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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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MEMORANDUM

OFFICE OF
PESTICIDES AND TOXIC SUBSTANCES

TO: Jay Ellenberger
Product Manager 12
Registration Division

THRU: Harry T. Craven, Head
Section IV
Ecological Effects Branch
Hazard Evaluation Division

THRU: Clayton Bushong, Chief
Ecological Effects Branch
Hazard Evaluation Division

SUBJECT: Aldicarb Registration Standard.

Attached is the Ecological Effects Branch Topical Summary and Disciplinary Review for aldicarb.

Richard R. Stevens
Ecological Effects Branch
Hazard Evaluation Division

attachment

cc. Heckmann
Burin

ECOLOGICAL EFFECTS

TOPICAL SUMMARY

Effects on Birds

Sixteen studies under eleven citations were evaluated under this topic. Toxicity data from these studies were acceptable for use in non-target avian hazard assessment.

Author	ID	Author	ID
Hill et al.	00022923	Beavers and Fink	BOWOAL02
Beavers and Fink	00102132	Haines	00101961
Hill and Camardese	BOWOAL01	Haines	00101962
Hill	BOWOAL04	Clarkson et al.	00101960
Beliles et al.	00080706	Lund and Haines	00101959
Hudson et al.	BOWOAL03		

The minimum testing required for establishing the avian short-term subacute effects of aldicarb are the results of two 8-day dietary studies conducted with technical product. Testing should be performed on two avian species: one species of wild waterfowl (preferably the mallard) and one species of upland game bird (preferably the bobwhite or other native quail, or ring-necked pheasant) [section 163.71-2]. The acceptable data are presented in Table 1.

Table I
Avian Dietary Studies Conducted with Technical Aldicarb

Species	% Active	8-day dietary LC50 (ppm	Author	Date	Study ID	Fulfills Guideline Requirements
Mallard Duck	99 99 99	594 (5 days)* <1000 (10 days) 381	Hill et al.	1975	00022923	Yes
Ring-necked Pheasant	99	>300	"	"	"	Partial
Bobwhite	100	71	Beavers and Fink	1979	00102132	yes
Japanese quail	99	786	Hill and Camardese	1981	BOWOAL01	Partial
Japanese Quail	99	247 ?	"	"	"	Partial
Japanese Quail	99	355	"	"	"	Partial
Japanese Quail	99	542	"	"	"	Partial

* age of test animal

There are sufficient data to characterize technical aldicarb as moderately toxic to waterfowl and at least highly toxic to upland game birds.

The guideline requirements for LC_{50} studies on waterfowl and upland game are satisfied.

The minimum data required for establishing the acute oral toxicity of aldicarb in birds are the results from one acute oral LD_{50} study with technical product for one avian species, either a waterfowl (i.e. mallard duck) or upland game (i.e. bobwhite quail or ring-necked pheasant) [163.71-1]. Table 2 lists the acceptable avian acute oral LD_{50} studies.

Table 2
Avian Acute Oral LD_{50} Studies Conducted with Technical Aldicarb

Species	% Active	LD_{50} (mg/kg)	Author	Date	Study ID	Fulfills guideline Requirements
Mallard	100	1	Beavers and Fink	1979	BOWOAL02	Yes
Bobwhite	99	2	Hill	1983	BOWOAL04	Partial
Mallard	95	1.92 (36 hr)* 3.60 (7 day) 6.73 (30 day) 4.44 (6 mo.)	Hudson et al.	1972	BOWOAL03	Partial

* age of test animal

There are no minimum data requirements for establishing the acute oral or subacute dietary toxicity of aldicarb formulations to non-target birds. However, Table 3 lists acceptable data that were reviewed.

Table 3

Studies Conducted with Formulated Aldicarb.

Species	% Active	LD_{50} (mg/kg)	LC_{50} (ppm)	Author	Date	Study ID	Fulfills Guideline Requirements
Bobwhite	15G	2.5		Hill	1983	BOWOAL04	partial
Bobwhite	10G		2400	Beliles et al.	1966	00080706	partial

The available avian acute oral toxicity studies satisfy guideline requirements and demonstrate that aldicarb (both technical and formulated product) is very highly toxic to mallards and bobwhite quail.

