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

OFFICE OF
PESTICIDES AND TOXIC SUBSTANCES

MEMORANDUM

SUBJECT: Terbufos Registration Standard

FROM: for John Bascietto, Biologist
Ecological Effects Branch
Hazard Evaluation Division (TS-769C)

Otto Gutenson 10/20/87

THRU: Otto Gutenson, Acting Head-Section IV
Ecological Effects Branch
Hazard Evaluation Division (TS-769C)

Otto Gutenson 10/20/87

THRU: Henry T. Craven, Acting Chief
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Henry T Craven 10/21/87

TO: Marilyn Mautz
Insecticide-Rodenticide Branch
Registration Division (TS-767C)

Attached are the Disciplinary Review, Topical Summaries, and Generic Data Requirements for the Ecological Effects Chapter of the Terbufos (FRSTR) Registration Standard.

Attachment

cc: J. Heckman (MSS) (Memorandum only)
K. Barbehenn (SIS)

32 pages

Ecological Effects

TOPICAL DISCUSSIONS - Terbufos

Effects on Birds

Sixteen studies (within sixteen references) were received and evaluated under this topic. Twelve studies are acceptable for use in hazard assessment and one study is not acceptable.

Author	MRID No.
Beavers and Fink	FE0TER02
Roberts and Wineholt	00087717
Krize and Terrell	00035120
Fink and Reno	00097892
Fink and Reno	00085177
Labisky and Anderson	00085178
Wang	00087726
Manuel	00085180
Labisky	00085179
Manuel	00085183
Labisky	FE0TER01
Begners	160387
Beavers	161573
Beavers	161574
Terrell and Krize	96392
Jaber and Dingledine	BA0TER01

The minimum data required to establish the acute and subacute toxicity of terbufos to birds (using technical terbufos) are as follows:

1. An avian single-dose acute oral LD_{50} study using one of the two species tested for the avian dietary LC_{50} (preferably the mallard, bobwhite quail or other native quails, or the ring-necked pheasant);

2. A subacute dietary LC_{50} study on one species of waterfowl (preferably the mallard duck); and

3. A subacute dietary LC_{50} study on one species of upland game bird (preferably the bobwhite quail or other native quails, or the ring-necked pheasant).

The acceptable acute oral LD_{50} study is listed below:

Species	% ai	LC_{50} and 95% C.I. (mg/kg)	Author	Date	MRID No.	Fulfills Guidelines Requirements
Bobwhite quail	89.6	28.6 (22.2 - 57.2)	Beavers & Fink	1982	FE0TER02	Yes

There is sufficient information to characterize terbufos as highly toxic to the bobwhite quail, based on the above acute oral study. The avian acute oral LD_{50} Guidelines requirements have been satisfied.

The acceptable dietary LC_{50} studies are listed below:

Species	% ai	LC_{50} and 95% C.I. (ppm)	Author	Date	MRID No.	Fulfills Guidelines Requirements
Mallard	86.0	No adverse effects seen at dietary levels of 100 or 150 ppm*	Krize & Terrell	1978	00035120	Partial
Bobwhite quail	86.0	143 (103 - 214) ppm	Roberts & Wineholt	1976	00087717	Yes

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* Because of severe reduction in food consumption in this study, a comparable LC_{50} cannot be determined. A prior mallard study was invalidated for this and other reasons. Because of the food rejection problem, further mallard testing is not deemed warranted.

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Species	% ai	LC_{50} and 95% C.I. (ppm)	Author	Date	MRID No.	Fulfills Guidelines Requirements
(cont'd)						
Bobwhite quail	87.8	157 (124 - 201) ppm	Beavers	1984	160387	Yes
Mallard duck	unknown	520 (400 - 676) ppm	Terrel & Krize	1978	96392	Partial

There is sufficient information to characterize terbufos as highly toxic to the bobwhite quail, based on the avian dietary LC_{50} studies. The avian dietary LC_{50} Guidelines requirements have been satisfied.

Avian reproduction studies with technical terbufos are needed as per Section 163.71-4 of proposed Guidelines (7/10/78) due to the broad use of terbufos on corn at the avian breeding season, repeat applications, and the combination of terbufos' high toxicity to birds (see above) and persistence in soil (e.g., EAB-validated half-life of approximately 11 weeks in a silt-loam soil). Two avian reproduction studies have been submitted.

The acceptable avian reproduction studies are listed below:

Species	% ai	LC_{50} and 95% C.I. (mg/kg)	Author	Date	MRID No.	Fulfills Guidelines Requirements
Mallard	89.0	No statistically significant impairment is reported at dietary levels of 2-20 ppm, but impairment is approaching significance (p=0.05) at 20 ppm.*	Fink & Reno	1973	00097892	Partial

* Pen-by-pen data are required for full statistical evaluation of results.

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Species	% ai	LC_{50} and 95% C.I. (mg/kg)	Author	Date	MRID No.	Fulfills Guidelines Requirements
(cont'd)						
Bobwhite quail	89.0	No statistically significant impairment is reported at dietary levels of 2-20 ppm.*	Fink & Reno	1973	00085177	Partial
Mallard duck	89.6	Possible, but not statistically significant effect on embryo viability at 15 ppm. No other reproductive impairments observed up to 15 ppm.	Beavers	1986	161574	Yes
Bobwhite quail	89.6	No effects at up to 30 ppm	Beavers	1986	161573	Yes

Simulated and/or actual field testing with birds is required as per Section 163.71-5(a) due to the high acute toxicity of terbufos to birds and the high potential for avian exposure to granules at or near the soil surface over a large acreage of treated corn fields.

The acceptable simulated and/or actual field tests are listed below:

Study	Results	Author	Date	MRID No.	Fulfills Guidelines Requirements
Terrestrial Field Study	Counter™ 15G, applied to corn fields at ca. 1 lb ai/A at time of planting under the conditions of this study, has	Labisky & Anderson	1973	00085178	Partial[1]
		Wang	1973	00087726	
		Manuel	1973	00085180	

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Study	Results	Author	Date	MRID No.	Fulfills Guidelines Requirements
Terrestrial Field Study (cont'd)	minimal acute effects on wildlife as far as can be determined by limited searches, residue analyses and miscellaneous wildlife observations.				
Outdoor simulated field study: exposure to treated soil	Ring-necked pheasants were exposed (principally dermally) to soil treated with COUNTER™ 15G at rates equivalent to 1 and 5 lb technical/acre, and did not have detectable residues 22 days after initial exposure nor poisoning symptoms or mortality at any time during the 55 days of exposure, or in posttreatment observation. Two of three birds exposed to a simulated accidential large spill died within 12 hours of initial exposure.	Labisky Manuel Labisky	1974 1973 1975	00085179 00085183 FEOTER01	Partial[1]
Terrestrial Field Study ("Level 1")	When applied by ground equipment at 16 oz per 1,000 ft of row, Counter 15G caused acute mortality of birds and reptiles in corn fields.	Jaber & Dingledine	1985	BAOTER01	Partial[2] (yes, for "Level 1" No, for "Level 2")

1/ Study protocols do not meet complete field study guidelines.
2/ "Level 1" study satisfies Guideline requirements, however, indicates need for a "Level 2" study.

