Appendix A Ecological Effects Data Summary

Toxicity to Terrestrial Animal

Based on the results for the avian acute/subacute dietary toxicity tests, phorate is found to be very highly toxic to avian species on an acute and subacute oral dietary toxicity basis. The results for these tests are tabulated below.

A. Toxicity to Birds

Oral Acute Avian Toxicity Studies:

Table 1-Avian Acute Toxicity with Technical Grade Phorate

Species	% ai	LD50 (mg/kg) (95% C.I.)	Toxicity Category	MRID No. Author/Year	Study Classification
Mallard duck *(Anas platyrhynchus*)	96.8	0.62 (0.37 – 1.03) [1]	Very highly toxic	00160000 Hudson, 1984	Acceptable
Ring-necked pheasant	98.8	7.12 (4.9 – 10.3) [1]	Very highly toxic	00160000 Hudson, 1984	Acceptable
Starlings	Tech.	7.5	Very highly toxic	00020560 Schafer, 1972	Supplemental [2]
Redwing blackbird	Tech.	1.0	Very highly toxic	00020560 Schafer, 1972	Supplemental [2]
Grackle	Tech.	1.3	Very highly toxic	00020560 Schafer, 1972	Supplemental [2]
Mallard duck *(Anas platyrhynchus)*	88.0	2.55 (2.02 – 3.21)	Very highly toxic	00160000 Hudson, 1984	Acceptable
Chukar	98.8	12.8 (3.2 – 51.2) [1]	Highly toxic	00160000 Hudson, 1984	Acceptable

[1] 3-month old birds

[2] Supplemental because there was no indication that there were control birds and the group size is smaller than EPA guidelines call for.

Table 2 - Avian Acute Toxicity with Formulated Product Containing Phorate

Species	% ai	Product LD_{50} (95% C.I.)	Active Ingredient LD_{50} [2] (95% C.I.)	Toxicity Category	MRID No. Author/Yr	Study Classification
Bobwhite quail (*Colinus virginianus*)	10 - ethoprop 10 - phorate	0.23 mg/kg	0.046 mg/kg	Very highly toxic	41923112 Grimes, Jaber, 1990	supplemental
Bobwhite quail (*Colinus virginianus*)	8.33 - fonofos 12.2 - phorate	85 mg/kg [1] (63-114)	17 mg/kg	moderately toxic	43049205 Pendersen, 1993	supplemental

1 The slope = 9.25

2 Active ingredient of both chemicals combined.

The studies are supplemental due to a mixture being tested.

Hudson gave the following description of the signs of intoxication:

"Ataxia, diarrhea, beak-sharpening reflex, polydipsia, lacrimation, loss of rightening reflex, immobility, irregular heart and respiratory rates, tremors, wing-beat convulsions, or opisthotonos. Levels as low as 0.09 mg/kg produced signs in mallards. This was an extremely fast-acting compound on all species tested. Signs occurred in pheasants as soon as 3 minutes after treatment. Mortality usually occurred between 10 minutes and 4 hours after treatment. Remission took up to 2 days."

Oral Acute/Subacute Avian Toxicity Dietary Studies

Table 3 – Avian Sub-Acute Toxicity Dietary with Technical Grade Phorate

Species	% ai	LC_{50} (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Mallard duck (*Anas platyrhynchus*)	90	240 (198 - 306)	Highly toxic	00022923 Hill, 1975	Acceptable
bobwhite quail (*Colinus virginianus)*	90	373 (326-431)	Highly toxic	00022923 Hill, 1975	Acceptable
Ring-necked pheasant	90	441 (381-510)	Highly toxic	00022923 Hill, 1975	Acceptable

Table 4 - Avian Sub-Acute Toxicity Dietary with Formulated Product Containing Phorate