The guidelines requirement for an avian LD_{50} with technical aldicarb is satisfied.

Field studies are required to determine the impact of certain aldicarb uses on birds [Sec. 163.71-5]. Acceptable data are listed in Table 4.

Table 4. Avian Field Studies

Author	Date	ID	Rate lb ai/A	Comment
Haines	1970	00101961	2 to 6 (10G)	Subsurface application exposure in cotton and sugarbeet fields in CA. Quail or pheasants died following ingestion of granules left on the surface during incorporation or spillage.
Haines	1970	00101962	2 to 6 (10G)	Vegetative exposure in sugarbeet fields in CA. Quail and pheasants were not affected by ingesting aldicarb contaminated foliage.
Clarkson et al.	1969	00101960	1 to 20 (10G)	Small-pen field test involving different methods of application to bare soil in N.C. Mortality was more severe (23/30 deaths) in non-irrigated v. irrigated (4/30 deaths) plots.

The effects of pesticides on bird communities can be variable and complex. It is seldom possible to identify any one field monitoring study as defining the hazard and fulfilling the guideline requirement for such testing. The available field studies for aldicarb are of this sort; no one study provides sufficient information to determine risks. These studies indicate that exposed granules following aldicarb treatments may result in local population reductions in some bird species. Whether these effects are excessive, long-lasting, or likely to diminish wildlife resources, cannot be said with any degree of certainty.

Field studies involving carcass searches and residue analyses are needed to further quantify non-target avian mortalities resulting from application of aldicarb to sorghum and citrus.

Precautionary Labeling

In light of the current available avian toxicity data, technical labels and labels for formulated products intended for outdoor use will require a statement indicating that this pesticide is toxic to birds.

Effects on Freshwater Fish

Seven studies under three citations were received and evaluated under this topic. Toxicity data obtained from these studies are acceptable for use in non-target aquatic hazard assessment.

Author	ID
Johnson and Finley	00003503
Hutchinson	BOWOAL06
Pickering and Gilliam	BOWOAL07

The minimum data required for establishing the acute toxicity of aldicarb to freshwater fish are results from two 96-hour studies with technical product [section 163.72-1] for one coldwater species (preferably rainbow trout) and one warmwater species (preferably bluegill).

Table 6 lists the acceptable freshwater fish data.

Table 6

Acute Toxicity Studies on Freshwater Fish with Technical Aldicarb

Species	% Active	96-hour LC50 (ug/l)	Author	Date	Study ID	Fulfills Guideline Requirements
Bluegill	100	63.6	Hutchinson	1979	BOWOAL06	Partial
Rainbow	100	560.0	"	"	"	Yes
Bluegill	100	50.0	Johnson and Finley	1980	00003503	Yes
Rainbow	100	560.0	"	"	"	Yes
Fathead	99	1,370	Pickering and Gilliam	1982	BOWOAL07	Yes

The available data satisfy guideline requirements and demonstrate that aldicarb is very highly toxic to freshwater fishes.

Chronic testing (life stage or life cycle) for the technical can be required if:

- the product is expected to be transported to water, and
- its presence in water is likely to be continuous, or
- any LC_{50} or EC_{50} is less than 1 ppm, or
- the estimated environmental concentration in water is equal to or greater than 0.01 of any LC_{50} or EC_{50}, or
- studies of other organisms indicate the reproductive physiology of fish and/or invertebrates may be affected. [72-4]

One longer-term embryo-larvae exposure study with fathead minnows was reviewed (Pickering and Gilliam, 1982, BOWOAL07). The results show that the MATC of aldicarb for the fathead is between 78 and 156 ug/l. At concentrations of 78 ug/l and less, there was no adverse effect on embryo survival or on larval-juvenile survival and growth. Survival of juveniles after 30 days exposure to 156 ug/l was significantly (50%) less than survival of controls. This study does not fulfill guideline requirements for chronic testing, however, it is suitable for use is aquatic hazard assessment. No chronic data are required at this time.

