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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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OFFICE OF PREVENTION, PESTICIDES AND TOXIC SUBSTANCES

MEMORANDUM

TO: Ben Chambliss, CRM
Special Review and Reregistration Division

FROM: David Farrar, Statistician, EFED task leader for Phorate *David Farrar 8/30/99*
Jim Breithaupt, Fate and Exposure scientist *Jim Breithaupt 8/30/99*
Environmental Risk Branch II
Environmental Fate and Effects Division (7507C)

THROUGH: Betsy Grim, Acting Branch Chief *Betsy Grim 8/30/99*
EFED/ERB II

DATE: August 30, 1999

RE: **Phorate**:
Completion of response to comments from American Cyanamid Co.;
Revision of exposure estimates for surface and ground water;
Updated EFED RED chapter;

DP BARCODE: D251987

On Dec. 23, 1998 EFED responded to comments from American Cyanamid Co. (Oct. 12, 1998) related to a draft EFED RED chapter, and provided a RED chapter that was updated to address a portion of Cyanamid's comments. EFED's 12/98 memo indicated that some items were still under review. The purpose of this communication is to provide a RED chapter updated to address comments from Cyanamid that were under review. (A revised RED chapter is attached.)

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EFED's description of the phorate terrestrial incidents has been revised, without changing the bottom-line conclusion that the incidents provide a strong basis for concern (see particularly the Risk Characterization section).

Incorporation of new fate information submitted by American Cyanamid Co.

Cyanamid has submitted guideline studies of fate properties of phorate sulfone and phorate sulfoxide, and a detailed review (G. Mangel, 9/14/98) based to some degree on journal articles. EFED has reviewed the journal articles, guideline studies, and a formation and decline spreadsheet document developed by G. Mangel. Based on this information, EFED has independently developed an analysis of formation and decline. Formation and decline constants from some of the studies were used in PRZM-EXAMS modeling, while other studies were referenced but not used quantitatively.

In addition, Cyanamid has submitted new guideline studies of mobility in soil for phorate metabolites, and hydrolysis and aerobic aquatic metabolism studies for parent phorate and phorate metabolites. This information has been incorporated into the RED chapter.

Revision of Exposure Estimates for Surface and Ground Water.

For both surface water and ground water, EFED has calculated exposure estimates in two ways: (1) for parent phorate only; and (2) for total toxic residue (parent phorate + phorate sulfoxide + phorate sulfone). For ground water, only the results for total toxic residue are presented in the RED chapter. (It appears that any phorate residues that reach ground water will be primarily phorate metabolites rather than parent phorate.) The revised estimates make use of all available fate information including material recently submitted by American Cyanamid. For surface water, we have used current model versions, which are PRZM 3.12 and EXAMS 2.975.

EFED has assumed a single application per year for each crop and procedure simulated. The labels actually permit two applications per year for corn (field and sweet) and grain sorghum. EFED is at this time conducting simulations assuming two applications per year for these crops.

For surface water, EFED has recalculated concentrations for phorate applied to field and sweet corn, peanuts, cotton, potatoes, and grain sorghum. The simulated application techniques included t-banded, in-furrow at planting and side-dress application once the applicable crop had emerged. These crops represented the maximum application rates and primary crops to which phorate is applied, and give the maximum EECs for applied phorate.

EFED did not simulate applications to sugarcane because the label states that this use is restricted to Florida. Florida sugarcane is grown primarily around Lake Okechobee, where water levels in the fields are managed by flooding canals. Therefore, it is impossible to properly simulate this scenario because of fluctuating water levels. In previous RED Chapters, EFED simulated application to sugarcane in Louisiana, but is no longer using this scenario for phorate in sugarcane.

EFED also did not simulate applications to winter wheat (North Dakota), soybeans (Iowa), dried beans (Michigan), or potatoes in Maine in the current RED Chapter. In previous modeling, winter wheat has been found to have low EECs as compared to other crops. Soybeans and dried beans are relatively minor uses compared to other crops, and phorate is not used significantly in Maine for potatoes. Also, EFED is now using an Ohio field corn scenario instead of the Iowa field corn scenario used in previous RED Chapters.

Responses to technical comments from Cyanamid on the environmental fate of phorate.

(See also EFED's response below to the Gagne-Mautz memo.)

• Cyanamid argues that important degradation pathways go directly to nontoxic metabolites rather than through p. sulfone and p. sulfoxide.

Response: Cyanamid is correct in noting that parent phorate degrades to both non-toxic and toxic metabolites in soil and water. EFED incorporated this information in the August 1999 Revised RED Chapter. EFED also incorporated this information into the surface water modeling, where the formation and decline constants for each metabolite were mathematically factored in the PRZM-EXAMS modeling.

• Regarding absorption-desorption kinetics of Phorate metabolites, in relation to runoff potential, Cyanamid argues that incorporation and leaching will tend to move the metabolites to a depth of 2-6 inches, so that runoff would be minimal. These conclusions are based on studies and other submissions under a separate cover dated 9/14/98.

Response: The registrant is generally correct in saying that movement of phorate and metabolites (or any pesticide) to 2-6 inches of depth will reduce surface runoff. Surface runoff is likely to decrease with increasing depth of placement in the soil. However, the registrant does not consider capillary action, where the soil water moves toward the surface of the soil in response to surface drying in finer-textured soils. This vertical movement of water may carry pesticides from lower soil depths to the surface, where it may be available for runoff. However, with deeper placement in the soil, the risk for ground water contamination becomes greater.

• Based on information in the Mangel review, Cyanamid argues that Phorate metabolites will degrade rapidly enough that they have low potential to contaminate ground water and will pose low chronic concern.

Response: For phorate sulfoxide, the half-lives calculated from the different guideline and literature studies ranged from 17-100 days in the soil. For phorate sulfone, the half-lives calculated from the different guideline and literature studies ranged from 15-30 days to >500

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days, depending on the data available and the method of calculation. However, some of the studies were not carried out for long enough to establish the decline of phorate sulfone.

EFED cannot confidently state a half-life long enough that ground water contamination will tend to occur. Nor can EFED say with much confidence that half-lives below a specific number of days will *not* lead to ground water contamination. In general, the risk of ground water contamination will increase with increasing persistence and mobility, and will depend on the treated soils, the depth to ground water, and the general climate.

Regarding possible chronic effects of metabolites, EFED has calculated chronic risk quotients for aquatic organisms based on the estimated combined concentration of parent phorate, phorate sulfone, and phorate sulfoxide. Based on an assumption of equal toxicity of parent phorate and phorate degradates, EFED used toxicity values for parent phorate in these calculations. Inclusion of phorate degradates resulted in a several-fold increase in the values of risk quotients.

• Cyanamid disagrees with the mobility constants (K_{ads} values) that were presented and used in the RED and with EFED's interpretation of the mobility constants. Cyanamid cites a soil mobility study conducted by Cyanamid (MRID 40174525) containing lower estimates of leaching potential than a study conducted by another registrant (MRID 42208201).

Response: Cyanamid is correct in noting that the results from the laboratory studies can be taken as indicators of potential mobility and persistence. They also cite another soil leaching-adsorption-desorption study in which they claim total phorate residues are less mobile than in the study cited by EFED. However, it appears that the data they are citing are in the same range as the values EFED uses (K_{ads} of 5-10 versus K_{ads} of 1.8-12).

• Cyanamid disagrees with the value for anaerobic soil metabolism that was used by EFED: EFED used a value of 32 days; Cyanamid cites a value of 13.6 days.

Response: The registrant refers to Figure 3 of the anaerobic soil metabolism study and suggests that the half-lives of parent phorate and phorate sulfoxide are 13.6 and 6.9 days, respectively. Since the previous version of the RED Chapter, EFED has recalculated the half-life of 32 days. The data from the anaerobic phase of the study show a linear half-life of 26.5 days, instead of the 13.6 days cited by the registrant. Also, for phorate sulfoxide, it is not possible to calculate a half-life because the concentration appeared to increase with anaerobic incubation time. The data that support a 6.9 day half-life for phorate sulfoxide is not evident. Therefore, EFED contends that the half-life for parent phorate in anaerobic soil is 26.5 days, and that no half-life can be calculated for phorate sulfoxide.

• Cyanamid comments on EFED's Tier II EEC estimates. Cyanamid argues that PRZM3 can represent various incorporation practices more accurately and disagrees with various inputs used by EFED.

Response: Cyanamid argues that the PRZM 2.3 modeling contained errors in inputs, overestimated concentrations due to overconservative extraction routines, and did not accurately incorporate the compound (assumed uniform distributions instead of proper placements). EFED reran the modeling using PRZM 3.12, which uses the new incorporation and pesticide extraction features. EFED also recalculated the half-lives and incorporated additional information on the degradation of phorate and the formation and decline of phorate sulfoxide and sulfone in the field and in the pond. EFED then provided concentrations in the pond for parent phorate only and for parent phorate plus the sulfoxide and sulfone metabolites. The results of the modeling did not change our conclusions for parent phorate, and increased both the acute and chronic values because it took into account the metabolites.

EFED response to the Dec. 3 1990 memo, Gagne to Mautz.

In recent communications, Cyanamid has repeatedly cited a Dec. 3 1990 memo from J. Gagne to M. Mautz, particularly in connection with interpretation of the terrestrial incident B000150-015 (March 1989, Hughes County S. Dakota). The incident is associated with application to winter wheat in September of the year preceding the incident. The current EFED RED chapter treats the incident as probably due to phorate use and not attributable to misuse. In a review of EFED files we find no previous review of the Gagne-Mautz memo. In order to respond fully to Cyanamid's comments, the EFED team obtained and reviewed a copy of the Gagne Mautz memo.

The memo contains summaries of two studies, a study by the Fish and Wildlife Service (FWS), of phorate residues in tissues and environmental media from the incident location, and a study undertaken at South Dakota State University (SDSU), of dissipation of phorate residues in soil samples from the location of the incident. We find that some material from the FWS memo was incorporated in versions of the EFED RED chapter that EFED transmitted in December 1998. The discussion of the FWS study has been expanded somewhat in the revised RED chapter attached (see Section C.4.a(4)). For the SDSU study, the dissipation rate of parent phorate was similar to what has been observed previously in aerobic soil metabolisms studies, but the dissipation rate of the metabolites was significantly more rapid. Therefore, in order to use this information, EFED would need to review a complete description of the study.

The study at SDSU evaluated dissipation of parent phorate, phorate sulfone, and phorate sulfoxide in soil samples from 3 locations associated with the incident, at constant temperature (about 21°C or 70°F) and constant soil moisture (70% of field capacity by weight). EFED has suggested that the degradation of phorate might have been unusually slow under the conditions in the fall-winter following the incident. Cyanamid uses the results of the study to argue that degradation would not have been unusual. However, the study at SDSU does not appear to provide specific information related to the incident because environmental conditions in the study might poorly represent environmental conditions in the fall and winter preceding the incident. In particular, we are concerned with the possibility that there were lower temperatures and anaerobic conditions preceding the incident, relative to the conditions in the lab study. We

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expect some tendency for degradation to be slower under conditions of low temperature and low oxygen.

The FWS study reported that some samples contained phorate metabolites without detectable parent phorate. However, an exception was the gastrointestinal (GI) tract contents of one eagle, which reportedly had parent phorate at 0.7 ppm but concentrations <0.1 ppm for each metabolite. In addition a goose GI tract found within the eagle GI tract had parent phorate at 127 ppm, phorate sulfoxide at 12 ppm, and phorate sulfone at 0.11 ppm.

Cyanamid concludes that the goose was probably killed by ingesting undegraded phorate, and the eagle was killed as a result of eating the goose. Cyanamid suggests that the phorate that killed these two birds was not derived from the September application, arguing that enough time had elapsed since the September application date for parent phorate to have degraded completely to phorate sulfoxide and/or phorate sulfone. Cyanamid supports this conclusion using results of the study at SDSU.

We conclude that the results of the FWS study do not refute EFED's overall conclusion for the incident because they apply to only two of 100 birds killed in the incident. It is our understanding that results for tissues of other bird carcasses associated with the incident are consistent with the conclusion that an incident resulted from use according to labels. In addition, we suggest that there is still uncertainty regarding the dissipation of phorate parent and metabolites under the conditions of the incident, despite the results from the study at SDSU. Also, phorate sulfoxide and phorate sulfone contain an organophosphate functional group and may be toxic. Before reaching any definitive conclusion based on the FWS study, EFED would need to review all of the residue information available for the incident.

The Gagne-Mautz memo also reports that a piece of a THIMET bag was found about 150 yards from the pool where most of the carcasses were found, indicating some improper disposal of bags in the area. However, this does not establish that the incident was due to improper disposal.

OUTLINE OF SECTION C. ENVIRONMENTAL ASSESSMENT

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1. Environmental Fate

a. Environmental Fate Assessment

Surface and ground water contamination may occur from the *sulfoxide and sulfone degradates of phorate, as well as from parent phorate*. However, the risk of water contamination is *primarily associated with phorate sulfone and phorate sulfoxide* rather than parent phorate based on increased persistence and mobility for the degradates.

Phorate itself (*parent phorate*) is *not persistent* in the environment. It has been shown to degrade in soil by chemical and microbial action and to dissipate in the field with half-lives of 2 - 15 days. It is *moderately mobile* in soil, and has been shown to leach to a maximum depth of 6 inches in loamy sand and sandy loam soils. Phorate is subject to rapid hydrolysis with a $t_{1/2}$ of about 3 days. Due to the limited migration and the rapid hydrolysis, parent phorate is not expected to pose a significant risk to ground water. In contrast to phorate, the *phorate degradates*, phorate sulfoxide and phorate sulfone, are both *more persistent and more mobile* in the environment.

While phorate contamination of *surface water* by surface runoff may be an acute problem, the rapid hydrolysis will tend to lessen the concentration in a relatively short period of time.

The aerobic soil metabolism half-lives ($t_{1/2}$s) are 100 days (linear) and 54 days (non-linear) for the sulfoxide and 30 days (non-linear) and 15 days (linear) for the sulfone. The 30-day non-linear half-life may be underestimating the true half-life of phorate sulfone in soil because the lack of fit in the non-linear model (r^2=0.43). No meaningful linear fit for decline of the sulfone metabolite was possible because of limited decline intervals. However, the potential of these degradates to migrate in soil was demonstrated in a Georgia field dissipation study where phorate sulfone was found at 12-18 inches depth and phorate sulfoxide at 6-12 inches depth. There is a *potential for ground water contamination by parent phorate and the degradates phorate sulfone and phorate sulfoxide*. The Agency has no reports of detections of these degradates (or phorate parent) in ground water; however, the degradates have been analyzed for in only 12 samples. Because there has been very limited sampling for phorate degradates in ground water, *the current lack of detections does not mean that these degradates are not leaching to ground water.*

Surface water may be contaminated by phorate and phorate degradates. The degradates may be available for runoff for a longer period than parent phorate because they have a greater tendency to partition preferentially to water and are more persistent. Parent adsorption to permeable soils low in organic matter is low to moderate with Freundlich K_{ads} = 1.5 - 3.5. The anaerobic soil metabolism $t_{1/2}$ is 26.5 days.

Results of modeling with PRZM and EXAMS indicated that residues of phorate and the total toxic residues are expected to reach surface and ground water, with more residues of phorate sulfoxide and sulfone estimated to reach water than parent phorate.

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Formaldehyde has been observed as a Phorate degradate in studies where hydrolysis is a major route of dissipation. This includes hydrolysis, aqueous photolysis, and the aerobic aquatic pond water studies.

b. Environmental Fate and Transport

(1) Degradation

Hydrolysis of Parent Phorate (161-1)--Phorate degraded with calculated half-lives of 2.6, 3.2, and 3.9 days in pH 5, 7, and 9 buffer solutions, respectively. The primary degradation product was formaldehyde, which increased until the end of the study (14 days). No OP metabolites were present at significant levels in the study. (MRID #41348507)

Hydrolysis of Parent Phorate and Phorate Sulfoxide and Sulfone (161-1)--The study was conducted using different temperatures for parent compound (10, 20, and 30 °C) than those used for Phorate sulfoxide and sulfone. In addition, the registrant conducted the pH 5 and 7 studies for Phorate sulfoxide and sulfone at 40, 50, and 60 °C and pH 9 metabolite studies at 20, 30, and 40 °C. This study design generally indicates that the compounds degrade faster at higher temperatures, regardless of pH. (MRID 44863001)

EFED did not use this study for risk assessment since the registrant provided the aerobic aquatic pond water study (MRID 44863002, 162-4) described below. The aerobic aquatic pond water study provided useful inputs for the EXAMS model.