Species	% ai	Product LC_{50} (95% C.I.)	Active Ingredient LC_{50} [3] (95% C.I.)	Toxicity Category	MRID No. Author/Yr	Study Classification
Mallard duck (*Anas platyrhynchus*)	10 - ethoprop 10 - phorate	1067 ppm	213.4	Slightly toxic	41923114 Grimes, 1990	supplemental
Bobwhite quail (*Colinus virginianus*)	10 - ethoprop 10 - phorate	270 ppm [1]	54 ppm	Very highly toxic	41923113 Grimes, 1990	supplemental
Bobwhite quail (*Colinus virginianus*)	8.0 - dyfonate 12 - phorate	856.2 ppm [2] (601-1364)	171.2 ppm	highly toxic	43049207 Ahmed, 1993	supplemental

1 The slope = 5.94
2 The slope = 3.3 (1.58 - 5.06)
3 Active ingredient of both chemicals combined.

The studies are supplemental due to a mixture being tested.

Avian Reproductive Studies (Chronic)

Avian reproductive studies for Phorate are tabulated below.

Table 4 - Avian Reproduction

Species	% ai	NOAEC (ppm)	Endpoints Affected	MRID No. Author/Year	Study Classification
bobwhite quail (*Colinus virginianus)*	92.1	>60	none	00158333 Beavers, 1986	Supplemental
Mallard duck (*Anas platyrhynchus)*	92.1	5	Eggs laid, viable embryo, normal hatchlings	00158333 Beavers, 1986	Acceptable

The acceptable avian reproduction study testing mallard duck showed significant

reductions in eggs laid, viable embryo, and normal hatchlings when they are fed 60 ppm of technical Phorate for 19 weeks. Morphological changes in reproductive organs such as regressed gonads and egg yolk peritonitis were observed at 60 ppm. It is likely that that bobwhite quail is not more sensitive than the mallard duck. Therefore, another study on the quail was not requested.

B. Toxicity to Mammals, Acute and Chronic

Rat or mouse toxicity values are obtained from the Agency's Health Effects Division (HED) as a substitute for wild mammal testing. The toxicity data are tabulated below.

Table 5 Mammalian acute toxicity

Species	% ai	Test Type	Toxicity Value	Affected Endpoints	Study Classification	MRID
Rat (*Rattus norvegicus*)	>92	Rat acute oral LD_{50}	LD_{50} = 3.7 mg/kg (male) 1.4 mg/kg (female)	mortality	Acceptable	42857001
Rat (*Rattus norvegicus*)	92	Dermal LD_{50}	LD_{50} = 9.3 mg/kg (male) 3.9 mg/kg (female)	mortality	Acceptable	00126343
Rat (*Rattus norvegicus*)	92	Inhalation LD_{50}	LD_{50} = 0.06 mg/kg (male) 0.011 mg/kg (female)	mortality	Acceptable	00126343

The following information was taken from the HED 2/18/1999 science chapter:

> "Technical phorate is highly toxic on an acute oral, dermal, and inhalation basis. The oral LD_{50} values for phorate with rats were 3.7 and 1.4 mg/kg in males and females, respectively (Toxicity Category I). All of the animals that died in this study showed typical clinical signs of cholinergic toxicity such as salivation, lacrimation, exophthalmos, muscle fasciculation and excessive urination and defecation.
>
> The dermal LD_{50} values for phorate with rats were 9.3 and 3.9 mg/kg in males and females, respectively (Toxicity Category I). The cholinergic signs noted for the acute oral study were also observed in the acute dermal study. In addition, a dermal LD_{50} of 415.6 mg/kg in guinea pigs with typical cholinergic signs noted at higher doses was also reported.
>
> The acute inhalation LC_{50} for rats were 0.06 and 0.011 mg/L for males and females, respectively (Toxicity Category I), based on a one-hour exposure to analytical grade phorate aerosol. Cholinergic signs were observed in intoxicated animals."

In addition, the HED 2/18/1999 science chapter reported that Phorate was not considered carcinogenic under the conditions of the two-year chronic toxicity/carcinogenicity study in rats (50/sex/group) because the treatment did not alter the spontaneous tumor profile in rats. Phorate was also not considered to be mutagenic because technical phorate did not

induce a genotoxic response in any of the tests used to detect mutagenicity.

