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OFFICE OF CHEMICAL SAFETY
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MEMORANDUM

SUBJECT: **Chlorpyrifos:** Draft Ecological Risk Assessment for Registration Review

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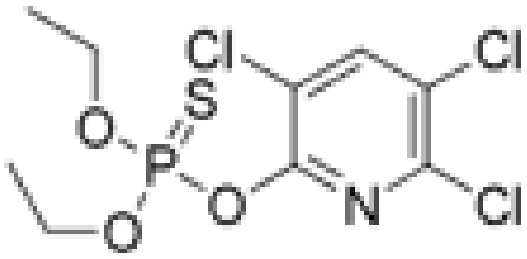
The Environmental Fate and Effects Division (EFED) has completed the streamlined draft ecological risk assessment in support of the Registration Review of the insecticide chlorpyrifos.

Draft Ecological Risk Assessment for the Registration Review of Chlorpyrifos



Chlorpyrifos

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1 Overview

Chlorpyrifos is an organophosphate used as an insecticide on a wide variety of terrestrial food and feed crops, terrestrial non-food crops, greenhouse food/non-food, and non-agricultural indoor and outdoor sites. Based on an Office of Pesticide Programs Information Network (OPPIN) query (conducted September 2020) there are currently 112 active product labels (76 Section 3s and 36 Special Local Needs), which include formulated products and technical grade chlorpyrifos. Chlorpyrifos can be applied in a liquid, granular, or encapsulated form or as a cattle ear tag or seed treatment. Aerial and ground application methods (including broadcast, soil incorporation, orchard airblast, and chemigation) are allowed.

Chlorpyrifos is currently registered on a variety of agricultural use sites, including: agricultural farm premises (such as, barns, empty chicken houses, dairy areas, calving pens), poultry litter, cattle (impregnated collars/ear tags), alfalfa, orchards [including, almonds, apple, cherries, citrus, figs, filberts, non-bearing fruit and nuts (nursery), grapes, nectarine, peach, pear, pecan, plum/prune, seed orchard trees, and walnut], asparagus, beans, beets (grown for seed), sugar beets, carrots (grown for seed), clover (grown for seed), cole crops, corn (all), cotton, cranberry, cucumber, ginseng (medicinal), grass (forage/fodder/hay), legumes, mint, nursery stock, peanut, peas, pepper, pineapple, pumpkin, radish, rutabaga, sod farms, onions, sorghum, soybean, strawberry, sunflower, sweet potato, tobacco, triticale, turnip, wheat, and tree plantations [including, Christmas trees, nursery plantations (conifer and deciduous trees), reforestation programs, conifers, and hybrid cottonwood/poplar].

Chlorpyrifos is also currently registered for use on a variety of non-agricultural use sites, including: commercial/institutional/industrial (indoor and outdoor – *e.g.*, warehouses, food processing plants, ship holds, railroad cars), golf course turf, greenhouse, households (indoor), mosquito control (outdoor), nonagricultural buildings (outdoor – *e.g.*, fences, construction foundations, dumps), ornamental plants, ornamental lawns, rights-of-way (including road medians), sewer manhole covers and walls, utilities (*e.g.*, power lines, railroad systems, telecommunication equipment), wide area general outdoor use (*e.g.*, for ants and other misc. pests), and wood protection treatment (for outdoor building products).

Registered labels for liquid formulations require 25-foot (ground boom and chemigation), 50-foot (orchard airblast), or 150-foot (aerial) no-spray buffer zones adjacent to waterbodies.

Several assessments for chlorpyrifos have been completed in recent years, including the Biological Evaluation for Endangered Species in 2017 (USEPA, 2017; hereafter referred to as biological evaluation), the 2016 Drinking Water Assessment (USEPA, 2016; hereafter referred to as 2016 DWA) and the concurrently completed 2020 Draft Drinking Water Assessment (USEPA, 2020; hereafter referred to as 2020 DWA). This streamlined DRA draws on available data and analysis from these assessments, particularly the biological evaluation, which includes extensive characterization of chlorpyrifos fate and toxicity data. The purpose of this DRA is to describe the

ecological risks posed by the current uses of chlorpyrifos in the context of FIFRA, by providing a range of screening level risk quotients (RQs).