Photolysis in water (161-2)--Phorate degraded with a dark control adjusted half-life of 1.9 days in pH 7 buffer solutions after 7 days of continuous irradiation. Formaldehyde was the major non-OP degradate formed in the study. Phorate sulfoxide ranged from 7-27 % of applied parent phorate in no particular pattern in the study. (MRID #41348508)

Aerobic soil metabolism (162-1)--The registrant provided several aerobic soil metabolism studies for parent phorate and the metabolites. Two of these were literature studies (Getzwin and Shanks, J. Econ. Entom. 63:52-58; and Chapman et al., J. Econ. Entomol. 75:112-117, 1982). The other studies (MRID 42459401; 41131112; 40077301) were conducted according to guidelines and were considered to be acceptable in previous documents. These studies were used to assess the potential for parent phorate to reach surface and ground water. However, the results from these guideline studies were not used for modeling for surface or ground water in the current RED chapter. EFED normally uses the results of studies conducted according to guidelines for modeling purposes. However, since the guideline aerobic soil metabolism study was not carried out to enough time intervals to address the formation and decline of phorate sulfone, EFED used the data from the Getzwin and Shanks article as model inputs. EFED did not present the data from the other aerobic soil metabolism studies (MRID 40077301 and Chapman, et al., 1982) in the current RED Chapter, but notes that the other studies provided similar results for persistence and formation percentages of phorate sulfoxide and sulfone.

Phorate degraded in a Sultan silt loam soil with a half life of 15.8 days calculated using linear regression (log concentration against time), and with a half life of 8.3 days calculated by fitting the first-order degradation model using nonlinear regression, with untransformed concentration measurements. The 15.8-day half-life was originally calculated in previous documents, but EFED recalculated this half-life using non-linear regression because formation and decline analysis was used for modeling purposes. The major metabolites were Phorate sulfoxide, Phorate sulfone, and CO_2. Non-linear half-lives for these metabolites were 54.5 and 30.4 days, respectively, calculated using nonlinear regression. The maximum concentrations of these metabolites were 33, 24, and 22%, respectively. The results of this study were used for PRZM modeling because the formation and decline of the Phorate metabolites was addressed in a silt loam soil, which is the predominant soil texture used to support corn production. (Getzwin and Shanks, J. Econ. Entom. 63:52-58)

Anaerobic soil metabolism (162-2)--Phorate degraded with a linear anaerobic half-life of 26.5 days in nonsterile flooded silt loam soil that was incubated under a nitrogen atmosphere for 60 days following 9 days of aerobic incubation. No nonlinear regressions were conducted since formation and decline analysis was not possible. The phorate sulfoxide metabolite varied between 1.8 and 8.7 % of applied after anaerobic conditions, and therefore no half-life could be calculated. Parent Phorate was 21.4% of the applied dose after 60 days of anaerobic conditions. The major non-OP metabolite was CO_2, which increased to a maximum of 32.5% of the applied dose. No other metabolite increased to more than 3.3 % of applied. The volatile residues increased with time to 35.5% at 60 days. The soil-extractable and water residues decreased with increasing anaerobic time, and the soil residues were approximately 3-5X those of the flood water. Because the conditions were aerobic initially, the calculated anaerobic half-life is probably an underestimation of the true anaerobic soil half-life. (MRID #s 41936002; 41936002; 40077302)

Aerobic Aquatic Metabolism in Pond Water Only (162-4)–The pond water study is acceptable and provides useful information for modeling purposes. EFED used these data in EXAMS to determine the persistence of parent Phorate, Phorate sulfoxide, and Phorate sulfone, the formation rate of Phorate sulfoxide from applied parent, and the formation rate of Phorate sulfone from applied sulfoxide. Parent Phorate degraded with an aerobic aquatic half-life of 0.5 days (upper 10^{th} confidence bound on mean of two replicates) using non-linear analysis in nonsterile pond water that was incubated for 30 days. Parent Phorate reached non-detectable levels by 10 days. Applied Phorate sulfoxide degraded with a half-life of 9 days (upper 10^{th} confidence bound on mean of two replicates) and declined to 20.6 % of applied by 55 days in one replicate (end of study) and to non-detectable levels by 30 days. Applied Phorate sulfone degraded with a calculated half-life of 20.9 days (upper 10^{th} confidence bound on mean of two replicates) and declined to 35.2-38.2 % of applied by 30 days (end of study). The major metabolite of parent phorate was formaldehyde, which reached 24.5-25 % of applied by 2-3 days after treatment. Formaldehyde decreased to 13.1-16.6 % of applied by 14 days after treatment. Since formaldehyde formed at higher quantities than sulfoxide, this indicates that hydrolysis proceeded faster than metabolism that would produce sulfoxide and sulfone metabolites. However, formaldehyde was not formed in as great a quantity from applied sulfoxide and sulfone (<10 % of applied).

For the degradation of phorate sulfoxide to phorate sulfone, EFED added the residues of des-ethyl phorate sulfoxide to the phorate sulfone to determine the percent of toxic residues formed from applied phorate sulfoxide. (MRID #44863002)

(2) Mobility

The mobility information for parent Phorate and the sulfoxide and sulfone metabolites is presented below in Table 1. Parent Phorate is moderately mobile, and the sulfoxide and sulfone metabolites are more mobile than parent phorate.

		Adsorption Coefficients	
Chemical	Soil	K_{ads} (ml/g)	K_{oc}(ml/g)
Parent Phorate[1]	DE sand (0.4 % OC, pH 6)	1.8	450
	NJ sandy loam (1.8 % OC, pH 6.9)	4.0	224
	NE silt loam (1.3 % OC, pH 5.2)	5.6	434
	ONT loam (1.7 % OC, pH 7)	12	706
Phorate Sulfoxide[2]	Beulah sandy loam (0.29 % OC, pH 6.5, AR)	0.6	210
	Sassafras loamy sand (0.58 % OC, pH 6.9, NJ)	0.5	91
	Tippencanoe silt loam (1.8 % OC, pH 5.2, IN)	3.1	172
	Plano loam (1.4 % OC, pH 7.1, WI)	0.9	71
Phorate Sulfone[3]	Beulah sandy loam (0.29 % OC, pH 6.5, AR)	0.44	152
	Sassafras loamy sand (0.58 % OC, pH 6.9, NJ)	0.63	109
	Tippencanoe silt loam (1.8 % OC, pH 5.2, IN)	2.57	143
	Plano loam (1.4 % OC, pH 7.1, WI)	0.9	65

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[1] The soil series information for the parent phorate study was not included because it was not immediately available (MRID 42208201). The adsorption of parent phorate was related to soil organic carbon content (r^2=0.39) and clay content (r^2=0.51), but not soil pH (r^2=0.02).
[2] The information for phorate sulfoxide was included in MRID 44671204. The adsorption of phorate sulfoxide was related to soil organic carbon content (r^2=0.67), clay content (r^2=0.45), and soil pH (r^2=0.97).
[3] The information for phorate sulfone was included in MRID 44671205. The adsorption of phorate sulfone was related to soil organic carbon content (r^2=0.74), clay content (r^2=0.55), and soil pH (r^2=0.95).

Soil Column Leaching Study (MRID 42208201)

The sulfone degradate was mobile in aged soil columns of loamy sand and sandy loam soils and was uniformity distributed in the column. Sulfoxide was found in the leachate at 12% and 3 %, respectively, in loamy sand and sandy loam soils. Parent did not move below 6 inches in the column. Parent appears to be moderately mobile in most mineral soils, but the degradates are more mobile than parent. Phorate sulfoxide is more mobile than phorate sulfone, and both degradates are more mobile than parent phorate. (MRID 42208201)

(3) Accumulation

The maximum accumulation in edible portions of fish was 326X. After 14 days depuration, approximately 90% of the residues were eliminated. (MRID 42701101)

(4) Field Dissipation

In general, parent phorate is not a persistent chemical; it degrades by chemical and microbial action and dissipates in the field with half-lives of 2 - 15 days. In a Georgia field dissipation study on sandy loam soil (MRID 42547701) parent did not move below 6 inches in soil, but phorate sulfone was found at 12-18 inches depth and phorate sulfoxide was found at 6-12 inches depth. The total toxic residue half-life (parent+sulfoxide+sulfone) was 17 days (non-linear) and 48 days (linear). In an Illinois study on silt loam soil (MRID 40586506) a comparable half-life of 9 - 15 days was observed for parent phorate. The total toxic residue half-life in Illinois was 108 days (non-linear) and 117 days (linear). No leaching of either the parent of degradates below 6 inches was observed. in the Illinois study. (MRID 40586500)

(5) Laboratory Volatility

Maximum volatility rates of 7.5 - 13.3 ug/cm^2/hr were observed at 3 days with corresponding maximum air concentrations of 530 - 1400 ug/m^3 from soil moistures of 50 and 75% FMC and flow rates of 100 and 300 mu/min. Phorate was 68 -71% of the applied material in the foam plug extracts at 14 days post treatment. Phorate sulfoxide was <5% in the foam plug extracts and phorate sulfone was present at <0.3%. In the soil extracts plus flask rinsates phorate was measured at 14.2 - 27.5% of the applied and the degradates, phorate sulfoxide and phorate sulfone, were measured at 3.1 - 6.4 and 0.7 - 4.5% respectively. (MRID 42930301)

3. Water Resources

Environmental fate properties of phorate and phorate degradates, reviewed above in the Environmental Fate Assessment, suggest that *surface water* contamination may occur from the *sulfoxide and sulfone degradates of phorate, as well as from parent phorate*. The risk of *ground water* contamination is *primarily associated with phorate sulfone and phorate sulfoxide* rather than parent phorate. This section provides evaluation of available monitoring information and modeling results estimating environmental concentrations, for *parent phorate*, for use in assessing dietary exposure and exposure to aquatic nontarget organisms. The information available on fate properties of phorate degradates is not sufficient for modeling concentrations in ground and surface water. (In particular, the Agency does not have values for mobility constants (K_{oc}'s) for the principal degradates.)

a. Surface Water

Phorate Occurrence in Surface Water. The State of Illinois (Moyer and Cross 1990) sampled 30 surface water sites for pesticides at various times from October 1985 through October 1988. Although substantial use in Illinois was a criteria for pesticides being included in the analyses, total phorate (parent phorate + phorate sulfoxide + phorate sulfone) was not detected in any of the samples above a detection limit of 0.05 ug/L.

The USGS (Kimbrough and Litke 1995) has sampled the South Platte River in Colorado, Western Lake Michigan, and the Albemarle-Pamlico River in Virginia and North Carolina for parent phorate. With a detection limit of 0.002 ug/L, detected residues of parent phorate ranged from 0.009-0.082 ug/L except for one detection of 0.6 ug/L in the South Platte. These watersheds are locations where corn, grain sorghum, and sugar beets are grown. EFED counted 104 samples. USGS monitoring is designed to measure water quality in a watershed with an area of 10-2,000 square miles that is associated with specific chemical use. It is not specifically designed to measure drinking water exposure. Degradates were not analyzed for.

The USGS (Coupe et al., 1995) sampled 8 widely dispersed locations in the Mississippi Basin from April 1991 through September 1992. Samples were collected once per week, twice per week, or once every two weeks depending upon the time of year. The samples were filtered before analysis. Parent phorate (dissolved) was not reported in any of the 360 samples (detection limit of 0.011 ug/L) for which an analysis for phorate was performed. Degradates were not analyzed for.

The South Florida Water Management District (Miles and Pfeuffer 1994) collected samples every two to three months from 27 surface water sites within the SFWMD from November 1988 through November 1993. Approximately 810 samples (30 sampling intervals X 27 sites sampled/interval) were collected from the 27 sites from November 1988 through November 1993. Phorate was not detected in any of the samples above detection limits ranging from 0.016 to 0.13 ug/L.

Monitoring for phorate residues in surface water does not usually include the phorate sulfoxide and sulfone degradates. Also, there is limited monitoring information for all phorate residues in surface water.

Tier II Estimated Surface Water Concentrations. Tier II estimated environmental concentrations (EECs) have been calculated for parent phorate and for total toxic residues of parent phorate. A Tier II EEC for a particular crop or use is based on a single site that represents a high exposure scenario for the crop or use. Tier II EECs are used to assess drinking water exposure and exposure to aquatic organisms for surface water. (These results are used as the basis of exposure estimates for dietary risk assessment displayed in the Drinking Water Assessment below.)

- Table 2 below gives persistence and mobility inputs used in calculating EECs.

- Table 3 below gives EECs estimated using the PRZM (Version 3.12) and EXAMS (Version 2.975) models.

To calculate a Tier II EEC, weather and agricultural practices are simulated at the site for 36 years to estimate the probability of exceeding a given concentration (maximum concentration or average concentration) in a single year. Maximum EECs are calculated so that there is a 10% probability that the maximum concentration in a given year will exceed the EEC at the site; 4-day, 21-day, 60-day, and 90-day EECs are calculated so that there is a 10% probability that the maximum average concentration for a given duration (4-day, 21-day, etc.) will equal or exceed the EEC at the site. Maximum EECs can also be considered to represent a 1-in-10-year exceedance.

EFED estimated drinking water concentrations for phorate applied to field and sweet corn, peanuts, cotton, potatoes, and grain sorghum. The simulated application techniques included t-banded, in-furrow at planting and side-dress application once the applicable crop had emerged. These crops represented the maximum application rates and primary crops to which phorate is applied, and give the maximum EECs for applied phorate. EFED did not run the sugarcane scenario because the label specifically states that this use is for Florida. Florida sugarcane is grown primarily around Lake Okechobee, and the water levels in the fields are managed by flooding canals. Therefore, it is impossible to properly simulate this scenario because of fluctuating water levels. In previous RED Chapters, EFED ran sugarcane in Louisiana , but is no longer using this scenario for phorate in sugarcane. EFED also did not run winter wheat (North Dakota), soybeans (Iowa), dried beans (Michigan), and potatoes in Maine in the current RED Chapter. Winter wheat produced relatively low EECs as compared to other crops. Soybeans and dried beans are relatively minor uses compared to other crops, and phorate is not used significantly in Maine for potatoes. Also, EFED is now using an Ohio field corn scenario instead of the Iowa field corn scenario used in previous RED Chapters.

For field corn, sweet corn, and grain sorghum two applications per year are allowed by the labels. EFED only modeled the at-plant application, based on the fact that the 9/16/97 fax from John Wrubel of Cyanamid stated that "greater than 95% of phorate applied to each these crops is applied at planting." Simulating two applications per year will not qualitatively effect the ecological level of concern exceedances.

Comparison of Modeling and Monitoring. Maximum concentrations of parent phorate estimated using PRZM-EXAMS ranged from 4.6 ug/L for field corn in Ohio to 27.6 ug/L for cotton in Mississippi. In surface water bodies with dilution the actual concentrations would likely be lower. The estimated chronic concentrations for all modeled crops ranged from 0.04-1.6 ug/L. Parent phorate was not found above 0.6 ug/L in surface monitoring data from Colorado, and most monitoring does not address the sulfoxide and sulfone metabolites. Therefore, EFED recommends using the total toxic residue EECs from PRZM-EXAMS modeling for drinking water estimates.

EFED simulated only the banded or lightly-incorporated applications of phorate, with the exception of potatoes, for which phorate is applied in-furrow. EFED did this because the PRZM-EXAMS model is likely underpredicting residues off the field when the pesticide is applied below 1 inch of soil depth. PRZM does not move pesticides upward from a fixed depth even though this can occur in the field in finer-textured soils through capillary action.

