours/day based on Dong, 1994; and for other job category, the work hours were 8 hr/day) * 7.6% dermal absorption (see dermal absorption section) ÷ 69.7 kg body weight (U.S. EPA, 1997a).

f The annual exposure months for field workers are determined by comparing the data of total activities periods (Table 22 and text) and application periods (Figure 7 - 14), see text.

g Annual Average Daily Dosage (AADD) = SADD * annual exposure months /12 months in a year.

h Lifetime Average Daily Dosage (LADD) = AADD * (40 years of work in a lifetime) / (75 years in a lifetime).

i Based on U.S. EPA (2000b), TF for cut flower pruning and harvesting is 7000. Since workers for roses need to wear gauntlet (elbow-length) gloves to avoid being hurt by thorns, the TFs for greenhouse rose pruning and harvesting was adjusted to 700 (90%).

j Since acephate was very seldom applied on nursery ornamentals, stone fruit, grape, and turf in California during recent five year (DPR, 2006b), only acute average daily dosage was estimated in this document.

k Since DFR data for stone fruit is unavailable, thinning exposures for these fruit trees were estimated using citrus (orange) DFR data.

Table 24. Estimates of Field Workers' Exposure to Methamidophos.

Task	Acute ADD[a] (µg/kg/day)	Ave. DFR[b] (µg/cm^2)	SADD[c] (µg/kg/day)	Annual Exposure Months	AADD[d] (µg/kg/day)	LADD[e] (µg/kg/day)
Cotton[f]						
Scout	0.25	0.0059	0.05	4	0.02	0.01
Succulent Beans						
Harvesting	0.1	0.0027	0.06	1	0.005	0.003
Greenhouse Roses						
Prune & Harvest	0.2	0.02	0.12	12	0.12	0.07
Nursery Ornamentals[g]						
Pruning & Harvest	0.1	-	-	-	-	-
Citrus [f]						
Pruning	0.65	0.0059	0.15	5	0.06	0.03
Stone Fruit						
Thinning	1.74	-	-	-	-	-
Grapes[f,g]						
Tying & Pruning	1.09	-	-	-	-	-
Turf[g]						
Harvesting	0.06	-	-	-	-	-

a Acute Absorbed Daily Dosage (ADD) is from Table 21.
b Average DFRs, which are the DFR values at the average reentry interval (the average reentry interval is assumed to be the expiration of REI plus 7 days, or the expiration of PHI plus 10 days), are assumed to be the DFR values on 7th day after the REI or 10th day after the PHI. For crops such as roses and grapes, which have intense activities close to the end of the PHI, seasonal, annual and lifetime exposures were estimated at an assumed average reentry REI plus 1 day for all activities.
c Seasonal Average Daily Dosage (SADD) = average DFR * dermal transfer factor * work hours/day (8 hr/day (except cotton scouts work 6 hours/day) * 7.6% dermal absorption (see dermal absorption section) ÷ 69.7 kg body weight (U.S. EPA, 1997a).
d Annual Average Daily Dosage (AADD) = SADD * annual exposure months /12 months in a year.
e Lifetime Average Daily Dosage (LADD) = AADD * (40 years of work in a lifetime)/(75 years in a lifetime).
f DFR data for cotton, grapes, citrus, stone fruit are not available, therefore, the DFR data with the highest percentage of methamidophos metabolized from acephate (bean, see Table 10) on the REI (1 day) was used as a surrogate.
g Since acephate was minimally applied to nursery ornamentals, stone fruit, grapes and turf in California (DPR, 2006b and 2007), only acute ADD was estimated for these crops in this document.

2. Residential and Institutional Uses

Residential and institutional pesticide applicators are likely to be exposed during acephate use. Due to the frequency and duration of acephate uses, it was determined that uses of acephate by residential and institutional pesticide applicators result in short-term exposures to these applicators.

2.1 Handlers

2.1.1 Exposure monitoring

(A) Acephate Pest Control Operator (PCO) Study

A study of exposure to commercial pesticide applicators handling acephate during applications to residential and commercial buildings was performed by Chevron Chemical

Company (Merricks, 1987a). Three residential sites and three commercial sites were tested. Each site was tested on a separate study day.

A total of nine PCO handlers were monitored during spot-treatments of acephate to baseboards, under counters, and behind equipment in commercial establishments. An additional nine PCOs were monitored while treating residential establishments. Three applicators were monitored at each site on each date.

The applicators were suited with protected (the patches were placed inside of work clothing) and non-protected (the patches were placed outside of work clothing) alpha-cellulose body and head patches (10 cm^2 x 10 cm^2), white cotton gloves (worn over latex gloves), and a personal air sampling pump. The applicators applied Orthene® PCO Spray Concentrate to a residential site. After sample media removal, the same applicators were resuited with fresh sampling media as described above. They then applied the same pesticide to a commercial site.

Each handler mixed two 1.0 gal. batches of Orthene® PCO Spray Concentrate and applied 1 qt. of spray solution. Each handler mixed one gallon of finished spray by tearing open one package (39.7 g, equivalent to 0.088 lb acephate) of wettable powder and adding the acephate to one gallon of water. The handler sprayed one quart of finished spray. (The remaining three quarts of spray were removed by individuals other than the applicator). The handler then mixed a second package but did not spray this mixture. The above work was considered one cycle of work by one applicator. The cycle was the same for both residential and commercial applications. The average time used for each work cycle at residential sites was 23 min, and at commercial sites was 20 min.

Dermal exposures were monitored using alpha-cellulose patches (Table 25 and 26). Hand exposures were monitored using white cotton gloves (Table 27). Inhalation exposures were monitored using personal air samplers with two polyurethane foam plugs (Table 28). The limits of detection were 2 μg per sample for the polyurethane plugs, 0.01 $\mu g/cm^2$ for the patches, and 100 μg per sample (whole pair) for the cotton gloves. In estimating the exposure, samples below the limit of detection were assumed to contain residues at one-half of the limit of detection.

Table 25. Acephate Found on Alpha-Cellulose Patches from Protected Sites of Pest Control Operators[a,b,c].

Applicator	Acephate (μg/cm^2)						
	Shoulders	Back	Chest	Upper arms	Forearms	Thighs	Ankles
Residential:							
R1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
R2	<.01	<.01	<.01	<.01	<.01	<.01	<.01
R3	<.01	<.01	<.01	<.01	<.01	<.01	<.01
R4	<.01	<.01	<.01	<.01	<.01	.06	.05
R5	<.01	<.01	<.01	<.01	<.01	.03	.06
R6	<.01	<.01	<.01	<.01	<.01	.11	.03
R7	<.01	<.01	<.01	<.01	<.01	.24	<.01
R8	<.01	<.01	<.01	<.01	<.01	<.01	<.01
R9	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Commercial:							
C1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
C2	<.01	<.01	<.01	<.01	<.01	<.01	<.01
C3	<.01	<.01	<.01	<.01	<.01	<.01	<.01
C4	<.01	<.01	<.01	<.01	<.01	.02	.04
C5	<.01	<.01	<.01	<.01	<.01	.03	.04
C6	<.01	<.01	<.01	<.01	<.01	.04	.03
C7	<.01	<.01	<.01	<.01	<.01	<.01	<.01
C8	<.01	<.01	<.01	<.01	<.01	<.01	<.01
C9	<.01	<.01	<.01	<.01	<.01	<.01	.01

a The data based on the study by Chevron Chemical Company (Merricks, 1987a).
b Minimal detection limit (MDL) = 0.01 μg/cm^2.
c Protected sites = the alpha-cellulose patches located inside the work clothing.

Table 26. Acephate Found on Patches from Non-Protected Sites of Pest Control Operators[a,b,c].

Applicator	Acephate (μg/cm^2)							
	Head	Shoulders	Back	Chest	Upper arms	Forearms	Thighs	Ankles
Residential:								
R1	<.01	<.01	<.01	<.01	<.01	<.01	.04	.01
R2	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.01
R3	<.01	<.01	<.01	<.01	<.01	.01	.01	.01
R4	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.01
R5	.01	<.01	<.01	<.01	<.01	<.01	.09	.03
R6	<.01	.01	<.01	.01	.01	.02	.02	.01
R7	<.01	.01	<.01	<.01	<.01	.02	.05	.03
R8	<.01	.01	<.01	<.01	<.01	.07	.02	.04
R9	.02	<.01	<.01	<.01	<.01	.04	.03	.01
Commercial:								
C1	<.01	.01	.01	<.01	<.01	.01	.13	.02
C2	<.01	<.01	<.01	<.01	<.01	.01	.01	.01
C3	<.01	<.01	<.01	<.01	<.01	.01	<.01	.02
C4	<.01	<.01	<.01	<.01	<.01	.02	<.01	.01
C5	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
C6	.01	.01	<.01	.01	.01	.02	.04	.08
C7	.01	.01	.01	.01	.01	.02	.06	.10
C8	<.01	.01	<.01	<.01	<.01	<.01	.02	.04
C9	.01	<.01	<.01	<.01	<.01	.02	.06	.01

a The data based on the study by Chevron Chemical Company (Merricks, 1987a).
b Minimal detection limit (MDL) = 0.01 μg/cm^2.
c Non-protected sites = the alpha-cellulose patches located outside the work clothing.

Table 27. Acephate Found on White Cotton Gloves of Pest Control Operators[a,b].

Applicator	Acephate (μg)
Residential:	
R1	4756.5
R2	264.3
R3	2022.0
R4	2027.5
R5	1706.0
R6	15260.0
R7	14910.0
R8	3198.0
R9	3640.0
Commercial:	
C1	55760.0
C2	673.8
C3	3816.0
C4	3922.0
C5	767.7
C6	5770.0
C7	3624.0
C8	2254.0
C9	3852.0

a The data based on the study by Chevron Chemical Company (Merricks, 1987a).
b MDL (minimal detection limit) = 100 μg.

Table 28. Acephate Found in Polyurethane Foam Plugs of Pest Control Operators[a,b].

Applicator	Acephate (μg)
Residential:	
R1	< 2.0
R2	< 2.0
R3	< 2.0
R4	< 2.0
R5	< 2.0
R6	< 2.0
R7	< 2.0
R8	< 2.0
R9	< 2.0
Commercial:	
C1	< 2.0
C2	< 2.0
C3	< 2.0
C4	< 2.0
C5	< 2.0
C6	2.1
C7	< 2.0
C8	< 2.0
C9	< 2.0

a The data based on the study by Chevron Chemical Company (Merricks, 1987a).

b MDL (minimal detection limit) = 2 μg.

The PCOs are assumed to wear long-sleeved shirts, long pants, and gloves. Based on available data, the residue levels at various sites are summarized in Table 29. The regional exposure (μg) equals average exposure (μg) times median body surface areas (Table 30).

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.

Results demonstrated that exposure to the hands represented 94 – 97% of total body exposure with an average of 95.5% for all workers studied. No acephate was detected on the polyurethane foam plugs, except one (C6) with 2.1 μg of acephate.

Table 29. Estimated Dermal Exposure to Acephate on Various Sites of Pest Control Operators[a,b].

	Regional Exposure (µg) [c,d]									Total Exposure[e] (µg)	Exposure[f] (µg/lb AI)	ADD [g] (µg/kg/day)
	Hands[h]	Head	Neck[i]	Back	Chest	Upper Arms	Forearms	Thighs	Lower Legs			
Residential												
R-1	475.7	6.02	1.165	15.9	15.9	7.165	5.87	17.7	11.9	557.2	3165.9	12.2
R-2	26.4	6.02	1.165	15.9	15.9	7.165	5.87	17.7	11.9	108.0	613.5	2.4
R-3	202.2	6.02	1.165	15.9	15.9	7.165	5.87	17.7	11.9	283.7	1612.2	6.2
R-4	202.8	6.02	1.165	15.9	15.9	7.165	5.87	212.4	118.5	675.7	3839.2	14.7
R-5	170.6	12.04	2.330	15.9	15.9	7.165	5.87	106.2	142.2	478.2	2716.9	10.4
R-6	1526.0	6.02	1.165	15.9	15.9	7.165	5.87	389.4	71.1	2038.5	11582.4	44.5
R-7	1491.0	6.02	1.165	15.9	15.9	7.165	5.87	849.6	11.9	2404.4	13661.6	52.4
R-8	319.8	6.02	1.165	15.9	15.9	7.165	5.87	17.7	11.9	401.3	2280.4	8.8
R-9	364.0	24.08	4.660	15.9	15.9	7.165	5.87	17.7	11.9	467.1	2654.0	10.2
Mean	530.9	8.7	1.683	15.9	15.9	7.165	5.87	182.9	44.8	837.7	4759.6	18.0
SD[j]	568.7	6.1	1.181	0.0	0.0	0.000	0.00	280.7	52.6	827.0	4699.1	18.0
Commercial												
C-1	5576.0	6.02	1.165	15.9	15.9	7.165	5.87	17.7	11.9	5657.5	32145.1	123.
C-2	67.4	6.02	1.165	15.9	15.9	7.165	5.87	17.7	11.9	148.9	846.2	3.2
C-3	381.6	6.02	1.165	15.9	15.9	7.165	5.87	17.7	11.9	463.1	2631.5	10.1
C-4	392.2	6.02	1.165	15.9	15.9	7.165	5.87	70.8	94.8	609.8	3464.7	13.3
C-5	76.8	6.02	1.165	15.9	15.9	7.165	5.87	106.2	94.8	329.8	1873.8	7.2
C-6	577.0	12.04	2.330	15.9	15.9	7.165	5.87	141.6	71.1	848.9	4823.2	18.5
C-7	362.4	12.04	2.330	15.9	15.9	7.165	5.87	17.7	11.9	451.1	2563.2	9.8
C-8	225.4	6.02	1.165	15.9	15.9	7.165	5.87	17.7	11.9	306.9	1744.0	6.7
C-9	385.2	12.04	2.330	15.9	15.9	7.165	5.87	17.7	23.7	485.8	2760.1	10.6
Mean	893.8	8.0	1.553	15.9	15.9	7.165	5.87	47.2	36.9	1046.7	5947.0	22.8
SD[j]	1763.4	3.0	0.582	0.0	0.0	0.000	0.00	47.7	38.1	1762.3	10013.1	38.4

a Since the product label requires the handler to wear chemical-resistant gloves, long pants, and long-sleeved shirt, the body exposure based on protected values (the patches were located inside of work clothing, see Table 25), and the head and neck exposure based on non-protected values (the patches were not covered by clothing, see Table 26).

b The values in this table are adjusted by field recoveries, the adjusted value (µg) = matrix raw value (µg) / matrix-specific and spike level-specific field recovery adjustment factor.

c Regional exposure (µg) = Average exposure (µg/cm^2) * Body Surface Area (BSA, cm^2), except hands data, BSA value based on Table 30.

d For those values less than minimal detection limit (MDL), half of MDL are used as defaults.

e Total exposure = Sum of regional exposure.

f Exposure = Exposure for an applicator handling one pound AI = Total exposure/0.176. The tested acephate levels from patches, cotton gloves and polyurethane foam plugs include mixing two 1.0 gallon batches of Orthene PCO Spray Concentrate and applied 1 qt. of spray solution (see text). One gallon equals 0.088 lb AI. Thus, each PCO handled 0.176 lb/work cycle (each handler mixed two 1.0 gal. batches of solution: 0.088 * 2).

g ADD (Absorbed Daily Dosage) = Exposure (µg/lb AI) * application rate * maximum amount/day * absorption rate ÷ body weight. Calculation assumptions include:

- Application rate = 0.088 lb/gallon (U.S. EPA, 2000a).
- The maximum amount used every day is 40 gallons based on RED document (U.S. EPA, 2000a).
- Absorption rate = 7.6% (see dermal absorption section).
- Default body weight = 69.7 kg (U.S. EPA, 1997a).

h The hand data multiplied by 0.1 for use of chemical-resistant gloves (Aprea *et al.,* 1994) based on requirement of the product label.

i The exposure values for neck = acephate levels of head * area of neck.

j SD = standard deviation.

Table 30. Median Body Surface Area (BSA) of Adults [a].

Body Region	Head	Neck [b]	Back	Chest	Upper Arm	Forearm	Thigh	Lower Legs	Total
BSA (cm^2)	1204	233	3178	3178	1433	1173	3540	2370	17213

a The body surface area (BSA) values are that of combined male and female (U.S. EPA, 1997a).

b The surface area of 233 cm^2 is the sum of front and back of neck (U.S. EPA, 1997a).

Based on above data and estimate, Table 31 summarizes the absorbed daily dosage.

Table 31. Estimated Average Dermal and Inhalation Daily Exposure and Absorbed Daily Dosage (ADD) of Pest Control Operators.

Handler	Total Exposure [a, b] (µg)		Exposure [c] (µg/lb AI)		ADD [d] (µg/kg/day)		Acute ADD [e] (µg/kg/day)		
	Dermal	Inhalation	Dermal	Inhalation	Dermal	Inhalation	Dermal	Inhalation	Total
Residential	827.0	1.0	4759.6	5.9	18.3	0.30	58.40	0.30	58.70
Commercial	1046.7	1.2	5947.0	6.6	22.8	0.34	62.80	0.49	63.30

a The dermal data are means of related data from Table 29.

b The total inhalation exposure data are based on Table 28. The results below the MDL were substituted by ½ MDL. The values in this table are adjusted by field recoveries, the adjusted value (µg) = matrix raw value (µg) / matrix-specific and spike level-specific field recovery adjustment factor.

c Dermal Exposure data are from Table 29.
Inhalation Exposure (µg/lb AI) = Total inhalation exposure/0.176 lb AI per handler handled each work cycle. AI = Active ingredient

d Dermal Absorbed Daily Dosage (ADD) data are from Table 29.
Inhalation Absorbed Daily Dosage (ADD) = Inhalation exposure (µg/lb AI) * application rate (0.088 lb/gallon) * absorption rate (100%) * maximum amount/day (40 gallons, U.S. EPA, 2000a) / body weight (69.7 kg, U.S. EPA, 1997a).

e Acute Absorbed Daily Dosage is an upper-bound estimate (95th percentile estimate, Powell, 2006); based on the arithmetic mean (AM) and standard deviation (SD) of the log-transformed data, then calculating: 95th percentile = Antilog {AM + 1.645 x SD}.

(B) Acephate Residential Garden Handler Exposure Study

A study was conducted by Chevron Chemical Company (Merricks, 1987b) to assess dermal and inhalation exposures of homeowners applying acephate outdoors by hose-end sprayers. The study was performed on July 21, 1987 in Catonsville, Maryland. One house and its yard shrubs represented the spray zone for a mixer/loader/applicator. Each residence contained several kinds of ornamental plantings, 10- to 15-foot tall shade trees and hedges.

Five mixer/loader/applicators were monitored as they mixed and sprayed 4 gallons of Orthene Systemic Insect Spray solution. Their activities included opening the formulation, adding 8 fl. oz. (237 ml) to the Spray-Ette® 4, adding water (600 ml) to the 4-gallon mark, closing the sprayer, shaking horizontally to mix, spraying the mixture onto yard shrubs and ornamentals, re-mixing and spraying another 4 gallons of finished product and then cleaning out the hose-end sprayer by back flushing. The average exposure time was 27 minutes for each person, which included two mix/load cycles and two applications.

All workers were suited in Tyvek® coveralls and latex gloves for personal protection. Respiratory exposure was monitored throughout the exposure period using personal air pumps drawing air through two polyurethane foam plugs worn near the breathing zone. Dermal exposure was monitored by dosimeters including both duplicate non-protected (alpha-cellulose) patches (located outside the work clothing) and duplicate protected patches (located inside the work clothing). All patches for monitoring exposure to the head were non-protected outside patches. The hands were monitored with white cotton gloves worn over latex gloves.

A blank sample of each matrix was opened to the experiment staging area prior to initiating the exposure period (negative controls). Two replicates of each type of sampling media were spiked in the field at 10, 100, and 1,000 µg to serve as positive controls. The laboratory detection limits were 1.0 µg/foam plug, 0.01 µg/cm^2 for the patches, and 2.0 µg per pair of gloves.

The results demonstrated that except for hand exposure, most residues were detected on the legs and arms for both non-protected and protected sites (Table 32). Hand dermal exposure was much greater and the major route of total dermal exposure (Table 33 and 32). No acephate was measured in polyurethane filters (Table 34), indicating that there was minimal inhalation exposure. The average recovery of acephate from control samples was 91.3% for alpha-cellulose, 79.3% for cotton gloves, and 81.3% for foam filters.

