Appendix G. Summary of Ecotoxicity Data

Note: The **bold** rows in the tables below indicate values used quantitatively in the SF Bay risk assessment. If the value used is not the most sensitive in the table, the reason is given in a footnote.

1 Toxicity to Terrestrial Animals

1.1 Birds, Acute and Sub-acute

1.1.1 Studies using the parent chemical, acephate

Table G.1. Avian Acute Oral Toxicity for Acephate

Species	% ai	LD_{50} (mg ai/kg)	Toxicity Category	MRID No. Author/Year	Study Classification
Mallard duck (*Anas platyrhynchos*)	89	350	moderately toxic	00014700 Mastalski, 1970	acceptable
Mallard duck (*Anas platyrhynchos*)	93.2	234	moderately toxic	00160000 Hudson, 1984	acceptable
Mallard duck (*Anas platyrhynchos*)	89	350	moderately toxic	00015962 Hudson, 1972	acceptable
Bobwhite quail *(Colinus virginianus)*	**15[1]**	**109[2]**	**moderately toxic**	**43939301 Campbell, 1992**	**acceptable**
Pheasant (*Phasianus colchicus*)	89	140	moderately toxic	00014701 Mastalski, 1970	acceptable
Dark eyed junco (*Junco hyemalis*)	75	106[3]	moderately toxic	00093911 Zinkl, 1981	supplemental

[1] This is a granular formulation. Slope = 5.4; Formulation LD50 = 734 mg/kg (86-139 mg/kg formulation)
[2] This endpoint is used in the terrestrial exposure modeling.

[3] The birds initially refused to ingest larvae that contained 16 µg acephate/larvae; however, the birds were willing to consume larvae containing five µg acephate. The study found that acephate given by gavage without larvae produced more inhibition than the larvae-fed birds. The study also concludes that the higher the dose, the more ChE inhibition is found in the birds. Increased time of exposure may prolong the time for recovery from ChE inhibition. Feeding the birds larvae containing acephate may decrease the activity of the acephate when compared to the gavage. The birds fed for five days recovered in 12 to 22 days.

These avian studies with technical and formulated grade acephate classify acephate as moderately toxic (LD_{50} = 51-500 mg/kg) to birds on an acute oral basis.

Table G.2. Avian Subacute Dietary Toxicity for Acephate

Species	% ai	5-Day LC_{50} (ppm ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Northern bobwhite quail *(Colinus virginianus)*	95.3	1280	slightly toxic	00015956 Fletcher, 1976	acceptable
Mallard duck (*Anas platyrhynchos*)	95.3	>5000	practically non-toxic	00015957 Fletcher, 1976	acceptable
Dark eyed junco (*Junco hyemalis*)	75	1485	slightly toxic	00093911 Zinkl, 1981	supplemental
Japanese Quail *(Coturnix japonica)*	**15.6**	**718**	**moderately toxic**	**40910905[1] Hill and Camardese, 1986**	**supplemental**
Japanese Quail *(Coturnix japonica)*	98	3275	slightly toxic	40910905[1] Hill and Camardese, 1986	supplemental
Other routes of exposure: Inhalation					
Northern bobwhite quail *(Colinus virginianus)*	formulation	3/6 dead within 100 minutes[2]	NA	Bertem and Chiles	ancillary

[1] Hill, E. F., and M. B. Camardese. 1986. Lethal dietary toxicities of environmental contaminants and pesticides to coturnix. U.S. Fish Wild. Serv., Tech. Rep. 2. 147 pp. Also reported in: Smith, G.J., 1987. Pesticide Use and Toxicology in Relation to Wildlife: Organophorous and Carbamate Compounds. U.S. Dept. of Interior, FWS Resource Publication 170. pg. 71.
[2] In this inhalation study, bobwhites were exposed to 2.2 mg/L of acephate for 100 minutes.
[3] Bertem, P.E., R.E. Chiles. Studies on the Inhalation Toxicity of Two Phosphoramidothioate Insecticides to Rodents and Quail. University of California, School of Public Health, Naval Biosciences Laboratory, Naval Supply Center, Oakland, California.

These avian studies with technical and formulated grade acephate classify acephate as moderately toxic (LC_{50} = 501-1000 ppm) to practically non-toxic (LC_{50} >5000 ppm) to birds on a sub-acute dietary basis.

1.1.2 Studies using the degradate, methamidophos

Table G.3. Avian Acute Oral Toxicity for Methamidophos

Species	% ai	LD_{50} (mg/kg) (confidence interval)	Toxicity Category (slope)	MRID No. Author/Year	Study Classification
Northern bobwhite quail *(Colinus virginianus)*	75	8 (6.2 – 10.3)	very highly toxic (7.36)	00014094, 00109717 Fletcher, 1971	supplemental[1]
Northern bobwhite quail *(Colinus virginianus)*	75	10.1 (7.9 – 13.1) (m) 11.0 (8.5 – 14.1) (f)	highly toxic	00041313 Nelson et al, 1979	acceptable
Mallard duck *(Anas platyrhynchos)*	75	8.48 (6.73 – 10.7)	very highly toxic	0016000 Hudson et al 1984	acceptable
Mallard duck *(Anas platyrhynchos)*	75	29.5 (27.3 – 31.9)	highly toxic	00014095, 00109718 Fletcher, 1971	supplemental[2]
Dark eyed junco (*Junco hyemalis)*	73	8	very highly toxic	ECOTOX # 39519 00093914 Zinkl et al, 1979	supplemental[3]
Common grackle (*Quiscalur quiscula*)	**55**	**6.7 ai (4.1 – 10.9)**	**very highly toxic**	**00144428 Lamb, 1972**	**supplemental[4]**
Starling (Sturnidae)	75	10 (5.6 – 17.8)	very highly toxic	00146286 Schafer, 1984	supplemental[5]

Redwing blackbird *(Agelaius phoeniceus)*	75	1.78	very highly toxic	00146286 Schafer, 1984	supplemental[5]

[1] Due to age of birds (older), insufficient number of hours birds fasted, insufficient description of study design. Death occurred 8 – 22 hrs after dosing.
[2] Due to poor dose response that precludes development of the best estimate of LD50. Death occurred 1 hr after dose.
[3] Due to post dose observations were only 6 hrs instead of 14 days.
[4] Due to five birds dosed per treatment level (including control) and insufficient environmental information. EPA guidelines call for ten birds per treatment level. All mortalities occurred within 24 hrs.
[5] This test is an "up/down" test by FWS. Only two doses were used (3.16 and 1.0 mg/kg) with resulting mortality being 2 out of 2 birds tested and 0 out of 2 birds tested, respectively.

These avian studies with technical and formulated grade methamidophos classify methamidophos as highly (LD_{50} = 10-50 mg/kg) to very highly (LD_{50} <10 mg/kg) toxic to avian species on an acute oral basis.

Table G.4. Avian Subacute Dietary Toxicity for Methamidophos

Species	% ai	5-Day LC_{50} (ppm) (confidence interval)	Toxicity Category (slope)	MRID No. Author/Year	Study Classification
Northern bobwhite quail *(Colinus virginianus)*	**74**	**42 (34 – 52)[1]**	**very highly toxic (3.4)**	**00093904 Beavers & Fink,1979**	**acceptable**
Northern bobwhite quail *(Colinus virginianus)*	75	57.5 (40 – 82)[2]	highly toxic	00014064 Jackson, 1968	supplemental[3]
Northern bobwhite quail *(Colinus virginianus)*	75	59 (48-72)	highly toxic (6.445)	44484404 Thompson-Cowley, 1981	supplemental
Mallard duck *(Anas platyrhynchos)*	75	1302 (906 – 1872)[1]	slightly toxic	00041658, Nelson et al 1979	acceptable
Mallard duck *(Anas platyrhynchos)*	75	847.7 (600 – 1198)[4]	moderately toxic (4.27)	00130823, 00014304 00145655, Lamb & Bunke 1977	supplemental[5]
Mallard duck *(Anas platyrhynchos)*	70	1650 (1138 – 2392)	slightly toxic	44484403 Shapiro, 1981	supplemental
Japanese Quail	73	92	highly toxic	Smith, 1987[6]	supplemental
Other routes of exposure: Dermal					
Starling (Sturnidae)	75	17.8 mg/kg	NA	00146286 Schafer, 1984	supplemental
Redwing blackbird *(Agelaius phoeniceus)*	75	31.6 mg/kg	NA	00146286 Schafer, 1984	supplemental

[1] Note that birds were too sick to eat.
[2] Observed repellency at 826 ppm. Death occurred at 2 to 7 days after exposure.
[3] Due to birds being 12 weeks of age instead of 10 to 17 days old.
[4] Death occurred 1 to 6 days after exposure. There is 60% mortality at 1000 ppm. Birds recover 5 to 8 days post treatment.
[5] Due to 60 gm average weight difference of birds in control to birds in treatment groups at day 0, 4 concentrations used instead of 6 concentrations, and incomplete design.
[6] Smith, G.J., 1987. Pesticide Use and Toxicology in Relation to Wildlife: Organophorous and Carbamate Compounds. U.S. Dept. of Interior, FWS Resource Publication 170. pg. 71.

These avian studies with technical and formulated grade methamidophos classify methamidophos as slightly (LC_{50} = 1001-5000 ppm) to very highly (LC_{50} < 50 ppm) toxic to avian species on a sub-acute dietary basis.

1.2 Birds, Chronic

1.2.1 Studies using the parent chemical, acephate

Table G.5. Avian Reproductive Toxicity for Acephate

Species	% ai	NOAEC/LOAEC (ppm)	LOAEC Endpoints	MRID No. Author/Year	Study Classification
Northern bobwhite quail *(Colinus virginianus)*	technical grade	20/80	Reduced body weight, number of eggs laid, eggs set, viable embryos, live 3-week embryos, normal hatchlings, and 14-day old survivors	00029692 Beavers, 1979	acceptable

Table G.5. Avian Reproductive Toxicity for Acephate					
Species	% ai	NOAEC/LOAEC (ppm)	LOAEC Endpoints	MRID No. Author/Year	Study Classification
Mallard duck ***(Anas platyrhynchos)***	**technical grade**	**5/20**	**Reduced number viable embryos, live 3-week embryos**	**00029691 Beavers, 1979**	**acceptable**

These avian reproduction studies with technical grade acephate indicate that when parents are fed between 5 and 20 ppm acephate, the survival of embryos is adversely affected.