Table 2. Environmental Fate Parameters used in PRZM-EXAMS Modeling for Parent Phorate, Phorate sulfoxide, and Phorate sulfone.

Parameter	Value	Source (MRID unless specified)	Uncertainty Factor[1]	Rate Constants (K-value)
Parent Phorate				
Freundlich K_{ads}	4.04 ml/g	42208201	Not Applicable	Not Applicable
Aerobic Soil Metabolism $T_{1/2}$	8.27 days[2]	Getzwin and Shanks	None	8.40×10^{-2} day^{-1}
Aerobic Aquatic Metabolism $T_{1/2}$	0.457 days[3]	44863002	None	1.9×10^{-2} hour^{-1}
Anaerobic Aquatic Metabolism $T_{1/2}$	Not Applicable	None	None	0 hour^{-1}
Phorate sulfoxide				
Freundlich K_{ads}	0.53 ml/g/	44671204	Not Applicable	Not Applicable
Aerobic Soil Metabolism $T_{1/2}$	54.5 days[2]	Getzwin and Shanks	None	1.27×10^{-2} day^{-1}
Aerobic Aquatic Metabolism $T_{1/2}$	9.06 days[3]	44863002	None	3.19×10^{-3} hour^{-1}

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Anaerobic Aquatic Metabolism $T_{1/2}$	Not Applicable	None	None	0 $hour^{-1}$
Phorate Sulfone				
Freundlich K_{ads}	0.90 ml/g	44671205	Not Applicable	Not Applicable
Aerobic Soil Metabolism $T_{1/2}$	30.35 days[2]	Getzwin and Shanks	None	2.30×10^{-2} day^{-1}
Aerobic Aquatic Metabolism $T_{1/2}$	20.9 days[3]	44863002	None	1.38×10^{-3} $hour^{-1}$
Anaerobic Aquatic Metabolism $T_{1/2}$	Not Applicable	None	None	0 $hour^{-1}$

[1] For laboratory metabolism studies, EFED normally multiplies a single metabolism study $T_{1/2}$ by 3 to account for the uncertainty of having only one half-life. Since EFED conducted a formation and decline analysis, no uncertainty factors were included, and the value given in Column 2 has been used in PRZM-EXAMS modeling, after conversion to a rate constant (Column 5).

[2] EFED used the lowest non-sand Kd values for each species, since adsorption was not significantly correlated with % organic carbon.

[3] $T_{1/2}$ values used for PRZM-EXAMS modeling were calculated by fitting the first-order dissipation model using nonlinear regression with untransformed concentration measurements. For the KBACS (pond sediment) rate value in EXAMS, EFED assumed no degradation, due to an absence of adequate anaerobic data.

[4] Since the aerobic aquatic metabolism study included two replicates of each treatment, EFED calculated a 90% upper confidence limit on the mean $T_{1/2}$ for the two replicates. EFED then converted these half lives to rate constants, and used them as inputs into the model.

Table 3. EECs for Surface Water Including Parent Phorate only and for Total Toxic Residues of Parent Phorate, Phorate Sulfoxide, and Phorate Sulfone.

Crop and Application Method	Parent only or Total toxic residue	EECs (ug/L)					
		Peak	4-Day	21-Day	60-Day	90-Day	Annual Mean
Sweet Corn T-banded at 1.3 lb ai/A (85 % in top 2 cm) [1]	Parent	21.3	13.6	3.3	1.2	0.8	0.2
	TTR	26.9	18.6	8.2	5.9	4.5	1.2
Peanuts (1.64 lb ai/A at plant in- furrow and 2.9 lbs a/A side- dressed 90 days prior to harvest	Parent	18.1	9.0	2.0	0.7	0.5	0.1
	TTR	25.2	16.0	8.8	4.7	3.4	0.9
Cotton (In-furrow at 0.5 inch)	Parent	23.1	13.2	3.9	1.4	0.9	0.2
	TTR	27.6	21.0	12.4	8.2	6.1	1.6
Potatoes in Idaho in-furrow (all at 2 inches of depth)	Parent	0	0	0	0	0	0
	TTR	0	0	0	0	0	0
Field Corn T-banded at 1.3 lb ai/A (85 % in top 2 cm) [1]	Parent	4.6	2.5	0.7	0.2	0.2	0.04
	TTR	7.7	5.7	3.9	2.5	1.8	0.5
Grain Sorghum T-banded at 1.3 lb ai/A [1] (85 % in top 2 cm)	Parent	7.5	4.1	1.2	0.4	0.3	0.07
	TTR	12.7	9.5	7.1	4.2	3.0	0.85

[1] Simulations for sweet corn, field corn, and grain sorghum have assumed a single application per year, while labels permit two applications per year. EFED is conducting simulations that assume 2 applications per year for these crops.

b. Ground Water

Occurrence of phorate in ground water. Review of environmental fate properties suggests that there is a potential for ground water contamination by the degradates phorate sulfone and phorate sulfoxide. The Agency has no reports of detections of these degradates (or phorate parent) in ground water; however, the degradates have been analyzed for in only 12 samples. Because there has been very limited sampling for phorate degradates in ground water, *the current lack of detections does not mean that these degradates are not leaching to ground water.*

A number of insecticides, including phorate, have been included as analytes in ground-water monitoring studies conducted by federal, state, or local agencies and chemical companies. Many of these studies are summarized in the Pesticides in Ground Water Database (PGWDB; Hoheisel, 1992). The PGWDB reports that parent phorate has not been detected in 3,341 ground-water samples summarized, which is consistent with the results of the laboratory and field dissipation studies. There were no detections of the degradates phorate sulfoxide and sulfone in 12 samples and phoratoxon sulfone and phoratoxon sulfide in 9 samples collected in California (USEPA, 1992). Fate data indicate that the degradates would likely be detected in vulnerable ground water if more extensive sampling were conducted. Phorate sulfoxide was detected at 6-12 inches depth and phorate sulfone at 12-18 inches depth in a terrestrial field dissipation study in Georgia with permeable soils and normal rainfall.

Estimated concentrations in ground Water (SCI-GROW). The table below displays estimates of parent phorate in ground water based on the SCI-GROW model (Barrett, 1997). (These results are also used in estimating concentrations for dietary exposure assessment as described in the Drinking Water Assessment below.)

SCI-GROW (Screening Concentrations in Ground Water) is a model for estimating "upper bound" concentrations of pesticides in ground water. SCI-GROW calculations are based on application rates, scaled ground water concentrations from ground water monitoring studies, and environmental fate properties (aerobic soil half-lives and organic carbon partitioning coefficients-Koc's). SCI-GROW provides a screening concentration; an estimate of likely ground water concentrations if the pesticide is used at the maximum allowed label rate in areas with ground water exceptionally vulnerable to contamination (soils vulnerable to leaching, and ground water at 10-30 feet). In most cases, a majority of the use area will have ground water that is less vulnerable to contamination than the areas used to derive the SCI-GROW estimate.

For total toxic residues of phorate, SCI-GROW results predict that maximum acute and chronic concentrations in shallow ground water will not exceed 13.5 ug/L for the labeled use sites at the highest rate (4.5 lbs ai/A). Estimated concentrations ranged from 3.0 to 13.5 ug/L (Table 4 below). The estimated concentrations in ground water will be proportionally lower in relation to the amount applied because of the linear relationship between application rates and SCI-GROW estimates. Table 5 contains the input parameters for the model for each crop.

Comparison of modeling and monitoring results for ground water. Results obtained using SCI-GROW indicate maximum concentrations in ground water of 13.5 ug/L for total toxic residues of phorate. There are very limited data (12 samples) to compare the ground water levels against, and therefore, the lack of detections cannot be compared to the modeling. Therefore, HED should use the SCI-GROW modeling numbers instead of the monitoring, since almost all of the samples were for parent only. There are no detections of parent phorate in 3,341 samples in the Pesticides in Ground Water Database (PGWDB). This result is also consistent with results of field dissipation studies which indicated negligible downward mobility in soil.

Based on environmental fate data, EFED predicts that the more persistent degradates may be found at higher levels in ground water than parent phorate.

Table 4. Acute and Chronic Estimated Environmental Concentrations[1] of Total Toxic Residues of Phorate (Maximum Labeled Rates) in Ground Water using the Tier 1 Model SCI-GROW.

Crop	Rate (lbs ai/A)	Acute and Chronic EECs (ug/L)[1]
Corn	2.6	7.8
Grain Sorghum	2.6	7.8
Soybeans	2.0	6.0
Sugar Beets	3.0	9.0
Sugarcane	3.9	11.7
Wheat	1.0	3.0
Peanuts	4.5	13.5
Potato	3.5	10.5
Beans	2.0	6.0
Cotton	3.8	11.4

[1] SCI-GROW is a Tier 1 model that does not provide different values for acute and chronic EECs. Therefore, the same exposure estimate would be used for both acute and chronic risk assessment.

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Table 5. Input Values for SCI-GROW for Total Toxic Residues of Phorate.

Crop	Maximum Annual Rate (lbs ai/A)	Number of Applications[1]	Koc[2] (ml/g)	Aerobic Soil Metabolism Half-Life (days)[3]
Corn	2.6	1	65	122 days
Grain Sorghum	2.6	1	65	122 days
Soybeans	2.0	1	65	122 days
Sugar Beets	3.0	1	65	122 days
Sugarcane	3.9	1	65	122 days
Wheat	1.0	1	65	122 days
Peanuts	4.5	1	65	122 days
Potato	3.5	1	65	122 days
Beans	2.0	1	65	122 days
Cotton	3.8	1	65	122 days

[1] Since SCI-GROW only takes into account the total amount of applied pesticide in a year and not the timing of application(s), the EFED reviewer used only one application in the model.

[2] The lowest K_{oc} from both the sulfoxide and sulfone metabolites was used since the adsorption of these metabolites was related to soil pH (r^2=0.98 for sulfoxide and 0.95 for sulfone).

[3] The 122-day half-life was calculated by adding the parent phorate, phorate sulfoxide, and phorate sulfone residues from the aerobic soil metabolism study (MRID 4077301) and running linear regression (r^2=0.94) on the log of the summed residues.

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c. Drinking Water Assessment

Surface water concentrations for drinking water exposure assessment. Table 3 above contains surface water concentrations of total toxic residues of phorate for use in a dietary risk assessment, based on modeling with PRZM Version 3.12 and EXAMS version 2.975. Parent phorate concentrations were provided for comparison purposes only.

Limitations of Tier II Surface Drinking Water Assessment. Obviously, a single 10 hectare field with a 1 hectare pond does not accurately reflect the dynamics in a watershed large enough to support a drinking water facility. A basin of this size would certainly not be planted completely to a single crop nor be completely treated with a pesticide. Additionally, treatment with the pesticide would likely occur over several days or weeks, rather than all on a single day. This would reduce the magnitude of the concentration peaks, but also make them broader, reducing the acute exposure but perhaps increasing the chronic exposure. The fact that the simulated pond has no outlet is also a limitation as water bodies in this size range would have at least some flow through (rivers) or turnover (reservoirs).

In spite of these limitations, a Tier II EEC can provide a reasonable upper bound on the concentration found in drinking water if not an accurate assessment of the real concentration. The EECs have been calculated so that in any given year, there is a 10% probability that the maximum average concentration of a given duration will equal or exceed the EEC. Tier II values can reasonably be used as refined screens to demonstrate that the risk is below the level of concern.

Ground water concentrations for drinking water exposure assessment. Table 4 above contains ground water concentrations of total toxic residue of phorate for use in a dietary risk assessment, based on modeling with SCI-GROW.

Uncertainties in estimating ground water concentrations. The SCI-GROW model is based on small-scale ground water monitoring studies conducted on highly vulnerable sandy soils with shallow ground water (10-30 ft in depth). Uncertainties in the SCI-GROW model are: 1) The model does not consider site specific factors regarding hydrology, soil properties, climatic conditions, and agronomic practices; 2) The model does not account for volatilization, and 3) Predicted ground water concentrations are linearly extrapolated from the application rates. This model is based on actual field data from "upper bound" ground water monitoring studies conducted on sandy soils and with heavy irrigation. Therefore the results should be considered to be an "upper bound" for phorate and its residues in ground water.

4. Ecological Toxicity Data

a. Toxicity to Terrestrial Animals

(1) Birds

Acute and subacute toxicity. An acute oral toxicity study using the technical grade of the active ingredient is required to establish the toxicity of a pesticide to birds. The preferred test species is either mallard duck or bobwhite quail. Results of this test are tabulated below.

Avian Acute Oral Toxicity

Species	%A.I.	LD50 mg/kg (95% confidence limits)	Toxicity Category	MRID No. Author/Year	Study Classification[1]
Mallard Duck	96.8	0.62 (0.37-1.03)	very highly toxic	160000 Hudson 1984	Supplemental
Ring necked Pheasant	98.8	7.12 (4.94-10.3)	very highly toxic	160000 Hudson 1984	Supplemental
Starlings	Tech.	7.5	very highly toxic	20560 Schafer 1972	Supplemental
Redwing Blackbird	Tech.	1	very highly toxic	20560 Schafer 1972	Supplemental
Grackle	Tech.	1.3	very highly toxic	20560 Schafer 1972	Supplemental
Mallard Duck	88	2.55 (2.02-3.21)	very highly toxic	160000 Hudson 1979	Supplemental
Chukar	98.8	12.8 (3.2-51.2)	highly toxic	160000 Hudson 1984	Supplemental

[1] Study classification is divided into three categories: "Core" which indicates that the study fulfills guideline requirements, "Supplemental" which indicates that the study is scientifically sound but does not fulfill guideline requirements, and "Invalid" which indicates the study is neither scientifically sound nor does it fulfill guideline requirements. "Invalid" studies are not included in any of the tables or discussion in this RED.

The results indicate that phorate is very highly toxic to avian species on an acute oral basis. The guideline requirement (71-1) is fulfilled (MRID Nos 160000 & 20560). Although no one study is fully acceptable, the consistency of the results indicates no further testing is warranted.

Hudson (1984) described several behavioral indications of intoxication in mallards at 0.09 mg/kg, which is about 15% of the LD50 dose used in risk quotient calculations. Symptoms were observed as soon as 3 minutes after treatment (by gavage), death occurred between 10 minutes and 4 hours after treatment, and remission required up to 2 days.

Two dietary studies using the technical grade of the active ingredient are required to establish the toxicity of a pesticide to birds. The preferred test species are mallard duck (a waterfowl) and bobwhite quail (an upland gamebird). Results of these tests are tabulated below.

Avian Dietary Toxicity

Surrogate Species	% A.I.	LC_{50} ppm (95% Confidence Limits)	Toxicity Category	MRID No. Author/ Year	Study Classification
Northern Bobwhite	90	373 (326-431)	highly toxic	00022923 Hill 1975	Core
Ring-necked Pheasant	90	441 (381-510)	highly toxic	00022923 Hill 1975	Core
Mallard	90	248 (198-306)	highly toxic	00022923 Hill 1975	Core

These results indicate that phorate is highly toxic to avian species on an dietary basis. The guideline requirement (71-2) is fulfilled (MRID No. 00022923).

Chronic toxicity. Avian reproduction studies using the technical grade of the active ingredient are required for phorate because present product labeling allows several applications of the end-use product per growing season. Results of these tests are tabulated below.

Avian Reproduction

Surrogate Species[1]	% A.I.	NOEL (ppm)	Affected Endpoint	MRID No. Author/ Year	Study Classification
Northern Bobwhite Quail	92.1	>60	None	158333 Beavers/ 1986	Supplemental
Mallard Duck	92.1	5	Eggs laid, Viable embryos, Normal hatchlings	0158334 Beavers/ 1986	Core

The acceptable mallard study shows the ability of adult mallards to lay eggs, to produce viable embryos and to produce hatchlings is significantly inhibited when they are fed 60 ppm of the technical phorate, 92.1% a.i., for 19 weeks. The guideline requirements are only partially fulfilled by the quail study due to poor egg production in the controls. However, it is not likely the quail is more sensitive than the mallard. Therefore, another study is not requested. The guideline requirement (71-4) is fulfilled (MRID #0158333).

