



CHEMICAL UPDATE WORKSHEET

Chemical Name:	Chlorpyrifos (DD)
CAS #:	2921-88-2
Revised By:	RRD Toxicology Unit
Revision Date:	September 24, 2015

(A) Chemical-Physical Properties

	Part 201 Value	Updated Value	Reference Source	Comments
Molecular Weight (g/mol)	350.59	350.59	EPI	EXP
Physical State at ambient temp	Solid	Solid	MDEQ	
Melting Point (°C)	---	42.00	EPI	EXP
Boiling Point (°C)	---	160	HSDB	EXP
Solubility (ug/L)	1120	2.03E-02	EPI	EXP
Vapor Pressure (mmHg at 25°C)	0.000019	2.03E-05	EPI	EXP
HLC (atm-m ³ /mol at 25°C)	7.80	2.93E-06	EPI	EXP
Log Kow (log P; octanol-water)	5.3	4.96	EPI	EXP
Koc (organic carbon; L/Kg)	18900	7283	EPI	EST
Ionizing Koc (L/kg)		NR	NA	NA
Diffusivity in Air (Di; cm ² /s)	0.08	2.21E-02	W9	EST
Diffusivity in Water (Dw; cm ² /s)	8.0E-6	5.6158E-06	W9	EST
Soil Water Partition Coefficient (Kd; inorganics)	NR	NR	NA	NA

	Part 201 Value	Updated Value	Reference Source	Comments
Flash Point (°C)	NA	27.8	PC	EXP
Lower Explosivity Level (LEL; unit less)	NA	NA	NA	NA
Critical Temperature (K)		NA	NA	NA
Enthalpy of Vaporization (cal/mol)		NA	NA	NA
Density (g/mL, g/cm ³)		1.44	PC	EXP
EMSOFT Flux Residential 2 m (mg/day/cm ²)	2.68E-05	4.70E-07	EMSOFT	EST
EMSOFT Flux Residential 5 m (mg/day/cm ²)	6.49E-05	4.70E-07	EMSOFT	EST
EMSOFT Flux Nonresidential 2 m (mg/day/cm ²)	3.82E-05	5.91E-07	EMSOFT	EST
EMSOFT Flux Nonresidential 5 m (mg/day/cm ²)	9.17E-05	5.91E-07	EMSOFT	EST