Table 6. Mammalian Reproductive Toxicity

Species	% ai	Test Type	Toxicity Value	Affected Endpoints	Study Classification	MRID
Rat (*Rattus norvegicus*)	92.1	2-generation reproductive	NOEL = 0.2 mg/kg/day (2 ppm) LOEL = 0.4 mg/kg/day (4 ppm)	Offspring toxicity = decreased pup survival and pup body weight parental systemic toxicity = clinical signs (tremors) and inhibitions of plasma and brain cholinesterase activity (F_1 females only).	Acceptable	44422302

C. Toxicity to Insects

The honeybee acute contact tests are not required for granular formulations. However studies have been submitted.

Table 7 - Non-target insect acute contact toxicity

Species	Study Type	% ai	Toxicity Endpoint	Toxicity Classification	MRID No. Author/Year	Study Classification
Honeybee *(Apis mellifera)*	Acute contact Acute oral	tech	LD_{50} = 0.32 µg ai/bee LD_{50} = 0.44 µg ai/bee	Highly toxic	05001991 Stevenson, 1978	Acceptable
Honeybee *(Apis mellifera)*	Acute contact	tech	LD_{50} = 10.07 µg /bee	Moderately toxic	00036935 Atkins, 1975	Acceptable
See species listed below	Acute Toxicity to various carabid beetles	15% Gran.	100% mortality at 1.12 kg ai/ha	n/a	05008149 Gholson, 1978	n/a

Scarites substriatus
Pterostichus chalcites
Bembidion quadrimaculatum
Bembidion rapidum
Harpalus pennsylvanicus

D. Toxicity to Frogs

Table 8 - Non-target insect acute contact toxicity

Species	Study Type	% ai	Toxicity Endpoint (95% CL)	MRID No. Author/Year	Study Classification
Bullfrog (terrestrial phase)	Acute oral	98.8	LD_{50} = 85.2 mg ai/kg-bw (59.3-122)	00016000 Hudson, Tucker, Haegele, 1984	Acceptable

E. Terrestrial Incidents

The following is the list of incidents EFED believes occurred under typical use scenarios.

On January 5, 1991, what appeared to be eight bobwhite quail were found dead adjacent to a phorate-treated field near Waynesboro, GA. Apparently, the wheat field had been planted in 1ate November. This is probably when the field was treated with phorate. The formulation was not Thimet, but another formulation of phorate. Apparently during

application, the equipment used had a tendency to clog because the soil was wet; and upon reaching the turn row, the applicator would lift the planter and whatever was clogged in the drill would spill out onto the ground. Phorate was determined to be the cause of death (B0001500-16. USEPA, 1991).

Two songbirds, including a robin, were found dead in a tilled corn field in Isle of Wight County, VA on April 5, 1991. The field had been treated with carbofuran (Furadan 15G) on April 4 and 5, 1991. This was under a field monitoring study being conducted at the time of observation. Based on residue analysis, it was determined that phorate probably caused the deaths, with residues of 7.9 ppm detected. How and where the birds had been exposed to phorate -remains unknown. (1000504-028. Southeastern Cooperative Wildlife Disease Study, 1991).

On March 26, 1989, Thimet 20G killed birds on a winter wheat field in Pierre, SD, that was treated on September 20, 1988 at the application rate of 1.2 oz per 1000 foot row with a 10-inch row spacing. If label instructions were followed, then granules would have been applied in-furrow at planting. During late winter to early spring, a pond had formed in the wheat field .from the thaw of the snow cover and from rain on March 16 and 17, 1989. On March 29, 1989, 70 Canada geese and other waterfowl were found dead around this temporary pond. A few days later, 12 Canada geese, ducks and a sharp-tailed grouse were found dead in a secluded small pond about one third mile from the first pond. On March 19, eagles had been observed at one of these ponds feeding on dead geese. Seven bald eagles and possibly one golden eagle are believed to have been fatally poisoned by phorate in this manner. Phorate residues were measured in wheat at 2.2 ppm and at 0.025 ppm in the pond water samples (FWS, 1989a). Additional information from FWS (letter dated Dec. 22, 1989) indicates seven bald eagles, 81 Canada geese, one snow goose, 13 waterfowl, and one sharp-tailed grouse were found dead at both ponds (B000150-015. 89BOl. South Dakota Department of Agriculture, 1989).

