HUMAN EXPOSURE ASSESSMENT FOR

NON-AGRICULTURAL USES OF IMIDACLOPRID

Principal Authors
Eric S.C. Kwok, Senior Toxicologist
W. Wendy Zhao, Staff Toxicologist (Specialist, Retired)

Contributing Author
Christopher H. Demars, Senior Environmental Scientist (Specialist)

Exposure Assessment and
Human Exposure & Health Effect Modeling Section

December 2024

California Environmental Protection Agency
Department of Pesticide Regulation
Human Health Assessment Branch
1001 I Street
P.O. Box 4015
Sacramento, CA 95812-4015

Contributing Statement:

Non-agricultural and residential use exposure assessments	Eric S. C. Kwok, PhD, MPhil, DABT Senior Toxicologist
	W. Wendy Zhao, PhD (Retired) Staff Toxicologist (Specialist)
Imidacloprid concentrations in drinking water	Christopher H. DeMars, BSc Senior Environmental Scientist (Specialist)
Non-agricultural exposure updates	Eric S. C. Kwok, PhD, MPhil, DABT Senior Toxicologist

Section Reviewers:
Terrell Barry, PhD
Research Scientist IV
Human Health Assessment Branch

Eric S. C. Kwok, PhD, MPhil, DABT
Senior Toxicologist
Human Health Assessment Branch

Senior Reviewer:
Shelley DuTeaux, PhD, MPH
Branch Chief
Human Health Assessment Branch

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. TECHNICAL SUMMARY

Imidacloprid (1-[(6-chloro-3-pyridinyl) methyl]-*N*-nitro-2-imidazolidinimine) is currently registered in California as a systemic and contact insecticide for use in agricultural and non-agricultural settings. The dermal absorption of imidacloprid in humans was determined to be 5% (revised from 17%). The inhalation absorption studies of imidacloprid are not available; default inhalation absorption value of 100% was used in this assessment.

DPR released the draft Exposure Assessment Document (EAD) for external scientific review in March 2024 that addressed exposures from non-agricultural uses of imidacloprid by professional applicators, users of home (consumer) products, and pet products. This final EAD incorporates comments received from external scientific review as appropriate as well as relevant new data and information made available since March 2024.

The scope of this exposure assessment is on exposures from non-agricultural use of imidacloprid. Multiple exposure scenarios were evaluated including handler use in residential and landscape settings, use of home products including flea and tick treatments, and post-application exposure scenarios. Durations of exposure examined included short-term, seasonal, annual, and lifetime. All approved application methods were evaluated for imidacloprid containing products in non-agricultural settings, even if the product was also approved for agricultural use. Dietary and drinking water exposures were estimated in the accompanying final Risk Characterization Document and not addressed here other than estimating the imidacloprid residue in surface water. Noteworthy findings of this final non-agricultural use exposure assessment include:

- The short-term absorbed daily dose (STADD) for professionals handling imidacloprid is estimated to range from 0.53 µg/kg/day for handgun mixer/loader handling flowable concentrate formulation to 573.37 µg/kg/day for mixer/loaders handling soluble powder formulation for aerial applications on turf.
- The STADD for non-agricultural reentry workers is estimated to range from 1.47 µg/kg/day for pruning ornamental plants to 30.75 µg/kg/day for cutting flowers.
- The STADD for residential handlers, including for home use, is estimated to range from 0.02 µg/kg/day for handling ant bait to 2.75 µg/kg/day for owners/groomers treating large dogs.
- The STADD for residential and home use post-application is estimated to range from 0.15 µg/kg/day for children with incidental hand-to-mouth ingestion by touching pets treated with spot-on treatment to 1.96 µg/kg/day for children petting small cats wearing impregnated flea and tick control collars.
- The seasonal average daily dose (SADD) for handlers is estimated to range from 0.19 µg/kg/day for handgun mixer/loader handling flowable concentrate formulation to 14.13 µg/kg/day for mixer/loaders handling soluble powder formulation for ground applications on ornamentals.

- The only estimate of seasonal exposure in residential or home use settings was a SADD estimated for owner/groomers treating large dogs on a semi-regular basis (as per label instructions) at 0.75 µg/kg/day.
- The annual average daily dose (AADD) for handlers is estimated to range from 0.096 µg/kg/day for handgun mixer/loader handling flowable concentrate formulations to 6.33 µg/kg/day for mixer/loaders handling soluble powder formulation for ground applications on ornamentals.
- The lifetime average daily dose (LADD) for handlers is estimated to range from 0.051µg/kg/day for handgun mixer/loader handling flowable concentrate formulations to 3.38 µg/kg/day for mixer/loaders handling soluble powder formulation for ground applications on ornamentals.
- Anticipated imidacloprid concentrations in the surface water for use in dietary and drinking water exposure assessment in the imidacloprid Risk Characterization Document were also developed: 51.83 ppb for the acute drinking water assessment and 0.389 ppb for the chronic drinking water assessment.

II. INTRODUCTION

Imidacloprid (code name BAY NTN 33893; chemical name1-[(6-chloro-3-pyridinyl) methyl]-*N*-nitro-2-imidazolidinimine; CAS-No. 138261-41-3) is a systemic and contact insecticide. This pesticide was first registered with the US Environmental Protection Agency (US EPA) and the Department of Pesticide Regulation (DPR) in 1994.

Based on the Federal Insecticide, Rodenticide, and Fungicide Act (FIFRA) Section 3 Product/Label database of DPR (as of August 2024), there are 234 actively registered imidacloprid-containing products for agricultural, non-agricultural, institutional, and home uses. The use sites include food crops (e.g., cereals, rice, cotton, vegetables, potatoes, peanuts, and fruits), non-food crops (e.g., turf, ornamentals), commercial and institutional structures, recreational areas, animals (e.g., pets), and residential areas. In addition to the Section 3 registration, there are four active FIFRA Section 24 special local need registrations for use on various fruits and (or) ornamentals that are not listed on each of the registered labels in California. Furthermore, imidacloprid is approved for use by the California Department of Food and Agriculture (CDFA) for the backyard eradication of Asian citrus psyllid. Currently, there are no active FIFRA Section 18 Emergency Exemption registrations in California. However, in 1993 an interim human exposure assessment on imidacloprid was performed in response to a Section 18 registration request for use on cotton (Dong, 1993).

Human exposure to imidacloprid may include inhalation, dermal, and incidental oral exposures from various uses under occupational and non-occupational settings. Imidacloprid exposure can also occur from eating food treated with imidacloprid or drinking water that may be contaminated with imidacloprid residues. For occupational and non-occupational exposures, the groups of interest include pesticide handlers (e.g., mixer/loader/applicators), workers entering previously treated areas, adults using approved consumer products containing imidacloprid, and adults and children entering previously treated areas (indoor and outdoor).

As part of departmental efforts to estimate the nature and likelihood of adverse health effects in human who may be exposure to pesticides, this Human Exposure Assessment Document (EAD) for imidacloprid provides essential exposure information under non-agricultural and non-dietary settings. This exposure information has been used in the development of the human health Risk Characterization Document (RCD) for non-agricultural uses of imidacloprid. The EAD also serves as a basis for developing mitigation strategies if exposure to imidacloprid is found to cause potential health concerns. Dietary and drinking water exposures are addressed in the imidacloprid RCD.

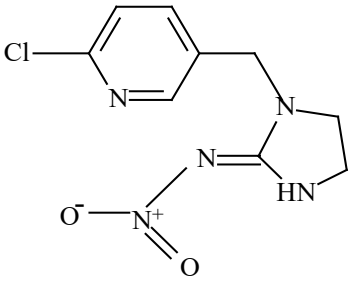
III. FACTORS DEFINING EXPOSURE SCENARIOS

A. Physical and Chemical Properties

Physical and chemical properties of imidacloprid, shown below, were obtained from the Bayer Corporation (Siemann, 1995; Fontaine, 1999), and the Merck Index (Budavari et al., 1989).

Chemical Name:	1-[(6-chloro-3-pyridinyl)methyl]-*N*-nitro-2-imidazolidinimine
Common Name:	imidacloprid
Code Name:	BAY NTN 33893
CAS-No:	138261-41-3

Structure:



Empirical Formula:	$C_9H_{10}ClN_5O_2$
Molecular Weight:	255.66
Appearance:	light yellow powder
Melting Range:	120 – 134°C
Vapor Pressure:	6 x 10^{-9} mm Hg at 20°C
Octanol/Water Partition Coefficient (log K_{ow}):	3.3 at 20°C
Solubility:	0.51 g/L in water at 20°C Soluble in acetone, methylene chloride, and dimethyl formamide
Density:	1.54 g/cm^2 at 25°C

B. Formulation and Label Uses

As mentioned previously, there are 234 actively registered imidacloprid containing products. These products include both non-end-use products (i.e., master labels, technical and manufacturing use products) and end-use products. The latter includes formulated products for agricultural use, residential/home use, institutional use, structural use, and use on animals (dogs or cats). Among these formulated products, some have overlapping uses such as residential and industrial uses.

Imidacloprid is currently formulated as flowable concentrate, dry flowable, granular/flake, pellet/tablet/cake/briquette, liquid, solution/liquid (ready-to-use), soluble powder, wettable powder, aqueous concentrate, pressurized liquid/sprays/foggers, suspension, dust/powder, emulsifiable concentrate, gel/paste/cream, bait (powder, dust, granular, strip), impregnated

material, and micro-injectable.

The registered uses of imidacloprid collectively result in numerous application sites which can be categorized into five broad areas as outlined below:

Agricultural use: Imidacloprid can be applied on field crops, vegetables, bush berries, stone fruits (apple, crabapple, loquat, mayhaw, pear, and quince), citrus, mango, pecans (supplemental label), grapes, ornamentals, trees, and turf. Treatment can be made directly to foliage, plants, or the soil. Imidacloprid can also be used in seed treatment products.

Residential: Imidacloprid can be applied indoors (e.g., carpet and mattresses) or around residential buildings, homes, and apartments. It can also be applied to residential lawns, trees, shrubs, ornamental plants, and fruit trees.

Institutional and Recreational: Imidacloprid can be applied in or around industrial, institutional, and commercial buildings. It can also be applied in or around recreational areas including golf courses, parks, etc.

Animal: Imidacloprid can be applied topically to dogs and cats for flea and tick control.

Other Non-food: Imidacloprid may be applied for insect control on field borders, fencerows, wood structures, and along roadways.

C. Target Pests

Imidacloprid may be used to control such insect pests as aphids, plant bugs, thrips, whiteflies, beetles, leaf miners, root weevil complex, scale insects, white grubs, mole crickets, hairy chinch bugs, wireworms, leafhoppers, mealy bugs, fleas, adelgids, sawflies, ants, bedbugs, cockroaches, and termites.

D. Pesticide Use

To ensure that the pesticide use pattern is representative, exposure estimates of imidacloprid in this assessment rely on the most recent five years of data (2017–2021) rather than data from any single year available from the DPR Pesticide Use Report (PUR) database. Based on the data retrieved from the PUR (DPR, 2024a), the total annual usage of imidacloprid applied by professional applicators in California ranged from approximately 330,708 to 442,205 pounds of active ingredient (AI) per year during 2017 to 2021 (Figure 1). Data reflecting total pounds used is the most relevant metric for describing the uses of imidacloprid by professional applicators in California. A significant number of these uses are from structural pest control and landscape maintenance which are considered "small scale operations" (Note: these are reported in PUR as small acreage treatment.) As such, acres treated is not the most appropriate metric to describe imidacloprid use in California and is, therefore, not used in this assessment. It is also noteworthy that PUR exempts reporting requirements on home and garden use as well as most industrial and institutional uses (Yanga and Steinmann, 2018). Therefore, not all imidacloprid uses in California are included in Figures 1–3, only those by licensed applicators.

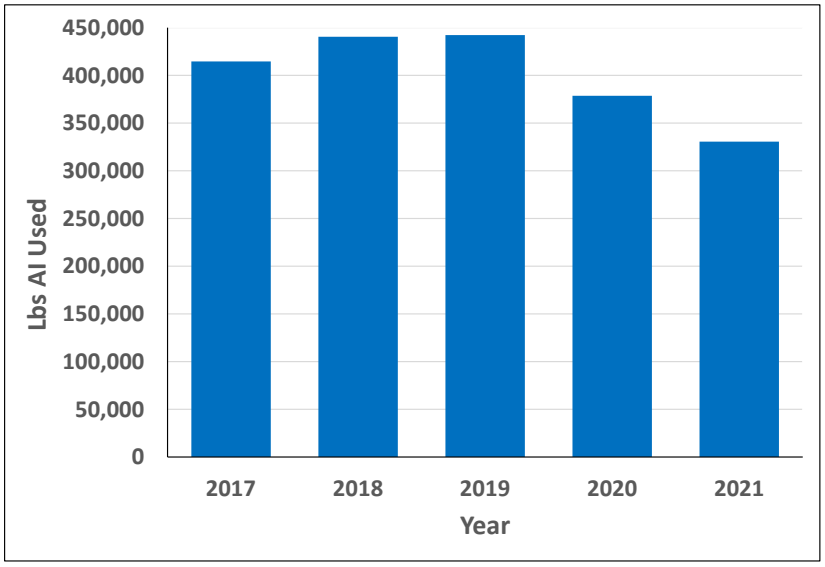


Figure 1. Total pounds AI reported in the PUR per year in California during 2017–2021

The major uses (> 1% of total amount) of imidacloprid in California as reported by the 2017–2023 PUR (Pesticide Use Report) database are shown in Figure 2. The major uses of imidacloprid include grapes (27.8%), tomato (9.96%), structural pest control (8.04%), lettuce (5.51%), orange (5.32%), tangerine (3.8%), pistachio (4.33%), broccoli (3.43%), cotton (3.34%), lemon (3.14%), landscape maintenance (3.09%), walnut (1.75%), cauliflower (1.41%), strawberry (1.18%), and other sites.

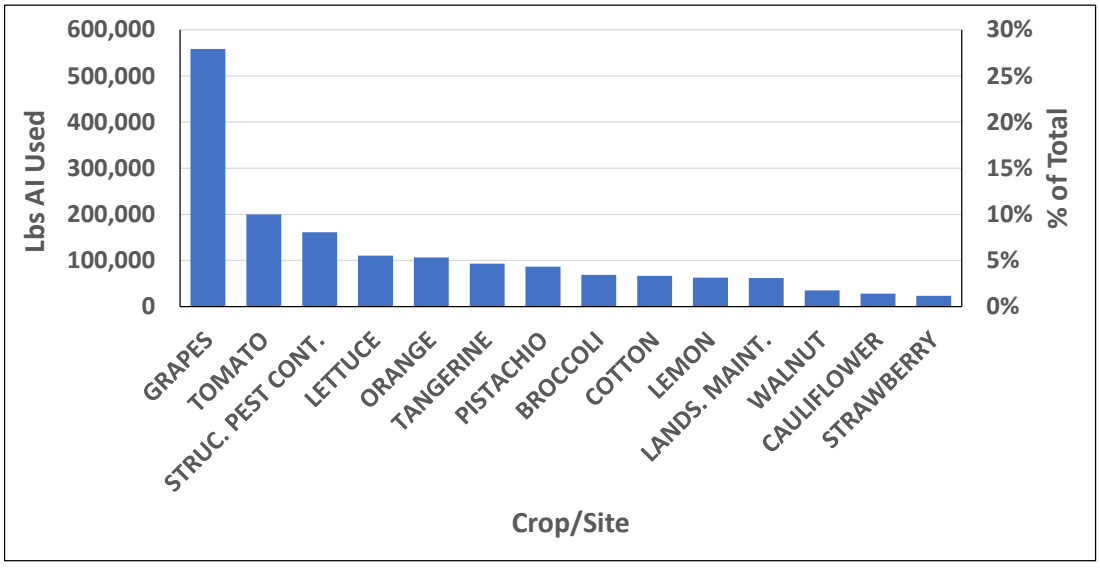


Figure 2. Pounds and relative percentage of uses for the major sites in California during 2017–2021

The amount and relative percentage of annual use each month are shown in Figure 3. The high-use months (above 5% of total annual usage) are March to October.

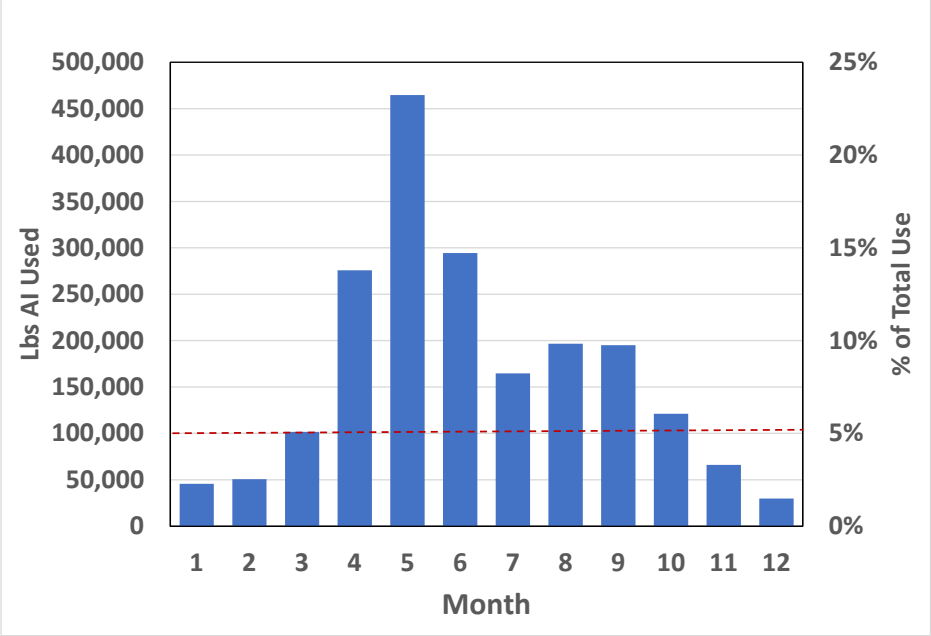


Figure 3. Pounds and relative percentage of season uses of imidacloprid in California during 2017–2021

Imidacloprid application methods include in-furrow, drench, soil application, ground application, aerial application, tree injection, spot, crack and crevice, bait treatments, and pet treatments. Liquid imidacloprid (including liquid mixtures with wettable powder or soluble pellet products) may be applied as foliar spray by several methods including aerial spray, airblast, backpack sprayer, groundboom, handgun, high-pressure sprayer, low-pressure handwand, and by an aerosol generator (greenhouse). Imidacloprid is also appropriate for soil application (irrigation/ chemigation) and seed treatment (hopper box and slurry). Granular imidacloprid can be applied by belly grinder, hand, tractor-drawn spreader, push-type spreader, and shaker can. Rates vary according to the method of application, pest, and whether the product is approved for indoor or outdoor use. Major use rates are summarized in Table 1.

Table 1. Maximum application rates for imidacloprid

Site/Crop	Maximum Use Rates (lbs AI/acre)
Turf	0.4
Soil Application/Chemigation	0.4
Foliar Application	0.4
Seed Treatment	0.5
Greenhouse Vegetables	0.02/1000 plants

AI – active ingredient

E. Label Precautions

Imidacloprid is classified Toxicity Category II, III or IV depending on the route of exposure. Based on the results of median lethal dose (LD50) or median lethal concentration (LC50) studies in laboratory animals, imidacloprid is classified as a Toxicity Category II acute oral hazard, a Toxicity Category III acute dermal hazard, and as a Toxicity Category IV acute inhalation hazard. The other acute hazards were classified as Toxicity Category IV (the lowest level) with no indication of a dermal sensitization potential. (DPR, 2024b).

Among all the registered imidacloprid products in California, three products are classified as having Toxicity Category I (with the signal word DANGER) and 46 products are classified as having Toxicity Category II (with the signal word WARNING). The remaining products are either classified as Toxicity Category III with the signal word CAUTION or as Toxicity Category IV which contains the signal word NONE. The required label language states that imidacloprid can be harmful if swallowed or absorbed through skin. Hazards and treatments of ingestion, inhalation, and dermal or eye contact are indicated on the product labels. Labels require that applicators and other handlers must wear the following protective clothing and equipment: long-sleeved shirt and long pants, waterproof gloves, shoes plus socks. In addition, some labels require handlers to wear a NIOSH approved respirator with any N, R, P or HE filter, protective eyewear, and chemical-resistant apron when mixing/loading.

F. Restricted Entry Interval

For most residential, landscape, institutional, and industrial uses, reentry is allowed when sprays have dried or dust has settled, which is in contrast with reentry for agricultural uses based on a restricted reentry interval (REI) and/or pre-harvest intervals (PHI). However, to assess exposure of non-agricultural reentry workers following imidacloprid applications, such as landscape maintenance and turf grass management, a specific reentry time is needed. Based on a detailed examination of all REI and PHI values available from imidacloprid product labels, the REI exhibits the lowest value, and the minimum reentry interval is either 12 hours or day 0. Accordingly, for a given product label, to assess the non-agricultural reentry exposure in humans, depending on the REI value specified and assuming it also applies to non-agricultural uses, either 12 hours or day 0 was used as the representative value instead of arbitrarily assigning a reentry time.

G. California Requirements

The product labels contain many of the requirements of the California regulations. However, the California Code of Regulations (CCR 6738(b)(1)) requires that protective eyewear be worn during mixing and loading and application activities. This requirement is not included on some Toxicity Category III and IV product labels. Imidacloprid is not classified as a restricted material at either the state or federal level.

H. Exposure Assessment Scope

With the adoption of "California Neonicotinoid Risk Determination" on January 1, 2024 (Title 3, California Code of Regulations, § 6990–6990.16 et seq.), it is anticipated there will be numerous changes to the reported use data, the major uses, use rates, and overall agricultural applications of imidacloprid. Accordingly, this assessment only presents the exposure resulting from non-agricultural residential, institutional, and industrial uses of imidacloprid including turf grass management and landscape maintenance. The inclusion of turf grass management and landscape maintenance in this assessment is due to the fact that these uses of imidacloprid are primarily for aesthetic, recreational, and/or ornamental purposes. Exposures resulting from the agricultural use of imidacloprid will be presented in a separate exposure assessment in the future.

I. Significant Exposure Scenarios

Human exposures to imidacloprid can occur through handling and applying the products, as well as contacting the treated surfaces. Accordingly, based on the uses prescribed on the product labels, potential human exposure scenarios consist of landscape maintenance and turf grass management, recreational areas, institutional, and residential uses, including pet treatments. Each of these use categories can further be subdivided into handler and reentry exposures.

1. Handler Exposure Assessment

Table 2 summarizes the handler exposures under landscape maintenance and turf grass management, recreational areas, institutional, and residential uses.