Precautionary Labeling

In light of the currently available fish toxicity data, technical labels and labeling for formulated products intended for outdoor use will require a statement indicating that this pesticide is toxic to fish.

Effects on Freshwater Aquatic Invertebrates

Two studies were evaluated under this topic. Toxicity data from one of these studies are acceptable for use in non-target aquatic invertebrate hazard assessment.

AUTHORS	STUDY I.D.
Vilkas	BOWOAL08
Staaterman	BOWOAL05

The minimum data required for establishing the acute toxicity of aldicarb to freshwater invertebrates are the results from a 48-hour LC_{50} study with technical product using preferably Daphnids or a 96-hour LC_{50} study with technical aldicarb using stonefly, amphipod or mayfly [section 163.72-2].

Table 5 lists acceptable invertebrate data.

Table 5

Acute Toxicity Study on a Freshwater Invertebrate with Technical Aldicarb.

Species	% Active	48-hr LC_{50} (ug/l)	Author	Date	I.D.	Fulfills Guideline Requirements
Daphnia magna	100.0	410.7	Vilkas	1977	BOWOAL08	Yes

There are sufficient data to characterize technical aldicarb very highly toxic to freshwater invertebrates.

The guidelines requirement for an LC_{50} to a freshwater aquatic invertebrate is satisfied.

Precautionary Labeling

In light of the avialable freshwater invertebrate toxicity data, technical labels and labels for formulated products intended for outdoor use will require a statement indicating that this pesticide is toxic to aquatic invertebrates.

EFFECTS ON ESTUARINE AND MARINE SPECIES

Eight studies under one citation were evaluated under this topic. All eight studies were acceptable for use in non-target estuarine/marine hazard assessment.

AUTHOR	I.D.
U.S. EPA	00066341

The minimum data required for establishing the acute toxicity of aldicarb to estuarine and marine organisms are the results from three studies with technical product: a 96-hour LC_{50} for a shrimp and an estuarine or marine fish, and a 48-hour LC_{50} for embryo-larvae or 96-hour EC_{50} shell deposition for a mollusk [section 163.72-3].

Table 7 lists results of acceptable acute estuarine/marine toxicity studies.

TABLE 7

Acute Estuarine and/or Marine Toxicity Studies Conducted with Technical Aldicarb.

SPECIES	% ACTIVE	96 hour LC50(ug/l)	AUTHOR	DATE	STUDY ID	FULFILLS GUIDELINES Requirements
Oyster larvae[1]	99.8	8,800*	U.S. EPA	1981	00066341	Yes
Pinfish[2]	99.8	80	"	"	"	Yes
Sheepshead minnow[2]	99.8	168	"	"	"	Yes
Spot[1]	99.8	202	"	"	"	Yes
Sheepshead minnow[1]	99.8	41	"	"	"	Yes
White shrimp[1]	99.8	72	"	"	"	Partial
Mysid shrimp[1]	99.8	13	"	"	"	Yes
Mysid shrimp[2]	99.8	16	"	"	"	Yes
Pink shrimp[2]	99.8	12	"	"	"	Yes

* 48 hour LC_{50}.
1 static
2 flow-through

There are sufficient data to characterize technical aldicarb as very highly toxic to estuarine/marine organisms.

Two longer-term life-cycle exposure studies of estuarine fish and invertebrate species to aldicarb were reviewed (U.S. EPA, 1981, 00066341). Results of a life-cycle toxicity test with mysid shrimp showed long-term effects to occur at significantly lower concentrations (1.5 and 2.1 ug/l) than that at which acute toxicity occurred (16 ug/l). Mortality of animals exposed to aldicarb concentrations $\geq$ 1.5 ug/l was significantly greater than that of controls, but the difference did not become significant until day 14 of the exposure. At the highest concentration tested, 2.1 ug/l, there were also effects on reproduction (no release of young), as well as reduced survival. The MATC based on measured concentrations was 1.0 to 1.5 ug/l.