2 Risk Conclusions Summary

Potential risks of concern were identified for mammals, birds, fish and terrestrial/freshwater invertebrates based on RQs. Citrus and tart cherries are associated with some of the highest RQs, but RQs exceed the level of concern (LOC) for all uses assessed for all taxa.

- Mammals
    - Acute RQs range up to 10, with half of the uses assessed resulting in RQs above 5
    - Chronic RQs range up to 625 (reproduction) and 1900 (growth), with 50% of uses resulting in RQs over 147 and 450, respectively
    - Chronic endpoints are based on reduced body weight and 30% loss of pups in litter
- Birds
    - Acute RQs range up to 380, with half of the uses assessed resulting in RQs above 95
    - Chronic RQs range up to 58, with 50% of uses resulting in RQs over 14
- Fish
    - Maximum acute and chronic RQs of 160 and 135, respectively
    - Half of all uses resulted in acute and chronic RQs above 32 and 20, respectively

- Terrestrial and aquatic invertebrates
    - Maximum acute RQs are 4300 and 4900, respectively, with 50% of all uses having RQs over 820 and 880, respectively.
    - Chronic aquatic RQs range up to 8600 with over 50% of uses assessed resulting in RQs above 1540.
    - No tier I chronic bee data available

In addition to LOC exceedances, ecological incidents have been reported for all taxa, and include notable incidents (*e.g.,* significant fish kills, large number of bird deaths, bee kills). Although no RQs exceeded the LOC for plants, there were also reported incidents involving plants.

3 Environmental Fate and Exposure Summary

3.1 Environmental Fate Properties

Chlorpyrifos will initially enter the environment via direct application (*e.g.*, liquid spray and granular) to use sites (*e.g.*, soil, foliage, seed treatments, urban surfaces). It may move off-site via spray drift, volatilization (primarily following foliar applications), and runoff (generally by soil erosion rather than dissolution in runoff water). Major routes of chlorpyrifos transformation in

the environment include alkaline hydrolysis, photolysis in air, and soil and aquatic metabolism (both aerobic and anaerobic). Chlorpyrifos is known to form chlorpyrifos-oxon, 3,5,6-trichloro-2-pyridinol (TCP), and 3,5,6-trichloro-2-methoxypyridine (TMP). The impact of chlorpyrifos-oxon, TCP and TMP were considered qualitatively in the biological evaluation, largely based on uncertainty regarding their formation in the environment. This assessment focuses primarily on anticipated ecological risks from parent chlorpyrifos. Further discussion on the consideration of residues of concern and the fate of chlorpyrifos is found in the biological evaluation, the 2016 DWA and the 2020 DWA.

3.2 Environmental Exposure Modeling and Results

3.2.1 Use Rates Modeled and Input Parameters

In general, current single maximum chlorpyrifos application rates do not exceed 4 lb a.i./A nationwide; however, single application rates greater than 4 lb a.i./A are currently permitted for some specific use patterns. Aerial applications are not permitted at rates higher than 2.0 lb a.i./ except for treatment of Asian citrus psyllid (citrus use).

For the purpose of this streamlined assessment, modeling for both the terrestrial and aquatic environment were based on an evaluation of uses assessed both in the biological evaluation and the 2016 and 2020 DWAs. Although all chlorpyrifos uses were not modeled for this assessment, the uses evaluated provide a comprehensive evaluation (or cover the range) of the pertinent rates and types of applications, thereby providing coverage of the anticipated RQs and ecological risks associated with chlorpyrifos uses as labeled and any agreed upon changes to these labels from the registrants. While the current labels may not reflect all the agreed upon changes, the registrants have agreed (in the form of a commitment letter) to update the chlorpyrifos labels to be reflective of these changes (see biological evaluation for further information). **Table 3-1** and **Table 3-2** summarize the uses, and application rates and methods, evaluated for this assessment.