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Study	Results	Author	Date	MRID No.	Fulfills Guidelines Requirements
Terrestrial Field Study (cont'd)	When applied aerially at 6.7 lb per acre (broadcast) Counter 15G caused significant mammal, bird and reptile acute mortality (and probably was the cause of a nearby fish kill).				

In the terrestrial field study cited, the application rate was near the minimum rate presently labeled for corn; before and after application census data were not taken; searches for dead animals were limited (one per site) and were taken as late as 12 to 13 days posttreatment; and no analyses for cholinesterase inhabition were made. The pen study cited indicated minimal hazard to the species tested (ring-necked pheasant) at up to 5 lb ai/A but exposure to COUNTER™ 15G was principally dermal since clean food and water were provided at all times.

In the "Level 1" terrestrial field study in corn, the actual use rates for soil-incorporated uses at planting and aerially broadcast past emergence SLN (Special Local Needs) use rates were employed. Both types of applications caused nontarget mortalities, with the SLN aerial applications being much more severe in their effects. The studies demonstrate field kills resulting from label directed uses (aerial is SLN only), but do not demonstrate an adequate margin of safety. Level 2 or, population studies are now required to qualify the potential effects on populations of birds, mammals and reptiles, based on the adverse effects detected in the "Level 1" study.

Precautionary Labeling

If the avian acute oral LD_{50} is $\leq$ 100 mg/kg or an avian dietary LC_{50} is $\leq$ 500 ppm, the label statement "This pesticide is toxic to wildlife" is specified by Section 162.10 of the July 3, 1975 Regulations and proposed Subdivision H (1982). These conditions are both met by terbufos and thus the above statement must appear on all labels.

In addition the following statements must appear on end-use products:

"Birds, mammals and reptiles utilizing treated fields may be killed".

"Harming or killing of wildlife protected by wildlife conservation laws such as the Migratory Bird Treaty Act or similar statutes may result in civil penalties".

Effects on Freshwater Invertebrates

Four studies (contained in four references) were received and evaluated under this topic. All were acceptable for use in hazard evaluation.

Author	MRID No.
Boudreau et al.	FE0TER03
Bentley	00085176
USEPA	FE0TER06
Forbis et al.	162525

The minimum data required to establish the acute toxicity of terbufos to freshwater invertebrates are the results from an acute LC_{50} study using technical terbufos. Test organisms should be first instar daphnids or early instar amphipods, stoneflies, or mayflies. Daphnids shall be tested for 48 hours. The acceptable studies are listed below:

Species	% ai	LC_{50} and 95% C.I.	Author	Date	MRID No.	Fulfills Guidelines Requirements
Daphnia magna	88.6	0.31 (0.27 - 0.36) ppb	Boudreau et al.	1982	FE0TER03	Yes
Crayfish	88.6	8.0 (6.9 - 10.2) ppb	Bentley	1973	00085176	Partial*

*Inappropriate Species

There is sufficient information to characterize terbufos as very highly toxic to Daphnia magna and the crayfish. The Guidelines requirements for a freshwater invertebrate LC_{50} with technical terbufos have been met.

An additional acute LC_{50} study using the 15% granular formulation with a freshwater invertebrate species, as above, may be needed for hazard evaluation of existing terbufos uses if, as per Section 163.72-1(c), the LC_{50} of the technical grade of the active ingredient approximates the expected residue levels in the aquatic environment when the pesticide product is used as directly or if a product component other than the active

ingredient is expected to substantially enhance the toxicity of the active ingredient. Based on initial modeling by the Environmental Fate Branch, estimated parental residues dissolved in the water column under the maximum use rate for corn do approach/exceed the lowest LC_{50} for a substantial portion of the period modeled. Further modeling and/or monitoring will enable an improved assessment of expected aquatic concentrations (see Disciplinary Review).

One acute LC_{50} study using the 15% granular formulation has been conducted and is listed below:

Species	LC_{50} and 95% C.I.	Author	Date	MRID No.
Daphnia magna	6.2 (5.1 - 7.7) ppb	USEPA	1976	FEOTER06

There is sufficient information to characterize this formulation as very highly toxic to D. magna. If needed, this study meets the intent of proposed Guidelines (7/10/78).

An invertebrate life cycle using D. magna is required as per Section 163.72-4 because the lowest LC_{50} (0.31 ppb) is far below 1 mg ai/L; the estimated concentration in water is far greater than 0.01 of the LC_{50} (based on initial modeling by EAB for the maximum use rate on corn, see Disciplinary Review); the hydrolytic half-life is greater than 4 days at pH 5, 7, and 9, some degradates (e.g., O,O-diethylphosphorodithioic acid), based on their structure, may have a toxicity similar or greater than that of the parent material; and terbufos has broad and repeated use on corn.

The acceptable freshwater aquatic invertebrate life cycle studies are listed below:

Mat acceptable to yield concentration.

Species	% ai	Results	Author	Date	MRID No.	Fulfills Guidelines Requirements
Daphnia magna	98.4	MATC > 30 < 76 ng/l (parts per trillion).	Forbis et al.	1986	162525	Yes

There is sufficient information to characterize terbufos as being extremely chronically toxic to freshwater aquatic invertebrates. MATCs in the parts per trillion range represent some of the most extremely chronically toxic materials available. The Guidelines requirements for an aquatic invertebrate life cycle study are satisfied.

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A simulated or actual field study with aquatic invertebrates must be performed to investigate the potential adverse effects to aquatic invertebrate populations of aquatic exposures to terbufos resulting from drift and runoff of agricultural applications.

Precautionary Labeling

Labeling for aquatic invertebrate hazard is not specified by proposed Subdivision H (1982) since a hazard statement is already specified for fish (see below).

Effects on Freshwater Fish

Eleven studies (within eight references) were received and evaluated under this topic. Six studies are acceptable for use in hazard assessment.