Hatching success of sheepshead minnows was not affected by exposure to $\leq$ 88 ug/l aldicarb. Percentage survival from fertilization through embryonic development to hatching ranged from 91 to 98% in all exposure aquaria. Embryonic abnormalities or hatching delays were not observed.

A 28-day posthatch exposure to $\leq$ 88 ug/l aldicarb did not significantly affect juvenile survival. The majority of the mortality in all test concentrations occured by day 14 posthatch. No physical abnormalities were observed among juvenile fish in any treatment.

Growth (mean standard length) of juvenile fish was affected at the highest exposure concentration, 88 ug/l. Chemical analyses of fish that survived each test exposure did not yield any residues of aldicarb. The estimated MATC for embryos and juveniles of sheepshead minnows exposed to aldicarb was >50<88 ug/l. The 96-hour LC_{50} (41 ug/l) was lower than the MATC limits. No obvious explanation for a lower LC_{50} is evident.

The guidelines requirements for estuarine and marine organism testing are satisfied.

Precautionary Labeling

In light of the currently available estuarine/marine toxicity data, technical labels and labels for formulated products intended for outdoor use will require a statement indicating that this pesticide is very highly toxic to estuarine/marine organisms.

Effect on Wild Mammals

One study was reviewed for the topic. It is acceptable for use in a hazard assessment. Lund and Haines (1969, 00101959) monitored white-tailed deer and Eastern cottontail rabbits in enclosures simulating "natural growth habitat" in Chester, N.J. to determine the effects of simulated spills of aldicarb 10G. They report that neither deer nor rabbits showed any ill effects following 7 days of exposure.

The Agency currently has no minimum data requirements for wild mammals. There are no acute wild mammal studies required for currently registered aldicarb uses.

TABLE 1. Generic Data Requirements for aldicarb: Ecological Effects

Guideline Citation	Name Of Test	Use Pattern[1]	Composition[2]	Does EPA Have Data To Patially or Totally Satisfy This Requirement? (Yes, No or Partially)	Bibliographic Citation	Must Additional Data be Submitted Under FIFRA 3(c) 2(B?
71-1	Avian Single-Dose Oral LD_{50}	A,B,F	Tech	Yes		No
	a. waterfowl				BOWOAL02*	
					BOWOAL03**	
	b. upland				BOWOAL04**	
71-2	Avian Dietary LC_{50}	A,B,F[4]	Tech	Yes		No
	a. waterfowl				00022923*	
	b. upland				00022923**	
					00102132*	
					BOWOAL01**	
71-3	Wild Mammal Toxicity	---	---			--
71-4	Avian Reproduction	A	Tech	No		No
71-5	Simulated and Actual Field Testing for Mammals & Birds	A	TEP	Partial	00101961**	Yes
					00101962**	
					00101960**	
					00101959**	
72-1	Fish Acute LC_{50}	A,B,F[4]	Tech	Yes		No
	a. warmwater				BOWOAL06**	
					BOWOAL07*	
					00003503*	
	b. coldwater				BOWOAL06*	
					00003503*	
72-2	Acute Toxicity to Freshwater Invertebrates	A,B,F	Tech	Yes	BOWOAL08*	No

TABLE 1. Continued

Guideline Citation	Name Of Test	Use Pattern[1]	Composition[2]	Does EPA Have Data To Patially or Totally Satisfy This Requirement? (Yes, No or Partially)	Bibliographic Citation	Must Additional Data be Submitted Under FIFRA 3(c) 2(B?
72-	Acute Testing for Estuarine and Marine Organisms a. shrimp b. fish c. mollusk	A	Tech	Yes	00066341*	No
72-4	Fish Early Life-Stage Aquatic Invert. Life-cycle a. Fr. fish b. shrimp	A	Tech	Partial Yes ✓	BOWOAL07** 00066341*	Reserved[5] No
72-5	Fish Life-Cycle[6]	A	Tech	Yes	00066341*	No
72-6	Aquatic Organism Accumulation	--	--			--
72-7	Simulated or Actual Field Testing for Aquatic Organisms	A	TEP	No		Reserved[7]

Footnotes:

1 The end use patterns are coded as follows: A=Terrestrial, Food Crop; B=Terrestrial, Non-Food Crop; C=Aquatic, Food Crop; D=Aquatic, Non-Food; E=Greenhouse, Food Crop; F=Greenhouse, Non-Food; G=Forestry; H=Domestic outdoor; I=Indoor.