Table 32. Acephate Found on Alpha-Cellulose Patches from Various Sites of Home Users[a,b].

	Acephate (µg/cm^2)							
Handler	Head[c]	Shoulders	Back	Chest	Upper arms	Forearms	Thighs	Ankles
PROTECTED[d]								
1		<.01	<.01	NA[e]	<.01	.03	.07	.02
2		<.01	<.01	<.01	<.01	<.01	<.01	<.01
3		<.01	.07	.19	.08	.09	<.01	.05
4		<.01	<.01	<.01	<.01	.17	<.01	<.01
5		.04	<.01	<.01	<.01	.21	<.01	.02
NON-PROTECTED[d]								
1	.35	1.84	.04	.28	.47	1.79	.32	2.18
2	<.01	.02	NA[e]	.02	.01	.05	.05	.01
3	.34	.06	.01	.06	.72	1.20	12.0[f]	1.34
4	<.01	<.01	<.01	.02	.02	.11	.15	.27
5	.02	.04	<.01	.02	.01	.33	1.72	1.63

[a] The data based on the study by Chevron Chemical Company (Merricks, 1987b).
[b] MDL (minimal detection limit) = 0.01 µg/cm^2.
[c] All of the head patches were non-protected.
[d] Protected data were from the patches located inside the work clothing;
Non-protected data were from the patches located outside the work clothing.
[e] NA = Data not available (sample missing).
[f] Analysis re-checked and confirmed.

Table 33. Acephate Found on White Cotton Gloves of Home Users[a,b].

M/L/A[c]	Acephate (µg)	Adjusted Values (µg) [d]
1	133,600	16847.4
2	10,600	1336.7
3	95,500	12042.9
4	31,000	3909.2
5	30,750	3877.7

[a] The data based on the study by Chevron Chemical Company (Merricks, 1987b).
[b] MDL (minimal detection limit) = 2.0 µg per pair of gloves.
[c] M/L/A = mixer/loader/applicator.
[d] The adjusted values = matrix raw value / matrix-specific and spike level-specific field recovery adjustment factor.

Table 34. Acephate Found in Polyurethane Foam Filters of Home Users[a,b].

M/L/A[c]	Acephate (µg)
1	< 1.0
2	< 1.0
3	< 1.0
4	< 1.0
5	< 1.0

[a] The data based on the study by Chevron Chemical Company (Merricks, 1987b).
[b] MDL (minimal detection limit) = 1.0 µg.
[c] M/L/A = mixer/loader/applicator.

The regional residue levels and total exposures are summarized in Table 35 based on available data (Tables 31, 32 and 33). Since the Tyvek is chemical-resistant, DPR considered the residues found on protected patches (located inside of Tyvek coveralls) inadequate for estimating the exposure. Therefore, the residues found on non-protected patches were used to estimate the exposure of mixer/loaders. Since the product labels require handlers to wear long pants and long-sleeved shirt, the non-protected patch data were corrected by adjusting 90% protection factor (Aprea *et al*, 1994).

Table 35. Estimated Dermal Exposure to Acephate of Home Users [a].

Handler	Regional Exposure (μg) [b]									Total Exposure (μg) [c]
	Hands[d]	Head	Neck[e]	Back	Chest	Upper Arm	Forearm	Thigh	Ankle	
1	16847.4	392.6	89.3	13.9	97.5	73.8	230.0	124.1	565.9	18434.4
2	1336.7	5.6	1.3	34.8	7.0	1.6	6.4	19.4	26.0	1438.7
3	12042.9	381.3	86.8	34.8[f]	208.8	113.0	154.2	4652.8	347.8	18022.5
4	3909.2	5.6	1.3	1.7	7.0	3.1	14.1	58.2	70.1	4070.3
5	3877.7	22.4	5.1	1.7	7.0	1.6	42.4	666.9	423.1	5047.9
Average	7602.7	161.5	36.7	17.4	65.4	38.6	89.4	1104.3	286.6	9402.7
SD [g]	6556.6	205.9	46.9	16.6	89.2	51.9	98.4	2001.0	232.0	8165.4

a Since the product label requires the handler to wear chemical-resistant gloves, long pants, and long-sleeved shirt, the body exposure is based on non-protected values (Table 32), which were adjusted with 90% protection factor. The head and neck exposure is based on non-protected values (Table 32).
The values in this table were adjusted by recoveries. Average recoveries were 91% for patches and 79% for gloves. The adjusted values = Matrix raw value / matrix-specific and spike level-specific field recovery adjustment factor.

b
- Regional Exposure (μg) = Average exposure (μg/cm^2) * body surface area (BSA, cm^2), except hands, BSA values are from Table 30.
- For those values less than test limit, half of test limits are taken as defaults.

c Total Exposure (μg) = Sum of regional exposure.

d The hand data multiplied by 0.1 for use of chemical-resistant gloves (Aprea *et al.,* 1994) based on requirement of the product label.

e The exposure values for neck = Acephate levels of head * area of neck. The surface area 233 cm^2 is the sum of front and back of neck (U.S. EPA, 1997a).

f Since this sample was missing, the highest value (#3) of rest handlers was used.

g SD = Standard deviation.

Based on above data and estimate, the absorbed dermal and inhalation daily dosage were summarized in Table 36.

Table 36. Estimated Daily Dermal and Inhalation Acephate Exposure and Absorbed Daily Dosage (ADD) of Home Users.

Exposure [a] (µg/ lb AI)			ADD [b] (µg/kg/day)			Acute ADD [c] (µg/kg/day)		
Dermal	Inhalation	Total	Dermal	Inhalation	Total	Dermal	Inhalation	Total
100029.2	0.6	100029.8	64.1	0.005	64.1	254.0	0.005	254.0

a Exposure = Exposure for a mixer/loader/applicator (M/L/A) to handle one pound active ingredient (AI) = Total exposure / (8 gal (every M/L/A handled) * 0.01175 lb AI/gal). For example, dermal exposure = 6688.3 µg / (8 gal * 0.01175 lb AI/gal) = 71152.5 µg/ lb AI.

b ADD (Absorbed Daily Dosage) = Daily exposure * application rate * maximum amount/day * absorption rate ÷ body weight. Calculation assumptions include:

- Application rate = 0.01175 lb AI/gal;
- Maximum amount/day = 50 gal. (U.S. EPA, 2000a);
- Dermal absorption rate = 7.6% (see Dermal Absorption Section);
- Inhalation absorption rate is assumed to be 100%;
- Body weight = 69.7 kg for both male and female (U.S. EPA, 1997a).

c Acute Absorbed Daily Dosage is an upper-bound estimate (95th percentile estimate, Powell, 2006); based on the arithmetic mean (AM) and standard deviation (SD) of the log-transformed data, then calculating: 95th percentile = Antilog {AM + (1.645 x SD)}.

The number of replicates was low but still sufficient and provided an ADD of 64.1 µg/kg/day and an acute ADD of 254.0 µg/kg/day. The hands accounted for the majority of the dermal exposure. The inhalation exposure was estimated to be 0.005 µg/kg/day. Since residential applications are conducted only occasionally, it is unnecessary to calculate SADD, AADD and LADD for residential applicators.

2.1.2 Exposure estimates using surrogate data

The chemical-specific data as described and evaluated above are the only data submitted to DPR for assessing human exposures during residential and/or institutional application of acephate. Thus, estimates for remaining exposure scenarios were derived using PHED (PHED, 1995). Table 37 summarizes the assumptions and conditions used in calculations of exposure estimates from PHED.

Table 37. Summary of Monitoring Study and Pesticide Handler Exposure Database (PHED) Exposure Estimates for Residential/Institutional Handlers of Acephate.

Exposure Scenarios [a]			Application Rate[d] (lb AI/A or lb AI/gal as noted)	Area/Day[e] (A/day or gal/day as noted)	Exposure[f] (µg/lb AI)		Absorbed Daily Dosage[g] (µg/kg/day)			N[h]	Acute ADD[i] (µg/kg/day)	Appendix Number
Task[b]	FM[c]	Method			Dermal	Inhalation	Dermal	Inhalation	Total			
1. M/L/A	WP	Low Pressure Hand Wand	Ornamentals, Flowers, Shrubs, Trees, Fire Ants = 0.023 lb/gal	2 gallons	12525.8	1040.0	0.63	0.686	1.31	15-16	6.6	10
			Wasps = 0.075 lb/l gal	5 gal	12525.8	1040.0	5.12	5.595	10.72	15-16	53.6	10
			Fire Ant (non-crop) = 0.47 lb/5 gal	5 gal	12525.8	1040.0	6.42	7.013	13.43	15-16	67.2	10
2. M/L/A	WP	Backpack Sprayer	Turf = 0.035 lb/gal	2 gallons	22309.7	17.5	1.70	0.018	1.72	11	10.3	9
			Fire Ant (non-crop)=0.47 lb/5 gal	5 gal	22309.7	17.5	11.43	0.118	11.55	11	68.9	9
			PCO = 0.088 lb/gal	40 gal	22309.7	17.5	85.63	0.884	86.51	11	516.0	9
3a. M/L/A	L	Hose-End Sprayer	Ornamentals, Flowers, Shrubs, Trees, Fire Ants = 0.023 lb/gal	50 gallons	6300.0	13.4	7.90	0.221	8.12	8	56.8	13
			Turf = 0.035 lb/gal	50 gallons	6300.0	13.4	12.02	0.336	12.36	8	86.5	13
			Roses, Flowers, Shrubs, Trees = 0.0076 lb/gal	50 gallons	6300.0	13.4	2.61	0.073	2.68	8	18.8	13
3b. M/L/A[j]	L	Hose-End Sprayer	Ornamentals, Shade Trees = 0.01175 lb/gal	50 gallons	1152.5	0.5	45.6	0.002	64.08	5	254.0	j
4. M/L/A	WP	Sprinkling Can	Ornamentals, Flowers, Shrubs, Trees, Fire Ants = 0.023 lb/gal	5 gallons	No Data	No Data	NA	NA	NA	NA	NA	NA
			Turf = 0.035 lb/gal	5 gallons	No Data	No Data	NA	NA	NA	NA	NA	NA
			Roses, Flowers, Shrubs, Trees = 0.0076 lb/gal	5 gallons	No Data	No Data	NA	NA	NA	NA	NA	NA
5. L/A	SP	Hand-tool/ Shaker Can	Fire Ants = 0.0069 lb/mound	7 mounds	26334.0	80.7	1.39	0.056	1.44	23-45	5.6	15
6. L/A	G	Shaker Cup	Ornamentals = 0.5 lb/1000 sq ft	100 sq ft	26334.0	80.7	2.87	0.116	2.99	23-45	5.8	15
			Roses = 0.1125 lb /1000 sq ft	5 sq ft/rose; 20 roses	26334.0	80.7	0.32	0.013	0.34	23-45	1.3	15
7. A	L	Aerosol Can	Crack & Crevice = 0.01 lb/can	2 cans (32 oz)	239000.0	1040.0	5.21	0.298	5.51	15	27.7	17
			Ornamentals = 0.03 lb/can	2 cans (32 oz)	239000.0	1040.0	15.64	0.895	16.53	15	83.0	17
8. M/L/A[j]	WP	Low Pressure Hand Wand	PCO (residential sites) = 0.88 lb/gal	40 gal	4680.7	5.7	18.0	0.14	18.14	9	57.8	j
			PCO (commercial sites) = 0.88 lb/gal	40 gal	5872.4	6.4	22.5	0.16	22.66	9	62.6	j
9. A	P	Paintbrush	Window frames = 0.083 lb/gal	2 gal	37700.0	308.0	6.82	0.734	7.56		65.6	18

Table 37. Summary Exposure Estimates for Residential/Institutional Handlers of Acephate (continued)

a The exposure scenarios are based on the Reregistration Eligibility Decision (RED) document (U.S. EPA, 2000a).

b A = Applicator,
M/L/A = Mixer/loader/applicator,
L/A = Loader/applicator.
Protective clothing and equipment for various scenarios are based on product labels (see "Label precaution" section).

c FM = Formulation.
WP = Wettable powder.
L = Liquid.
FC = Flowable concentrate
SP = Soluble powder.
G = Granule.
P = Pellet.

d Maximum application rates are based on values found in the RED (U.S. EPA, 2000a). AI = Active ingredient; A= Acres; PCO = Pest control operator

e Daily acres and volumes to be treated in each scenario were based on the RED (U.S. EPA, 2000a).

f From the Pesticide Handler Exposure Database (PHED) and software (PHED, 1995) except indicated monitoring studies. Appropriate protection factors were applied depending on label precaution and are listed in Appendices.

g Absorbed Daily Dosage (ADD) = Exposure * absorption rate * application rate * acres (or volume)/day ÷ body weight. Calculation assumptions include:
- The maximum label rate based on the RED (U.S. EPA, 2000a) for all scenarios;
- Dermal absorption rate = 7.6% (see Dermal Absorption section);
- Inhalation absorption is assumed to be 100%;
- Body weight = 69.7 kg for both male and female (U.S. EPA, 1997a).

h N = Median number(s) of observations in PHED data set or in monitoring studies (includes inhalation and all dermal body parts).

i Acute Absorbed Daily Dosage is 90% upper confidence limit for the 95th percentile estimate from PHED; multipliers for PHED subsets are from Powell (2001), the calculations are shown in Appendices; or see monitoring studies sections.

j Estimate was based on the monitoring study.

2.2 Post-application exposure

2.2.1 Post-application dermal exposure from residues on turf

Adults or children who enter treated yards for recreation, yard work, or other residential activities could be subject to some incidental exposure to transferable residues of acephate and methamidophos. As no exposure data were available for these scenarios, estimates were completed according to U.S. EPA guidelines(1997b). Due to the frequency and duration of potential post-application residential exposures coupled with the dissipation of acephate and methamidophos following acephate treatments, it was determined that residential acephate uses would result in potential short-term dermal and oral acephate and methamidophos post-application residential exposures. Potential inhalation exposures are not anticipated for post-application residential exposures because acephate is a nonvolatile chemical with low vapor pressure of 1.7×10^{-6} mmHg at 25 °C. Studies (Ware *et al.,* 1973, 1974, 1975) indicated that inhalation is a relatively minor exposure route for nonvolatile AIs. U.S. EPA also estimated that inhalation post-application exposure would be negligible (U.S. EPA, 2001a).

Acephate and methamidophos exposures may also occur from contact (i.e., pruning, cutting and weeding) with treated ornamentals, flowers, trees, and shrubs. However, these exposures would not be as significant as exposures to residues on turf grass because of lower contact rates and the frequency and duration of potential contacts. Therefore, these potential exposures are not addressed in this assessment.

The post-application residential exposures were assessed for both acephate and methamidophos in following scenarios: 1) Dermal exposure from residues on turf (adult and child); 2) Incidental non-dietary ingestion of residues on grass from hand-to-mouth transfer (child); and 3) Ingestion of treated grass (child). The results were summarized in Table 38.

The potential post-application residential exposures were assessed on the same day acephate would be applied to the grass because it was assumed that the public could be exposed immediately following an acephate treatment. TTRs measured following the second application to turf (see Environmental Concentration section) were used in the post-application residential assessment. An adjustment for the difference in turf application rates between occupational and residential environments was made based on the RED document (U.S. EPA, 2001a). It was assumed that the grass residues were equivalent to the study TTRs. The hand-to-mouth exposure was estimated using the hand-to-mouth contact frequency per hour, the hand surface area mouthed on each contact and a TF (U.S. EPA, 2001b). It is assumed that 50% of the residue on the hands is transferred to the mouth by saliva and ingested (U.S. EPA, 2001b).

For estimating incidental ingestion, this document assumes that children spend two hours per day in contact with turf.

Table 38. Estimated Dermal Exposure of Residents to Acephate and Methamidophos Residues on Turfgrass [a].

Exposure Route	TF[b] (cm^2/hr)	ET[c] (hr)	HSA[d] (cm^2/event)	IR[e] (cm^2/day)	FQ[f] (events/hr)	ACEPHATE TTR[g] ($\mu g/cm^2$)	ACEPHATE ADD[h] ($\mu g/kg/day$)	METHAMIDOPHOS TTR[g] ($\mu g/cm^2$)	METHAMIDOPHOS ADD[h] ($\mu g/kg/day$)
Dermal									
Adult	14500	2	-	-	-	0.29	9.14	0.00074	0.0348
Toddlers	5200	2	-	-	-	0.29	15.10	0.00074	0.0576
Oral (Toddlers)									
Hand-to-mouth	-	2	20	-	20	0.29	3.83	0.00074	0.0146
Grass ingestion	-	-	-	25	-	0.20	0.48	0.00074	0.0018

a The application rate = 5.0 lb active ingredient (AI)/acre, which is the highest registered maximum one time application rate for use on commercial/residential turf based on the product label. All adult data are averaged male and female data; all children data are for 3 year-old children.

b TF (transfer factor) values are based on the Standard Operating Procedures (SOP) (U.S. EPA, 2001b).

c ET, exposure time. Dermal exposure time is assumed to be 2 hr/day (U.S. EPA, 2001b). Oral (hand-to-mouth for children) exposure time is assumed to be 1 hr/day by WHS.

d HSA (hand surface area) is based on U.S. EPA's SOP (U.S. EPA, 2001b).

e IR (ingestion rate) is based on U.S. EPA's SOP (U.S. EPA, 2001b).

f FQ (hand-to-mouth contact frequency per hour) is based on U.S. EPA's SOP (U.S. EPA, 1997b).

g TTR (turf transferable residues) for acephate = 0.289 $\mu g/cm^2$ (Table 10); TTR value averaged from actual field measurements made following the second application of registrant's study (provided in RED, U.S. EPA, 2000a), the application rate was 5.0 lb AI/acre.
TTR for methamidophos = 0.0011 $\mu g/cm^2$ (Table 10); TTR data were averaged from actual field measurements made following the second application of the registrant's study (provided in RED, U.S. EPA, 2001a).

h ADD (absorbed daily dosage):
- Dermal exposure (adult/toddler) = TTR ($\mu g/cm^2$) * TF (cm^2/hr) * ET (hour/day) * 7.6% dermal absorption (see dermal absorption section) ÷ body weight (69.7 kg for adults, and 15.1 kg for toddlers) (U.S. EPA, 1997b).
- Hand-to-mouth = TTR ($\mu g/cm^2$) * HSA (cm^2/event) * FQ (events/hr) * ET (hour/day) * 50% (saliva extraction factor) ÷ 15.1 kg body weight (U.S. EPA, 1997a, U.S. EPA, 2001b).
- Turfgrass ingestion = TTR ($\mu g/cm^2$) * IR (cm^2/day) ÷ 15.1 kg body weight (U.S. EPA, 2001b).

2.2.2 Estimating the exposure of post-indoor treatment with acephate

Adults or children who enter treated residential, industrial, institutional or commercial buildings could be subject to potential dermal and inhalation exposure to acephate. The applications allowed on the label are spot and perimeter treatments where insects may be harboring and active, like openings around pipes and sinks, under refrigerators, window frame, behind baseboards, washing machines, stoves cabinets, sewer, floor drains and meter boxes, structural cracks and crevices, etc. Since methamidophos is a plant and soil metabolite (Lee, 1972), it is assumed that this chemical is not likely to be formed after an indoor structural application.

(A) Indoor Post-Application Potential Exposure Monitoring Study

A monitoring study of inhalation and dermal exposure following post-application to residential and commercial buildings was performed by Chevron Chemical Company (Merricks, 1987a). This study was conducted in accordance with the U.S. EPA Good Laboratory Practice Standards (40 CFR, Part 160). All residential rooms are closed

bathrooms, approximately 48 ft^2. Commercial rooms 1 and 4 are closed offices, approximately 250 ft^2, and commercial room 7 is a warehouse, an open area, approximately 4200 ft^2. All cracks and crevices, as well as under counters and behind equipment were spot sprayed. The spot was limited to less than 2 square feet. Care was taken by the applicators to avoid directly spraying the alpha-cellulose cards or air sampling equipment. The exposure was monitored for four days post-application by analyzing polyurethane foam plugs (poly plugs) and alpha-cellulose cards maintained in the rooms. Temperature and relative humidity were measured during each application period. The average temperature was 20 °C, and the average humidity was 51%. Alpha-cellulose cards (eight on the floor and eight on the wall) were placed in the bathroom of a residence, and in one area in a commercial building on each test date, along with an air-sampling pump fitted with a polyurethane foam plug. The pump was run during and post-application for four hours. All rooms were closed during sample pump operation except for commercial room 7 where one large warehouse area was sprayed. The poly plug and duplicated alpha cellulose cards from the wall and floor area were collected at the end of the 4-hour period on day zero. Air samples and cards were also collected on days 1, 2, and 4 post-application, where the air sampling pump was fitted with a fresh poly plug and run for four hours on each day.