1.2.2 Studies using the degradate methamidophos

Table G.6. Avian Reproductive Toxicity for Methamidophos					
Species	% ai	NOAEC/LOAEC (ppm)	LOAEC Endpoints	MRID No. Author/Year	Study Classification
Northern bobwhite quail ***(Colinus virginianus)***	**73**	**3/5**	**Eggshell thickness, embryo viability, embryo development, hatchability, survivability of hatchlings**	**00014114 Beavers & Fink, 1978**	**acceptable**
Mallard duck *(Anas platyrhynchos)*	73	>15	No effect	00014113 Fink, 1977	supplemental
Northern bobwhite quail *(Colinus virginianus)*	73	5/7.8	Egg production	ECOTOX # 40022 Stromberg, et. al., 1986	open literature study

These avian reproduction studies with formulated grade methamidophos indicate that when parents are fed between 3 and 5 ppm methamidophos, the survival of embryos and chicks are adversely affected.

1.3 Mammals, Acute and Chronic

1.3.1 Studies using the parent chemical, acephate

Table G.7. Mammalian Toxicity for Acephate					
Species	% ai	Test Type	Toxicity Value	Affected Endpoints	MRID No. Author/Year
Rat *(Rattus norvegicus)*	23.7	oral acute	LD_{50}= 970 mg/kg (f)	mortality	237487
Rat *(Rattus norvegicus)*	85	oral acute	LD_{50}= 1490 mg/kg (m) 739 mg/kg (f)	mortality	236863, 236864
Rat *(Rattus norvegicus)*	98	oral acute	LD_{50}= 945 mg/kg (m) 866 mg/kg (f)	mortality	00014675
White-footed mouse *(Peromyscus leucopus noveboracensis)*	98	oral acute	LD_{50}= 380 mg/kg	mortality	ECOTOX #38448 Rattner and Hoffman, 1984[1]
Meadow vole ***(Microtus pennsylvanicus)***	**98**	**oral acute**	**LD_{50}= 321 mg/kg**	**mortality**	**ECOTOX #38448 Rattner and Hoffman, 1984[1]**
Mouse *(Mus musculus)*	70%	oral acute	LD_{50}= 720 mg ai/kg	mortality	ECOTOX #39704 Clark and Rattner, 1987[2]

Table G.7. Mammalian Toxicity for Acephate					
Species	% ai	Test Type	Toxicity Value	Affected Endpoints	MRID No. Author/Year
Mouse *(Mus musculus)*	98	oral acute	LD_{50}= 351 mg/kg	mortality	ECOTOX #38448 Rattner and Hoffman, 1984[1]
Brown bat *(Myotis lucifugus)*	70%	oral acute	LD_{50}>1500 mg ai/kg ED_{50}= 687 mg ai/kg	mortality	ECOTOX #39704 Clark and Rattner, 1987[2]
Charles River rat *(Rattus norvegicus)*	98.7	3-generation reproductive	NOAEC = 50 ppm LOAEC = 500 ppm	parental and pup weight, food consumption, litter size, mating performance and viability	40323401 40605701

[1] Rattner, B.A., D.J. Hoffman. 1984. Comparative toxicity of acephate in laboratory mice, white-footed mice, and meadow voles. Arch. Environ. Contam. Toxicol. 13:483-491.
[2] Clarke Jr., D.R., B.A. Rattner. 1987. Orthene[R] Toxicity to Little Brown Bats (*Myotis lucifugus*): Acetylchlorinesterase Inhibition, Coordination Loss, and Mortality. Environ. Toxicol. and Chem. Vol 6 pp. 705-708.

These mammalian toxicity studies with technical and formulated grade acephate classify acephate as from slightly (LD_{50} = 501-2000 mg/kg) to moderately (LD_{50} = 51-500 mg/kg) toxic to small mammals on an acute oral basis. The 3-generation reproductive study indicates that when parents are fed between 50 and 500 ppm acephate their reproductive abilities are adversely affected. There does not appear to be a palatability problem in the above studies (personal communication Nancy McCarroll, HED, 2/10/98).

1.3.2 Studies using the degradate methamidophos

Table G.8. Mammalian Toxicity for Methamidophos					
Species	% ai	Test Type	Toxicity Value	Affected Endpoints	MRID No. Author/Year
Laboratory rat *(Rattus norvegicus)*	**95**	**acute oral**	**LD_{50}= 15.6 mg/kg (m) LD_{50}= 13.0 mg/kg (f)[1]**	**mortality**	**00014044 Cavalli & Hallesy,1968**
Laboratory mouse *(Mus musculus)*	95	acute oral	LD_{50}= 16.2 mg/kg (f)	mortality	00014047 1968 Cavalli & Hallesy,1968
Laboratory mouse *(Mus musculus)*	75	acute oral	LD_{50}= 18 mg/kg (f)	mortality	00014048 1968
Laboratory rat *(Rattus norvegicus)*	**70.5**	**2-generation reproductive**	**NOAEC=10 ppm[2] LOAEC= 33 ppm[2]**	**Decrease in number of births, pup viability and body weight**	**00148455 41234301 1984**

[1] Data is not reported for the two lowest test concentrations for the female rats. The male rat LD_{50} value is used in the risk assessment.
[2] The study indicates that 10 ppm = 0.5 mg/kg/day and 33 ppm = 1.65 mg/kg/day. 33 ppm was the highest dose tested.

These mammalian toxicity studies with technical and formulated grade methamidophos classify methamidophos as highly toxic (LD_{50} = 10-50) to small mammals on an acute oral basis. The 2-generation reproductive study indicates that when parents are fed between 10 and 33 ppm methamidophos the survival of embryos and pups is adversely affected. There does not appear to be a palatability problem in the above studies (personal communication Nancy McCarroll, HED, 2/10/98).

1.4 Terrestrial Invertebrates

1.4.1 Studies using the parent chemical, acephate

Table G.9. Non-target Insect Acute Contact and Oral Toxicity for Acephate

Species	Product	LD_{50}	Toxicity Category	MRID No. Author/Year	Study Classification
Honey bee *(Apis mellifera)*	**orthene**	**1.20 µg a.i./bee**	**highly toxic**	**00014714, 44038201 Atkins, 1971**	**acceptable**
Honey bee *(Apis mellifera)*	orthene	<0.25 ppm[1]	NA	ECOTOX #79198 Fielder, 1987[2]	supplemental
Honey bee *(Apis mellifera)*	orthene	NA[3]	NA	Stoner et al., 1985[4]	supplemental
Green lacewing[5] *Chrysopa carnea*	orthene	5.57 µg/vial	NA	05004012 Plapp, 1978	supplemental

[1] 74.5% mortality at 0.25 ppm acephate in sugar syrup after 14 days.
[2] Fielder, L. 1987. Assessment of Chronic Toxicity of Selected Insecticides to Honeybees. Journal of Apicultural Research 26(2):115-122.
[3] Acephate fed to worker bees via sugar syrup showed up in the royal jelly for the queen, indicating that acephate is systemic to bees. These concentrations of 1 ppm or less were harmless to the worker bees but levels at 0.1 ppm showed significant reduction of the surviving brood.
[4] Stoner, A., W. Wilson, J. Harvey. 1985. Acephate (Orthene®): Effects on Honey Bee Queen, Brood, and Worker Survival. American Bee Journal, June 1985, p. 448-450.
[5] Predator of tobacco budworm.

These insect toxicity studies with acephate classify acephate as highly toxic (LD_{50} <2 µg/bee) to bees and beneficial insects on an acute contact basis.

Table G.10. Non-target Insect Acute Residue Toxicity for Acephate Formulations

Species	% ai	lb ai applied	No. hrs. after initial exposure and % dead after contact[1]	MRID No. Author/Year	Study Classification
Honey bee *(Apis mellifera)*	75	1.0	0 hr. = 100 2 hr. = 79 8 hr. = 17	00014715 Sakamoto, 1971	acceptable
Alkali bee (*Nomia melanderi*)	75	1.0	2 hr. = 83 8 hr. = 30	00014715 Sakamoto, 1971	acceptable
Alfalfa leaf cutter bee (*Megachile rotundata*)	75	1.0	2 hr. = 69 8 hr. = 21	00014715 Sakamoto, 1971	acceptable
Bumble bee	75	1.0	2hr. = 43	00014715 Sakamoto, 1971	acceptable
Honey bee *(Apis mellifera)*	75	1.0	2 hr. = 79 8 hr. = 16	05000837 Johansen, 1972	acceptable
Alkali bee (*Nomia melanderi*)	75	1.0	2 hr. = 81 8 hr. = 23	05000837 Johansen, 1972	acceptable
Honey bee *(Apis mellifera)*	orthene	0.48	1 hr. = 4.5 24 hr. = 98.5 96 hr. = 5.0	00014714 Atkins, 1971	acceptable
Honey bee *(Apis mellifera)*	orthene	0.97	1 hr. = 3.2 24 hr. = 100 96 hr. = 41.7	00014714 Atkins, 1971	acceptable
Spiders	acephate	560 gm/ha (0.5 lb ai/A)	Spiders were found to have high mortality (74% dead) at 20 days post spray.	05020212 Hydron, 1979	supplemental
Honey bee *(Apis mellifera)*	63	1.37 Slope = 10.32	highly toxic	00036935 Atkins et al., 1975	acceptable

[1] Foliage was sprayed, collected after varying time periods, and then put with bees.