2 Composition: Tech = Technical grade of the active ingredient; TEP = Typical end-use product.

3 * Study on its own satisfies Guideline requirements; ** Study must be combined with other studies to fulfill Guidelines.

4 Data required for one species only.

5 This requirement is reserved pending registrant satisfying certain of the environmental fate data requirements (photodegradation in water, aquatic metabolism, leaching and adsorption/desorption, and laboratory and field volatility) and a better understanding of the likelihood of aldicarb to transport to water via runoff.

6 Estuarine fish, Sheepshead minnow.

7 Reserved pending receipt of 72-4, if required.

ECOLOGICAL EFFECTS PROFILE

A. Manufacturing Use- Technical Aldicarb

Birds

Beavers and Fink (1979; 00102132), Hill, et al. (1975; 00022923) and Hill and Camardese (1981; BOWOAL01) have shown that technical grade aldicarb ranges from high toxicity for upland game to moderate toxicity for waterfowl in subacute doses (LC_{50} = 71 ppm for bobwhite and 594 ppm for mallard).

Beavers and Fink (1979; BOWOAL02) and Hill (1983; BOWOAL04) have demostrated that oral doses of technical alidcarb are very highly toxic to upland game birds and waterfowl (LD_{50} = 2 mg/kg and 1 mg/kg for bobwhite and mallard, respectively).

Freshwater fish and invertebrates

Short-term fish bioassays with technical material indicates that aldicarb is highly toxic to certain fishes. Both Hutchinson (1979; BOWOAL06) and Johnson and Finley (1980; 00003503) found that technical aldicarb was more acutely toxic to warmwater fish (bluegill LC50 = 63.6 and 50 ppb, respectively) than to coldwater fish (rainbow LC50 = 560 ppb). Aldicarb is moderately toxic to fathead minnows based on the reported 96-hour LC_{50} value of 1.37 ppm (Pickering and Gilliam, 1982, BOWOAL07).

Pickering and Gilliam (1982; BOWOAL07) conducted a 30 day embryo-larvae study with fathead minnows in order to determine the maximum acceptable toxicant concentration (MATC) for technical alidcarb. The estimated MATC for fathead minnows is between >78 ppb and <150 ppb. At concentrations of 78 ppb or less, there was no adverse effect on embryo survival or on larvae/juvenile survival and growth. Survival of larvae/juveniles after 30 days of exposure to 156 ppb was significantly less (50%) than survival of control fish.

Vilkas (1977, BOWOAL08) determined the medium lethal concentration for technical aldicarb to freshwater invertebrates to be highly toxic (Daphnia magna, 48-hour LC50 = 0.41 ppm).

Estuarine and marine fish and invertebrates

Acute toxicity testing of aldicarb, in either static or flow-through 96-hour exposures showed the range of toxicity varied from 12 ug/l to 72 ug/l for marine invertebrates; and from 41 ug/l to 202 ug/l for marine fish (U.S. EPA, 1981, 00066341). Oyster larvae were much less sensitive than either estuarine fish or invertebrate species tested (48-hour EC_{50} = 8.8 ppm).

Two longer-term life-cycle exposure studies of estuarine fish and invertebrate species to aldicarb were reviewed (U.S. EPA, 1981, 00066341). Results of a life-cycle toxicity test with mysid shrimp showed long-term effects to occur at significantly lower concentrations (1.5 and 2.1 ug/l) than that at which acute toxicity occurred (16 ug/l). Mortality of animals exposed to aldicarb concentrations $\geq$ 1.5 ug/l was significantly greater than that of controls, but the difference did not become significant until day 14 of the exposure. At the highest concentration tested, 2.1 ug/l, there were also effects on reproduction (no release of young), as well as reduced survival. The MATC based on measured concentrations was 1.0 to 1.5 ug/l.