The overall acephate recovery from samples fortified in the laboratory and analyzed with the field samples was 103% for alpha-cellulose, and 96% for polyurethane foam plugs. This study is deemed acceptable for use in exposure assessments. The results on each measurement day are shown in Table 39.

Table 39. Residues Found in Rooms Post-Application of Acephate [a].

Site [b]		Residue Found on Day Post-Application			
		0 Day	1 Day	2 Day	4 Day
Walls [c] (μg/cm^2)	R1	<0.01	<0.01	<0.01	<0.01
	R4	<0.01	<0.01	<0.01	<0.01
	R7	<0.01	<0.01	<0.01	<0.01
	C1	<0.01	<0.01	<0.01	0.01
	C4	<0.01	<0.01	0.01	0.01
	C7	<0.01	<0.01	<0.01	0.01
Floor [d] (μg/cm^2)	R1	0.12	0.01	0.01	0.01
	R4	0.11	0.01	0.01	0.01
	R7	0.02	0.01	0.01	0.01
	C1	<0.01	0.01	0.01	0.01
	C4	<0.01	0.01	0.01	0.01
	C7	0.01	0.01	0.01	0.04
Air [e] (μg)	R1	<2.0	<2.0	<2.0	<2.0
	R4	<2.0	<2.0	<2.0	<2.0
	R7	<2.0	<2.0	<2.0	<2.0
	C1	<2.0	<2.0	<2.0	<2.0
	C4	<2.0	<2.0	<2.0	<2.0
	C7	3.5	<2.0	<2.0	<2.0

a The data is based on the study by Chevron Chemical Company (Merricks, 1987a).

b One room each measured for residue levels on each test date for residential and commercial buildings. All residential rooms are closed bathroom, approximately 48 ft^2. Commercial rooms 1 and 4 (C1 & C4) are closed offices, approximately 250 ft^2, and commercial room 7 is a warehouse, an open area, approximately 4200 ft^2.

c Residue on the wall was monitored by analyzing alpha-cellulose cards which were placed on the wall. The alpha cellulose cards remained in the room throughout the four days until sampled.

d Residue on the floor was monitored by analyzing alpha-cellulose cards which were placed on the floor. The alpha cellulose cards remained in the room throughout the four days until sampled.

e Residue in the air was monitored by analyzing polyurethane foam plugs maintained in the rooms, an air sampling pump was operated in one room for four hours on each sampling day.

It indicated that no residue was measured on the walls of treated residential sites through four days post-application. However, detected residues appeared in all commercial rooms by day four post-treatment. These measurements were taken from areas where the direct line of spray during application was avoided. Measurements for acephate on the floor of treated rooms showed measurable residues in residential and commercial sites on all days. The floor levels in all rooms (residential and commercial) were at the method detection limit for all 4 days post-application. No acephate was measured in the room air of closed rooms from any of the treated rooms through four days post-application. There was detected residue in air of the open warehouse on the day zero, the application day, for unknown reason.

Based on the monitoring study, residential inhalation exposure from indoor air was not considered in this assessment because of extremely low measured air concentrations. U.S. EPA made the same conclusion (U.S. EPA, 2001a). However, there are some detected residues of acephate on floor. As mentioned in the initial study, the applicators took care to avoid directly spraying the alpha-cellulose cards or air sampling equipment. The data might lead to underestimating the dermal exposure if children or adults contact the area being directly sprayed. Therefore, the dermal exposure estimate in this

document was made based on the floor residues and default assumptions, which are shown in following section (B).

(B) Indoor Post-Application Dermal Exposure Estimate Basing on Default Values

An indoor dermal exposure estimate depends on the level of surface residues, dislodgeability of residues, transferability of residues and the rate of dermal contact. As no acceptable exposure data were available for this scenario, estimates were completed according to U.S. EPA (2001b) guidelines by using default TFs and dislodgeable surface residues. The post-application residential/institutional exposures were assessed for acephate in following scenarios: 1) Dermal exposure from residues on surface (adult and child); 2) Incidental non-dietary ingestion of residues on hard surface or carpet from hand-to-mouth transfer (child). The results were summarized in Table 40.

The potential post-application residential exposures were assessed on the same day acephate would be applied indoors. Hand-to-mouth exposure was estimated using the hand-to-mouth contact frequency per hour, the area of 1-3 fingers representing each hand-to-mouth event, and a TF (U.S. EPA, 2001b). It is assumed that 50% of the residue on the hands is transferred to the mouth by saliva.

Table 40. Estimated Dermal Exposure to Acephate Residues on Hard Surfaces and Carpet after Indoor Application[a].

Exposure Route	TF[b] (cm^2/hr)	ET[c] (hr)	HSA[d] (cm^2/event)	FQ[e] (events/hr)	TR[f] (μg/cm^2)	ADD[g] (μg/kg/day)
Hard Surface						
Adult	16700	4	-	-	0.008	0.60
Children	6000	4	-	-	0.008	1.00
Carpet						
Adult	16700	8	-	-	0.004	0.60
Children	6000	8	-	-	0.004	1.00
Oral (Children)						
Hand-to-mouth	-	2	20	20	0.01	0.22

a The application rate = 0.083 lb active ingredient (AI)/gal, based on the product label. All adult data are averaged male and female data; all children data are for 3 year-old children.

b TF (transfer factor): 16,700 cm^2/hr for adults, and 6,000 cm^2/hr for children (1-6 years) based on U.S. EPA (2001b).

c ET (exposure time) for dermal exposure is based on U.S. EPA policy (U.S. EPA, 2001b).

d HSA (hand surface area)is based on U.S. EPA's SOP (U.S. EPA, 2001b).

e FQ (hand-to-mouth contact frequency per hour) is based on U.S. EPA's SOP (U.S. EPA, 2001b).

f TR (transferable residues): 10% of application rate (0.083 lb AI/gal) for hard surfaces; and 5% of application rate (0.083 lb AI/gal) for carpets (U.S. EPA, 2001b).

g ADD (absorbed daily dosage):

- Dermal exposure (adult) = TR (μg/cm^2) * TF (cm^2/hr) * ET (hour/day) * 7.6% dermal absorption (see dermal absorption section) ÷ body weight (69.7 kg for adults, and 15.1 kg for children) (U.S. EPA, 1997b, 2001b).
- Hand-to-mouth = TR (μg/cm^2) * HSA (cm^2/event) * FQ (events/hr) * ET (hour/day) * 50% (saliva extraction factor) ÷ 15.1 kg body weight (U.S. EPA, 1997b, 2001b).

3. Recreational Areas

Acephate is applied to recreational areas, including golf courses, tennis courts, and parks.

3.1 Golf Course Uses

The handlers, golf course maintenance workers and golfers are subject to exposure to acephate and methamidophos from entering golf courses treated with acephate.

3.1.1 Handlers

A study was performed by Chevron Chemical Company (Merricks, 1987c) to monitor and quantify the acephate exposure of mixer/loaders and applicators. The study took place in Boca Raton, Florida, in July 1987 using ground boom equipment, which is typically used for golf course applications. This study was conducted in accordance with the U.S. EPA Good Laboratory Practice Standard (40 CFR, Part 160).

Twelve mixer/loaders and 12 applicators were exposed during the three-day field test. Separate test days were used to obtain three distinct sets of weather conditions during the three exposure periods. All workers wore Tyvek® coveralls, and latex gloves for personal protection. Each worker was suited with non-protected alpha-cellulose patches and protected patches covered with shirt cloth or denim cloth. White cotton glove dosimeters were worn over rubber gloves, and a personal sampling pump drew air through a polyurethane filter placed near the breathing zone.

Each mixer/loader prepared 100 gallons of Orthene 75S Soluble Powder spray solution. The applicator applied an adequate volume of the spray solution to golf course greens and fairways at the rate of 5.2 lbs formulation (3.90 lbs AI)/acre. Based on original study, M/L-1 to M/L-4 and A-1 to A-4 handled 12 1-lb cans of product, while M/L-5 to M/L-12 and A-5 to A-12 handled 6 1-lb cans of product. Residues (except hands) on protected (the patches were located inside of Tyvek® coveralls) and non-protected (the patches were located outside of Tyvek® coveralls) patches from mixer/loaders are shown in Table 40, and those from applicators are shown in Table 41.

Table 40. Acephate Found on Alpha-Cellulose Patches of Mixer/Loaders for Golf Course Applications[a,b].

M/L [c]	Acephate (μg/cm²)							
	Shoulders	Back	Chest	Upper Arms	Forearms	Thighs	Ankles	Head
Protected [d]:								
M/L-1	<.01	<.01	<.01	<.01	.02	<.01	<.01	
M/L-2	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
M/L-3	<.01	<.01	<.01	<.01	.06	<.01	.02	
M/L-4	<.01	<.01	<.01	<.01	.02	<.01	<.01	
M/L-5	<.01	<.01	<.01	<.01	.02	<.01	<.01	
M/L-6	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
M/L-7	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
M/L-8	<.01	<.01	<.01	<.01	.03	<.01	<.01	
M/L-9	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
M/L-10	<.01	<.01	<.01	<.01	<.01	<.01	.01	
M/L-11	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
M/L-12	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
Non-protected [d]:								
M/L-1	.08	.02	.02	.12	.11	.04	.02	.04
M/L-2	.01	.01	.01	.02	.13	<.01	<.01	<.01
M/L-3	.03	<.01	.07	.02	.29	.03	.30	.01
M/L-4	.03	<.01	.04	.03	.31	.02	<.01	<.01
M/L-5	.04	.02	.02	.05	.24	.08	.02	.03
M/L-6	.01	.01	<.01	<.01	.06	.01	.01	<.01
M/L-7	.04	.02	<.01	.03	.13	.16	<.01	.01
M/L-8	.02	.02	.01	.02	.09	.16	<.01	.01
M/L-9	.03	<.01	.02	.03	.06	.02	<.01	.01
M/L-10	.04	<.01	.02	.02	.05	.02	.06	<.01
M/L-11	<.01	<.01	<.01	<.01	.04	<.01	<.01	<.01
M/L-12	.02	<.01	.03	.02	.05	.04	.01	<.01

[a] The data is based on the study by Chevron Chemical Company (Merricks, 1987c).
[b] MDL (minimal detection limit) = 0.01 μg/cm².
[c] M/L = Mixer/loader.
[d] Protected data were from the patches located inside of work clothing;
Non-protected data were from the patches located outside of work clothing.

Table 41. Acephate Found on Alpha-Cellulose Patches of Golf Course Applicators[a,b].

Applicator	Acephate (µg/cm^2)							
	Shoulders	Back	Chest	Upper arms	Forearms	Thighs	Ankles	Head
Protected [c]:								
A-1	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
A -2	<.01	<.01	<.01	<.01	1.03	<.01	<.01	
A -3	<.01	<.01	<.01	<.01	0.01	<.01	<.01	
A -4	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
A -5	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
A -6	<.01	<.01	<.01	0.09	0.26	<.01	55.1[d]	
A -7	<.01	<.01	<.01	<.01	<.01	<.01	0.12	
A -8	<.01	<.01	<.01	<.01	<.01	<.01	0.03	
A -9	<.01	<.01	<.01	<.01	0.10	<.01	<.01	
A -10	<.01	<.01	<.01	<.01	0.08	<.01	<.01	
A -11	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
A -12	<.01	<.01	<.01	<.01	0.01	<.01	<.01	
Non-protected [c]:								
A -1	0.05	<.01	0.03	0.06	0.04	0.08	0.01	0.03
A -2	0.05	0.02	0.05	0.04	0.08	0.09	0.05	0.05
A -3	.03	0.03	<.01	0.02	0.02	0.02	0.01	0.03
A -4	0.04	0.28	0.02	0.04	0.04	.05	0.07	0.04
A -5	<.01	<.01	<.01	<.01	0.02	<.01	0.08	<.01
A -6	0.02	<.01	0.04	<.01	<.01	6.36	28.28	<.01
A -7	0.04	<.01	0.01	0.06	0.06	0.11	0.17	0.02
A -8	0.04	0.03	0.02	0.11	0.11	0.02	0.09	0.04
A -9	<.01	<.01	<.01	<.01	<.01	0.02	[e]	<.01
A -10	0.02	0.02	0.02	0.05	0.05	<.01	0.02	0.01
A -11	0.02	0.03	<.01	0.02	0.02	0.01	0.02	0.01
A -12	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01

a The data based on the study by Chevron Chemical Company (Merricks, 1987c).
b MDL (minimal detection limit) = 0.01 µg/cm^2.
c Protected data were from the patches located inside of work clothing;
Non-protected data were from the patches located outside of work clothing.
d Calculations were rechecked to verify the high value. Although Applicator 6 was an extreme outlier, it was kept in the estimate for this scenario as there was no reasonable justification to remove it.
e Lost in laboratory accident.

The hand exposures were monitored using white cotton gloves worn over latex gloves (Table 42). The white cotton gloves were the sampling media, and the latex gloves protected the cotton gloves from contamination from the workers' hands as well as protecting the workers.

Table 42. Acephate Found on White Cotton Gloves of Golf Course Mixer/Loaders and Applicators[a,b].

Workers	Acephate (µg)
Mixer/Loaders:	
M/L-1	4034
M/L-2	9773
M/L-3	12425
M/L-4	3753
M/L-5	80075
M/L-6	3087
M/L-7	30740
M/L-8	38760
M/L-9	7025
M/L-10	3913
M/L-11	1126
M/L-12	5358
Applicators:	
A-1	3638
A-2	1247
A-3	488
A-4	796
A-5	14
A-6	402
A-7	260
A-8	488
A-9	1105
A-10	855
A-11	282
A-12	1330

[a] The data based on the study by Chevron Chemical Company (Merricks, 1987c).
[b] MDL (minimal detection limit) = 2.0 µg.

Respiratory exposure was monitored using personal air sampling pumps worn throughout the exposure period (Table 43). The air monitoring devices drew air through two polyurethane foam plugs placed in the handlers' breathing zone.

Table 43. Acephate Found in Polyurethane Foam Filters of Golf Course Mixer/Loaders and Applicators[a,b].

Workers		Acephate (µg)
Mixer/Loaders:	M/L-1	1.7
	M/L-2	<1.0
	M/L-3	2.3
	M/L-4	1.4
	M/L-5	2.0
	M/L-6	<1.0
	M/L-7	<1.0
	M/L-8	<1.0
	M/L-9	<1.0
	M/L-10	1.1
	M/L-11	<1.0
	M/L-12	<1.0
Applicators:	A-1	<1.0
	A-2	<1.0
	A-3	<1.0
	A-4	<1.0
	A-5	<1.0
	A-6	<1.0
	A-7	<1.0
	A-8	<1.0
	A-9	<1.0
	A-10	<1.0
	A-11	<1.0
	A-12	<1.0

[a] The data based on the study by Chevron Chemical Company (Merricks, 1987c).
[b] MDL (minimal detection limit) = 1.0 µg.

Since the Tyvek is chemical-resistant, DPR considered the protected patches (located inside of Tyvek overall) data were inaccurate for estimating the exposure. Therefore, the non-protected patches data were used to estimate the exposure of mixer/loaders. The product labels require handlers must wear long pants and long-sleeved shirt, so the non-protected patches data were corrected by adjusting 90% protection factor (Aprea *et al*, 1994). The results demonstrated that hand residues were very high for mixer/loaders and applicators. The mixer/loaders had higher dermal exposure than applicators do. The mixer/loaders were exposed to low respiratory levels of acephate. The laboratory detection limits were 1.0 µg/foam plug, 0.01 µg/cm^2 for the patches, and 2.0 µg per pair of gloves. The average recoveries were 86% for patches, 80% for gloves and 91% for filters fortified at 10, 100, and 1000 µg of acephate. The exposure estimates in this document were adjusted by these recoveries.

Based on available data, the dermal residue levels at various sites were summarized in Table 44. The body exposures were based on protected data, as product label requires handlers to wear long pants, and long sleeved-shirts. Hand data were multiplied by a 0.1 protection factor for use of chemical-resistant gloves based on requirement of the product label. Absorbed daily dosage (ADD) is calculated based on exposure levels, application rate, dermal absorption rate and body weight.

Table 44. Estimated Dermal Exposure to Acephate of Golf Course Mixer/Loaders and Applicators[a].

	Regional Exposure (µg) [b]									Total Exposure[c] (µg)	Exposure[d] (µg/lb AI)	ADD [e] (µg/kg/ day)
	Hands[f]	Head	Neck[g]	Back	Chest	Upper Arms	Forearms	Thighs	Lower Legs			
Mixer/Loaders:												
M/L -1	504.25	56.0	10.8	29.6	7.4	20.0	15.0	16.5	5.5	665.0	41.6	9.1
M/L -2	1221.6	7.0	1.4	3.7	3.7	3.3	17.7	2.1	1.4	1261.9	78.9	17.2
M/L -3	1553.1	14.0	2.7	11.1	1.8	3.3	39.6	12.3	82.7	1720.7	107.5	23.5
M/L -4	469.13	7.0	1.4	11.1	1.8	5.0	42.3	8.2	1.4	547.3	34.2	7.5
M/L -5	10009	42.0	8.1	14.8	7.4	8.3	32.7	32.9	5.5	10161.2	1270.1	277.0
M/L -6	385.88	7.0	1.4	3.7	3.7	0.8	8.2	4.1	2.8	417.5	52.2	11.4
M/L -7	3842.5	14.0	2.7	14.8	7.4	5.0	17.7	65.9	1.4	3971.4	496.4	108.3
M/L -8	4845	14.0	2.7	7.4	7.4	3.3	12.3	65.9	1.4	4959.3	619.9	135.2
M/L -9	878.13	14.0	2.7	11.1	1.8	5.0	8.2	8.2	1.4	930.6	116.3	25.4
M/L-10	489.13	7.0	1.4	14.8	1.8	3.3	6.8	8.2	16.5	549.0	68.6	15.0
M/L-11	140.75	7.0	1.4	1.8	1.8	0.8	5.5	0.8	1.4	161.3	20.2	4.4
M/L-12	669.75	7.0	1.4	7.4	1.8	3.3	6.8	16.5	2.8	716.7	89.6	19.5
Mean	2084.1	16.3	3.2	10.9	4.0	5.1	17.7	20.1	10.3	2171.8	249.6	54.4
SD[i]	2896.9	15.9	3.1	7.4	2.6	5.1	13.2	23.0	23.2	2926.2	374.9	81.8
Applicators:												
A-1	454.8	42.0	10.8	1.8	11.1	10.0	5.5	32.9	2.8	571.7	35.7	7.8
A-2	155.9	70.0	1.4	7.4	18.5	6.7	10.9	37.0	13.8	321.5	20.1	4.4
A-3	61	42.0	2.7	11.1	1.8	3.3	2.7	8.2	2.8	135.7	8.5	1.8
A-4	99.5	56.0	1.4	103.5	7.4	6.7	5.5	20.6	19.3	319.7	20.0	4.4
A-5	1.8	7.0	8.1	1.8	1.8	0.8	2.7	2.1	22.0	48.2	6.0	1.3
A-6	50.3	7.0	1.4	1.8	14.8	0.8	0.7	2618.0	7793.4	10488.1	1311.0	285.9
A-7	32.5	28.0	2.7	1.8	3.7	10.0	8.2	45.3	46.8	179.1	22.4	4.9
A-8	61	56.0	2.7	11.1	7.4	18.3	15.0	8.2	24.8	204.6	25.6	5.6
A-9	138.1	7.0	2.7	1.8	1.8	0.8	0.7	8.2	NA[h]	161.3	20.2	4.4
A-10	106.9	14.0	1.4	7.4	7.4	8.3	6.8	2.1	5.5	159.7	20.0	4.4
A-11	35.3	14.0	1.4	11.1	1.8	3.3	2.7	4.1	5.5	79.2	9.9	2.2
A-12	166.3	7.0	1.4	1.8	1.8	0.8	0.7	2.1	1.4	183.3	22.9	5.0
Mean	113.6	29.2	3.2	13.5	6.6	5.8	5.2	232.4	721.6	1071.0	126.9	27.7
SD[i]	119.3	23.1	3.1	28.6	5.7	5.3	4.5	751.4	2345.5	2968.9	373.0	81.3

a Since the product label requires the handler to wear chemical-resistant gloves, long pants, and long-sleeved shirt, the body exposure is based on non-protected values, which were adjusted with 90% protection factor (Table 40 and 41). The head and neck exposure is based on non-protected values (Table 40 and 41). The values in this table are adjusted by recoveries, the adjusted value (µg) = raw value (µg) / recovery adjustment factor. Average recoveries were 86% for patches, 80% for gloves at 10, 100, and 1000 µg of acephate.

b
- Regional exposure (µg) = Average exposure (µg/cm^2) * body surface area (BSA, cm^2), except hand data which is based on the data in Table 40, 41, and Table 30 (body surface area).
- For those values less than minimal detection limit (MDL), half of MDL are used in the calculation.

c Total exposure = Sum of regional exposure.

d Dermal exposure (µg/lb AI) = Total dermal exposure (µg)/amount each handler used * 75% AI. The tested acephate levels from patches and cotton gloves include mixing 6 or 12 1-lb cans of Orthene 75S (depending upon site). Based on original study, M/L-1 to M/L-4 and A-1 to A-4 handled 12 1-lb cans of product, while M/L-5 to M/L-12 and A-5 to A-12 handled 6 1-lb cans of product.

e ADD (Absorbed Daily Dosage) = Exposure (µg/lb AI) * application rate * maximum amount/day * absorption rate ÷ body weight.