Table G.11. Target Insect Acute Residue Toxicity for Acephate[1]					
Species	% ai	LC_{50}/LD_{50}	Exposure Type	MRID No. Author/Year	Study Classification
Lepidoptera species					
Cotton bollworm larvae[2] *(Helicoverpa armigera)*	95	5.5 µg/larvae (48 hr)	topical	ECTOX #108057 Gunning et al., 1999	open literature study
Diamondback moth larvae *(Plutella xylostella)*	15	42.1 ppm (48 hr)	dipped foliage	ECOTOX #152992 Sonoda & Igaki, 2010	open literature study
Douglas-fir tussock moth larvae *(Hemerocampa pseudotsugata)*	technical grade	76.1 µg/g bw (7 day)[3]	topical	ECOTOX #53649 Robertson & Lyon, 1973	open literature study
Gypsy moth larvae *(Lymantria dispar)*	75	0.960 µg/larvae (24 hr)	topical	ECOTOX #99802 Respicio & Forgash, 1984	open literature study
Mediterranean flour moth larvae *(Anagasta kuehniella)*	99.3	48.27 µg/g (24 hr)	topical	48650403 ECOTOX #153300 Mohamad & Oloffs, 1987	open literature study
Oriental fruit moth larvae *(Grapholita molesta)*	technical grade	227.3 µg/g (2 hr)	spray	ECOTOX #63915 Pree et al., 1998	open literature study
Soybean looper larvae ***(Pseudoplusia includes)***	**97**	**20.34 µg/g bw (72 hr)[4]**	**topical**	**48650402** **ECOTOX #73702** **Ottens et al., 1984**	**open literature study**
Soybean looper larvae *(Pseudoplusia includes)*	97	58.4 µg/g bw (72 hr)[5]	topical	ECOTOX #153446 Martin & Brown, 1984	open literature study
Tobacco budworm larvae *(Heliothis virescens)*	technical grade	74.3 µg/g bw (72 hr)[6]	topical	ECOTOX #152802 Rose & Sparks, 1984	open literature study
Western spruce budworm larvae *(Choristoneura occidentalis)*	>95	40.9 µg/g bw (7 day)[7]	topical	ECOTOX # 113233 Robertson & Smith, 1984	open literature study
Western spruce budworm larvae *(Choristoneura occidentalis)*	99.3	23.21 µg/g (24 hr)	topical	48650403 ECOTOX #153300 Mohamad & Oloffs, 1987	open literature study
Coleoptera species					
Boll weevil adult *(Anthonomus grandis grandis)*	technical grade	>5700.0 µg/g bw (72 hr)[8]	topical	ECOTOX #152802 Rose & Sparks, 1984	open literature study
Coffee bean weevil adult *(Araecerus fasciculatus)*	99.3	>300 µg/g bw (24 hr)[9]	topical	ECOTOX #107388 Childers & Nigg, 1982	open literature study
Mealybug destroyer adult[10] *(Cryptolaemus montrouzieri)*	75	988 mg/l (48 hr)	sprayed foliage	ECOTOX #69300 Morse & Bellows, 1986	open literature study

bw = body weight
[1] Target insect studies are not typically used in assessments of the risks to non-target species. However, this endangered species assessment includes a Lepidoptera species and a Coleoptera species and studies on insects in these orders are therefore considered here.
[2] This study used a pyrethroid resistant strain of *H. armigera* that was organophosphate susceptible.
[3] Average larvae weight was 75 mg. LD_{50} = 5.7 µg/larvae.
[4] Larvae weight range 25-40 mg. Assuming avg weight of 32.5, LD_{50} = 0.66 µg/ larvae.
[5] Average larvae weight was 35 mg. LD_{50} = 2.04 µg/ larvae.
[6] Larvae weight range 30-40 mg. Assuming avg weight of 35, LD_{50} = 2.6 µg/ larvae.
[7] Average larvae weight was 84.3 mg. This equates to LD_{50} = 3.45 µg/larvae.
[8] Larvae weight range 15-20 mg. Assuming avg weight of 17.5, LD_{50} >99.8 µg/ weevil.
[9] Average weight was 6 mg. LD_{50} >1.8 µg/weevil.
[10] A beneficial insect predator of the mealybug.

Using the toxicity categories for honey bees, these insect toxicity studies with acephate classify acephate as moderately (LD_{50} = 2-11 µg/organism) to highly (LD_{50} <2 µg/organism) toxic to Lepidoptera species and at most highly toxic to Coleoptera species on an acute contact basis.

ECOTOX #40531. Roberts and Dorough 1983. Two species of earthworms (Eisenia foetida and Lumbricus rubellus) were exposed to technical grade acephate on filter paper in vials for 48 hrs. The LC_{50} for E. foetida was 851.0 µg/cm2 (95% CI 525.0-1378.0) and the LC_{50} for L. rubellus was 692.0 µg/cm^2 (95% CI: 424.0-1127.0). Acephate was classified as moderately toxic (LC_{50} = 100-1000 µg/cm^2) to both species on an acute basis. Acephate was the least toxic of five organophosphate pesticides (fonofos, malathion, parathion, chlorpyrifos, and acephate) tested on these two species of earthworms by an order of magnitude.

1.4.2 Studies using the degradate, methamidophos

Table G.12. Non-target Insect Acute Contact and Oral Toxicity for Methamidophos					
Species	% ai	LD_{50}	Toxicity Category	MRID No. Author/Year	Study Classification
Honey bee *(Apis mellifera)*	**63**	**1.37 µg a.i./bee Slope = 10.32**	**highly toxic**	**00036935 Atkins et al., 1975**	**acceptable**
Honey bee *(Apis mellifera)*	technical grade (>97.5%)	<0.25 ppm[1]	NA	ECOTOX #79198 Fielder, 1987[2]	supplemental

[1] 64.0% mortality at 0.25 ppm methamidophos in sugar syrup after 14 days.
[2] Fielder, L. 1987. Assessment of Chronic Toxicity of Selected Insecticides to Honeybees. Journal of Apicultural Research 26(2):115-122.

These insect toxicity studies with methamidophos classify methamidophos as highly toxic (LD_{50} <2 µg/bee) to bees and beneficial insects on an acute contact basis.

Table G.13. Target Insect Acute Residue Toxicity for Methamidophos[1]					
Species	% ai	LC_{50}/LD_{50}	Exposure Type	MRID No. Author/Year	Study Classification
Lepidoptera species					
Diamondback moth larvae *(Plutella xylostella)*	technical grade	26.7 µg/g (48 hr)	topical	ECOTOX #103261 Yu & Nguyen, 1996	open literature study
Douglas-fir tussock moth larvae *(Hemerocampa pseudotsugata)*	technical grade	32.8 µg/g bw (7 day)[2]	topical	ECOTOX #53649 Robertson & Lyon, 1973	open literature study
Oriental fruit moth larvae *(Grapholita molesta)*	technical grade	54.7 µg/g (2 hr)	spray	ECOTOX #63915 Pree et al., 1998	open literature study
Tobacco budworm larvae *(Heliothis virescens)*	technical grade	85.7 µg/g bw (72 hr)[3] 57.1 µg/g bw (120 hr)[4]	topical	ECOTOX #152802 Rose & Sparks, 1984	open literature study
Western spruce budworm larvae *(Choristoneura occidentalis)*	**99.3**	**7.45 µg/g (24 hr)**	**topical**	**48650403 ECOTOX #153300 Mohamad & Oloffs, 1987**	**open literature study**
Coleoptera species					
Boll weevil adult *(Anthonomus grandis grandis)*	technical grade	128.6 µg/g bw (72 hr)[5]	topical	ECOTOX #152802 Rose & Sparks, 1984	open literature study

[1] Target insect studies are not typically used in assessments of the risks to non-target species. However, this endangered species assessment includes a Lepidoptera species and a Coleoptera species and studies on insects in these orders are therefore considered here.
[2] Average larvae weight was 77 mg. LD_{50} = 2.5 µg/larvae.
[3] Larvae weight range was 30-40 mg. Assuming avg weight of 35 mg, LD_{50} = 3.0 µg/larvae.
[4] Larvae weight range was 30-40 mg. Assuming avg weight of 35 mg, LD_{50} = 2.0 µg/larvae.
[5] Larvae weight range was 15-20 mg. Assuming avg weight of 17.5 mg, LD_{50} = 2.3 µg/weevil.

Using the toxicity categories for honey bees, these insect toxicity studies with methamidophos classify methamidophos as moderately toxic (LD_{50} = 2-11 µg/organism) to Lepidoptera and Coleoptera insects on an acute contact basis.

2 Toxicity to Freshwater Aquatic Animals

2.1 Freshwater Fish, Acute

2.1.1 Studies using the parent chemical, acephate

Table G.14. Freshwater Fish Acute Toxicity for Acephate					
Species	% ai	96-hour LC_{50} (ppm ai)	Toxicity Category	MRID No. Author/Year	Study Classification

Table G.14. Freshwater Fish Acute Toxicity for Acephate					
Species	% ai	96-hour LC_{50} (ppm ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Rainbow trout 1.1 g (static) *(Oncorhynchus mykiss)* 17 °C, pH 7.4, 40 mg/L $CaCO_3$	97	>100[1]	practically non-toxic	40098001 Mayer, 1986	supplemental
Rainbow trout (static) *(Oncorhynchus mykiss)*	technical	>1000	practically non-toxic	00014705 Hutchinson, 1970	acceptable
Rainbow trout 0.2 g (static) (*O. mykiss*), 12 °C, pH 7.4, 40 mg/L $CaCO_3$	97	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Rainbow trout 0.2 g (static) (*O. mykiss*), 12 °C, pH 7.4, 40 mg/L $CaCO_3$	97	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Rainbow trout 0.9 g (static) (*O. mykiss*), 12 °C, pH 7.4, 40 mg/L $CaCO_3$	94	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Rainbow trout 0.9 g (static) (*O. mykiss*), 12 °C, pH 7.4, 320 mg/L $CaCO_3$	94	>1000	practically non-toxic	40098001 Mayer, 1986	supplemental
Rainbow trout 1.0 g (static) (*O. mykiss*), 12 °C, pH 6.5, 40 mg/L $CaCO_3$	94	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Rainbow trout 1.0 g (static) (*O. mykiss*), 12 °C, pH 8.5, 40 mg/L $CaCO_3$	94	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Rainbow trout 1.5 g (static) *(Oncorhynchus mykiss)*, 10 °C, pH 7.4, 40 mg/L $CaCO_3$	94	832[2]	practically non-toxic	40094602 Johnson, 1980 40098001 Mayer, 1986	supplemental
Rainbow trout 12.9 g (flow-through) *(Oncorhynchus mykiss)*, 15°C, pH 6.5	**92**[3]	**852 (95% CI 598-1213)**	**practically non-toxic**	**48650401 ECOTOX #7317 Duangsawasdi, 1977**	**supplemental**
Bluegill sunfish (static) *(Lepomis macrochirus)*	94	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Bluegill sunfish (static) *(Lepomis macrochirus)*	94	>1000	practically non-toxic	40098001 Mayer, 1986	supplemental
Atlantic salmon yolk-sac fry (static) (*Salmo salar*), 7 °C, pH 7.5, 40 mg/L $CaCO_3$	97	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Atlantic salmon 0.2 g (static) (*Salmo salar*), 7 °C, pH 7.5, 40 mg/L $CaCO_3$	97	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Atlantic salmon 0.2 g (static) (*S. salar*), 17 °C, pH 7.5, 40 mg/L $CaCO_3$	97	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Atlantic salmon 0.2 g (static) (*S. salar*), 12 °C, pH 7.5, 40 mg/L $CaCO_3$	97	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Atlantic salmon 0.2 g (static) (*S. salar*), 12 °C, pH 7.5, 12 mg/L $CaCO_3$	97	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Atlantic salmon 0.2 g (static) (*S. salar*), 12 °C, pH 7.5, 40 mg/L $CaCO_3$	97	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Atlantic salmon 0.2 g (static) (*S. salar*), 12 °C, pH 6.5, 40 mg/L $CaCO_3$	97	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Atlantic salmon 0.2 g (static) (*S. salar*), 12 °C, pH 8.5, 40 mg/L $CaCO_3$	97	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Brook trout 0.2 g (static) (*Salvelinus fontinalis*), 12 °C	94	>100	practically non-toxic	40094602 Johnson, 1980	supplemental