Author	MRID No.
Sleight	00037483
Bentley	00085176
Roberts and Winehold	00087718
USEPA	FEOTER04
USEPA	FEOTER05
McAllister	40009301

The minimum data required to establish the acute toxicity of terbufos to freshwater fish are the results from two 96-hour LC_{50} studies using technical terbufos, one using a coldwater species (preferably the rainbow trout) and one using a warmwater species (preferably the bluegill sunfish).

The acceptable acute toxicity studies are listed below:

Species	% ai	LC_{50} and 95% C.I.	Author	Date	MRID No.	Fulfills Guidelines Requirements
Bluegill sunfish	86.0	0.77 (0.72 - 0.83) ppb	Roberts & Wineholt	1976	00087718	Yes
Bluegill sunfish	86.3	3.8 (2.8 - 4.9) ppb	Sleight	1972	00037483	Yes
Bluegill sunfish	88.6	0.87 (0.77 - 1.0) ppb	Bentley	1973	00085176	Partial
Brown trout	86.0	20 (12.6 - 34.3) ppb	Roberts & Wineholt	1976	00087718	Yes

Species	% ai	LC_{50} and 95% C.I.	Author	Date	MRID No.	Fulfills Guidelines Requirements
(cont'd)						
Rainbow trout	86.3	9.4 (7.7 - 11.4) ppb	Sleight	1972	00037483	Yes
Channel catfish	88.6	96. (8.5 - 11.1) ppb	Bentley	1973	00085176	Partial

There is sufficient information to characterize terbufos as very highly toxic to all of the fish species tested. The guidelines requirements for freshwater fish acute LC_{50} data with technical terbufos have been met.

Two 96-hour LC_{50} fish studies using the 15% granular formulation may be needed for hazard evaluation of existing terbufos uses if, as per Section 163.72-1(c), the LC_{50} of the technical grade of active ingredient approximates the expected residue level in the aquatic environment when the pesticide product is used as directed, or if a product component other than the active ingredient is expected to substantially enhance the toxicity of the active ingredient. If needed, one study should be conducted on a coldwater species and one on a warmwater species. Based on initial modeling by EAB, estimated parental residues dissolved in the water column under the maximum use rate for corn do approach/exceed the lowest LC_{50} for a substantial portion of the period modeled. Further modeling and/or monitoring will enable an improved assessment of expected aquatic concentrations (see Disciplinary Review).

Two 96-hour LC_{50} studies have been conducted using the 15% granular formulation of terbufos and are listed below:

Species	LC_{50} (and 95% C.I.)	Author	Date	MRID No.
Bluegill sunfish	12.3 (9.8 - 15.2) ppb*	USEPA	1975	FEOTER04
Rainbow trout	59.7 (48.1 - 74.3) ppb*	USEPA	1975	FEOTER05

* values based on total formulation

There is sufficient information to characterize this formulation as very highly toxic to bluegill sunfish and rainbow trout. If needed, these studies meet the intent of proposed guidelines (7/10/78).

A fish embryolarvae study (early life stage) is required as per Section 163.72-4 because the lowest fish LC_{50} value (0.77 ppb) is well under 1 mg ai/L, the estimated aquatic concentration in water is greater than 0.01 of the LC_{50} (based on initial modeling by EAB for the maximum use rate on corn, see Disciplinary Review), the hydrolytic half-life is greater than 4 days at pH 5, 7, and 9, some degradates (e.g., O,O-diethylphosphorodithioic acid), based on their structure, may have a toxicity similar or greater than that of the parent material, and terbufos has broad and repeated use on corn.

The acceptable fish early life stage studies are listed below:

Species	% ai	Results	Author	Date	MRID No.	Fulfills Guidelines Requirements
Rainbow Trout	98.5	The MATC could not be calculated. The NOEL was 1.4 ppb, the highest concentration tested.	McAllister	1986	40009301	Partial

There is insufficient information to completely characterize the chronic toxicity to terbufos to Rainbow Trout in an early life stage test. The study failed to meet the Guidelines requirements that "at least one test level must adversely affect a life stage." The MATC can be estimated at > 1.4 ppb < 11.5 ppb because the NOEL is known and the upper limits of the Rainbow Trout 96-hour LC_{50} are known. However, this information is not adequate, and the fish early life stage study must be redone.

Precautionary Labeling

"This pesticide is toxic to fish".

Effects on Estuarine and Marine Organisms

Two studies were evaluated under this topic (two references). Both are acceptable in hazard evaluation.

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Author	MRID No.
Forbis et al.	162523
Swigert et al.	162524

Acute toxicity studies with estuarine and marine organisms are needed for hazard evaluation as per Section 163.72-3(a) due to existing registrations on two crops (field corn and sorghum) with greater than 300,000 acres in coastal counties of the U.S. and EAB initial estimates of runoff from corn fields (see Disciplinary Review), indicating a potential for acutely toxic effects.

The minimum data to establish the acute toxicity of terbufos to marine/estuarine fish are the results of a 96-hour acute toxicity (LC_{50}) study of a marine/estuarine fish species. The acceptable data are listed below:

Species	% ai	Result	Author	Date	MRID No.	Fulfills Guidelines Requirements
Sheepshead Minnow	98.4	96-hr LC_{50}= 1.6 (0.77 - 3.2) ppb	Swigert et al.	1986	162524	Partial

Technical terbufos appears to be at least very highly toxic to sheepshead minnows. However, there is insufficient acceptable data to completely characterize the acute toxicity of technical terbufos to a marine/estuarine fish.

The above study deviated from recommended protocol, and thus could not satisfy the Guidelines requirements for an acute toxicity study of a marine/estuarine fish species.

The minimum acceptable data for establishing the acute toxicity of technical terbufos to marine/estuarine invertebrates are the results of:

(a) Shrimp 96-hour Acute Toxicity Test

AND

(b) Acute Toxicity Test for Mollusc (either a 96-hour flow through shell deposition study, or a 48-hour embryolarvae study).

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The acceptable marine/estuarine invertebrate data are listed below:

Species	% ai	Result	Author	Date	MRID No.	Fulfills Guidelines Requirements
Mysid Shrimp	98.4	96-hr LC_{50} = 0.22 (0.144 - 0.358) ppb	Forbis et al.	1986	162523	Partial

Although terbufos appears to be at least very highly toxic to mysid shrimp, there is insufficient acceptable data to completely characterize the acute toxicity of technical terbufos to a marine/estuarine shrimp species. The above study departed from recommended protocol and thus could not satisfy the Guidelines requirements for the shrimp toxicity study.