For terrestrial modeling, application rates were modeled that were representative of the use rates for groups of uses or crops (i.e., by use data layer, as defined in the biological evaluation) as provided in the biological evaluation. **Table 1** shows the use groups modeled and the application rates, number of applications and the retreatment interval used to represent that group based on maximum label rates.

Table 3-1. Use data layer (UDL) groups, application rates and methods evaluated for terrestrial exposure (all modeled as foliar spray)

Use Data Layer (UDL) grouping	Maximum single application rate (lb a.i./A)	Number of applications	Retreatment interval (days)
Corn	1.5	2	10
Cotton	2.2	1	NA
Orchards and Vineyards	6	1	NA
Other Crops	3.76	2	3

Other Grains	1	1	NA
Other Row Crops	2	2	30
Pasture	1	4	10
Soybeans	1	3	14
Vegetables and Ground Fruit	3	3	30
Wheat	1	2	7
Developed	1	26	7
Managed Forests	1	6	7
Nurseries	4	1	NA
Open Space Developed	1	3	7
Right of Way	1	2	7
Christmas Trees	1	6	7
Golf courses	1	2	7
Wide Area Use	1	26	7

For aquatic exposure estimates, the modeling focused on those crops that provide a comprehensive national coverage of EECs. These crops still generally covered the same groups included in terrestrial modeling but focus on crops within these groups. **Table 3-2** provides a high-level summary of the aquatic exposure modeling. Additional details including scenarios and application dates and the batch input utilized in modeling are provided in **Appendix A**.

Table 3-2. Summary of use site, UDL groups, application rates and methods evaluated for aquatic exposure[1]

Use Site	UDL Grouping	Maximum single application rate[1]	Maximum number of applications[1]
corn	Corn	1.61	5
alfalfa	Pasture/hay/forage	1	4
almonds	Orchards and Vineyards	4	5
apples	Orchards and Vineyards	2	2
asparagus	Vegetables and ground fruit	1	3
beets	Other row crops	1.88	1
carrots	Vegetables and ground fruit	0.94	1
cauliflower	Vegetables and ground fruit	2.25	4
Christmas trees	Christmas Trees	1	4
citrus	Orchards and Vineyards	6	5
clover	Other crops	1.9	1
cole crops	Vegetables and ground fruit	2	6
cotton	Cotton	2.23	2

figs	Orchards and Vineyards	1	1
filbert	Orchards and Vineyards	2	4
ginseng	Vegetables and ground fruit	2	1
golf courses	Golf courses	1	2
grapes	Orchards and Vineyards	2.25	1
grapes3	Orchards and Vineyards	1	4
legumes	Vegetables and ground fruit	1	1
mint	Vegetables and ground fruit	2	2
nectarine	Orchards and Vineyards	3	2
nursery	Nurseries	4	1
onion	Vegetables and ground fruit	1	2
peach	Orchards and Vineyards	3	3
peanuts	Other row crops	2	2
pear	Orchards and Vineyards	2	2
pecans	Orchards and Vineyards	4.3	4
peppers	Vegetables and ground fruit	1	8
plums	Orchards and Vineyards	2	2
radishes	Vegetables and ground fruit	3	4
rutabaga	Vegetables and ground fruit	3	5
sorghum	Other grains	1	4
soybeans	Soybeans	2.23	2
strawberry	Vegetables and ground fruit	1	2
sugar beets	Other row crops	1	3
sunflower	Other row crops	2	3
sweet cherries	Orchards and Vineyards	2.5	2
sweet potatoes	Vegetables and ground fruit	2	1
tart cherries	Orchards and Vineyards	2	5
tobacco	Other row crops	2	1
turnips	Vegetables and ground fruit	2.3	2
walnuts	Orchards and Vineyards	4	4
wheat	Wheat	1	3

[1] Some applications modeled included variable rates for multiple applications. Rate listed in table is maximum application rate used in modeling. See **Appendix A** for more details on aquatic modeling runs, including application dates modeled.

Summaries of the environmental fate input parameters used in the PWC modeling of chlorpyrifos are presented in **Table 3-3** below.