Table 44 continued:

Calculation assumptions include:

- Maximum application rate = 5.0 lb AI/acre based on the product label.
- The maximum amount used every day is 40 gallons based on RED (U.S. EPA, 2000a).
- Absorption rate = 7.6% (see dermal absorption section).
- Default body weight = 69.7 kg (U.S. EPA, 1997a).

f Since the product label requires the handler to wear chemical-resistant gloves, the hand data is multiplied by 0.1 for use of chemical-resistant gloves (Aprea *et al.,* 1994).

g The exposure values for neck = Acephate levels for head * area of neck.

h Lost in laboratory accident.

i SD = standard deviation.

Table 45 shows calculated inhalation exposure of golf course mixer/loaders and applicators based on data in Table 43.

Table 45. Estimated Inhalation Exposure of Pesticide Handlers to Acephate from the Application to Golf Courses.

Workers	Acephate[a] (µg)	Inhalation Exposure[b] (µg/lb AI)	ADD[c] (µg/kg/day)
Mixer/Loaders:			
M/L -1	1.9	0.12	0.34
M/L -2	0.5	0.03	0.10
M/L -3	2.5	0.16	0.45
M/L -4	1.5	0.10	0.28
M/L -5	2.2	0.27	0.79
M/L -6	0.5	0.07	0.20
M/L -7	0.5	0.07	0.20
M/L -8	0.5	0.07	0.20
M/L -9	0.5	0.07	0.20
M/L-10	1.2	0.15	0.43
M/L-11	0.5	0.07	0.20
M/L-12	0.5	0.07	0.20
Mean	1.10	0.10	0.30
SD[d]	0.7	0.07	0.19
Applicators:			
A-1	0.5	0.03	0.10
A-2	0.5	0.03	0.10
A-3	0.5	0.03	0.10
A-4	0.5	0.03	0.10
A-5	0.5	0.07	0.20
A-6	0.5	0.07	0.20
A-7	0.5	0.07	0.20
A-8	0.5	0.07	0.20
A-9	0.5	0.07	0.20
A-10	0.5	0.07	0.20
A-11	0.5	0.07	0.20
A-12	0.5	0.07	0.20
Mean	0.5	0.06	0.16
SD[d]	0.0	0.02	0.05

a The acephate levels (µg) are from Table 43. One-half the MDL was substituted for values below the MDL. The values in this table are adjusted by recoveries. Average recoveries were 91% for filters fortified at 10, 100, and 1000 µg of acephate.

b Inhalation exposure (µg/lb AI) = Inhalation exposure (µg)/amount each handler used * 75% active ingredient (AI). Polyurethane foam plugs were worn throughout the exposure period. Based on original study, M/L-1 to M/L-4 and A-1 to A-4 handled 12 1-lb cans of product, while M/L-5 to M/L-12 and A-5 to A-12 handled 6 1-lb cans of product.

c ADD (Absorbed Daily Dosage) = Exposure (µg/lb AI) * application rate * maximum amount/day * absorption rate ÷ body weight.
Calculation assumptions include:
- Maximum application rate = 5.0 lb AI/acre.
- The maximum amount used/day is 40 gallons based on the RED (U.S. EPA, 2000a).
- Inhalation absorption rate is assumed to be 100%.
- Default body weight = 69.7 kg (U.S. EPA, 1997a).

d SD = standard deviation.

Table 46 shows the total ADD with the combined the dermal and inhalation ADD, and the standard deviation.

Table 46. Total Absorbed Daily Dosage (ADD) of Golf Course Pesticide Handlers to Acephate.

Workers	Dermal ADD[a] (µg/kg/day)	Inhalation ADD[b] (µg/kg/day)	Total ADD[c] (µg/kg/day)
Mixer/Loaders:			
1	9.1	0.34	9.40
2	17.2	0.10	17.30
3	23.5	0.45	23.90
4	7.5	0.28	7.74
5	277.0	0.79	278.00
6	11.4	0.20	11.60
7	108.3	0.20	108.50
8	135.2	0.20	135.00
9	25.4	0.20	25.60
10	15.0	0.43	15.40
11	4.4	0.20	4.59
12	19.5	0.20	19.70
Mean	54.4	0.30	54.74
SD[d]	81.8	0.19	81.88
Applicators:			
1	7.8	0.10	7.89
2	4.4	0.10	4.48
3	1.8	0.10	1.95
4	4.4	0.10	4.46
5	1.3	0.20	1.51
6	285.9	0.20	286.10
7	4.9	0.20	5.08
8	5.6	0.20	5.77
9	4.4	0.20	4.55
10	2.2	0.20	2.36
11	5.0	0.20	5.19
12	4.4	0.20	4.59
Mean	27.7	0.16	29.94
SD[d]	81.3	0.05	84.98

a Dermal ADD data from Table 44.
b Inhalation ADD data from Table 45.
c Total ADD is the combined dermal ADD and inhalation ADD.
d SD = Standard deviation.

Acephate is applied on golf courses for fire ant control, and is not applied more than once per year (U.S. EPA, 2001a). Therefore, only acute exposure was estimated in this document (Table 47).

Table 47. Estimated Short-Term Exposure of Handlers to Acephate from the Application to Golf Courses.

Workers[a]	Acute ADD[b] (µg/kg/day)	Exposure Months[c]	SADD[d] (µg/kg/day)	AADD[d] (µg/kg/day)	LADD[d] (µg/kg/day)
M/L	191.0	< 1	-	-	-
Appl	56.4	< 1	-	-	-

a M/L = Mixer/loader; Appl = Applicator.

b Acute ADD is an upper-bound estimate (95th percentile estimate, Powell, 2006), based on the arithmetic mean (AM) and standard deviation (SD) of the log-transformed ADD, then calculating: 95th percentile = Antilog (AM + 1.645 * SD).

c Based on use history information provided in the Pesticide Use Report (DPR, 2006b), during last 7 years, no acephate was used on golf course turf.

d Since minimal acephate was used for golf courses, only acute exposure was estimated, and intermediate- and long-term exposures were not estimated in this document.

3.1.2 Post-application dermal exposure of golfers and mowers from residues on turf

Based on use history information provided in the Pesticide Use Report (DPR, 2006b), during last 5 years, no acephate was used on golf course turf, although this chemical is allowed to be applied on golf course turf. Therefore, only acute exposure was estimated, and intermediate- and long-term exposures were not estimated in this document.

Table 48. Estimated Exposure of Mowers and Golfers to Acephate Following the Application of Acephate to Golf Courses.

Exposed People	REI[a] (day)	TF[b] (cm^2/hr)	TTR[c] (µg/cm^2)	Acute ADD[d] (µg/kg/day)	Exposure Months[e]	SADD[f] (µg/kg/day)	AADD[f] (µg/kg/day)	LADD[f] (µg/kg/day)
Mowers	0	500	0.2890	1.26	< 1	-	-	-
Golfers	0	100	0.2890	0.13	< 1	-	-	-
Maintainers	0	16500	0.2890	20.80	< 1	-	-	-

a Since product label stated that the REI (restricted entry interval) for non-agricultural reentry is "spray is dry," the REI is assumed to be zero.

b TF (transfer factor) value for mowers workers are taken from U.S. EPA (2000b); TF value for golfers are based on the RED (U.S. EPA, 2000a); TF value for maintainers using TF value for golf course turf transplanting, which are taken from U.S. EPA (2000b).

c TTR (turf transferable residues) values at the REI, see Dislodgeable Foliar Residues section.

d Acute ADD = DFR value on the expiration of the REI * TF * exposure hour(s) * dermal absorption rate ÷ body weight.

Calculation assumptions include:

- Exposure hours for mowers was assumed to be 8 hours per day;
  Exposure hours for golfers was assumed to be 4 hours (golfing 18 holes).
- Dermal absorption rate = 7.6% (see Dermal Absorption section).
- Body weight = 69.7 kg (U.S. EPA, 1997a).

e Based on use history information provided in the Pesticide Use Report (DPR, 2006b), during last 5 years, no acephate was used on golf course turf.

f Since during last five years, there is no record of applying acephate to golf course turf in California (DPR, 2006b), only acute exposure was estimated, and intermediate- and long-term exposure were not estimated in this document.

3.2. Other Recreational Areas Uses

Acephate may be applied to other recreational areas, including tennis courts, parks, etc. Since no exposure studies are available for these sites, the exposure estimates for these sites and scenarios are covered by representative scenarios with enough data.

3.2.1 Tennis Courts

Tennis court handler's and maintenance worker's exposures are covered by the golf course handler and maintenance worker's exposure. Tennis player's exposure is covered by golfer's exposure.

3.2.2. Parks

Park turf grass mower's and maintenance worker's exposures are covered by golf course mower's and maintenance worker's exposure. The exposure of player (adult and/or children) in park is covered by the exposure of player (adult and/or children) on home yard turf grass.

4. Summary of All Exposure Scenarios

In order to make it convenient for comparing exposure results of various activities, all scenarios are summarized in Table 49. Table 50 shows the highest exposure estimates for each exposure scenario. For example, among aerial application mixing/loading activities, exposure of mixer/loaders for turf applications is ranked the highest exposure. Therefore, this exposure scenario is taken and shown in Table 50 for the aerial application mixing/loading scenario. If a mitigation measure is needed, depending on the margins of exposure, exposure estimates shown in Table 49 should be used in the mitigation process.

Table 49. Summary of Exposure Estimates for Agriculture (Ag), Residential/Institutional and Golf-Course Handler/Post-Application Exposure to Acephate from Monitoring Studies and the Pesticide Handler Exposure Database).

Scenarios [a]	FM[b]	Use Rate[c] (lb AI/A or gal)	Acute ADD[d] (µg/kg/day)	SADD[e] (µg/kg/day)	AADD[f] (µg/kg/day)	LADD[g] (µg/kg/day)
Agricultural Handlers						
Aerial						
M/L[h]	WSP	Cotton =1.0	52.0	9.6	4.0	2.1
M/L	SP	Ag = 1.0	7580.0	1680.0	701.0	374.0
	SP	Turf[i] = 5.0	11100.0	-	-	-
	SP	Pasture = 0.125	276.0	61.3	25.5	13.6
Applicator		Ag = 1.0	1220.0	408.0	170.0	90.8
		Turf[i] = 5.0	1770.0	-	-	-
		Pasture = 0.125	76.4	14.9	6.2	3.3
		Forest = 0.75	458.0	306.0	128.0	68.1
Flagging		Ag = 1.0	185.0	46.2	19.3	10.3
		Turf[i] = 5.0	270.0	-	-	-
		Pasture = 0.125	6.7	1.7	0.7	0.4
		Forest = 0.75	139.0	34.7	14.4	7.7
Ground M/L						
Groundboom	SP	Ag = 1.0	1260.0	280.0	164.0	87.2
	SP	Pasture = 0.125	63.1	14.0	8.2	4.4
	SP	Turf[i] = 5.0	2530.0	-	-	-
	SP	Golf Course Turf[j] = 5.0	1260.0	-	-	-
Airblast	SP	Non-Bearing Citrus = 0.5	126.0	28.0	16.3	8.7
	SP	Trees/Shrubs = 1.0 lb/100 gal	63.1	14.0	8.2	4.4
	SP	Outdoor Floral = 0.5 lb/100 gal	31.6	7.0	4.1	2.2
Handgun	SP	Trees, Shrubs, Outdoor Floral Crops = 1.0 lb/100 gal	63.1	14.0	8.2	4.4
	SP	Turf[i] = 5.0	158.0	-	-	-
Slurry Seed Treatment	SP	Cotton Seed = 0.04 lb/100 lb seed	505.0	112.0	65.4	34.9
Hopper Box[h]	SP	Cotton Seed = 0.225	7490.0	1310.0	765.0	406.0
Chemigation	SP	Cranberries = 1.0	115.0	42.0	24.5	13.1
Slurry Seed Treatment	DF	Cotton Seed = 0.04 lb/100 lb seed	63.6	15.9	9.3	5.0
Tractor-Drawn Spreader	G	Cotton = 1.0	47.5	11.9	6.9	3.72
	G	Turf[i] = 5.0	95.0	-	-	-
	G	Golf Course Turf[j] = 5.0	47.5	-	-	-

Table 49. Summary of Exposure Estimates for Agriculture, Residential/Institutional and Golf-Course Handler/Post-Application Exposure to Acephate from Monitoring Studies and the Pesticide Handler Exposure Database (continued).

Scenarios [a]	FM[b]	Use Rate[c] (lb AI/A or gal)	Acute ADD[d] (µg/kg/day)	SADD[e] (µg/kg/day)	AADD[f] (µg/kg/day)	LADD[g] (µg/kg/day)
Ground Application						
Groundboom	SP	Ag = 1.0	35.8	8.9	5.2	2.8
		Pasture = 0.125	3.6	0.9	0.4	0.3
		Turf[i] = 5.0	71.6	-	-	-
		Golf Course Turf[j] =5.0	35.8	-	-	-
Airblast	SP	Non-bearing citrus = 0.5	87.0	21.7	12.7	6.8
		Trees & Shrubs = 1.0 lb/100 gal	104.4	26.0	15.2	8.1
		Outdoor Floral = 0.5 lb/100 gal	52.2	13.0	7.6	4.1
Handgun	SP	Trees, Shrubs, Outdoor Floral Crops = 1.0 lb/100 gal	468.0	187.0	109.0	58.3
		Turf[i] = 5.0	1170.0	-	-	-
Tractor-Drawn Drop- Type Spreader	G	Cotton = 1.0	4.6	1.1	0.7	0.4
		Turf[i] = 5.0	9.1	-	-	-
		Golf Course Turf [jk] = 5.0	4.6	-	-	-
Paintbrush	WP	Window Frame etc. = 0.083 lb/gal, 2 gal/event (U.S. EPA, 1997b)	62.2	-	-	-
Ground M/L/A						
Hopper Box [h]	SP	Cotton Seed = 0.225	542.0	111.0	64.6	34.4
Low Pressure Hand Wand	SP	Trees, Shrubs, Roses, Ground Cover, Floral Crops = 1.0 lb/100 gal	57.2	11.4	6.7	3.6
		Wasps=0.075 lb/l gal	53.6	10.7	6.3	3.3
Backpack Sprayer	SP/WP	Trees, Shrubs, Roses, Ground Cover, Floral Crops = 1.0 lb/100 gal	59.0	19.7	11.5	6.1
		Wasps = 0.075 lb/l gal	55.3	18.4	10.7	5.7
High Pressure Sprayer	SP	Trees, Shrubs, Roses, Ground Cover, Floral Crops = 1.0 lb/100 gal	468.0	187.0	109.0	58.3
Belly Grinder	G	Trees, Shrubs, Ornamentals = 0.1125 lb/1000 sq ft	1170.0	292.0	171.0	91.0
Shaker Can/Handtool	G	Trees, Shrubs, Ornamentals = 0.1125 lb/1000 sq ft	134.0	33.6	19.6	10.5
		Fire ants [k] = 2 tsp/mound (0.00694 lb/5 gal)	8.3	-	-	-
By Hand	G	0.00099 lb per pot up to 12 in diameter.	546.0	109.0	63.8	34.0
		Fire ants[k] = 2 tsp/mound (0.008 lb/mound)	44.2	-	-	-
		Trees, Shrubs, Ornamentals = 0.1125 lb/1000 sq ft	62.1	12.4	7.2	3.9

Table 49. Summary of Exposure Estimates for Agriculture, Residential/Institutional and Golf-Course Handler/Post-Application Exposure to Acephate from Monitoring Studies and the Pesticide Handler Exposure Database (continued).

Scenarios [a]	FM[b]	Use Rate[c] (lb AI/A or gal)	Acute ADD[d] (µg/kg/day)	SADD[e] (µg/kg/day)	AADD[f] (µg/kg/day)	LADD[g] (µg/kg/day)
Field Workers						
Cotton Scout			32.7	1.9	0.63	0.33
Cauliflower Harvest			1.6	0.5	0.47	0.25
Succulent Bean Harvest			0.8	0.1	0.01	0.005
Citrus Pruning			163.0	68.3	28.5	15.2
Stone Fruit Thinning[i]			433.0	-	-	-
Greenhouse Rose Pruning and Harvest			7.4	5.9	5.85	3.12
Grape Tying & Pruning			89.8	-	-	
Nursery Ornamental Pruning and Harvest			4.2	-	-	
Turf Mowing[i]			1.0	-	-	
Turf Harvest[i]			12.9	-	-	
Residential and Institute Handlers (M/L/A) [l]						
Low Pressure Hand Wand		Ornamentals, Flowers, Shrubs, Trees, Fire Ants = 0.023 lb/gal	6.6	-	-	-
Backpack Sprayer		Turf = 0.035 lb/gal	10.3	-	-	-
		Fire Ant (non-crop) = 0.47 lb/5 gal	68.9	-	-	-
		PCO (0.088n lb/gal)	516.0	-	-	-
Hose-End Sprayer		Fire Ants = 0.023 lb/gal	56.8	-	-	-
		Turf = 0.035 lb/gal	86.5	-	-	-
		Roses, Flowers, Shrubs, trees = 0.0076 lb/gal	18.8	-	-	-
		Ornamentals and Turf = 0.058 lb/1000 sq ft	57.3	-	-	-
Hose-End Sprayer[h]		Ornamentals, Shade Trees, Hedges = 0.01175 lb/gal	171.0	-	-	-
Sprinkling Can		Ornamentals, Flowers, Shrubs, Trees, Fire Ants = 0.023 lb/gal	NA	-	-	-
		Turf = 0.035 lb/gal	NA	-	-	-
		Roses, Flowers, shrubs, Trees = 0.0076 lb/gal	NA	-	-	-
Handtool/Shaker Can		Fire Ants = 0.0069 lb/mound	5.6	-	-	-
Shaker Cup		Ornamentals = 0.5 lb/1000 sq ft	5.8	-	-	-
		Roses = 0.1125 lb /1000 sq ft	1.3	-	-	-
Aerosol Can		Crack & Crevice = 0.01 lb/can	27.7	-	-	-
		Ornamentals = 0.03 lb/can	83.0	-	-	-
Low Pressure Hand Wand		Wasps = 0.075 lb/l gal	53.6	-	-	-

Table 49. Summary of Exposure Estimates for Agriculture, Residential/Institutional and Golf-Course Handler/Post-Application Exposure to Acephate from Monitoring Studies and the Pesticide Handler Exposure Database (continued).