There was no information available to characterize the toxicity of technical terbufos to marine/estuarine molluses. The Guidelines requirements for such data are not satisfied.

Ecological Effects

DISCIPLINARY REVIEW - Terbufos

1. Ecological Effects Profile

A. Manufacturing Use

Avian acute oral toxicity data indicate that terbufos is highly toxic to the bobwhite quail, with an LD_{50} value of 28.6 mg/kg (Beavers and Fink 1982, FEOTER02).

Avian dietary toxicity data indicate that terbufos is highly toxic to the bobwhite quail, with an LC_{50} value of 143 ppm (Roberts and Wineholt 1976, 00087717). Additional studies of dietary toxicity confirm that technical terbufos is highly toxic to bobwhite quail with an LC_{50} = 157 ppm (Beavers 1984, MRID No. 160387). A mallard duck LC_{50} of 520 ppm was calculated (Terrell and Krige 1978, MRID No. 96392) which indicates that technical terbufos is moderately toxic to mallard ducks on a dietary basis.

Avian reproduction studies report no adverse reproductive effects in the bobwhite quail at dietary levels of 2 to 20 ppm. For the mallard, no adverse reproductive effects were reported at 2 to 20 ppm but 20 ppm is considered by the investigators to approach a level at which reproductive impairment should be expected since impairment at this level was approaching statistical significance (at $p = 0.05$) (Fink and Reno 1973, 00097892; Fink and Reno 1973, 00085177).

Additional avian reproduction studies showed that technical terbufos does not appear to cause toxic effects or affect reproduction in bobwhite quail at concentrations up to 30 ppm in the diet (Beavers 1986, MRID No. 161573). When mallard ducks were tested in a one generation reproduction study with technical terbufos there were no apparent effects at 1 and 5 ppm but there was a slight reduction in embryo viability at 15 ppm that was not statistically significant (Beavers 1986, MRID No. 161574).

Freshwater fish acute toxicity data indicate that terbufos is very highly toxic to the bluegill sunfish, LC_{50} values ranging from 0.77 to 3.8 ppb (Roberts and Wineholt 1976, 00087718; Sleight 1972, 00037483), rainbow trout, LC_{50} = 9.4 ppb (Sleight 1972, 00037483), brown trout, LC_{50} = 20 ppb (Roberts and Wineholt 1976, 00087718), and channel catfish, LC_{50} = 9.6 ppb (Bentley 1973, 00085176).

A sheepshead minnow LC_{50} = 1.6 ppb showed that technical terbufos is very highly toxic to marine/estuarine fish (Sarigent et al. 1986, MRID No. 162524).

Technical terbufos was used to test the chronic toxicity to fish. An MATC could not be calculated for Rainbow Trout, but the no-effect level observed in this early life stage study was 1.4 ppb (McAllister 1986, MRID 400093-01).

Freshwater invertebrate acute toxicity data indicate that terbufos is very highly toxic to D. magna, LC_{50} = 0.31 ppb (Boudreau et al. 1982, FE0TER03), and the crayfish, LC_{50} = 8.0 ppb (Bentley 1973, 00085176).

An acute toxicity study on mysid shrimp indicated that technical terbufos is very highly toxic to marine/estuarine invertebrates with a 96-hour LC_{50} = 0.22 to 0.34 ppb for mysids (Forbis et al. 1986, MRID No. 162523).

Chronic toxicity of technical terbufos for freshwater aquatic invertebrates (Daphnia magna) was indicated by a flow through test (21-day life cycle) which resulted in MATC limits between 30 and 76 NANOgrams/liter (MATC > 30 < 76 pp th). This is an extremely toxic result based on adult mean length, survival, and young/adult/reproductive day data.

B. Formulated Products

A terrestrial field study, with limited searches, residue analyses, and miscellaneous wildlife observations, implies minimal acute effects on wildlife when COUNTER™ 15G is applied to corn at ca. 1 lb ai/acre (Labisky and Anderson 1973, 00085178; Wang 1973, 00087726; Manuel 1973, 00085180). An outdoor simulated field study in which penned ring-necked pheasants were exposed (principally dermally) to soil treated with COUNTER™ 15G at rates equivalent to 1 and 5 lb technical/acre indicated non-detectable tissue residues 22 days after initial exposure. No birds died or exhibited signs of poisoning during the 55 days of exposure or in posttreatment observation. Two of three birds exposed to a simulated accidental large spill died within 12 hours of initial exposure. (Labisky 1974, 00085179; Manuel 1973, 00085183; Labisky 1975, FE0TER01).

Carcass search studies (level 1 type) in corn have demonstrated the potential for exposure of nontarget organisms and that birds, mammals, reptiles, and fish can be killed by certain applications. Soil incorporated granules (at-planting) resulted in a few dead birds and reptiles (2 lb ai/A) (Jaber and Dingledine 1985, MRID No. 00145854). Aerially broadcast unincorporated granules applied to a maturing corn crop at 1 lb ai/A, resulted in significant terrestrial nontarget organism mortality, as well as a fish kill. Passerine birds and other types of birds, as well as small to medium-sized mammals such as rats, mice, shrews, rabbits, woodchucks, skunks, and raccoons were killed.

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Freshwater invertebrate acute toxicity data indicates that COUNTER® 15G is very highly toxic to D. magna, LC_{50} = 6.2 ppb (USEPA 1976, FE0TER06). Freshwater fish acute toxicity data indicates that COUNTER® 15G is very highly toxic to the bluegill sunfish, LC_{50} = 12.3 ppb, and rainbow trout, LC_{50} = 59.7 ppb. (USEPA 1975, FE0TER04 and FE0TER05).

Ecological Hazard Assessment

Terbufos is a soil insecticide/nematicide presently registered in a 15% ai granular form for use on corn and sorghum. Maximum application rates are 2.4 oz ai/1000 ft of row for corn and sorghum. Terbufos is applied only by certified applicators (or those under direct supervision of certified applicators) using ground equipment.

Corn is presently the major terbufos use. Terbufos is probably the most heavily used corn insecticide in the United States. Corn rootworm is the principal pest for which terbufos is used. Application is at planting in spring and/or postemergence late spring or early summer. Planting in the corn belt is at its peak around the middle of May. One or two applications are applied to corn fields that have been planted to corn for more than one season. Granules are applied by a band or an in-furrow application. Incorporation is light, to a maximum to 2 inches. With a band application, granules are pressed into the soil. Additional incorporation may or may not be made with the use of drag chains, tines, or other devices. The minimum row width specified by the label is 20 inches. The maximum row spacing generally used with corn is 48 inches with an average of 35 to 39 inches.