(2) Mammals

Wild mammal testing is required on a case-by-case basis, depending on the results of lower tier laboratory mammalian studies, intended use pattern and pertinent environmental fate characteristics. In most cases, rat or mouse toxicity values based on requirements for health effects studies substitute for wild mammal testing.

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An acute oral LD_{50} of 1.4-3.7 mg/kg for rats indicates that phorate is *very highly toxic to small mammals on an acute oral basis*. The dietary LC_{50} was found to be 28 ppm for the Albino Norway Rat. Also relevant to the risk to wildlife is significant dermal toxicity (Dermal LD_{50} 3.9 to 9.3 mg/kg in rats). Additional support for high dietary toxicity is provided by two 90 day feeding studies with rats and a 105 day feeding study with dogs, with cholinesterase inhibition as the measurement endpoint.

The 90 day feeding studies with phorate and phorate sulfoxide show cholinesterase differences from the control at very low concentrations, the NOAELS are 0.66 ppm and 0.32 ppm, respectively. The Agency has not adopted descriptive toxicity categories for the results of mammalian chronic studies. The human health section of the RED provided insight into the above study and the 105-day feeding study:

The health effects data indicated that "Phorate can be metabolized to more potent anticholinesterase compounds through oxidative desulfuration and/or sulfide oxidation. These processes would produce phorate oxygen analog, phorate sulfoxide, phorate oxygen analog sulfoxide, phorate sulfone, and phorate oxygen analog sulfone."

(3) Insects

A honeybee acute contact study using the technical grade of the active ingredient is not required for granular formulations. However, studies have been submitted. The following table tabulates the available bee studies.

Nontarget Insect Acute Toxicity

Surrogate Species	% A.I.	LD_{50} (μg/bee)	Toxicity[1] Category	Author/ Year	Study Class.
Honeybee	Tech.	0.32	Highly toxic	Steveson/1978	Core
	Tech.	10.07	Moderately toxic	Atkins/1975	Core

The results indicate that phorate is moderately to highly toxic to honeybees on an acute contact basis. These studies fulfill guideline requirement (141-1) (MRID 05001991; 00036935).

Exposure to honeybees is expected to be minimal for a granular pesticide. However, a variety of beneficial insects may be associated with soil, including Hymenoptera other than honeybees.

(4) Terrestrial Field Testing and Incidents

Simulated Field Studies. Small pen studies are simulated field studies with cages (pens) of birds and /or mammals placed in a treated crop.

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• Four pen studies have been conducted to evaluate the effect of phorate on bobwhite quail. Because this type of study did not address all of the species and stresses associated with a particular use site the amount of useful information is limited. The following findings from these bobwhite quail studies are of interest to the risk assessment.

1. Thimet 20G was applied to both irrigated and non-irrigated corn. Mortality occurred on all treated plots (MRID No. 00074623).

2. Although the quail is not as sensitive to phorate as the mallard duck, red winged blackbird, or common grackle, four pen studies with quail showed mortality.(MRID Nos. 00074623; 0074624; 00074625; 00074626)

3. Both whorl and soil application resulted in adverse effects. (MRID Nos. 00074623; 0074624; 00074625; 00074626)

• A littoral mesocosm field study was conducted in the Prairie Pothole Region of South Dakota. Three mesocosms were treated in both the upland and wetland portions of the mesocosm with phorate at the following rates: 1, 2, and 4.3 lbs a.i./A. Mallard ducklings were the surrogate species. The ducklings died at all three treatment levels. In the second year of the study 15 of 24 ducklings required restocking on days 2-3 post-treatment due to high mortality. (MRID No. 43819501)

Field Studies. A field study was conducted using phorate on corn with at-plant, at-cultivation, and aerial applications. The usefulness of the study was limited because the researchers did not sufficiently search the treated areas. Even so, the study showed that phorate granules kill birds and mammals. Among the killed and poisoned species found were a peacock, raccoon, indigo bunting, goldfinch, short-tailed shrews, and starlings. Residue analysis indicated that phorate and its degradates were sufficient to cause death to birds and mammals for two to three weeks after application, at least for aerial application methods and possibly for application by other procedures as well. (MRID No. 40165901)

Terrestrial Incidents (see also Appendix 2 for Table of Incidents). A number of terrestrial incident reports are available. Together with the field studies, these indicate that the use of phorate will result in adverse effects. The incidents demonstrate mortality to a wide range of vertebrate species. The incidents are discussed further in the risk characterization.

The incident information suggests that poisoning of wildlife by phorate and/or phorate degradates may occur several months following application. Fall applications in cool climates may pose a particular hazard. In particular, there are three incidents supporting high avian risk associated with fall applications for winter wheat, with no indications of misuse or very limited indications of misuse. Of these, two occurred months after application:

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- B000150-015 (Hughes County S. Dakota) involved over 100 birds (primarily waterfowl and raptors.) The incident occurred in March following a September application.

- Reports associated with incident number B000150-008 appear to represent two incidents associated with winter wheat in S. Dakota, of which only one (in Potter County) is attributable to misuse. The incident occurred in Lyman County occurred in October.

- B000150-016 involved mortality in the January following a November application to wheat in Georgia. The indications of misuse for that incident are minimal: Phorate was applied to soil that was too wet for adequate soil coverage of applied granules.

The incident that has been the subject of most attention and research has been B000150-015. On March 26, 1989, Thimet 20G killed birds on a winter wheat field in Hughes County, SD, 10 miles north of Pierre, that was treated on September 20, 1988 at the application rate of 1.2 oz/1000 foot row with a 10-inch row spacing. The incident report did not specify the application method but did report that the granules were incorporated. If label instructions were followed, the 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 second 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.

Analysis by the Fish and Wildlife Service detected phorate metabolites but not parent phorate in some tissue samples; however, the results for one eagle carcass was exceptional in having parent phorate at a high concentration relative to concentrations of the metabolites, in the gastrointestinal (GI) tract. Also the eagle GI tract contained a goose GI tract with parent phorate at a relatively high concentration. American Cyanamid has argued that the goose was mostly killed by ingesting undegraded phorate and the eagle was then killed by feeding on the goose carcass (J. Gagne to M. Mautz, Dec. 3, 1990). Cyanamid maintains that exposure to parent phorate in March could not result from an application in September given the degradation rate of parent phorate. Before reaching any definitive conclusion based on the FWS study, EFED would need to review all of the residue information available for the incident.

The Gagne-Mautz memo also reports that a piece of a THIMET bag was found about 150 yards from the pool where most of the carcasses were found, indicating some improper disposal of bags in the area. However, this does not establish that the incident was due to improper disposal.

EFED finds that Cyanamid's argument does not refute the use of the incident as a whole as an indication of adverse effects corresponding to normal use. Primarily, this is because the results apply to only two of a large number of carcasses. For most of the carcasses the results are consistent with the conclusion that an incident resulted from normal use. In addition, there is some uncertainty regarding the dissipation of phorate residues in fall-winter conditions in South Dakota.

b. Toxicity to Aquatic Animals

(1) Freshwater Fish

Acute toxicity findings. Two freshwater fish toxicity studies using the technical grade of the active ingredient are required to establish the toxicity of a pesticide to fish. The preferred test species are rainbow trout (a cold-water fish) and bluegill sunfish (a warmwater fish). Results of these tests are tabulated below.

Freshwater Fish Acute Toxicity

Surrogate Species	% A.I.	LC_{50} (ppb)	Toxicity Category	MRID No. Author/Year	Study Class.
Rainbow trout *(Onchorynchus mykiss)*	100	13	Very highly toxic	40094602/ Johnson & Finley/ 1980	Core
Bluegill sunfish *(Lepomis macrochirus)*	100	1	Very highly toxic	40098001/ Mayer & Ellersieck/ 1986	Core

The results indicate that phorate is very highly toxic to freshwater fish on an acute basis. The guideline requirement (72-1) is fulfilled. (MRID Nos. 40094602 & 40098001)

Chronic toxicity findings. A fish early life stage test is required for phorate because LC_{50} is < 1 mg/kg and monitoring data indicate that phorate (6.8 and 32.2 ppb) was present in a pond where fish died. Results of this test are tabulated below.

Freshwater Fish Early Life-Stage Toxicity

Surrogate Species	% A.I.	NOEC/LOEC (ppb)	MATC (ppb)	Endpoints Affected	MRID No. Author/Year	Study Class.
Rainbow trout *(Onchorynchus mykiss)*	92.1%	1.9/4.2	2.6 μg/L	Total length	158335/ Surprenant/ 1986	Core

The guideline requirement (72-4a) is fulfilled (MRID #158335). The NOEC, MATC, and LOEC are very low and indicate minimal concentrations are needed to effect growth.

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A full life cycle study is not required. The rainbow trout early life stage NOEC was used to estimate an NOEC for the bluegill sunfish. The resultant risk quotients exceed the chronic effects LOC. Although the full life cycle study is expected to provide a lower NOEC, all LOCs are exceeded with the short term study.

(2) Freshwater Invertebrates

Acute toxicity findings. A freshwater aquatic invertebrate toxicity test using the technical grade of the active ingredient is required to assess the toxicity of a pesticide to invertebrates. The preferred test species is *Daphnia magna*. Results of this test are tabulated below:

Freshwater Invertebrate Acute Toxicity

Surrogate Species	% A.I.	LC_{50}/ EC_{50} ppb (confidence limits)	Toxicity Category	MRID No. Author/Year	Study Classification
G.fasciatus	Tech	0.68 (0.36-1.0) 0.60 (0.3-0.8)	Very highly toxic	05017538 Sanders/1972	Supplemental
G.fasciatus	Tech	9(5.1-13)	Very highly toxic	0097842 Sanders/1969	Supplemental
G.fasciatus	Tech	4(2-7)	Very highly toxic	0003503 Johnson/1980	Supplemental
Pteronarcys	100	4(2-6)	Very highly toxic	0003503 Johnson/1980	Supplemental
Orconectes nais	Tech	50 (30-75)	Very highly toxic	05017538 Sanders/1972	Supplemental
			Formulation Testing[1]		
Daphnia magna	20% (Thimet 20G)	37(30-44)	Very highly toxic	0161825 Nicholson/ 1986	Core
Midge larvae (*Paratanytarsus parthenogenica)*	20% (Thimet 20G)	41(38-45)	Very highly toxic	0161826 Nicholson/ 1986	Core
Mayfly nymphs (*Hexagenia sp.)*	20% (Thimet 20G)	65 (47-74)	Very highly toxic	0161827 Hoberg 1986	Core

[1] The LC50 values are expressed as concentration of formulated product.

The results indicate that both the technical grade and 20% product of phorate are very highly toxic to aquatic invertebrates on an acute basis. The guideline requirement (72-2) is fulfilled MRID Nos. 05017538, 0097842, & 0003503). Although, no study is fully acceptable alone, the consistency of the results indicates no further testing is warranted.

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Chronic toxicity findings. An aquatic invertebrate life-cycle test is required for phorate because 1) the lowest LC_{50} value is 0.68 μg/L and 2) and monitoring data indicate that phorate (6.8 to 32.3 μg/L) was present in a pond where fish were killed. Results of this test are tabulated below.

Freshwater Aquatic Invertebrate Life-Cycle Toxicity

Surrogate Species	% A.I.	NOEC/ LOEC (ppb)	MATC (ppb)	Endpoints Affected	MRID No. Author/Year	Study Classification
Daphnid *(Daphnia magna)*	100	0.21/0.41	0.29	Number of offspring per female and growth of parental daphnids	42227102 Yurk, J.J./1991	Core

The NOEC, MATC, and LOEC are very low and indicate minimal concentrations are needed to effect reproduction and growth. The guideline requirement (72-4) is fulfilled (MRID No. 42227102).

(3) Estuarine and Marine Animals

Acute toxicity findings. Acute toxicity testing with estuarine/marine organisms (fish, shrimp and oyster) using the technical grade of the active ingredient is required when an end-use product is intended for direct application to the marine/estuarine environment or the active ingredient is expected to reach this environment because of its use in coastal counties. The preferred test species are sheepshead minnow, mysid and eastern oyster. Estuarine/marine

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acute toxicity testing is required for phorate because the active ingredient is expected to be transported to estuarine waters. Results of these tests are tabulated below.

Estuarine/Marine Acute Toxicity for Phorate Technical

Surrogate Species	% A.I.	LC_{50}/EC_{50} (confidence limits) ppb	Toxicity Category	MRID No. Author/ Year	Study Class.
Eastern oyster embryo-larvae *(Crassostrea virginica)*	89.5	900 (400-1900)	Highly toxic	40228401 U.S.EPA/ 1981	Core
Mysid *(Americamysis bahia)*	89	1.9(1.0-3.2)	Very highly toxic	40228401 U.S.EPA/ 1981	Core
Mysid *(Americamysis bahia)*	90	0.33(0.27-0.43)	Very highly toxic	40228401/ U.S. EPA/ 1981	Supple-mental
Penaeid shrimp	89.5	0.27(0.18-0.32)	Very highly toxic	40228401 U.S.EPA/ 1981	Supple-mental
Pink shrimp	89.5	0.11(0.08-0.160)	Very highly toxic	40228401 U.S.EPA/ 1981	Supple-mental
Spot	89.5	5.0(4.2-5.6)	Very highly toxic	40228401 U.S.EPA/ 1981	Core
Spot	89.5	3.9(3.1-5.6)	Very highly toxic	40228401 U.S.EPA/ 1981	Supple-mental
Sheepshead minnow	89.5	1.3(0.97-1.7)	Very highly toxic	40228401 U.S.EPA/ 1981	Supple-mental
Longnose Killifish	90	0.36	Very highly toxic	40228401/ U.S.EPA/ 1981	Supple-mental
Sheepshead minnow	89.5	4.0(3.5-4.5)	Very highly toxic	40228401 U.S.EPA/ 1981	Core

Estuarine/Marine Acute Toxicity for Formulated Phorate

Surrogate Species	% A.I.	LC_{50}/EC_{50} (confidence limits) ppb	Toxicity Category	MRID No. Author/ Year	Study Class.
Quahog clam	Thimet 20G (20% a.i.)	17(4.4-71)	Very highly toxic	40004201/Suprenant/ 1986	Core
Sheepshead minnow *(Cyprinodon variegatus)*	Thimet 20G (20% a.i.)	8.2(5.5-10)	Very highly toxic	40001801/ Suprenant/1986	Core
Mysid *(Americamysis bahia)*	Thimet 20G (20% a.i.)	0.3(0.26-0.35)	Very highly toxic	41803804 Sousa/ 1990	Core

The results indicate that technical grade and 25% product of phorate are very highly toxic to estuarine/marine fish and invertebrates on an acute basis. The guideline requirement (72-3a) is fulfilled (MRID # 40228401 and 41803804).

Chronic toxicity findings. Estuarine/marine fish early life-stage and aquatic invertebrate life-cycle toxicity tests are required for phorate because (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity; (2) acute LC_{50} and EC_{50} are less than 1 mg/L; (3) the EEC in water is equal to or greater than 0.01 of any acute EC_{50} and LC_{50} values; or (4) the actual and estimated environmental concentration in water resulting from use is less than 0.01 of any acute EC_{50} or LC_{50} value and studies of other organisms indicate the reproductive physiology of invertebrates may be affected, or the pesticide is persistent in water (e.g. half-life greater than 4 days). Results of this test are tabulated below:

Estuarine/Marine Chronic Toxicity

Surrogate Species	% A.I.	NOEC/LOEC (pptr)	MATC (pptr)	Endpoints Affected	MRID No. Author/Year	Study Classification
Mysid *(Americamysis bahia)*	99	5.3/9.8	7.5	total length and dry weight	43730501 Overman & Wisk/1995	Supplemental
Mysid *(Americamysis bahia)*	99	9/21	13.74	Survivability	40228401/ USEPA/1981	Supplemental
Sheepshead Minnow *(Cyprinodon variegatus)*	99	96/190	72.2	weight and length	418038-06/ Sousa/1991	Core

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The guideline requirement (72-4a) is fulfilled (MRID #41803806); (72-4b) is not fulfilled (MRID #43730501). However, no further chronic mysid testing is required. The additional testing is not expected to result in a significantly different NOEC.