Table G.14. Freshwater Fish Acute Toxicity for Acephate					
Species	% ai	96-hour LC_{50} (ppm ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Brook trout 1.5 g (static) (*S. fontinalis*), 12 ^oC, pH 7.5, 42 mg/L $CaCO_3$	94	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Cutthroat trout, 0.7 g (static) (*Salmo clarki*), 12 ^oC, pH 7.5, 42 mg/L $CaCO_3$	94	>100	practically non-toxic	40098001 Mayer, 1986	supplemental
Cutthroat trout, 0.8 g (static) (*Salmo clarki*), 12 ^oC, pH 7.8 42 mg/L $CaCO_3$	94	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Cutthroat trout, 0.9 g (static) (*S. clarki*), 7 ^oC, pH 7.5, 42 mg/L $CaCO_3$	94	>100	practically non-toxic	40098001 Mayer, 1986	supplemental
Cutthroat trout, 0.9 g (static) (*S. clarki*), 12 ^oC, pH 8.5, 42 mg/L $CaCO_3$	94	>60	at most slightly toxic	40098001 Mayer, 1986	supplemental
Cutthroat trout, 1.0 g (static) (*S. clarki*), 12 ^oC, pH 6.5, 42 mg/L $CaCO_3$	94	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Cutthroat trout, 1.0 g (static) (*S. clarki*), 12 ^oC, pH 7.8, 330 mg/L $CaCO_3$	94	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Cutthroat trout (static) (*Salmo clarki*)	94	>100	practically non-toxic	00120401 Woodward, 1980	supplemental
Yellow perch (static) (*Perca flavescens*)	94	>50	at most slightly toxic	40098001 Mayer, 1986	supplemental
Channel Catfish 2.0 g (static) (*Ictalurus punctatus*), 22 ^oC, pH 7.4, 40 mg/L $CaCO_3$	94	>1000	practically non-toxic	40094602 Johnson and Finley, 1980 40098001 Mayer, 1986	supplemental
Fathead Minnow (static) (*Pimephales promelas*)	94	>1000	practically non-toxic	40094602 Johnson, 1980	supplemental

[1] This study has a reported LC_{50} of 110 mg/L (95% CI: 63-190) but does not achieve 50% mortality at any concentration. Therefore, this endpoint is not used quantitatively.
[2] Evaluation of this data using ToxAnal gives an LC_{50} of 832 mg/L using the binomial method. This endpoint is not used quantitatively in the risk assessment due to use of only 5 fish per treatment level, no replication, and no mortality below the highest test concentration. The reported LC_{50} in the original report by Mayer & Ellersieck calculates the LC_{50} as 1100 mg/L (95% CI: 775-1561).
[3] Technical grade soluble powder.

These freshwater fish acute toxicity studies with technical grade acephate classify acephate as practically non-toxic (LC_{50} >100 ppm) to freshwater fish species, or at most slightly toxic (LC_{50} = >10-100), on an acute exposure basis.

Table G.15. Freshwater Fish Acute Toxicity for Acephate Formulations					
Species	% ai[1]	96-hour LC_{50} (ppm ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Rainbow trout 1.2 g (static) *(Oncorhynchus mykiss*), 10 ^oC, pH 7.4, 40 mg/L $CaCO_3$	75 WP	730 (95% CI 580- 920)[2]	practically non-toxic	40094602 Johnson and Finley, 1980 40098001 Mayer, 1986	supplemental
Rainbow trout (static) *(Oncorhynchus mykiss)*	75	2740	practically non-toxic	Geen et al., 1984[3]	supplemental
Bluegill sunfish (static) *(Lepomis macrochirus)*	75	2000[4]	practically non-toxic	00014706 Thompson, 1971	acceptable
Bluegill sunfish (static) *(Lepomis macrochirus)*	75 WP	>200	practically non-toxic	40098001 Mayer, 1986	supplemental
Bluegill sunfish (static) *(Lepomis macrochirus)*	75 WP	>1000	practically non-toxic	40094602 Johnson, 1980	supplemental
Brook trout 0.2 g (static) (*Salvelinus fontinalis*), 12 ^oC, pH 6.5, 42 mg/L $CaCO_3$	75 WP	>100	practically non-toxic	40098001 Mayer, 1986	supplemental

Table G.15. Freshwater Fish Acute Toxicity for Acephate Formulations					
Species	% ai[1]	96-hour LC_{50} (ppm ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Brook trout 0.2 g (static) (*S. fontinalis*), 12 °C, pH 7.5, 42 mg/L $CaCO_3$	75 WP	>100	practically non-toxic	40098001 Mayer, 1986	supplemental
Brook trout 0.2 g (static) (*S. fontinalis*), 12 °C, pH 8, 12 mg/L $CaCO_3$	75 WP	>100	practically non-toxic	40098001 Mayer, 1986	supplemental
Brook trout 0.2 g (static) (*S. fontinalis*), 12 °C, pH 8, 44 mg/L $CaCO_3$	75 WP	>100	practically non-toxic	40098001 Mayer, 1986	supplemental
Brook trout 0.2 g (static) (*S. fontinalis*), 12 °C, pH 8, 300 mg/L $CaCO_3$	75 WP	>100	practically non-toxic	40098001 Mayer, 1986	supplemental
Brook trout 0.2 g (static) (*S. fontinalis*), 12 °C, pH 9, 42 mg/L $CaCO_3$	75 WP	>100	practically non-toxic	40098001 Mayer, 1986	supplemental
Brook trout 0.7 g (static) (*Salvelinus fontinalis*), 7 °C, pH 7.5, 42 mg/L $CaCO_3$	75 WP	>100	practically non-toxic	40098001 Mayer, 1986	supplemental
Brook trout 0.7 g (static) (*S. fontinalis*), 17 °C, pH 7.5, 42 mg/L $CaCO_3$	75 WP	>100	practically non-toxic	40098001 Mayer, 1986	supplemental
Brook trout 1.0 g (static) (*S. fontinalis*), 7 °C, pH 7.5, 40 mg/L $CaCO_3$	75 WP	>100	practically non-toxic	40098001 Mayer, 1986	supplemental
Brook trout 1.0 g (static) (*S. fontinalis*), 17 °C, pH 7.5, 42 mg/L $CaCO_3$	75 WP	>100	practically non-toxic	40098001 Mayer, 1986	supplemental
Largemouth bass (static) (*Micropterus salmoides*)	75	3000[5]	practically non-toxic	00014707 Thompson, 1971	supplemental
Cutthroat trout 0.9 g (static) (Salmo clarki), 12 °C, pH 7.5, 42 mg/L $CaCO_3$	75 WP	>100	practically non-toxic	40098001 Mayer, 1986	supplemental
Cutthroat trout (static) (*Salmo clarki*)	75	>100	practically non-toxic	00120401 Woodward, 1980	supplemental
Gold fish (static) (*Carassius auratus)*	75	>4000[6]	practically non-toxic	00014710 Thompson, 1971	supplemental
Yellow perch (static) (*Perca flavescens*)	75 WP	>100	practically non-toxic	40098001 Mayer, 1986	supplemental
Channel Catfish, 0.5 g (static) *(Ictiobus cyrinallus)*	75 WP	(95% CI 560-1000)	practically non-toxic	40094602 Johnson and Finley, 1980 40098001 Mayer, 1986	supplemental
Channel Catfish (static) *(Ictiobus cyrinallus)*	75	1500[7]	practically non-toxic	00014708 Thompson, 1971	acceptable
Fathead Minnow 1.0 g (static) *(Pimephales promelas*), 20 °C, pH 7.4, 40 mg/L $CaCO_3$	75 WP	>1000	practically non-toxic	40098001 Mayer, 1986	supplemental
Fathead Minnow 1.0 g (static) (*P. promelas*), 20 °C, pH 7.4, 40 mg/L $CaCO_3$	75 WP	>1000	practically non-toxic	40098001 Mayer, 1986	supplemental
Mosquito fish (static) (*Gambusia affinis*)	75	6000[8]	practically non-toxic	00014709 Thompson, 1971	supplemental

[1] WP = wettable powder
[2] This study does not use a control. Therefore, this endpoint is not used in the risk assessment.
[3] Geen, G.H., B.A. McKeown, P.C. Oloffs, 1984. Acephate in Rainbow Trout (*Salmo gairdneri*), Acute Toxicity, Uptake, and Elimination. J. Environ. Science and Health B19(2) p. 131-155.
[4] There was 100% mortality at 8,000 ppm. No mortality at 500 ppm
[5] There was 100% mortality at 4,000 ppm. No mortality at 500 ppm
[6] No mortality at 1000 and 2000 ppm

[7] No mortality at 1000 ppm
[8] No mortality at 4000 ppm

These freshwater fish acute toxicity studies with formulated acephate classify acephate as practically non-toxic (LC_{50} >100 ppm) to freshwater fish species on an acute exposure basis.

2.1.2 Studies using the degradate, methamidophos

Table G.16. Freshwater Fish Acute Toxicity for Methamidophos

Species	% ai	96-hour LC_{50} (ppm ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Carp (static) ***(Cyprinpus carpio)***	**90**	**68[1]**	**slightly toxic**	**05008361 Chin, 1979**	**supplemental**

[1] Sublethal doses affect growth rate of carp. Brain and liver acetylcholinesterase activities are depressed at 20 ppm concentrations for 48 hours.

This freshwater fish acute toxicity study with technical grade methamidophos classify methamidophos as slightly toxic (LC_{50} = >10-100 ppm) to freshwater fish species on an acute exposure basis.