Sorghum application is at planting or bedding and can be banded (5-7 inches) or knifed-in (drilled below and/or to side of seed). Only one application is permitted per year.

Terrestrial organisms can be exposed to terbufos directly via the granules. Aquatic organisms may be exposed via runoff of the granules or via transport of soil or water containing residues of terbufos or its degradates.

Since corn is by far the principal currently-registered terbufos use, application to this crop can be used to estimate nontarget hazard. The maximum application rate of 2.4 oz ai/1000 ft of row is equivalent to 3.92 lb ai/A at the minimum permitted row spacing (20"), 1.64 lb ai/A at the maximum spacing generally used (48"), and 2.24 to 2.01 lb ai/A at a "typical" spacing (35 to 39").

Granule weight estimates (Bascietto 1987 EEB hazard assessment for granular carbofuran and alternatives 6/4/87) indicate that there are approximately 4 million terbufos granules/lb of formulated product. Each granule thus weighs approximately 0.1 mg. At 15% ai, each granule contains approximately 0.015 mg active ingredient. With an LD_{50} of 28.6 mg ai/kg (bobwhite quail), it would take approximately 0.4 mg ai, or about 27 granules, to reach the LD_{50} of a small bird such as a field sparrow or grasshopper sparrow (0.0139 kg), if such a bird had the same sensitivity to terbufos as the bobwhite quail. However, in toxicity screening studies (Balcomb et al. 1984) using the formulated product (Counter 15G), it was found that 10 granules were sufficient to kill all five redwinged blackbirds given this dose. Doses of 1 and 5 granules did not kill any of the blackbirds and a dose of 20 granules killed four of the five blackbirds receiving this dose. Doses of 1 and 5 granules did not kill any of the house sparrows tested and 10 granules killed two of the five birds receiving this dose.

The above results suggest that an approximate LD_{50} for the redwinged blackbird is likely > 5 and < 10 granules, or > 0.075 and < 0.15 mg terbufos. With a redwinged blackbird weight of approximately 0.07 kg, the LD_{50} would be > 1.1 and < 2.1 mg ai/kg body weight. Since only granules were tested, it was not clear whether the increased toxicity compared to the 28.6 mg/kg value for bobwhite quail (> 13X) was due to differences in sensitivity between the two test species or increased toxicity of the formulation, or both. Hill and Camardese (1984) tested both technical terbufos and Counter 15G for acute oral toxicity to the bobwhite quail. Results indicate Counter 15G is less toxic than terbufos technical on an active ingredient basis. The results, however do not address the species sensitivity question.

A terrestrial field study, with limited searches, residue analyses, and miscellaneous wildlife observations, implies minimal acute effects on wildlife when Counter 15G is applied to corn at ca. 1 lb ai/A (Labisky and Anderson 1973, 00085178; Wang 1973, 00087726; Manuel 1973, 00085180). An outdoor simulated field study in which penned ring-necked pheasants were exposed (principally dermally) to soil treated with Counter 15G at rates equivalent to 1 and 5 lb technical/A indicated nondetectable tissue residues 22 days after initial exposure. No birds died or exhibited signs of poisoning during the 55 days of exposure or in posttreatment observation. Two of three birds exposed to a simulated accidental large spill died within 12 hours of initial exposure. (Labisky 1974, 00085179; Manuel 1973, 00085183; Labisky 1975, FEOTER01).

Mammalian toxicity data were reviewed for the Registration Standard. Based on preliminary acute oral data, terbufos is up to 17.9 times more acutely toxic to small mammals than birds.

Extensive terrestrial field testing has been required to support registrations of Counter 15G. Carcass search studies in corn, similar to those performed with carbofuran, have demonstrated potential for exposure to terbufos and for nontarget kills, particularly through unincorporated, aerial broadcast use. Soil-incorporated use, however, resulted in only a few dead birds and reptiles. Application rates in this study (Jaber and Dingledine 1985) were maximum label-directed rates for 30" center corn (2 lb ai/A). Avian mortalities observed were equivalent to 0.07 to 0.17 per acre. Reptiles (snakes and turtles) were killed at a rate of 0.07 per acre. No mammal carcasses were found dead in the soil-incorporated test.

Jaber and Dingledine (1985) reported that an aerially broadcast (unincorporated) field test on a maturing corn crop at 1 lb ai/A resulted in significant terrestrial nontarget mortality. Birds were killed at a rate of 0.06 to 0.33 per acre; small mammals (rats, mice, shrews) at 0.07 to 0.39 per acre; medium mammals (rabbits, woodchuck, skunks, raccoons) at 0.02 to 0.33 per acre; reptiles at 0.07 per acre. These rates of kill are comparable to those for carbofuran soil-incorporated at 1 and 4 lb ai/A. No secondary poisonings were observed with terbufos.

Aquatic Hazard

EXAMS pond model was as follows: Residues were modeled for a total of 60 days. Peak residues dissolved in the water column were 7.4 ppb on Day 15, immediately after the second runoff event. Peak residues sorbed to benthic sediments were 3.7 ppb on Day 26. By Day 60, residues dissolved in the water column declined to 0.035 ppb and residues sorbed to the benthic sediments declined to 2.1 ppb. These residues are for parental terbufos only; the model was not able to consider degradates, certain of which (based on molecular structure) may be as toxic as parental terbufos.

Residue levels of concern to EEB, for fish and aquatic invertebrates, are shown in the following table:

Restricted Use	Fish	Aquatic Invertebrates
($\geq$ 1/10-1/2 LC_{50})	$\geq$ 0.077-0.385 ppb	$\geq$ 0.031-0.155 ppb
Special Review (> 1/2 LC_{50})	> 0.385 ppb	> 0.155 ppb
Endangered Species		
1. $\geq$ 1/10 LC_{50}	$\geq$ 0.077 ppb	$\geq$ 0.031 ppb
2. $\geq$ 1/20 LC_{50}	$\geq$ 0.0385 ppb	$\geq$ 0.0155 ppb

The lowest validated LC_{50} and LC_{10} values for each taxon are used in this table. These residues are of concern if present in aquatic habitat for > 96 hours for fish and > 48 hours for aquatic invertebrates. Modeled residues dissolved in the water column (after the first runoff) exceed the above criteria for endangered species continuously through Day 57 (fish, both criteria) and Day 60 (aquatic invertebrates, both criteria); for Restricted Use, continuously through Day 54 (fish) and Day 60 (aquatic invertebrates); for Special Review, continuously through Day 44, except Days 33-34 (fish) and Day 49 (aquatic invertebrates). In sum, residue levels of concern are exceeded for 38 to 56 days out of 56 days following initial pesticide runoff.