Scenarios [a]	FM[b]	Use Rate[c] (lb AI/A 0r gal)	Acute ADD[d] (µg/kg/day)	SADD[e] (µg/kg/day)	AADD[f] (µg/kg/day)	LADD[g] (µg/kg/day)
Low Pressure Hand Wand		Fire Ant (non-crop) = 0.47 lb/5 gal	67.2	-	-	-
Low Pressure Hand Wand[h]		PCO (residential sites) = 0.088 lb/gal	57.8	-	-	-
		PCO (commercial sites) = 0.088 lb/gal	62.6	-	-	-
Paintbrush		Window Frame = 0.083 lb/gal	65.6	-	-	-
Residential Post-Application						
Residential Lawns						
Adult Dermal		Turf = 5.0	9.1	-	-	-
Children Dermal		Turf = 5.0	15.1	-	-	-
Children Hand-to-Mouth		Turf = 5.0	3.8	-	-	-
Children Grass Ingestion		Turf = 5.0	0.5	-	-	-
Residential Indoor						
Adult Dermal (Hard Surface)		Crack/crevice, Spot Spray = 0.088 lb/gal	0.60			
Children Dermal (Hard Surface)		Crack/crevice, Spot Spray = 0.088 lb/gal	1.00			
Adult Dermal (Carpet)		Spot Spray = 0.088 lb/gal	0.60			
Children Dermal (Carpet)		Spot Spray = 0.088 lb/gal	1.00			
Children Hand-to-Mouth		Spot Spray = 0.088 lb/gal	0.22			
Golf Course Handlers						
M/L[h]		5.0 lb AI/acre	191.0	-	-	-
Applicator[h]		5.0 lb AI/acre	56.4	-	-	-
Golf Course Post-Application						
Mowers		Turf = 5.0	1.3	-	-	-
Golfers		Turf = 5.0	0.1	-	-	-
Maintenance Worker (by hand)		Turf = 5.0	20.8	-	-	-

a The exposure scenarios are based on the RED (U.S. EPA, 2001a).
d Acute Absorbed Daily Dosage (ADD) is 90% upper confidence limit for the 95th percentile estimate (Powell, 2002), the calculations are shown in Appendices.
e Seasonal Average Daily Dosage (SADD) is a 90% upper confidence estimate of absorbed dose (Powell, 2002), the calculations are shown in Appendices.
f Annual Average Daily Dosage (AADD) = SADD * annual use months per year/12 months in a year. The estimated high-use season for handler was based on California Pesticide Use Report Database (DPR, 2006b, see text and Figure 6).
g Lifetime Annual Daily Dosage (LADD) = AADD * 40 years of work in a lifetime/75 years in a lifetime.
h Indicates the estimate is based on a monitoring study.
i Since acephate was minimally applied to these sites in California (DPR, 2006b and 2007), only acute ADDs were estimated in this document.
j Since during last seven years, there is no record of applying acephate to golf course turf in California (DPR, 2006b), only acute exposure was estimated, and intermediate- and long-term exposure were not estimated in this document. The use rate in the monitoring study was 3.9 lb AI/acre, it was adjusted to 5.0 lb AI/acre according to the product labels allowed maximum use rate.

k Since acephate is not recommended chemical in the California Department of Food and Agriculture (CDFA) eradication program, it is minimally used to control the fire ants in California. Therefore, only acute absorbed daily dosage was estimated in this document.

l Due to the frequency and duration of acephate uses, it was determined that uses of acephate by residential and institutional pesticide applicators result in short-term exposures to these applicators.

Table 50. Summary of Highest Exposure Estimates for Agriculture (Ag), Residential/Institutional and Golf-Course Handler/Post-Application Exposure to Acephate from Monitoring Studies and the Pesticide Handler Exposure Database[a].

Scenarios[a]	Use Rate[a] (lb AI/A or gal)	Acute ADD[b] (µg/kg/day)	SADD[c] (µg/kg/day)	AADD[d] (µg/kg/day)	LADD[e] (µg/kg/day)
Agricultural Handlers					
Aerial[f]					
M/L	Ag = 1.0	7580.0	1680.0	701.0	374.0
Applicator	Ag = 1.0	1220.0	408.0	170.0	90.8
Flagger	Ag = 1.0	185.0	46.2	19.3	10.3
Ground M/L[f,g]					
Groundboom	Ag = 1.0	1260.0	280.0	163.0	87.2
Ground Application[f]					
Handgun	Trees, Shrubs, Outdoor Floral Crops = 1.0 lb/100 gal	468.0	187.0	109.0	58.3
Ground M/L/A					
Belly Grinder	Trees, Shrubs, Ornamentals = 0.1125 lb/1000 sq ft	1170.0	292.0	171.0	91.0
Field Workers					
Citrus Pruning[h]		163.0	68.3	28.5	15.2
Residential and Institute Handlers (M/L/A)					
Hose-End Sprayer	Ornamentals, Shade Trees = 0.01175 lb/gal	171.0			
Residential Post-Application					
Adult Dermal		19.0			
Children Dermal		17.7			
Children Hand-to-Mouth		3.7			
Golf Course Handlers[i]					
M/L	5.0 lb AI/acre	191.0	-	-	-
Golf Course Post-Application[i]					
Maintenance Workers		20.8	-	-	-

a The data from Table 49. The purpose of this table is to show the highest exposure estimate for each exposure scenario.

b Acute Absorbed Daily Dosage (ADD) is 90% upper confidence limit for the 95th percentile estimate (Powell, 2002), the calculations are shown in Appendices.

c Seasonal Average Daily Dosage (SADD) is a 90% upper confidence estimate of absorbed dose (Powell, 2002), the calculations are shown in Appendices.

d Annual Average Daily Dosage (AADD) = SADD * annual use months per year/12 months in a year. The estimated high-use season for handler was based on California Pesticide Use Report Database (DPR, 2006b, see text and Figure 6).

e Lifetime Annual Daily Dosage (LADD) = AADD * 40 years of work in a lifetime/75 years in a lifetime.

f In these scenarios, the highest exposure were handlers of acephate on turf. However, based on pesticide use report (DPR, 2006b), acephate was minimally applied to turf in California, and therefore only acute ADD was estimated in this document. Considering the highest exposure scenario shown in this table should represent high exposure in all of acute ADD, SADD, AADD, and LADD, therefore the highest exposure sites next to turf were listed in this table.

g For the ground mixer/loader scenarios, the highest exposure was loader/seed treater using a hopper box. However, due to a lack of information, the worst case exposure was estimated based on the assumption that a worker was loading/treating seed for whole day though it seems unpractical. Thus the highest ground mixer/loader exposure scenario shown in this table is for groundboom applications.

h For field worker post-application scenarios, the highest exposure was stone fruit thinning. However, based on pesticide use report (DPR, 2007), acephate was minimally applied to these fruit trees in California, and therefore only acute ADD was estimated in this document. The highest exposure scenario shown in this table should represent high exposure for acute ADD, SADD, AADD, and LADD, therefore the highest exposure sites next to these fruit trees was listed in this table. Another reason for not list stone fruit tree thinning exposure in this table is DFRs used for this exposure are surrogate data due to lack of the original studies. Therefore, citrus tree pruning was list in this table.

i In last seven years, there are no records of acephate applications to golf courses in California (DPR, 2006b), thus only acute exposure was estimated.

VII. EXPOSURE APPRAISAL

1. Use PHED Data as Surrogate to Estimate Dermal and Inhalation Exposure.

For agricultural uses, there were only two chemical-specific monitoring studies; they involved mixer/loaders for cotton aerial application, and loader/treater/planters using a hopper box. Most handler exposure scenarios lack chemical-specific handler exposure data for acephate, and therefore, PHED was used. Comparing the results from the monitoring study and PHED, we found that the estimated exposure calculated from the monitoring study of mixer/loaders for aerial application to cotton (Acute ADD = 50.2 μg/kg/day) is much lower than exposure calculated from PHED (Acute ADD = 7580.0 μg/kg/day) at the same application rate. However, the chemical specific monitoring study used a pellet formulation, while PHED only provides the scenario of exposure to wettable powder. Since the use of pellets would be expected to result in lower exposures than powder formulations, any application of powder formulation allowed by the product labels should based on the estimates from the surrogate data estimates. If everything else is equal, chemical-specific data are generally considered more reliable than surrogate data, which combines exposure data from multiple field monitoring studies of different AIs.

For those scenarios without chemical-specific data we relied on PHED (1995) as surrogate. However, PHED, though useful, has limitations as a surrogate database. It combines measurements from studies conducted using different protocols, analytical methods and residue detection limits. Most dermal exposure studies in the PHED use the patch dosimetry method of Durham and Wolfe (1962); residues on small patches placed on different regions of the body are extrapolated to estimate exposure to that region. In some of these studies, patches are placed on only a few body regions, such as the hands, arms and face. As a consequence, the estimate of dermal exposure for each body region is based on a different set of individuals. For some handler scenarios, the number of matching observations in the PHED is sufficiently small that the possibility they do not represent the target scenario is substantial. Due to the degree of uncertainty introduced by using this surrogate data, WHS calculates upper confidence limits on the exposure statistics to increase the confidence in the estimates of exposure. Without acceptable chemical-specific exposure monitoring data available, applying exposure data from PHED provides the best exposure estimates. U.S. EPA also relied on PHED data for handler exposure estimates (U.S. EPA, 2000a).

Data quality grades in PHED have been assigned based on Quality Assurance/Quality Control data provided in exposure study reports. Grades A and B are high-quality grades, with lab recoveries of 90-110% and 80-100%, respectively (field recoveries range 70-120% and 50-120%). Grade C represents moderate quality, with lab and field recoveries of 70-120% and 30-120%, respectively. Grade D and E are the lowest quality grades, and are assigned to PHED data that do not meet basic quality assurance (U.S. EPA, 1998).

In this document, PHED was used to estimate 16 agricultural, and 7 residential/institutional dermal and inhalation handler exposure scenarios. These exposure values were used to calculate ADDs. Table 51 summarizes data quality grades and the number of observations for each PHED data set used in the exposure estimates.

Table 51. Data Quality in the Pesticide Handler Exposure Database Used to Estimate Handler Exposure [a]

Exposure Subsets [b]	Dermal Exposure		Hand Exposure		Inhalation Exposure		Appendix #
	Obs.[c]	Grade	Obs.[c]	Grade	Obs.[c]	Grade	
1. M/L (WP)	24-36	AB	20	AB	17	A	1
2. M/L (DF)	16-26	AB	21	AB	23	A	2
3. M/L (L)	72-122	AB	59	A	85	AB	3
4. Load (G)	3-36	A	45	AB	58	AB	4
5. Aerial Appl. (L)	10-17	AC	9	AC	14	BC	5
6. Groundboom Appl.	29-42	ABC	29	AB	22	AB	6
7. Airblast Appl.	32-49	AB	22	AB	47	AB	7
8. Appl. (G) with Broadcast Spreader	2-30	A	24	AB	37	AB	8
9. M/L/A (L) Backpack Sprayer	9-11	AB	11	C	11	AB	9
10. M/L/A (SP) LP Hand Wand	16	C	15	A	16	C	10
11. M/L/A HP Sprayer	7-13	A	13	C	13	A	11
12. L/A (SP) Using Hand/Handtool/Shaker Can	16	AC	15	C	16	AC	12
13. M/L/A Using Garden Hose End Sprayer	8	C	8	E	8	C	13
14. L/A (G) Using Push-Type Spreader	0-15	C	15	C	15	B	14
15. L/A (G) Using Belly Grinder	29-45	AC	23	C	40	AB	15
16. Flagger	18-28	A	30	AB	28	AB	16
17. Appl. Using Aerosol Can	15	A	15	A	15	A	17

[a] Data were from Pesticide Handlers Exposure Database (PHED, 1995). Data quality grades are described in Versar (1992).

[b] M/L = Mixer/loader; A = Applicator; M/L/A = Mixer/loader/applicator; L/A = Loader/applicator; Appl. = Applicator.
WP = Wettable powder; DF = Dry flowable; L = Liquid; G = Granule; SP = Soluble powder.
LP hand Wand = Low-pressure hand wand; HP sprayer = High-pressure sprayer.

[c] Obs. = Number of observations.

Results indicate that the dermal exposure assessment for subsets 1-4, 7-8, and subset 16-17 are made with high confidence. In these subsets the dermal and hand data quality was high (AB), and the observations are generally greater than 15. Although the lowest number of observations in subsets 4 and 8 are as low as 3 and 2, these observations are limited to neck data, and the observations for the rest of the body were greater than 15.

The dermal exposure assessment for subsets 6, 10, 12, 14 15 and 18 are made with medium confidence. In these subsets the dermal and data quality was moderate (including grade C), and the observations were equal to or greater than 15. The dermal exposure assessment for subsets 5, 9, 11, and 13 are made with low confidence since there were less than 15 observations per body part, although some had high data quality. Hand exposure assessments are made with high confidence for subsets 1-4, 6-8, 10, and 16-18, because the data qualities were high (A or B) and the observations were equal or greater than 15. Hand exposure assessments are made with medium confidence for subsets 12 and 14-15 as the data qualities were moderate (including grade C), and the observations were equal or greater than 15 in these subsets. Hand exposure assessments for subsets 5, 9, 11 and 13 are made with low confidence since there were less than 15 observations per body part, or data quality was poor (grade E in subset 13). Inhalation exposure assessments are developed with high confidence for subsets 1-4, 6-8, and 14-17, because the data qualities were high (A or B) and the observations were equal or greater than 15. Inhalation exposure assessments are made with medium confidence for subsets 10, 12, and 18 as the data qualities were moderate (including grade C), and the observations were greater than 15 in these subsets. Inhalation exposure assessments for subsets 5, 9, 11, 13, and 14 are made with low confidence since there were less than 15 observations per body part, although they had high or moderate data quality.

U.S. EPA also uses PHED to estimate handler exposure; however, U.S. EPA approaches PHED data somewhat differently than DPR. First, as explained in U.S. EPA's policy for use of PHED data (U.S. EPA, 1999): "Once the data for a given exposure scenario have been selected, the data are normalized (i.e., divided by) by the amount of pesticide handled resulting in standard unit exposures (milligrams of exposure per pound of active ingredient handled). Following normalization, the data are statistically summarized. The distribution of exposure values for each body part (i.e., chest upper arm) is categorized as normal, lognormal, or "other" (i.e., neither normal nor lognormal). A central tendency value is then selected from the distribution of the exposure values for each body part. These values are the arithmetic mean for normal distributions, the geometric mean for lognormal distributions, and the median for all "other" distributions. Once selected, the central tendency values for each body part are composited into a "best fit" exposure value representing the entire body." In other words, U.S. EPA uses various central tendency estimates (often the geometric mean or median, as PHED data rarely follow a normal distribution), while DPR believes the arithmetic mean is the appropriate statistic regardless of the sample distribution (Powell, 2003). Second, for acute exposure estimates DPR uses a 95th percentile upper bound estimate, while U.S. EPA uses a central tendency estimate for all exposure durations. Third, as explained in the Exposure Assessment section, DPR calculates upper 90% confidence limits for both upper bound and mean exposures, while U.S. EPA does not. (Note: DPR's policies for handling PHED data have been reviewed informally and are currently under formal review by a statistician at the University of California). The differences between exposure rate and acute exposure estimates calculated according to DPR and U.S. EPA policies are summarized in Table 52 for an example scenario, mixer/loader for agriculture aerial application. U.S. EPA values are from the RED document (U.S. EPA, 2000a). An acute ADD estimate based on data from Valent U.S.A. Corporation (Bruce *et al.*, 2002) is also

included in Table 52, for comparison with both estimates calculated with PHED surrogate data.

Table 52. Comparison of Aerial Mixer/Loader (Open System) Exposure to Acephate Estimated from Surrogate Data by DPR and U.S. EPA Policy with Chemical-Specific Exposure [a]

Exposure Estimate	Exposure Rate (µg AI/lb handled) [b]	Acute ADD (µg/kg/day) [c]
From PHED, according to DPR policy [d]	684.0	7580.0
From PHED, according to U.S. EPA (2000a) [e]	213.0	3660.0
From study, arithmetic mean of exposure data [f]	15.8	52.0

[a] In order to compare PHED values estimated from DPR, U.S. EPA, and monitoring study, the use rate was assumed to be 1.0 lb/acre according to the product label; the daily treated acres were assumed to be 1200 acres/day based on the RED document (2000a). However, note that U.S. EPA used the geometric mean, while DPR used the arithmetic mean. An arithmetic mean was used to calculate exposure for data from the monitoring study.

[b] Total exposure rate, dermal, hands plus inhalation. AI = Active ingredient.

[c] Acute Absorbed Daily Dosage (ADD) estimates assumed application rate of 1.0 lbs AI/acre, and an 8-hour workday. Amount treated was assumed to be 1200 acres treated/day (U.S. EPA, 2000a) for agriculture use. Dermal absorption was assumed to be 7.6% (see Section IV-1) for both DPR estimates and from the monitoring study, and 100% for U.S. EPA estimates (2000a). Inhalation absorption assumed to be 100% for the monitoring study, DPR estimates and U.S. EPA estimates, and the body weight was assumed to be 67.9 kg (U.S. EPA, 1997a) for both monitoring study calculations and DPR estimates, and 70 kg for U.S. EPA estimates (2000a).

[d] Department of Pesticide Regulation (DPR) policy is described in Exposure Assessment section. Exposure rate and acute ADD are from Table 19 and 20.

[e] U.S. Environmental Protection Agency (U.S. EPA) exposure estimates are obtained from U.S. EPA (2000a, Table 1 and 2 in Appendix A). Since the product labels require the handlers to wear chemical-resistant gloves, long pants, and a long-sleeved shirt, the hand PHED data were adjusted for wearing gloves. That adjustment also maintains consistency with the PPE conditions used in the monitoring study and DPR estimates. The daily treated acres were adjusted from 350 acres to 1200 acres.

[f] The monitoring study values come from Tables 11 – 14.

In Table 52, the exposure rates estimated according to DPR and U.S. EPA policies are 684.0 and 213.0 µg AI/lb handled, respectively. The exposure rate estimated from a monitoring study and DPR correction factors is 15.8 µg AI/lb handled. The acute ADDs estimated according to DPR and U.S. EPA policies are 7580.0 and 3660.0 µg/kg/day, respectively. The acute ADD estimate calculated from the monitoring study is 52.0 µg/kg/day. The above ADD calculation is based on treating 1200 acres per day for "typical" aerial applications to agricultural crops (U.S. EPA, 2000c). Since the product labels require the handlers to wear chemical-resistant gloves, long pants, and a long-sleeved shirt, the exposure values calculated by DPR from the monitoring study data and those calculated by DPR from PHED data are based on these requirements. In the RED document (U.S. EPA, 2000a), the exposure values were calculated based on either baseline (the handlers wearing long pants, long sleeved shirt, no gloves, open mixing/loading), or PPE values (the handlers using chemical-resistant gloves, an additional layer of clothing, and the use of an appropriate respirator). To compare the exposure data, and make the estimates according to the requirements on the product labels, the baseline values in the RED document (U.S. EPA, 2000a) were used, and hand data were adjusted for wearing gloves. It should also be noted that EPA used geometric means, while DPR used arithmetic means.

2. Estimating the Annual Exposure Frequency of Handlers and Field Workers Based on PUR Data.

PUR data were used to estimate likely months of exposure based on the distribution of applications in high-use California counties. These high-use periods describe potential work history of the handler population, and the exposure frequency probably overestimates the workdays for any single individual. While possible, it is unlikely for the same worker would apply acephate every day during the high-use period. In assuming this possibility, annual exposure estimate may be overestimates for typical workers.

3. Estimating the Field Worker Exposure Based on DFR Data.

For field worker exposure, the estimates derived from DFR served as the starting point. Since the DFR values are point estimates, it is not possible to derive the upper bound values for the exposures of field workers. In this assessment document, DFR on the first day after the REI had expired was used as the upper bound to estimate acute ADD. While that may overestimate the acute ADD for most workers, it is assumed to be a reasonable upper-bound estimate as field workers may enter the treated field on the expiration of REI.