Table G.17. Freshwater Fish Acute Toxicity for Methamidophos Formulations

Species	% ai	96-hour LC_{50} (ppm ai) (95% CI)	Toxicity Category	MRID No. Author/Year	Study Classification
Rainbow trout (static) *(Oncorhynchus mykiss)*	74	25 (21-29)	slightly toxic	00041312 Nelson & Roney, 1979	acceptable
Rainbow trout (static) *(Oncorhynchus mykiss)*	71	40 (35-46)	slightly toxic	00144429 Hermann, 1980	not reviewed
Rainbow trout (static) *(Oncorhynchus mykiss)*	40[1]	37 (28-49)	slightly toxic	00144432 Lamb, 1972	not reviewed
Rainbow trout (static) *(Oncorhynchus mykiss)*	75	51 (36-72)	slightly toxic	00014063 Schoenig, 1968	supplemental[2]
Bluegill sunfish *(static)* *(Lepomis macrochirus)*	74	34 (30-38)	slightly toxic	00041312 Nelson & Roney, 1979	acceptable
Bluegill sunfish *(static)* *(Lepomis macrochirus)*	40[1]	31 (21-46)	slightly toxic	00144432 Lamb & Roney, 1972	not reviewed
Bluegill sunfish (static) *(Lepomis macrochirus)*	75.4	45 (35-58)	slightly toxic	44484402 McCann, 1977	supplemental[3]
Bluegill sunfish (static) *(Lepomis macrochirus)*	75	46 (34-62)	slightly toxic	00014063 Schoenig, 1968	supplemental[2]

[1] Formulation of 40% is in propylene glycol. Author concludes that propylene glycol contributes to bluegill toxicity in the formulation. There was 10% mortality in the negative control and 30% mortality in the solvent control. There was no mortality in the trout controls.
[2] Due to polyethylene liners used in test.
[3] Due to being a static jar study and insufficient environmental information.

This freshwater fish acute toxicity study with formulated methamidophos classify methamidophos as slightly toxic (LC_{50} = >10-100 ppm) to freshwater fish species on an acute exposure basis.

2.2 Freshwater Fish, Chronic

No chronic toxicity studies for freshwater fish for either acephate or methamidophos have been submitted by registrants or identified in the ECOTOX database. Acute-to-chronic ratios are calculated for use in the risk assessment.

2.3 Amphibians

2.3.1 Studies using the parent chemical, acephate

Table G.18. Amphibian Acute Toxicity for Acephate					
Species	% ai	96-hour LC_{50} (ppm ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Green frog larvae/tadpole (*Rani clamitans*)	**90**	**6433 (24 hr)**	**practically non-toxic**	**00093943, 05019255 Lyons, 1976**	**supplemental[1]**
Frog larvae (*Rani catesbelana*)	98	>5	NA[2]	44042901 Hall, 1980	supplemental[1]
Salamander larvae (*Ambystoma gracile*)	97	8816 (96 hr)	practically non-toxic	Geen et al., 1984[3]	supplemental[1]

[1] Supplemental study due to no available FIFRA test guideline and no raw data for statistical analysis.
[2] This study tested for bio-concentrations to amphibians. Neither bio-accumulation nor toxicity were noted.
[3] Geen, G.H., B.A. McKeown, T.A. Watson, D.B. Parker. 1984. Effects of Acephate (Orthene) on Development and Survival of the Salamander *Ambystoma gracile*, (Baird). Environ. Sci. Health, B19 (2), 157-170 (1984).

2.4 Freshwater Invertebrates, Acute

2.4.1 Studies using the parent chemical, acephate

Table G.19. Freshwater Invertebrate Acute Toxicity for Acephate					
Species	% ai	96-hour LC_{50} (ppm ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Mayfly larvae, age not reported *Ephemerida*	98	3.2 (24 hr)[1]	N/A	ECOTOX #37219 Hussain et al. 1985	supplemental
Stonefly 1st year class (*Pteronarcella badia*), 12°C, pH 6.5, 40 mg/L $CaCO_3$, static	94	6.4 (95% CI 5.3-7.8)	moderately toxic	40098001 Mayer, 1986	supplemental
Stonefly, 1st year class (*Pteronarcella badia*)	94	9.5	moderately toxic	00120401 Woodward, 1980	supplemental
Stonefly, 1st year class (*Pteronarcella badia*), 12°C, 7.5 pH, 38 mg/L $CaCO_3$	94	9.5 (95% CI 7.3-12.3)	moderately toxic	40098001 Mayer, 1986, 40094602 Johnson, and Finley 1980	supplemental
Stonefly, 1st year class, 12°C, pH 8.5, 38 mg/L $CaCO_3$, static	94	21.2 (95% CI 15.6-28.2)	slightly toxic	40098001 Mayer 1986	supplemental
Stonefly, 1st year class (*Isogenus* sp.), 7 °C, pH 7, 35 mg/L $CaCO_3$, static	94	11.7 (95% CI 8.7-15.8)	slightly toxic	40098001 Mayer, 1986	supplemental
Stonefly, naiad (*Skwala* sp.), 7 °C, 40 mg/L $CaCO_3$, static	95	12 (95% CI 8.7-16)	slightly toxic	40094602 Johnson and Finley, 1980	supplemental
Stonefly larvae, age not reported Plecoptera	98	37 (24 hr)[1]	N/A	ECOTOX #37219 Hussain et al. 1985	supplemental
Water-boatman, adults Corixidae	98	8.2 (24 hr)	moderately toxic	ECOTOX #11371 Hussain et al. 1984	supplemental
Backswimmer, adults Notonectidae	98	10.4 (24 hr)	slightly toxic	ECOTOX #11371 Hussain et al. 1984	supplemental
Waterflea *(Daphnia magna)*	98	71.8 (48 hr EC_{50}) (95% CI 62.9 – 81.7) Slope = 6.3	slightly toxic	00014565 Wheeler, 1978	acceptable
Scud, mature (*Gammarus pseudolimneaus*), 12°C 40 mg/L $CaCO_3$, static	94	>50 (48 hr)	at most slightly toxic	40094602 Johnson and Finley, 1980 40098001 Mayer, 1986	supplemental

Scud, mature (*Gammarus pseudolimneaus*), 12^{o}C, static, 320 mg/L $CaCO_3$	94	>50 (48 hr)	at most slightly toxic	40098001 Mayer, 1986	supplemental
Scud (*Gammarus pseudolimneaus)*	94	>100	practically non-toxic	00014861, 05018314 Schoettger, 1970	acceptable
Midge, 4th instar (*Chironomus plumosus*), 20^{o}C, static	94	>1000	practically non-toxic	40094602 Johnson and Finley, 1980	supplemental
Midge, 3rd instar (*Chironomus plumosus*), 17^{o}C, pH 7.4, 40 mg/L $CaCO_3$, static	94	>50 (48 hr EC_{50})	at most slightly toxic	40098001 Mayer, 1986	supplemental
Midge, 3rd instar (Chironomus plumosus), 17^{o}C, pH 7.4, 320 mg/L $CaCO_3$, static	94	>50 (48 hr EC_{50})	at most slightly toxic	40098001 Mayer, 1986	supplemental
Damselfly larvae, age not reported Zygoptera	98	140 (24 hr LC_{50})[1]	N/A	ECOTOX #37219 Hussain et al. 1985	supplemental
Mosquito, 3rd instar (*Aedes aegypti*)	98	650 (24 hr LC_{50})[1]	N/A	ECOTOX #37219 Hussain et al. 1985	supplemental

[1] Mean of two tests (Note: author does not report if the mean is a geometric or arithmetic mean).

These freshwater invertebrate acute toxicity studies with technical grade acephate classify acephate as practically non-toxic (LC_{50} >100 ppm) to moderately toxic (LC_{50} = >1-10 ppm) to freshwater invertebrate species on an acute exposure basis.

Table G.20. Freshwater Invertebrate Acute Toxicity for Acephate Formulations

Species	% ai[1]	96-hour LC_{50} (ppm ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Waterflea *(Daphnia magna)*	**75 WP**	**1.11 (48 hr EC_{50}) (95% CI 0.65-1.88) Slope = 1.62**	**moderately toxic**	**47116601 Thompson, 1978**	**acceptable**
Stonefly, 1st year class *(Isogenus* sp.), 7 ^{o}C, pH 7.5, 42 mg/L $CaCO_3$, static	75 WP	12 (95% CI 8.0-17.9)	slightly toxic	40098001 Mayer, 1986	supplemental
Stonefly, naiad (*Skwala* sp.), 7 ^{o}C, static, 40 mg/L $CaCO_3$, static	75 WP	12 (95% CI 8.0 – 18)	slightly toxic	40094602 Johnson and Finley, 1980	supplemental
Midge, 3rd instar (*Chironomus plumosus*), 20 ^{o}C, pH 7.2, 40 mg/L $CaCO_3$, static	75 WP	>1000 (48 hr EC_{50})[2]	practically non-toxic	40098001 Mayer, 1986	supplemental
Crayfish *(Procamborus clarki)*	75	120-h LC_{50} >750 No mortality	practically non-toxic	00014712 Sleight, 1972	supplemental

[1] WP = wettable powder
[2] Additionally, three tests with the same environmental conditions were conducted using solutions aged 1, 3, and 7 days prior to test initiation. The 48-h EC_{50} values were >1000 ppm ai (initial concentration) for each test.

These freshwater invertebrate acute toxicity studies with formulated acephate classify acephate as practically non-toxic (LC_{50} >100 ppm) to moderately toxic (LC_{50} = >1-10 ppm) to freshwater invertebrate species on an acute exposure basis.

2.4.2 Studies using the degradate, methamidophos

Table G.21. Freshwater Invertebrate Acute Toxicity for Methamidophos

Species	% ai	48-hour LC_{50}/ EC_{50} (ppm) (95% CI)	Toxicity Category	MRID No. Author/Year	Study Classification
Waterflea *(Daphnia magna)*	**74**	**0.026 (0.20–0.034)**	**very highly toxic**	**00041311 Nelson & Roney 1979**	**acceptable**
Waterflea *(Daphnia magna)*	72	0.050 (0.040-0.070)	very highly toxic	00014110 Wheeler 1978	acceptable
Waterflea *(Daphnia magna)*	74	0.027 (0.014-0.053)	very highly toxic	00014305 Nelson & Roney 1977	supplemental[1]

Table G.21. Freshwater Invertebrate Acute Toxicity for Methamidophos					
Waterflea *(Daphnia magna)*	99	0.034	very highly toxic	ECOTOX #99572 Lin et al., 2006[2]	open literature study

[1] Due to temperature of 24°C instead of 18 °C.
[2] Lin, K., S. Zhou, C. Xu, W. Liu. 2006. Enantiomeric resolution and biotoxicity of methamidophos. J. Agric. Ood Chem. 54:8134-8138.

These freshwater invertebrate acute toxicity studies with formulated methamidophos classify methamidophos as very highly toxic (LC_{50} <0.1 ppm) to freshwater invertebrate species on an acute exposure basis.