Table 2. Handler exposure scenarios for non-agricultural applications of imidacloprid

	Formulation[a,b]	Application Method	Use Site	Maximum Use Rate (lbs AI/acre)	Acres Treated, Gallon Spray, or Other Unit/ Day
Professional Handlers					
Mixer/Loader					
	Soluble powder	Aerial	Turf	0.4	350
	Soluble powder	Groundboom	Turf	0.4	Turf = 80 Golf course = 40
	Soluble powder	Soil Application	Ornamentals	0.4	24
	Flowable concentrate	Handgun	Ornamentals, Trees, Fruits	0.1	1000 gal
Mixer/Loader/Applicator					
	Soluble powder	Low-pressure Handwand	Turf	0.16/100 gal	40 gal
			Ornamentals	0.1/100 gal	40 gal
	Aqueous concentrate	Low-pressure Handwand	Turf	0.16/100 gal	1000 gal
			Ornamentals	0.3/100 gal	1000 gal
	Flowable concentrate	Backpack Sprayer	Tree, shrubs, outdoor floral	0.1/100 gal	40 gal
Loader/Applicator					
	Granular	Belly Grinder	Landscape	0.03	2
Applicator					
	Soluble powder	Groundboom	Turf	0.4	80
			Golf Course Turf	0.4	40
	Flowable concentrate	Handgun Sprayer	Ornamentals, Trees, Fruits	0.1/100 gal	1000 gal
	Soluble powder	Aerial Spray	Turf	0.4	350
Other					
Flagging	Soluble powder	Aerial Spray	Turf	0.4	350
Residential Handlers and Home Users					
Mixer/Loader/Applicator					
	Wettable powder	Low Pressure Handwand	Ornamentals, Flowers, Shrubs, Trees	0.4/100 gal	5 gal
	Flowable concentrate	Backpack Sprayer	Turf	0.1/100 gal	5 gal
	Liquid	Low-pressure Handwand	Bed Bug Treatment	0.008/gal	0.5 gal

Table 2. Handler exposure scenarios for non-agricultural applications of imidacloprid

	Formulation[a,b]	Application Method	Use Site	Maximum Use Rate (lbs AI/acre)	Acres Treated, Gallon Spray, or Other Unit/ Day
	Liquid	Low-pressure Handwand	Crack & crevice	0.008/gal	0.5 gal
Loader/Applicator					
	Granular	Push-type/rotary spreader (no glove)	Turf	0.4	1200 ft^2
Applicator					
	Water soluble packets	Low-pressure Handwand	Construction & Wood	1/100 gal	0.5 gal
	Liquid	Pressurized Can	Carpet	5.32E-4 lbs/can	0.5 can
	Gel	Gel	Household, Cracks	0.033/tube	NA
	Bait	Bait	Rodents & their Fleas (Station)	0.001/container	1 container
	Bait	Bait	Ant Bait (Crack & Crevice)	0.00008/container	1 container
Other					
Pet Owners	Liquid (RTU)	Topical	Dogs, Cats	0.001/pet	2 pets
Pet Owners	IM	Collar	Dogs, Cats	0.0028-0.0099/pet[c]	2 pets

Note: The product label requires that the handlers wear long-sleeved shirt and long pants, water-proof gloves, and shoes plus socks

[a] L - liquid; RTU - ready-to-use; IM: impregnated material

[b] Handler exposure scenarios were derived based on products with active registration as of August 2024.

[c] Application rate based on pet's body weight (i.e., 0.0028 lb/pet for the body weight up to 18 lb and 0.0099 lb/pet for the body weight more than 18 lb).

2. Post Application Exposure Assessment

In addition to handler exposure, there is the potential for post-application (reentry) occupational and residential exposures to imidacloprid. Detailed information on all reentry exposures scenarios was not available. To address these various exposure scenarios, it was assumed that the nature and magnitude of exposures are generally similar among individuals reentering treated areas who are performing the same or similar tasks. In other words, the reentry exposure estimates may apply to multiple activities, allowing for their grouping (US EPA, 2017a). Within each group, a representative use site and reentry exposure activity (or activities) are chosen and referred to as the "representative use site" and "representative reentry activities," respectively. These are expected to result in exposures similar to or greater than those encompassed by all exposure scenarios, which this assessment refers as "covered use sites" and "covered reentry activities."

Table 3 summarizes non-agricultural reentry worker exposure scenarios based on use sites listed in product labels. Reentry scenarios include activities for turf, construction, and ornamentals and trees, including landscape maintenance. Table 4 summarizes the residential and other post-application exposure scenarios.

Table 3. Summary of non-agricultural post-application exposure scenarios for reentry workers

Representative Use Site	Representative Reentry Activities	Covered Use Sites	Covered Reentry Activities
Turf			
Turf grass	Mowing	Lawns, Parks	Aerating, Pruning (including Flower cutting), Scouting, Irrigating, Golfing, Weeding
Construction			
Wood	Handling treated wood (adults), playing on treated wood (children)	N/A	Residents in homes using treated wood (adults, children)
Residential & Institutional area	Reentry into Residential Structure (adults, children)	N/A	Reentry Into Institutional Structure (adults)
Ornamentals and trees			
Trees, Evergreens	Scouting, Thinning fruit, Pruning (hand)	Christmas trees, Evergreens,	Scouting, Chopping Brush, Irrigating, Pruning, Weeding, Transplanting
Nursery, greenhouse ornamentals pruning (hand), cut flowers or greens	Pruning (Hand)	Indoor & outdoor potted plants, Foliage plants, Ground covers, Ornamental plants, Interior plantscapes, Shrubs, Landscape/Home lawn	Irrigating, Scouting, Hand Thinning, Turning, Tying, Weeding, Transplanting

Abbreviation: N/A, not applicable

Table 4. Summary of residential and recreational area activities with potential post-application exposure to imidacloprid

Representative Exposure	Representative Reentry Activities	Covered Reentry Activities
Residential Post-Application		
Adult Dermal	Entering for recreation, yard work, or other homeowner activities on turf grass	Player in Park (adult), Noncrop areas (Field borders, Fencerows, Roadside, Ditchbanks, Borrow pits, Wasteland)
Children Dermal	Entering and playing on turf grass	Player in Park (children)
Hand-to-Mouth	Entering and playing on turf grass	Player in Park (children)
Toddlers Grass Ingestion	Entering and playing on turf grass	Player in Park (children)
Indoor Pest Control	Reentering into building	
Pets	Treatment	
Recreational Areas Post-Application		
Golf Course Mower	Mowing turf grass of golf course	Park Turf Grass Mower
Golfers	Playing on golf course	
Maintenance Worker	Mowing, playing surface maintenance, hand weeding	
Pets Post-Application		
Dogs/Cats	Hug/holding treated pets (adults, children); Children hand-to-mouth	Petting or handling treated pets (adults, children)

IV. DERMAL/INHALATION ABSORPTION

As required for pesticide registration, Bayer CropScience conducted an *in vivo* dermal absorption study for imidacloprid (Odin-Feurtet, 2009). This assessment did not identify any other studies submitted by other registrants or found in the open literature.

In the study by Odin-Feurtet (2009), sixteen male Wistar rats were topically treated with single dose at three levels: 0.5 g/L (low dose), 70 g/L (intermediate dose), and 350 g/L (high dose) of the imidacloprid formulation (four rats each group). The test material was ^{14}C-labeled. The rats were allocated individually into metabolism cages (Jenson's Metabowls Mk III or Radleys) for 8 hours, equivalent to a standard working day. After the exposure period, the treated rats were sacrificed at 8, 24, 72, and 168 hours post-application, and the amount of radioactivity absorbed, excreted, and present on or in the skin, was quantified.

The mean dermal absorption for each timepoint at each dose level has been summarized below with additional detail found in Appendix B). Based on DPR practice, dermal absorption is defined as the percent total potentially absorbable dose (PAD) of the active ingredient. This value is determined by combining the total directly absorbed amount with the total bound at the dose site including the stratum corneum (i.e., bound skin residue) which is the potentially

absorbable at the longest post-application time point in the low-dose group (i.e., 168 hours at 0.5 g/L). For imidacloprid, the bound skin residue is approximately 3 times higher at this time-dose (please see Appendix B for details). Initially DPR determined the total dermal absorption based on data from Odin-Feurtet (2009) to be 17%. This value originally included the bound dose in the stratum corneum. US EPA used the same registrant-submitted study to derive its DAF. Based on current practices, US EPA selected the 5 μg/cm^2 dose at the 168-hour time point and combined treated and surrounding skin, untreated skin, urine, feces, cage wash, blood, and carcass fractions to determine an absorbed fraction of 4.8%. However, US EPA did not include the bound dose in the stratum corneum (accounting for ~12%) in the calculation of the DAF, as it found there was no evidence of movement of the chemical into systemic absorption from the skin layers after washing. As a result, imidacloprid detected in the stratum corneum and associated skin measures was not considered absorbable by US EPA and was not added to the agency's final DAF for imidacloprid.

Accordingly, DPR revised its derivation of the DAF in the final EAD. In considering all the monitoring periods at the lowest test dose, there was no significant decrease in the percentage of bound skin residue in the stratum corneum (based on DPR's independent statistical tests including analysis of variance (ANOVA) followed by Tukey's Honestly Significant Difference (HSD) post-hoc test). This suggests that the bound skin residue may not be available for absorption, therefore confirming US EPA's findings. Hence, DPR's derivation of the potentially absorbable dose (PAD) is revised to now consist of the percentage of directly absorbed and total at the dose site, equaling 4.823% as appeared in Odin-Feurtet (2009). The rounded-up value of 5% is used in this assessment to update all dermal exposure values. The resulting risk estimates based on dermal routes of exposure have been similarly updated in the final RCD.

No inhalation absorption studies are available. In the absence of these data, the default inhalation absorption value of 100% is used for calculations of doses absorbed via inhalation based on DPR practice (Frank, 2008, Cochran, 2005).

V. ENVIRONMENTAL CONCENTRATIONS

A. Air

Preliminary ambient air monitoring studies were conducted in Butte, Santa Clara, Imperial, and Solano counties in California (DPR, 2001; 2002a, 2002b, 2002c; 2004c). Ground applications of imidacloprid foliar spray were applied around businesses, commercial parking lots, curbsides, public parks, and residential properties, in Chico (Butte County), Cupertino (Santa Clara County), the Paradise Lane, Imperial Spa and Bombay Beach areas (Imperial County), and Vacaville (Solano County) in locations infested with glassy-winged sharpshooter. Nine air samples (using XAD-2 resin as the sampling medium) from the treated areas were analyzed at the time of application, 24 hours post-application, and 48 hours post-application. Information about the geographic relationship between the location of the monitoring and the application site was not provided. Vapor-phase imidacloprid was not detected above the limit of detection (0.5 μg) in results of any of the nine air monitoring studies. This is not unexpected, as the low vapor

pressure of imidacloprid (6 x 10^{-9} mm Hg at 20°C) would result in negligible detections in the air following foliar applications.

B. Dislodgeable Foliar Residue (DFR)

Dislodgeable foliar residue (DFR) is defined as the amount of pesticide residue that can be removed from both sides of treated foliage surfaces using aqueous surfactant. DFR can be a source of exposure if transferred to individuals contacting leaves that have been treated with pesticides. DFR, along with an appropriate transfer factor, can be used to estimate the amount of pesticide transferred to individuals who enter a previously treated area. Several DFR studies are available in the open literature (Gunther et al., 1973a, 1973b). The protocol involves sampling a leaf by cutting out a disc-shaped fraction, which is then rinsed or wiped with a solvent to remove any dislodgeable fraction of pesticide residue. The liquid is then analyzed by gas-liquid chromatography and expressed as an amount of pesticide per surface area samples (μg/cm^2). A general equation for calculating DFR is:

$$DFR_t = DFR_0 \times \exp(-kt)$$

where DFR_0 represents initial DFR level, *t* represents the day after treatment, and *k* is the constant derived from regression. Data were analyzed using exponential regression with a first-order rate kinetic assumption (i.e., the rate, *k*, is a linear function independent of the amount of DFR removed from treated foliage). DFR values used to estimate exposure are listed in Table 10 in the Exposure Assessment section.

C. Transferable Turf Residue (TTR)

Evaluating transferable turf residue is an important component of conducting human exposure assessments for pesticides that can be applied to lawn or turf. It is used to determine exposure for individuals reentering a treated area and provides an estimate of the amount of pesticide residue that can be transferred from the grass to the person. Transferable turf residue refers to the amount of residue available per unit area as determined by a given sampling method (US EPA, 2017a). Four transferable turf residue studies on imidacloprid were evaluated for this assessment including Eberhart and Ellisor (1994), Welsh, et al. (2005), Kroiski (2016) and Veal (2020).

Eberhart and Ellisor (1994)
Eberhart and Ellisor (1994) conducted TTR studies in Florida, Kansas, and New Jersey, monitoring transferable residue levels (ng/cm^2) of the product Merit® at various sampling intervals (1, 2, 3, 5, 7 and 14 days post-application). No measured data were recorded on Day 0 (the day of the application), however the researchers predicted what the level would be using log-quadratic or log-linear regression models. On the remaining post-application sampling days, three residue samples were collected from each plot at each location using groundboom equipment. The resulting data are summarized in Table 5.

Table 5. Merit® transferable residue levels in ng/cm^2

Days post-application	Florida		New Jersey		Kansas	
	Measured Data[a] (ng/cm^2)	**Predicted Data**[b] (ng/cm^2)	**Measured Data** (ng/cm^2)	**Predicted Data**[c] (ng/cm^2)	**Measured Data** (ng/cm^2)	**Predicted Data**[d] (ng/cm^2)
0	--	3.1891	--	10.6793	--	3.0475
1	3.33 (± 3.6)	2.7745	38.4 (± 12.6)	7.8175	114.7 (± 33.3)	2.9312
2	2.26 (± 5.7)	2.4453	4.26 (± 2.6)	5.7226	0.62 (± 1.3)	2.8193
3	1.78 (± 12.1)	2.1835	3.0 (± 2.2)	4.1891	0.46 (± 0.6)	2.7117
5	1.76 (± 6.5)	1.9752	0.92 (± 2.4)	3.0665	0.64 (± 2.2)	2.5087
7	1.84 (± 3.8)	1.5809	0.54 (± 1.2)	1.2029	3.23 (± 15.5)	2.3208
14	1.45 (± 9.8)	1.4094	0.28 (± 0.0)	0.1355	3.41 (± 5.1)	1.7674

Data based on the study by Eberhart and Ellisor, 1994.

[a] Arithmetic mean of n = 3 samples; ± standard deviation

[b] The predicted data were calculated for Florida using the log-quadratic model:

[c] The predicted data were calculated for New Jersey using the log-linear regression model:

[d] The predicted data were calculated for Kansas using the log-linear regression model:

It is noteworthy that both climate and usage conditions in the Florida, New Jersey, and Kansas study sites differ significantly from California. In addition, the study results collected from the Kansas and New Jersey sites had poor R-squared value (r^2) values (0.01). Because of these factors, the TTR study by Eberhart and Ellisor (1994) was not selected for this assessment.

Welsh et al. (2005)

Welsh et al. (2005) conducted a TTR study in California comparing two sampling techniques, the Modified California Roller (MCR) and a specific variation of the California Roller (CR). Interestingly, results showed increasing TTR values post-application. This deviates from the expected linear degradation trend when pesticides are subjected to environmental degradation over time. The reasons for this result are unclear, but the investigators suggested that it might be due to foggy conditions and/or high moisture on of some of the sampling days after application. Also, the r^2 of logarithm measured TTR versus time was 0.19, indicating highly variable data. Due to the reversed dissipation trend of collected samples, the TTR values in this study were not considered reliable for estimating exposure. Therefore, Welsh et al., 2005 was not used in this assessment.

Kroiski (2016)

This TTR study was conducted in three states including California. Because of the applicability of California-specific data for DPR assessments, results from the other two states are not discussed here. In Kroiski (2016), imidacloprid residues were examined on turf after applications of the product 12ESP703SC, a suspension concentrate formulation, was applied at a rate of 0.5 lb

AI/acre in Sanger, CA. This application rate exceeds the current maximum application rate of imidacloprid products in CA (i.e., 0.4 lbs AI/acre). The product was applied once using a single spray droplet size with properly calibrated equipment that simulates the commercial application. Using Modified California Roller technique, samples were collected in triplicate at 1, 2, 4, 8, 12, 24, 32, 48, 72, 96, 120, 144 and 168 hours post-application. The average concurrent recoveries were 93–96% with the limit of quantification (LOQ) reported as 0.00018 µg/cm^2. The study was conducted and reported in accordance with FIFRA (40 CFR 160) Good Laboratory Practice Standards, including the recording and reporting of sample preparation, extraction and analysis, method validation, and recoveries within an acceptable range. However, the r^2 value of logarithm measured TTR versus time was 0.1.

Veal (2020)

The Veal (2020) TTR study was also conducted in three US states, however only the California data are discussed here. Residues were evaluated after applications of Merit 2F® at 0.4 lbs AI/acre in a suspension concentrate formulation in Fresno, CA. The product was sprayed once (i.e., a single application) with properly calibrated equipment that simulates the commercial application using either medium or coarse droplet size. Samples were collected using the Modified California Roller technique at 1, 2, 4, 8, 12, 24, 32, 48, 72, 96, 120, 144 and 168 hours post-application. One sample was collected from each of the two spray droplet sizes employed (i.e., medium and coarse). The average concurrent recoveries were 96–107% with the limit of quantification (LOQ) reported as 0.00018 µg/cm^2. The study was conducted and reported in accordance with FIFRA (40 CFR 160) Good Laboratory Practice Standards, including the recording and reporting of sample preparation, extraction and analysis, method validation, and recoveries within an acceptable range. The r^2 of logarithm measured TTR versus time was 0.94. Table 6 provides a summary of the initial residue samples collected 1 hour post application from the Kroiski (2016) and Veal (2002) TTR studies.

Table 6. Initial imidacloprid residues sampling data and estimated transferable turf residues from selected California sites

California Study Location	**Grass Type**	**Application Rate (lbs AI/acre)**	**Highest Measured Residue (µg/cm^2)**	**Adjusted Residue (µg/cm^2)**	**TTR (as % Application Rate)**
Sanger[a]	Bermuda	0.5	0.656[c]	**0.525[e]**	12.3%
Fresno[b]	Bermuda	0.4	0.03[d]	0.03	0.68%

[a] Data from Kroiski, 2016 (r^2 = 0.1).

[b] Data from Veal, 2020 (r^2 = 0.93).

[c] No adjustment was made to the TTR value due to high field recovery (i.e., >90%) (US EPA, 1998).

[d] TTR is calculated using the values collected from both spray droplet sizes due to no significant difference (based on a permutation test) between the medium- and coarse-size droplet TTR values. Accordingly, both datasets are combined to identify the highest TTR value.

[e] TTR is adjusted to 0.525 µg/cm^2 (i.e., 0.656 x 0.4/0.5) based on CA maximum application rate of 0.4 lbs AI/acre. **Bolded** value was used to develop a high-end exposure estimate.

The registrant-submitted TTR studies by Kroiski (2016) and Veal (2020) both collected samples following application of imidacloprid in California. Using data from either study would allow for the estimation of human exposure to imidacloprid using California-specific data, as preferred by DPR and consistent with recommendations from the National Academy of Sciences (NAS) following its independent peer review of the department's risk and exposure assessment practices (NRC, 2015). Between these values, despite the high variability associated with data from Kroiski (2016), the value of 0.525 µg/cm² on day 0 was used for developing a high-end exposure estimate in this assessment because it is not a predicted value, and there is no evidence to show that the value is erroneous.

VI. EXPOSURE ASSESSMENT

For occupational handlers and reentry workers, this analysis assessed the imidacloprid exposures for four periods: short-term, seasonal, annual and lifetime. Short-term exposure represents the highest exposure an individual may realistically experience while performing a label-permitted activity. It is assessed using the "upper-bound" estimate of exposure, i.e., the 95th percentile of daily exposure (Powell, 2007). To evaluate post-application short-term exposures for reentry workers, it was assumed that workers enter the treated areas immediately after the specified REI has expired or as specified on the label if no REI is established, such as for numerous products approved for residential, industrial, and landscape uses. For assessing seasonal, annual and lifetime exposures, this assessment used the arithmetic mean instead of 95th percentile exposure value, as continuous daily exposure at the upper-bound level is unlikely. For residential and home use, scenarios covered both application and post-application exposures and activities including indoor and outdoor treatments around the home and in the garden, the use of pet products, various recreational activities and the CDFA Citrus Pest and Disease Prevention Program. For more information on the latter, visit https://www.cdfa.ca.gov/citrus/pests_diseases/acp/regulation.html.

A. Professional Handlers

At the time this EAD was prepared, no imidacloprid specific studies were available to develop handler exposure estimates. Therefore, the Pesticide Handler Exposure Database (PHED, 1995) data were used to estimate exposure based on DPR practice. There are two assumptions inherent in the PHED data (Versar, 1992): (1) exposure is primarily a function of the pesticide application method/equipment and formulation type, rather than the physical-chemical properties of the specific AI; and (2) exposure is proportional to the amount of AI handled.

The limitations of using PHED as a surrogate database were described in Beauvais et al. (2007). Using PHED increases uncertainty in the exposure estimates. To account for the uncertainty when using these surrogate data to estimate short-term exposure, DPR uses the 90% upper confidence limit (UCL) on the 95th percentile as practice. The approximation method was introduced in Powell (2007). Handler exposure scenarios and related exposure data are based on product labels, a practice also used by DPR to capture the most relevant exposure estimates based on approved legal uses and assumptions used for exposure calculations (Beauvais, et al.,

2007). The estimations of handler (mixer/loader/application) exposures based on label-allowed conditions and using PHED surrogate data subsets are summarized in Table 7.

When PHED is used to estimate seasonal exposure, a 90% UCL is applied to the arithmetic mean to estimate the uncertainty of using surrogate data. The method used to obtain UCL on the arithmetic mean was described by Powell (2007). The intermediate and long-term worker exposures were estimated by investigating temporal patterns in imidacloprid use. The total annual applied pounds of AI from 2017 to 2021 is shown in Table 8 using data from DPR's Pesticide Use Report (DPR, 2024). To estimate annual exposure, only monthly usage equal to or greater than 5% of the annual application over the most recent five-year period was included. Because the PUR database indicates that Fresno County has the highest annual pounds of imidacloprid applied among all counties in California, it was selected for this assessment to capture the potential highest exposure in California. It is noteworthy that PUR exempts reporting requirements for some non-agricultural uses (Yanga and Steinmann, 2018). Hence, if based solely on non-agricultural uses, the high-use seasons would likely be underestimated. Accordingly, for this assessment, the entire Fresno County PUR dataset was conservatively used to estimate the use season. Figure 4 summarizes aerial and ground applications of imidacloprid in Fresno County by month and percent of annual use calculated from PUR data (DPR, 2024).