Table 3-3. Input parameters used for aquatic modeling

Parameter (units)	Value	Source	Comments
Organic-carbon Normalized Soil-water Partitioning Coefficient (K_{OC} (L/kg-$_{OC}$))	6040	Acc. # 260794	The mean K_{oc} value (K_{oc} values = 7300, 5860 and 4960 mL/g_{OC}) is used for modeling.
Water Column Metabolism Half-life or Aerobic Aquatic Metabolism Half-life (days) 25 ˚C	91.2	MRID 44083401	Only one half-life value is available, so this value (30.4 days) is multiplied by 3 to get 91.2 days. This half-life value was not corrected for hydrolysis.
Benthic Metabolism Half-life or Anaerobic Aquatic Metabolism Half-life (days), 25^{o}C	202.7	MRID 00025619	The 90th percentile confidence bound on the mean chlorpyrifos half-life value determined following the NAFTA kinetics guidance is 87.6 + [(3.078 x 52.9)/√2)] = 202.7 days.
Aqueous Photolysis Half-life at pH 7 (days) and 40° Latitude, 25 °C	29.6	MRID 41747206	
Hydrolysis Half-life (days)	0	MRIDs 00155577 (Acc. # 260794) and 40840901	Since the aerobic aquatic metabolism half-life value was not corrected for hydrolysis, it is possible that hydrolysis would be double counted in the model simulation. Therefore, hydrolysis is set to 0 (stable) here as it is already accounted for in the aerobic aquatic metabolism study and input parameter.
Soil Half-life or Aerobic Soil Metabolism Half-life (days), 25 °C	170.6	Acc. # 241547 and MRID 42144911	Half-life values of 19, 36.7, 31.1, 33.4, 156, 297, 193, and 185 days are obtained from empirical data following the NAFTA kinetics guidance. The 90th percentile confidence bound on the mean chlorpyrifos half-life value is 118.9 + [(1.415 x 103.3)/√8)] = 170.6 days.
Molecular Weight (g/mol)	350.57	product chemistry	
Vapor Pressure (Torr) at 25 °C	1.87 x 10^{-5}	product chemistry BC 2062713	
Solubility in Water at 25 °C (mg/L)	1.4	MRID 41829006	The water solubility of chlorpyrifos is reported to be between 0.5-2.0 mg/L for temperatures between 20 – 25 °C. Based on data submitted to EPA, 1.4 mg/L was used in modeling.
Foliar Half-life (days)	0	Default value	
Application Efficiency	0.99 (ground; air-blast) 0.95 (aerial)	Default Values	
Application Drift	0.009 (ground) 0.008 (air blast) 0.039 (air)	AgDRIFT modeling based on label restrictions	Labels contain aquatic buffer distances of 25, 50 and 150 ft for ground, airblast and aerial applications.

Drift fractions used in this assessment for liquid formulation are presented in **Table 3-4.** Spray drift estimates consider the currently labeled buffer restrictions [25 ft. (ground), 50 ft. (air-

blast), and 150 ft. (aerial)] for aquatic water bodies included on all agricultural chlorpyrifos labels. No spray drift is assumed for granular applications.

Table 3-4. Chlorpyrifos Spray Drift Estimates for Liquid Formulations Used in PWC

Spray Drift Fraction (unitless) Application Method and Buffer		
Ground	**Air-blast**	**Aerial**
25 ft	**50 ft**	**150 ft**
0.008	0.009	0.039

3.2.2 Exposure modeling results

Various models are used to calculate aquatic and terrestrial EECs. The specific models used in this assessment included PWC version 1.52, T-REX version 1.5.2, TerrPlant version 1.2.2 and BeeREX version 1.0[1].

EECs on terrestrial food items range from 15 to 1440 mg/kg-diet based on upper bound Kenaga values and 7 to 510 mg/kg-diet based on mean Kenaga values. Results for specific uses and taxa are found in **Appendix B**.

Aquatic exposure EECs range from 0.72 to 59 ug/L for 1-day EECs, 0.37 to 39 for 21-day EECs and 0.30 to 34 for 60-day EECs. The maximum EECs were associated with applications modeled on tart cherries. EECs are summarized below in **Table 3-5** and detailed results for uses modeled are provided in **Appendix B.**

Table 3-5. Ranges of aquatic EECs for modeled uses.