The methamidophos RED (1998) includes a freshwater prawn (*Macrobrachium rosenbergii*) study classified as supplemental in the above table.[1] This study is not cited here because the study does not meet EPA's validity criteria and has been downgraded to invalid. The study was a static renewal study in which the organisms were handled every 24 hours. During the handling process, mortality occurred. The mortality in the controls ranged from 60% to 80%. EPA's criteria only allows up to 10% mortality in the controls. Furthermore, EPA recognizes that in the FWS Recovery Plan for the California Red-Legged Frog[2], this study is cited as evidence that methamidophos is very highly toxic to aquatic invertebrates.

2.5 Freshwater Invertebrates, Chronic

2.5.1 Studies using the parent chemical, acephate

Table G.22. Freshwater Invertebrate Life-Cycle Toxicity for Acephate

Species	% ai	21-day NOAEC/LOAEC (ppm)	Endpoints Affected	MRID No. Author/Year	Study Classification
Waterflea ***(Daphnia magna)***	**75 WP**	**0.150/0.375**	**Reduction in numbers of young at 375 ppb and higher**	**44466601 Thompson, 1978**	**supplemental[1]**

[1] This study was classified acceptable in a 1982 review. The study has been downgraded to supplemental because the control had 35% mortality of the adults and the treatments range from 10% to 35% mortality with the highest concentration level having 10% mortality. There is a dose response trend of offspring per adult per day.

This freshwater invertebrate chronic toxicity study with acephate indicates that when parents are exposed to between 0.150 and 0.375 ppm acephate, production of young is affected.

2.5.2 Studies using the degradate, methamidophos

Table G.23. Freshwater Invertebrate Life-Cycle Toxicity for Methamidophos

Species	% ai	NOEC (ppm)	Endpoints	MRID No. Author/Year	Study Classification
Waterflea ***(Daphnia magna)***	**78.5**	**0.0045**	**<u>21-day dry weight</u>** **NOAEC: 4.49 µg ai/L** **LOAEC: 5.32 µg ai/L** **<u>21-day immobility</u>** **NOAEC: 11.9 µg ai/L** **LOAEC: 21.8 µg ai/L** **<u>21-day reproduction endpoint</u>** **NOAEC: 5.32 µg ai/L** **LOAEC: 11.9 µg ai/L**	**46554501 Kern and Lam, 2005**	**supplemental[1]**

[1] Increasing concentrations of test substance in weekly measurements throughout the study.

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[1] Juarez, L.M., J. Sanchez, 1989. Toxicity of the Organophosphorous Insecticide Methamidophos (O,S-Dimethyl Phosphoramidothioate) to Larvae of the Freshwater Prawn, *Macrobachium rosenbergii* (DeMan) and the Blue Shrimp, *Penaeus stylirostris* Stimpson. Bull. Environ. Contam. Toxicol. (1989) 43:302-309.
[2] U.S. Fish and Wildlife Service. 2002. Recovery Plan for the California Red-Legged Frog (*Rana aurora draytonii*). U.S. Fish and Wildlife Service, Portland, OR. viii + 173 pp.

This freshwater invertebrate chronic toxicity study with methamidophos indicates that when parents are exposed to between 0.00449 and 0.00532 ppm methamidophos, production of young is affected.

3 Toxicity to Estuarine and Marine Aquatic Animals

3.1 Estuarine and Marine Fish, Acute

3.1.1 Studies using the parent chemical, acephate

Table G.24. Estuarine/Marine Fish Acute Toxicity for Acephate

Species (Static or Flow-through)	% ai	96-hour LC_{50} (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Sheepshead minnow (flow-through) *(Cyprinodon variegatus)*	94	910	practically non-toxic	40228401 Mayer, 1986	supplemental
Sheepshead minnow (static) *(Cyprinodon variegatus)*	94	>3200 (28 days)	practically non-toxic	40228401 Mayer, 1986	supplemental
Mummichog (static) *(Fundulus heteroclitus)*	75	2872 (m) 3299 (f)	practically non-toxic	Fulton and Scott, 1991[1]	ancillary
Pin Fish (flow-through) (*Lagodon rhomboides*)	**94**	**85**	**slightly toxic**	**40228401 Mayer, 1986**	**supplemental**
Spot (static) (*Leinstomus xanthurns*)	94	>100	practically non-toxic	40228401 Mayer, 1986	supplemental

[1] Fulton, M.H. and G.I. Scott. 1991. The Effects of Certain Intrinsic Variables on the Acute Toxicity of Selected Organophosphorous Insecticides to the Mummichog, *Fundulus heteroclitus.* J. Environ. Sci. Health B26 (5&6), 459-478.

These estuarine/marine fish acute toxicity studies with acephate classify acephate as practically non-toxic (LC_{50} >100 ppm) to slightly toxic (LC_{50} = >10-100 ppm) to estuarine/marine fish species on an acute exposure basis.

3.1.2 Studies using the degradate, methamidophos

Table G.25. Estuarine/Marine Fish Acute Toxicity for Methamidophos

Species	% ai	96-hour LC_{50} (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Sheepshead minnow *(Cyprinodon variegatus)*	**70.1**	**5.63 (95% CI 4.13-6.89)**	**moderately toxic**	**00144431 Larkin, 1983**	**acceptable**

This estuarine/marine fish acute toxicity study with methamidophos classify methamidophos as moderately toxic (LC_{50} = >1-10 ppm) to estuarine/marine fish species on an acute exposure basis.

3.2 Estuarine and Marine Fish, Chronic

No chronic toxicity studies for estuarine/marine fish for either acephate or methamidophos have been submitted by registrants or identified in the ECOTOX database.

3.3 Estuarine and Marine Invertebrates, Acute

3.3.1 Studies using the parent chemical, acephate

Table G.26. Estuarine/Marine Invertebrate Acute Toxicity for Acephate

Species (Static or Flow-through)	% ai	96-hour LC_{50} (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Eastern oyster (embryo-larvae) *(Crassostrea virginica)*	89	5.41 (48 hr) (95% CI 3.3 – 8.9)	moderately toxic	00014713 Sleight, 1970	acceptable
Eastern oyster (embryo-larvae) (static) *(Crassostrea virginica)*	94	150	practically non-toxic	40228401 Mayer, 1986	supplemental
Mysid *(Americamysis bahia)* (flow-through)	94	7.3	slightly toxic	40228401 Mayer, 1986	supplemental
Brown shrimp (*Penaeus aztecus*)	89	22.9 (48 hr) (95% CI 9.5 – 54.9)	slightly toxic	00014711 Sleight, 1970	supplemental
Pink Shrimp (flow-through) (*Penaeus duorarum*)	**94**	**3.8**	**moderately toxic**	**40228401 Mayer, 1986**	**supplemental**
Pink Shrimp (static) (*Penaeus duorarum*)	94	>10	slightly toxic	40228401 Mayer, 1986	supplemental

These estuarine/marine invertebrate acute toxicity studies with acephate classify acephate as moderately toxic (LC_{50} = >1-10 ppm) to practically non-toxic (LC_{50} >100 ppm) to estuarine/marine invertebrate species on an acute exposure basis.

3.3.2 Studies for the degradate methamidophos.

Table G.27. Estuarine/Marine Invertebrate Acute Toxicity for Methamidophos

Species	% ai	96-hour LC_{50} (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Oyster – shell deposition (*Crassostrea virginica*)	72.9	36 (95% CI 30-47)	slightly toxic	40088601, 40074701 Surprenant, 1987	supplemental[1]
Mysid shrimp *(Americamysis bahia)*	**technical**	**1.054 (95% CI 0.756 – infinity)[2]**	**moderately toxic**	**00144430 Larkin, 1983**	**acceptable**
White shrimp *(Litopenaeus vannamei)*	600 g/L formulation	1.46 (corrected for %ai)	moderately toxic	ECOTOX #88461 Garcia-de la Parra et al. 2006[3]	open literature study

[1] Due to the lack of raw data.
[2] Of the 5 test concentrations, only the highest concentration showed any mortality (70%).
3 Garcia-de la Parra, L.M., J.C. Bautista-Covarrubias, N. Rivera-de la Rosa, M. Betancourt-Lozano, L. Guilhermino. 2006. Effects of methamidophos on acetylcholinesterase activity, behavior, and feeding rate of the white shrimp (*Litopenaeus vannamei*). Ecotoxicology and Environmental Safety 65:372-380.

The methamidophos RED (1998) includes a blue shrimp (*Penaeus stylirostris*) study classified as supplemental in the above table.[3] This study is not cited here because the study does not meet EPA's validity criteria and has been downgraded to invalid. The study was a static renewal study in which the organisms were handled every 24 hours. During the handling process, mortality occurred. The mortality in the controls ranged from 60% to 80%. EPA's criteria only allows up to 10% mortality in the controls. Furthermore, EPA recognizes that in the

[3] Juarez, L.M., J. Sanchez, 1989. Toxicity of the Organophosphorous Insecticide Methamidophos (O,S-Dimethyl Phosphoramidothioate) to Larvae of the Freshwater Prawn, *Macrobachium rosenbergii* (DeMan) and the Blue Shrimp, *Penaeus stylirostris* Stimpson. Bull. Environ. Contam. Toxicol. (1989) 43:302-309.

FWS Recovery Plan for the California Red-Legged Frog, [4] this study is cited as evidence that methamidophos is very highly toxic to aquatic invertebrates.

These estuarine/marine invertebrate acute toxicity studies with methamidophos classify methamidophos as slightly toxic (LC_{50} = >10-100 ppm) to moderately toxic (LC_{50} = >1-10 ppm) to estuarine/marine invertebrate species on an acute exposure basis.

3.4 Estuarine and Marine Invertebrate, Chronic

3.4.1 Studies using the parent chemical, acephate

Table G.28. Estuarine/Marine Invertebrate Life-Cycle Toxicity for Acephate

Species	% ai	21-day NOAEC/LOAEC (ppm)	Endpoints Affected	MRID No. Author/Year	Study Classification
Mysid shrimp *(Americamysis bahia)*	**technical grade**	**0.58/1.4**	**mortality[1]**	**00066341, 40228401 Mayer, 1986**	**supplemental**

[1] Survival of the progeny of the acephate-exposed mysids was not affected.

This estuarine/marine invertebrate chronic toxicity study with acephate indicates that when parents are exposed to between 0.58 and 1.4 ppm acephate, parent survival is affected.

3.4.2 Studies using the degradate, methamidophos

Table G.29. Estuarine/Marine Invertebrate Life Cycle Toxicity for Methamidophos

Species	% ai	21-day NOAEC/LOAEC (ppm)	Endpoints Affected	MRID No. Author/Year	Study Classification
Mysid shrimp *(Americamysis bahia)*	**78.5**	**0.174/0.360**	**dry weight[1]**	**46646001 Blankinship et. al., 2005**	**acceptable**

[1] Other endpoint NOAEC/LOAEC: offspring per reproductive day 0.360/0.669; larvae survival 0.669/1.35; length 0.360/0.669

This estuarine/marine invertebrate chronic toxicity study with methamidophos indicates that when parents are exposed to between 0.174 and 0.360 ppm methamidophos, parental growth is affected.