(4) Aquatic Field Testing and Incidents

Field studies.

- An aquatic pond study conducted in Iowa used Thimet 20G insecticide. The study involved 5 study ponds (2 control ponds and 3 treated ponds). The treated ponds were situated close to fields treated with phorate so that contaminated water would enter the ponds as a result of natural (rather than simulated) runoff events. A series of rainfall events resulted in a period of about a month in which phorate degradates phorate sulfone and phorate sulfoxide (but not parent phorate) were detectable in pond water. It is difficult to draw definitive conclusions from the study for reasons that included poor comparability of the physical properties of the ponds, limited replication (i.e., few ponds), and high natural variability. A fish kill (i.e., simultaneous death of multiple fish) was not observed; however, because of the limitations of the study it cannot be used to refute the potential for effects of ecological concern in general.

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

Aquatic incidents. The EPA has received several reports of field incidents involving phorate products through the Pesticide Incident Monitoring System (PIMS) (See Appendix 2 for table of aquatic incidents).

c. Toxicity to Plants

Currently, *terrestrial plant testing* is not required for granular insecticides. Aquatic plant testing is not required for granular insecticides. Supplemental information suggests that technical phorate is not toxic to the marine diatom *Skeletonema*, based on a 96 hr. LC50 of 1.3 ppm (MRID 40228401).

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5. Ecological Exposure and Risk Characterization

a. Evaluation of LOC exceedances

Risk Quotients (RQs) and the Levels of Concern (LOCs). In order to integrate exposure information with toxicity information, a risk quotient (RQ) is calculated by dividing exposure

$$\text{Risk Quotient} = \frac{\text{Exposure}}{\text{Toxicity}}$$

Examples of toxicity measurements used in the calculation of RQs are:

- LC_{50} (fish and amphibians; birds)
- LD_{50} (birds and mammals)
- EC_{50} (aquatic plants and invertebrates)
- EC_{25} (terrestrial plants)
- EC_{05} or NOEC (endangered plants)

To assess whether there is an ecological concern, RQ values are compared to Levels of Concern (LOCs). The LOCs depend on whether the Toxicity measurement represents acute or chronic toxicity, and there are different LOCs for the acute RQs (see table below). The Agency interprets exceedances of LOCs as follows:

- *acute high risk* - potential for acute risk is high; regulatory action may be warranted in addition to restricted use classification;
- *acute restricted use* - the potential for acute risk is high, but this may be mitigated through restricted use classification;
- *acute endangered species* - the potential for acute risk to endangered species is high; regulatory action may be warranted;
- *chronic risk* - the potential for chronic risk is high; regulatory action may be warranted.

Currently, EFED has no procedures for assessing chronic risk to plants, acute or chronic risks to nontarget insects, or chronic risk from granular/bait formulations to mammalian or avian species.

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Levels of Concern (LOCs) for Assessing whether Risk Quotient indicates an ecological concern.

RISK PRESUMPTION	RISK QUOTIENT	LEVEL OF CONCERN
Birds and Reptiles		
Acute High Risk	EEC[1]/LC_{50} or LD_{50}/sqft[2] or LD_{50}/day[3]	0.5
Acute Restricted Use	EEC/LC_{50} or LD_{50}/sqft or LD_{50}/day (or LD_{50} < 50 mg/kg)	0.2
Acute Endangered Species	EEC/LC_{50} or LD50/sqft LD_{50}/day	0.1
Chronic Risk [4]	EEC/NOEC	1
Wild Mammals		
Acute High Risk	EEC/LC_{50} or LD50/sqft or LD_{50}/day	0.5
Acute Restricted Use	EEC/LC_{50} or LD_{50}/sqft or LD_{50}/day (or LD_{50} < 50 mg/kg)	0.2
Acute Endangered Species	EEC/LC_{50} or LD50/sqft or LD_{50}/day	0.1
Chronic Risk [4]	EEC/NOEC	1

[1] abbreviation for Estimated Environmental Concentration; designated ppm in avian/mammalian food items

[2] $\frac{mg/ft^2}{LD_{50} * \text{wt. of bird}}$ [3] $\frac{\text{mg of toxicant consumed/day}}{LD_{50} * \text{wt. of bird}}$

[4] EFED does not have a standard approach for calculating chronic risk quotients for granular pesticides. Thus chronic risk quotients have not been calculated for phorate.

Aquatic Animals		
RISK PRESUMPTION	**RISK QUOTIENT**	**LEVEL OF CONCERN**
Acute High Risk	EEC[1]/LC_{50} or EC_{50}	0.5
Acute Restricted Use	EEC/LC_{50} or EC_{50}	0.1
Acute Endangered Species	EEC/LC_{50} or EC_{50}	0.05
Chronic Risk	EEC/MATC or NOEC	1

[1] abbreviation for Estimated Environmental Concentration; designated ppb/ppm in water

(1) Terrestrial LOC evaluation

Birds. Birds may be exposed to granular pesticides by ingesting granules when foraging for food or grit. They also may be exposed by other routes, such as by walking on exposed granules or drinking water contaminated by granules. The number of lethal doses (LD_{50}s) that are available within one square foot immediately after application ($LD_{50}s/ft^2$) is used as the risk quotient for granular/bait products. Risk quotients are calculated for three separate weight class of birds: 1000 g (e.g. waterfowl), 180 g (e.g. upland gamebird) and 50 g (e.g. songbird).

Consumption of granules depends on their availability, bird behavior, characteristics of grit/granules preferred by birds, and grit/granule retention in the gizzard (Best and Fischer, 1992). Exposure of nontarget organisms, particularly birds, to pesticide granules is assumed to be related to the application rate and number of granules present on or near the soil surface. The quantity of pesticide near the ground surface after application, in a unit area -- typically, one square foot is used to estimate terrestrial exposure to pesticide granules. Support for this approach can be found in the literature. DeWitt (1966), after conducting a quail field study, concluded, "Losses of birds may be expected if the quantity of toxicant per square foot equals or exceeds the quantity causing deaths of quail in short term feeding tests."

All application methods for granular formulations will result in the presence of some granules at or near the soil surface, where they are accessible to foraging wildlife. Both band and in-furrow application of granular pesticides using conventional commercial application equipment may result in the occurrence of exposed granules on the soil surface. In a laboratory soil study using a variety of incorporation techniques and several models of planters operated at different speeds, Hummel (1983) found granule incorporation ranged from 69% to 96% for band application, and generally 99% for in-furrow application. Erbach and Tollefson (1983) found that an average of 15% of the granules remained visible when no incorporation other than a press wheel was used.

Tables below are percentages of applied granules assumed to be visible to birds for different application techniques. These percentages probably underestimate the actual fraction remaining because the information available is for granule counts within rows and does not represent row ends. The number of granules found in turn areas at row ends (where application equipment is raised from the soil) would be considerably higher than along row areas where granules are incorporated. Also, the fluorescent techniques used to observe granules were not 100% efficient, and thus did not allow the identification of all granules (Tollefson, 1979).

Percentage of pesticide granules remaining exposed after application (all crops)

APPLICATION METHODS	% UNINCORPORATED
Preplant broadcast	15
In-furrow, drill, shank	1
T-band or band (applied over emerged plants, incorporated, or in front of the press wheel)	15
Post-plant/at-cultivation (band)	15

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The acute risk quotients for broadcast applications with no incorporation of granular products are tabulated below.

Avian Risk Quotients for Granular Products (Broadcast , No Incorporation)

Site/Method Lbs (ai/A)	%(decimal) of Unincorporated Pesticide	Body Weight (g)	LD_{50} (mg/kg)	Acute RQ[1] (LD_{50}/ft^2)
Corn and Hops				
3	1.0	50	1.0	624.0
3	1.0	180	7.0	24.8
3	1.0	1000	0.62	50.3
Corn, Sorghum and Wheat				
1	1.0	50	1.0	208.0
1	1.0	180	7.0	8.3
1	1.0	1000	0.62	16.8
Sugar beets				
1.6	1.0	50	1.0	332.8
1.6	1.0	180	7.0	13.2
1.6	1.0	1000	0.62	26.8

[1] The equation for the RQ is:

$$\frac{\text{App. Rate (lbs a.i./A)} * (453{,}590 \text{ mg/lb}/43{,}560 \text{ ft}^2/\text{A})}{LD_{50} \text{ mg/kg} * \text{Weight of Animal (g)} * 1000 \text{ g/kg}}$$

The results indicate that for broadcast applications of granular products with no incorporation, avian acute high risk, restricted use, and endangered species levels of concern are all exceeded. The acute risk quotients for banded or in-furrow applications of granular products are tabulated below.

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Avian Acute Risk Quotients for Granular Products (Banded or In-furrow)

Site/Method		Bird Type & Body Weight (grams)	% (dec.) of Phorate Unincorp.	Exposed mg/ft²	LD_{50} (mg/kg)	Acute RQ[1] (LD_{50}/Ft²)
Band Width	Oz.a.i./1000 ft of row					
Beans (soil band)						
0.17	1.875	Songbird (50)	0.01	3.13	1	62.6
0.17	1.875	Upland Gamebird (180)	0.01	3.13	7	2.5
0.17	1.875	Waterfowl (1000)	0.01	3.13	0.62	5.0
Corn (Banded over the Row at planting) Sorghum (soil band)						
0.6	1.2	Songbird (50)	0.15	8.50	1	170.0
0.6	1.2	Upland Gamebird (180)	0.15	8.50	7	6.7
0.6	1.2	Waterfowl (1000)	0.15	8.50	0.62	13.7
Cotton (soil sidedress treatment incorporated)						
0.5	2.4	Songbird (50)	0.15	20.41	1	408.2
0.5	2.4	Upland Gamebird (180)	0.15	20.41	7	16.2
0.5	2.4	Waterfowl (1000)	0.15	20.41	0.62	32.9
Filed Grown Lilies and Daffodils[2]						
1	4.7	Songbird (50)	0.01	1.33	1	26.6
1	4.7	Upland Gamebird (180)	0.01	1.33	7	1.1
1	4.7	Waterfowl (1000)	0.01	1.33	0.62	2.1
Peanuts (Soil band, at pegging)						
0.5	2.2	Songbird (50)	0.15	18.71	1	374.2
0.5	2.2	Upland Gamebird (180)	0.105	13.10	7	10.4
0.5	2.2	Waterfowl (1000)	0.15	18.71	0.62	30.2

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Avian Acute Risk Quotients for Granular Products (Banded or In-furrow)

Site/Method		Bird Type & Body Weight (grams)	% (dec.) of Phorate Unincorp.	Exposed mg/ft²	LD_{50} (mg/kg)	Acute RQ[1] (LD_{50}/Ft²)
Band Width	Oz.a.i./1000 ft of row					
Potato, White/Irish(Soil band)						
0.6	3.5	Songbird (50)	0.15	24.81	1	496.2
0.6	3.5	Upland Gamebird (180)	0.15	24.81	7	19.7
0.6	3.5	Waterfowl (1000)	0.15	24.81	0.62	40.0
Radish (soil sidedress)						
0.17	1.25	Songbird (50)	0.15	31.27	1	625.4
0.17	1.25	Upland Gamebird (180)	0.15	31.27	7	24.8
0.17	1.25	Waterfowl (1000)	0.15	31.27	0.62	50.4
Soybeans (Soil band)						
0.6	1.8	Songbird (50)	0.15	12.76	1	255.2
0.6	1.8	Upland Gamebird (180)	0.15	12.76	7	10.1
0.6	1.8	Waterfowl (1000)	0.15	12.76	0.62	20.6
Sugar beets[3]						
0.8	0.9	Songbird (50)	0.15	4.78	1	95.6
0.8	0.9	Upland Gamebird (180)	0.15	4.78	7	3.8
0.8	0.9	Waterfowl (1000)	0.15	4.78	0.62	7.7
Sugarcane						
1	8.6	Songbird (50)	0.01	2.44	1	48.8
1	8.6	Upland Gamebird (180)	0.01	2.44	7	1.9
1	8.6	Waterfowl (1000)	0.01	2.44	0.62	3.9

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Avian Acute Risk Quotients for Granular Products (Banded or In-furrow)

Site/Method		Bird Type & Body Weight (grams)	% (dec.) of Phorate Unincorp.	Exposed mg/ft[2]	LD_{50} (mg/kg)	Acute RQ[1] (LD_{50}/Ft^2)
Band Width	Oz.a.i./1000 ft of row					
Wheat (Soil in-furrow)						
0.1	0.24	Songbird (50)	0.01	0.68	1	13.6
0.1	0.24	Upland Gamebird (180)	0.01	0.68	7	0.5
0.1	0.24	Waterfowl (1000)	0.01	0.68	0.62	1.1

[1] The equation for the RQ is:

$$\frac{\text{oz. a.i. per 1000 ft.} * 28349 \text{ mg/oz} * \% \text{ Unincorporated / bandwidth (ft)} * 1000 \text{ ft}}{\text{LD50(mg/kg)} * \text{Weight of the Animal (g)} * 1000 \text{ (g/kg)}}$$

[2] The equation used to calculate the number of ounces per 1000 foot of row from 8 pounds per acre rate is shown below:

Oz. a.i./1000 ft of row * (43.56 feet/row spacing) = Lbs/A

[3] This is a post-emergence application. This scenario assumes every row was two plants wide, the post-treatment was foliar, and the band extended from the outside of one plant to the outside edge of the other plant or a 14 inch band was used. Based on the label, this use was not soil incorporated.

The results indicate that for banded and in-furrow applications of granular products, avian acute high risk, restricted use, and endangered species levels of concern are all exceeded. The labeling carries the following warnings:

1. Beans - Do not place Phorate 20G granules in direct contact with seed at planting time.
2. Field corn, Sorghum, Soybeans, Sugar beets - Do not place Phorate 20G granules in direct contact with seed.
3. Do not apply in-furrow or allow to come in direct contact with the seed.

The phytotoxicity and label warnings would appear to rule out in-furrow as a risk reduction measure for most crops. Sugarcane and wheat appear to be the only two in-furrow crops at the present time. As shown in the table above sugarcane and wheat acute risk quotients for songbirds are 48.8 and 13.6, respectively. Wheat had the lowest RQ values among banded and in-furrow applications.

The table below, based on the Corn Cluster Analysis, compares phorate to four other corn OP pesticides, based on two indices, the estimated number of granules per square foot and the number of granules that a bird would need to ingest in order to obtain an amount of pesticide equal to the LD50.

Estimated Number of Granules per Square Foot and Number of Granules per LD_{50} for Corn at Plant

Pesticide	Formulation[1] (%AI/100)	Granule Wt.[1] (mg)	Range of Granule Wt.[1] (mg)	App. Rate[2] (oz/1000 ft of row)	Band Width[2] (ft)	Percent Unincorporated[5] (decimal)	Amount of Active Ingredient Exposed[3] (mg/ft²)	No. of Exposed Granules[4] (/ft²)	No. of Granules/ LD_{50}[6,7] (granules)
Chlorpyrifos	0.15	0.064	0.062-0.078	2.4	0.6	0.15	17.01	1,771.88	28.9
	0.15	0.064	0.062-0.078	2.4	0.1	0.01	6.80	708.33	28.9
Fonofos[8]	0.20	0.197	0.184-0.560	4.8	0.6	0.15	34.02	863.45	13.4
	0.10	0.197	0.184-0.560	4.8	0.6	0.15	34.02	1,726.90	26.7
Phorate	**0.20**	**0.085**	**0.067-0.143**	**1.2**	**0.6**	**0.15**	**8.50**	**500.00**	**3.1**
	0.15	**0.085**	**0.067-0.143**	**1.2**	**0.6**	**0.15**	**8.50**	**666.67**	**4.1**
Terbufos	0.20	0.85	0.056-0.080	1.2	0.6	0.15	8.50	50.00	4.6
	0.20	0.85	0.056-0.080	1.2	0.1	0.01	3.40	20.00	4.6
	0.15	0.066	0.056-0.080	1.2	0.6	0.15	8.50	858.59	79.7
	0.15	0.066	0.056-0.080	1.2	0.1	0.01	3.40	343.43	79.7

[1] Granule weights were obtained from Hill and Camardese, 1984, except the for terbufos 20% product which was provides by registrant.