It thus appears that there is potential for a substantial acute hazard for freshwater and marine/estuarine species because the effects levels are in the very low ppb range. The chronic hazards for freshwater invertebrates are even greater than the acute hazards or the chronic hazards for fish. Daphnia were extremely sensitive to technical terbufos, with a 21-day chronic (life cycle) exposure resulting in MATC > 30 < 76 parts per trillion, based on growth survival and reproduction. A field study for effects on aquatic organisms is clearly indicated in this case (N.B. - fish kills had already been reported).*

Since soil-incorporated applications typically provide less exposure than aerial broadcast applications, potentially greater hazards are likely for aerial applications of terbufos granules, including those for aquatic environments. Thus the hazards for the "Special Local Need" registrations (SLNs) of aerial use could be particularly high. These should also be investigated in separate aquatic field studies. Perhaps restrictions on the SLNs will be necessary if any SLN areas can expose estuarine environments. (An estuarine fish kill was reported to have occurred in the Chesapeake Bay Region during an aerial broadcast application to a corn field during an avian field study - see Dingledine 1985.)

Endangered Species Considerations

Terbufos has been identified as one of several toxic insecticides posing risks to endangered species exposed as a result of use of these chemicals on corn fields. The endangered

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* The company has failed to provide the required aquatic monitoring data (see previous standard). Request for aquatic field study is based on new acute and chronic data as well as the reported fish kills. The aquatic field studies should be both freshwater and marine/estuarine sites with corn as the crop.

species hazards are described in the "crop cluster" assessment, and the appropriate use restrictions are being implemented through Federal Register notice PR Notice 87-5 as part of EPA's endangered species implementation plan. In that notice, labeling for Terbufos did not include listed birds determined to be in jeopardy from certain crop pesticides, including Terbufos. Subsequent updates to EPA's Implementation Plan will include birds on the Terbufos label.

When results of the aquatic field tests required by this review are available, the crop cluster and endangered species bulletins may require updating for terbufos' effects on endangered aquatic species, depending on the results of these studies. Alternatively, if monitoring data become available showing that terbufos contamination of water bodies results from label - directed uses, then the endangered species crop bulletins (corn) may also be updated to reflect the hazards to endangered aquatic species prior to completion of the aquatic field studies required herein.

The following federally endangered species are identified as being potentially exposed to terbufos as a result of their proximity to sugarbeet fields. Since terbufos is known to kill birds, mammals, fish (and presumably other aquatic species or aquatic life stages of amphibian species and aquatic invertebrates) and reptiles, its use in sugarbeets may affect the continued existence of the following species (except plants which are included here for informational purposes).

Having made this "may affect" determination, EPA is required to seek a formal consultation with the Office of Endangered Species, U.S. Fish and Wildlife Service, under Section 7 of the Endangered Species Act. This procedure is now necessary because there are no "cluster opinions" available which consider sugarbeets.

"May AFFECT" Species list For Terbufos used on Sugarbeets (Except Plants)

Mammals

Indiana Bat
Grizzly Bear
Black-Footed Ferret
N. Swift Fox
Son Joaquin Kit Fox
Salt Marsh Harvest Mouse
S. Sea Otter
Sonoran Proughorn
Morro Bay Kangaroo Rat
Gray Wolfe

("May AFFECT" List, con't)

Birds

Whooping Crane
Bald Eagle
Aleutian Canada Goose
Brown Pelican
California Clapper Rail
Light-footed Clapper Rail
Yuma Clapper Rail
California Least Tern
Kirtland's Warbler

Reptiles

Blunt-nosed Leopard Lizard
Coachella Valley Fringe-toed Lizard
Island Night Lizard

Amphibians

Desert Slender Salamander
Santa Cruz Long-toed Salamander

Fish

Mohave Chub
Unarmored Threespine Stickleback
Gila Top Minnow
Greenback Cutthroat Trout
Little Kern Golden Trout

Insects

Delta Green Ground Beetle
Valley Elderberry Longhorn Beetle
El Segundo Blue Butterfly
Lange's Metalmark Butterfly
Palos Verdes Blue Butterfly
Smith's Blue Butterfly
Kern Primrose Sphinx Moth

Plants

Arizona Hedgehog Catus
Nichol's Turk's Head Cactus
Solano Grass
Santa Barbara Island Liveforever
San Clemente Broom
San Clemente Island Indian Paintbrush
San Clemente Island Larksput
San Clemente Island Bushmallow

3. Data Gaps

See Table A and footnotes.

4. Precautionary Label Statements

A. Manufacturing Use Products

"This pesticide is extremely toxic to fish and wildlife. Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or public waters unless this product is specifically identified and addressed in an NPDES permit. Do not discharge effluent containing this product into sewer systems without previously notifying the sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of the EPA."

B. End-Use Products

Counter 15G:

"This pesticide is extremely toxic to fish and wildlife. Birds, mammals, and reptiles utilizing treated fields may be killed. Harming or killing of wildlife protected by wildlife conservation laws such as the Migratory Bird Treaty Act or similar statutes may result in civil penalties."

"Do not apply directly to water or wetlands (including swamps, marshes, bags, and potholes). Runoff and drift from treated areas may be hazardous to aquatic organisms in adjacent aquatic sites. Do not contaminate water by cleaning of equipment or disposal of wastes. Cover or incorporate granules that are spilled during mixing and loading."

Required Bee Precaution

(None required for granulars).

5. Classification

Terbufos is classified as a RESTRICTED USE PESTICIDE.