(B) Toxicity Values/Benchmarks

	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues																		
Reference Dose (RfD) (mg/kg/day)	3.0E-3	4.7E-3	OPP, 2014																			
RfD details	<p>3E-3 mg/kg/day; Human 20-day Cholinesterase Inhibition study (Dow Chemical, 1972) (Coulston et al., 1971 (unpublished report)); NOAEL = 0.03 mg/kg-day; Critical effect = decrease in plasma ChE activity after 9 days. UF=10; Short-term human study. Medium confidence in RfD. Entry date: 3/1/1988</p>	<p>Tier 1 Source: USEPA-OPP Basis: OPP is a more recent evaluation than ATSDR. OPP Human Health Risk Assessment (HHRA) (12/29/2014) derived acute (24 hour) Population Adjusted Dose (aPAD) and steady state (21 day) PAD (ssPAD) for food only for different age groups (see table below). For acute and chronic exposure, the subgroup with the lowest PAD was females (13-49 years old). MDEQ recommends the aPAD, 4.7E-3 mg/kg-day, for females 13-49 years to be the generic RfD to protect for acute and subchronic exposures of the most susceptible population, pregnant woman and her developing fetus, for both residential and nonresidential exposures.</p> <table border="1"> <thead> <tr> <th>Population Subgroup</th> <th>aPAD (µg/kg-day)</th> <th>ssPAD (µg/kg-day)</th> </tr> </thead> <tbody> <tr> <td>Infants (<1 year)</td> <td>15</td> <td>2.6</td> </tr> <tr> <td>Children (1-2 years)</td> <td>14</td> <td>2.5</td> </tr> <tr> <td>Youths (6-12 years)</td> <td>13</td> <td>2.2</td> </tr> <tr> <td>Adults (females 13-49 years)</td> <td>4.7</td> <td>0.78</td> </tr> <tr> <td>Generic Risk Value</td> <td>4.7 (4.7E-3 mg/kg-day)</td> <td>0.78 (7.8E-4 mg/kg-day)</td> </tr> </tbody> </table> <p>The PAD values were based on predicted points of departure (PODs). The PBPK-PD model is a data derived approach to estimate the PoDs for different exposure scenarios (dietary (via drinking water or food), residential and occupational) corresponding to 10% AChE inhibition. For the dietary scenario, PODs were developed for acute exposure (24-hour) and steady state (21-day) exposure of various sensitive groups (<1 year, 1-2 years, 6-11 years, youths, and females 13-49 years). See HHRA Table 4.8.4. Unlike the traditional approach (e.g. NOAEL, BMDL); the PODs are modeled estimates of acceptable exposure levels for two exposure scenario, 24 hour (acute) and 21 day (steady state). Critical Studies: Moser et al., 2006; CCA Study (MRID 48139301); Dow (MRID</p>	Population Subgroup	aPAD (µg/kg-day)	ssPAD (µg/kg-day)	Infants (<1 year)	15	2.6	Children (1-2 years)	14	2.5	Youths (6-12 years)	13	2.2	Adults (females 13-49 years)	4.7	0.78	Generic Risk Value	4.7 (4.7E-3 mg/kg-day)	0.78 (7.8E-4 mg/kg-day)		Complete
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	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		<p>44556901, Maurissen et al., 2000); Dow (MRID 44648101, Mattsson et al., 2000); and Sub chronic oral (MRID 40952801). Refer to HHRA Table App 1-2 to 1-5.</p> <p>Methods: Refer to OPP HHRA Table App 1-11 and 1-12.</p> <p>Critical effects: AChE/ChE inhibition and neurodevelopmental outcomes. Using AChE inhibition as a regulatory endpoint is protective of downstream cholinergic effect (neurotoxicity) and other potential toxicities.</p> <p>End point or Point of Departure (POD): 10% AChE inhibition (several lines of evidence together support a conclusion that exposure to chlorpyrifos results in adverse neurodevelopmental outcomes in humans, at least under some conditions, and the dose-response relationship of AChE inhibition across different life stages is established).</p> <p>Uncertainty Factors: UF = 100 for females 13-49 yrs. (10 for interspecies and 10 FQPA safety factor; UF = 40 for other populations (4 for interspecies and 10 for FQPA safety factor). The FQPA Safety Factor = 10 for increased susceptibility of infants, children and females ages 13-50) is retained by OPP for the following reasons: The MOAs/AOPs for neurodevelopmental outcomes are not well established. Sufficient uncertainty in the human dose-response relationship for neurodevelopmental effects prevents the reduction or removal of the statutory 10X FQPA Safety Factor. Thus, the FQPA 10X Safety Factor was retained for infants, children, youths, and women of childbearing age for all exposure scenarios. In addition, the current PBPK-PD model does not account for physiological, anatomical and biochemical changes associated with pregnancy. This uncertainty in extrapolating the current model predictions among women who may be pregnant is addressed by applying the standard 10X intra-species extrapolation factor for women of child bearing age.</p> <p>Source and date: OPP Memorandum: Chlorpyrifos: Revised Human Health Risk Assessment (HHRA) for Registration Review, 12/29/2014 (EPA-HQ-OPP-2008-0850-0195); Notice on Chlorpyrifos Registration Review; Revised Human Health Risk Assessment for Comments was posted on January, 2015 (EPA-HQ-OPP-2008-0850).</p> <p>Tier 1 and 2 Sources:</p>		