[2] Rates from BEAD,(D.Brassard's June 25th memorandum "Transmittal of Corn Cluster Use Information for EFED Risk Assessment").

[3] Amount of pesticide exposed (mg/ft²) calculated with the following formula:

[(oz a.i./1000 ft of row)*(28349 mg/oz conversion factor)]/[1000 ft of row * bandwidth (ft)] * [0.15 % unincorporated]

[4] Number of exposed granules per square foot was determined by the following formula:
(mg of a.i./ft² exposed / percent a.i. of the product) / dividing the that by the weight of the granule.

[5] Based on the rationale from the "Comparative Analysis of Acute Avian Risk from Granular Pesticides (1992) which indicates that 85% of the granules are incorporated.

[6] Number of granules per LD_{50} was calculated with the following formula:

[(LD_{50} * bird weight)] / [(%a.i./100) * granule weight]

[7] The species with the lowest LD_{50} was used in this calculation. They were: house sparrow, red-winged blackbird, and bobwhite quail for chlorpyrifos, fonofos, phorate, and terbufos, respectively. Unlike the other chemicals, for terbufos the only available LD_{50} was for bobwhite quail. The smaller weight of passerine species increases the risk ratio. Therefore, to adjust for this, the weight of the red-winged blackbird was used with the bobwhite quail LD_{50} value to estimate an LD_{50} for red-winged blackbird.

[8] The weight of the 10% product was not available for fonofos. Hence the weight for the 20% product was used in these calculations.

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Avian chronic risk. Risk quotients have not been developed for chronic/reproductive avian effects. However a variety of considerations suggest chronic risk, as discussed in greater detail in the risk characterization below. In avian reproduction studies adverse effects were observed at low dietary concentrations (5 ppm in mallard and 60 ppm in quail).

Risk to mammals. Mammals may be exposed to granular pesticides ingesting granules when foraging for food, grooming, by walking on exposed granules or drinking contaminated water. The number of lethal doses (LD_{50}s) that are available within one square foot immediately after application ($LD_{50}s/ft^2$)is used as the risk quotient for granular/bait products. Risk quotients are calculated for three separate weight classes of mammals: 1000 g, 35 g and 15 g.

The acute risk quotients for broadcast applications of granular products are tabulated below.

Mammalian Risk Quotients for Granular Products (Broadcast, unincorporated) Based on a Rat LD_{50} of 1.4 mg/kg

Site/Method Lbs(ai)/A Unincorporated	%(decimal) of Pesticide Left on the Surface	Body Weight (g)	LD_{50} (mg/kg)	Acute RQ[1] (LD_{50}/ft^2)
Corn and Hops				
3	1	15	1.4	1,485.71
3	1	35	1.4	636.73
3	1	1000	1.4	22.29
Corn, Sorghum and Wheat				
1	1	15	1.4	495.24
1	1	35	1.4	212.24
1	1	1000	1.4	7.43
Sugar beets				
1.5	1	15	1.4	742.86
1.5	1	35	1.4	318.37
1.5	1	1000	1.4	1.11

[1] The equation for the RQ is:

$$\frac{\text{App. Rate (lbs a.i./A)} * (453{,}590\ \text{mg/lb}/43{,}560\ \text{ft}^2/\text{A})}{LD_{50}\ \text{mg/kg} * \text{Weight of Animal (g)} * 1000\ \text{g/kg}}$$

The results indicate that for broadcast, unincorporated granular products, acute high risk and restricted use LOCs are all exceeded. Also endangered species LOC has been exceeded for all weight classes. As with the avian analysis, the band width and application rates were selected to produce the highest EEC for each crop.

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The acute risk quotients for banded or in-furrow applications of granular products are tabulated below.

Mammalian Acute Risk Quotients for Granular Products (Banded or In-furrow) Based on a rat LD_{50} of 1.4 mg/kg

Band Width (feet)	oz. a.i./1000 ft of row	Body Weight (kg)	% (decimal) of Unincorporated Pesticide	Exposed mg/ft[2]	Rat LD_{50} (mg/kg)	Acute[1] RQ[2] (LD_{50}/ft^2)
Beans (Banded incorporated)						
0.17	1.875	15	0.01	3.13	1.4	149.0
0.17	1.875	35	0.01	3.13	1.4	63.9
0.17	1.875	1000	0.01	3.13	1.4	2.2
Corn and Sorghum						
0.6	1.2	15	0.15	8.50	1.4	404.8
0.6	1.2	35	0.15	8.50	1.4	173.5
0.6	1.2	1000	0.15	8.50	1.4	6.1
Cotton (Soil sidedress treatment,incorporated)						
0.5	2.4	15	0.15	20.41	1.4	971.9
0.5	2.4	35	0.15	20.41	1.4	416.5
0.5	2.4	1000	0.15	20.41	1.4	14.6
Field Grown Lilies and Daffodils						
1	4.7	15	0.01	1.33	1.4	63.3
1	4.7	35	0.01	1.33	1.4	27.1
1	4.7	1000	0.01	1.33	1.4	1.0
Peanuts (Soil band, at pegging)						
0.5	2.2	15	0.15	18.71	1.4	891.0
0.5	2.2	35	0.15	18.71	1.4	381.8
0.5	2.2	1000	0.15	18.71	1.4	13.4
Potato White/Irish (Soil band)						
0.6	3.45	15	0.15	24.45	1.4	1,164.3
0.6	3.45	35	0.15	24.45	1.4	499.0
0.6	3.45	1000	0.15	24.45	1.4	17.5
Radish (Soil sidedress)						

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Mammalian Acute Risk Quotients for Granular Products (Banded or In-furrow) Based on a rat LD_{50} of 1.4 mg/kg

Band Width (feet)	oz. a.i./1000 ft of row	Body Weight (kg)	% (decimal) of Unincorporated Pesticide	Exposed mg/ft[2]	Rat LD_{50} (mg/kg)	Acute[1] RQ[2] (LD_{50}/ft^2)
0.17	1.25	15	0.15	31.27	1.4	1,489.0
0.17	1.25	35	0.15	31.27	1.4	638.2
0.17	1.25	1000	0.15	31.27	1.4	22.3
Soybeans (Soil band)						
0.6	1.8	15	0.15	12.76	1.4	607.6
0.6	1.8	35	0.15	12.76	1.4	260.4
0.6	1.8	1000	0.15	12.76	1.4	9.1
Sugar beets [2]						
0.8	0.9	15	0.15	4.78	1.4	227.6
0.8	0.9	35	0.15	4.78	1.4	97.6
0.8	0.9	1000	0.15	4.78	1.4	3.4
Sugarcane						
1	8.6	15	0.01	2.44	1.4	116.2
1	8.6	35	0.01	2.44	1.4	49.8
1	8.6	1000	0.01	2.44	1.4	1.7
Wheat (Soil in-furrow)						
0.1	0.24	15	0.01	0.68	1.4	32.4
0.1	0.24	35	0.01	0.68	1.4	13.9
0.1	0.24	1000	0.01	0.68	1.4	0.5

[1] The equation for the RQ is: $\frac{\text{oz. a.i. per 1000 ft.} * 28349 \text{ mg/oz} * \% \text{ Unincorporated/bandwidth (ft)} * 1000 \text{ ft}}{LD_{50}(\text{mg/kg}) * \text{Weight of the Animal (g)} * 1000 \text{ g/kg}}$

[2] This is a post-emergence application. This scenario assumes every row was two plants wide, the post-treatment was foliar, and the band extended from the outside of one plant to the outside edge of the other plant or a 14 inch band was used. Based on the label this use was not soil incorporated.

Insects. Currently, EFED has no procedure for assessing risk to nontarget insects. Results of acceptable studies are used for recommending appropriate label precautions. EFED assumes that for granular formulations the hazard is minimal to bees.

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(3) Aquatic Level of Concern Evaluation

Levels of concern for impacts on aquatic organisms and ecosystems are based on toxicity results from guideline studies, and Tier II estimated environmental concentrations (EECs). The calculation of EECs is described in detail in the section "Water Resources" above, which also displays all of the EEC values calculated. The EEC in each category (maximum, 4-day, etc.) is expected to be equaled or exceed once every ten years, that is it has a 1 in 10 year return frequency.

EECs have been calculated in two ways representing (1) parent phorate only and (2) the combined concentration of parent phorate, phorate sulfoxide, and phorate sulfone ("total OP residue"). The same exposure estimates have been used for estuarine/marine animals as for freshwater animals. The tables on the following pages display four sets of risk quotients:

- concentration of parent phorate relative to toxicity to freshwater (FW) animals;
- concentration of total OP residue relative to toxicity to freshwater animals;
- concentration of parent phorate relative to toxicity for marine/estuarine animals;
- concentration of total OP residue relative to toxicity for marine/estuarine animals.

At this time, toxicity information is not available for phorate metabolites. Risk quotients for total OP residue have been calculated using the available toxicity measurements, which are for parent phorate, assuming equal toxicity of parent phorate and phorate metabolites.

In addition to the scenarios evaluated in the Water Resources Assessment, based on use information from American Cyanamid, an RQ has been calculated for lilies and daffodils, with an application rate of 8 lb ai/A, by multiplying the RQs for cotton by the ratio of application rates 8/1.6.

For the potato scenario with in-furrow application, the modeling results suggest negligible exposure. However, EFED is not confident that the incorporation options in the current version of the PRZM model adequately represent availability of pesticide for in-furrow applications and therefore is not confident that exposures would be negligible for in-furrow applications to potatoes. For the scenarios other than the potato scenario, all acute risk quotients exceed high risk criteria. Most of the chronic RQs exceed levels of concern: The exception is the FW fish chronic RQ of 0.08.

The RQs for estuarine/marine animals are higher than the RQs for freshwater animals for each of the four aquatic toxicity endpoints (fish acute, fish chronic, invertebrate acute, invertebrate chronic), reflecting the higher toxicity observed for each category.

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(4) Exposure and Risk to Nontarget Plants

Plant testing is not required for granular pesticides or insecticides.

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Risk quotients for freshwater fish and invertebrates based on estimated concentration of parent Phorate

Crop	Application rate, procedure	Estimated Environmental Concentration (EEC, ppb)			Risk Quotients by Crop, rate etc.			
					fish, acute	fish, chronic	invert., acute	invert., chronic
					Toxic concentration (LC50 or NOAEC, ppb)[1]			
					1	2.6	0.6	0.21
					Exposure column for EEC			
		peak	21 day	60 day	peak	60 day	peak	21 day
Sweet Corn	T-banded at 1.3 lb ai/A	21.3	3.3	1.2	21	0.46	36	16
Peanuts	1.64 lb ai/A at plant in-furrow, 2.9 lbs a/A side dressed 90 days prior to harvest	18.1	2	0.7	18	0.27	30	10
Cotton	In-furrow at 1.6 lb ai/A	23.1	3.9	1	23	0.54	39	19
Potatoes	Idaho, in-furrow at 3.5 lb ai/A	[Estimated exposure = zero [2]]						
Field corn	T-banded at 1.3 lb ai/A	4.6	0.7	0.2	4.6	0.08	7.7	3.3
Grain sorghum	T-banded at 2 lb ai/A	7.5	1.2	0.4	7.5	0.15	13	5.7
Lilies & Daffodils	8 lb ai/A	115.5	19.5	7	116	2.7	193	93

[1] Toxicity Measurements: Acute, FW fish: LC50 for bluegill sunfish; Chronic, FW fish: NOEC for rainbow trout; Acute, FW invert.: LC50 for *Gammarus* (Crustacea); Chronic, FW invert: NOEC for *Daphnia* (Crustacea)

[2] See discussion of model limitations in the environmental fate assessment. Incorporation options in the current version of the PRZM model may not adequately represent the availability of the chemical for runoff.

Risk quotients for freshwater fish and invertebrates based on estimated combined concentration of parent Phorate, Phorate sulfone, and Phorate sulfoxide

Crop	Application rate, procedure	Estimated Environmental Concentration (EEC, ppb)			Risk Quotients by Crop, rate etc.			
					fish, acute	fish, chronic	invert., acute	invert., chronic
					Toxic concentration (LC50 or NOAEC, ppb)[1]			
					1	2.6	0.6	0.21
					Exposure column for EEC			
		peak	21 day	60 day	peak	60 day	peak	21 day
Sweet Corn	T-banded at 1.3 lb ai/A	26.9	8.2	5.9	27	2.3	45	39
Peanuts	1.64 lb ai/A at plant in-furrow, 2.9 lbs a/A side dressed 90 days prior to harvest	25.2	8.8	4.7	25	1.8	42	42
Cotton	In-furrow at 1.6 lb ai/A	27.6	12.4	8.2	28	3.2	46	59
Potatoes	Idaho, in-furrow at 3.5 lb ai/A	[Estimated exposure = zero [2]]						
Field corn	T-banded at 1.3 lb ai/A	7.7	3.9	2.5	7.7	1.0	13	19
Grain sorghum	T-banded at 2 lb ai/A	12.7	7.1	4.2	13	1.6	21	34
Lilies & Daffodils	8 lb ai/A	138	62	41	138	15.8	230	295

[1] Toxicity Measurements: Acute, FW fish: LC50 for bluegill sunfish; Chronic, FW fish: NOEC for rainbow trout; Acute, FW invert.: LC50 for *Gammarus* (Crustacea); Chronic, FW invert: NOEC for *Daphnia* (Crustacea)

[2] See discussion of model limitations in the environmental fate assessment. Incorporation options in the current version of the PRZM model may not adequately represent the availability of the chemical for runoff.

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Risk quotients for marine/estuarine fish and invertebrates based on estimated concentration of parent Phorate

Crop	Application rate, procedure	Estimated Environmental Concentration (EEC, ppb)			Risk Quotients by Crop, rate etc.			
					fish, acute	fish, chronic	invert., acute	invert., chronic
					Toxic concentration (LC50 or NOAEC, ppb)[1]			
					0.36	0.096	0.11	0.0053
					Exposure column for EEC			
		peak	21 day	60 day	peak	60 day	peak	21 day
Sweet Corn	T-banded at 1.3 lb ai/A	21.3	3.3	1.2	59	34	194	623
Peanuts	1.64 lb ai/A at plant in-furrow, 2.9 lbs a/A side dressed 90 days prior to harvest	18.1	2	0.7	50	21	165	377
Cotton	In-furrow at 1.6 lb ai/A	23.1	3.9	1	64	41	210	736
Potatoes	Idaho, in-furrow at 3.5 lb ai/A	[Estimated exposure = zero [2]]						
Field corn	T-banded at 1.3 lb ai/A	4.6	0.7	0.2	13	7.3	42	132
Grain sorghum	T-banded at 2 lb ai/A	7.5	1.2	0.4	21	13	68	226
Lilies and Daffodils	8 lb ai/A	115.5	19.5	7	321	72.9	1050	3679

[1] Toxicity Measurements: Acute, fish: EC50 for killifish; Chronic, fish: NOEC for sheepshead minnow; Acute, invert.: EC50 for pink shrimp; Chronic, invert: NOEC for mysid (Crustacea)

[2] See discussion of model limitations in the environmental fate assessment. Incorporation options in the current version of the PRZM model may not adequately represent the availability of the chemical for runoff.