Table A
GENERIC DATA REQUIREMENTS FOR TERBUFOS

Guideline Citation	Data Requirement	Composition and Use Pattern	Does EPA Have Data To Satisfy This Requirement? (Yes, No, or Partially	Bibliographic Citation	Must Additional Data Be Submitted Under FIFRA Section 3(c)(2)(B)
71-1	Avian Single - Dose Oral LD_{50}	A	Yes	FEOTER02	No
71-2	Avian Dietary LC_{50}	A	Yes	00087717 00035120 160387	No
71-3	Wild Mammal Toxicity	----	----	----	No
71-4	Avian Reproduction	A	Yes	161573 161574	No
71-5	Simulated and Actual Field Testing for Mammals & Birds	A	Partially[1]/	Labisky & Anderson 00085178 Wang, 00087726 Manuel, 00085180 (Jaber and Dingledine) 00145854 (Corp for "Level 1") Labisky, 00085179 Manuel, 00085183 Labisky, FEOTER01	Yes[2]/
72-1	Fish Acute LC_{50}	A	Yes	Sleight, 00037483 Bentley, 00085176 Roberts and Wineholt, 00087718	No
		A	Yes	USEPA, FEOTER04 USEPA, FEOTER05	No

Table A
GENERIC DATA REQUIREMENTS FOR TERBUROS (cont'd)

Guideline Citation	Data Requirement	Composition and Use Pattern[1/]	Does EPA Have Data To Satisfy This Requirement? (Yes, No, or Partially	Bibliographic Citation	Must Additional Data Be Submitted Under FIFRA Section 3(c)(2)(B)
72-2	Acute LC_{50} Aquatic Invertebrates	A	Yes	Boudreau, et al., FEOTER03, Bentley, 00085176	No
		A	Yes	USEPA, FEOTER06	No
72-3	Acute LC_{50} Estuarine + Marine Organisms	A	Partially	162524[3/] 162523[3/]	Yes[4/]
72-4	Fish Early Life Stage/Aquatic Invertebrate Life Cycle	A	(Fish-partial) (invert.-yes)	40009301[3/] 162525	Yes[5/]
72-5	Fish Life Cycle	A	No	----	No
72-6	Aquatic Organism Accumulation	A	No	----	Yes
72-7	Simulated or Actual Field Testing for Aquatic Organisms	A	No	----	Yes[6/] (for corn)

1/ Level 1 is satisfied. Level 2 is required for corn.

2/ Actual field testing with birds is required, as per 40 CFR 158.145, to support the use of terbufos products on ~~any crops~~ corn and sorghum, where the estimated environmental concentrations (EEC's) exceed the effect levels, if any, that are determined for the more sensitive species in the required avian reproduction tests. Unless actual residue and residue decline data that are applicable to wildlife food sources (e.g., foliar and insect residues) are submitted, EEC's will be estimated based on initial residues from the EEB nomograph, the minimum spray interval for the particular use, and the maximum half-life for foliar dissipation. The design of the field studies must include appropriate techniques to determine the potential field effects on reproduction and populations of birds in a multiple year study.

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Protocols for conducting field studies must be submitted to the Agency for review within 6 months of the publication of the standard. A Guidance Document is available from the Agency, which outlines an acceptable approach to these studies. The Agency encourages registrants to consult with EEB staff for assistance, as needed.

3/ Supplemental data.

4/ All three studies must be re-done.

5/ Only the fish early life stage needs to be re-done.

6/ Aquatic field studies are required to support the corn use. Field studies for other use patterns are reserved, pending an evaluation of the results for corn and an analysis of applicability to support other crop uses. For either mesocosm or full field studies the study design must include appropriate techniques to determine acute mortality and effects on productivity and diversity of fish and aquatic invertebrates. A protocol for a mesocosm or full field study must be submitted to the Agency for review within 6 months of the publication of this standard. A Guidance Document is available from the Agency, which outlines an acceptable approach to mesocosm studies. This document also provides relevant, although general, guidance for full field studies, which, if selected in place of mesocosm studies, must include multiple treated ponds and control ponds. The Agency encourages registrants to consult with EEB staff for assistance as needed.

A Synopsis of the Ecological Effects
Data Base for Terbufos.

Compiled From EEB/HED Active Ingredient Files
By:

John Bascietto, Wildlife Biologist
Ecological Effects Branch /HED/ OPP

Dec. 30, 1986

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TERBUFOS - COUNTER 15G

Avian acute oral toxicity data indicate that terbufos is highly toxic to the bobwhite quail, with an LD_{50} value of 28.6 mg/kg. and an LC_{50} value of 143 ppm.

Avian reproduction studies report no adverse reproductive effects in the bobwhite quail at dietary levels of 2 to 20 ppm. For the mallard, no adverse reproductive effects were reported at 2 to 20 ppm.

Freshwater invertebrate acute toxicity data indicate that terbufos is very highly toxic to D. magna, LC_{50} = 0.31 ppb and the crayfish, LC_{50} = 8.0 ppb.

Freshwater fish acute toxicity data indicate that terbufos is very highly toxic to the bluegill sunfish, LC_{50} values ranging from 0.77 to 3.8 ppb, rainbow trout, LC_{50} = 9.4 ppb, brown trout, LC_{50} = 20 ppb, and channel catfish, LC_{50} = 9.6 ppb.

Freshwater invertebrate acute toxicity data indicate that Counter™ 15G is very highly toxic to D. magna, LC_{50} = 6.2 ppb. Freshwater fish acute toxicity data indicate that Counter™ 15G is very highly toxic to bluegill sunfish LC_{50} = 12.3 ppb, and rainbow trout LC_{50} = 5 ppb.

Ecological Hazard Assessment

Terbufos is a soil insecticide/nematicide presently registered in a 15% ai granular form for use on corn and sorghum. Maximum application rates are 2.4 oz ai/1000 feet of row for corn and sorghum. Terbufos is applied only by certified applicators (or those under direct supervision of certified applicators) using ground equipment.

Corn is presently the major terbufos use. Terbufos is probably the most heavily used corn insecticide in the United States. Corn rootworm is the principal pest for which terbufos is used. Application is at planting in spring and/or postemergence late spring or early summer.Planting in the corn belt is at

its peak around the middle of May. One to two applications are applied to corn fields that have been planted to corn for more than one season. Granules are applied by a band or an in-furrow application. Incorporation is light, to a maximum to two inches. With a band application, granules are pressed into the soil. Additional incorporation may or may not be made with the use of drag chains, tines, or other device. The minimum row width specified by the label is 20 inches. The maximum row spacing generally used with corn is 48 inches with an average of 35 to 39 inches.

Sorghum application is at planting or bedding and can be banded (5-7 inches) or knifed-in (drilled below and/or to side of seed). Only one application is permitted per year.

Terrestrial organisms can be exposed to terbufos directly via the granules. Aquatic organisms may be exposed via runoff of the granules or via transport of soil or water containing residues of terbufos or its degradates.

Since corn is by far the principal currently-registered terbufos use, application to this crop can be used to estimate nontarget hazard. The maximum application rate of 2.4 oz ai/1000 feet of row is equivalent to 3.92 lb ai/acre at the minimum permitted row spacing (20"), 1.64 lb ai/acre at the maximum spacing generally used (48"), and 2.24 to 2.01 lb ai/acre at a "typical" spacing (35 to 39").