Additionally, for seasonal exposure of field workers, this assessment uses DFR values on the expiration of REI plus 7 days (for most reentry activities), or DFR values on the expiration of PHI plus 10 days (for harvesting), as average DFR to calculate the SADD. For roses, which have intense activity close to the end of the PHI, seasonal exposure was estimated at an assumed average reentry REI plus 1 day for all activities. While this assumption may not cover every possible situation, for seasonal exposures, it is considered to be a reasonable, conservative (health protective) assumption.

4. Estimating the Dermal Absorption Rate Based on Animal Study.

The dermal absorption rate used in this document was estimated to be 7.6% based on a rat study. However, as indicated previously (Section IV-1), permeability of rat skin is different than human skin (Bartek *et al*., 1972). The skin of rat is much thinner than skin of human (Bronaugh *et al.,* 1982). Using rat studies as a surrogate of human dermal absorption may overestimate, however, existing information is insufficient to quantitatively address the impact of this extrapolation.

5. Cancellation Order for Residential Uses.

On March 6, 2002, U.S. EPA published in the Federal Register a cancellation order for all acephate product registrations cited in voluntary cancellation requests submitted by seven registrants. The acephate product cancellations and use deletions were requested to reduce certain residential risks, including risks to children, which exceeded the Agency's level of concern. The effective date of the cancellations is March 6, 2002, the date of publication. However, effective dates of use deletions vary, as do last dates for use of

existing stocks to formulate end use products. Since residents may use existing stocks of acephate, their potential exposure was assessed in this document.

6. Using Surrogate Acephate DFR Data for Some Crops

Stone fruit and pome fruit thinning are scenarios in which high exposure may occur. However, there are no DFR data for these crops. Therefore, citrus DFR data was used as surrogate DFR.

7. Using Surrogate Methamidophos DFR Data for Some Crops

Methamidophos is a metabolite of acephate in plants and soil. Therefore, the potential exposure to methamidophos for fieldworkers involved in agricultural, residential and recreational post-application were assessed in this document. However, the methamidophos DFR measurements were not available for cotton, grapefruit and oranges. To estimates the exposure of the fieldworkers to methamidophos on these crops, DPR used available DFR data. These surrogate DFR data were selected from the available methamidophos DFR data for other crops. Those with the highest percentage of metabolism rate to degrade acephate to methamidophos were selected as surrogate methamidophos DFR data.

8. Selecting Reasonable Cauliflower DFR data

There are two acephate DFR studies following applications to cauliflower. However, one of them was not used since the initial DFR of the last application (0.053 $\mu g/cm^2$) is much lower than initial DFR of the first application (0.28 $\mu g/cm^2$) and initial DFR of other previous applications (0.197 $\mu g/cm^2$). The other acephate DFR study was accepted as acephate DFR data following applications to cauliflower (see Section IV. 2.2).

9. Selecting Reasonable Grape DFR data

There are two tests that were conducted to determine the DFR after ground application of acephate. The test with longer half-life was selected to estimate exposure of field workers in this document. The DFR values were reported as ppm in the study. The ppm values were converted to $\mu g/cm^2$ by converting the average weight of leaf to surface area as described by Dong *et al.* (1991). This conversion method is assumed reasonable. However, it should be noted that this method has not been validated.

10. Missing Data for Hopper Box Monitoring Study

In the monitoring study of the exposure to workers during application of acephate using a hopper box, loading/treating seed and planting were completed by same workers, and the exposure was measured for the entire workday, rather than separate periods for loading/treating seed and planting. In some small farms, loading/treating and planting by the same worker(s) appears to be common practice. However, in some moderate and large size farms, the applicator could plant the seeds treated right after his/her co-worker

have loaded/treated them. Therefore, in this document, the exposures of workers loading/treating, as well as workers loading/treating seed/planting were also estimated. Due to lack of residues data for either loader/seed treaters or planters, the estimate for loader/seed treaters was based on the assumption planting resulted in relatively insignificant exposure. Therefore, monitoring data for loading/treating/and planting was used for estimating loading/treating only. In practice, a loader/seed treater may not conduct that activity continuously for 8 hours and full-day exposure estimates may not be representative of a typical loader/seed treater workday. However, since there is no data available to address this issue, the maximum potential exposure time was assumed. It is noteworthy that the exposure of the same scenario estimated from PHED was much lower than that from the monitoring study. In this case, the chemical specific information was assumed to be more representative.

11. Non-Agricultural Reentry Using the Day Zero DFR Data.

The product labels state that reentry time following non-agricultural applications is "spray is dry." Thus, the DFR on the day zero was used to estimate the post-application exposure following application to golf courses. It may overestimate the exposure because it's not like that the reentry will occur immediately after the application.

12. DPR and U.S. EPA Estimates.

The handler exposure estimates described in this EAD are different from the estimates made by U.S. EPA (2000a). The main reasons that may lead to these differences include:

1) U.S. EPA used geometric means to summarize PHED data, whereas DPR used arithmetic means in accordance with DPR policy. Also, U.S. EPA estimates were based on means rather than the upper confidence limits used by DPR. That results in higher DPR exposure estimates compared to U.S. EPA. DPR uses the arithmetic mean rather than the geometric mean or the median because, although it can be argued that the latter statistics better indicate the location of the center of a skewed distribution, it is not the center that is of interest in exposure assessment, but the expected magnitude of exposure (Powell, 2002).

2) DPR used the estimated dermal absorption of 7.6%, whereas, U.S. EPA assumed 100% absorption for dermal. The dermal absorption difference resulted in the DPR exposure estimation to be lower than U.S. EPA's.

3) Since it is not clear from the RED which PHED subsets the U.S. EPA used, there is a reasonable likelihood that the two agencies used different settings, such as study grade limitations, formulation types, mixing and application procedures, airborne conditions, etc. These differences would lead to different estimates.

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APPENDIX A
Agricultural Reentry Scenarios for Acephate Uses in California

The following table was prepared by reviewing acephate product labels. Reentry activities were listed for each use site, and assigned to tiers based on anticipated exposure. Tier I: Most of the body (approximately > 50 % of the body surface) is in contact with residues. Tier II: Some of the body (approximately 25 - 50 % of the body surface) is in contact with residues (e.g., hands, arms and face; or hands, forearms, feet, and lower legs). Tier III: Very little of the body (approximately < 25 % of the body surface) is in contact with residues (e.g., hands only; or hands and feet only).

Within Tier I and Tier II, suggested representative activities are shown in bold. These are activities that generally should be addressed specifically in an exposure assessment. Tier III activities are considered to be covered by Tier I and Tier II activities. For an activity designated "None" means a representative activity was not assigned or chosen for that Tier activity.

Site Cat [a]	Use Sites [b]	REI [c] (day)	PHI [d] (day)	Tier I Activities (High)	Tier II Activities (Medium)	Tier III Activities (Low)
FC	Cotton	1	21	**Scouting**	Irrigating [e], Weeding, Harvesting (Mech.)	None
FC	Tobacco	1	3	**Harvesting** (Hand)	**Scouting**	Irrigating [e], Weeding, Harvesting (Mech.), Thinning, Topping, Reset
FN	Citrus	1	365	None [g]	**Pruning** (Hand)	Scouting, Weeding (Hand, Mech.), Irrigating [e], Transplant/Propagate [f]
FN	Cranberries	1	90	None	Pruning, Weeding (Hand), Scouting, Thinning [g]	Irrigating [e], Weeding, Harvesting (Mech.), Sanding beds, Scouting, Transplant/Propagate
FN	Stone Fruits (Apricot, Cherry, Plum, Prune)	1	356	Thinning	**Pruning** (Nondormant)	Scouting, Irrigating [e], Weeding (Mech.), Pruning (Dormant), Propping, Transplanting/ Propagating [f]
FN	Pome Fruits (Apple, Pear)	1	356	Thinning	**Pruning** (Nondormant)	Scouting, Irrigating [e], Weeding (Mech.), Pruning (Dormant), Propping, Transplanting/ Propagating [f]
FN	Kiwi	1	356	Thinning [g]	**Pruning** (Nondormant)	Scouting, Irrigating [e], Weeding (Mech.), Pruning (Dormant), Propping, Transplanting/ Propagating [f]
FN	Nut (Almond, Walnut, Pistachio)	1	356	None	None [g]	Weeding (Mech.), Irrigating [e], Scouting, Transplant/Propagate [f], Pruning (Dormant)

Site Cat [a]	Use Sites [b]	REI [c] (day)	PHI [d] (day)	Tier I Activities (High)	Tier II Activities (Medium)	Tier III Activities (Low)
FN	Grape	1	356	Cane Turning	Thinning, Scouting, Tying/Training/ Trellising, Cane Cutting [g]	Weeding (Hand), Irrigating [e], Transplant/Propagate [f], Suckering
M	Turf, Golf Course	0.5	0.5	None	None	Aerating, Pruning, Scouting, Irrigating [e], Golfing, Weeding, Mowing
M	Lawns	0.5	-	None	**Contact with treated turf, ingest treated soil**	Aerating, irrigating[e], weeding, mowing, scouting
M	Non-Crop Areas (Field borders, Fencerows, Roadsides, Ditchbanks, Borrow pits, Wasteland)	1	-	None	None	Scouting, Weeding
OT	Nursery Ornamentals (Tree/Shrubs, Flowering, Crape Myrtle)	1	-	None	**Pruning**	Scouting, Irrigating [e], Thinning, Weeding, Transplanting [f]
OT	Nursery Plants in Containers	1	1	None	**Harvesting (Hand)**	Irrigating [e], Scouting, Thinning, Turning, Tying, Weeding, Transplanting [f]
OT	Outdoor Floral crops and Ground Covers	1	-	None	**Harvesting (Hand)**	Irrigating [e], Scouting, Thinning, Turning, Tying, Weeding, Transplanting [f]
OT	Greenhouse (Cut Flowers or Greens)	1	1	None	**Harvesting (Hand)**	Irrigating [e], Scouting, Thinning, Turning, Tying, Weeding, Bud Pinching (flowers), Transplanting [f]
OT	Mint	1	14	None	None	Irrigating [e], Scouting, Harvesting
V	Beans (Succulent and Dried)	1	14	**Harvesting** (Hand)	Irrigating [e], **Scouting**	Weeding, Harvesting (Mech.)
V	Brussels Sprouts	1	14	Irrigating[e], Topping, **Harvesting (Hand)**	**Scouting**	Weeding, Thinning, Transplanting [f], Harvesting (Mech.)
V	Cauliflower	1	14	Tying, Irrigating[e], Banding, **Harvesting (Hand)**	Scouting	Weeding, Transplanting[f], Harvesting (Mech.)
V	Celery	1	21	**Harvesting (Hand)**	Irrigating [e], **Scouting**	Weeding, Transplanting [f]

Site Cat [a]	Use Sites [b]	REI [c] (day)	PHI [d] (day)	Tier I Activities (High)	Tier II Activities (Medium)	Tier III Activities (Low)
V	Head Lettuce	1	21	Head Breaking, **Harvesting** (Hand)	Irrigating [e], **Scouting**	Weeding, Thinning, Transplanting [f]
V	Onion	1	14	None	**Harvesting (Hand)**	Scouting, Irrigating [e], Weeding, Transplanting[f], Thinning
V	Peanut	1	14	None	Irrigating [e], **Scouting**	Weeding, Harvesting (Mech.)
V	Pepper (Bell and Non-Bell types)	1	7	Thinning, **Harvesting (Hand)**	Irrigating [e], **Scouting**	Weeding, Transplanting[f]
V	Potato	1	N/A	None	Irrigating [e], **Scouting**	Weeding, Transplanting[f], Harvesting (Mech.)
V	Tomato (Fresh Market, Processing/ Canning)	1		Tying, Training, Staking, **Harvesting (Hand)**	Irrigating [e], **Scouting**	Weeding, Thinning, Transplanting [f]

[a] Use site categories: FC = Field crops; FN = Fruits and nuts; M = Miscellaneous; OT = Ornamentals, herbs, trees, nursery/greenhouse; V = Vegetables.

[b] Use Sites were listed basing on the product labels.

[c] REI = Minimum restricted entry interval listed for crop in California on any product label.

[d] PHI = Minimum preharvest interval listed for crop in California on any product label.

[e] Irrigator exposure is dependent upon the method of irrigation used for the crop, which are (1) drip irrigation is Tier III (low), (2) flood or furrow irrigation of crops less than 18 inches high is Tier III (low), (3) flood or furrow irrigation of crops 18 inches or taller is Tier II (moderate), (4) sprinkler irrigation of crops less than 18 inches high is Tier II (moderate), and (5) sprinkler irrigation of crops 18 inches or taller is Tier I (high).

[f] Transplant/propagate activity has little potential for exposure in the field, but may present a potential for exposure during the propagation stage in the nursery or greenhouse setting. Refer to greenhouse/nursery scenario.

[g] Based on the product labels, acephate is limited to application to non-bearing fruit trees, nut trees and bines in nursery fields or non-bearing orchards. Therefore, harvest activities on fruits were not assessed in this document.

[h] Mechanical (Mech.) harvesting by shaking and sweeping to drop and collect fruits/nuts, respectively, may generate dust and debris (falling leaves, branches, produce) sufficient to expose harvester to pesticide residues by dermal contact or via inhalation of debris/dust.

APPENDIX B
Summaries and Exposure Estimates for PHED Scenarios

Appendix 1: Subset from PHED for Exposure of Mixer/Loaders to Wettable Powder Products Using an Open Pour System.
Appendix 2: Subset from PHED for Exposure of Mixer/Loaders to Dry Flowable Products Using an Open Pour System.
Appendix 3: Subset from PHED for Exposure of Mixer/Loaders to Liquid Products Using an Open Pour System.
Appendix 4: Subset from PHED for Exposure of Loaders to Granular Products Using an Open Pour System.
Appendix 5: Subset from PHED for Exposure of Aerial Applicators to Liquids Products Using Open Cockpit.
Appendix 6: Subset from PHED for Exposure of Groundboom Applicators, Open Cab.
Appendix 7: Subset from PHED for Exposure of Airblast Applicators, Open Cab (No Gloves).
Appendix 7A: Subset from PHED for Exposure of Airblast Applicators, Open Cab (With Gloves).
Appendix 8: Subset from PHED for Exposure of Broadcast Spreader Applicator (Truck or Tractor), Granular (No Gloves).
Appendix 8A: Subset from PHED for Exposure of Broadcast Spreader Applicator (Truck or Tractor), Granular (With Gloves).
Appendix 9: Subset from PHED for Exposure of Mixer/Loader/Applicators Using Backpack, Liquid (open pour).
Appendix 10: Subset from PHED for Exposure of Mixer/Loader/Applicators Using Low Pressure Hand Wands.
Appendix 11: Subset from PHED for Exposure of Mixer/Loader/Applicators Using High Pressure Sprayers.
Appendix 12: Subset from PHED for Exposure of Applicators Using Hands Spreading of Bait
Appendix 13: Subset from PHED for Exposure of Mixer/Loader/Applicators Using Garden Hose End Sprayer, Open Pour.
Appendix 14: Subset from PHED for Exposure of Loader/Applicators to Granular Products Using Push-Type Granular Spreaders
Appendix 15: Subset from PHED for Exposure of Loader/Applicators to Granular Products Using Belly Grinder
Appendix 16: Subset from PHED for Exposure of Aerial Flaggers, Liquids.
Appendix 17: Subset from PHED for Exposure of Applicators Using Aerosol Cans (No Gloves).
Appendix 17A: Subset from PHED for Exposure of Applicators Using Aerosol Cans (With Gloves).
Appendix 18: Subset from PHED for Exposure of Applicators Using Paintbrush.

Note: 1. Appendices 1 – 18 provide detailed information on values used in handler exposure estimates. As described in the Exposure Assessment section, the Pesticide Handlers Exposure Database (PHED) combines exposure data

from multiple field monitoring studies of different AIs. The user selects a subset of the data having the same or a similar application method and formulation type as the target scenario. Sufficient information is given in the appendix for each scenario to allow other PHED users to duplicate the subsets and generate the same values. Attached PHED reports prepared using Version 1.1 (1995).

2. Once the PHED subsets were generated, inputs for exposure calculations were entered, according to WHS policy. Exposures were requested in µg per pound of AI handled, because the total work time spent within each handling task is not as well defined. For dermal exposure, both actual and estimated head patches were included. For inhalation exposure, the WHS default inhalation rate for handlers of 16.7 L/min was used. Clothing and gloves were chosen based on requirements listed on the label.

3. Because of an error in the PHED database (U.S. EPA, 1998), no data for feet were available in some scenarios. The error is anticipated to be repaired in Version 2 of the PHED (U.S. EPA, 1998). The missed feet data are corrected by addition of a default value that was based on the assumption that exposure to feet differed from lower legs only due to differences in surface area. Correction = 0.52 (ratio of feet/lower leg surface area, U.S. EPA [1997a]) x value of lower legs.

Appendix 1: Subset from PHED for Exposure of Mixer/Loaders to Wettable Powder Products Using an Open Pour System.

Table 1-1. Description of PHED subsets for Appendix 1[a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Solid Type	Wettable powder	Wettable powder
Mixing Procedure	Open	Open

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered and Hand are all Grade A or B; Airborne data are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 1-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) dermal subset for Appendix 1[a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	12.1008	159.063	3.243	24
NECK.FRONT	49.7781	241.7376	1.6288	24
NECK.BACK	35.299	250.8502	.9205	24
UPPER ARMS	181.099	412.7976	15.4083	30
CHEST	155.2533	458.3228	9.6478	36
BACK	165.361	437.2647	9.8479	36
FOREARMS	12.2599	180.986	4.6336	28
THIGHS	5.7027	140.9473	2.8042	28
LOWER LEGS	4.046	120.7341	1.9477	28

Subset Name:
S1DERMAL.MLOD

[a] Subset criteria included actual and estimated head patches. Of the 24 head observations, all were actual.

Table 1-2. PHED data from dermal, hand, and inhalation subsets for Appendix 1 [a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	611.5 [c]	28 [d]	4	1
Hand (with gloves)	23.7	20	4	1
Inhalation	49.4	17	5	1

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA,1997a).
Dermal total value was corrected by adjusting head data, which multiplied by 0.05 for use of headgear based on the assumption that headgear material provides similar protection of chemical-resistant PPE.
[d] Median number of replicates was used in determining subset multipliers.

Table 1-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 1

	Short-Term Exposure	Long-Term Exposure
Total Dermal	4(611.5) + 4(23.7) = 2,541 µg/lb AI handled	1(611.5) + 1(23.7) = 635 µg/lb AI handled
Inhalation	5(49.4) = 247 µg/lb AI handled	1(49.4) = 49.4 µg/lb AI handled

[a] Values from Table 1-2. Results rounded to three significant figures.

Appendix 2: Subset from PHED for Exposure of Mixer/Loaders to Dry Flowable Products Using an Open Pour System

Table 2-1. Description of PHED subsets for Appendix 2 [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Solid Type	Dry flowable	Dry flowable
Mixing Procedure	Open	Open

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered and Hand are all Grade A or B; Airborne data are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 2-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) dermal subset for Appendix 2 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	30.5021	124.7406	11.9921	19
NECK.FRONT	13.9106	102.7059	5.8389	16
NECK.BACK	3.2942	170.3236	.7453	19
UPPER ARMS	8.3504	98.8935	6.5856	23
CHEST	8.9296	67.003	6.7856	26
BACK	6.786	73.1388	4.8789	26
FOREARMS	3.7089	66.0196	3.0986	23
THIGHS	90.2695	296.5869	11.3605	26
LOWER LEGS	17.8317	298.7707	4.2874	26

Subset Name:
S2DERMAL.MLOD

[a] Subset criteria included actual and estimated head patches. Of the 19 head observations, 16 were actual and 1 was estimated from nearby patches (Versar, 1992).

Table 2-2. PHED data from dermal, hand, and inhalation subsets for Appendix 2 [a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	164 [c]	23 [d]	4	1
Hand (with gloves)	9.74	21	4	1
Inhalation	0.655	23	4	1

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
Dermal total value was corrected by adjusting head data, which multiplied by 0.05 for use of headgear based on the assumption that headgear material provides similar protection of chemical-resistant PPE.
[d] Median number of replicates was used in determining subset multipliers.