Table 7. Pesticide Handler Exposure Database (PHED) exposure estimates for non-agricultural professional handlers applying imidacloprid in landscape maintenance and turf grass management scenarios

Exposure Scenarios[a]			Maximum Application Rate[d] (lbs AI/treated unit as noted)	Daily Treated[e] (Units as noted/day)	Average Exposure[f] (µg/lbs AI)		Observations[g]	Scenario[h]
Task[b]	Formulation[c]	Application Method			Dermal	Inhalation		
M/L	SP	Aerial	Turf = 0.4	350 acres	646.7	49.4	17–33	1
M/L	SP	Groundboom	Turf = 0.4	Turf 80 acres	646.7	49.4	17–33	1
				Golf course 40 acres	646.7	49.4	17–33	1
M/L	SP	Soil application	Ornamentals = 0.4	24 acres	646.7	49.4	17–33	1
M/L	FC	Handgun	Ornamentals, fruit, trees = 0.1	1000 gal	202.7	0.66	21–25	2
M/L/A	SP	Low-pressure handwand	Turf = 0.16/100 gal	40 gal	15030	1040	15–16	23
M/L/A	SP	Low-pressure handwand	Ornamentals = 0.1/100 gal	40 gal	15030	1040	15–16	23
M/L/A	AC	Low-pressure handwand	Ornamentals = 0.3/100 gal	1000 gal	1580.4	22.8	10–35	22
M/L/A	AC	Low-pressure handwand	Turf = 0.16/100 gal	1000 gal	1580.4	22.8	10–35	22
M/L/A	FC	Backpack sprayer	Tree, shrubs, outdoor floral = 0.1/100 gal	40 gal	22310	17.5	11	20
L/A	G	Belly grinder	Landscape = 0.03	2 acres	26334	80.7	23–44	27
A	SP	Groundboom	Turf = 0.4	Turf 80 acres	25.5	1.2	22–34	11
				Golf course 40 acres	25.5	1.2	22–34	11
A	FC	Handgun sprayer[i]	Ornamentals = 0.1/100 gal	1000 gal	1580.4	22.8	10–35	22
A	SP	Aerial spray	Turf = 0.4	350 acres	61.8	0.6	9–14	17
F	SP	Aerial spray	Turf = 0.4	350 acres	43.4	0.2	21–30	7

[a] Exposure scenarios are based on uses listed on the product labels.

[b] Tasks include 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).

[c] SP = Soluble powder; FC = Flowable concentrate; AC = Aqueous concentrate; G = Granular

[d] Maximum application rates are values found on currently registered labels. AI = active ingredient; gal = gallon

[e] Maximum daily acres and volumes to be treated in each scenario are based on DPR default estimates (US EPA, 2001).

[f] Exposure data are from PHED (PHED, 1995). Dermal values are sum of body dermal (exclusion of hand) and hand (see Appendix A). Appropriate protection factors were applied depending on label precaution and DPR practice (Beauvais et al., 2007). Based on the product labels, all handlers at least must wear:

- Long-sleeved shirt and pants, and dermal exposure value from PHED were adjusted by 90% protection factor on body dermal exposure (Thongsinthusak and Dong, 2010).
- Hand exposure values with waterproof gloves, if unavailable directly from the PHED database, were adjusted using the non-glove hand exposure values and a 90% protection factor (Thongsinthusak and Dong, 2010).
- Shoes plus socks, and feet dermal exposure were adjusted by 90% protection factor (Thongsinthusak and Dong, 2010).

[g] Median number of observations for dermal (non-hand), hand and inhalation exposures in PHED data set.

[h] The scenario number that corresponds to scenarios described in the DPR guidance (Beauvais et al., 2007).

[i] No PHED data available for this scenario; estimates used the PHED data for the low-pressure handwand.

Table 8. Yearly summary of imidacloprid use based on the total number of pounds of active ingredient (AI) applied in the top 10 high-use counties in California from 2017 to 2021

County	Total Applied AI (lbs)				
	2017	2018	2019	2020	2021
Fresno	74685	93147	72189	70249	53844
Kern	63600	55968	47092	55654	41180
Imperial	23230	16288	99898	21862	15110
Tulare	35010	26366	28879	35637	24810
San Joaquin	28574	28457	23115	18939	16830
Santa Barbara	22131	25564	21313	22860	20555
Riverside	12781	33169	13111	11745	12500
Monterey	18987	16346	15242	18812	12404
San Luis Obispo	15704	18159	11756	14238	13040
Madera	16348	13939	15374	14315	12477

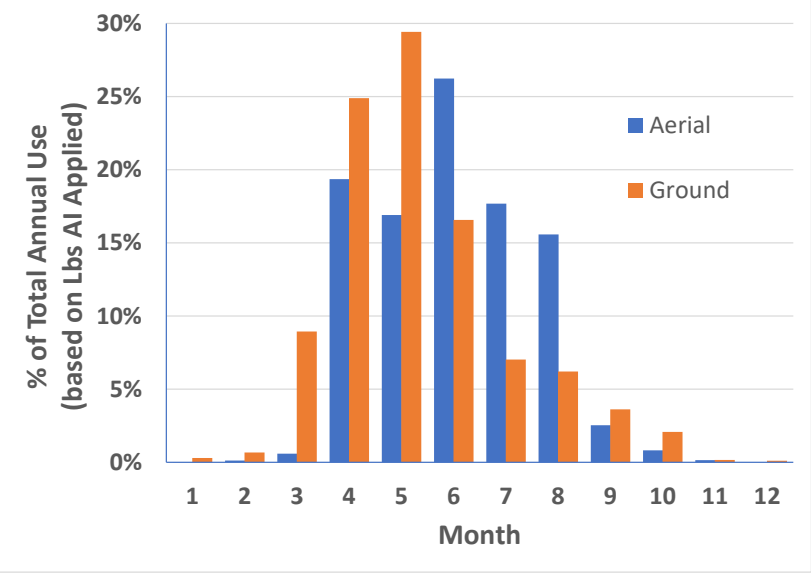


Figure 4. Aerial and ground applications of imidacloprid in Fresno (the highest use California county) from 2017–2021

Table 9 summarizes the estimates of acute, seasonal, annual, and lifetime exposures for imidacloprid handlers. These values are provided as the Short-term Absorbed Daily Dose (STADD), the Seasonal Average Daily Dose (SADD), Annual Average Daily Dose (AADD), and Lifetime Average Daily Dose (LADD), respectively. The AADD estimates are based on the peak use periods for aerial and ground applications. However, for most exposure scenarios, only STADD values were calculated because longer-term exposures are not anticipated based on the uses prescribed on the product labels.

Table 9. Estimates of short, intermediate, and long-term exposure to non-agricultural professional handlers applying imidacloprid in landscape maintenance and turf grass management scenarios

Job Category[a]	Formulation[b]	Use Rate[c] (lbs AI used, or units as indicated)	STADD[d,i] (µg/kg/day)	SADD[e,i] (µg/kg/day)	AADD[f,i] (µg/kg/day)	LADD[g] (µg/kg/day)
Aerial (All Activities)						
Mixing/Loading	SP	Turf[h] = 0.4, 350 acre/day	573.37	-	-	-
Application		Turf = 0.4, 350 acre/day	27.86	-	-	-
Flagging		Turf = 0.4, 350 acre/day	14.66	-	-	-
Ground (Mixer/Loader)						
Groundboom	SP	Turf = 0.4, 80 acre/day	131.06	-	-	-
		Golf course turf = 0.4, 40 acre/day	65.53	-	-	-
Handgun	FC	Ornamentals, fruit, trees, shrubs = 0.1 lbs/100 gal	0.53	0.19	0.096	0.051
Soil Application	SP	Ornamentals = 0.4	39.32	14.13	6.33	3.38
Ground (Applicator)						
Groundboom	SP	Turf = 0.4	3.83	-	-	-
		Golf course turf[h] = 0.4	1.92	-	-	-
Handgun	FC	Ornamentals, trees, fruit = 0.1/100 gal	5.03	1.81	0.91	0.48
Ground (Mixer/Loader/Applicator)						
Low Pressure Handwand	SP	Turf = 0.16/100 gal	5.96	-	-	-
		Ornamentals = 0.1/100 gal	3.72	1.34	0.67	0.36
Low Pressure Handwand	AC	Turf = 0.16/100 gal	8.47	-	-	-
		Ornamentals = 0.3/100 gal	15.10	5.43	2.71	1.45
Backpack Sprayer	FC	Tree, shrubs, outdoor floral = 0.1/100 gal	2.49	0.89	0.45	0.24
Belly Grinder	G	Landscape = 0.03	3.92	1.41	0.71	0.38

[a]Exposure scenarios are based on the product labels.

[b]SP = Soluble powder; FC = Flowable concentrate; AC = Aqueous concentrate; G = Granular.

[c]Use rates are based on the product labels. AI = Active ingredient; lbs = pounds; gal = gallons.

[d]STADD = Short-term Absorbed Daily Dose

Dermal STADD = 90% upper confidence limit for 95th percentile estimates of dermal exposure × dermal absorption factor × maximum application rate × maximum daily treated acres (or volume) ÷ body weight.

Inhalation STADD = 90% upper confidence limit for 95th percentile estimates of inhalation exposure × inhalation absorption rate × maximum application rate × maximum daily treated acres (or volume) ÷ body weight.

Calculation assumptions include:

- Short-term exposures are estimated based on the DPR guidance document by Beauvais, et al. (2007).
- Dermal absorption factor = 5 % (Odin-Feurtet, 2009).
- Inhalation absorption is assumed to be 100% default inhalation absorption rate based on DPR practice (Frank 2008).
- Body weight = 70 kg for both male and female (US EPA, 1997).

[e]SADD = Seasonal Average Daily Dose

Dermal SADD = 90% upper confidence limit of the mean of dermal exposure x Dermal absorption factor × maximum application rate x maximum daily treated acres (or volume) ÷ body weight.

Inhalation SADD = 90% upper confidence limit of the mean of inhalation exposure x inhalation absorption rate × maximum application rate × maximum daily treated acres (or volume) ÷ body weight.

Calculation assumptions include:

- Long-term exposures are estimated based on the DPR guidance document by Beauvais, et al. (2007).
- Dermal absorption factor = 5% (Odin-Feurtet, 2009).
- Inhalation absorption is assumed to be 100%. Default inhalation absorption rate based on DPR practice (Frank, 2008) which is consistent with US EPA policy (1992).
- Body weight = 70 kg for both male and female (US EPA, 1997).

[f]Annual Average Daily Dose (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, 2023, see text and Figure 4). AADD value is the sum of dermal and inhalation exposure.

[g]Lifetime Average Daily Dose = AADD × 40 years of work in a lifetime/75 years in a lifetime. DPR assumes the workers would work between ages from 25 to 65, total 40 years. According to the census data from the Statistical Abstract of the United States (US Census Bureau Statistical Abstract Series, available at https://www.census.gov/library/publications/time-series/statistical_abstracts.html) the average life expectancy is around 75.5. LADD value is the sum of dermal and inhalation exposure.

[h]All turf values, including use on golf courses, are based on the Pesticide Use Report (DPR, 2024a), during a recent 5-year interval (2017–2021), minute quantity (average 10 lbs./year) of imidacloprid was used on turf. Therefore, only STADD for application on turf was estimated in this document.

[i]STADD, SADD, and AADD values by exposure routes (i.e., dermal and inhalation) are provided in Appendix A for reference purposes only.

B. Reentry Workers

A typical exposure assessment would evaluate post-application exposures to reentry workers. Routes of exposure of interest include inhalation and dermal exposure. Importantly, reentry workers are subjected to dermal exposure of imidacloprid through dislodgeable foliar residues (DFRs). The inhalation component was not included in the reentry exposures since, as stated previously, imidacloprid is nonvolatile. Studies of reentry worker exposure in areas treated with other nonvolatile pesticides suggest that inhalation is a very minor contributor to overall exposure (Ware et al., 1973, 1974, 1975). Therefore, only dermal exposure was estimated.

Data on imidacloprid dermal exposure was not available for reentry workers. Therefore, it was necessary to estimate the dermal exposure using a task-specific dermal transfer factor (TF), defined as the ratio of hourly dermal exposure in µg/hour to DFR in µg/cm^2, and the DFR expected at the time of reentry. As mentioned in Section F, Restricted Entry Interval above, a specific reentry time may not be available for landscape maintenance and turf grass management. Accordingly, instead of arbitrarily assigning a reentry time, an REI of either 12 hours or day 0 was used for determining the DFR in this assessment. When multiplied with a proper dermal TF, the DFR can be converted to hourly dermal exposure of workers entering a treated area. TFs and DFR values were used to estimate the potential human exposure of reentry workers performing different activities. Reentry workers are not required to wear protective clothing unless they enter before the expiration of the REI. Therefore, reentry worker exposure calculations were not adjusted for any protection factors.

Short-term exposures were estimated using DFR at the expiration of REI, as it represents the earliest time workers could legally enter a treated area, resulting in the highest DFR that workers would typically encounter. Table 10 summarizes the dissipation or default DFRs and dermal TFs used to estimate short-term imidacloprid exposures of reentry workers related to turf grass management and landscape maintenance. Based on use information provided by the PUR database, (DPR, 2024a), short-term exposure durations are the most appropriate durations to assess reentry worker exposure from turf grass management and landscape maintenance (see Table 10). Therefore, any exposures longer in duration were not estimated.

Table 10. Estimated dermal exposure of non-agricultural reentry workers following imidacloprid applications for landscape maintenance and turf grass management

	Representative Reentry Activity	REI[b] (day)	TF[c] (cm^2/hr)	TTR/DFR[d] (µg/cm^2)	Daily Exposure (µg/person/day)	STADD[e] (µg/kg/day)
Turf						
Turf grass[f]	Mowing, tractor or push	REI = 0 day	500	0.525	2100	1.50
	Turf maintenance, weeding	REI = 0 day	3700	0.525	7770	5.55
Ornamentals and Trees						
Trees, Evergreens	Scouting	REI = 12 hr	580	1.12	5201	3.72
	Irrigation (hand)	REI = 12 hr	1900	1.12	17039	12.17
Nursery Ornamentals	Pruning (hand)	REI = 0 day	230	1.12	2063	1.47
Flowers, Cut[g]	Harvesting (hand)	REI = 0 day	4800	1.12	43046	30.75
Rose, Cut[h]	Harvesting (hand)	REI = 0 day	480	1.12	4305	3.07

[a] Representative reentry activity as provided in the US EPA (2017a)

[b] REI (restricted entry interval) from the product label.

[c] TF (transfer factor) values are taken from the Default Transfer Coefficients (US EPA, 2017a), with a few exceptions. The TF for nursery ornamentals is from Klonne et al. (2000). The TF for mowing is derived from the US EPA TF of 3700 cm^2/hr, scaled by the ratio between exposed surfaces, i.e., head (1204 cm^2), neck (233 cm^2), and hands (904 cm^2), and the total body surface area (i.e., 17,213 cm^2), i.e., 2341/17,213 = 0.136 (please see Table 15 for additional details); 3700 cm^2 /hr × 0.136 ≈ 500 cm^2 /hr. The rationale for scaling the TF of 3700 cm^2/hr is to consider exposure from the "exposed body surface areas," i.e., head, neck, and hands, given that the mowing activity, unlike other activities in Table 10, does not constitute direct contact with the treated surface.

[d] The residue value for turf grass in the TTR/DFR column is TTR. The TTR value is based on a study by Bayer CropScience (Kroiski, 2016). The highest reported TTR value of 0.656 µg/cm^2 was adjusted to 0.525 µg/cm^2 (i.e., 0.656 x 0.4/0.5) using the California maximum application rate of 0.4 lbs AI/acre and the study application rate of 0.5 lbs AI/acre. No imidacloprid-specific dislodgeable foliar residue (DFR) value is available; hence, a default DFR (25% of the maximum use rate) was used as a surrogate. In each scenario, the maximum use rate from the product label is 0.4 lbs AI/acre. Daily exposure (µg/person/day) = TF × DFR × work hours/day. Assuming 8 hours worked at task per day for all activities, except for turf maintenance which was 4 hours per day. Workers were assumed to wear long pants, long-sleeved shirts, without gloves.

[e] STADD (Short-term Absorbed Daily Dose) = daily exposure (DFR on REI) × dermal absorption factor ÷ body weight.

- Dermal absorption factor = 5% (Odin-Feurtet, 2009)
- Body weight = 70 kg (US EPA, 1997).

[f] Based on the Pesticide Use Report (DPR, 2023), during a recent 5–year interval (2017–2021), only minute quantities of imidacloprid (up to 1 lb/year in whole California) were used on turf. Therefore, only the STADD for application on turf was estimated in this document. The TTR value from a study by Bayer CropScience (Kroiski, 2016) after adjusting to 0.525 µg/cm^2 (i.e., 0.656 x 0.4/0.5) based on CA maximum application rate of 0.4 lbs AI/acre, was used to estimate exposure from mowing and turf maintenance (weeding).

[g] Based on US EPA (2017a), TF for cut flower (harvesting) is 4800.

[h] Based on US EPA (2017a), TF for cut flower (harvesting) is 4800. Since rose workers must wear gauntlet (elbow-length) gloves to avoid being injured by thorns, the TFs for rose pruning were adjusted to 480 to account for the 90% protection factor from gloves.

C. Residential, Home and Recreational Use

Formulated products containing imidacloprid are used in a variety of residential, home, and recreational settings. Licensed pesticide applicators in their capacity as a mixer, loader, and/or applicator can use imidacloprid on ornamentals, flowers, shrubs and trees, and turf/lawn to control insects. Application can be made by low pressure handwand, backpack sprayer, and rotary spreaders. Licensed pesticide applicators can also conduct indoor treatments, such as on indoor wood, lumber during construction, crack and crevice treatments, and indoor treatments for rodents, fleas, ants, and bed bugs on mattresses, carpets, and hard surfaces. There are numerous commercially available imidacloprid products designated for home use, both indoor and outdoor. A resident or homeowner can apply products to their own lawns and gardens or around and inside a home or dwelling to control ants and other insects. There are also registered uses of imidacloprid to control fleas and ticks on companion animals, including spot-on liquids and impregnated collars. These products can be used by professional handlers, such as in a veterinarian office or pet groomers. They can also be used at home by users over the age of 18.

Numerous exposure scenarios are used in this assessment to determine post-application exposures to residential bystanders and home users, including sensitive subpopulations. Extensive analyses were included for adult or child post-application exposure to imidacloprid residues on turf and lawn, either from professional or home-use applications. Imidacloprid residues from indoor treatments or applications (again, either professional or home use products) were assessed for adults and children, including incidental hand to mouth activity of toddlers. A special assessment was included for potential exposures of residents from the California Department of Food and Agriculture (CDFA) eradication program for Asian Citrus Psyllid (ACP). Post-application exposure to pet products is also analyzed, as well scenarios for imidacloprid use on golf courses and in other recreational areas. Anticipated residues of imidacloprid in drinking water were also assessed for inclusion in the dietary and drinking water assessment that is part of DPR's final Risk Characterization Document for Non-Agricultural Uses of Imidacloprid.

1. Handler Exposure

No chemical-specific data were available on pesticide handlers, including licensed pesticide applicators, using imidacloprid-based products in residential and institutional settings. Estimates for exposure scenarios for mixer/loader/applicators were based on the US EPA Standard Operating Procedures (SOP) for Residential Exposure Assessment (US EPA, 2012). For non-professional applications, the "handler" is assumed to be an adult resident or home user of commercially available imidacloprid products. Residential handlers/home users may be exposed when they apply lawn and garden products outdoors or apply approved products to indoors to control various insects. For these handlers and home users, short-term exposures were estimated based on the highest use allowed and realistic use according to label directions. Home use products often do not contain specific requirements for users (handlers) to wear special protective equipment. Hence, this assessment assumed that residential handlers/home users were only wearing basic clothing such as shorts and T-shirts, at the time of application. The 95th

percentile of mean exposure is used as the upper-bound estimate for short-term exposure based on DPR practice (Beauvais et al., 2007).

Pet owners or groomers may be exposed to imidacloprid when treating dogs and cats with flea and tick control products. As of August 2024, there were 49 imidacloprid products registered in California for treating dogs and cats, with the majority formulated as ready-to-use topical solutions or impregnated collars containing between 8.8% and 9.1% active ingredient (AI). These products are designed for use on animals 7 weeks old or older and should be applied only by adults. No pet owner-applicator or groomer monitoring studies were available. Accordingly, the exposures were estimated using the residential handler algorithms in the US EPA SOP for Residential Pesticide Exposure Assessment (US EPA, 2012). It is noteworthy that because product-specific values are available for pet collars, adjustments were made to some of the algorithm default parameters: liquid and dust unit exposure values and application rate. Specifically, the unit exposure rates of liquid and dust were adjusted by a liquid-to-solid ratio of 0.9971/0.0029; this ratio was developed by US EPA (2019b) based on two registrant-submitted studies (Hammer, 2016; Jiritschka, 2011). Unlike the spot-on application, imidacloprid is released gradually from the pet collar. Hence, the pet collar application rate was adjusted based on the release rate of imidacloprid (i.e., 40%) as specified in the study by Lunchick (2010). Because not all products require gloves during application, exposure was estimated for bare hands. No exposure to other body parts was included in this assessment, assuming that the applicator/home user was wearing normal clothing. According to the 2012 US EPA Residential SOP, a dog owner-applicator/groomer may treat as many as two pets per day, generally at 30-day intervals per product directions with liquid or spray-type pet products. Use directions for impregnated collars typically call for replacement every 7–8 months unless the animal is bathed more than monthly or swims frequently.

The assumptions and conditions used in calculation of exposure estimates for handlers (mixer/loader/applicators) applying in residential settings as well as residents/home users of lawn and garden, indoor, and pet products are found in Table 11.