	1-day EECs	21-days EECs	60-day EECs
Minimum values	0.72	0.37	0.30
Maximum values	59	39	34
Maximum EEC Crop	Tart cherries	Tart cherries	Tart cherries
50% of all uses modeled exceed an EEC of...	12	7.1	5.5

4 Ecological Effects Summary

4.1 Ecological Effects Endpoints

Chlorpyrifos is an insecticide that acts by inhibiting cholinesterase activity, thereby preventing the natural breakdown of various cholines and ultimately causing the neuromuscular system to seize. This may lead to a series of various effects, which may culminate in death. The effects of chlorpyrifos have been studied extensively in many taxa, particularly in fish and aquatic and

[1] https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment

terrestrial invertebrates. Studies include acute and chronic laboratory studies with either technical or formulated chlorpyrifos and include both registrant-submitted and open literature studies. A detailed description of the toxicity data available for chlorpyrifos is detailed in the biological evaluation.

One study that was not reviewed for the 2017 biological evaluation was an acute larval honeybee study. A registrant study (MRID 49960301) was submitted on the effects of chlorpyrifos to honeybee larvae after acute exposure. This study resulted in an LD_{50} of 0.0165 µg a.i./larva. This represented the most sensitive endpoint available for effects to honeybee larvae and was used as the endpoint for risk estimation in this DRA.

Table 4-1 includes a summary of the toxicological endpoints used for risk estimation in this assessment. These endpoints were extracted from ***Appendix 3.6*** *Chlorpyrifos Input Parameters for Weight of Evidence Matrices* in the biological evaluation. For all studies other than the acute honeybee larval study discussed above, additional study information can be found in the biological evaluation. Other endpoints and the large toxicological dataset available for chlorpyrifos is extensively discussed in the biological evaluation; only those endpoints used in this assessment are listed below. Where a NOAEC was not defined, a LOAEC was used as a surrogate in the analysis, but listed RQs could be higher than those reported.

Table 4-1. Toxicity endpoints used for risk estimation.

Study Type	Test Species	Toxicity Value	MRID or ECOTOX No.
Birds			
Acute Oral	Ring-Necked Pheasant *(Phasianus colchicus)* Body weight = 1133.5 g	LD_{50} = 7.95 mg a.i./kg-bw	ECOTOX No. 35499
Sub-acute dietary	Mallard Duck (*Anas platyrhynchos*)	LC_{50} = 203 mg a.i./kg-diet	MRID 40854702
Chronic	Mallard Duck (*Anas platyrhynchos*)	NOAEC = 25 LOAEC = 125 mg/kg-diet based on 83% reduction in eggs laid	MRID 0046952
Mammals			
Acute Oral	House Mouse (*Mus musculus*) Body weight = 26 g	LD_{50} = 60 mg a.i./kg-bw	ECOTOX No. 93364, Cometa *et al.* 2007
Acute Oral Dietary	Norway rat *(Rattus Norvegicus)*	LC_{50} = 1330 mg a.i./kg-diet	MRID 44585409
Chronic (growth)	Norway rat *(Rattus Norvegicus)*	NOAEL = 0.33 LOAEL = 6.99 mg a.i./kg-bw/day based on 4-5% decreased body weight	MRID 42172802
Chronic (reproduction)	Norway rat *(Rattus Norvegicu)s*	NOAEL = 1 LOAEL = 5 mg a.i./kg-bw/day based on 30% loss of pups	ECOTOX No. 82431