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		<p>IRIS: Per IRIS (3/24/11), no value at this time. IRIS indicated that it does not currently develop updated assessments for registered pesticides such as chlorpyrifos. Per IRIS, the “user should consult OPP Reregistration Eligibility Decision (RED) documents prepared by the Office of Pesticide Programs for additional health assessment information.”</p> <p><i>Per IRIS, the RfD = 0.003 (3.0E-3) mg/kg-day derived on 3/1/1988 was removed in 2011. This retracted RfD was derived as follows:</i></p> <p>Critical Study: Dow Chemical Company. 1972. Accession No. 112118. Available from EPA</p> <p>Method(s): Human male volunteers were treated (4/dose) with 0, 0.014, 0.03, or 0.10 mg/kg/day of chlorpyrifos by capsule for a total of 20 days at the low and mid dose, and for 9 days at the high dose. Treatment of the high-dose group (0.1 mg/kg/day) was discontinued after 9 days due to a runny nose and blurred vision in one individual.</p> <p>Critical effect: decreased mean plasma cholinesterase (ChE)</p> <p>End point or Point of Departure (POD): NOEL = 0.03 mg/kg/day</p> <p>Uncertainty Factors: UF = 10 to account for human variability (sensitive subpopulation)</p> <p>Source and date: IRIS, 3/1/1988</p> <p>PPRTV: No PPRTV record available at this time.</p> <p>MRL: Per ATSDR (09/1997), oral chronic MRL = 0.001 mg/kg-day.</p> <p>Critical Study: McCollister SB, Kociba RJ, Humiston CG. et al. 1974. Studies of the acute and long term oral toxicity of chlorpyrifos (O,O diethyl O (3,5,6 trichloro 2 pyridyl) phosphorothioate). Food Cosmet Toxicol 12(1):(45-61).</p> <p>Method(s): Sherman rats (25/sex/dose group) were fed chlorpyrifos at 0, 0.01, 0.03, 0.1, 1, or 3 mg/kg/day for 2 years beginning at 7-weeks of age. Additional groups (5-7 rats/sex/group) was set up to provide interim pathological examination and cholinesterase (ChE) determinations. ChE was measured in rats killed at 6, 12, 18, and 24 months. To characterize the recovery of the ChE activity in plasma, red cells and brain, some rats were maintained on the various diets containing chlorpyrifos for 12 months, and subsequently on the</p>		

	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
		<p>control diet for 7-8 weeks prior to sacrifice. Critical effect: acetylcholinesterase inhibition End point or Point of Departure (POD): NOAEL = 0.1 mg/kg-day Uncertainty Factors: UF = 100 (10 each for interspecies variability and interspecies extrapolation) Source and date: ATSDR, 09/1997 Per ATSDR (1997), acute or intermediate oral MRLs = 0.003 mg/kg-day: Critical Study: Coulston F, Golberg L, Abraham R, et al. 1972. Final Report on Safety Evaluation and Metabolic Studies on Dow Co. 179(IN151). Inst Exp Path01 Toxicol, Albany Medical College. Methods: 16 adult human male volunteers (4 per dose group) were treated with 0, 0.014, 0.03, or 0.10 mg/kg/day chlorpyrifos by capsule. Those subjects receiving 0.014 and 0.03 mg/kg/day were exposed for 20 days; those receiving 0.10 mg/kg/day were exposed for only 9 days. Critical effect: plasma cholinesterase inhibition End point or Point of Departure (POD): NOAEL = 0.03 mg/kg-day Uncertainty Factors: UF = 10 for interspecies variability Source and date: ATSDR, 09/1997</p> <p>Tier 3 Sources: MDEQ: Per DEQ-CCD/RRD (3/1/1988), RfD = 3E-3 mg/kg-day is based on a 1988 IRIS RfD that was retracted by IRIS in 2011. See Part 201 Value RfD details. MDEQ: Per DEQ-CCD/WRD (5/4/1994), RfD = 3E-3 mg/kg-day. The basis for the RfD is similar to the 1988 IRIS RfD derivation. See IRIS RfD details.</p>		
Oral Cancer Slope Factor (CSF) (mg/kg-day)⁻¹	--	NA	MDEQ, 2015	
CSF details	NA	<p>Tier 1 and 2 Sources: IRIS: Per IRIS (3/24/11), no value at this time. PPRTV: No PPRTV record available at this time. MRL: NA; MRLs are for non-cancer effects only.</p> <p>Tier 3 Source:</p>		Complete