Table 11. (a) Summary of residential handler and home user exposure to imidacloprid (top table) and (b) summary of pet handler exposure to imidacloprid (bottom table)

Task	Formulation	Method	Application Rate[b]	Application unit/day[c]	95th percentile exposure[d] (µg/lbs AI)		STADD[e] (µg/kg/day)	
					Dermal	Inhalation	Dermal	Inhalation
Landscape and turf								
M/L/A[a]	Wettable powder	Low Pressure Handwand	Ornamentals, Flowers, Shrubs, Trees, 0.004 lbs/gal	5 gallons	240000	3700	3.43	1.06
M/L/A	Flowable concentrate	Backpack Sprayer	Turf, 0.001 lbs/gal	5 gallons	240000	3700	0.86	0.26
L/A	Granule	Push-type/rotary spreader (no glove)	Turf, 0.4 lbs/acre	1200 ft^2 (0.03 acre)	1900	8.9	0.27	0.26
Indoor carpet, baseboard and mattress								
A	Water soluble packets	Construction & Wood	0.012 lbs/gal	0.5 gallons	240000	3700	1.00	0.31
A	Liquid	Carpet	0.00053 lbs/can	0.5 can	240000	3700	0.046	0.014
A	Gel[h]	Household, cracks	0.033/tube	-	-	-	-	-
	Bait[i]	Rodents & their fleas (station)	0.001/container	-	-	-	-	-
A	Bait	Ant bait (crack & crevice)	0.00008 lbs/container	1 container	351100	1270	0.02	0.001
M/L/A	Liquid	Bed bug treatment	0.008 lbs/gal	0.5 gal	240000	3700	0.69	0.21
M/L/A	Liquid	Crack & crevice	0.008 lbs/gal	0.5 gal	240000	3700	0.69	0.21

Pets (dogs or cats)[j]								
Task	Formulation	Method	Application Rate[b] (lbs AI/pet)	Application[c] (pet/day)	95th percentile exposure[d] Dermal (µg/lbs AI)	STADD[e] (µg/kg/day)	Mean Dermal Exposure[f] (µg/lbs AI)	Intermediate Dermal ADD[g] (µg/lbs AI)
A	Liquid	Spot-on	0.001 lbs/pet	2 pets	460000	0.66	120000	0.17
A	IM	Collar[k]	0.0028 lbs/pet (up to 18 lb pet)	2 pets	485346	0.78	132122	0.21
A	IM	Collar[k]	0.0099 lbs/pet (18+ lb pet)	2 pets	485346	2.75	132122	0.75

All exposure scenarios are based on the registered product labels.

Abbreviations: A = Applicator; AI = active ingredient; gal = gallon; IM = Impregnated Material; M/L/A – mixer/loader/applicator.

[a] M/L/A = Mixer/loader/applicator. Protective clothing and equipment for various scenarios are based on product labels (see "Label precaution" section); Applicator = in residential setting can include home user, pet groomer, or adult pet owner.

[b] Maximum application rates are based on the product labels.

[c] Daily application unit/volumes to be treated in each scenario were based on the default values from Risk Assessment for Registration Review (US EPA, 2017b), and the US EPA SOP (US EPA, 2012)

[d] The default values from US EPA (2012). Based on DPR practice, STADD (short-term absorbed daily dose) is an upper-bound estimate of daily exposure, 95th percentile of mean exposure was used. The values for all scenarios are from the US EPA SOP (US EPA, 2012).

[e] Short-term Absorbed Daily Dose (STADD) = [(short-term dermal exposure x Dermal absorption factor + short-term inhalation exposure x inhalation absorption rate) x application rate x application unit/day] ÷ body weight. Calculation assumptions include:

- The maximum label rate based on the product labels
- Dermal and inhalation exposure (µg/lbs AI) from default 95th percentile exposure values based on US EPA SOP (2012)
- Dermal absorption factor = 5% (Odin-Feurtet, 2009)
- Inhalation absorption = 100% (Frank, 2008)
- Body weight = 70 kg for both male and female (Andrews and Patterson, 2000)

[f] Mean exposure values are from US EPA SOP (US EPA, 2012).

[g] Intermediate ADD = [(mean dermal exposure x Dermal absorption factor + mean inhalation exposure x inhalation absorption rate) x application rate x application unit/day] ÷ body weight.

[h] Exposure for this application scenario is considered negligible based on US EPA SOP (2012).

[i] No exposure data available for bait handler scenario in SOP for residential exposure (US EPA, 2012), the exposure for bait station is considered negligible. The exposure for ant bait handler scenario was assessed using DPR practice (Beauvais, et al*.,* 2007), Scenario 15 (Granular bait).

[j] Pet application rates based on US EPA 2017b. The large dog (55 lbs) was used as default pet size, to cover medium and small size dogs and cats. Based on US EPA SOP (US EPA, 2012), handlers can treat two (2) pets per day. Inhalation exposures for pet owner/groomers are assumed to be negligible because the imidacloprid products used by pet owner-applicators/groomers have low vapor pressures. All products for pet use are ready-to-use topical solutions or collars.

[k] The pet collar liquid-to-solid ratio of 0.9971/0.0029 (US EPA 2019a) and a release rate of 40% (Lunchick, 2010) were used to adjust the unit exposure rate and application rate, respectively, to perform the exposure estimates.

2. Post-application Exposure of Residents and Home Users

There are many products approved for lawn and garden use by residents and home uses. Generally, these exposures are not of concern if the applicator/home user follows the label directions for use. However, once applied, there are opportunities for incidental exposures to imidacloprid residues. This is especially important for imidacloprid applications to turf and lawn and potential dermal and hand-to-mouth exposures, as explained below.

a) Post-application exposure from residues on turf

Miles Inc. (Eberhart and Ellisor, 1994) performed a study to monitor and quantify dermal and inhalation exposures of human volunteers to imidacloprid from treated turf. The study monitored dermal and inhalation exposure of 10 volunteers during the performance of a choreographed exercise (Jazzercise®) routine on a Merit®-treated turf plot. The Jazzercise® routine began immediately after the spray application was dry. This exercise activity was designed to provide continuous contact with the treated turf and is believed to represent an upper-bound exposure potential for persons contacting treated turf. An additional volunteer performed the same exercise routine on an untreated control plot. The turf plot was treated with Merit® at rate of 0.5 lbs AI/acre. A 20 ft x 46 ft Kentucky Bluegrass turf plot was utilized during the exposure monitoring portion in the study. The plot was mowed to a height of 3 inches just prior to the application. The arithmetic mean (n = 9) of deposited residues of Merit® measured on the exposure evaluation plot was 3.8 (± 1.62) µg/cm^2, equivalent to approximately 68% of the theoretical deposition at an application rate of 0.5 lbs AI/acre. The arithmetic mean (n = 3) of transferable residues of Merit® measured just prior to the exercise routine was 0.074 (± 0.016) µg/cm^2, equivalent to approximately 1.9% of the deposited Merit® residues.

Inhalation exposure was measured using a conventional industrial hygiene sampling technique. Merit® air concentrations were measured in the immediate vicinity of each volunteer during performance of their exercise routine. The air samples were collected using 37 mm quartz microfiber acetate filters connected by polyvinylchloride tubing to portable industrial hygiene air sampling pumps. It was impossible to collect the air samples in the breathing-zone of the volunteers because the air filters and portable pumps would interfere with their exercise routine. Therefore, each volunteer's air sampling pump was placed on the turf in the corner of their designated exercise areas, and the filter cassette was suspended 25 cm above the ground (representing the position of the volunteer's breathing zone when in the prone position) by taping the polyvinylchloride tubing to a wooden dowel rod. The air sampling pumps were turned on as soon as the exercise routine began and were turned off as soon as the routine was completed. After collection, the pre-labeled filter cassettes were capped, sealed in Zip-Lock® bags and stored in coolers on dry ice or in a -20°F freezer until they were transported by overnight express to the laboratory for analysis. All inhalation samples and corresponding fortified QA samples were analyzed using reverse-phase high-pressure liquid chromatography. Table 16 summarizes inhalation exposure data from Eberhart and Ellisor (1994). The inhalation exposure value from Table 16 is used to estimate inhalation exposure for various age groups as shown in Table 17.

The label maximum application rate = 0.4 lbs active ingredient (AI)/acre. This rate is a one-time application rate for use on commercial/residential turf.

Table 12. Adjusted imidacloprid inhalation exposure of exercising volunteers on treated turf

VS[a]	Filter[b] (µg)	Correction Factor[c]	Adjusted Value (µg)[d]	Volume (L)[e]	Particulate Conc (µg/m^3)[f]	Inhalation Exposure (µg/hr)[g]
1	0.09	0.896	0.100	41.4	2.4	3.8
2	0.439	1.218	0.439	40.7	8.9	14.2
3	0.234	0.896	0.261	40.6	6.4	10.2
4	0.09	0.896	0.100	40.2	2.5	4.0
5	0.261	0.896	0.291	41.7	7.0	11.2
6	0.186	0.896	0.208	42.8	4.9	7.8
7	0.206	0.896	0.230	41.1	5.6	9.0
8	0.405	0.896	0.452	39.9	11.3	18.1
9	0.177	0.896	0.198	41.2	4.8	7.7
10	0.210	0.896	0.234	40.6	5.8	9.3
11	0.346	0.896	0.386	42.0	9.2	14.7
Mean[h]	0.255	0.928	0.264	41.1	6.3	10.6
SD[i]	0.109	0.102	0.120	0.84	2.7	4.1

[a] VS = Volunteer Subject. #1 is control, the volunteer performed on untreated plot.

[b] Particulates trapped on the filter.

[c] Correction Factor is a matrix-specific and spike level-specific field recovery adjustment factor.

[d] Calculated values are adjusted by field recoveries (correction factor). Based on DPR practice, when the recovery was less than 90%, the measured data were adjusted; when the recovery was more than 90%, the measured data were used for calculating exposure.

[e] Sample volume (L) = air sampling pump flow rate (L/min) × sampling duration (min). Flow rate = 1 (L/min).

[f] Particulate concentration (µg/m^3) = Filter adjusted value (µg) / [sample volume (L) x m^3/1000L]. Analytical limit of detection = 2.5 µg/cm^3

[g] Inhalation Exposure = Inhalation Rate (m^3/hr) of moderate activity (1.6 m^3/hr) × Particulate Concentration (µg/m^3). In the calculation, the inhalation rate using default inhalation rate of moderate activity rate (Andrews and Patterson, 2000).

[h] The mean value does not include #1 result (control subject).

[i] SD = Standard deviation. The SD value does not include #1 result (control subject).

Table 13. Short-term inhalation exposure estimates for adults and children playing on imidacloprid-treated lawns

Age (Sex)	Inhalation Rate (cm^3/day)[a]	Adj. Inhalation Exposure (µg/hr)[b]	Exposure (hr)[c]	BW (kg)[d]	Inhalation STADD (µg/kg/day)[e]
Adult (M/F)	20	10.6	1.5	70	0.23
1–2 (M/F)	6.8	3.6	1.5	12.2	0.44
3–5 (M/F)	8.3	4.4	1.5	17.2	0.38
6–8 (M/F)	10	5.3	1.5	24.5	0.32
9–11 (M/F)	13.5	7.2	1.5	34.5	0.31
12–14 (M/F)	13.5	7.2	1.5	49.2	0.22

Table 13. Short-term inhalation exposure estimates for adults and children playing on imidacloprid-treated lawns

Age (Sex)	Inhalation Rate (cm^3/day)[a]	Adj. Inhalation Exposure (µg/hr)[b]	Exposure (hr)[c]	BW (kg)[d]	Inhalation STADD (µg/kg/day)[e]
15–18 (M)	17	9.0	1.5	65.2	0.21
15–18 (F)	12	6.4	1.5	55.9	0.17

[a] Inhalation rates are based on a non-specific activity pattern (Andrews and Patterson, 2000).

[b] The adjusted exposure estimates for children are calculated from exposure data from Table 12 and adjusted for inhalation rates of various age groups.

[c] Dermal exposure time is assumed to be 1.5hr/day (US EPA, 2012).

[d] BW = body weight, the values based on US EPA (1997).

[e] Inhalation STADD (Inhalation Short-Term Absorbed Daily Dose) is calculated as follows:
Inhalation STADD (adult or children) = Adj. Inhalation Exposure (µg/hr) × ET (hour) x 100% inhalation absorption (see inhalation absorption section) ÷ body weight (averaged male and female body weights except for the 15–18 year-old group) (US EPA, 1997). The current maximum application rate is 0.4 lbs AI/acre, so the STADD values were adjusted by this application rate.

Dermal exposure of volunteers performing the exercise routine on the Merit®-treated turf plot was measured by whole-body dosimetry. Each volunteer wore the following during a 20-minute exposure monitoring period: 1) Two pairs of white cotton/synthetic blend footless tights (the lower dosimeter garments); 2) Two long-sleeved white cotton/synthetic blend T-shirts (the upper dosimeter garments); 3) Two thin white 100% cotton gloves on each hand; and 4) Two white, 100% cotton athletic ankle socks on each foot. Before the start of the exposure monitoring period, each subject donned (with the assistance of study team members) the dosimeter garments over shorts and a T-Shirt. The Jazzercise® routine began as soon as the turf application had dried. Immediately following the 20-minute exposure monitoring period, study team members carefully removed the dosimeter garments, gloves, and socks from each subject. Each dosimeter garment was placed in a pre-labeled glass jar, sealed with a Teflon-lined lid, and stored in a cooler on dry ice. Samples remained on dry ice or in a -20°F freezer until shipped via overnight express to the laboratory for analysis. Both outside gloves were sealed, stored, shipped, and analyzed together as were the two outside socks, the two inside gloves, and the two inside socks. Analyzing the outside dosimeters separately from the inside dosimeters provides a basis for estimating the amount of imidacloprid that penetrated the outer garments and, therefore the amount of imidacloprid that would have reached the skin of a person wearing a single layer of clothing. All dermal exposure samples and corresponding fortified QA samples were analyzed using reverse-phase high-pressure liquid chromatography (HPLC). This assessment assumed that typical clothing worn during activities on turf including short pants, a sleeveless shirt, and shoes plus socks. The inner dosimeter values are used for estimating dermal exposure of trunk and thighs. Combined outer and inner dosimeter values are used for estimating dermal exposure to arms and lower legs. Exposure to each body part was estimated by the average residue of total upper or lower dosimeter multiplied by the body surface area. Surrogate average data were used for head and neck. Adjusted dermal exposure values for volunteers are summarized in Table 14 and median surface area of adults is listed in Table 15.

Table 14. Adjusted dermal exposure to imidacloprid of volunteers exercising on the treated turf

V[a]	Adjusted Residues from Inner Dosimeters[b]										Adjusted Residues from Outer Dosimeters[c]									**Total Dermal Residue (µg)[q]**	**Dermal Exposure (µg/hr)[r]**
	Upper Inner (µg)[d]	UA Inner[e] (µg/cm^2)	Trunk Inner (µg)[f]	Arm Inner (µg)[f]	Lower Inner (µg)[g]	LA Inner[h] (µg/cm^2)	Thighs Inner (µg)[f]	Low leg Inner (µg)[f]	Glove Inner (µg)[f]	Sock Inner (µg)[i]	Upper Outer (µg)[j]	UA Outer[k] (µg/cm^2)	Head Outer (µg)[l]	Neck Outer (µg)[m]	Arms Outer (µg)[f]	Lower Outer (µg)[n]	LA Outer[o] (µg/cm^2)	Low leg Outer (µg)[f]	Glove Outer (µg)[p]		
1	11.9	1.3E-03	8.5	3.5	11.9	2.0E-03	7.10	0.1	0.36	0.271	0.263	2.9E-05	0.04	0.0	0.1	0.3	0.0	0.1	0.4	20.3	61.7
2	14.9	1.7E-03	10.6	4.3	0.3	4.0E-05	0.16	212.1	0.36	0.271	346.4	3.9E-02	46.5	9.0	100.7	529.0	0.1	212.1	339.9	936.1	2836.8
3	0.3	2.9E-05	0.2	0.1	0.3	4.0E-05	0.16	225.7	0.36	0.271	370.7	4.1E-02	49.8	9.6	107.8	562.7	0.1	225.7	255.3	874.9	2651.2
4	0.3	2.9E-05	0.2	0.1	0.3	4.0E-05	0.16	188.9	0.36	1.19	530.6	5.9E-02	71.3	13.8	154.3	471.0	0.1	188.9	179.0	798.1	2418.5
5	11.7	1.3E-03	8.3	3.4	0.3	4.0E-05	0.16	248.6	0.36	3.496	568.2	6.3E-02	76.3	14.8	165.2	619.9	0.1	248.6	222.5	991.7	3005.2
6	10.7	1.2E-03	7.6	3.1	0.3	4.0E-05	0.16	165.3	0.36	0.271	442	4.9E-02	59.4	11.5	128.5	412.2	0.1	165.3	193.8	735.3	2228.1
7	18.1	2.0E-03	12.8	5.3	78.3	1.3E-02	46.89	614.1	8.96	0.271	1444.3	1.6E-01	194.0	37.5	420.0	1531.3	0.3	614.1	621.5	2575.4	7804.4
8	0.3	2.9E-05	0.2	0.1	0.3	4.0E-05	0.16	246.7	0.36	0.271	513.3	5.7E-02	69.0	13.3	149.3	615.2	0.1	246.7	238.9	964.9	2924.0
9	0.3	2.9E-05	0.2	0.1	0.3	4.0E-05	0.16	273.4	20.42	0.271	1244.9	1.4E-01	167.2	32.4	362.0	681.8	0.1	273.4	430.2	1559.7	4726.5
10	0.3	2.9E-05	0.2	0.1	0.3	4.0E-05	0.16	196.4	26.05	0.271	761.8	8.5E-02	102.3	19.8	221.5	489.8	0.1	196.4	379.3	1142.5	3462.3
11	31.6	3.5E-03	22.4	9.2	33.6	5.7E-03	20.13	218.8	15.34	0.271	729.6	8.1E-02	98.0	19.0	212.2	545.5	0.1	218.8	267.0	1101.0	3336.5
AM[s]	8.8	0.0010	6.3	2.6	11.4	1.9E-03	6.8	259.0	7.29	0.69	695.2	0.08	93.4	18.1	202.1	645.8	0.1	259.0	312.7	1168.0	3539.3
SD[t]	10.7	0.0012	7.6	3.1	25.7	4.4E-03	15.4	128.7	9.89	1.03	370.6	0.04	49.8	9.6	107.8	321.0	0.0	128.7	135.5	545.2	1652.2

Note: Table data excerpted from Eberhart and Ellisor (1994). Median body part surface area values for male and female adults are based on the US EPA Exposure Factors Handbook (US EPA 2017) and summarized in Table 19. Some small values were expressed using exponential notation, where E±n represents 10 to the nth power. For example, 2.9E-05 (scientific exponential notation) = 2.9 x 10^{-5} (scientific notation) = 0.000029.

[a] V = Volunteer. #1 is control.

[b] Values from inner dosimeters were adjusted by field recoveries (correction factor), which is an average matrix-specific and spike level-specific field recovery adjustment factor. Based on DPR practice, when the recovery was less than 90%, the measured data were adjusted; when the recovery was more than 90%, the measured data were used for calculating exposure.

[c] Values from Outer dosimeters were adjusted by field recoveries (correction factor), which is an average matrix-specific and spike level-specific field recovery adjustment factor. Based on DPR practice, when the recovery was less than 90%, the measured data were adjusted; when the recovery was more than 90%, the measured data were used for calculating exposure.

[d] The residues from whole inner upper dosimeter.

[e] UA Inner (Upper Average from the inner dosimeter) = total residues from whole inner dosimeter on upper body / surface area of upper body.

[f] The various body surface area values used in the calculation are the averaged male and female data.

[g] The residues from whole inner lower dosimeter.

[h] LA Inner (Lower Average from the inner dosimeter) = total residues from whole inner dosimeter on lower body / surface area of lower body.

[I] The residues from the inner socks.

[j] The residues from whole outer upper dosimeter.

[k] UA Outer (Upper Average from the outer dosimeter) = total residues from whole outer dosimeter on upper body / surface area of upper body.

[l] Head value = Upper average residue x surface area of head. Considering that children may roll over on the turf and their heads may touch the turf, the estimated head exposure was added to the total dermal exposure in this document.
[m] Neck value = Upper average residue x surface area of neck. Considering that children may roll over on the turf and their necks may touch the turf, the estimated neck exposure was added to the total dermal exposure in this document.
[n] The residues from whole outer lower dosimeter.
[o] LA Outer (Lower Average from the outer dosimeter) = total residues from whole outer dosimeter on lower body / surface area of lower body.
[p] The residues from outer cotton gloves.
[q] Sum of adjusted values of trunk (inner), arms (outer + inner), hands (outer + inner gloves), thighs (inner), lower legs (outer + inner), feet (inner socks), and calculated head/neck exposures. The mean value does not include #1 result (control subject).
[r] Length of exposure replicate = 0.33 hours (20 min).
[s] AM = Arithmetic Mean. Calculations do not include #1 result (control subject).
[t] SD = Standard deviation.

Table 15. Median body surface area (BSA) of adults

Body Region	Head	Neck [b]	Back	Chest	Upper Arm	Forearm	Hand	Thigh	Lower Legs	Total
BSA[a] (cm^2)	1204	233	3178	3178	1433	1173	904	3540	2370	17213

[a] The body surface area (BSA) values are the average of male and female (US EPA, 1997).
[b] The surface area of 233 cm^2 is the sum of front and back of neck (US EPA, 1997).
[c] The surface area of the hands is derived from Table 6-2 and Table 6-3 of the US EPA (1997).

Because of the likelihood of young children playing on and contacting treated turf, their dermal exposures were estimated for this assessment. No child dermal exposure monitoring data were available for imidacloprid, so these values were estimated from adult volunteer data (Eberhart and Ellisor, 1994). The data were adjusted by the body surface area based on the age and gender of the child. It was assumed that children were wearing typical clothing when coming into contact with treated turf/lawn. Eberhart and Ellisor (1994) used a one-time application rate of 0.5 lbs AI/acre for commercial and residential turf. Since the study was published, the maximum allowable application rate has been reduced to 0.4 lbs AI/acre. The STADD values were adjusted accordingly. Data are summarized in Table 16, below.

Table 16. Estimated dermal exposure of children to imidacloprid residues on treated turf

Age (Sex)	Body Surface Areas (cm^2)[a]	Adjusted Dermal Exposure (µg/hr)[b]	Exposure (hrs)[c]	Dermal STADD (µg/kg/day)[d]
Adult (M/F)	18150	6470[e]	1.5	5.20
1–2 (M/F)	5275	1880	1.5	8.66
3–5 (M/F)	6875	2451	1.5	27.55
6–8 (M/F)	8905	3174	1.5	19.16
9–11 (M/F)	11200	3993	1.5	13.22
12–14 (M/F)	13700	4884	1.5	9.02
15–18 (M)	17533	6250	1.5	7.11
15–18 (F)	16000	5704	1.5	5.91

[a] The body surface areas are the average of male and female data, except for the 15–18 year-old group (US EPA, 1997).
[b] The adjusted exposures for children assume dermal exposure using adult dermal exposure data adjusted for body surface area.
[c] Dermal exposure time is assumed to be 1.5 hr/day (US EPA, 2012).
[d] Dermal STADD (Dermal Short-Term Absorbed Daily Dose) is calculated as follows:
Dermal STADD (adult or children) = 95% percentile of mean of Adjusted Dermal Exposure per hour (µg/hr) x ET (1.5 hour/day) × 5% dermal absorption (see dermal absorption section) ÷ body weight (averaged male and female body weights) (US EPA, 1997). The final values are adjusted by current maximum application rate 0.4 lbs AI/acre instead of 0.5 lbs AI/acre used in the monitoring study.
[e] Adjusted dermal exposure for adults is 95th percentile of the mean dermal exposure from monitoring study (Table 14).