Study Type	Test Species	Toxicity Value	MRID or ECOTOX No.
Terrestrial Invertebrates			
Acute contact (adult)	Honey bee (*Apis mellifera L.*)	LD_{50} = 0.059 µg a.i./bee	MRID 05001991
Acute oral (adult)	Honey bee (*Apis mellifera L.*)	No data	No data
Chronic oral (adult)	Honey bee (*Apis mellifera L.*)	No data	No data
Acute oral (larval)	Honey bee (*Apis mellifera L.*)	LD_{50} = 0.0165 µg a.i./larvae	MRID 49960301
Chronic oral (larval)	Honey bee (*Apis mellifera L.*)	No data	No data
Terrestrial and Wetland Plants			
Seedling Emergence	Various species	Dicots (Lettuce): IC_{25} = 2.03 lb a.i./acre; Monocots (No effects seen): IC_{25} >5.79 lb a.i./acre	MIRD 49307202
Vegetative Vigor	Various species	Dicots (No effects seen): IC_{25} >5.7 lb a.i./acre Monocots (No effects seen): IC_{25} >5.7 lb a.i./acre	MRID 48602604 MRID 49307201
Freshwater Fish			
Acute	Bluegill *(Lepomis macrochirus*)	LC_{50} = 1.7 ug a.i./L	ECOTOX No. 6797
Chronic	Fathead minnow *(Lepomis macrochirus*)	NOAEC <0.251 ug a.i./L LOAEC= 0.251 ug a.i./L based on 52% reduction in fecundity	MRID 48615505
Estuarine/Marine Fish			
Acute	Tidewater Silverside (*Menidia peninsulae*)	LC_{50} = 0.37 ug a.i./L	E11868
Chronic	Atlantic Silverside (*Menidia menidia*)	NOAEC <0.28 ug a.i./L LOAEC= 0.48 ug a.i./L based on 32% reduction in bodyweight	Goodman et al 1985; MRID 154718
Freshwater Invertebrates			
Acute	Scud (Hyalella azteca)	LC_{50} = 0.0138 ug a.i./L	MRID 44345601
Chronic	Water flea (*Daphnia magna*)	NOAEC <0. 0.005 ug a.i./L LOAEC= 0.005 ug a.i./L based on ↓offspring per female (~20%)	Zalizniak et al, 2006 (E107384)

Study Type	Test Species	Toxicity Value	MRID or ECOTOX No.
Estuarine/Marine Invertebrates			
Acute	Mysid (*Americamysis bahia*)	LC_{50} = 0.035 ug a.i./L	15639 MRID 40228401
Chronic	Mysid (*Americamysis bahia*)	NOAEC <0.0046 ug a.i./L LOAEC= 0.0046 ug a.i./L based on ↓progeny at all concentrations	MRID 42664901
Aquatic Plants			
Vascular	*Pistia stratiotes* and *Lemna minor*	NOAEC =500 ug a.i./L LOAEC= 1000 ug a.i./L based on Relative growth rate (no EC_{50} available)	E155150
Non-vascular	Marine species (*Isochrysis galband*)	IC_{50} = 140 ug a.i./L IC_{10}= 37 ug a.i./L based on decreased photosynthesis	MRID 40228401

4.2 Incident Data

An extensive analysis of reported incidents was provided in the biological evaluation on chlorpyrifos, broken down into analysis by individual taxa. Some notable highlights from the assessment include:

- Chlorpyrifos has been reported as the 'probable' or 'highly probable' causative agent for 110 adverse aquatic incidents (e.g., fish kills).
- For birds, 64 incidents have been associated with a certainty index of 'possible', 'probable' or 'highly probable'
- 43 terrestrial plant incident reports with a certainty index of 'possible', 'probable' or 'highly probable'. Most of the terrestrial plant incident reports involve damage to the crop treated, but some were associated with spray drift.
- 36 terrestrial invertebrate incident reports (all for bees) in the EIIS with a certainty index of 'possible', 'probable' or 'highly probable'. All of the terrestrial invertebrate incident reports involve honeybees, with bees being exposed via spray drift or by foraging on treated plants.

An updated incident report was generated on August 14, 2020 from the Incident Data System (IDS) for the time period from January 1, 2015 (approximate date when last incident report was generated for the biological evaluation) to present. In IDS, there were 20 unique incidents reported associated with wildlife, plants or other nontarget organism. All of these incidents, except for one where the organism impacted was not specified, were associated with bee kills. In addition to these incident reports, there have also been 2 aggregate incidents reported to

the agency, one involving 'Other Non-Target' (ONT) organisms, which are generally presumed to be bees, and one involving non-specified wildlife. Only limited information is available on aggregated incidents.