Table 2-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 2 [a]

	Short-Term	Long-Term
Total Dermal	4(164) + 4(9.74) = 695µg/lb AI handled	1(164) + 1(9.74) = 174 µg/lb AI handled
Inhalation	4(0.655) = 2.62 µg/lb AI handled	1(0.655) = 0.655 µg/lb AI handled

[a] Values from Table 2-2.

Appendix 3: Subset from PHED for Exposure of Mixer/Loaders to Liquids Products Using an Open Pour System

Table 3-1. Description of PHED subsets Appendix 3 [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Liquid Type	Emulsifiable concentrate, aqueous suspension, microencapsulated, solution, or undiluted liquid	Emulsifiable concentrate, solution
Mixing Procedure	Open	Open

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered and Airborne are all Grade A or B; Hand data are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 3-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) dermal subset for Appendix 3 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	127.9871	495.5875	4.1314	122
NECK.FRONT	23.0158	362.6609	1.7263	104
NECK.BACK	15.5714	383.462	.5412	110
UPPER ARMS	157.6735	903.2036	1.4925	90
CHEST	19.0359	263.976	3.4214	90
BACK	10.8933	223.0206	1.8685	89
FOREARMS	4.4266	211.9821	.8927	84
THIGHS	16.6064	198.1742	3.9823	72
LOWER LEGS	37.8101	824.4477	1.1046	82

Subset Name:
S5DERMAL.MLOD

[a] Subset criteria included actual and estimated head patches. Of the 122 head observations, 96 were actual and 26 were estimated from nearby patches (Versar, 1992).

Table 3-2. PHED data from dermal, hand, and inhalation subsets for Appendix 5 [a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	311.4 [c]	90 [d]	4	1
Hand (with gloves)	58.2	59	4	1
Inhalation	2.35	85	4	1

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
Dermal total value was corrected by adjusting head data, which multiplied by 0.05 for use of headgear based on the assumption that headgear material provides similar protection of chemical-resistant PPE.
[d] Median number of replicates was used in determining subset multipliers.

Table 3-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 3 [a]

	Short-Term	Long-Term
Total Dermal	4(311.4) + 4(58.2) = 1,478 µg/lb AI handled	1(311.4) + 1(58.2) = 370 µg/lb AI handled
Inhalation	4(2.35) = 9.40 µg/lb AI handled	1(2.35) = 2.35 µg/lb AI handled

[a]Values from Table 5-2.

Appendix 4: Subset from PHED for Exposure of Mixer/Loaders to Granular Products Using an Open Pour System

Table 4-1. Description of PHED subsets for Appendix 4[a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Solid Type	Granular	Granular
Mixing Procedure [c]	Open	Open

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered are all Grade A; Airborne and Hand data are all Grade A or B . Data quality grades are defined in the text and in Versar (1992).
[c] Loading by open pour rather than through a closed system (PHED listes as a miming procedure).

Figure 4-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) dermal subset for Appendix 4[a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	.6052	111.649	.4573	29
NECK.FRONT	1.27	114.3228	.5317	3
NECK.BACK	.1063	155.3151	.033	3
UPPER ARMS	1.067	127.0853	.768	36
CHEST	1.3555	126.3593	.9812	33
BACK	1.3555	126.3593	.9812	33
FOREARMS	.4974	128.9505	.3399	36
THIGHS	1.227	100.8068	.9099	33
LOWER LEGS	.7801	101.9997	.5622	36

Subset Name:
S4DERMAL.MLOD

[a] Subset criteria included actual and estimated head patches. Of the 29 head observations, all were actual.

Table 4-2. PHED data from dermal, hand, and inhalation subsets for Appendix 4 [a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	8.10 [c]	33 [d]	4	1
Hand (with gloves)	0.977	45	4	1
Inhalation	3.45	58	4	1

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
Dermal total value was corrected by adjusting head data, which multiplied by 0.05 for use of headgear based on the assumption that headgear material provides similar protection of chemical-resistant PPE.
[d] Median number of replicates was used in determining subset multipliers.

Table 4-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 4[a]

	Short-Term	Long-Term
Total Dermal (with gloves)	4(8.10) + 4(0.977) = 36.3 µg/lb AI handled	1(8.10) + 1(0.977) = 9.08 µg/lb AI handled
Inhalation	4(3.45) = 13.8 µg/lb AI handled	1(3.45) = 3.45 µg/lb AI handled

[a] Values from Table 4-2.
[b] Gloves assumed to provide 90% protection (Aprea *et al*, 1994); exposure of bare hands is calculated as ten times exposure of gloved hands.

Appendix 5: Subset from PHED for Exposure of Aerial Applicators to Liquids Products Using Open Cockpit

Table 5-1. Description of PHED subsets for Appendix 5 [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Liquid Type	Not specified	All emulsifiable concentrate
Solid Type	Exclude granular	none
Application Method	Fixed- or rotary-wing	All fixed-wing
Cab Type	Open Cab or Closed Cab with Open Window	Open Cab or Closed Cab with Open Window

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered and Hand are Grade A or B; Airborne data are Grade B or C. Data quality grades are defined in the text and in Versar (1992).

Figure 5-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Scenario 5 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	4.212	118.2574	1.2438	10
NECK.FRONT	.414	143.6715	.1169	10
NECK.BACK	.3124	139.1485	.0741	10
UPPER ARMS	8.5554	109.6232	5.7532	10
CHEST	6.3065	158.1987	2.1395	17
BACK	8.7497	141.5614	3.131	17
FOREARMS	2.7901	131.7516	1.1744	17
THIGHS	9.55	157.4126	3.4718	13
LOWER LEGS	7.4494	138.0769	3.3312	10

Subset Name:
S17DERMAL.APPL

[a] Subset criteria included actual and estimated head patches. Of the 10 head observations, 7 were actual and 3 were estimated from nearby patches (Versar, 1992).

Table 5-2. PHED data from dermal, hand, and inhalation subsets for Scenario 5 [a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	52.2 [c]	10 [d]	6	2
Hand (no gloves)	96.3 [e]	9	6	2
Inhalation	0.573	14	5	2

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
[d] Median number of replicates was used in determining subset multipliers.
[e] The hands exposure value are gloved data in PHED. However, product labels do not require all applicators must wear gloves. Therefore, exposure of no gloved hands is calculated as ten times exposure of gloved hands, based on the assuming gloves provide 90% protection (Aprea *et al*, 1994).

Table 5-3. Values Used in Short-Term and Long-Term Exposure Calculations for Scenario 5 [a]

	Short-Term	Long-Term
Total Dermal (with gloves)	6(52.2) + 6(9.63) = 371 µg/lb AI handled	2(52.2) + 2(9.63) = 124 µg/lb AI handled
Total Dermal (no gloves) [b]	6(52.2) + 60(9.63) = 891 µg/lb AI handled	2(52.2) + 20(9.63) = 297 µg/lb AI handled
Inhalation	5(0.573) = 2.86 µg/lb AI handled	2(0.573) = 1.15 µg/lb AI handled

[a] Values from Table 5-2.
[b] Gloves assumed to provide 90% protection (Aprea *et al*, 1994); exposure of bare hands is calculated as ten times exposure of gloved hands.

Appendix 6: Subset from PHED for Exposure of Groundboom Applicator, Open Cab

Table 6-1. Description of PHED subsets for Appendix 6[a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B,C
Liquid Type or Solid Type	Not specified	Emulsifiable concentrate or wettable powder
Application Method	Groundboom, Truck or Tractor	Groundboom, Tractor
Cab Type	Open Cab or Closed Cab with Open Window	Open Cab or Closed Cab with Open Window

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality grades for Airborne, Dermal Uncovered, Dermal Covered and Hand are all Grade A or B, with the exception of one dermal replicate that has Dermal Uncovered Grade C (Dermal Covered for that replicate is Grade B). Data quality grades are defined in the text and in Versar (1992).

Figure 6-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Appendix 6 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, no gloves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	2.7891	136.1192	1.0464	33
NECK.FRONT	1.5763	167.9503	.3296	23
NECK.BACK	1.0063	173.5765	.2335	29
UPPER ARMS	1.6914	88.749	1.1637	32
CHEST	1.7581	98.5154	1.1329	42
BACK	3.0175	233.2361	1.3959	42
FOREARMS	2.7301	419.1055	.564	32
THIGHS	3.1255	185.5703	1.1806	33
LOWER LEGS	2.1148	172.3425	.7466	35

Subset Name:
S11DERMAL.APPL

[a] Subset criteria included actual and estimated head patches. Of the 33 head observations, all were actual.

Table 6-2. PHED data from dermal, hand, and inhalation subsets for Appendix 6 [a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	20.9 [c]	33 [d]	4	1
Hand (no gloves)	45.6	29	4	1
Inhalation	1.18	22	4	1

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
[d] Median number of replicates was used in determining subset multipliers.

Table 6-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 6 [a]

	Short-Term	Long-Term
Total Dermal (with gloves) [b]	4(20.9) + 0.4(45.6) = 102 µg/lb AI handled	1(20.9) + 0.1(45.6) = 25.5 µg/lb AI handled
Total Dermal (no gloves)	4(20.9) + 4(45.6) = 266 µg/lb AI handled	1(20.9) + 1(45.6) = 66.5 µg/lb AI handled
Inhalation	4(1.18) = 4.72 µg/lb AI handled	1(1.18) = 1.18 µg/lb AI handled

[a] Values from Table 11-2.
[b] Gloves assumed to provide 90% protection (Aprea *et al*, 1994); exposure of gloved hands is calculated as one tenth exposure of bare hands.

Appendix 7: Subset from PHED for Exposure of Airblast Applicator, Open Cab (No Gloves)

Table 7-1. Description of PHED subsets for Appendix 7[a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Liquid Type or Solid Type	Not specified	Emulsifiable concentrate, dry flowable or wettable powder
Application Method	Airblast	Airblast
Cab Type	Open Cab or Closed Cab with Open Window	Open Cab or Closed Cab with Open Window

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality grades for Airborne, Dermal Uncovered, Dermal Covered and Hand are all Grade A or B. Data quality grades are defined in the text and in Versar (1992).

Figure 7-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Appendix 7[a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	778.5762	155.5207	176.2608	42
NECK.FRONT	37.1325	147.948	12.193	38
NECK.BACK	27.8342	159.3144	8.7825	42
UPPER ARMS	42.3987	265.4846	6.4049	40
CHEST	21.8289	177.8784	5.4396	49
BACK	14.7289	174.1332	4.204	49
FOREARMS	7.4511	148.7525	2.0066	38
THIGHS	56.8344	189.968	16.9924	32
LOWER LEGS	17.2699	129.16	7.0944	32

Subset Name:
S9DERMAL.APPL

[a] Subset criteria included actual and estimated head patches. Of the 42 head observations, 41 were actual and 1 was estimated from nearby patches (Versar, 1992).

Table 7-2. PHED data from dermal, hand, and inhalation subsets for Appendix 7[a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	915.3 [c]	40 [d]	4	1
Hand (no gloves)	645	22	4	1
Inhalation	5.41	47	4	1

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
Dermal total value was corrected by adjusting head data, which multiplied by 0.05 for use of headgear based on the assumption that headgear material provides similar protection of chemical-resistant PPE.
[d] Median number of replicates was used in determining subset multipliers.

Table 7-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 7[a]

	Short-Term	Long-Term
Total Dermal	4(915.3) + 4(645) = 6,241 µg/lb AI handled	1(915.3) + 1(645) = 1,560 µg/lb AI handled
Inhalation	4(5.41) = 21.6 µg/lb AI handled	1(5.41) = 5.41 µg/lb AI handled

[a]Values from Table 7-2.

Appendix 7A: Subset from PHED for Exposure of Airblast Applicator, Open Cab (With Gloves)

Table 7-1A. Description of PHED subsets for Appendix 7 [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Liquid Type or Solid Type	Not specified	Emulsifiable concentrate, dry flowable or wettable powder
Application Method	Airblast	Airblast
Cab Type	Open Cab or Closed Cab with Open Window	Open Cab or Closed Cab with Open Window

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered are all Grade A; Airborne and Hand data are all Grade A or B. Data quality grades are defined in the text and in Versar (1992).

Figure 7A-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Appendix 7 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	778.5762	155.5207	176.2608	42
NECK.FRONT	37.1325	147.948	12.193	38
NECK.BACK	27.8342	159.3144	8.7825	42
UPPER ARMS	42.3987	265.4846	6.4049	40
CHEST	21.8289	177.8784	5.4396	49
BACK	14.7289	174.1332	4.204	49
FOREARMS	7.4511	148.7525	2.0066	38
THIGHS	56.8344	189.968	16.9924	32
LOWER LEGS	17.2699	129.16	7.0944	32

Subset Name:
S9DERMAL.APPL

[a] Subset criteria included actual and estimated head patches. Of the 42 head observations, 41 were actual and 1 was estimated from nearby patches (Versar, 1992).

Table 7A-2. PHED data from dermal, hand, and inhalation subsets for Appendix 7 [a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	915.3[c]	40 [d]	4	1
Hand (with gloves)	8.52	18	5	1
Inhalation	5.41	47	4	1

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
Dermal total value was corrected by adjusting head data, which multiplied by 0.05 for use of headgear based on the assumption that headgear material provides similar protection of chemical-resistant PPE.
[d] Median number of replicates was used in determining subset multipliers.

Table 7A-3. Values Used in Short-Term and Long-Term Exposure Calculations [a]

	Short-Term	Long-Term
Total Dermal	4(915.3) + 5(8.52) = 3,704 µg/lb AI handled	1(915.3) + 1(8.52) = 924 µg/lb AI handled
Inhalation	4(5.41) = 21.6 µg/lb AI handled	1(5.41) = 5.41 µg/lb AI handled

[a]Values from Table 7A-2.

Appendix 8: Subset from PHED for Exposure of Broadcast Spreader Applicator (Truck or Tractor), Granular (No Gloves)

Table 8-1. Description of PHED subsets for Appendix 8[a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Solid Type	Granular	Granular
Application Method	Broadcast spreader (tractor/truck/ag uses)	Broadcast spreader (tractor/truck/ag uses)
Cab Type [c]	Closed Cab or Closed Cab with Filtered Air	Closed Cab or Closed Cab with Filtered Air

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered are all Grade A; Airborne and Hand data are all Grade A or B. Data quality grades are defined in the text and in Versar (1992).
[b] Cab type specified to eliminate 4 replicates with open cab (insufficient data to estimate exposure for applicators with open cabs).

Figure 8-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Appendix 8 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	.13	0	.13	27
NECK.FRONT	.015	0	.015	2
NECK.BACK	.011	0	.011	2
UPPER ARMS	.291	0	.291	30
CHEST	.355	0	.355	28
BACK	.355	0	.355	28
FOREARMS	.1335	50.4869	.1269	29
THIGHS	.4244	28.8172	.4126	27
LOWER LEGS	.2626	28.1036	.2557	29

Subset Name:
S14DERMAL.APPL

[a] Subset criteria included actual and estimated head patches. All 27 head observations were actual.

Table 8-2. PHED data from dermal, hand, and inhalation subsets for Appendix 8[a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	2.11 [c]	28[d]	4	1
Hand (no gloves)	0.326	24	4	1
Inhalation	0.220	37	4	1

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
[d] Median number of replicates was used in determining subset multipliers.

Table 8-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 8[a]

	Short-Term	Long-Term
Total Dermal	4(2.11) + 4(0.326) = 10.0 µg/lb AI handled	1(2.11 + 0.326) = 2.44 µg/lb AI handled
Inhalation	4(0.220) = 0.880 µg/lb AI handled	1(0.220) = 0.220 µg/lb AI handled

[a]Values from Table 8-2.

Appendix 8A: Subset from PHED for Exposure of Broadcast Spreader Applicator (Truck or Tractor), Granular (With Gloves)

Table 8A-1. Description of PHED subsets for Appendix 8[a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Solid Type	Granular	Granular
Application Method	Broadcast spreader (tractor/truck/ag uses)	Broadcast spreader (tractor/truck/ag uses)
Cab Type [c]	Closed Cab or Closed Cab with Filtered Air	Closed Cab or Closed Cab with Filtered Air

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered are all Grade A; Airborne and Hand data are all Grade A or B. Data quality grades are defined in the text and in Versar (1992).
[b] Cab type specified to eliminate 4 replicates with open cab (insufficient data to estimate exposure for applicators with open cabs).

Figure 8A-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Appendix 8 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	.13	0	.13	27
NECK.FRONT	.015	0	.015	2
NECK.BACK	.011	0	.011	2
UPPER ARMS	.291	0	.291	30
CHEST	.355	0	.355	28
BACK	.355	0	.355	28
FOREARMS	.1335	50.4869	.1269	29
THIGHS	.4244	28.8172	.4126	27
LOWER LEGS	.2626	28.1036	.2557	29

Subset Name:
S14DERMAL.APPL

[a] Subset criteria included actual and estimated head patches. All 27 head observations were actual.

Table 8A-2. PHED data from dermal, hand, and inhalation subsets for Appendix 8[a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	2.11 [c]	28 [d]	4	1
Hand (with gloves)	0.171	17	5	1
Inhalation	0.220	37	4	1

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
[d] Median number of replicates was used in determining subset multipliers.

Table 8A-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 8[a]

	Short-Term	Long-Term
Total Dermal	4(2.11) + 5(0.171) = 9.30 µg/lb AI handled	1(2.11 + 0.171) = 2.28 µg/lb AI handled
Inhalation	4(0.220) = 0.880 µg/lb AI handled	1(0.220) = 0.220 µg/lb AI handled

[a]Values from Table 8A-2.

Appendix 9: Subset from PHED for Exposure of Mixer/Loader/Applicators Using Backpack, Liquid (open pour)

Table 9-1. Description of PHED subsets for Appendix 9 [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Liquid Type	Not specified	Solution, Microencapsulated
Application Method	Backpack	Backpack
Mixing Procedure	Open	Open

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered are all Grade A or B; Hand data are all Grade C. Data quality grades are defined in the text and in Versar (1992).

Figure 9-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Appendix 9 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	345.2564	194.899	91.4483	11
NECK.FRONT	178.6391	155.1078	38.2719	11
NECK.BACK	1163.209	108.1731	611.9794	11
UPPER ARMS	10116.4827	239.4633	257.2654	11
CHEST	275.4477	170.903	65.7564	11
BACK	8918.1809	167.9854	1044.0635	11
FOREARMS	153.593	184.2219	30.0425	11
THIGHS	597.2782	282.8189	49.147	9
LOWER LEGS	425.8878	230.6324	64.6874	9

Subset Name:
S20DERMAL.MLAP

[a] Subset criteria included actual and estimated head patches. Of the 11 head observations, all were actual.

Table 9-2. PHED data from dermal, hand, and inhalation subsets for Appendix 9 [a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	22,300 [c]	11 [d]	6	2
Hand (with gloves)	9.68	11	6	2
Inhalation	17.5	11	6	2

[a] Results from subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
[d] Median number of replicates was used in determining subset multipliers.

Table 9-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 9 [a]

	Short-Term	Long-Term
Total Dermal (with gloves)	6(22,300 + 9.68) = 134,000 µg/lb AI handled	2(22,300 + 9.68) = 44,600 µg/lb AI handled
Total Dermal (no gloves) [b]	6(22,300) + 60(9.68) = 134,000 µg/lb AI handled	2(22,300) + 20(9.68) = 44,800 µg/lb AI handled
Inhalation	6(17.5) = 105 µg/lb AI handled	2(17.5) = 35.0 µg/lb AI handled

[a] Values from Table 20-2.
[b] Gloves assumed to provide 90% protection (Aprea *et al*, 1994); exposure of bare hands is calculated as ten times exposure of gloved hands.

Appendix 10: Subset from PHED for Exposure of Mixer/Loader/Applicators Using Low Pressure Hand Wands

Table 10-1. Description of PHED subsets for Appendix 10

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Solid Type	Wettable powder	Wettable powder
Application Method	Low Pressure Hand Wand	Low Pressure Hand Wand
Mixing Procedure	Not specified	All open

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered were all Grades C; Hand data are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 10-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Appendix 10 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	2636.0019	179.0708	1267.5067	16
NECK.FRONT	756.6675	296.038	176.9167	16
NECK.BACK	151.0809	73.0526	109.8324	16
UPPER ARMS	494.7182	36.3833	463.0868	16
CHEST	700.3928	71.0002	603.0781	16
BACK	611.7981	38.4089	569.1622	16
FOREARMS	448.2142	146.8857	287.9792	16
THIGHS	5126.2967	165.785	2440.9362	16
LOWER LEGS	458.983	52.9223	410.828	16

Subset Name:
S23DERMAL.MLAP

[a] Subset criteria included actual and estimated head patches. Of the 16 head observations, all were actual.