It is possible for young children to be exposed to imidacloprid residues through incidental hand-to-mouth contact and ingestion of treated grass. The incidental oral ingestion exposures were based on the label maximum application rate of 0.4 lbs AI/acre, which is a one-time application rate for use on commercial/residential turf. The estimated exposures for toddlers aged 1–2 years old are summarized in Table 17.

Table 17. Estimated toddler incidental ingestion of imidacloprid residues on treated turf

Exposure Route	Exposure (hr)	HSA[b] (cm^2)	F_m[c] (F/evt)	TTR_0[d] ($\mu g/cm^2$)	TC[e] (cm^2/hr)	Exp[f] (μg)	F_{AI}[g]	HR[h] ($\mu g/cm^2$)	FQ[i] (events/hr)	F_o[j]	OR[k] ($\mu g/cm^2$)	SAM_o[l] (cm^2/event)	N_Replen[m] (interval/hr)	SE[n] (fraction)	FQ[o] (event/hr)	Daily Exp[p] (μg/day)	STADD[q] (μg/kg/day)
Hand-to-mouth[a]	1.5	150	0.127	0.525	49000	38587.5	0.06	7.7175	13.9	-	-	-	4	0.48	13.9	791.2	60.9
Non-Dietary Grass ingestion	1.5	-	-	-	-	-	-	-	8.8	0.01	0.525	10	4	0.48	8.8	24.02	1.85

[a] Oral (hand-to-mouth for children) exposure time is assumed to be 1.5 hours/day (US EPA, 2012).
[b] HSA (hand surface area) is based on US EPA, 2012.
[c] F_m: fraction hand surface area mouthed (fraction/event), 0.127 (US EPA, 2012)
[d] TTR (transferable turf residues on day 0) for imidacloprid from TTR study (Kroiski, 2016); for details refer to Section C. Transferable Turf Residues under Environmental Concentrations.
[e] TC: transfer coefficient, 49000 cm^2/hour (US EPA, 2012).
[f] Exp: exposure: Total dermal exposure = $TTR_0 \times TC \times ET$.
[g] F_{AI}: fraction of AI on hands from dermal transfer coefficient study, 0.06. Unitless value from US EPA, 2012.
[h] HR: hand residue loading (US EPA, 2012). $HR = (F_{AI} \times Exposure)/(HAS \times 2)$.
[I] FQ (hand-to-mouth contact frequency per hour, or object-to-mouth events per hour) is based on US EPA (2012).
[j] F_o: Fraction of application rate as chemical residue loading on the object (0.01), based on US EPA (2012).
[k] OR: chemical residue loading on the object; for details refer to Section C. Transferable Turf Residues under Environmental Concentrations.
[l] SAM_o: Typical surface area of object mouthed is 10 cm^2/event based on US EPA (2012).
[m] N_Replen: number of replenishment intervals per hour, 4 (US EPA, 2012).
[n] SE: saliva extraction factor, 0.48 (US EPA, 2012).
[o] FQ: frequency.
- Hand-to-mouth events per hour = 13.9 (US EPA, 2012).
- Grass-to-mouth events per hour = 8.8 (US EPA, 2012).

[p] Daily Exp: Daily exposure (US EPA, 2012).
- Non-Dietary grass ingestion: Daily Exp = $\{HR \times (HSA \times \underline{F_m}) \times (ET \times N\_Replen) \times [\ 1-(1-SE)^{(FQ/N\_Replen}]\}$
- For Non-Dietary grass ingestion: $E=\{OR \times CF1 \times SAM_o \times (ET \times N\_Replen) \times [1- (1-SE)^{(FQ/N\_Replen}]\}$

[q] STADD (Short-term Absorbed Daily Dose), calculated based on US EPA SOP (2012).
- For Hand-to-mouth: STADD = Exp / body weight (13kg for 1-2 year old children).
- For Non-Dietary grass ingestion: STADD = Exp / body weight (13kg for 1-2 year old children).

b) Post-application exposures from indoor applications and indoor home use

Potential post-application exposures to imidacloprid following professional indoor applications and indoor home use applications were assessed for both adults and children (including infants). The following post-application residential/institutional imidacloprid exposure scenarios were estimated: 1) Dermal exposure from residues on hard surface (adult and child); and 2) Incidental non-dietary ingestion of residues on hard surface or carpet from hand-to-mouth transfer (child). Indoor dermal exposure estimates depend on the level of surface residues, the dislodgeability of residues, the transferability of residues, and the rate of dermal contact.

Post-application exposures were assessed on the same day imidacloprid would be applied indoors. The application rate was 0.001 lbs active ingredient (AI)/gal based on the product label. All adult data are averages of male and female data. All child data pertain to 1–2 year-old children. Hand-to-mouth exposure was estimated using the hand-to-mouth contact frequency per hour, the surface area of 1–3 fingers representing each hand-to-mouth event and a TF (US EPA, 2012). This assessment assumed that 50% of the residue on the hands is transferred to the mouth by saliva. No imidacloprid exposure data from monitoring or experimental studies were available for these scenarios. Therefore, estimates were completed according to US EPA (2017) guideline using default TFs and dislodgeable surface residues. The results are summarized in Table 18.

Table 18. Estimated dermal exposure to imidacloprid residues on hard surfaces and carpet after indoor application

Exposure Route	TC[a] (cm^2/hr)	Exposure[b] (hr)	F_{AI}[c]	DepR[d] (µg/cm^2)	TR[e] (µg/cm^2)	F_m[f] (fra/event)	HSA[g] (cm^2)	HR[h] (µg/cm^2)	N_Replen[i] (inter/hr)	SE[j]	Freq_HtM[k] (events/hr)	Exposure[l] (µg/day)	STADD[m] (µg/kg/day)
Bait for ant[n] (Crack and crevice)	-	-	-	-	-	-	-	-	-	-	-	-	-
Adult	-	-	-	-	-	-	-	-	-	-	-	-	-
Children dermal	-	-	-	-	-	-	-	-	-	-	-	-	-
Children oral	-	-	-	-	-	-	-	-	-	-	-	-	-
Hard Surface	-	-	-	-	-	-	-	-	-	-	-	-	-
Adult	6800	2	0.08	4.5	0.360	-	-	-	-	-	-	4896	3.50
Children	1800	2	0.08	4.5	0.360	-	-	-	-	-	-	1296	4.98
Carpet	-	-	-	-	-	-	-	-	-	-	-	-	-
Adult	6800	8	0.06	4.5	0.270	-	-	-	-	-	-	14688	10.49
Children	1800	4	0.06	4.5	0.270	-	-	-	-	-	-	1944	7.48
Oral (1–2 yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
Hand-to-mouth (carpet)	-	4	-	-	-	0.13	150	0.972	4	0.48	20	292	22.4

[a] TC (transfer coefficient): 6800 cm^2/hour for adults, and 1800 cm^2/hour for 1–2 year old children based on US EPA (2012).

[b] Exposure time for dermal exposure is based on US EPA(2012).

[c] F_{AI}: fraction of AI available for transfer from carpet or hard surface. Unitless value from US EPA (2012).

[d] DepR: deposited residue (µg/cm^2). The default TR values from US EPA (2012); this value corresponds to the recommended default residue value for Perimeter/Spot/Bedbug (Coarse) treatment.

[e] TR (transferable residues): TR = DepR × F_{AI}, based on US EPA (2012).

[f] F_m: fraction hand surface area mouthed/event, the value is from US EPA's SOP (2012).

[g] HSA: hand surface area, the value from US EPA's SOP (2012).

[h] HR: hand residue loading. HR = F_{AI} × dermal exposure / (HAS × 2), based on US EPA's SOP (2012).

[I] N_Replen: number of replenishment intervals per hour, the value from US EPA's SOP (2012).

[j] SE: saliva extraction factor; unitless value from US EPA (2012).

[k] Freq_HtM: number of hand-to-mouth contact events per hour, the value is based on US EPA's SOP (2012).

[l] Exposure:

- Exposure from dermal contact = TR × TC × ET, based on US EPA (2012).
- Exposure from hand-to-mouth = $\{HR \times (F_m \times HAS) \times (ET \times N\_Replen) \times [1-(1-SE)^{(Freq\_HtM/N\_Replen)}]\}$, the formula is from US EPA's SOP (2012).

[m] STADD (Short-term Absorbed Daily Dose):

- STADD for dermal contact = Dermal exposure × Dermal absorption factor (5%) / body weight (70kg for adults or 13kg for 1–2 year old children)
- STADD for Hand-to-mouth = Exposure from hand-to-mouth / body weight (13kg for 1–2 year old children).

[n] Based on US EPA (2012), no exposure data available for the scenarios, exposure is considered negligible.

3. Residential ACP Eradication Program

In California, imidacloprid is employed by the California Department of Food and Agriculture (CDFA) for control of Asian Citrus Psyllid (ACP) in potentially infested areas including residential yards. Based on the reports by Kim (2012a, 2012b, 2012c), the CDFA ACP control and eradication methods include drenching the soil around tree trunks to allow for systemic uptake via the roots. Because data are not available for handler exposure to drench-type applications, this assessment conservatively uses foliar spray application as a surrogate. DPR acknowledges that a spray applicator is expected to have more exposure than a drench applicator. Therefore, the drench application handler exposure expected during ACP control/eradication is likely covered by a handler who uses spray instruments (e.g., low pressure handwand or backpack sprayer) and push/rotary spreaders.

For residential exposure to drench applications, the assessment relies upon the ACP eradication program exposure assessment conducted by the Office of Environmental Health Hazard Assessment (OEHHA) (Arcus-Arth and Ting, 2015). DPR concurs with OEHHA regarding the insignificant risk of inhalation exposure from the eradication program based on the physical properties of imidacloprid as well as results of DPR air monitoring (Zhao, 2014; Kim 2012a, 2012b, 2012c). OEHHA's assessment concluded that the consumption of fruit from residential trees was the only significant pathway of exposure, and that dermal contact would not result in significant exposure because of soil application (Arcus-Arth and Ting, 2015). While it is reasonable to assume that systemic treatment carries a low risk of dermal exposure through such post-application activities as pruning and harvesting residential fruit for home use, the assessment did not consider other potential dermal exposure scenarios. There would still be a potential for imidacloprid dermal exposure through the following: 1) weeding by hand in the area near the drench application; 2) irrigating near the drench area (moving and setting pipes, hoses); and 3) child dermal exposure through contact of treated surfaces in neighborhoods that were treated for ACP; and 4) potential dermal exposure of those mixing/loading and spraying for the ACP treatment (Beauvais, 2014).

For homeowners or residents, CDFA provides instructions on how to water-in the imidacloprid for several days following the drench. The instructions do not provide homeowners or residents with anything equivalent to a restricted entry interval or any other instructions to avoid contact with the treated area. Therefore, it is possible for residential adults and children to contact the drenched soil. There are no available methods to assess potential homeowner or resident exposure post-drench. Instead, DPR took the conservative approach of equating ACP treatment with residential reentry exposure to treated turf, mentioned earlier in this document.

4. Post-application Exposure of Home Users and Pet Owners and Their Children Following Use of Flea and Tick Products

Adults and children can be exposed to imidacloprid by contact with companion animals (dogs and cats) treated with flea and tick products containing imidacloprid. The routes of exposure include dermal contact and incidental oral (hand-to-mouth). Inhalation exposure is assumed to be

negligible because of the low vapor pressure of imidacloprid. This assessment used the following assumptions to estimate exposure from application of pet products or directly from the treated pets:

- Only short-term exposures are estimated since they are the highest estimates and protective of longer-term exposures.
- Post-application inhalation exposure is considered negligible due to low vapor pressure.
- Subpopulations of interest include adults and children (1–2 years old) based on US EPA guidance (2012).

Pet product exposures (i.e., spot-on treatment and pet collar) were estimated using US EPA Residential SOP and exposure estimating methods (2012, 2017b, 2019a, 2019b). For the spot-on treatment, the F_{AR} (fraction of active ingredient available for transfer) used in exposure estimates calculated by US EPA (2017b) is 0.000025. However, this F_{AR} was much lower than that published in a previous US EPA guidance (0.02; US EPA 2012) and the 2017 publication did not provide a source to support this much lower value. Therefore, DPR used a surrogate F_{AR} from a previous post-application pet study (Reeve, 2014). In addition, three studies of other spot-on formulations containing either imidacloprid or the active ingredient fipronil provided information for estimating transferable residues of imidacloprid products (de Fontenay et al., 1997; Jennings et al*.,* 2000; Bach, 2002). Each study provided empirical data for quantifying residue transferred to human hands from treated pets using a cotton glove dosimeter. After evaluating these studies, de Fontenay et al. (1997) was used as surrogate data for imidacloprid-containing flea and tick products based on following considerations:

1) The study evaluated the longest sampling duration (30-day efficacy).
2) The petting event consisted of 5 strokes along the treated dog with a cotton gloved hand, covering the bulk of its body. This petting is more closely approximates how a 1-2 year old child would hold and hug a pet.
3) Both the parent AI and its major metabolites were measured and summed to provide the total amount of AI transferred.
4) Sample recoveries obtained for spiked gloves were greater than 90%.

Investigators treated dogs with spot-on flea and tick treatment containing fipronil (de Fontenay et al., 1997). After which, investigators petted the dogs with gloved hands at 1, 4 and 8 hours after treatment as well as 1, 2, 4, 7, 14, 21, and 28 days following treatment. Six cotton glove dosimeter samples were collected at the 1, 4 and 8-hour post-application time points. The investigators noted that transferred residues declined with time and that the highest residues transferred were measured on the day of the application (de Fontenay et al., 1997). The total mean percentage of applied dose transferred to the gloves on the day of the application was 2.4%. The highest mean percentage transferred to a glove on the day of application was 1.1% at the 4-hour time point. The highest mean percentage (i.e., 1.08%) of the three time points sampled on the application day was used to estimate acute exposure for a child aged 1 to 2 years old who hugs a treated dog; this mean percentage was used as the F_{AR} value (0.0108) for this assessment.

Because de Fontenay et al. (1997) used cotton glove dosimeters which can load much more residue than human skin, this assessment applied a correction factor from Lu and Fenske (1999) to adjust for the extra loading. In Lu and Fenske (1999), carpet was treated with chlorpyrifos via broadcast or aerosol application methods, then the residues were loaded onto a gauze pad wiped on a 100 cm section carpet. This was compared to residues loaded onto the bare hand pressed on and dragged across the carpet. Results indicate that the amount of chlorpyrifos transferred from carpet to bare hands was 23–24 times less than that transferred to gauze wipes (Lu and Fenske, 1999). Therefore, to adjust for the potential difference in loading between the cotton gloves used in the petting studies and human skin, the F_{AR} value of 0.0108 was divided by 23.5, resulting in an adjusted F_{AR} of 0.00046. For the pet collar, in addition to the liquid-to-solid ratio of product formulation, US EPA updated the imidacloprid-specific fur transferable residue factors (F_{AR}) from the Agency's default value to 0.001 and 0.0037 for the small and large collars, respectively (2019a; 2019b). Similar to the handler exposure, the application rate of the pet collar was adjusted by 40% (Lunchick, 2010).

Tables 19–21 summarize the potential exposure of adults (average of male and female data) and children (1–2 year old child) who have close contact with pets treated with spot-on flea and tick products or impregnated collars both containing imidacloprid.

Table 19. Estimated adult and child dermal exposures to imidacloprid residues from pets treated with spot-on flea and tick products

Exposure Route		TC[a] (cm^2/hr)	AR[b] (µg/pet)	F_{AR}[c]	SA[d] (cm^2)	Exposure duration[e] (hr)	TR[f] (µg/cm^2)	Exposure[g] (µg/day)	STADD[h] (µg/kg/day)
Dermal (hug)									
Tube（Liquid）	*Small cat (up to 5 lbs)*								
	Adult	5200	453592	0.00046	1500	0.77	0.14	557	0.40
	1–2 yr old child	1400	453592	0.00046	1500	1.0	0.14	195	0.75
	Medium cat (6-12 lbs)								
	Adult	5200	453592	0.00046	2500	0.77	0.08	334	0.24
	1–2 yr old child	1400	453592	0.00046	2500	1.0	0.08	117	0.45
	Large cat (13 and up)								
	Adult	5200	453592	0.00046	4000	0.77	0.05	209	0.15
	1–2 yr old child	1400	453592	0.00046	4000	1.0	0.05	73	0.28
	Small dog (up to 20 lbs)								
	Adult	5200	453592	0.00046	3000	0.77	0.07	278	0.20
	1–2 yr old child	1400	453592	0.00046	3000	1.0	0.07	97	0.37
	Medium dog (21 to 50 lbs)								
	Adult	5200	453592	0.00046	7000	0.77	0.03	119	0.09
	1–2 yr old child	1400	453592	0.00046	7000	1.0	0.03	42	0.16
	Large dog (51 lbs and up)								
	Adult	5200	453592	0.00046	11000	0.77	0.02	76	0.05
	1–2 yr old child	1400	453592	0.00046	11000	1.0	0.02	27	0.10

[a] TC (transfer coefficient): Based on US EPA (2001), TCs of 5200 cm^2/hr for adults, and 1400 cm^2/hr for 1–2 yr old children for addressing all post-application exposure for all RTU liquid formulations (including aerosol/trigger sprays, dips, pet collars, shampoos and spot-on).

[b] AR: application rate, i.e., amount applied to animal. The maximum application rate 0.001 lbs active ingredient (AI)/pet is used based on the product label.

[c] F_{AR}: fraction of the application rate available as transferable residue, based on a surrogate study on fipronil (de Fontenay et al., 1997). The factor between cotton glove and bare skin is from study conducted by Lu and Fenske (1999). The studies also were used by DPR for another pesticide used for pets (Reeve, 2014).
[d] SA: surface area of the pet, select surface area for medium sized dogs (US EPA, 2012).
[e] ET: exposure time, based on US EPA (2012).
[f] TR (transferable residues): TR = (AR × F_{AR})/SA, based on US EPA (2012).
[g] Exposure from dermal contact = TC × TR × ET, based on US EPA (2012).
[h] STADD (Short-term Absorbed Daily Dose) for dermal contact = Dermal exposure × Dermal absorption factor (5%) / body weight (70 kg for adults or 13kg for 1–2-year-old children based on DPR policy (Andrews and Patterson, 2000)).

Table 20. Estimated adult and child dermal exposures to imidacloprid residues from impregnated flea and tick collars

Exposure Route		TC[b] (cm^2/hr)	AR[c] (µg/pet)	F_{AR}[d]	SA[e] (cm^2)	Exposure duration[f] (hr)	TR[g] (µg/cm^2)	Exposure[h] (µg/day)	STADD[i] (µg/kg/day)
Dermal (hug)									
Collar（0.9971/0.0029 Liquid-to-Solid Ratio)[a]	*Small cat (up to 5 lbs)*								
	Adult	5590.92	508023.6	0.001	1500	0.77	0.34	1458.03	1.04
	1–2 yr old child	1506.14	508023.6	0.001	1500	1.0	0.34	510.10	1.96
	Medium cat (6-12 lbs)								
	Adult	5590.92	508023.6	0.001	2500	0.77	0.20	874.82	0.62
	1–2 yr old child	1506.14	508023.6	0.001	2500	1.0	0.20	306.06	1.18
	Large cat (13 and up)								
	Adult	5590.92	508023.6	0.001	4000	0.77	0.127	546.76	0.39
	1–2 yr old child	1506.14	508023.6	0.001	4000	1.0	0.127	191.29	0.74
	Small dog (up to 20 lbs)								
	Adult	5590.92	508023.6	0.001	3000	0.77	0.17	729.02	0.52
	1–2 yr old child	1506.14	508023.6	0.001	3000	1.0	0.17	255.05	0.98
	Medium dog (21 to 50 lbs)								
	Adult	5590.92	1796225.6	0.0037	7000	0.77	0.95	4087.32	2.92
	1–2 yr old child	1506.14	1796225.6	0.0037	7000	1.0	0.95	1429.98	5.50
	Large dog (51 lbs and up)								
	Adult	5590.92	1796225.6	0.0037	11000	0.77	0.60	2601.02	1.86
	1–2 yr old child	1506.14	1796225.6	0.0037	11000	1.0	0.60	909.99	3.50

[a] Based on US EPA (2019) and the references therein (Hammer, 2016; Jiritschka, 2011), the liquid-to-solid ratio for the percent AI contained in collars (approximately 8–9% by volume) was set to 0.9971/0.0029. The remainder of the collar mass or volume was assumed to be made up of inert ingredients.
[b] TC (transfer coefficient): Based on US EPA (2001), liquid TCs are 5200 cm^2/hr for adults, and 1400 cm^2/hr for children (1–2 years old); solids TCs are140,000 cm^2/hr for adults, and 38,000 cm^2/hr for children (1–2 years). The respective TC values for adults and children are derived by adjusting the liquid and solid TC values with the collar liquid-to-solid ratio of 0.9971/0.0029.
[c] AR: application rate, i.e., amount applied to each animal. The maximum application rates are used as:

- For pets under 18 lbs, AR = 0.0028 lbs AI/pet (US EPA, 2017b)
- For pets over 18 lbs, AR = 0.0099 lbs AI/pet (US EPA, 2017b)
- These maximum application rates were adjusted by 40% based on the study by Lunchick (2010).

[d] F_{AR}: fraction of the application rates available as transferable residue was based on US EPA (2019b) (i.e., 0.001 for small collar and 0.0037 for large collar).
[e] SA: Surface area of the pets (US EPA, 2012).
[f] Exposure duration based on US EPA (2012) (i.e., 0.77 hours for adults and 1 hour for children).
[g] TR (transferable residues): TR = (AR × F_{AR})/SA, based on US EPA (2012).
[h] Exposure from dermal contact = TC × TR × ET, based on US EPA (2012).

[I] STADD (Short-term Absorbed Daily Dose) for dermal contact = Dermal exposure × Dermal absorption factor (5%) / body weight (70 kg for adults or 13 for 1–2 year old children based on Andrews and Patterson (2000).