5 Risk Characterization and RQ Summary Table

Based on the analysis described above, RQs for all taxa except plants exceeded the LOC for both acute and chronic risks. Terrestrial animal RQs range as high as 390 for acute effects and 1900 for chronic effects. Chronic risks in animals were generally based on significant reproductive effects in terrestrial and aquatic environments (*e.g.*, 52% reduction in fecundity, 30% loss of pups). Terrestrial invertebrate acute RQs range as high as 4900. For aquatic animals and invertebrates, RQs range up to 4300 for acute effects and 8600 for chronic effects. RQs were not exceeded for terrestrial or aquatic plants. **Table 5-1** below describes the range of RQs and for chronic RQs, the effects associated with each RQ. These RQs are consistent with previous assessments, including the Reregistration Eligibility Decisions (RED), and are consistent with the known toxicity of chlorpyrifos as an OP, having general toxicity against numerous taxa.

As described above, numerous incidents have also been reported for chlorpyrifos, Chlorpyrifos has been reported with incidents related to various wildlife, including fish and birds, sometimes with a high certainty level that chlorpyrifos was the associated causative agent. Incidents were additionally reported involving plants. The recent incident updated incident report conducted for this assessment generally reported incidents associated with honeybees.

For terrestrial invertebrates, a complete set of Tier I data is not available for chlorpyrifos.

Table 5-1. Summary of Risk Quotients for Taxonomic Groups from Current Uses of Chlorpyrifos

Taxa	Range of Acute RQs[1]	50% of all uses have an RQ greater than...	Range of Chronic RQs[1]	50% of all uses have an RQ greater than...	Chronic endpoint based on
Birds	0.07 to **380**	**93**	0.60 to **58**	**14**	83% reduction in number of eggs laid
Mammals (Chronic RQs for both growth and reproduction endpoints provided)	0.01 to **10**	**5**	**2.01** to **1900**	**450**	4-5% decrease in body weight
			0.66 to **625**	**148**	30% loss of pups in litter
Terrestrial invertebrates[2]	**820** to **4900**	**820**	No data	No data	No data

Terrestrial Plants	<0.01 to 0.33	0.05	NA	NA	NA
Fish	0.42 to **160**	**33**	**1.1** to **135**	**52**	52% reduction in fecundity
Aquatic Invertebrates	**6.5** to **4300**	**880**	**46** to **8600**	**1540**	20% decrease in offspring per female
Aquatic Plants	0.01 to 0.42	0.09	NA	NA	NA

Level of Concern (LOC) Definitions:
Terrestrial Animals: Acute=0.5; Chronic=1.0; Terrestrial invertebrates=0.4
Aquatic Animals: Acute=0.5; Chronic=1.0
Plants: 1.0
Bold indicates RQs exceed the LOC
[1] RQs reflect exposure estimates for chlorpyrifos and maximum application rates allowed on labels. Minimum value in range of EECs for terrestrial animals represents minimum application rate and minimum dietary item EEC
[2] RQs for terrestrial invertebrates are applicable to honey bees, which are also a surrogate for other species of bees. Risks to other terrestrial invertebrates (*e.g.*, earthworms, beneficial arthropods) are only characterized when toxicity data are available.

6 REFERENCES

USEPA, 2016. *Chlorpyrifos Refined Drinking Water Assessment for Registration Review*. Office of Pesticide Programs. U.S. Environmental Agency, April 14, 2016. DP 432921.

USEPA, 2017. *Chlorpyrifos Biological Evaluation for Endangered Species*. Office of Pesticide Programs. U.S. Environmental Agency, January 2017.

USEPA, 2020. *Updated Chlorpyrifos Refined Drinking Water Assessment for Registration Review*. Office of Pesticide Programs. U.S. Environmental Agency, September 15, 2020. DP 459269.