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Risk quotients for marine/estuarine fish and invertebrates based on estimated combined concentration of parent Phorate, Phorate sulfone, and Phorate sulfoxide

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Crop	Application rate, procedure	Estimated Environmental Concentration (EEC, ppb)			Risk Quotients by Crop, rate etc.			
					fish, acute	fish, chronic	invert., acute	invert., chronic
					Toxic concentration (LC50 or NOAEC, ppb)[1]			
					0.36	0.096	0.11	0.0053
					Exposure column for EEC			
		peak	21 day	60 day	peak	60 day	peak	21 day
Sweet Corn	T-banded at 1.3 lb ai/A	26.9	8.2	5.9	75	85	245	1547
Peanuts	1.64 lb ai/A at plant in-furrow, 2.9 lbs a/A side dressed 90 days prior to harvest	25.2	8.8	4.7	70	92	229	1660
Cotton	In-furrow at 1.6 lb ai/A	27.6	12.4	8	77	129	251	2340
Potatoes	Idaho, in-furrow at 3.5 lb ai/A	[Estimated exposure = zero [2]]						
Field corn	T-banded at 1.3 lb ai/A	7.7	3.9	2.5	21	41	70	736
Grain sorghum	T-banded at 2 lb ai/A	12.7	7.1	4.2	35	74	115	1340
Lilies & Daffodils	8 lb ai/A	138	62	41	383	646	1255	11698

[1]Toxicity Measurements: Acute, fish: EC50 for killifish; Chronic, fish: NOEC for sheepshead minnow; Acute, invert.: EC50 for pink shrimp; Chronic, invert: NOEC for mysid (Crustacea)

[2] See discussion of model limitations in the environmental fate assessment. Incorporation options in the current version of the PRZM model may not adequately represent the availability of the chemical for runoff.

(5) Endangered Species

All terrestrial and aquatic endangered species LOCs are exceeded for phorate, with the exception of in-furrow applications to potatoes. (As discussed previously, EFED is not confident that exposure would be negligible with in-furrow applications to potatoes.)

The Endangered Species Protection Program is expected to become final in the future. Limitations in the use of phorate will be required to protect endangered and threatened species,. but these limitations have not been defined and may be formulation specific. EPA anticipates that a consultation with the Fish and Wildlife Service will be conducted in accordance with the species-based priority approach described in the Program. After completion of consultation, registrants will be informed if any required label modifications are necessary. Such modifications would most likely consist of the generic label statement referring pesticide users to use limitations contained in county Bulletins.

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b. Risk Characterization

(I) Fate and transport of phorate and phorate metabolites

Surface and ground water contamination may occur from the *sulfoxide and sulfone degradates of phorate, as well as from parent phorate*. However, the risk of water contamination is *primarily associated with phorate sulfone and phorate sulfoxide* rather than parent phorate, based on higher persistence and mobility of the degradates.

Phorate itself (*parent phorate*) is *not persistent* in the environment. It has been shown to degrade in soil by chemical and microbial action and to dissipate in the field with half-lives of 2 - 15 days. It is *moderately mobile* in soil, and has been shown to leach to a maximum depth of 6 inches in loamy sand and sandy loam soils. Phorate is subject to rapid hydrolysis with a t1/2 of about 3 days. Due to the limited migration and the rapid hydrolysis, parent phorate is not expected to pose a significant risk to ground water. In contrast to phorate, the *phorate degradates*, phorate sulfoxide and phorate sulfone, are both *more persistent and more mobile* in the environment.

(ii) Terrestrial Risk Characterization

Exceedances of Ecological Concern Levels. For terrestrial species acute Levels of Concern (LOC) are exceeded for all species, crops, and applications rates. The greatest exceedances were calculated for small mammals. Risk Quotient values greater than 1000 were obtained for broadcast applications for corn and hops, banded or in-furrow for potatoes, and banded or in-furrow for radishes. For mammals whose body weight approximates 1000 g, the RQs range from 22 for broadcast use for corn and hops and side-dress radishes to 0.5 for banded or in-furrow use in wheat.

Avian RQ values ranged from about 600 for songbirds in broadcast use in corn and hops to 0.5 for upland gamebirds for soil in-furrow use in wheat. The risk quotient values suggest that songbirds are the birds most at risk: the RQ value ranged from two to three orders of magnitude greater than the level of concern for all uses and all application methods.

Chronic risk quotients for reproductive effects have not been developed for birds. A mallard reproduction study with a reported NOAEL of 5 ppm indicates high toxicity on a chronic basis. The potential for adverse chronic effects on birds is discussed further below.

Field information on avian risk, including incident information. Simulated field studies, as discussed in the ecological toxicity data section, confirm the toxicity and exposure estimates. They also suggest that contaminated water may be a route of exposure. All four bobwhite quail pen studies show mortality, even though quail are not the most sensitive species based on the LD50 studies. Mallard duck, red-winged blackbird, and common grackle are all more sensitive. Both whorl and soil application resulted in adverse effects. There is additional exposure to birds in the turn row areas, increasing the overall risk to birds. At the rate of 6 oz per 1000 row feet, 71 granules per square foot were found in the row, while over twice that many were found in the turn rows (150 granules per square foot).

Incident reports which describe fatalities to birds and mammals support the conclusion that Phorate use poses a risk to wildlife. A wide range of species was affected in the reported incidents. (See Section C.4.a and Appendix C.1.)

The incident information suggests that poisoning of wildlife by phorate and/or phorate degradates may occur several months following application. Fall applications in cool climates may pose a particular hazard. In particular, there are three incidents supporting high avian risk associated with fall applications for winter wheat. Of these, two occurred months after application. (See additional discussion in Section C.4.a.)

The incident record suggests a tendency for waterfowl to be affected directly. This may be consequence of slow degradation in wet parts of a field, due to some combination of anaerobic soil conditions associated with waterlogging, and (in the case of fall applications, particularly in S. Dakota) relatively low temperatures associated with application late in the year. During spring, puddles will form in low-lying parts of a field. Waterfowl will enter shallow water and disturb sediments by feeding, possibly causing release or ingestion of any phorate residues that have persisted, and oral and/or dermal exposure of the waterfowl. Alternatively, phorate residues may be washed by spring rains into low-lying areas from other parts of a field, where puddles will form and waterfowl gather. The possibility of exposure may be particularly severe in S. Dakota if phorate residues persist into winter, because the soil may become frozen, limiting dissipation by leaching as well as by degradation.

This suggests that direct involvement of phorate metabolites may be more significant than involvement of parent phorate, which tends to degrade more rapidly. Phorate sulfoxide and phorate sulfone are OP chemicals, which suggests that they may be toxic. However, toxicity measurements are not available at this time for phorate metabolites.

EFED suggests that these generalizations derive some support from incidents with greater indications of "misuse," relative to the incidents listed above. Winter wheat incidents occur in multiple states and years. The incidents tend to involve waterfowl and tend to involve wetland areas more than permanent water bodies. Even if it is assumed that 100% of winter wheat incidents are due to "misuse," EFED suggests that it is desirable to determine why winter wheat, which accounts for a small percentage of phorate use and a high percentage of phorate avian incidents, is prone to being misused in a way that leads to the specific pattern of incidents indicated.

The information available to EFED at this time suggests that incorporation of phorate into soil is likely to reduce exposure to wildlife. Exposure to wildlife may also be limited if phorate is not

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allowed to wash into parts of a field that tend to remain wet, and if phorate is applied early enough in the year for phorate residues to degrade more completely.

Wildlife ingestion of granular pesticides. Wildlife may ingest granular pesticides by mechanisms that include (1) "intentional" ingestion of granules for grit by birds; or (2) incidental ingestion of phorate or phorate metabolites along with food (ingestion of phorate granules and/or contaminated soil or sediment); (3) drinking water contaminated with phorate or phorate metabolites; and (4) preening or grooming.

Consumption of granules depends on their availability, bird behavior, characteristics of grit preferred by birds, and grit retention in the gizzard (Best and Fischer, 1992). Evidence from insecticides other than phorate indicates that birds feeding on soil invertebrates brought to the surface during planting and application may ingest 3 or 4 granules adhering to an insect or grub. Various species of birds including waterfowl will ingest some soil in the course of foraging. A severe incident for terbufos occurred in Texas in 1996 when hawks ingested soil while feeding opportunistically on grubs.

Some small mammal species may be particularly vulnerable to granular pesticides because of close association with soil. Mammals are more sensitive to phorate than birds on a dietary basis: The lowest mammal LC50 is 28 ppm and the lowest avian LC50 is 248 ppm.

Assessment of hazard of granular pesticides to wildlife. Exposure of nontarget organisms, particularly birds, to pesticide granules is assumed to be related to the application rate and number of granules present on or near the soil surface. All application methods for granular formulations will result in the presence of some granules at or near the soil surface, where they are accessible to foraging wildlife. Both band and in furrow application of granular pesticides using conventional commercial application equipment result in exposed granules on the soil surface. In a laboratory soil study using a variety of incorporation techniques and several models of planters operated at different speeds, Hummel (1983) found granule incorporation ranged from 69% to 96% for band application, and generally 99% for in-furrow application. Erbach and Tollefson (1983) found that an average of 15% of the granules remained visible when no incorporation other than a press wheel was used.

These percentages of visible granules probably underestimates the actual number of granules remaining, because granule counts were within rows and did not include row ends. Also, the fluorescent techniques used to observe granules were not 100% efficient, and thus did not allow the identification of all granules (Tollefson 1979). In addition, the number of granules found in turn areas at row ends (where application equipment is raised from the soil) would be considerably higher than along row areas where granules are incorporated.

The number of lethal doses (LD50s) that are available within one-square foot immediately after application (LD50s/ft^2) is used as the risk quotient for granular products. Risk quotients are calculated for three separate weight class of birds: 1000 g (e.g. waterfowl), 180 g (e.g. upland

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gamebird) and 50 g (e.g. songbird). surface. Support for this approach can be found in the literature. DeWitt (1966), after conducting a quail field study, concluded, "Losses of birds may be expected if the quantity of toxicant per square foot equals or exceeds the quantity causing deaths of quail in short term feeding tests."

Phorate granules are probably relatively hazardous to birds for the following reasons:

1. Only 3 or 4 granules are necessary to equal the lethal dose. These calculations are supported by Balcomb et al. (1984). He gave red-winged blackbirds 1, 5, and 10 granules of Thimet 15G at 5 granules 60% of the birds died and at 10 granules 80% of the birds died.

2. The number of granules per square foot is relatively high (500 to 667 granules per sq. ft.) considering the few granules needed to be fatal.

Avian dermal exposure. Dermal exposure may play an important role in poisoning. An example of typical bird behavior where dermal exposure is likely would be birds dusting themselves.

It is likely that where phorate contacts the skin it will be absorbed. In particular, for many birds dermal uptake may be very efficient in the skin located where the wing meets the body, because that area of skin is bare in many bird species. Tests with parathion revealed dermal toxicity results that were very similar to oral toxicity results (Schafer et al. 1973), when the skin under the wing was exposed.

Human incidents suggest that dermal and inhalation poisoning are likely. These incidents usually do not involve oral exposure. The victims are usually handling the product, e.g., loaders and applicators. Toxicity data indicate that dermal and oral toxicity are similar. If mammals are a surrogate for birds (oral LD50=0.62 mg/kg) the mammal dermal LD50 is nearly the same as the oral LD50, 3.9 and 1.4 mg/kg, respectively.

However, for birds Hudson et al. (1984) performed a 24 hour percutaneous LD50 with one year old mallard hens and the 88% technical product. This dermal foot treatment indicated that for this route of exposure the LD50 was 203 mg/kg which is in the moderately toxic range. The exposed skin under the wing may be more likely to absorb the chemical that the feet. The two tissues (foot skin and skin under the wing) are very different and dermal exposure cannot be discounted at this time. Dermal exposure may or may not contribute significantly to total avian exposure for phorate.

Effects on wildlife food chains. Dieter et al. (1996) applied phorate to mesocosms at rates intended to simulate runoff or direct application to tilled wetlands. They found that amphipods and chironomids were affected for 1 month at applications rates as low as 1 pound per acre. (The application rate of 1 lb ai/A corresponded to a median concentration of 23 µg/L one day after treatment in the water and higher concentrations in sediment.) These invertebrates are an

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important food source for waterfowl. Dieter et al. also reviewed studies of the effects of various insecticides other than phorate on birds in the prairie pothole region. Various studies have associated decreased abundance of food with abandonment of nests, emigration from or reduced use of treated wetlands, or decreased growth rates.

Chronic avian risk. Although risk quotients for chronic/reproductive effects have not been developed the following considerations indicate that there is a potential for adverse effects.

• Reproductive effects (eggs laid, viable embryos, and normal hatchling) are seen at low dietary levels. The toxicity information for mammals suggests that the phorate sulfoxide metabolite may be more toxic on a chronic basis than parent phorate. A 90 day rat feeding study shows that phorate sulfoxide has a lower NOEL than phorate, 0.66 ppm for phorate and 0.32 ppm for phorate sulfoxide. In both studies cholinesterase inhibition was the endpoint. Other phorate degradates that retain the organophosphate structure, phorate sulfone, phorate oxygen analog, phorate oxygen analog sulfoxide, and phorate oxygen analog sulfone metabolites are expected to also exhibit cholinesterase inhibition.

• Data on preharvest intervals indicate that 30 days is required for residues in treated corn plants to reach a level below the tolerance level (0.1 ppm for phorate).

• Studies with organophosphate pesticides other than phorate have shown that negative effects on avian reproduction can result from exposures of short durations, e.g., 8-10 days (Bennett and Ganio, 1991). Bennett and Ganio (1991) mention effects on egg production, eggshell quality, incubation, and brood-rearing behavior.

• Terrestrial incident information indicates phorate residues persisting for weeks or months following application, at levels that caused adverse effects in birds.

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(iii) Aquatic Risk Characterization

All acute risk quotients exceed high risk criteria and most chronic risk quotients exceed levels of concern. The exception is for the potato scenario involving in-furrow application. For that scenario, the exposure modeling results suggest negligible exposure. However, EFED is not confident that the incorporation options in the current version of the PRZM model adequately represent availability of pesticide for in-furrow applications.

Field studies and incidents confirm risk to aquatic organisms. We find that there are two aquatic incidents probably associated with phorate use (B000150-001,002; B000150-001,003). A pond study reported did not produce results that could refute a significant ecological risk.

Some of the terrestrial incidents suggests hazard to birds foraging in puddles in early spring, from phorate applied in the preceding fall (e.g., to winter wheat). These incidents suggests that phorate and/or phorate metabolites may be present in a critical time window for amphibian breeding in early spring. The Agency does not have information on toxicity of phorate to amphibians. The ecotoxicity information available for fish (considered the best surrogates) suggests very high acute toxicity.

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APPENDIX C.1. STATUS OF ECOLOGICAL EFFECTS DATA REQUIREMENTS.