Table 21. Estimated incidental oral exposure in children (aged 1–2 years) from imidacloprid residues from treated pets

Exposure Route	Exposure duration[a] (hr)	F_m[b] (fra/event)	HSA[c] (cm^2)	F_{AI}[d]	HR[e] (µg/cm^2)	N_Replen[f] (inter/hr)	SE[g]	Freq_HtM[h] (events/hr)	Exposure[i] (µg/day)	STADD[j] (µg/kg/day)
Hand-to-mouth (spot-on)	1	0.13	150	0.04	0.03	4	0.48	20	1.95	0.15
Hand-to-mouth (collar)	1	0.13	150	0.041	0.07	4	0.48	20	5	0.40

[a] ET: exposure time, based on US EPA (2012).

[b] F_m: fraction hand surface area mouthed/event, the value is from US EPA (2012).

[c] HSA: hand surface area, the value from US EPA (2012).

[d] F_{AI}: fraction of AI on hands from transfer coefficient studies, the value from US EPA (2012). The F_{AI} for pet collar was derived using the liquid-to-solid ratio of 0.9971/0.0029, F_{AI} for the liquid portion (0.04), and F_{AI} for the solid portion (0.37); (0.04 × 0.9971 + 0.37 × 0.0029), or 0.041.

[e] HR: hand residue loading. HR = F_{AI} × dermal exposure / (HSA × 2), based on US EPA (2012). The highest dermal exposure estimates for children (small cat, see Table 19 [spot-on] and 20 [pet-collar]) were used to estimate incidental oral exposure in children.

[f] N_Replen: number of replenishment intervals per hour, the value from US EPA (2012).

[g] SE: saliva extraction factor, the value from US EPA's SOP (US EPA, 2012).

[h] Freq_HtM: number of hand-to-mouth contact events per hour, the value is based on US EPA (2012).

[i] Exposure from hand-to-mouth = HR × (F_m × HAS) × (ET × N_Replen) × [1-(1-SE)$^{(Freq\_HtM/N\_Replen)}$].

[j] STADD (Short-term Absorbed Daily Dose) for Hand-to-mouth = Exposure from hand-to-mouth / body weight (13 kg for 1-2 years old children based on DPR policy (Andrews and Patterson, 2000)).

5. Golf Courses and Other Recreational Areas

Imidacloprid may be applied to golf courses and other recreational areas including parks. Even though application of imidacloprid to golf course turf is allowed by the label, PUR data indicate that only a very small amount of imidacloprid (up to 1 lb/year) was used on golf courses in California during 2017–2021 (DPR, 2023). For handler exposure estimates following golf course turf application, see Section A. Professional Handlers in VI. Exposure Assessment, earlier in this document. To estimate golf course maintenance worker exposure (e.g., those who mow and maintain the playing surfaces such as by hand weeding), the assessment uses the reentry worker estimates for turf grass in Table 10, above (see turf grass mowing). Because of the low use-rate of imidacloprid on golf courses, it was only appropriate to estimate short-term exposures. The same is true for estimating maintenance worker exposures in urban or regional parks. No data were available to estimate exposures for recreational golfers or adults or children visiting and playing in recreation parks. Therefore, these exposure estimates are covered by the residential turf grass post-application exposure scenarios. A summary of these post-application exposure estimates is found later in this document in Table 23.

D. Anticipated Residue in Drinking Water

The following section provides an analysis of imidacloprid concentrations in surface water to provide imidacloprid residue levels for calculating acute and chronic exposures from drinking water. This analysis uses imidacloprid residue data from a variety of agencies including DPR, the US Geological Survey (USGS), and the State Water Resources Control Board (SWRCB) to provide a reasonable scenario for drinking water sourced from surface water.

Imidacloprid use has increased in California since 1994, with more recent agricultural use increases starting in 2007 (Figure 5). Approximately four hundred thousand pounds of imidacloprid was applied to crops in 2019, the peak year of use, with use falling approximately seventy thousand pounds in 2020 and falling another sixty thousand pounds in 2021. Figure 5 shows statewide imidacloprid use in pounds of active ingredient by year for production agricultural use (red) and non-agricultural use (blue). It is noteworthy that private residential use of products bought from the retail supply chain is not included in either category. As shown in Figure 5, peak use for commercial non-agricultural purposes occurred in 2002, with approximately 150,000 pounds used. Figure 6 shows the Public Land Survey System (PLSS) section map of the maximum annual production agricultural use of imidacloprid overlaid with SURF testing sites' maximum positive detection for imidacloprid (orange dots) and testing sites that measured below the Limit of Quantitation (LOQ) (black dots). The upper right contains a monthly boxplot of detects for two specified regions with average monthly use plotted in red. Specified regions are colored blue (Central) and green (South) in the map and boxplots and were selected due to each having a large number of detections and internally similar cropping patterns. As shown in Figure 6, imidacloprid is used in all of California's agricultural regions, with applications ranging from > 1 to 18,927 lbs AI per square mile.

Due to the extensive spatial use of imidacloprid throughout California, and the large mass of AI applied, this assessment provides a first-tier analysis of the current surface water testing database, including identification of samples from waterways that could be used for drinking water extraction and the range of sample concentrations and non-detects.

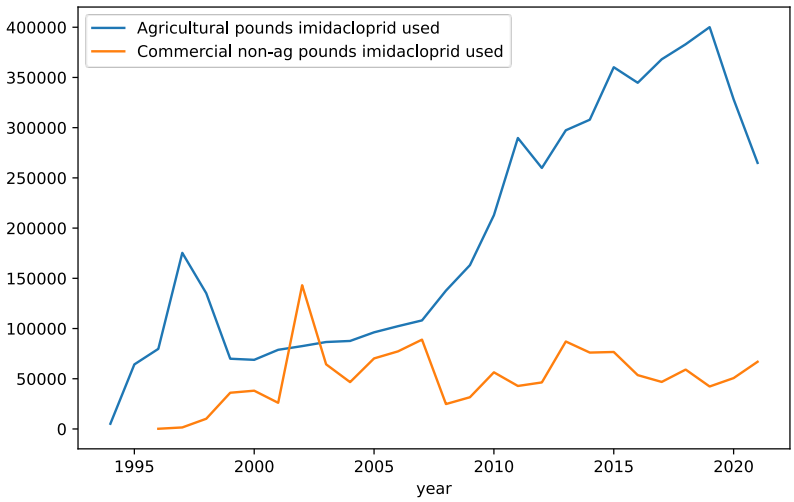


Figure 5. Statewide imidacloprid use in pounds of active ingredient by year for production agricultural use (red) and non-agricultural use (blue).

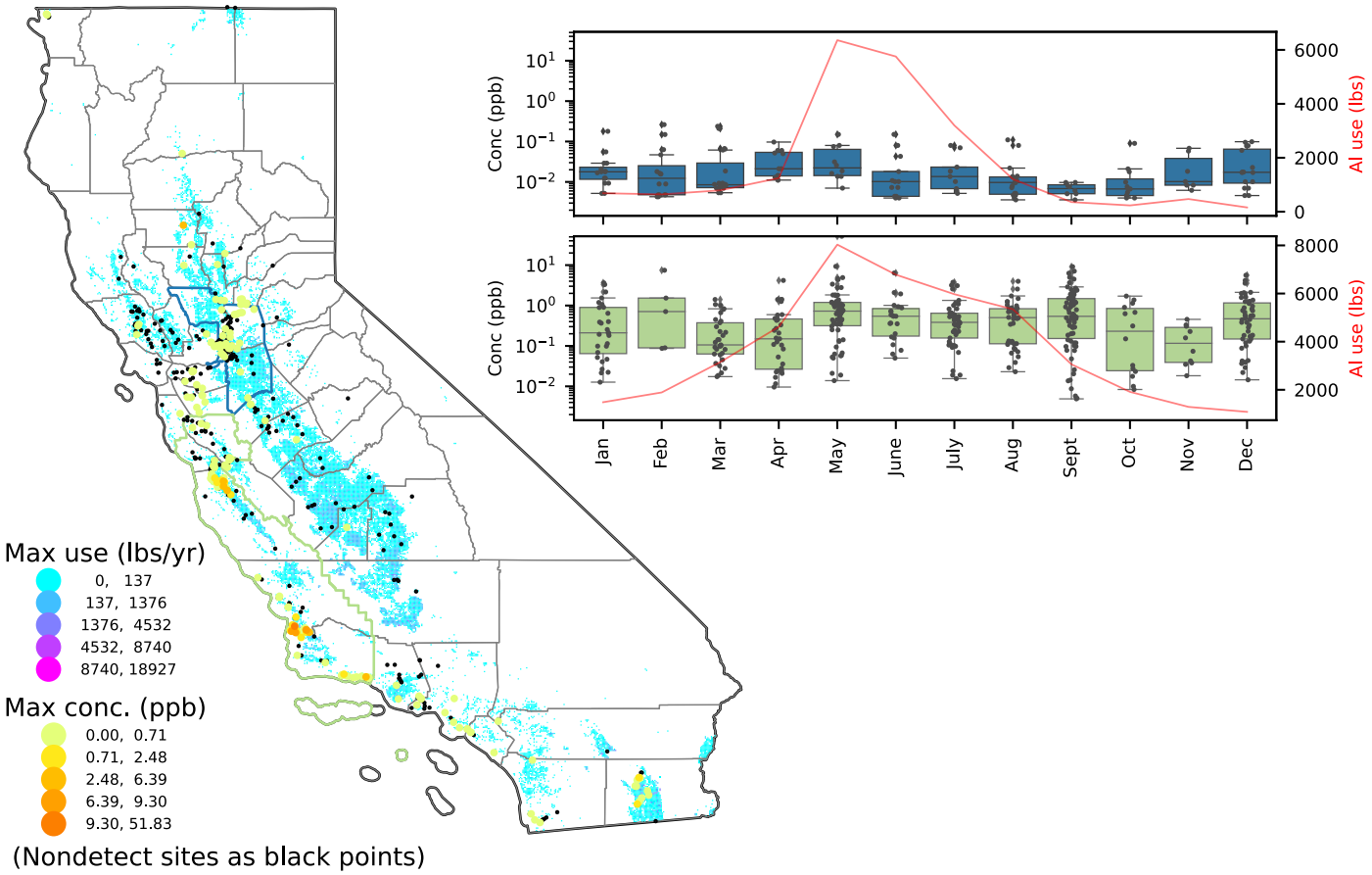


Figure 6. Public Land Survey System (PLSS) section map of the maximum annual production agricultural use of imidacloprid overlaid with SURF testing sites' maximum positive detection for imidacloprid (orange dots) and testing sites (black dots).

1. Drinking Water Residue Analysis Methodology

DPR's Environmental Monitoring Branch (EM) curates a database of analytical results of surface water sampling conducted in California by DPR, US Geological Survey, and other state, local, and federal agencies (SURF[1]). DPR considered all SURF samples that were tested for imidacloprid for further data analysis.

There was less testing for degradates than for the parent compound, and most of those resulted in non-detects. At the 68 sites that tested for degradates, there was no detection of imidacloprid olefinic-guanidine or imidacloprid urea in 57 samples. Imidacloprid guanidine had a maximum concentration of 0.291 ppb. In comparison, the maximum concentration of imidacloprid at those same sites was 6.39 ppb. Due to the limited number of sites and sampling for degradates, and to allow for a direct comparison with parent residue data in groundwater and surface water, only analytical testing results for imidacloprid (the parent compound), and not the guanidine, olefin, and urea degradates were included in this analysis.

The data were further refined to include only surface water that may feed or contribute to a drinking water source. To do so, SURF sites flagged as 'Engineered Conveyance,' 'Ocean,' or 'Estuary' in the SURF 'waterbody_type' field, or any site_type listed as 'Ag Ditch', or any 'site' name containing 'Bay', 'Sfbay', 'ditch', 'drain', 'lagoon', and 'slough' were removed as these are presumably non-potable sources of water. The remaining sites may or may not be co-located near a drinking water extraction site, but still likely to be a free-flowing fresh water source that may contribute to potable water. Only SURF sites that had imidacloprid use within their contributing watershed during the previous 12 months were included in the analysis. Only samples taken during the last two decades of available data (2001–2021) were included to best represent current usage patterns.

2. Drinking Water Residue Results

There was a total of 493 sites that met the criteria above. Each site had a range of 1 to 281 samples per site, averaging approximately 7.5 samples per site. Of these, 182 sites had at least one imidacloprid detection, ranging from one to 137 detections per site and an average of approximately 6 detections per site. Samples that tested for imidacloprid range in time from 3/28/2001to 12/29/2021. The first detection was at 10/1/2004 (0.09 ppb) followed by a few equally small detections in 2004 and 2005, followed by no detections until 2010 when detections became fairly common with regular spikes over 1 ppb. Basic statistics of the samples in the SURF dataset are found in Table 22. The arithmetic mean of concentrations across all samples, assuming non-detects are equal to zero concentration, is 0.118 ppb, but it cannot be guaranteed that non-detect samples actually had no imidacloprid present or, alternatively, if there was even a

[1] The Department of Pesticide Regulation's (DPR) Surface Water Database (SURF) is available through online query/export or as downloadable comma delimited (.csv) files. As of this writing, data is available at https://www.cdpr.ca.gov/environmental-monitoring/surface-water/

possibility of that sampling location having imidacloprid. Therefore, a second mean was calculated using just the samples that had a detection (0.389 ppb).

Table 22. Basic SURF Statistics for Imidacloprid Surface Water Residue Detections

Minimum concentration (non-zero samples) (ppb)	0.00145
Maximum concentration (ppb)	51.83
Mean concentration (all samples; non-detect = 0) (ppb)	0.118
Mean concentration (non-zero, detection, samples) (ppb)	0.389
Total number of surface water samples with imidacloprid residue (n)	3688
Number of detect samples (n)	1116
Number of non-detect samples (n)	2572

Sites that had at least one positive imidacloprid test are depicted as colored dots in Figure 6 while sites that tested for imidacloprid but had no result over the analytical limit of quantitation (LOQ) are in black. The histogram of positive imidacloprid detections can be found in Figure 7, below. Across the 493 selected sites, a total of 3688 samples were tested for imidacloprid. There were 1116samples that tested above the LOQ and 2572 samples testing at or below the LOQ. The LOQ for the non-detection samples ranged from 0.0038 to 0.2 ppb, depending on the laboratory and analytical method employed. For samples taken from possible potable water sources with imidacloprid detected (n = 3688), the residues ranged from a minimum of 0.00145 ppb to a maximum of 51.83 ppb. The vast majority of surface water samples from free-flowing sites with detections (80%) contained less than 0.4 ppb imidacloprid.

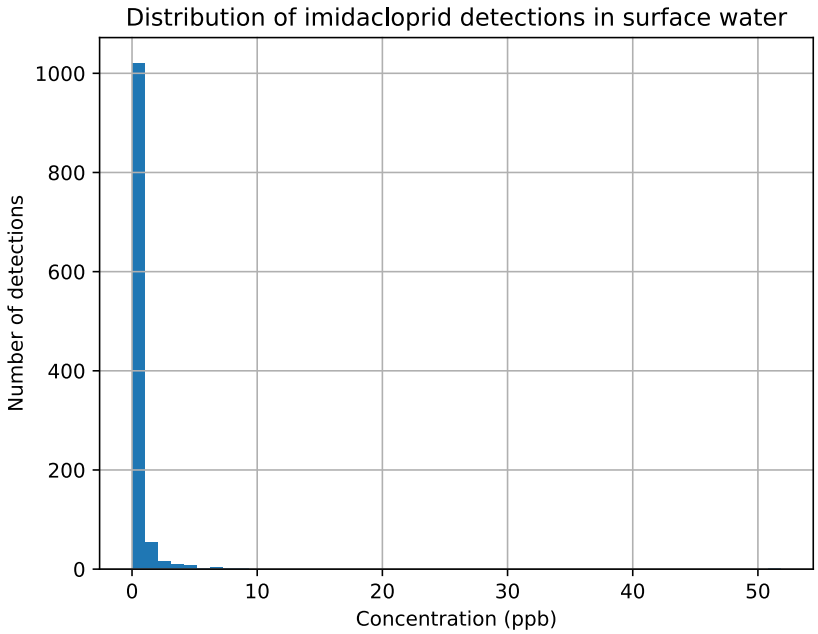


Figure 7. Surface water samples from the SURF database with imidacloprid detection by concentration (ppb)

3. Drinking Water Conclusion Recommendations

This assessment provides a first-tier analysis of the current surface water testing database and provides residue values of imidacloprid in potential potable water sources. Following reanalysis of the database and consideration of higher measured residue levels, as suggested in external scientific review of the draft EAD, it is recommended that the maximum concentration (51.83 ppb) be used to calculate acute exposure and the mean concentration of the non-zero values (0.389 ppb) be used to calculate chronic exposure. If the risk from exposures based on the recommended drinking water residues exceeds the target risk, additional refinement of the surface water data analysis can be provided as needed. Because this section describes a first-tier analysis of the current surface water testing database to provide residue values of imidacloprid in potential potable water sources, if the risk from exposures based on the recommended drinking water residues exceeds the target risk, additional refinement of the surface water data analysis will be needed. It should be noted that all surface water used as drinking water must go through additional water treatment in order to be potable, and that will likely make the above estimates even more conservative.

E. Summary of All Exposure Scenarios

Table 23 presents a summary of non-agricultural exposure estimates for all handler and post-application exposure scenarios (reentry worker, residential, home use, and recreational) developed for this assessment. Scenarios analyzed in this assessment where no exposures are likely are omitted from this summary table (e.g., gel and bait station home applications listed in Table 11). Table 24 provides a summary of the highest exposure estimates for each handler and post-application exposure scenario. As can be seen in Table 24, exposure of mixer/loaders for turf applications is ranked the highest exposure among all the activities presented.

Table 23. Summary of exposure estimates for handlers and post-application exposure to non-agricultural uses of imidacloprid

Scenarios[a]	Formulation[b]	Use Rate[c] (lbs AI/acre or as indicated)	STADD[d] (µg/kg/day)	SADD[e] (µg/kg/day)	AADD[f] (µg/kg/day)	LADD[g] (µg/kg/day)
Professional Handlers						
Aerial (All Activities)						
M/L	Soluble powder	Turf[h] = 0.4, 350 acres/day	573.37	–	–	–
Applicator		Turf[h] = 0.4, 350 acres/day	27.86	–	–	–
Flagging		Turf[h] = 0.4, 350 acres/day	14.66	–	–	–
Ground (Mixer/Loader)						
Groundboom	Soluble powder	Turf[h] = 0.4, 80 acres/day	131.06	-	-	-
		Golf course turf[h] = 0.4, 40 acres/day	65.53	-	-	-
Handgun	Followable concentrate	Ornamentals, fruit, trees, shrubs = 0.1 lbs/100 gal	0.53	0.19	0.096	0.051
Soil application	Soluble powder	Ornamentals, citrus = 0.4	39.32	14.13	6.33	3.38
Ground (Applicator)						
Groundboom	Soluble powder	Turf[h] = 0.4, 80 acre/day	3.83	-	-	-
		Golf course turf[h] = 0.4, 40 acre/day	1.92	-	-	-
Handgun	Followable concentrate	Ornamentals, trees, fruit= 0.1/100 gal	5.03	1.81	0.91	0.48
Ground (Mixer/Loader/Applicator)						
Low pressure handwand	Soluble powder	Turf = 0.16/100 gal	5.96	-	-	-
		Ornamentals = 0.1/100 gal	3.72	1.34	0.67	0.36
	Aqueous concentrate	Turf = 0.16/100 gal	8.47	-	-	-
		Ornamentals = 0.3/100 gal	15.10	5.43	2.71	1.45
Backpack sprayer	Followable concentrate	Tree, shrubs, outdoor floral = 0.1/100 gal	2.49	0.89	0.45	0.24
Belly grinder	Granule	Landscape = 0.03	3.92	1.41	0.71	0.38
Reentry Workers						
Turf mowing	NA	Turf = 0.4	1.50	–	–	–
Turf maintenance	NA	Turf = 0.4	5.55			
Trees & evergreens scouting	NA	Turf = 0.4	3.72	–	–	–
Trees & evergreens irrigation (hand)	NA	Turf = 0.4	12.17	–	–	–
Nursery Ornamentals						
Pruning (hand)	NA	Turf = 0.4	1.47	–	–	–
Flowers, harvesting (hand)	NA	Turf = 0.4	30.75	–	–	–
Rose, harvesting (hand)	NA	Turf = 0.4	3.07	–	–	–
Residential Handlers and Home Users						
Handlers (M/L/A)[i] Landscape & Turf						
Low pressure handwand	Wettable power	Ornamentals, flowers, shrubs, trees = 0.004 lbs/gal	4.49	–	–	–
Backpack sprayer	Flowable concentrate	Turf = 0.001 lbs/gal	1.12	–	–	–
Push-type spreader (no glove)	Granule	Turf = 0.4 lbs/acre	0.54	–	–	–

Table 23. Summary of exposure estimates for handlers and post-application exposure to non-agricultural uses of imidacloprid

Scenarios[a]	Formulation[b]	Use Rate[c] (lbs AI/acre or as indicated)	STADD[d] (µg/kg/day)	SADD[e] (µg/kg/day)	AADD[f] (µg/kg/day)	LADD[g] (µg/kg/day)
Professional Applicators and Home Use of Products on Indoor Carpet, Hard Surfaces and Mattresses						
Construction & wood	Water soluble packet	0.012 lbs/gal	1.31	–	–	–
Carpet	Liquid	0.00053 lbs/can	0.06	–	–	–
Ant bait	Granule	0.00008 lbs/bait	0.021	–	–	–
Bed bug treatment	Liquid	0.008 lbs/gal	0.9	–	–	–
Crack & crevice	Liquid	0.008 lbs/gal	0.9	–	–	–
Home Application of Pet Treatments (dogs or cats)						
Pet Owners (adult)	Liquid (spot-on)[j]	0.001 lbs/pet	0.66	0.17	–	–
Pet Owners (adult)	IM collar for small pets	0.0028 lbs/pet (up to 18 lb pet)	0.788	0.21	–	–
	IM collar	0.0099 lbs/pet (18+ lb pet)	2.75	0.75	–	–
Post-Application Exposures (Adult and Child)[i] following Professional Residential Applications and Home Uses						
Residential Lawns						
Dermal[k]						
Adult	Liquid	Turf = 0.4	5.20	–	–	–
Child 1–2 (M/F)			8.66	–	–	–
Child 3–5 (M/F)			27.55	–	–	–
Child 6–8 (M/F)			19.16	–	–	–
Child 9–11 (M/F)	Liquid	Turf = 0.4	13.22	–	–	–
Child 12–14 (M/F)			9.02	–	–	–
Child 15–18 (M)			7.11	–	–	–
Child 15–18 (F)			5.91	–	–	–
Child Hand-to-Mouth			60.9	–	–	–
Child Grass Ingestion			1.85	–	–	–
Residential Applications and Home Use – Indoor						
Hard Surface						
Adult Dermal	Liquid	Crack/crevice, Spot Spray = 0.001 lbs/gal	3.50	–	–	–
Child Dermal		Crack/crevice, Spot Spray = 0.001 lbs/gal	4.98	–	–	–
Carpet						
Adult Dermal	Liquid	Spot Spray = 0.001 lbs/gal	10.49	–	–	–
Child Dermal		Spot Spray = 0.001 lbs/gal	7.48	–	–	–
Child Hand-to-Mouth		Spot Spray = 0.001 lbs/gal	22.4	–	–	–
Post-Application Exposures from Pet Treatments (dogs or cats)						
Dermal Exposure (Adult and Child) following spot-on treatment						
Adult	Liquid	Small cat (up to 5 lbs) 0.001 lbs/pet	0.40	–	–	–
Child			0.75	–	–	–
Adult	Liquid	Medium cat (6–12 lbs) 0.001 lbs/pet	0.24	–	–	–