Granule weight estimates made by R. Balcomb of EEB indicate that there are approximately 4 million terbufos granules/lb of formulated product. Each granule thus weighs approximately 0.1 mg. At 15% ai, each granule contains approximately 0.015 mg active ingredient. With an LD_{50} of 28.6 mg ai/kg (bobwhite quail), it would take approximately 0.4 mg ai, or about 27 granules, to reach the LD_{50} of a small bird such as a field sparrow or grasshopper sparrow (0.0139 kg), if such a bird had the same sensitivity to terbufos as the bobwhite quail. However, in toxicity screening studies by R. Balcomb, using the formulated product (Counter 15G), it was found that 10 granules were sufficient to kill all five redwinged blackbirds given this dose. Doses of one and five granules did not kill any of the blackbirds and a dose of 20 granules killed four of the five blackbirds receiving this dose. Doses of one and five granules did not kill any of the house sparrows tested and 10 granules killed two of the five birds receiving this dose.

The above results suggest that an approximate LD_{50} for the redwinged blackbird is likely > 5 and < 10 granules, or > 0.075 and < 0.15 mg terbufos. With a redwinged blackbird weight of approximately 0.07 kg, the LD_{50} would be > 1.1 and < 2.1 mg ai/kg body weight. Since only granules were tested, it was not

clear whether the increased toxicity compared to the 28.6 mg/kg value for bobwhite quail (> 13X) was due to differences in sensitivity between the two test species or increased toxicity of the formulation, or both. Hill and Camardese (1984) tested both technical terbufos and Counter 15G for acute oral toxicity to the bobwhite quail. Results indicate Counter 15G is less toxic than terbufos technical on an active ingredient basis. The results do not address the species sensitivity question, however.

A terrestrial field study, with limited searches, residue analyses, and miscellaneous wildlife observations, implies minimal acute effects on wildlife when Counter 15G is applied to corn at ca. 1 lb ai/acre (Labisky and Anderson, 1973, 00085178; Wang, 1973, 00087726; Manuel, 1973, 00085180). An outdoor simulated field study in which penned ring-necked pheasants were exposed (principally dermally) to soil treated with Counter 15G at rates equivalent to 1 and 5 lb technical/A indicated nondetectable tissue residues 22 days after initial exposure. No birds died or exhibited signs of poisoning during the 55 days of exposure or in posttreatment observation. Two of three birds exposed to a simulated accidental large spill died within 12 hours of initial exposure. (Labisky, 1974, 00085179; Manuel, 1973, 00085183; Labisky, 1975, FE0TER01).

Mammalian toxicity data were reviewed for the Registration Standard. Based on preliminary acute oral data, terbufos is up to 17.9 times more acutely toxic to small mammals than birds.

Extensive terrestrial field testing has been required to support registrations of Counter 15G. Carcass search studies in corn, similar to those performed with carbofuran, have demonstrated potential for exposure to terbufos and for nontarget kills, particularly through unincorporated, aerial broadcast use. Soil-incorporated use, however, resulted in only a few dead birds and reptiles. Application rates in this study (Dingledine, 1985) were maximum label-directed rates for 30" center corn (2 lb ai/A). Avian mortalities observed were equivalent to 0.07 to 0.17 per acre. Reptiles (snakes, and turtles) were killed at a rate of 0.07 per acre. No mammal carcasses were found dead in the soil-incorporated test.

Dingledine (1985) reported that an aerially broadcast (unincorporated) field test on a maturing corn crop at 1 lb ai/A resulted in significant terrestrial nontarget mortality. Birds were killed at a rate of 0.06 to 0.33 per acre; small mammals (rats, mice, shrews) at 0.07 to 0.39 per acre; medium mammals (rabbits, woodchuck, skunks, raccoons) at 0.02 to 0.33 per acre; reptiles at 0.07 per acre. These rates of kill are comparable to those for carbofuran soil-incorporated at 1 and 4 lb ai/A. No secondary poisonings were observed with terbufos.

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Aquatic Hazard

EXAMS pond model was as follows: Residues were modeled for a total of 60 days. Peak residues dissolved in the water column were 7.4 ppb on Day 15, immediately after the second runoff event. Peak residues sorbed to benthic sediments were 3.7 ppb on Day 26. By Day 60, residues dissolved in the water column declined to 0.035 ppb and residues sorbed to the benthic sediments declined to 2.1 ppb. These residues are for parental terbufos only; the model was not able to consider degradates, certain of which (based on molecular structure) may be as toxic as parental terbufos.

Residue levels of concern to EEB, for fish and aquatic invertebrates, are shown in the following table:

Restricted Use	Fish	Aquatic Invertebrates
($\geq$ 1/10-1/2 LC_{50})	$\geq$ 0.077-0.385 ppb	$\geq$ 0.031-0.155 ppb
RPAR (> 1/2 LC_{50})	> 0.385 ppm	> 0.155 ppb
Endangered Species		
1. $\geq$ 1/10 LC_{50}	$\geq$ 0.051 ppb	$\geq$ 0.021 ppb
2. $\geq$ 1/20 LC_{50}	$\geq$ 0.0385 ppb	$\geq$ 0.0155 ppb

The lowest validated LC_{50} and LC_{10} values for each taxon are used in this table. These residues are of concern if present in aquatic habitat for $\geq$ 96 hours for fish and $\geq$ 48 hours for aquatic invertebrates. Modeled residues dissolved in the water column (after the first runoff) exceed the above criteria for endangered species continuously through Day 57 (fish, both criteria) and Day 60 (aquatic invertebrates, both criteria); for Restricted Use, continuously through Day 54 (fish) and Day 60 (aquatic invertebrates); for RPAR, continuously through Day 44, except Days 33-34 (fish) and Day 49 (aquatic invertebrates). In sum, residue levels of concern are exceeded for 38 to 56 days out of 56 days following initial pesticide runoff. It thus appears that there is potential for

substantial hazard to aquatic organisms under existing terbufos registrations. Results of further modeling (e.g., of other use patterns/rates) and/or field monitoring of residues will enable an improved hazard assessment.

Since soil-incorporated registrations are known to provide substantially less exposure than aerial broadcasts, at least the same conclusions can be drawn for the incremental exposure of aerial applications, i.e., more potential hazard is likely for aquatic systems, compared with incorporated uses. Exposure values in the model will be considerably reduced due to soil-incorporation "at-planting", thus eliminating substantially aquatic hazard concerns.

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