Hatching success of sheepshead minnows was not affected by exposure to $\leq$ 88 ug/l aldicarb. Percentage survival from fertilization through embryonic development to hatching ranged from 91 to 98% in all exposure aquaria. There were no reported embryonic abnormalities or hatching delays.

A 28-day posthatch exposure to $\leq$ 88 ug/l aldicarb did not significantly affect juvenile survival. The majority of the mortality in all test concentrations occured by day 14 posthatch. No physical abnormalities were observed among juvenile fish in any treatment.

Growth (mean standard length) of juvenile fish was affected at the highest exposure concentration, 88 ug/l. Chemical analyses of fish that survived each test exposure did not yield any residues of aldicarb. The estimated MATC for embryos and juveniles of sheepshead minnows exposed to aldicarb was >50<88 ug/l. The 96-hour LC_{50} of 41 ug/l is lower than the MATC limits, however, the 96-hour LC_{50} value of 168 ug/l is not.

B. Formulated Product Testing

Terrestrial Organisms

The formulated product Temik 15G has been tested on Bobwhite (Hill, 1983, BOWOAL04). Like technical aldicarb, the product is very highly toxic (acute oral LD_{50} = 2.5 mg/kg). All mortalities occured within 3 hours of dosing.

Three avian field studies involving three different exposure situations with Temik 10G were reviewed. In the first, Haines, 1970, 00101961), three varieties of subsurface applications (2-4" incorporation at 2-6 lb ai/A) in cotton and sugarbeet fields in California resulted in some mortality (up to 25 of 30, specific number and causes of death unexplained) to Valley quail or ring-necked pheasants following ingestion of granules either left on the surface during incorporation or spillage.

In the second study (Haines, 1970, 00101962), caged Valley quail and ring-necked pheasants were located over half mature (12-14") sugar beet beds that had been treated once at-plant, and twice side-dressed in the post-emergence period at 2 lb ai/A, incorporated to 3.5". Mortality in quail resulted when Temik 10G granules were ingested. Leaf samples analyzed from the test plot were reported to average 19 ppm aldicarb. The game farm raised pheasants and quail were not affected by ingesting aldicarb contaminated sugar beet foliage during this 7 day test period.

In the third study (Clarkson et al., 1969, 00101960), bobwhite quail were exposed to various applications of Temik 10G in small pen field trials. Pens were placed on bare soil to which Temik 10G had been applied at 10 lb ai/A broadcast with no incorporation, at 20 lb ai/A incorporated to a depth of 4-6", or at 1.0 lb ai/A in-furrow to a depth of 0.5-1.0". Half of each field received irrigation, the other half not. Mortality reached 100% in one in-furrow and one unincorporated non-irrigated site. Mortality was in excess of 50% in another non-irrigated unincorporated site and in the broadcast site to which Temik had been incorporated 4-6". Mortality was more severe (23/30 deaths) in non-irrigated plots compared with irrigated plots (4/30 deaths) of the same application conditions.

Lund and Haines (1969, 00101959) monitored white-tailed deer and Eastern cottontail rabbits in enclosures simulating "natural growth habitat" in Chester, N.J. to determine the effect of simulated spills of Temik 10G. They report that neither deer nor rabbits showed any ill effects following 7 days of exposure.

Precautionary Labeling

The available data support the following label statements for aldicarb:

Manufacturing Use Labels

"This pesticide is toxic to fish and wildlife. Do not discharge into lakes, streams, ponds or public waters unless in accordance with an NPDES permit. For guidance contact your regional office of the EPA."

End Use Products in Greenhouses

"This pesticide is toxic to fish and wildlife. Do not contaminate water by cleaning of equipment or disposal of waste."

End Use Products Outdoors

"This pesticide is toxic to fish and wildlife. Birds feeding in treated areas may be killed. Cover or incorporate granules in spill areas. Runoff from treated areas may be hazardous to fish in neighboring areas. Do not apply directly to water or wetlands. Do not contaminate water by cleaning of equipment or disposal of waste."