Table 23. Summary of exposure estimates for handlers and post-application exposure to non-agricultural uses of imidacloprid

Scenarios[a]	Formulation[b]	Use Rate[c] (lbs AI/acre or as indicated)	STADD[d] (µg/kg/day)	SADD[e] (µg/kg/day)	AADD[f] (µg/kg/day)	LADD[g] (µg/kg/day)
Child			0.45	–	–	–
Adult	Liquid	Large cat (13+ lbs) 0.001 lbs/pet	0.15	–	–	–
Child			0.28	–	–	–
Adult	Liquid	Small dog (up to 20 lbs) 0.001 lbs/pet	0.20	–	–	–
Child			0.37	–	–	–
Adult	Liquid	Medium dog (21–50 lbs) 0.001 lbs/pet	0.09	–	–	–
Child			0.16	–	–	–
Adult	Liquid	Large dog (51+ lbs) 0.001 lbs/pet	0.05	–	–	–
Child			0.10	–	–	–
Dermal Exposure (Adult and Child) following collar use						
Adult	IM	Small cat (up to 5 lbs) 0.0028 lbs/small pet (up to 18 lbs)	1.04	–	–	–
Child			1.96	–	–	–
Adult	IM	Medium cat (6–12 lbs) 0.0028 lbs/small pet (up to 18 lbs)	0.62	–	–	–
Child			1.18	–	–	–
Adult	IM	Large cat (13+ lbs) 0.0028 lbs/small pet (up to 18 lbs)	0.39	–	–	–
Child			0.74	–	–	–
Adult	IM	Small dog (up to 20 lbs) 0.0099 lbs/large pet (18+ lbs)	0.52	–	–	–
Child			0.98	–	–	–
Adult	IM	Medium dog (21–50 lbs) 0.0099 lbs/large pet (18+ lbs)	2.92	–	–	–
Child			5.50	–	–	–
Adult	IM	Large Dog (51+ lbs) 0.0099 lbs/large pet (18+ lbs)	1.86	–	–	–
Child			3.50	–	–	–
Child Incidental Hand to Mouth	Liquid	Small cat (up to 5 lbs) 0.001 lbs/pet	0.15	–	–	–
	IM	Small cat (up to 5 lbs) 0.0028 lbs/small pet (up to 18 lbs)	0.40	–	–	–
Golf Course Post-Application Exposures						
Mowers	Granule/Liquid	Turf = 0.4	1.50[l]	–	–	–
Maintenance Worker (hand weeding)			5.55	–	–	–

[a] Exposure scenarios are based on the product labels.

[b] Formulation according to product labels; IM = impregnated material; N/A for field workers means the specific restricted entry interval and pre-harvest interval were taken into account for the exposure estimations.

[c] Use rates are based on product labels; highest allowable use rate used to assess field worker exposure; AI = Active ingredient; gal = gallon; lbs = pounds

[d] Short-term Absorbed Daily Dose (STADD) are upper-bound estimates, calculations based on:

- For data from PHED, the 90% upper confidence limit for the 95th percentile of the PHED exposure estimate (Powell, 2007)
- For data from monitoring study, the 95th percentile of arithmetic mean
- For reentry scenarios, 95th percentiles of TC values (US EPA, 2012) are used, or maximum DFR values are used to estimate related exposures.

[e] Seasonal Average Daily Dose (SADD) is based on the 90% upper confidence limit of the arithmetic mean PHED exposure (Powell, 2007); See Appendices.
[f] Annual Average Daily Dose (AADD) = SADD x annual use months per year/12 months in a year. High-use season based on pesticide use data.
[g] Lifetime Average Daily Dose (LADD) = AADD × 40 years of work in a lifetime/75 years in a lifetime.
[h] Based on limit pesticide use for this specific application, only STADD exposure estimates are calculated.
[i] Short-term exposures are most appropriate based on residential and home use application frequency and duration
[j] No exposure data available for gel formulation, however, exposure is considered negligible based on US EPA (2012).
[k] Estimate is based on monitoring data; see Tables 14 and 17 above.
[l] No data was available for golfers. Golfer exposures are assumed to be less than for mowers. The mower exposure data are from Table 10.

Table 24. Highest exposure estimates for non-agricultural handler and post-application exposure to imidacloprid from monitoring studies and the pesticide handler exposure database

Scenarios[a]	Use Rate[a] (lbs AI/acre or as indicated)	STADD[b] (µg/kg/day)	SADD[c] (µg/kg/day)	AADD[d] (µg/kg/day)	LADD[e] (µg/kg/day)
Professional Handlers					
Aerial (All Activities)					
Mixing/Loading	Turf = 0.4 lbs AI/acre	573.37	–	–	–
Application	Turf = 0.4 lbs AI/acre	27.86	–	–	–
Flagging	Turf = 0.4 lbs AI/acre	14.66	–	–	–
Ground (Mixer/Loader)					
Groundboom	Turf[h] = 0.4, 80 acres/day	131.06	–	–	–
	Golf course turf[h] = 0.4, 40 acres/day	65.53	–	–	–
Ground (Applicator)					
Handgun	Ornamentals, trees, fruit= 0.1/100 gal	0.53	0.19	0.096	0.051
Ground M/L/A					
Low Pressure Handwand (Aqueous concentrate)	Ornamentals = 0.3 lbs AI/100 gal	15.10	5.43	2.71	1.45
Reentry Workers					
Flowers Cut	0.4 lbs AI/acre	30.75	–	–	–
Residential Applicators or Home Users					
Low Pressure Handwand	Ornamentals, flowers, shrubs, trees = 0.004 lbs/gal	4.49	–	–	–
Indoor (construction & wood)	0.01 lbs/gal	1.31	–	–	–
Home Pet Treatment					
Pet Collar Handler	Large pet, 0.0099 lbs/pet	2.75	0.75	–	–
Post-Application Residential or Home Uses					
Adult Dermal	Turf = 0.4 lbs AI/acre	5.20	–	–	–
Child Dermal (1–2 yr old)	Turf = 0.4 lbs AI/acre	8.66	–	–	–
Child Hand-to-Mouth (1–2 yr old)	Turf = 0.4 lbs AI/acre	60.9	–	–	–
Post-application Home Pet Treatment					
Adult Dermal (hugging pet with pet collar)	0.0028 lbs AI/pet	1.04	–	–	–
Child Dermal (1–2 yr old hugging pet with pet collar)	0.0028 lbs AI/pet	1.96	–	–	–
Child Oral (hand-to-mouth from pet collar)	0.0028 lbs AI/pet	0.40	–	–	–

[a] Data from Table 23. This table shows only the highest exposure estimate for each exposure scenario.

[b] Short-term Absorbed Daily Dose (STADD) are upper-bound estimates. For detailed calculations see Table 23.

[c] Seasonal Average Daily Dose (SADD) is based on the 90% upper confidence limit of the arithmetic mean PHED exposure (Powell, 2007)

[d] Annual Average Daily Dose (AADD) = SADD * annual use months per year/12 months in a year. High-use season for handler based on pesticide use data.

[e] Lifetime Average Daily Dose (LADD) = AADD * 40 years of work in a lifetime/75 years in a lifetime

VII. EXPOSURE APPRAISAL

DPR's human exposure assessments use the "indirect estimation" method which relies on a series of scenarios to estimate exposures. This contrasts with a point-of-contact approach which utilizes direct exposure measurement or dose/exposure reconstruction to estimate (or back-calculate) exposure based on the effect observed. DPR develops exposure scenarios based on reasonable worse-case conditions derived from the approved label for imidacloprid products registered for use in California. Populations of interest include pesticide handlers, reentry workers, home users, and adult and child residents who may be exposed following an application but that were not involved in the applications themselves. Sensitive subpopulations include infants and women of childbearing age. Exposure scenarios are further refined by using California-specific data and adjusted by protection factors associated with the required personal protective equipment (PPE). This type of exposure assessment provides a comprehensive view of the magnitude and potential for pesticide exposures.

The main uncertainties in quantifying imidacloprid exposure center around the data assumptions used in the quantitative evaluation. These including using the PHED data as a surrogate to estimate dermal and inhalation exposure, using PUR data to estimate the annual exposure frequency of pesticide handlers and reentry workers, using dislodgeable foliar residue data (or default values) to estimate reentry worker exposure, and some assumptions around pet products containing imidacloprid, as explained below.

A. Use of PHED Data as a Surrogate to Estimate Dermal and Inhalation Exposure

There were no monitoring studies available for non-agricultural uses. All handler exposure scenarios lacked chemical-specific handler exposure data for imidacloprid. Therefore, PHED (1995) was used as surrogate. PHED is a database that houses results from many worker exposure studies. These studies differ in protocols and laboratory analytical methods used to analyze samples. In addition, the dermal exposure section of the PHED database was assembled in a way that dermal exposure results for each body region are estimated from different individuals. In addition, the number of exposure observations may be too small to be considered a representative sample for some scenarios. The nature of the PHED database introduces an unknown degree of uncertainty into exposure estimates. Therefore, DPR calculates 90% upper confidence limits on the 95th percentile exposure statistics to increase the confidence in the estimates of exposure.

Data quality grades in PHED are assigned according to Quality Assurance/Quality Control data provided in exposure study reports as described in Versar (1992). 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 (US EPA, 1998).

PHED was used to estimate 9 handler dermal and inhalation exposure scenarios in this assessment. These exposure values were used to calculate ADDs. Table 25 summarizes the data quality and number of observations for each PHED data set used to estimate exposure.

Table 25. Pesticide Handler Exposure Database (PHED) data quality used to estimate handler exposure

Exposure Subsets[a]	Dermal Exposure		Hand Exposure		Inhalation Exposure		Scenario No.[c]
	Obs.[b]	Grade	Obs.[b]	Grade	Obs.[b]	Grade	
1. M/L (WP)	2–36	AB[d]	20	AB	17	A	1
2. M/L (DF)	16–26	AB	21	AB	23	A	2
3. Flagger	18–28	A	30	AB	28	AB	7
4. Groundboom Appl.	29–42	ABC	29	AB	22	AB	11
5. Aerial Appl. (L)	10-17	AC	9	AC	14	BC	17
6. M/L/A (L) Backpack	9-11	AB	11	C	11	AB	20
7. M/L/A (L) LP handwand	9-80	ABC	10	ABC	10	AB	22
8. M/L/A (SP) LP handwand	16	C	15	A	16	C	23
9. L/A (G) Using Belly Grinder	29-45	AC	23	C	40	AB	27

[a] 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 handwand = Low-pressure handwand.

[b] Obs. = Number of observations.

[c] The scenario number is the number order in scenarios summary of DPR guidance document (Beauvais et al., 2007).

[d] The highest quality PHED datasets are designated Grade A and B, or a mix of Grade AB. Lower quality data are graded ABC, BC or C.

Results indicate that the dermal exposure assessment for subsets 1–4 and 6 are made with high confidence (subset numbers are from Beauvais et al., 2007). In these subsets the dermal data quality was high (AB), and the observations are generally greater than 15. Although the lowest number of observations in subsets 6 are as low as 2, those were for neck exposure, which has little contribution to total exposure. The number of observations for the rest of the body regions was greater than 15. The dermal exposure assessment for subsets 5 and 11 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 7, 8 and 9 are made with low confidence since there were less than 15 observations per body part, although some had high data quality. Some observations in subset 9 are as high as 80, but those were head and neck observations, and other body parts contributing more to total exposure numbered fewer than15 observations. Hand exposure assessments are made with high confidence for subsets 1–6 and 10, 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 subset 11 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 7, 8, and 9 are made with low confidence since there were less than 15 observations per body part. Inhalation exposure assessments are developed with high confidence for subsets 1–6 and 11, 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 subset 11 as the data qualities were moderate (including grade C), and the observations were greater than 15 in

these subsets. Inhalation exposure assessments for subsets 7, 8, and 9 are made with low confidence since there were less than 15 observations per body part, although they had high or moderate data quality.

US EPA also uses PHED to estimate handler exposure. However, US EPA approaches PHED data differently than DPR in three mains ways: 1) While DPR believes the arithmetic mean is the appropriate statistic regardless of the sample distribution (Powell, 2003), US EPA selects their central tendency statistic based on distributional assumptions; 2) For short-term exposure estimates, DPR uses a 95th percentile upper bound estimate, while US EPA uses a central tendency estimate for all exposure durations; and, 3) DPR calculates upper 90% confidence limits for both upper bound and mean exposures, while US EPA does not.

B. Estimating the Annual Exposure Frequency of Handlers and Reentry Workers Based on PUR Data

PUR data were used to estimate likely exposure months of workers, based on the distribution of licensed non-agricultural applications in high-use California counties. These high-use periods describe the potential work history of the handler population, and the exposure frequency likely overestimates the workdays for any single individual. While possible, it is unlikely that the same worker would apply imidacloprid every day during the high-use period. Therefore, annual exposure estimates may overestimate typical annual worker exposure.

C. Estimating the Dermal Absorption Based on an Animal Study

Comments received on the draft EAD from US EPA, OEHHA, and one registrant all noted an overly conservative assumption of dermal absorption of imidacloprid. DPR has since revised the dermal absorption factor (DAF) from an initial value of 17% in the draft EAD to 5% used in the final assessment. The value was based on a rat study (Odin-Feurtet, M. 2009) and calculated by measuring the amount of imidacloprid directly absorbed into the animal and the amount retained at the external dose site. The initial value included the bound dose in the stratum corneum. However, following additional review of US EPA's approach for deriving its imidacloprid DAF and after conducting independent statistical tests on individual data points from the registrant-submitted study, DPR revised its DAF to 4.823% (rounded to 5% for use in this assessment). The dermal exposure scenarios have been updated to incorporate the revised DAF, as have the resulting risk estimates based on dermal routes in the final RCD.

Although the amount of imidacloprid bound in the stratum corneum (i.e., bound skin residues) was not considered to be potentially absorbable in this assessment, it is possible that some of the bound pesticide residue would still be available for absorption. However, no data were available to estimate the longer-term loss (i.e., > 168 hours) of bound skin residues. Nevertheless, rat skin has different permeability and is thinner than human skin (Bartek et al., 1972; Bronaugh et al., 1982). Hence, using the results of rat skin absorption studies for assessing human dermal absorption may compensate for not considering the potentially absorbed bound skin residue.

D. Establishing the Default Imidacloprid DFR

Since no chemical specific DFR data are available for most use sites, 25% of the maximum use rate is used as default day zero DFR. Available data have been used by DPR (Beauvais and Frank, 2010) and US EPA (2017a) to investigate the likelihood that day zero DFR would exceed the 25% assumption. In a preliminary analysis, DPR found that mean day zero DFR exceeded 25% in eight of 34 crop-chemical combinations with available data, but that most DFR results were substantially less than 25% (Beauvais and Frank, 2010). US EPA analyzed a different data set and found the median day zero DFR was 18% of the application rate (US EPA, 2017). Both analyses included several chemicals, but neither included imidacloprid. Based on these analyses, in this assessment, DPR used 25% of the maximum use rate as a reasonable assumption for day zero DFR for exposure resulting from residential, institutional, and industrial uses of imidacloprid, including landscape maintenance.

E. Using Transferable Turf Residues (TTR) for Estimating Post-application Exposure from Turf

Pesticide residues on plant foliage that can transfer off to other surfaces, such as human skin, are referred to as dislodgeable foliar residues, or DFR. Similarly, residues on turf that may transfer to another surface or object are referred to as turf transferrable residues, or TTR. Although DFR and TTR are similar in that they quantify pesticide residues available for exposure, they are measured using different techniques and, therefore, cannot be used as surrogate values for one another. Several techniques have been proposed for measuring TTR including the Modified California Roller, core sampling and extraction, dosimeter (glove) sampling, and several others. The results using different techniques are generally not interchangeable. Even within a single TTR study, the data usually do not support a consistent relationship between TTR and dermal exposure.

Four TTR studies were available for imidacloprid (see Section V.C. Transferable Turf Residues). The registrant-submitted TTR studies by Kroiski (2016) and Veal (2020) both collected samples following application of imidacloprid in California. Using data from either study would allow for the estimation of human exposure to imidacloprid using California-specific data, consistent with recommendations from the National Academy of Sciences (NAS) following its independent peer review of the department's risk and exposure assessment practices. Between these values, 0.525 $\mu g/cm^2$ was used for developing a high-end exposure estimate in this assessment. However, the value was much higher than default TTR based on US EPA Policy (US EPA, 2017a). Therefore, the post-application exposures on turf may be overestimated.

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

Most imidacloprid containing products labeled for non-agricultural use do not specify specific REIs. More common is that the product label would state that reentry is restricted following application until is "spray is dry." Thus, the DFR on day zero was used to estimate the post-

application exposure following application to golf courses. It may overestimate the exposure if reentry does not occur immediately after the application.

VIII. CONCLUSION

This exposure assessment developed a total of 80 representative scenarios under different non-agricultural occupational and non-occupational settings: professional handlers and reentry workers, residential handlers, home use scenarios including post-application exposure to adults and children, pet products, and worker and player exposure to imidacloprid on golf courses and in other reactional areas. These exposure scenarios were translated into the corresponding exposure potentials based on the legal product use patterns in California as well as information derived from environmental and exposure monitoring studies, surrogate pesticide data, generic handler exposure data (PHED), SOPs from the US EPA and DPR, published research findings in the open literature, and computer modeling. These exposure potentials in turn were subdivided into three exposure durations: STADD (short-term), SADD (intermediate term/seasonal), and AADD (annual).

For professional handlers, exposure may occur during the mixing and loading of powder, concentrate (flowable or liquid), and granular formulated products, as well as the application of all these products (in all formulations). Among these activities, the exposure of mixer/loaders for turf application (dermal and inhalation combined) ranks as the highest exposure. In addition to powders, concentrates, and granulated products, residential and home uses involve other formulations, including gels, liquids, and impregnated materials (e.g., pet collars). The impregnated material in pet collars constitutes the highest exposure via the dermal route for home users. Post-application exposures were evaluated for reentry workers, as well as residential adults and children, for bait products, turf granules, structural liquid concentrates, and pet products. For reentry workers, flower cutting constitutes the highest exposure via the dermal route among all the activities examined. Among residential and home uses, adult exposures were highest via the dermal route for pet products. For children, exposures were largest via dermal and oral routes for pet products and incidental oral exposure to treated turf (i.e., children eating grass).

IX. REFERENCES

Andrews, C. 2000. HSM-00011: Worker Health and Safety Branch Policy on the Statistical Analysis for Dislodgeable Foliar Residue Data. Memorandum to Worker Health and Safety Branch Staff, from Andrews, Chuck, Branch Chief. https://apps.cdpr.ca.gov/whsrpts/hsmemo/hsmem_adv_action.cfm

Andrews, C., and Patterson, G. 2000. Interim Guidance for Selecting Default Inhalation Rates for Children and Adults. Memorandum to Worker Health and Safety Branch Staff and Medical Toxicology Branch Staff, from Andrews, Chuck Chief, Worker Health and Safety Branch and Patterson, Gary, Chief, Medical Toxicology Branch, dated December 1. https://apps.cdpr.ca.gov/whsrpts/hsmemo/hsmem_adv_action.cfm

Arcus-Arth, A. and Ting, D. 2015. Exposure assessment: Soil application of imidacloprid to non-commercial citrus trees for Asian citrus psyllid control. Pesticide and Environmental Toxicology Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. Sacramento, CA. https://oehha.ca.gov/pesticides/report/exposure-assessment-imidacloprid-soil-application-non-commercial-citrus-trees

Bach, T. 2002. Stroking Test in Dogs after Topical Application of Imidacloprid 10% (w/v) + Permethrin 50% (w/v) Spot-On. Lab Project Number: V 02-004. Unpublished study prepared by Bayer AG. EPA MRID 46594103.

Bartek, M.J., LaBuddle, J.A. and Maibach, H.I. 1972. Skin permeability *in vivo*: Comparison in rat, rabbit, pig, and man. J. Invest. Derm. 58: 114-123.

Beauvais S., Powell S., and Zhao W. 2007. Surrogate handler exposure estimates for use in assessments by the California Department of Pesticide Regulation. HS-1826. Sacramento, CA: Worker Health and Safety Branch, Department of Pesticide Regulation, California Environmental Protection Agency. https://apps.cdpr.ca.gov/whsrpts/hsrep/hsrep_hsno_action.cfm

Beauvais, S. 2008. Health-protective estimates of seasonal and annual reentry exposure to endosulfan: typical reentry days. HSM-08001.Sacramento, CA: California Department of Pesticide Regulation, Worker Health and Safety Branch. https://apps.cdpr.ca.gov/whsrpts/hsmemo/hsmem_hsmno_action.cfm

Beauvais, S. 2014. HS-1788: Carbaryl (1-naphthyl methylcarbamate): Human Exposure Assessment Document for Carbaryl pp. 136. California Environmental Protection Agency. Department of Pesticide Regulation. Worker Health and Safety Branch, Sacramento (CA). https://apps.cdpr.ca.gov/whsrpts/hsrep/hsrep_hsno_action.cfm

Beauvais, S.L. and J.P. Frank. 2010. Dislodgeable Foliar Residues: Initial Deposition on Various Crops in California. Presented at the 239th National Meeting and Exposition of the American Chemical Society, San Francisco, CA, March 2010

Bronaugh, R.L., Stewart, R.F. and Congdon, E.R. 1982. Methods for *in vitro* percutaneous absorption studies. II. Animal models for human skin. Tox. App. Pharm. 62: 481-488.

Budavari, S. 1989. The Merck index : an encyclopedia of chemicals, drugs, and biologicals. 11th Centennial Ed. Rahway, N.J., USA: Merck.