	Part 201 Value	Updated Value	Source/Reference/Date	Comments/Notes/Issues
		MDEQ: Per DEQ-CCD, no value at this time.		
Reference Concentration (RfC) or Initial Threshold Screening Level (ITSL) ($\mu\text{g}/\text{m}^3$)	2.0	1.0E+0	MDEQ, 1992	
RfC/ITSL details	AQD basis: TLV Entry date: 10/29/1992	<p>Tier 3 Source: MDEQ: Basis: No non-cancer inhalation toxicity values other than the AQD ITSL were located. See details below.</p> <p>Tier 1 and 2 Source: IRIS: Per IRIS (3/24/11), no value at this time. PPRTV: No PPRTV record available at this time. MRL: Per ATSDR (9/1997), no inhalation MRL at this time.</p> <p>Tier 3 Source: MDEQ: Per DEQ-CCD-AQD 10/29/1992, the ITSL is $1.0 \mu\text{g}/\text{m}^3$. On 1/17/2013 the ITSL based on the TLV was changed to $1 \mu\text{g}/\text{m}^3$. This change was made as a part of a project to update ITSLs based on outdated occupational exposure limits. No review of the 24-hour based ITSL was done at this time. The AQD calculation date was left with the original 1992 date as no review or change was made to the 24-hour based ITSL.</p>		Complete
Inhalation Unit Risk Factor (IURF) ($(\mu\text{g}/\text{m}^3)^{-1}$)	--	NA	MDEQ, 2015	
IURF details	NA	<p>Tier 1 and 2 Sources: IRIS: Per IRIS (3/24/11), no value at this time. PPRTV: No PPRTV record available at this time. MRL: NA; MRLs are for non-cancer effects only.</p> <p>Tier 3 Source:</p>		Complete



	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
		MDEQ: Per DEQ-CCD, no value at this time.		
Mutagenic Mode of Action (MMOA)? (Y/N)	--	NO	USEPA, 2015	
MMOA Details	--	NA Not listed as a carcinogen with mutagenic MOA in the USEPA OSWER List.		
Developmental or Reproductive Effector? (Y/N)	No	YES - oral , the RfD is based on a reproductive-developmental effect. Oral Exposure Pathways- Single Exposure No – the inhalation RfC/ITSL is not based on a reproductive-developmental effect.	MDEQ, 2015	
Developmental or Reproductive Toxicity Details	NA	<p>Basis: OPP Human Health Risk Assessment (HHRA) (12/29/2014) derived acute (24 hr.) Population Adjusted Dose (aPAD) and steady state (21 day) PAD (ssPAD) for food only for different age groups (See HHRA Tables 5.4.3 and 5.4.4). For acute and chronic exposure, the subgroup with the lowest PAD was females (13-49 years old). MDEQ recommends that the aPAD (4.7) and ssPAD (0.78) for females 13-49 years (0.78) be considered the generic RfD for pregnant women for both residential and nonresidential land use.</p> <p>Critical Study(ies): Moser et al., 2006; CCA Study (MRID 48139301); Dow (MRID 44556901, Maurissen et al., 2000); Dow (MRID 44648101, Mattsson et al., 2000); and Sub chronic oral (MRID 40952801). Refer to HHRA Table App 1-2 to 1-5.</p> <p>Method(s): Refer to OPP HHRA Table App 1-11 and 1-12.</p> <p>Critical effects: AChE/ChE inhibition and neurodevelopmental outcomes. Using AChE inhibition as a regulatory endpoint is protective of downstream cholinergic effect (neurotoxicity) and other potential toxicities.</p> <p>End point or Point of Departure (POD): 10% AChE inhibition (several lines of evidence together support a conclusion that exposure to chlorpyrifos results in adverse neurodevelopmental outcomes in humans, at least under some conditions, and the dose-response relationship of AChE inhibition across different life stages is established).</p>		
State Drinking Water Standard	--	NO	SDWA, 1976	