Ten Canada geese, 55 mallards; one barn owl, one skunk, and two opossums were killed by phorate from April through June 1989 in Spring Green, WI. The .conditions under which the incidents occurred were not reported (B000150-013.FWS,1989).

On January 16,1987, a red-tailed hawk was reported dead in Solano County, CA from a weakened, stressed condition in a mud field nine miles from Dixon. The cause of death was from exposure to phorate through an unknown set of circumstances (B000150-009. Littrell, 1987). . .

On February 16, 1987, in Jefferson County, ID, a bald eagle was found dead with a concentration of phorate in its stomach of 631 ppm. The mode of death is undetermined. American Cyanamid proposed that the eagle died after eating from a predator-control carcass poisoned with phorate because the stomach contents contained high amounts of fat and wavy white hair (B000150-011. American Cyanamid, 1990).

On November 4,1986, 50 to 60 mallards and pintails were found dead in a field that had been planted in barley the previous summer in Tulelake, AL (FWS, 1989). Patuxent

Wildlife Research Center analysis of crop contents for 7 birds (5 mallards and 2 pintails) identified phorate in every crop. No evidence of misuse was found. (B000150-010. USEPA, 1991).

In October 1982, an incident occurred from the use of phorate on wheat fields in Lyman County, SD. Species (and number of each) found dead were: mallards (38), gadwalls (four), widgeons (nine), pintails (six), green-winged teal (seven), red-tailed hawk (one), and golden eagle(one). Details were not reported (B000150-008. FWS, 1989).

On October 18 and 20, 1982, about 350 waterfowl (133 mallards, 51 pintails, 42 widgeons, 36 gadwall, 12 green-winged teal, three Canada geese, six marsh harriers, two red-tailed hawks, and four great horned owls were found dead in two ponds in Potter County, SD (FWS, 1989). Exposure apparently was from two wetland areas: an adjacent field treated with Thimet 15G in a band-in the grass around a winter wheat field; and a second pond, also located in the middle of a winter wheat field, that had been entirely treated. Both ponds also had been exposed by a spill of Thimet 15G and Thimet 20G. A bag of Thimet 15G had been found floating in the pond, and the second pond had two bags in the vicinity. Heavy precipitation had been reported. Runoff was implicated for the second pond.(B000150-007. South Dakota Department of Agriculture .1982)

On December 5, 1982, in Potter County, SD, a bald eagle was found near the previous bird kill area. Various duck parts containing residues of 26 ppm phorate were found the eagle's gastrointestinal tract. The eagle probably died from eating the remains of the duck carcass that had not been removed (B000150-018. American Cyanamid, 1990).

0n February 19, 1981 in Fresno County, CA, an incident involving phorate killed 2,000 blackbirds, two pheasants and several pigeons. Thirnet 15 G was applied by air to a wheat field at the recommended rate nine days after reseeding. Standing water was observed in several irrigation ditches as a result of a rain storm about one week before application. American Cyanamid suspects that the birds contacted contaminated irrigation ditch water. Phorate residues were detected in the blackbirds at 24 ppm (B000150-005.California Fish and Game Department, 1981).

On February 21, 1981 in Merced, CA, phorate, while being applied by aerial application to an alfalfa field, was inadvertently-applied to an adjacent property. Due to a faulty dump mechanism, a large amount was also dumped into the waterway around the field . One hundred waterfowl and 100 other birds of various species died. Phorate residues were 54 ppm in teal and 31 ppm in coots. Phorate also was detected in water and vegetation within the property boundary. Although this is a case of misapplication the low lethal doses should be noted (B000150-006. California Department of Food and Agriculture, 198 1).