Data Requirements	Composition[1]	Use Pattern[2]	Does EPA Have Data To Satisfy This Requirement? (Yes, No)	Bibliographic Citation	Must Additional Data Be Submitted under FIFRA3(c)(2)(B)?
6 Basic Studies in Bold					
71-1(a) Acute Avian Oral, Quail/Duck	(TGAI)	A,B	No[3]	16000000020560	No
71-1(b) Acute Avian Oral, Quail/Duck	(TEP)	A,B	N/A	N/A	No
71-2(a) Acute Avian Diet, Quail	(TGAI)	A,B	Yes	22923	No
71-2(b) Acute Avian Diet, Duck	(TGAI)	A,B	Yes	22923	
71-3 Wild Mammal Toxicity	(TGAI)	A,B	No	4396110105014313	No[4]
71-4(a) Avian Reproduction Quail	(TGAI)	A,B	No	158333	No
71-4(b) Avian Reproduction Duck	(TGAI)	A,B	Yes	158334	No
71-5(a) Simulated Terrestrial Field Study	(TEP)	A,B	No[5]	7.46237462475e+34	No
71-5(b) Actual Terrestrial Field Study	(TEP)	A,B	No[6]	40165901	No[7]
72-1(a) Acute Fish Toxicity Bluegill	(TGAI)	A,B	Yes	4009800140094602	No
72-1(b) Acute Fish Toxicity Bluegill	(TEP)	A,B	Yes	161823	No
72-1(c) Acute Fish Toxicity Rainbow Trout	(TGAI)	A,B	Yes	40094602	No
72-1(d) Acute Fish Toxicity Rainbow Trout	(TEP)	A,B	Yes	90490161822	No
72-2(a) Acute Aquatic Invertebrate Toxicity	(TGAI)	A,B	No	5017538009784242000000	No
72-2(b) Acute Aquatic Invertebrate Toxicity	(TEP)	A,B	Yes	16182501618260165000	No
72-3(a) Acute Estu/Mari Tox Fish	(TGAI)	A,B	Yes	4022840140001801	No
72-3(b) Acute Estu/Mari Tox Mollusk	(TGAI)	A,B	Yes	40228401	No
72-3(c) Acute Estu.Mari Tox Shrimp	(TGAI)	A,B	Yes	40228401	No
72-3(d) Acute Estu/Mari Tox Fish	(TEP)	A,B	Yes	40001801	No
72-3(e) Acute Estu/Mari Tox Mollusk	(TEP)	A,B	Yes	40004201	No
72-3(f) Acute Estu/Mari Tox Shrimp	(TEP)	A,B	Yes	4180380440001802	No
72-4(a) Early Life-Stage Fish	(TGAI)	A,B	Yes	1583354022840144000000	No
72-4(b) Live-Cycle Aquatic Invertebrate	(TGAI)	A,B	Yes	1.58335422271e+29	No
72-5 Life-Cycle Fish		A,B		—	No[8]
72-6 Aquatic Org. Accumulation	(TGAI)	A,B	No	—	No[9]
72-7(a) Simulated Aquatic Field Study	(TEP)	A,B	No	4222710143957801	No[7]
72-7(b) Actual Aquatic Field Study	(TEP)	A,B	No	—	No
122-1(a) Seed Germ./Seedling Emerg.	(TEP)	A,B	No	—	No

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Data Requirements	Composition[1]	Use Pattern[2]	Does EPA Have Data To Satisfy This Requirement? (Yes, No)	Bibliographic Citation	Must Additional Data Be Submitted under FIFRA3(c)(2)(B)?
122-1(b) Vegetative Vigor	(TEP)	A,B	No	---	No
122-2 Aquatic Plant Growth	(TEP)	A,B	Yes	40228401	No
123-1(a) Seed Germ./Seedling Emerg.	(TEP)	A,B	No	---	No
123-1(b) Vegetative Vigor	(TEP)	A,B	No	---	No
123-2 Aquatic Plant Growth	(TEP)	A,B	No	---	No
124-1 Terrestrial Field Study	(TEP)	A,B			No
124-2 Aquatic Field Study	(TEP)	A,B			No
141-1 Honey Bee Acute Contact	(TGAI)	A,B	Yes[10]	500199100036935	No
141-2 Honey Bee Residue on Foliage		A,B	No[11]	----	No
141-5 Field Test for Pollinators		A,B	No[11]	----	No

[1]Composition: TGAI=Technical grade of the active ingredient; PAIRA=Pure active ingredient, radiolabeled; TEP=Typical end-use product

[2]Use Patterns: A=Terrestrial/Food; B=Terrestrial/Feed; C=Terrestrial Non-Food; D=Aquatic Food; E=Aquatic Non-Food (Outdoor); F=Aquatic Non-Food (Industrial); G=Aquatic Non-Food (Residential); H=Greenhouse Food; I=Greenhouse Non-Food; J=Forestry; K=Residential Outdoor; L=Indoor Food; M=Indoor Non-Food; N=Indoor Medical; O=Indoor Residential

[3] Although these studies do not fulfill the guideline requirements, because of similarity of results further testing is not expected to add significantly to the database.

[4] The rat acute oral study submitted for human health database (MRID No. 05014313) and the rat LC_{50} (1981);MRID No. 43961101) were substituted for 71-3 wild mammal toxicity test.

[5] These studies are not required because they are usually not sufficient to rebut the presumed risk.

[6] This field study did not fulfill the guideline requirement because, among other things, the search area was insufficient.

[7] Additional testing is not required. L.Fisher's Memorandum of October 1992 indicated that the Agency would make risk assessments based on the laboratory data.

[8] The MATC from the fish early life-stage study shows that phorate is toxic at extremely low concentrations, <190.0 parts per trillion for sheepshead minnow. Therefore, the further testing was not required.

[9] The bioaccumulation study required by the EFGWB (MRID No. 42701101) was used in lieu of the EEB study 72-6.

[10] These studies are not required for granular formulated products.

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Appendix C.1 Phorate Ecological Incidents

Table 1. Phorate Ecological Incidents, Organized by Type of Organism (Terrestrial or Aquatic), Crop, Year, and State.

PHORATE					
Year	State	Crop	Number Affected	Species Affected	Certainty Index, Use Pattern, Residue and CHE Analysis, (Reference) Mitigation or Rebuttal Comments
Terrestrial					
1981	CA	alfalfa	100 100	waterfowl sparrows blackbirds killdeer larks	**Highly probable/Misapplication.** 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. (B000150-006. California Department of Food and Agriculture, 1981).
1978	CA	alfalfa	195	ring billed gulls, cattle egrets, and curlews	**Highly Probable/Misapplication.** On Nov. 4, 1978, in Calipatria, CA, Thimet 10G was applied, contrary to label instructions, to an alfalfa field during irrigation (The label specifies not to apply phorate 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 various arthropods. Phorate residues in the egrets were 150 ppm (B000150-004. FWS, 1989; and USEPA, 1991).
1986	CA	barley	50-75	mallards and pintails	**Highly Probable** 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, CA (FWS, 1989). Patuxent Wildlife Research Center analysis of crop contents for seven birds (5 mallards and two pintails) identified phorate in every crop. No evidence of misuse was found. (B000150-010. USEPA, 1991). Barley has been voluntarily withdrawn from American Cyanamide's label.
1985	VA	peanut	1	bald eagle	**Possible.** One debilitated bald eagle was found on the ground in a peanut field on May 23, 1985. Phorate, aldicarb, carbofuran, captan, and carboxin had been applied to the peanut field. No residue analyses were conducted. The eagle was treated with atropine, recovered, and released. (I004169-008)
1972	CA	sugar beet	25	ducks and blackneck stilts	**Highly Probable.** 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 (I005754-010; B000150-014. Bischoff, 1973).

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PHORATE					
Year	State	Crop	Number Affected	Species Affected	**Certainty Index**, Use Pattern, Residue and CHE Analysis, (Reference) Mitigation or Rebuttal Comments
1991	GA	winter wheat	8	bobwhite quail	**Probable/Misapplication** On January 5, 1991, what appeared to be eight bobwhite quail were found dead adjacent to a phorate-treated wheat field near Waynesboro, GA. Apparently, the field had been planted in late November, and the field had most likely been treated at planting. 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. Examination of the crop and gizzard revealed wheat seed mixed with phorate. Phorate was determined to be the cause of death (B000150-016. USEPA, 1991). This incident occurred in the year following application. If the pesticide is deposited on the soil surface in piles because of misuse, degradation is likely to be slower than if the pesticide is incorporated into soil.
1989	SD	winter wheat	7 81 1 13 1	bald eagles Canada geese Snow Goose Waterfowl sharp-tailed grouse	**Highly Probable** On March 26, 1989, Thimet 20G killed birds on a winter wheat field in Hughes County, SD, 10 miles north of Pierre, that was treated on September 20, 1988 at the application rate of 1.2 oz/1000 foot row with a 10-inch row spacing. The incident report did not specify the application method but did report that the granules were incorporated. If label instructions were followed, the 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 second 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. Phorate residues were also detected in the goose intestine found inside a bald eagle. (FWS, 1989a). See further discussion of the incident in the text of the RED chapter (B000150-015; B000150-012; B000151-001; I000805-006; South Dakota Department of Agriculture, 1989; FWS letter dated December 22, 1989).

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PHORATE					
Year	State	Crop	Number Affected	Species Affected	**Certainty Index**, Use Pattern, Residue and CHE Analysis, (Reference) - Mitigation or Rebuttal Comments
1982	SD	winter wheat	38 4 9 6 7 1 1	mallards gadwalls wigeons pintails green-winged teal red-tailed hawk golden eagle	**Highly Probable.** In October 1982, an incident occurred from the use of phorate on wheat fields near Gettysburgh in Lyman County, SD. The birds were found dead in an intermittent wetland basin several days after a heavy rain. Residue analysis showed 7 ppb in the water and 14 ppb in the sediment. There is some potential for confusion regarding this incident and the incident that follows in Potter County, because I000804-008 represents simultaneous investigation of both incidents. (B000150-008; I000804-008; FWS, 1989)
1982	SD	winter wheat	133 51 42 36 12 3 6 2 4	mallards pintails wigeons gadwall green-winged teal Canada geese marsh harriers red-tailed hawks great-horned owls	**Highly Probable/Misuse.** On October 18 and 20, 1982, 277 waterfowl and 12 raptors were found dead in two ponds in Reliance, 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. There is some potential for confusion regarding this incident and the preceding incident in Lyman County, because I000804-008 represents simultaneous investigation of both incidents. (I000804-008; B000150-007. South Dakota Department of Agriculture 1982).
1982	SD	winter wheat	1	bald eagle	**Highly Probable/Misuse.** On December 5, 1982, in Potter County, SD, a bald eagle was found near the bird kill area cited in B000150-008. Various duck parts containing residues of 26 ppm phorate were found in 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).
1981	CA	winter wheat	2,000 2 several	blackbirds pheasant pigeons	**Highly probable.** On February 19, 1981 in Fresno County, CA, an incident involving phorate killed 2,000 blackbirds, two pheasants and several pigeons. Thimet 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 consumed contaminated irrigation ditch water. Phorate residues were detected in the gizzards of the blackbirds at 24 ppm (B000150-005. California Fish and Game Department, 1981).

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PHORATE					
Year	State	Crop	Number Affected	Species Affected	Certainty Index, Use Pattern, Residue and CHE Analysis, (Reference) Mitigation or Rebuttal Comments
1996	KS	NR	3	swift fox	**Highly Probable** Five foxes were found dead in Kansas (Range W, Township 11 S) in June and July 1996. Phorate residues ranging from 23.5 to 58.9 ppm were found in the stomach contents of 3 of the 5 foxes. (I004756-001)
1993	CD	NR	11	Bald eagles	**Highly Probable/Possible Misuse** In December, 1993 11 bald eagles were poisoned and killed in the Ladner area (Lower Fraser Valley) of Vancouver, British Columbia, Canada. (An earlier report [I002486-002] listed 3 dead and 2 debilitated eagles) American Cyanamide speculates that the eagles became poisoned after feeding on dead or debilitated waterfowl. American Cyanamid suspects misuse because the kill occurred 8 months after the normal use season and because the residues consisted of mostly the parent compound (phorate) and not its sulfone or sulfoxide degradates. American Cyanamide temporarily withdrew the [Canadian?] registration of the Thimet 15 G formulation because of this incident. (I002486-002; I002679-001)
1991	VA	NR	2	robins	**Possible** 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 (0.3 ppm of carbofuran were also detected). How and where the birds had been exposed to phorate remains unknown (I000504-028. Southeastern Cooperative Wildlife Disease Study, 1991).
1989	WI	NR	10 55 1 1 2	Canada geese mallards barn owl skunk opossum	**Misuse** Incident occurred from April through June 1989 in Spring Green, WI. About 40 pounds of spilled or dumped phorate were reportedly discovered nearby. The Agency has no additional information on the cause of the incident. (B000150-013. FWS, 1989).
1987	CA	NR	1	red-tailed hawk	**Possible.** On January 16, 1987 a red-tailed hawk was found in a weakened condition in a "mud" field 9 miles from Dixon, Solano County, CA. The hawk subsequently died in a rehabilitation facility. A diagnosis of organophosphate poisoning was based on severe AChE inhibition and fecal residues of an unidentified OP. Use of phorate nearby was considered the most probable source of exposure. (B000150-009; USFWS).

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PHORATE					
Year	State	Crop	Number Affected	Species Affected	**Certainty Index**, Use Pattern, Residue and CHE Analysis, (Reference) Mitigation or Rebuttal Comments
1987	ID	NR	1	bald eagle	**Highly Probable/Possible** Misuse 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).
Aquatic					
1985	NE	sorghum	1000	fish	**Possible.** Phorate was applied in a sorghum field in Butler County, NE on May 8, 1985. Heavy rain fell five days later and hundreds of fish were killed nine days later. The water source for this pond was filtered overflow from a larger pond which had also suffered a fish kill at the same time. Terbufos (applied in-furrow to corn) and phorate (applied to sorghum) had recently been used in nearby fields above the pond. (I000598-001A; Nebraska Game and Parks Commission, 1985).
1976	AR	spill	90,000 1 1	fish raccoon deer	**Accidental Spill.** A truck carrying 4500 gallons of triester/phorate industrial waste developed a leak and spilled the entire load onto the shoulder of a road, down an embankment, and into a creek. 90,000 sunfish, bass, buffalo, and crappie were killed. Two cows were also killed. (B000300-55)
1970	IL	corn	2000-3000 2 1	bluegill, bass, greengills, silver minnows, catfish, crappies fox squirrels water snake	**Probable.** Runoff from a 60 acre corn field into a 2 acre pond reportedly caused this kill. Residue analysis revealed phorate in the pond water at 9.7 to 32.3 ppb 15 days post application. Propachlor and 2,4-D were also applied to the field. (B000150-001; B000150-002)
1970	IL	corn	NR	fish	**Probable.** Runoff from a corn field into a nearby pond reportedly caused this fish kill. Residue analysis revealed phorate in the pond water at 12.1 ppb 37 days post application. Propachlor and atrazine were also applied to the field. (B000150-001; B000150-003)

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Table 2. Phorate Aquatic Incidents Summary, Organized by Type of Incident (Discontinued Use Pattern, Misuse, Normal Use, etc.), Crop, Year, and State.

PHORATE					
Year	State	Crop	Number Affected	Species Affected	Certainty Index, Use Pattern, Residue and CHE Analysis, (Reference) Mitigation or Rebuttal Comments
The Following Incidents Occurred as a Result of Misuse[1]					
1976	AR	spill	90,000 1 1	fish raccoon deer	**Accidental Spill.** A truck carrying 4500 gallons of triester/phorate industrial waste developed a leak and spilled the entire load onto the shoulder of a road, down an embankment, and into a creek. 90,000 sunfish, bass, buffalo, and crappie were killed. Two cows were also killed. (B000300-55)
The Following Incidents Occurred as a Result Normal Use or Casual Misapplication[2]					
1970	IL	corn	2000-3000 2 1	bluegill, bass, greengills, silver minnows, catfish, crappies fox squirrels water snake	**Probable.** Runoff from a 60 acre corn field into a 2 acre pond reportedly caused this kill. Residue analysis revealed phorate in the pond water at 9.7 to 32.3 ppb 15 days post application. Propachlor and 2,4-D were also applied to the field. (B000150-001; B000150-002)
1970	IL	corn	NR	fish	**Probable.** Runoff from a corn field into a nearby pond reportedly caused this fish kill. Residue analysis revealed phorate in the pond water at 12.1 ppb 37 days post application. Propachlor and atrazine were also applied to the field. (B000150-001; B000150-003)
The Following Incidents were not Associated with Specific Use Patterns and/or Causality was not Definitively Established					
1985	NE	sorghum	1000	fish	**Possible.** Phorate was applied in a sorghum field in Butler County, NE on May 8, 1985. Heavy rain fell five days later and hundreds of fish were killed nine days later. The water source for this pond was filtered overflow from a larger pond which had also suffered a fish kill at the same time. Terbufos (applied in-furrow to corn) and phorate (applied to sorghum) had recently been used in nearby fields above the pond. (I000598-001A; Nebraska Game and Parks Commission, 1985).

1. **Misuse** refers to deliberate application procedures that are prohibited by or contrary to label instructions. These include improper disposal of unused material; application in ways not specified by the label, etc.

2. **Casual Misapplication** refers to unintentional application mishaps that are difficult for growers to avoid and probably occur frequently in production agriculture. Examples include: clogging of equipment from application to wet soil. Misapplication can be differentiated from misuse in that they do not represent deliberate actions that are prohibited by current labeling.

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