	Part 201 Value	Updated Value	Source/Reference/ Date	Comments/Notes /Issues
(SDWS) (ug/L)				
SDWS details	NA	MI Safe Drinking Water Act (SDWA) 1976 PA 399		
Secondary Maximum Contaminant Level (SMCL) (ug/L)	--	NO	SDWA, 1976 and USEPA SMCL List, 2015	
SMCL details	NA	SDWA, 1976 and USEPA SMCL List, 2015		
Is there an aesthetic value for drinking water? (Y/N)	NO	Not evaluated.	NA	
Aesthetic value (ug/L)	NA	NA	NA	
Aesthetic Value details	NA	NA		
Phytotoxicity Value? (Y/N)	NO	Not evaluated.	NA	
Phytotoxicity details	NA	NA	NA	
Others				

(C) Chemical-specific Absorption Factors

	Part 201 Value	Update	Source/Reference/ Dates	Comments/Notes /Issues
Gastrointestinal absorption efficiency value (ABS _{gi})	---	1.0	MDEQ, 2015/USEPA RAGS-E, 2004	
ABS _{gi} details		RAGS E (USEPA, 2004) Default Value		
Skin absorption efficiency value (AE _d)	---	0.1	MDEQ, 2015	
AE _d details				
Ingestion Absorption Efficiency (AE _i)		0.5	MDEQ, 2015	
AE _i Details				
Relative Source Contribution for Water (RSC _w)		0.2	MDEQ, 2015	
Relative Source Contribution for Soil (RSC _s)		1.0		
Relative Source Contribution for Air (RSC _a)		1.0	MDEQ, 2015	
Others				

(D) Rule 57 Water Quality Values and GSI Criteria

Current GSI value (µg/L)	2.0 (M); 0.002
Updated GSI value (µg/L)	2 (M); 0.002
Rule 57 Drinking Water Value (µg/L)	2 (M); 0.002

	Rule 57 Value (µg/L)	Verification Date
Human Non-cancer Values- Drinking water source (HNV-drink)	* (0.002)	NA
Human Non-Cancer Values- Non-drinking water sources (HNV-Non-drink)	* (0.002)	NA
Wildlife Value (WV)	NA	NA
Human Cancer Values for Drinking Water Source (HCV-drink)	NA	NA
Human Cancer values for non-drinking water source (HCV-Non-drink)	NA	NA
Final Chronic Value (FCV)	0.002	1/2003
Aquatic maximum value (AMV)	0.027	1/2003
Final Acute Value (FAV)	0.053	1/2003

Sources:

1. MDEQ Surface Water Assessment Section Rule 57 [website](#)
2. MDEQ Rule 57 [table](#)

(E) Target Detection Limits (TDL)

	Value	Source
Target Detection Limit – Soil ($\mu\text{g}/\text{kg}$)	100	MDEQ, 2015
Target Detection Limit – Water ($\mu\text{g}/\text{L}$)	2	MDEQ, 2015
Target Detection Limit – Air (ppbv)	1.38E-01	MDEQ, 2015
Target Detection Limit – Soil Gas (ppbv)	4.61E+00	MDEQ, 2015

CHEMICAL UPDATE WORKSHEET ABBREVIATIONS:

CAS # - Chemical Abstract Service Number.