On Nov. 4, 1978, in Calipatria, CA, Thirnet 1OG was applied, contrary to label instructions, to an alfalfa field during irrigation. Two days after application, 195 bird carcasses were removed, including ring-billed gulls, cattle egrets, and curlews. Phorate was detected in all of the gulls. Phorate residues ranged from 0.05 ppm to 56 ppm.

Regurgitated gizzard contents found at the exposure site contained nearly 100% crickets and 92.7 ppm phorate. Brain cholinesterase activity was inhibited by 76% to 96%. Cattle egrets had consumed coleoptera, orthoptera and arachnids. Phorate residues in the egrets were 150 ppm (B000150-004. FWS, 1989; and USEPA, 1991).

In June 1972, it was reported that 25 ducks and blackneck stilts died in the tail water area of a sugar beet field in Fresno, CA. Two days earlier, the field was treated with phorate. Residues were 90 ppm (B000150-014. Bischoff, 1973).

In conclusion the field studies and the incidents indicate that the use of phorate will result in adverse effects. Phorate and its metabolites can express their toxicity several months after application as shown in the above incidents. The Agency believes that during the winter the topsoil and subsoil are frozen, and there is slow degradation until spring thaws when phorate and metabolites begin to move. Storage stability data cited in the human health assessment chapter indicating that phorate and the metabolites are stable for 1 to 3 years if stored under frozen conditions lend support to the above scenario. No downward movement of phorate or metabolites will occur until the subsoil thaws, but spring rains wash phorate and metabolites into surface water ponds, lakes and streams. The waterfowl deaths appear to be connected with this flooding of treated fields. The flooded fields will attract the birds. The water could poison the birds in many different ways. For example, it could be through the skin, drinking, preening, or through eating contaminated flora or fauna growing in the puddle but, as with many incidents, the exact route of exposure could be single or multiple. Also of equal significance, incidents show phorate can kill songbirds, upland gamebirds, and mammals, as well as waterfowl. Field studies both simulated and actual with corn show that phorate presents a risk under more conventional application and exposure scenarios

D. Toxicity to Aquatic Animals

The results of acute testing show that phorate is categorized as highly toxic to cold-water, warm-water fish species, and invertebrate species. Results of freshwater animal acute toxicity testing are tabulated below.

Table 9 - Freshwater Fish Acute Toxicity with Technical Grade Phorate

Species and test conditions	% ai	LC_{50} (µg ai/L) (95% C.I.)	Toxicity Category	MRID No. Author/Year	Study Classification
Rainbow trout *(Oncorhynchus mykiss)* 44 mg/L $CaCO_3$ 272 mg/L $CaCO_3$	100	 13 (11-16) 21 (16-27)	Very highly toxic	40094602 Johnson, Finley, 1980	Acceptable
Bluegill sunfish (15°C, 44 mg/L $CaCO_3$) *(Lepomis macrochirus)* 0.29 gm wt. 0.6 gm wt. 1.0 gm wt. 1.22 gm wt. 1.6 gm wt. 4.0 gm wt.	100	See comments below < 2.1 2.42 (2.1-2.7) <1.4 (0.01-2.2) 3.57 (3.0 - 4.2) 2.35 3.95	Very highly toxic	40098001 Mayer, Ellersieck, 1986	supplemental
Channel catfish			Highly toxic	40098001	Supplemental

Species and test conditions	% ai	LC_{50} (µg ai/L) (95% C.I.)	Toxicity Category	MRID No. Author/Year	Study Classification
(*Ictalurus punctatus*) (15°C, 44 mg/L $CaCO_3$)	100	280 (115-680)		Mayer, Ellersieck, 1986	
Cutthroat trout (12°C) 44 mg/L $CaCO_3$ 272 mg/L $CaCO_3$	100	 44 66 (61-71)	Very highly toxic	40098001 Mayer, Ellersieck, 1986	Supplemental
Northern pike (15°C, 272 mg/L $CaCO_3$)	100	110 (90-130)	Highly toxic	40098001 Mayer, Ellersieck, 1986	Supplemental
Largemouth Bass (15°C, 272 mg/L $CaCO_3$)	100	5.0 (4.7-5.4)	Very highly toxic	40098001 Mayer, Ellersieck, 1986	Supplemental
Walleye (15°C, 272 mg/L $CaCO_3$) 1.2 gm wt. 1.4 gm wt.	100	 57 (42-77) 340 (270-430)	Very highly toxic	40098001 Mayer, Ellersieck, 1986	Supplemental