7 APPENDICES

Appendix A Aquatic modeling parameters

Appendix A Chlorpyrifos aquatic (SEE ATTACHED)

Use	Scenario	Maximum Application Rate (lb/A)	Number of applications[1]	Application method
alfalfa	TXalfalfaOP	1.00	4	aerial
almonds	CAalmond_WirrigSTD	4.00	5	ground
apples	PAappleSTD_V2	2.00	2	ground
apples	NCappleSTD	1.50	2	ground
apples	ORappleSTD	2.00	1	ground
asparagus	MIAsparagusSTD	1.00	3	aerial
beets	ORsnbeansSTD	1.88	1	ground
carrot	ORsnbeansSTD	0.94	1	aerial
cauliflower	MImelonStd	2.25	4	ground
cauliflower	CAColeCropRLF_V2	2.25	4	ground
christmas_trees	ORXmasTreeSTD	1.00	4	ground
christmas_trees	NCappleSTD	1.00	4	ground
christmas_trees	PAappleSTD_V2	1.00	4	ground
tartcherries	MICherriesSTD	2.00	5	ground
citrus	FLcitrusSTD	4.00	5	ground
citrus	CAcitrus_WirrigSTD	6.00	5	ground
clover	CAalfalfa_WirrigOP	1.90	1	ground
colecrop	FLcabbageSTD	1.00	6	aerial
colecrop	CAColeCropRLF_V2	2.00	6	ground
corn	KSCornStd	1.61	5	ground
cotton	NCcottonSTD	2.23	2	granular
figs	CAalmond_WirrigSTD	1.00	1	ground
filbert	ORfilbertsSTD	2.00	4	aerial
ginseng	MImelonStd	2.00	1	granular
golfcourse	PAturfSTD	1.00	2	ground
golfcourse	FLturfSTD	1.00	2	ground
golfcourse	CATurfRLF	1.00	2	ground
grapes	NYGrapesSTD	2.25	1	ground
grapes3	CAgrapes_WirrigSTD	1.00	4	ground
legume	MSsoybeanSTD	1.00	1	aerial

mint	ORmintSTD	2.00	2	ground
nectarine	PAappleSTD_V2	3.00	2	ground
nectarine	CAalmond_WirrigSTD	3.00	2	ground
nursery2	FLnurserySTD_V2	4.00	1	ground
nursery2	CAnurserySTD_V2	4.00	1	ground
onion	GAOnion_WirrigSTD	1.00	1	ground
onion	IDNpotato_WirrigSTD	1.00	2	ground
peach	GAPeachesSTD	2.50	3	ground
peach	PAappleSTD_V2	3.00	2	ground
peach	ORfilbertsSTD	3.00	2	ground
peanut	NCpeanutSTD	2.00	2	aerial
pear	ORfilbertsSTD	2.00	2	ground
pear	CAalmond_WirrigSTD	2.00	2	ground
pecan	GAPecansSTD	4.30	4	ground
pepper	FLpeppersSTD	1.00	8	ground
sorghum	KSsorghumSTD	1.00	4	aerial
strawberry	CAStrawberry-noplasticRLF_V2	1.00	2	aerial
strawberry	FLstrawberry_WirrigSTD	1.00	2	aerial
sugarbeet	MNsugarbeetSTD	1.00	3	aerial
Sunflower	NDwheatSTD	2.00	3	aerial
wheat	NDwheatSTD	0.00	3	granular
soybean	MSsoybeanSTD	2.23	2	granular
sweetcherries	PAappleSTD_V2	2.50	2	ground
sweetcherries	ORfilbertsSTD	2.50	2	ground
sweetpotato	NCSweetPotatoSTD	2.00	1	aerial
tobacco	NCtobaccoSTD	2.00	1	aerial
walnut	CAalmond_WirrigSTD	4.00	4	ground
plum	CAalmond_WirrigSTD	2.00	2	aerial
turnip	NCSweetPotatoSTD	2.30	2	ground
rutabaga	CAColeCropRLF_V2	3.00	5	granular
radish	CAColeCropRLF_V2	3.00	4	granular

Appendix B Details of aquatic and terrestrial output, summary tables for EECs and RQs

Aquatic results

Appendix B Aquatic exposure concentrat

(SEE ATTACHED)

Terrestrial results

Appendix B Terrestrial output ta

(SEE ATTACHED)