Cochran, R. 2005. Default Values for Inhalation Retention/Absorption of Airborne Pesticides. Memorandum to Joseph P. Frank, Senior Toxicologist, Worker Health and Safety Branch, California Department of Pesticide Regulation, from Roger Cochran, Staff Toxicologist. Worker Health and Safety Branch, California Department of Pesticide Regulation. Dated March 23, 2005. Sacramento, CA.

de Fontenay, G., Campagna, J. F., Suberville, S., Birckel, P., and Weil, A. 1997. Dislodgeable residues of fipronil following a topical application of Frontline® spot-on treatment to dogs. MRID 44531203. DPR Data Volume 52062-0229, Record No. 162592.

Dong, M.H. 1993. Human Pesticide Exposure Assessment (For Section 18 Use on Cotton) – Imidacloprid. HS-1682. Sacramento, CA: Worker Health and Safety Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA. https://apps.cdpr.ca.gov/whsrpts/hsrep/hsrep_hsno_action.cfm

DPR. 2001. Memorandum Subject: Preliminary Monitoring Results of Imidacloprid and Cyfluthrin Applications for Glassy-Winged Sharpshooter Control in Commercial Areas of Butte County (Study 197). Dated October 18, 2001. Environmental Monitoring Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA.

DPR. 2002a. Memorandum Subject: Preliminary Monitoring Results of Imidacloprid Applications for Glassy-Winged Sharpshooter Control in Residential Areas of Santa Clara County (Study 197). Dated July 24, 2002. From Randy Segawa and Shifang Fan. Environmental Monitoring Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA. https://www.cdpr.ca.gov/wp-content/uploads/2024/11/r072402.pdf

DPR. 2002b. Memorandum Subject: Preliminary Monitoring Results of Imidacloprid and Carbaryl Applications for Glassy-Winged Sharpshooter Control in Residential Areas of Imperial County (Study 197). Dated October 9, 2002. From Randy Segawa, Johanna Walters, Shifang Fan, Suzanne Matsumoto and Heather Casjes. Environmental Monitoring Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA. https://www.cdpr.ca.gov/wp-content/uploads/2024/11/r100902.pdf

DPR. 2002c. Memorandum Subject: Preliminary Monitoring Results of Imidacloprid Applications for Glassy-Winged Sharpshooter Control in Residential Areas of Santa Clara County (Study 197). Dated October 16, 2002. From Randy Segawa and Johanna Walters. Environmental Monitoring Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA.

DPR. 2004c. Memorandum Subject: Preliminary Monitoring Results of Imidacloprid and Cyfluthrin Applications for Glassy-Winged Sharpshooter Control in Residential Areas of Solano County (Study 197). Dated September 17, 2004.From Randy Segawa, Johanna Walters, and Shifang Fan. Environmental Monitoring Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA. https://www.cdpr.ca.gov/wp-content/uploads/2024/11/gwss091704.pdf

DPR. 2024a. California Pesticide Information Portal (CalPIP), Pesticide Use Report database. Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA. Website accessed for database queries on November 1, 2023. https://calpip.cdpr.ca.gov/main.cfm

DPR, 2024b. Summary of Toxicological Data for Imidacloprid. Chemical Code 3849. Human Health Assessment Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA. Original 5/24/1993, Revised 1/26/2024.

Eberhart, D.C. and Ellisor, G.K. 1994. Evaluation of potential exposure resulting from contact with Merit®-treated turf. Miles Inc., Kansas City, Missouri. DPR Data Volume 51950-165, Record No. 130258.

Fontaine, L.D. 1999. Product Chemistry of Merit® 2.5 PR. Bayer Corporation, Kansas City, Missouri. DPR Data Volume 51950-380.

Frank, J. P. 2008. Default inhalation retention/absorption values to be used for estimating exposure to airborne pesticides. Memo No. HSM-08011, dated December 31. Sacramento, CA: Worker Health and Safety Branch, California Department of Pesticide Regulation. https://apps.cdpr.ca.gov/whsrpts/hsmemo/hsmem_hsmno_action.cfm

Gunther, F.A., Westlake, W.E. and Barkley, J.H. 1973a. Establishing dislodgeable pesticide residues on leaf surfaces. Bull. Envir. Cont. Tox., Vol. 9, No. 4.

Gunther, F.A., Barkley, J.H. and Westlake, W.E. 1973b. Worker environment research. II. Sampling and processing techniques for determining dislodgeable pesticide residues on leaf surfaces. Bull. Envir. Cont. Tox., Vol. 12, No. 6.

Hammer, M. 2016. Flumethrin Release from Seresto Collars by Torsional Stressing. Project Number: S00UI/006938, 44739. Bayer HealthCare, LLC. : Bayer HealthCare, LLC. Animal Health Division P.O. Box 390, Shawnee Mission, KS 66201-0390. MRID 50140804. DPR Data Volume 51950-1007, Record No. 309034.

Jennings, K.A., Canerdy, T.D., Keller, R.J., Atieh, B.H., Doss, R.B., Gupta, R.C. 2000. Human Exposure to Fipronil from Dogs Treated with Frontline. Vet Hum Toxicol. 44 (5):301-3.

Jiritschka, W. 2011. Imidacloprid/ Flumethrin 10%/ 4.5% Collar (All Sizes) - Investigation of Composition of Surface Abrasion After Mechanical Stress. Project Number: 37090, 1427, TGOLL111028. Bayer HealthCare, LLC.: MRID 50140803.

Kim, D. 2012a. Memorandum Subject: Results for the Monitoring of Imidacloprid and Cyfluthrin Used in the Asian Citrus Psyllid Eradication Program in Imperial County (Study #258). Dated October 30, 2012. From David Kim. Environmental Monitoring Branch, California Department of Pesticide Regulation. Sacramento, CA. https://www.cdpr.ca.gov/wp-content/uploads/2024/11/acp_imperial.pdf

Kim, D. 2012b. Memorandum Subject: Results for the Monitoring of Imidacloprid and Cyfluthrin Used in the Asian Citrus Psyllid Eradication Program in Los Angeles County (Study #258). Dated October 24, 2012. From David Kim. Environmental Monitoring Branch, California Department of Pesticide Regulation. Sacramento, CA. https://www.cdpr.ca.gov/wp-content/uploads/2024/11/acp_los_angeles.pdf

Kim, D. 2012c. Memorandum Subject: Results for the Monitoring of Imidacloprid and Cyfluthrin Used in the Asian Citrus Psyllid Eradication Program in San Diego County (Study #258). Dated October 24, 2012. From David Kim. Environmental Monitoring Branch, California Department of Pesticide Regulation Sacramento, CA. https://www.cdpr.ca.gov/wp-content/uploads/2024/11/acp_san_diego.pdf

Klonne, D.R., Fuller, R. and Howell, C. 2000. Determination of dermal and inhalation exposure to reentry workers during harvesting in nursery stock. Unpublished study submitted by the Agricultural Reentry Task Force. ARTF Study ARF044. DPR Data Volume 50366-176, Record No. 181586.

Kroiski, M.E. 2016. Imidacloprid – Determination of transferable residues from turf. Bayer CropScience, Research Triangle Park, North Carolina. DPR Data Volume 51950-0909, Record No. 290521.

Lu, C. and Fenske, R.A. 1999. Dermal Transfer of Chlorpyrifos Residues from Residential Surfaces: Comparison of Hand Press, Hand Drag, Wipe, and Polyurethane Foam Roller Measurements after Broadcast and Aerosol Pesticide Applications. Environmental Health Perspectives 107(6), 463-467.

Lunchick, C. 2010. Occupational and Residential Exposure and Risk Assessment for PNR 1427 Dog and Cat Collars Formulated with Imidacloprid and Flumethrin (ID 33861). Bayer HealthCare LLC, Animal Health Division, P.O. Box 390, Shawnee Mission, KS 66201-0390: Bayer HealthCare LLC, Animal Health Division, P.O. Box 390, Shawnee Mission, KS 66201-0390. DPR Data Volume 51950-1009, Record No. 354387.

Human Health Draft Risk Assessment for Registration Review Scoping Document (ID 45476). Bayer HealthCare, LLC, Animal Health Division, P.O. Box 390, Shawnee Mission, KS 66201-0390: Bayer HealthCare, LLC, Animal Health Division, P.O. Box 390, Shawnee Mission, KS 66201-0390. DPR Data Volume 51950-1009, Record No. 354386.

NRC, 2015. Review of California's Risk Assessment Process for Pesticides. National Academy of Science, National Research Council, Washington, DC: The National Academies Press. https://doi.org/10.17226/21664.

Odin-Feurtet, M. 2009. Gaucho FS 350 (Imidacloprid): *In vivo* dermal absorption study in the male rat. Bayer CropScience, 355, rue Dostoïevski, BP 153, 06903 Sophia Antipolis Cedex, France.

PHED. 1995. Pesticide Handlers Exposure Database, Version 1.1. Prepared for the PHED Task Force: Health Canada, US EPA and the American Crop Protection Association, by Versar, Inc., Springfield, VA.

Powell, S. 2003. Why Worker Health and Safety Branch uses arithmetic means in exposure assessment. Memo No.HSM-03022. Sacramento, CA: Worker Health and Safety Branch, California Department of Pesticide Regulation, California Environmental Protection Agency. https://apps.cdpr.ca.gov/whsrpts/hsmemo/hsmem_hsmno_action.cfm

Powell, S. 2007. Recommended Method for Approximating Confidence Limits for Upper Bound and Mean Exposure Estimates from the Pesticide Handlers Exposure Database (PHED) to Replace the Method of HSM-02037. Memo No.HSM-07004. Sacramento, CA: Worker Health and Safety Branch, California Department of Pesticide Regulation, California Environmental Protection Agency. https://apps.cdpr.ca.gov/whsrpts/hsmemo/hsmem_hsmno_action.cfm

Reeve, I. Estimation of exposure to persons in California to Amitraz® in spot-on formulation anti-flea and tick treatments for dogs, dog collars for anti-tick treatment, and plastic strip for the in-hive control of varroa destructor mites. Memo No. HSM-14001, dated January 21, 2014. Sacramento, CA: Worker Health and Safety Branch, California Department of Pesticide Regulation. https://apps.cdpr.ca.gov/whsrpts/hsmemo/hsmem_hsmno_action.cfm

Siemann, L. 1995. Formulation Product Chemistry: Series 63-Physical and Chemical Characteristics. Miles, Inc., Merriam, Kansas. DPR Data Volume 51950-0266. Record No. 145471.

Thongsinthusak, T. and Dong, M. H. 2010. Chapter 54 - Mitigation Measures for Exposure to Pesticides. In Hayes' Handbook of Pesticide Toxicology (Third Edition), edited by R. Krieger. New York: Academic Press, pp. 1157-1172. http://www.sciencedirect.com/science/article/pii/B9780123743671000549.

USEPA. 1992. Guidelines for exposure assessment. EPA/600Z-92/001. Washington, DC: Office of Research and Development, US Environmental Protection Agency.

USEPA. 1997. Exposure Factors Handbook. EPA/600/P-95/002. Office of Health and Environmental Assessment, US Environmental Protection Agency, Washington, DC.

USEPA. 1998. PHED surrogate exposure guide. Estimates of worker exposure from the pesticide handler exposure database, Version 1.1. US Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances, Washington, DC.

USEPA 2001. Policy Number 009.1: Standard Values for Daily Acres Treated in Agriculture. Science Advisory Council for Exposure Policy, pp. 7. United States Environmental Protection Agency, Washington, D.C.

USEPA. 2006. Reregistration eligibility decision for acephate. Office of Prevention, Pesticide and Toxic Substances, US Environmental Protection Agency, Washington, DC.

USEPA. 2012. Standard Operating Procedures (SOPs) for Residential Pesticide Exposure Assessment (dated October 2012). Washington, DC: Health Effects Division, Office of Pesticide Programs, US Environmental Protection Agency.

USEPA. 2017a. Science Advisory Council for Exposure (ExpoSAC) Policy 3 (dated January 2017). Washington, DC: Science Advisory Council for Exposure, Health Effects Division, Office of Pesticide Programs, US Environmental Protection Agency.

USEPA 2017b. Imidacloprid: Human Health Draft Risk Assessment for Registration Review. https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0844-1235.

USEPA 2019a. Imidacloprid. Updated Residential Exposure Assessment in Response to Draft Risk Assessment (DRA) Comments. https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0844-1616.

USEPA 2019b. Imidacloprid: Draft Human Health Risk Assessment (DRA) for Registration Review – Response to Comments. https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0844-1613.

Veal, M. W. 2020. Determination of Imidacloprid Transferable Residue from Turf after Spray Application of Merit® 2F (240 g/L Imidacloprid) in North America. Bayer CropScience, Environmental Safety, 700 Chestfield Pkwy West, Chesterfield, MO 63017: Bayer CropScience. MRID 51085501. DPR Data Volume 51590-0991, Record No. 336940.

Versar. 1992. PHED: The Pesticide Handlers Exposure Database Reference Manual. Prepared for the PHED Task Force: Health and Welfare Canada, US Environmental Protection Agency, National Agricultural Chemicals Association. Springfield, VA: Versar, Inc.

Ware, G. W., Morgan, D. P., Estesen, B. J., Cahill, W. P., and Whitacre, D. M. 1973. Establishment of reentry intervals for organophosphate-treated cotton fields based on human data. I. Ethyl- and methyl parathion. Arch Environ Contam Toxicol 1:48-59.

Ware, G. W., Morgan, D. P., Estesen, B. J., and Cahill, W. P. 1974. Establishment of reentry intervals for organophosphate-treated cotton fields based on human data. II. Azodrin, ethyl and methylparathion. Arch Environ Contam Toxicol 2:117-129.

Ware, G. W., Morgan, D. P., Estesen, B. J., and Cahill, W. P. 1975. Establishment of reentry intervals for organophosphate-treated cotton fields based on human data: III. 12 To 72 hours post-treatment exposure to monocrotophos, ethyl- and methyl parathion. Arch Environ Contam Toxicol 3:289-306.

Welsh, A., Powell, S., Spencer, J., Schneider, F., Hernandez, B. Z., Beauvais, S., Fredrickson, A. S., and Edmiston, S. 2005. HS-1860: Transferable Turf Residue Following Imidacloprid Application pp. 44.

Yanga, N., and Steinmann, K. 2018. The Infrastructure of California's Pesticide Use Reporting Program. In Managing and Analyzing Pesticide Use Data for Pest Management, Environmental Monitoring, Public Health, and Public Policy: American Chemical Society, pp. 15-30.

Zhao, W. 2014. Review of Exposure Assessment of Imidacloprid: Soil Application to Non-Commercial Citrus Trees for Asian Citrus Psyllid Control. Memorandum to Sheryl Beauvais, Branch Chief, Human Health Assessment Branch from Wendy Zhao, Staff Toxicologist, Exposure Assessment Section. Dated July 31, 2014. California Department of Pesticide Regulation, California Environmental Protection Agency.

APPENDICES

Appendix A: Short-, intermediate- and long-term exposure estimated for non-agricultural professional handlers applying imidacloprid in landscape maintenance and turf grass management scenarios

Job Category [a]	FM[b]	Use Rate[c] (lbs AI used, or units as indicated)	STADD[d] (µg/kg/day)		SADD[e] (µg/kg/day)		AADD[f] (µg/kg/day)	
			Dermal	Inhalation	Dermal	Inhalation	Dermal	Inhalation
Aerial (All Activities)								
Mixing/Loading	SP	Turf[h] = 0.4, 350 acres/day	217.37	356.0	–	–	–	–
Application		Turf[h] = 0.4, 350 acres/day	23.62	4.24	–	–	–	–
Flagging		Turf[h] = 0.4, 350 acres/day	13.30	1.36	–	–	–	–
Ground (Mixer/Loader)								
Groundboom	SP	Turf[h] = 0.4, 80 acres/day	49.69	81.37	–	–	–	–
		Golf course turf[h] = 0.4, 40 acres/day	24.84	40.69	–	–	–	–
Handgun	FC	Ornamentals, fruit, trees = 0.11 lbs/100 gal	0.5	0.03	0.18	0.01	0.09	0.006
Soil application	SP	Ornamentals = 0.4	14.91	24.41	5.35	8.78	2.67	3.66
Ground (Applicator)								
Groundboom	SP	Turf[h] = 0.4	1.95	1.88	–	–	–	–
		Golf course turf[h] = 0.4	0.98	0.94	–	–	–	–
Handgun	FC	Ornamentals, trees, fruits = 0.3/100 gal	3.77	1.27	1.35	0.46	0.68	0.23
Ground (Mixer/Loader/Applicator)								
Low pressure handwand	SP	Turf[h] = 0.16/100 gal	2.50	3.46	–	–	–	–
		Ornamentals = 0.1/100 gal	1.56	2.16	0.56	0.78	0.28	0.39
	AC	Turf[h] = 0.16/100 gal	6.44	2.03	–	–	–	–
		Ornamentals = 0.3/100 gal	11.29	3.81	4.06	1.37	2.03	0.68
Backpack sprayer	FC	Tree, shrubs, outdoor floral = 0.1/100 gal	2.45	0.038	0.88	0.014	0.44	0.0069
Belly grinder	Granule	Landscape = 0.03	3.69	0.23	1.33	0.082	0.66	0.041

Definition of each footnote can be found in Table 9 in the main document.

Appendix B: Dermal absorption results

	Termination Time (Hr)[a]			
	8 hr	**24 hr**	**72 hr**	**168 hr**
Low dose level (0.5 g/L)				
Total & swabs[b]	79.3 ± 5.4	82.5 ± 7.9	85.6 ± 2.0	79.2 ± 6.4
Surface dose[c]	6.0 ± 4.3	2.6 ± 1.2	2.9 ± 1.5	6.7 ± 4.5
Fur	-[g]	-[g]	-[g]	-[g]
Dressing	0.8 ± 1.1	4.9 ± 6.3	10.7 ± 2.0	1.3 ± 0.7
Stratum corneum[d]	13.119 ± 4.486	12.330 ± 5.748	10.742 ± 2.0	11.873 ± 3.0
Treated skin[e]	1.796 ± 0.4	1.049 ± 0.3	0.336 ± 0.1	0.256 ± 0.1
Surrounding skin	0.452 ± 0.3	0.124 ± 0.1	0.235 ± 0.1	0.620 ± 0.5
Total % excreted[f]	0.342 ± 0.2	1.967 ± 1.0	2.749 ± 0.8	3.067± 0.9
Cardiac Blood	ND	0.001 ± 0.002	ND	ND
Non treated skin	0.298 ± 0.1	0.262 ± 0.2	0.161 ± 0.1	0.393 ± 0.1
Carcass	1.476 ± 0.4	0.806 ± 0.1	0.704 ± 0.1	0.488 ± 0.2
Total % directly absorbed[i]	2.116 ± 0.668	3.037 ± 0.841	3.614 ± 0.736	3.948 ± 1.145
Total% potentially absorbable[j]	4.364 ± 1.08	4.209 ± 1.054	4.186 ± 0.728	4.823 ± 1.565
Intermediate dose level (70 g/L)				
Total & swabs[b]	95.3 ± 2.1	95.6 ± 2.0	92.1 ± 1.1	92.9 ± 4.6
Surface dose[c]	0.08 ± 0.05	0.03 ± 0.03	0.1±0.1	0.03 ± 0.01
Fur	-[g]	0.003 ± 0.006	-[g]	0.01 ± 0.01
Dressing	1.2 ± 2.2	0.06 ± 0.06	0.4 ± 0.1	1.6 ± 1.1
Stratum corneum[d]	0.2 ± 0.09	0.3 ± 0.3	0.4 ± 0.2	0.2 ± 0.07
Treated skin[e]	0.03 ± 0.005	0.08 ± 0.07	0.06 ± 0.07	0.04 ± 0.02
Surrounding skin	0.04 ± 0.3	0.1 ± 0.08	0.2 ± 0.2	0.09 ± 0.01
Total % excreted[f]	0. 01 ± 0.004	0.08 ± 1.0	0.05 ± 0.03	0.2 ± 0.1
Cardiac Blood	ND	ND	ND	ND
Non treated skin	0.1 ± 0.02	0.06 ± 0.008	0.2 ± 0.1	0.1 ± 0.06
Carcass	0.3 ± 0.06	0.2 ± 0.04	0.3 ± 0.03	0.3 ± 0.04
Total % directly absorbed[i]	0.425 ± 0.062	0.360 ± 0.081	0.480 ± 0.115	0.554 ± 0.166
Total % potentially absorbable[j]	0.492 ± 0.062	0.537 ± 0.193	0.745 ± 0.196	0.677 ± 0.266
High dose level (350 g/L)				
Total % swabs[b]	102.4 ± 3.1	102.1 ± 2.1	104.9 ± 0.8	105.1 ± 0.8
Surface dose [c]	0.009 ± 0.004	0.1 ± 0.2	0.02 ± 0.2	0.03 ± 0.02
Fur	-[g]	-[g]	-[g]	0.04 ± 0.04
Dressing	0.8 ± 0.9	0.3 ± 0.2	0.06 ± 0.02	0.2 ± 0.1
Stratum corneum[d]	0.04 ± 0.02	0.5 ± 0.6	0.08 ± 0.02	0.2 ± 0.04
Treated skin[e]	0.02 ± 0.003	0.08 ± 0.08	0.02 ± 0.006	0.05 ± 0.06
Surrounding skin	0.04 ± 0.02	0.1 ± 0.2	0.07 ± 0.02	0.1 ± 0.08
Total % excreted[f]	0. 003 ± 0.001	0.02 ± 0.02	0.03 ± 0.01	0.05 ± 0.01
Cardiac Blood	ND[h]	ND	ND	0.02 ± 0.02
Non treated skin	1.0 ± 1.8	0.06 ± 0.007	0.08 ± 0.007	0.09 ± 0.02
Carcass	0.9 ± 1.2	0.2 ± 0.04	0.3 ± 0.03	0.3 ± 0.05

	Termination Time (Hr)[a]			
	8 hr	**24 hr**	**72 hr**	**168 hr**
Total % directly absorbed[i]	1.924 ± 3.057	0.302 ± 0.032	0.367 ± 0.033	0.425 ± 0.047
Total % potentially absorbable[j]	1.978 ± 3.051	0.529 ± 0.138	0.439 ± 0.029	0.613 ± 0.135

a: The data were obtained from Odin-Feurtet (2009).
b: The sum of skin swabs at 8 hours, termination time, and surrounding swabs.
c: First two tape-strips.
d: Residue from tape-strips excluding the first two.
e: Skin after tape stripping procedure.
f: Sum of % urine, % feces, and % cage wash.
g: no sample.
h: ND = Not Detected.
i: Sum of total % excreted, cardiac blood, non-treated skin and carcass.
j: Sum of total % directly absorbed and total at dose site.