Mayer and Ellersieck studies are supplemental due to lack of raw data analyzed and not tested at current test standards.

Comments concerning the Phorate Bluegill Toxicity (40098001; Mayer, Ellersieck, 1986):

<u>Wt group of fish</u>

0.29 gm --- Lowest dose has 90% mortality. Mayer's LC_{50} <2.35 ppb. Approx. LC_{50} with Toxanal is <2.1 ppb based on binominal test. **The LC50 is not used since it is very uncertain.**

0.60 gm --- Lowest dose has 20% mortality; next lowest dose has 80% mortality. All other doses have 100% mortality. Toxanal LC_{50} = **2.42 ppb** (2.1 – 2.7) Slope =14.1.

1.0 gm --- Lowest dose = 60% mortality. Mayer LC_{50} = 2.0. **Toxanal LC_{50} = < 1.4 (0.01-2.2). Slope = 3.2.**

1.22 gm --- Good dose response. Mayer LC_{50} = 3.8 ppb. Toxanal LC_{50} = 3.57 (3.0 – 4.2). Slope = 6.0.

1.6 gm --- Lowest conc. has 30% mortality; next lowest dose has 80% mortality. All other doses have 100% mortality. Mayer's LC_{50} = 2.3 ppb. Toxanal LC_{50} = **2.35** (1.5 – 2.86) based on moving average. **This appears to be most sensitive valid value to use for risk assessment.**

4.1 gm --- No mortality at lowest concentration. Next lowest dose has 30% mortality. Other 4 doses have 100% mortality. Toxanal LC_{50} = **3.95** ppb based on moving average. When there is less than two concentrations in which the per cent dead is between 0 and 100, neither the moving average nor the probit method can give any statistically sound results.

Table 10 - Freshwater Fish Acute Toxicity with Phorate Formulation

Species and test conditions	% ai	LC_{50} (µg product/L) (95% C.I.)	LC_{50} (µg ai/L)	Toxicity Category	MRID No. Author/Year	Study Classification
Rainbow trout *(Oncorhynchus mykiss)*	20G	45 (37-57) 8.7 slope	9	Very highly toxic	00161822 Nicholson, 1986	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	20G	12 (8-13) 11.4 slope	2.4	Very highly toxic	00161823 Nicholson, 1986	Acceptable
Channel catfish (*Ictalurus punctatus*)	20G	2.2 (1.0-1.4) 1.7 slope	0.44	Very highly toxic	00161824 Nicholson, 1986	Supplemental due to species

Species and test conditions	% ai	LC_{50} (µg product/L) (95% C.I.)	LC_{50} (µg ai/L)	Toxicity Category	MRID No. Author/Year	Study Classification
(15°C, 44 mg/L $CaCO_3$)						
Rainbow trout *(Oncorhynchus mykiss)*	10% phorate 10% ethoprop	130	--	Very highly toxic	41923110 LeLievre, 1991	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	10% phorate 10% ethoprop	25	--	Very highly toxic	41923109 LeLievre, 1991	Acceptable
Rainbow trout – 55°F *(Oncorhynchus mykiss)*	66% phorate 17% xylene	19 (96 hr) (14.5-24.3)	--	Very highly toxic	00090490 McCann, 1971	Acceptable
Bluegill sunfish – 65°F *(Lepomis macrochirus)*	66% phorate 17% xylene	< 2.8 (48 hr.)	--	Very highly toxic	00090491 McCann, 1971	Acceptable
Rainbow trout *(Oncorhynchus mykiss)*	8% - fonofos 12% - phorate	106.4 (91.6-122.6)	---	Very highly toxic	43049203 Boeri, 1993	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	8% - fonofos 12% - phorate	6.5 (5.7-8.7)	---	Very highly toxic	43049204 Boeri, 1993	Acceptable