4 Toxicity to Plants

4.1 Terrestrial Plants

4.1.1 Studies using the parent chemical, acephate

Table G.30. Terrestrial Plant Toxicity for Acephate: Non-Guideline

MRID	Author, Year	Phytotoxicity Information
00014623	Davis, 1977	Orthene Insect Spray formulation (15.6% a.i.) tested on poinsettia at 0.75 lb / 100 gal. applied up to 3X. Phytoxicity symptoms observed on plants (tomato, watermelon, fuchsia, begonia, *Hedra helix*, and philodendron, angelwings, coleus, poinsettia, *Chrysanthemum* spp., *Diffenbachia picta, Gynura aurantiaca,* and *Dracaena marginata*) are slight tip burn and foliar distortion, marginal leaf necrosis, slight leaf chlorosis caused by formulation. The technical grade acephate, whenever it is tested, did not cause any leaf damage. The formulation with methyl cellosolve caused some tip burn and foliar distortion on new growth.

[4] U.S. Fish and Wildlife Service. 2002. Recovery Plan for the California Red-Legged Frog (*Rana aurora draytonii*). U.S. Fish and Wildlife Service, Portland, OR. viii + 173 pp.

00014928	Shaefer, 1975	Marginal necrosis and slight stunting on18 inch tall *Viburnum suspensum* from 2 applications of 1 lb /100 gal water of Orthene formulation. Fourteen other different species of nursery plants tested with no symptoms of effects.
00014929	Clark, 1975	Slight to mild phytotoxicity symptoms on leaves for Lombardy cottonwood from 2 applications of 0.5 lb and 1.0 lb ai/A. Sixty different species of nursery plants tested with no symptoms of effects. No information provided as to what the formulation of acephate that is used.

Table G.31. Terrestrial Plant Toxicity for Acephate: Vegetative Vigor Tier II
Reference: Porch, J.R., *et al*., 2003; MRID 46173204

Crop	Plant height[1]		Dry weight[1]		Most sensitive parameter
	NOEC	EC_{25}	NOEC	EC_{25}	
Onion	3.96	>3.96	3.96	>3.96	None
Ryegrass	3.96	>3.96	3.96	>3.96	None
Wheat	3.96	>3.96	3.96	>3.96	None
Corn	3.96	>3.96	3.96	>3.96	None
Buckwheat	3.96	>3.96	3.96	>3.96	None
Soybean	3.96	>3.96	3.96	>3.96	None
Lettuce	3.96	>3.96	3.96	>3.96	None
Flax	3.96	>3.96	3.96	>3.96	None
Tomato	3.96	>3.96	3.96	>3.96	None
Radish	3.96	>3.96	3.96	>3.96	None

[1] Units are lb ai/A. 3.96 lb ai/A is equivalent to 4.50 kg a.i./ha.

Table G.32. Terrestrial Plant Toxicity for Acephate: Seedling Emergence Tier II
Reference: Porch, J.R., *et al*., 2003; MRID 46173203

Crop	Emergence[1]		Survival[1]		Plant height[1]		Dry weight[1]		Most sensitive parameter
	NOEC	EC_{25}	NOEC	EC_{25}	NOEC	EC_{25}	NOEC	EC_{25}	
Onion	3.96	>3.96	3.96	>3.96	3.96	<3.96	3.96	<3.96	Dry weight[2]
Ryegrass	3.96	>3.96	3.96	>3.96	3.96	>3.96	3.96	>3.96	None
Wheat	3.96	>3.96	3.96	>3.96	3.96	>3.96	3.96	>3.96	None
Corn	3.96	>3.96	3.96	>3.96	3.96	>3.96	3.96	>3.96	None
Buckwheat	3.96	>3.96	3.96	>3.96	<3.96	>3.96	<3.96	>3.96	Plant height[3]
Soybean	3.96	>3.96	3.96	>3.96	3.96	>3.96	3.96	>3.96	None
Lettuce	3.96	>3.96	3.96	>3.96	3.96	>3.96	3.96	>3.96	None
Flax	3.96	>3.96	3.96	>3.96	3.96	>3.96	3.96	>3.96	None
Tomato	3.96	>3.96	3.96	>3.96	3.96	>3.96	3.96	>3.96	None
Radish	3.96	>3.96	3.96	>3.96	3.96	>3.96	3.96	>3.96	None

[1] Units are lb ai/A. 3.96 lb ai/A is equivalent to 4.50 kg a.i./ha.
[2] The study author discounted the >25% inhibition exhibited by onion height and biomass because these responses did not follow a clear dose-dependent pattern.
[3] The 7% inhibition exhibited by buckwheat height did not follow a clear dose-dependent pattern.

The NOAEC for acephate seedling emergence and vegetative vigor studies is 3.96 lb ai/A.

4.1.2 Studies using the degradate, methamidophos

Table G.33. Terrestrial Plant Toxicity for Methamidophos: Seedling Emergence Tier I
Reference: Christ & Lam, 2005: MRID 46655802

Species	% ai	% inhibition length	% inhibition weight	Maximum Dose	MRID No. Author, Year	Study Classification
Cabbage	42.6	3	0	4 lb ai/A	46655802 Christ and Lam, 2005	Acceptable
Corn		0	0			
Cucumber		2	0			
Lettuce		0	3			
Oat		0	0			
Onion		3	0			
Radish		0	6			
Ryegrass		0	0			
Soybean		2	0			
Tomato		15	0			

Table G.34. Terrestrial Plant Toxicity for Methamidophos: Vegetative Vigor Tier I Reference: Christ & Lam, 2005: MRID 46655802						
Species	% ai	% inhibition length	% inhibition weight	Maximum Dose	MRID No. Author, Year	Study Classification
Cabbage	42.6	0	6	4.0 lb ai/A	46655802 Christ and Lam, 2005	Acceptable
Corn		3	1			
Cucumber		0	1			
Lettuce		5	4			
Oat		4	8			
Onion		1	4			
Radish		6	5			
Ryegrass		0	0			
Soybean		1	4			
Tomato		0	6			

The NOAEC for methamidophos seedling emergence and vegetative vigor studies is 4.0 lb ai/A.

4.2 Aquatic Plants

4.2.1 Studies using the parent chemical, acephate

Table G.35. Aquatic Plant Toxicity for Acephate					
Species	% ai	NOAEC (mg/L)	EC_{50} (mg/L)	MRID No. Author/Year	Study Classification
Diatom *(Skeletonema costatum)*	94	Not provided[1]	>50	40228401 Mayer, 1986	supplemental

[1] Previous acephate assessments have attributed a NOAEC of 5.0 mg/L to this study, but the source of that number is unclear.

4.2.2 Studies using the degradate, methamidophos

No methamidophos toxicity studies for aquatic plants have been submitted by registrants or identified in the ECOTOX database. The acephate study above has been used as a surrogate in previous risk assessments.

5 Field Testing and Literature Findings

5.1 Terrestrial Organisms

Table G.36. Terrestrial Field Studies and Incidents for Acephate		
Terrestrial Organism	Summary	Reference
Sparrows	Migratory white-throated sparrows (*Zonotrichia albicollis*) were exposed to acephate to determine its effects on migratory orientation and behavior. Birds were exposed to polarizer sheets to determine the mechanism by which acephate may affect migratory orientation. Adult birds exposed to 256 ppm acephate a.i. were not able to establish a preferred migratory orientation and exhibited random activity. All juvenile treatment groups displayed a seasonally correct southward migratory orientation. The author hypothesized that acephate may have produced aberrant migratory behavior by affecting the memory of the adult's migratory route and wintering ground. The "experiment reveals that an environmentally relevant concentration" (similar to 0.5 lb ai/A application) of an OP such as acephate "can alter migratory orientation, but its effect is markedly different between adult and juvenile sparrows. Results suggest that the survival of free-flying adult passerine migrants may be compromised following organophosphorus pesticide exposure."	Vyas et. al., 1995 ECOTOX 40313

Table G.36. Terrestrial Field Studies and Incidents for Acephate		
Terrestrial Organism	Summary	Reference
Birds	Acephate was sprayed in a forest at 0.5 lb ai/A. Eleven species of birds had ChE inhibition that ranged on average from 20 to 40%. The maximum depression of ChE found in chipping sparrows was 57% at day six. Western tanager species was found to have significant inhibition up to 26 days after application. Brain residue analysis of a western tanager collected on day three contained 0.318 ppm of acephate and 0.055 ppm of methamidophos. The authors concluded that brain ChE inhibition that occurred from forest application of 0.5 lb. ai/A is sufficient to be life threatening to the birds.	Zinkl, J. G., C.J. Henny, and P.J. Shea. 1979. Brain cholinesterase activities of passerine birds in forests sprayed with cholinesterase inhibitors. Pages 356-365. In: Animals as Monitors of Environmental Pollutants, National Academy of Science, Washington, DC.
Sparrows	The effects of a 14-day dietary exposure of acephate on cholinesterase activity in three regions; basal ganglia, hippocampus, and hypothamulus were examined in the brain of the white-throated sparrow, *Zonotrichia albicollis*. All three regions experienced depressed cholinesterase activity between 0.5-2 ppm ai acephate. The regions exhibited cholinesterase recovery at 2-16 ppm ai acephate; however, cholinerase activity dropped and showed no recovery at higher dietary levels (> 16 ppm acephate) which suggests that each region maintains its own ChE activity level integrity until the brain is saturated. Each region of the brain is responsible for different survival areas such as a foraging and escaping predators, memory and spatial orientation, food and water intake, reproduction and several others. Evidence indicated that the recovery is initiated by the magnitude of depression, not the duration. In general, as acephate concentration increased, depression in ChE activity among brain regions increased and differences of ChE activity among the three brain regions decreased. The pattern of ChE depression in different regions of the brain following low level exposure may prove to be a critical factor in the survival of the bird. The authors hypothesized that adverse effects to birds in the field may occur at pesticide exposure levels customarily considered negligible.	Vyas et. al., 1996 ECOTOX 40343
Passerine birds	Several large acreages of forest were sprayed with 0.5, 1.0 or 2.0 lb ai/A application rates. There was no brain ChE inhibition on day zero after application. Birds collected from the 2 lb ai/A plots from day one through six post spray showed ChE inhibition. Brain ChE inhibition was shown in birds 33 days after treatment but not 89 days after treatment. Birds seemed to have more inhibition of ChE in summer application when compared to the fall application in the 1 lb ai/A plots (30-50% and 25-40% depression, respectively). The greatest ChE inhibition occurred in dark-eyed juncos (65%) collected 15 days after treatment. In the 2 lb ai/A plots, dark-eyed juncos and golden-crowned kinglets had 54% ChE inhibition. Of the 14 species collected, only pine siskins *(Siinus pinus)* did not show any ChE inhibition. Symptoms of organophosphate poisoning were observed such as a warbling vireo salivating profusely, an American robin having difficulty maintaining a perching position, and a mountain chickadee having visible tremors. All of these observations were made in the 1 lb ai/A plots. The authors concluded that since marked ChE inhibition did not occur on day zero, but was evident up to 33 days after application, there was either an accumulative effect that was detected later or acephate was converted to a more potent ChE inhibitor such as methamidophos. Spraying the forest with 0.5, 1.0 or 2.0 lb ai/A caused marked and widespread, and prolonged ChE depression in passerine birds.	Zinkl, 1977
Red-eye Vireos	Site: Acephate was applied in this study on June 13 at 0.55 kg/ha (0.5 lb ai/A) on two 200 hectare plots. Significant (P<0.05) decline in number of red-eyed vireos was observed. The decline was concentrated in the interior of the treated plots rather than spread throughout. The authors concluded that this was directly attributed to acephate.	05014922, 00163173 (Bart, 1979)
American Kestrels	Kestrels were dosed with 50 mg/kg of 75% acephate formulation. Serum ChE was 37% inhibited and returned to predosed levels eight days later. Then the birds were dosed again and the serum ChE activity was inhibited at 42%; brain ChE was at 26% inhibition. The kestrel prey-catching activity was not altered.	00141694 (Rudolph, 1984)