Table 10-2. PHED data from dermal, hand, and inhalation subsets for Appendix 10[a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	9,096 [c]	16 [d]	5	1
Hand (with gloves)	3,430	15	5	1
Inhalation	1,040	16	5	1

[a] Results from subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
Dermal total value was corrected by adjusting head data, which multiplied by 0.05 for use of headgear based on the assumption that headgear material provides similar protection of chemical-resistant PPE.
[d] Median number of replicates was used in determining subset multipliers.

Table 10-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 10[a]

	Short-Term	Long-Term
Total Dermal (with gloves)	5(9,096 + 3,430) = 62,630µg/lb AI handled	1(9,096 + 3,430) = 12,526 µg/lb AI handled
Inhalation	5(1,040) = 5,200 µg/lb AI handled	1(1,040) = 1,040 µg/lb AI handled

[a] Values from Table 10-2.

Appendix 11: Subset from PHED for Exposure of Mixer/Loader/Applicators Using High Pressure Hand Wand

Table 11-1. Description of PHED subsets for Appendix 11 [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Liquid Type	Not specified	Microencapsulated
Application Method	High pressure hand wand	High Pressure Hand Wand, Greenhouse/Ornamental
Mixing Procedure	Open	All open

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered are all Grades A; Hand data are all Grade C. Data quality grades are defined in the text and in Versar (1992).

Figure 11-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Appendix 11 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	335.34	189.3598	108.1326	13
NECK.FRONT	684.7243	169.8879	240.7374	7
NECK.BACK	502.1311	169.8879	176.5408	7
UPPER ARMS	1000.3013	153.8867	353.808	13
CHEST	1220.2988	153.8867	431.6215	13
BACK	1220.2988	153.8867	431.6215	13
FOREARMS	415.9328	153.8867	147.1161	13
THIGHS	614.7471	125.9135	325.0308	7
LOWER LEGS	383.01	125.9135	202.5061	7

Subset Name:
S21DERMAL.MLAP

[a] Subset criteria included actual and estimated head patches. Of the 80 head observations, 10 were actual and 70 were estimated from nearby patches (Versar, 1992).

Table 11-2. PHED data from dermal, hand, and inhalation subsets for Appendix 11[a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	6,261 [c]	13 [d]	5	2
Hand (with gloves)	339	13	5	2
Inhalation	151	13	5	2

[a] Results from subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
Dermal total value was corrected by adjusting head data, which multiplied by 0.05 for use of headgear based on the assumption that headgear material provides similar protection of chemical-resistant PPE.
[d] Median number of replicates was used in determining subset multipliers.

Table 11-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 11[a]

	Short-Term	Long-Term
Total Dermal (with gloves)	5(6,261 + 339) = 33,000 µg/lb AI handled	2(6,261 + 339) = 13,200 µg/lb AI handled
Inhalation	5(151) = 755 µg/lb AI handled	2(339) = 302 µg/lb AI handled

[a] Values from Table 11-2.

Appendix 12: Subset from PHED for Exposure of Spreading Bait Using Hands

Table 12-1. Description of PHED subsets for Appendix 12 [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Solid Type	Granular	Granular
Pesticide Action	Insecticide	Insecticide
Application Method	Other	Other
Study Code	Exclude 1027 [c]	520

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered are all Grade A or C; Hand data are all Grade C. Data quality grades are defined in the text and in Versar (1992).
[c] Study 1027 omitted because applications done with equipment, rather than by hand. Application equipment in Study Code 520 is blank.

Figure 12-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) Subset for Appendix 12 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	5911.8638	65.7229	4628.6454	16
NECK.FRONT	788.2688	56.8973	652.267	16
NECK.BACK	500.2346	65.7229	391.6546	16
UPPER ARMS	13233.4796	65.7229	10361.0448	16
CHEST	16143.9356	65.7229	12639.7626	16
BACK	16143.9356	65.7229	12639.7626	16
FOREARMS	5502.5809	65.7229	4308.2008	16
THIGHS	17371.7842	65.7229	13601.0966	16
LOWER LEGS	10823.2582	65.7229	8473.9817	16

Subset Name:

S15DERMAL.APPL

[a] Subset criteria included actual and estimated head patches. All 16 head observations were actual.

Table 12-2. PHED data from dermal, hand, and inhalation subsets for Appendix 12 [a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	92,000 [c]	16 [d]	5	1
Hand (with gloves)	4,660	15	5	1
Inhalation	350	16	5	1

[a] Results from subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
[d] Median number of replicates was used in determining subset multipliers.

Table 12-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 12 [a]

	Short-Term	Long-Term
Total Dermal	5(92,000 + 4,660) = 483,000 µg/lb AI handled	1(92,000 + 4,660) = 96,700 µg/lb AI handled
Inhalation	5(350) = 1,750 µg/lb AI handled	1(350) = 350 µg/lb AI handled

[a]Values from Table 12-2.

Appendix 13: Subset from PHED for Exposure of Mixer/Loader/Applicators Using Garden Hose End Sprayer, Open Pour

Table 13-1. Description of PHED subsets for Appendix 13[a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C (except hands; not specified)	C or E
Liquid Type	Not specified	All Solution
Application Method	Garden-hose-end sprayer (residential)	Garden-hose-end sprayer(residential)
Mixing Procedure	Not specified	All open

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne and Dermal Uncovered were all Grade C. Hand data were all Grade E. Data quality grades are defined in the text and in Versar (1992).

Figure 13-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Appendix 13 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: No clothing (total deposition)

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	520.6988	82.6901	393.5742	8
NECK.FRONT	73.8637	118.0917	44.7307	8
NECK.BACK	53.1781	122.7107	28.7246	8
UPPER ARMS	902.5729	50.5155	800.8678	8
CHEST	1748.1087	118.0916	1058.6268	8
BACK	1716.2031	122.7107	927.0225	8
FOREARMS	594.5486	116.5038	339.8912	8
THIGHS	1778.8308	64.8833	1526.4968	8
LOWER LEGS	1098.8758	50.0588	965.4128	8

Subset Name:
S26DERMAL.MLAP

[a] Of the 8 head observations all were estimated from nearby patches (Versar, 1992).

Table 13-2. PHED data from dermal, hand, and inhalation subsets for Appendix 13 [a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	1,460 [c]	8 [d]	7	2
Hand (with gloves)	4,840 [e]	8	7	2
Inhalation	13.4	8	7	2

[a] Results from subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a). Also, upper arms, chest, back, forearms, thighs and lower legs and feet multiplied by 0.1 for work clothing (Thongsinthusak *et al.*, 1991).
[d] Median number of replicates was used in determining subset multipliers.
[e] The hands exposure value are no gloves data in PHED. However, product labels require all mixer/loader must wear waterproof gloves. Therefore, exposure of gloved hands is calculated as one tenth exposure of bare hands, based on the assuming gloves provide 90% protection (Aprea *et al*, 1994).

Table 13-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 13 [a]

	Short-Term Exposure	Long-Term Exposure
Total Dermal (with gloves)	7(1,460) + 7(4,840) = 44,100 µg/lb AI handled	2(1,460) + 2(4,840) = 12,600 µg/lb AI handled
Inhalation	7(13.4) = 93.8 µg/lb AI handled	2(13.4) = 26.8 µg/lb AI handled

[a] Values from Table 13-2. Results rounded to three significant figures.

Appendix 14: Subset from PHED for Exposure of Loader/Applicators Using Push-Type Broadcast Spreader, Granular

Table 14-1. Description of PHED subsets for Appendix 14

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Solid Type	Granular	Granular
Application Method	Broadcast spreader, Scotts type	Broadcast spreader, Scotts type
Mixing Procedure	Not specified	All open

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered, and Hand were Grade C; Airborne data were all Grade B. Data quality grades are defined in the text and in Versar (1992).

Figure 14-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset Appendix 14 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, no gloves

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)				0
NECK.FRONT				0
NECK.BACK				0
UPPER ARMS	322.4862	141.6077	200.2811	15
CHEST	393.411	141.6077	244.3291	15
BACK	393.411	141.6077	244.3291	15
FOREARMS	134.0922	141.6077	83.2784	15
THIGHS	397.8912	119.3712	198.8172	15
LOWER LEGS	247.9008	119.3712	123.8704	15

Subset Name:
S25DERM.MLAP

Table 14-2. PHED data from dermal, hand, and inhalation subsets Appendix 14[a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	2,190 [c]	15 [d]	5	1
Hand (with gloves)	2,43[e]	15	5	1
Inhalation	5.83	15	5	1

[a] Results from subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total corrected by replacement of reported value with default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area and by addition of default head and neck value of 0.45 x (value for chest); ratio of surface areas (U.S. EPA, 1997a).
[d] Median number of replicates was used in determining subset multipliers.
[e] The hands exposure value are no gloves data in PHED. However, product labels require all mixer/loader must wear waterproof gloves. Therefore, exposure of gloved hands is calculated as one tenth exposure of bare hands, based on the assuming gloves provide 90% protection (Aprea *et al*, 1994).

Table 14-3. Values Used in Short-Term and Long-Term Exposure Calculations Appendix 14[a]

	Short-Term Exposure		Long-Term Exposure	
Total Dermal (with gloves)	5(2,190) + 5(243) =	12,200 µg/lb AI handled	1(2,190) + 1(243) =	2,430 µg/lb AI handled
Inhalation	5(5.83) =	29.2 µg/lb AI handled	1(5.83) =	5.83 µg/lb AI handled

[a] Values from Table 14-2. Results rounded to three significant figures.

Appendix 15: Subset from PHED for Exposure of Loader/Applicators to Granular Products Using Belly Grinder

Table 15-1. Description of PHED subsets for Appendix 15

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Solid Type	Granular	Granular
Application Method	Broadcast spreader, belly grinder	Broadcast spreader, belly grinder

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered were Grade A or C; Hand data were Grade C; Airborne data were Grade A or B. Data quality grades are defined in the text and in Versar (1992).

Figure 15-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Appendix 15 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, no gloves

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	1880.7055	188.0913	402.1796	29
NECK.FRONT	616.9102	132.1463	191.35	29
NECK.BACK	381.6992	150.612	117.46	29
UPPER ARMS	3675.8344	145.6315	631.9432	45
CHEST	5559.0338	164.0897	983.8566	44
BACK	4484.9596	145.5984	740.016	45
FOREARMS	2745.8288	308.5469	318.7088	45
THIGHS	3645.2817	149.0803	797.0017	45
LOWER LEGS	1780.0866	134.3576	335.439	45

Subset Name:
S27DERMAL.MLAP

[a] Subset criteria included actual and estimated head patches. Of the 29 head observations, all were actual.

Table 15-2. PHED data from dermal, hand, and inhalation subsets for Appendix 15[a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	25,700 [c]	45 [d]	4	1
Hand (no gloves)	634 [e]	23	4	1
Inhalation	80.7	40	4	1

[a] Results from subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
[d] Median number of replicates was used in determining subset multipliers.
[e] The hands exposure value are no gloves data in PHED. However, product labels require all mixer/loader must wear waterproof gloves. Therefore, exposure of gloved hands is calculated as one tenth exposure of bare hands, based on the assuming gloves provide 90% protection (Aprea *et al*, 1994).

Table 15-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 15 [a]

	Short-Term	Long-Term
Total Dermal (with gloves)	4(25,700) + 4(634) = 105,336 µg/lb AI handled	1(25,700) + 1(634) = 26,334 µg/lb AI handled
Inhalation	4(80.7) = 323 µg/lb AI handled	1(80.7) = 80.7 µg/lb AI handled

[a] Values from Table 15-2.

Appendix 16: Subset from PHED for Exposure of Aerial Flagger, Liquids

Table 16-1. Description of PHED subsets for Appendix 16 [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Liquid Type or Solid Type	Not specified	Emulsifiable concentrate or dry flowable
Application Method	Fixed- or rotary-wing	All rotary-wing

[a] Subsets of Flagger data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Coveredare all Grade A; Airborne and Hand data are all Grade A or B. Data quality grades are defined in the text and in Versar (1992).

Figure 16-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Appendix 16 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	11.3028	127.5702	5.6188	18
NECK.FRONT	.9533	134.3334	.5146	18
NECK.BACK	1.4111	215.8529	.4931	18
UPPER ARMS	3.9285	195.1025	.8284	28
CHEST	5.1065	188.8378	1.0384	26
BACK	5.1065	188.8378	1.0384	26
FOREARMS	1.802	179.5283	.3837	28
THIGHS	4.0404	308.6996	.9165	26
LOWER LEGS	2.448	305.6618	.612	28

Subset Name:
S7DERMAL.FLAG

[a] Subset criteria included actual and estimated head patches. Of the 18 head observations, all were actual.

Table 16-2. PHED data from dermal, hand, and inhalation subsets for Appendix 16 [a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	26.7 [c]	26 [d]	4	1
Hand (no gloves)	5.97	30	4	1
Inhalation	0.200	28	4	1

[a] Results from subsets of Flagger data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
Dermal total value was corrected by adjusting head data, which multiplied by 0.05 for use of headgear based on the assumption that headgear material provides similar protection of chemical-resistant PPE.
[d] Median number of replicates was used in determining subset multipliers.

Table 16-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 16 [a]

	Short-Term Exposure	Long-Term Exposure
Total Dermal (no gloves) [b]	4(26.7) + 4(5.97) = 130.7 µg/lb AI handled	1(26.7) + 1(5.97) = 32.7 µg/lb AI handled
Inhalation	4(0.200) = 0.800 µg/lb AI handled	1(0.200) = 0.200 µg/lb AI handled

[a] Values from Table 7-2. Results rounded to three significant figures.
[b] Gloves assumed to provide 90% protection (Aprea *et al*, 1994); exposure of gloved hands is calculated as one tenth exposure of bare hands.

Appendix 17: Subset from PHED for Exposure of Aerosol Can Applicators (No Gloves)

Table 17-1. Description of PHED subsets for Appendix 17[a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Application Method	Aerosol Can	Aerosol Can

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered and Hand are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 17-1. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Appendix 17[a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	69769.2667	124.9606	41026.2018	15
NECK.FRONT	7149.9	217.7599	2512.8897	15
NECK.BACK	2612.3533	80.9252	1995.1883	15
UPPER ARMS	5907.3	0	5907.0886	15
CHEST	7206.5	0	7206.2421	15
BACK	7206.5	0	7206.2421	15
FOREARMS	2737.4233	39.7741	2625.4536	15
THIGHS	7754.6	0	7754.3224	15
LOWER LEGS	4831.4	0	4831.2271	15

Subset Name:
S13DERMAL.APPL

[a] Subset criteria included actual and estimated head patches. All 15 head observations were actual.

Table 17-2. PHED data from dermal, hand, and inhalation subsets for Appendix 17 [a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	118,000 [c]	15 [d]	5	1
Hand (no gloves)	121,000	15	5	1
Inhalation	1,040	15	5	1

[a] Results from subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
[d] Median number of replicates was used in determining subset multipliers.

Table 17-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 17[a]

	Short-Term	Long-Term
Total Dermal	5(118,000 + 121,000) = 1,200,000 µg/lb AI handled	1(118,000 + 121,000) = 239,000 µg/lb AI handled
Inhalation	5(1,040) = 5,200 µg/lb AI handled	1(1,040) = 1,040 µg/lb AI handled

[a] Values from Table 17-2.

Appendix 17A: Subset from PHED for Exposure of Aerosol Can Applicators (With Gloves)

Table 17A-1. Description of PHED subsets for Appendix 17A[a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Application Method	Aerosol Can	Aerosol Can

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered and Hand are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 17A. Summary of results from the Pesticide Handlers Exposure Database (PHED) subset for Appendix 17A[a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	69769.2667	124.9606	41026.2018	15
NECK.FRONT	7149.9	217.7599	2512.8897	15
NECK.BACK	2612.3533	80.9252	1995.1883	15
UPPER ARMS	5907.3	0	5907.0886	15
CHEST	7206.5	0	7206.2421	15
BACK	7206.5	0	7206.2421	15
FOREARMS	2737.4233	39.7741	2625.4536	15
THIGHS	7754.6	0	7754.3224	15
LOWER LEGS	4831.4	0	4831.2271	15

Subset Name:
S13DERMAL.APPL

[a] Subset criteria included actual and estimated head patches. All 15 head observations were actual.

Table 17A-2. PHED data from dermal, hand, and inhalation subsets for Appendix 17A[a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand)	118,000 [c]	15 [d]	5	1
Hand (with gloves)	1,670	15	5	1
Inhalation	1,040	15	5	1

[a] Results from subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures.
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997a).
[d] Median number of replicates was used in determining subset multipliers.

Table 17A-3. Values Used in Short-Term and Long-Term Exposure Calculations for Appendix 17A[a]

	Short-Term	Long-Term
Total Dermal	5(118,000 + 1,670) = 598,000 µg/lb AI handled	1(118,000 + 1,670) = 120,000 µg/lb AI handled
Inhalation	5(1,040) = 5,200 µg/lb AI handled	1(1,040) = 1,040 µg/lb AI handled

[a]Values from Table 17A-2.

Scenario 18: Paintbrush Applicator

Table 18-1. Description of Pesticide Handlers Exposure Database (PHED) subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Application Method	Paintbrush	Paintbrush

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered were Grade C; Hand data were Grade B; Airborne data were Grade C. Data quality grades are defined in the text and in Versar (1992).

Figure 18-1. Summary of results from the PHED dermal subset for Scenario 28 [a]

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES
SCENARIO: Long pants, long sleeves, no gloves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	4341.87	10899.2607	189.0617	3127.282	15
NECK.FRONT	603.825	3203.592	167.6246	785.9412	15
NECK.BACK	21.736	105.4937	172.9478	39.0046	15
UPPER ARMS	287.508	1432.5736	215.8231	538.4358	15
CHEST	350.74	7948.0003	238.318	1051.7277	15
BACK	350.74	1509.1287	206.7452	561.6448	15
FOREARMS	3464.956	11935.561	152.0554	4285.5991	15
THIGHS	377.416	352.0512	19.0136	343.7148	15
LOWER LEGS	235.144	219.3408	19.0136	214.1469	15

[a] Subset criteria included actual and estimated head patches. Of the 15 head observations, all were actual.

Table 18-2. PHED data from dermal, hand, and inhalation subsets for Scenario 28 [a]

Exposure Category	Exposure (µg/lb AI handled)	Replicates in subset	Short-Term Multiplier [b]	Long-Term Multiplier [b]
Dermal (non-hand) [c]	37,700	15 [d]	5	1
Hand (no gloves)	308,000	15	5	1
Inhalation	308	15	5	1

[a] Results from subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Results rounded to three significant figures. U.S. EPA (1998) noted that most replicates in this subset (11/15) handled larger quantities than listed in PHED (0.0510 vs. 0.0253 lb AI); however, two replicates in the subset do not match amounts stated by U.S. EPA (1998). To the extent that amounts handled were understated in PHED, exposures would be overestimated (i.e., 0.0510/0.0253 = 2-fold difference).
[b] Multipliers are explained in the text and in Powell (2002).
[c] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[d] Median number of replicates was used in determining subset multipliers.

Table 18-3. Values Used in Scenario 28 Exposure Calculations [a]

	Short-Term Exposure		Long-Term Exposure	
Total Dermal (with gloves) [b]	5(37,700) + 0.5(308,000) =	342,000 µg/lb AI handled	1(37,700) + 0.1(308,000) =	38,500 µg/lb AI handled
Total Dermal (no gloves)	5(37,700 + 308,000) =	1,730,000 µg/lb AI handled	1(37,700 + 308,000) =	761,000 µg/lb AI handled
Inhalation	5(308) =	1,540 µg/lb AI handled	1(308) =	308 µg/lb AI handled

[a] Values from Table 28-2. Results rounded to three significant figures.
[b] Gloves assumed to provide 90% protection (Aprea *et al*, 1994); exposure of gloved hands is calculated as one tenth exposure of bare hands.