Table 11 - Freshwater Aquatic Invertebrate Life-Cycle Toxicity and Fish Early Life-Stage Toxicity

Species	% ai	NOAEC/ LOAEC (µg ai/L)	Endpoints Affected	MRID No. Author/Year	Study Classification
Rainbow trout *(Oncorhynchus mykiss)*	92.1	1.9/4.2	Total length	00015835 Surprenant, 1986 41695101 Surprenant, 1991	Acceptable

The bluegill sunfish is more sensitive than the rainbow trout on an acute basis. The rainbow trout early life stage NOEC was used to estimate the NOEC for the bluegill sunfish. The rainbow trout NOEC value is similar to the LC_{50} value of the bluegill sunfish.

Table 12 - Freshwater Invertebrate Acute Toxicity with Technical Grade Phorate

Species	% ai	EC_{50} (C.I.) µg ai/L	Toxicity Category	MRID No. Author/Year	Study Classification
Stoneflies (48 hr.) *Pteronarcys*	100	4 (2-6)		00003503 Johnson, 1980	Supplemental due to species test
Scud (21°C, 96 hr.,static) (*Gammarus fasciatus*)	Tech.	0.68 (0.36-1.0) (constituted water) 0.60 (0.3-0.8) (raw stream water)	Highly toxic	05017538 Sanders, 1972	Supplemental due to scud being too mature, lack of raw data
Scud (70°F (21°C), 96 hr.) (*Gammarus fasciatus*)	Tech	9 (5.1-13.0) (constituted water) (2 month old scud)	Highly toxic	00097842 Sanders, 1969	Supplemental due to species tested
Scud (*Gammarus fasciatus*)	100	4 (2-6)	Highly toxic	00003503 Johnson, 1980	Supplemental due to species tested
Crayfish (96 hr.) (*Orconectes nais*)	Tech	50 (30-75)	Not established	05017538 Sanders, 1972	Supplemental due to species is too mature

Table 13 - Freshwater Invertebrate Acute Toxicity with Phorate Formulation

Species and test conditions	% ai	LC_{50} (µg product/L) (95% C.I.)	LC_{50} (µg ai/L)	Toxicity Category	MRID No. Author/Year	Study Classification
Waterflea *(Daphnia magna)*	20G	37 (30-44)	7.4	Very highly toxic	00161825 Nicholson, 1986	Acceptable
Midge larvae *(Paratanytarsus parthenogenica*)	20G	41(38-45)	8.2	Very highly toxic	00161826 Nicholson, 1986	Acceptable
Mayfly nymphs *(Hexagenia sp.)*	20G	65 (47-74) Slope = 3.4	13.0	Very highly toxic	00161827 Hoberg, 1986	Supplemental due to being at later stage of development
Waterflea (48 hr.) *(Daphnia magna*)	8% - fonofos 12% - phorate	18 (16-26)	---	Very highly toxic	43049202 Boeri, 1993	Acceptable
Waterflea (48 hr.) *(Daphnia magna*)	10% phorate 10% ethoprop	24	---	Very highly toxic	41923111 LeLievre, 1991	Acceptable

A letter dated 11/24/1998 from Lynn Miko (Vice-President, Global Qud, Assurance & Regulatory Compliance, American Cynamid Co.) and Dr. Mark Gallery of American Cynamid to OPP/EPA provided information on toxicity of two of phorate's degradates, phorate sulfone and phorate sulfoxide. The following information was made available:

Phorate sulfoxide
Daphnia magna EC_{50} = 4.0 ppb ai
Bluegill sunfish (*Lepomis macrochirus*) LC_{50} = 22 ppb

Phorate sulfone
Daphnia magna EC_{50} = 0.4 ppb ai

This information is considered to be supplemental since no raw data were provided; this test was a preliminary screen with 10X progression.