Table G.36. Terrestrial Field Studies and Incidents for Acephate		
Terrestrial Organism	Summary	Reference
Forest birds	Site: Wallowa-Whitman National Forest. Applications of 1.12 (1.0 lb ai/A) and 2.24 (2.0 lb ai/A) kg/ha were made on forest plots in Oregon. Extensive inhibition of brain ChE activity (commonly at 30-50%) for up to 33 days for 11 of the 12 species of birds that were collected was observed. The highest frequency of ChE inhibition was observed on day two post spray. Two species of birds had observable population decreases. Some birds on the plots treated with 1.12 kg/ha had 65% ChE inhibition which is considered to be fatal amounts. At both plots, birds were found with coordination problems, salivating profusely, and unable to fly. These behaviors were observed up to 20 days after application in the 2.24 kg/ha plot. It was also observed that breeding pairs for the warbling vireo and yellow-rumpled warbler decreased. The authors concluded that application of acephate at rates of 1.12 and 2.24 kg/ha can cause sickness and death to forest birds.	40644802 (Richmond, 1979)
Birds	Site: Seven western states. USDA applied 1.05 oz ai/A ULV aerially for grasshopper control in 38,000 to 51,000 acre plots in May 1980. Most birds collected showed reduced brain ChE activity. The greatest inhibitions were found in the last birds collected. Horned larks showed more than 20% inhibition at the end of the 24-day post spray period. Some of these birds were showing 40% inhibition of brain ChE.	00032188 (Mazuravich, 1972)
Birds and Deer Mice	Site: WY, UT and AZ rangeland. In 1979 and 1980, the birds and small mammals collected up to 24 days after application had reduced ChE activity. Reduction of 20% or more is indicative of exposure to brain ChE inhibitor. Of the birds collected in AZ, 24.5% had reduced ChE activity >20%. The birds with the most ChE inhibition were the last ones collected (21-24 days post treatment). In 1981, horned larks and lark buntings were collected in WY on a 12,000 acre plot that was treated with acephate at the rate of 0.105 kg/ha. More than 20% ChE inhibition was found in 19% of the horned larks and 25% of the lark buntings. Deer mice were also collected in WY. They were found to have ChE inhibition that ranged from 12.7% to 14.6%.	00093909 (McEwen, 1981)
Squirrel	There is a marked inhibition of brain ChE activity in squirrels after aerial treatment of forests at rates of 0.57 kg/ha (0.51 lb/A) of Orthene.	40329701 (Zinkl, 1980)
Insectivorous mammals	Increased ingestion of arthropods by insectivorous mammals has been reported following acephate application. This signifies a direct pathway for substantial exposure to acephate due to consumption of dead and dying insects.	Stehn, et. al., 1976
Queen bees	Acephate appears to be systemic in nurse bees, causing glandular secretions fed to queens to be toxic. All colonies fed the 10 ppm rate lost queens early in the study and the affected colonies were unable to rear new queens. The study implied infrequent encounters by honey bee foragers with acephate on crops at levels of 1 ppm (1 ppm is NOAEC level) or less should be harmless. However, foragers may be expected to encounter levels greater than 1 ppm in the field because of 6-9 day residue persistence and residual systemic activity of acephate in plants for up to 15 days. Consequently, the study concluded that acephate is a hazard to honey bees because of its high contact toxicity, and because of its systemic nature.	Stoner et. al., 1984
Honey bees	Orthene was found to be more detrimental to honey bee populations than carbaryl. Brood cycles of some colonies were found to be permanently broken, so the colonies were technically dead. Depression in the numbers of wild foraging bees was apparent. Measured seed and fruit production of various plants were reduced from lack of pollination.	00099762 (Johansen, 1977)
Yellow jacket wasps and ants	Severe impacts on yellow jacket wasps and ants at rates of application of 1 and 2 lb ai/A sprayed on forest. Temperature seems to affect the exposure of wasps in that cooler temperature (39^{o}F) causes wasps not to forage out of nests and therefore not be exposed as much, whereas warmer temperatures (59^{o}F) increases the activity of wasps and the exposure to acephate.	00099763 (Johansen, 1977)

5.2 Aquatic Organisms

Table G.37. Aquatic Field Studies and Incidents for Acephate

Aquatic organism	Summary	Reference
Fish	Site: Moosehead Lake, ME. A 75% acephate formulation was applied at 0.5 lb. ai/A on forest. Brook trout and landlocked salmonoid did not show any decreases in ChE activity but suckers, a bottom feeder, showed 28% drop in ChE activity. There was a gradual return to pre spray ChE activity by eight days after treatment. The brook trout changed their diet a few days after spraying in response to the killed arthropods entering the stream. Macro invertebrates increased drift into the stream moderately and temporarily from the spraying. The invertebrate standing crop was not affected. Salmonoid growth was unaffected and newly hatched smelt grew normally.	00014547, 05012201 (Rabeni, 1979)
Fish	Site: Two forest ponds and a stream in PA. 0.5 lb. ai/A was applied to two forest ponds and a stream in PA, where 65 caged fish (bluegills, perch, and bullheads) were held. The fish and the sampled benthic invertebrates showed no effect up to eight days post treatment. The authors concluded that the "aquatic ecosystem under study was not significantly affected."	00014637 Bocsor, 1975
Fish and invertebrates	Author compared Orthene with Sumithion, Carbaryl, Dylox, Matacil, and Dimilin regarding brook trout, Atlantic salmon, scud and stoneflies. Author concluded that "Orthene should not pose any significant toxicity hazard to fish or (aquatic) invertebrates" when compared to the other chemicals.	00014861 (Schoettger, 1976)
Fish and invertebrates	Direct application to stream for 5 hour at concentration of 1000 ppb from 8 a.m. to 1 p.m. Measurements of acephate remained constantly at 1100 to 1200 ppb during this time. No mortality was noted in trout and benthic insects in the stream.	Geen et. al., 1981
Rainbow trout	"Brain ChE activity was depressed (38.2%) in trout exposed for 24 hours to 400 mg acephate per liter. After 24 hours of being in uncontaminated water, brain ChE was still depressed (42.5%)." There was no significant difference in the 100 mg/L for ChE depression when compared to control. Brain ChE activity remains depressed 8 days after a 24-hour exposure to 25 mg/L of methamidophos and 15 days after exposure to 400 mg/L of acephate. Because of low toxicity of acephate to rainbow trout, the study failed to determine at what % ChE inhibition would cause death. The level of depression that suggests poisoning by acephate or methamidophos is greater than 70% since brain ChE inhibition is at least this much in some trout that did not die. There is persistent ChE depression (8 days for methamidophos and 15 days for acephate) which suggests sublethal effects such as inability to sustain physical activity in search of food, eluding predators, and maintaining position in flowing water would occur. The author suggested that trout could die as a indirect result of sublethal toxicity.	Zinkl et. al., 1987
Mussels and clams	Reports of mussel die-off occurring in North Carolina prompted this study (See Fleming et. al. 1995). *Elliptio complanata* (freshwater mussel) and *Corbicula fluminea* (asiatic clam) were both tested. *E. Complanata* ChE depression was significant at 1.3 mg/L at the adductor muscle at 21°C at 96 hour exposure (no mortality was observed). When the temperature was raised to 30°C, there was significant mortality at observed at 5 mg/L. Cholinesterase activities of the adductor muscle (which was depressed 94-96%), began to recover 12 days after exposure, but was not fully recovered until more than 24 days after exposure. Acephate reduced the shell closure responsiveness at 5 mg/L with more pronounced affect at 27°C. This appears to confirm a die-off of mussels in North Carolina in August at a time of low water flow and seasonally peaked temperatures. When compared to carbamates, recovery is less rapid due to the accepted generalization (O'Brien, 1976) that OP chemicals irreversibly bind (phosphorylation) to ChE sites whereas carbamates reversibly bind (carbamylation) to ChE sites.	Moulton et. al., 1996
Mussels	"In 1990, we investigated a die-off of freshwater mussels in north-central North Carolina. An estimated 1,000 mussels of several species were found dead or moribund, including about 111 Tar spinymussels (Elliptio steinstansana), a federally listed endangered species. The die-off occurred during a period of low flow and high water temperature in a stream reach dominated by forestry and agriculture. Pathological examinations did not show any abnormalities and indicated that the die-off was an acute event. Chemical analyses of mussels, sediments, and water revealed no organophosphorus or carbamate pesticides. Cholinesterase activity in adductor muscle from Eastern elliptios (Elliptio complanata) collected at the kill site and downstream was depressed 73 and 65%, respectively, compared with upstream reference samples. The depression is consistent with a diagnosis of anticholinesterase poisoning. This is the first documented case in which cholinesterase-inhibiting compounds have been implicated in a die-off of freshwater mussels."	Fleming et. al., 1995