Section (A) Chemical-Physical Properties**Reference Source(s):**

CRC	Chemical Rubber Company Handbook of Chemistry and Physics, 95th edition, 2014-2015
EMSOFT	USEPA Exposure Model for Soil-Organic Fate and Transport (EMSOFT) (EPA, 2002)
EPA2001	USEPA (2001) Fact Sheet, Correcting the Henry's Law Constant for Soil Temperature. Office of Solid Waste and Emergency Response, Washington, D.C.
EPA4	USEPA (2004) User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings. February 22, 2004.
EPI	USEPA's Estimation Programs Interface SUITE 4.1, Copyright 2000-2012
HSDB	Hazardous Substances Data Bank
MDEQ	Michigan Department of Environmental Quality
NPG	National Institute for Occupational Safety and Health Pocket Guide to Chemical Hazards
PC	National Center for Biotechnology Information's PubChem database
PP	Syracuse Research Corporation's PhysProp database
SCDM	USEPA's Superfund Chemical Data Matrix
SSG	USEPA's Soil Screening Guidance: Technical Background Document, Second Edition, 1996
USEPA/EPA	United States environmental protection agency's Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). July, 2004.

W9	USEPA's User Guide for Water9 Software, Version 2.0.0, 2001
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Basis/Comments:

EST	estimated
EXP	experimental
EXT	extrapolated
NA	not available or not applicable
NR	not relevant

Section (B) Toxicity Values/Benchmarks**Sources/References:**

ATSDR	Agency for Toxic Substances and Disease Registry
CALEPA	California Environmental Protection Agency
CAL DTSC	California Department of Toxic Substances Control
CAL OEHHA	CAEPA Office of Environmental Health Hazard Assessment
CCD	MDEQ Chemical Criteria Database
ECHA	European Chemicals Agency (REACH)
OECD HPV	Organization for Economic Cooperation and Development HPV Database
HEAST	USEPA's Health Effects Assessment Summary Tables
IRIS	USEPA's Integrated Risk Information System
MADEP	Massachusetts Department of Environmental Protection
MDEQ/DEQ	Michigan Department of Environmental Quality
DEQ-CCD/AQD	MDEQ Air Quality Division
DEQ-CCD/RRD	MDEQ Remediation and Redevelopment Division
DEQ-CCD/WRD	MDEQ Water Resources Division
MNDOH	Minnesota Department of Health

NJDEP	New Jersey Department of Environmental Protection
NYDEC	New York State Department of Environmental Conservation
OPP/OPPT	USEPA's Office of Pesticide Programs
PPRTV	USEPA's Provisional Peer Reviewed Toxicity Values
RIVM	The Netherlands National Institute of Public Health and the Environment
TCEQ	Texas Commission on Environmental Quality
USEPA	United States Environmental Protection Agency
USEPA OSWER	USEPA Office of Solid Waste and Emergency Response
USEPA MCL	USEPA Maximum Contaminant Level
WHO	World Health Organization
WHO IPCS	International Programme on Chemical Safety (IPCS/INCHEM)
WHO IARC	International Agency for Research on Cancers
NA	Not Available.
NR	Not Relevant.

Toxicity terms:

BMC	Benchmark concentration
BMCL	Lower bound confidence limit on the BMC
BMD	benchmark dose
BMDL	Lower bound confidence limit on the BMD
CSF	Cancer slope Factor
CNS	Central nervous system
IURF or IUR	Inhalation unit risk factor
LOAEL	Lowest observed adverse effect level
LOEL	Lowest observed effect level
MRL	Minimal risk level (ATSDR)
NOAEL	No observed adverse effect level
NOEL	No observed effect level

RfC	Reference concentration
RfD	Reference dose
p-RfD	Provisional RfD
aRfD	Acute RfD
UF	Uncertainty factor
WOE	Weight of evidence

Section (C) Chemical-specific Absorption Factors

MDEQ	Michigan Department of Environmental Quality
USEPA RAGS-E	United States Environmental Protection Agency's Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). July, 2004.

Section (D) Rule 57 Water Quality Values and GSI Criteria

GSI	Groundwater-surface water interface
NA	A value is not available or not applicable.
ID	Insufficient data to derive value
NLS	No literature search has been conducted