Table 14 - Freshwater Aquatic Invertebrate Life-Cycle Toxicity

Species	% ai	NOAEC/ LOAEC (µg ai/L)	Endpoints Affected	MRID No. Author/Year	Study Classification
Waterflea *(Daphnia magna)*	100	0.21 / 0.41	Number of offspring per female, and growth of parental Daphnids	42227102 Yurk, 1991	Acceptable
Waterflea *(Daphnia magna)*	100	0.29 / 0.44	Survival of adults and production of young	00158336, 41131115 Suprenant, 1990	Acceptable

Aquatic Field Testing

Aquatic Field Testing and Incidents

An aquatic field study conducted in Iowa used Thimet 20G insecticide. The study only

produced comparable data for 3 of 5 ponds. Three ponds have similar chemical and physical characteristics. One pond was a reference pond, the other two were watersheds treated with Thimet 20G. Significant rainfall events did not occur until 10-14 days after treatment. Reductions to invertebrate populations, fish growth and bluegill fecundity were apparent in ponds adjacent to the treated field. Most of the population reductions noted in the study were as a result of exposure to the metabolites of phorate, phorate sulfone and sulfoxide. Both metabolites were found when the pond water was analyzed. Despite several factors that compromised comparisons between treated and untreated areas, the study provided valuable data concerning phorate behavior in the environment. The authors of the study suggest that phorate may significantly decrease diversity in natural ecosystem. (MRID No.42227101).

A mesocosms study in South Dakota investigated the effects of phorate to wetlands ' macroinvertebrates. Each wetland had a reference and 3 treated mesocosms with application rates of 1.2, 2.4, and 4.8 kg/ha (1, .2, and 4.3 lbs/A), respectively. For one month all rates resulted in mortality to all amphipods and chironomids (Dieter et al.,1995; MRID No. 43957801)

The EPA has received several reports of field incidents involving phorate products through the Pesticide Incident Monitoring System (PIMS). Three fish kills were reported in Illinois involving phorate combined with propachlor, atrazine, EPTC**,** or esters of 2,4-D. As phorate is considered more toxic than the other chemicals the Agency believes that phorate was primarily responsible for the mortalities.

In May l970, fish kills were reported involving three ponds following the use of phorate, propachlor, EPTC, atrazine, or the isooctyl ester of 2,4-D on corn fields. Phorate residues were measured in the three ponds. Two ponds were measured two weeks post-application and reported residues of 8.3 and 32.3 ppb. The third pond was measured 37 days post-application and revealed concentrations as high as 12.1 ppb. The effects for the three ponds varied from 30 to 50 dead bluegill and bass for one pond and about 2,000 to 3,000 bluegill, bass, greengills, silver minnows, catfish and crappies, a watersnake, and fox squirrels for the second pond, approximately three to four days postapplication. In the third pond phorate, atrazine, and propachlor probably caused the death of bass and bluegill 7 to 14 days post-application (B000150-001,002,003).

Toxicity to Terrestrial and Aquatic Plants

No terrestrial phytotoxicity data are available for phorate.

Only aquatic plant phytotoxicity data available is for the saltwater diatom, *Skeletonema costatum.* Aquatic plant testing (Tier II) results are tabulated below.

Table – 15. Non-target Aquatic Plant Toxicity (Tier II)					
Species	% ai	EC_{50} (µg/L	NOAEL (µg/L)	MRID No. Author/Year	Study Classification
Vascular Plants					
Duckweed ,*Lemna gibba*		Not available			
Nonvascular Plants					
Green algae *Kirchneria subcapitata* (formerly *Selenastrum capricornutum*)		Not available			
Freshwater diatom *Navicula pelliculosa*		Not available			
Blue-green algae *Anabaena flos-aquae*		Not available			
Marine diatom (*Skeletonema costatum*)	90	>1300	N/A	00066341 EPA, 1981	acceptable