HAZARD ASSESSMENT

Aldicarb, a registered insecticide/nematicide, is currently used on cotton, potatoes, peanuts, soybeans, pecans, sugar beets, citrus, beans, sweet potatoes, sugar cane, sorghum, and a variety of indoor and outdoor, including lawns and turf, ornamentals. End use products are formulated as 5, 10 and 15% granules. Table 1 summarizes rates and methods of application (Qualitative Use Assessment, BFSD, Ludvik, 1983).

Aquatic Organisms

Contamination of water from the use of granular aldicarb is most likely to occur from runoff. Laboratory studies demonstrate that aldicarb is acutely toxic to freshwater fish (bluegill LC_{50} = 0.05 ppm, rainbow trout LC_{50} = 0.560 ppm, Johnson and Finley, 1980, 00003503) and aquatic invertebrates (Daphina magna LC_{50} = 0.41 ppm, Vilkas, 1977, BOWOAL08). The same, or slightly higher, toxicity was demonstrated for estuarine/marine organisms (U.S. EPA, 1981, 00066341). Acute testing of aldicarb showed that the toxicity ranges from 12 ug/l (pink shrimp) to 72 ug/l (white shrimp) for estuarine invertebrates; and from 41 ug/l (sheepshead minnow) to 202 ug/l (spot) for estuarine fishes. Two longer-term life-cycle exposure studies of estuarine fish and invertebrates revealed that the MATC for the mysid shrimp and sheepshead minnow are 1.0 to 1.5 ug/l and 50 to 88 ug/l, respectively.

According to the Environmental Fate and Exposure Assessment (Contract No. 68-01-6679, 1983), "...aldicarb hydrolyzes fairly rapidly under alkaline conditions (pH 9), but is essentially stable at pH 5 and 7. Aldicarb sulfoxide undergoes rapid hydrolysis at pH 9, is fairly stable at pH 7, and stable at pH 5. Aldicarb sulfoxide is relatively stable to photolysis, with [approx] 93% of the applied compound remaining unchanged in water after 14 days of irradiation." "Carbamate residues do not move horizontally from bare, sloping field (1% slope) irrigated to runoff, following treatment with aldicarb at 10 lb ai/A." "Total carbamate residues dissipate from field soils with half-lives of 1-7 days. "...loss of applied aldicarb from these fields may have partly resulted from leaching..." "Aldicarb residues have been found in well water ... in New York (Long Island), Wisconsin, Florida, Maine, Virginia, and North Carolina. Accumulation of aldicarb in aquatic nontarget organisms is expected to be minimal..."

A 96-hour bluegill sunfish bioassay was used to establish a freshwater fish classification trigger (1/10 LC_{50} of 0.05 ppm) of 5 ppb. A 48-hour Daphnia magna bioassay was used to calculate a freshwater invertebrate classification trigger (1/10 LC_{50} of 0.41 ppm) of 40 ppb.

Projected residues of aldicarb in water resulting from runoff (SWRB and EXAMS modeling, V2.0: Mode 2, R. Lee, EEB, 1983) are 133 ppb from cotton and 10 ppb from soybeans. Modeling for citrus orchards is forthcoming. Previous estimations of runoff from citrus (HR 257, EFB, 7-9-81) put aldicarb in small ponds at 400 ppb. Residues from cotton modeling persisted for at least 20 days at or above 20 ppb. Residues from soybean modeling were persistent at or above 4 ppb for 10 days, and at or above 1.6 ppb for 20 days. It

Table 1: Aldicarb Uses[1]

Agricultural Site	Rate of Application[2] (lbs A/A)	Expected Number of Applications	Time of Application	Interval Between Application	No of Acres Treated
Cotton	0.3-4.0	2	At planting Post planting	None	885,200
Potatoes[3]	2.0-5.0	1	At planting		172,500
Peanuts	1.0-3.0	1	At planting	N.A.	274,200
Soybeans	1.5-3.0	1	At planting	N.A.	640,000
Pecans (southeast only GA, AL, FL, MS, SC, & NC)	5.0-10	1	Bud break & Bud set	N.A.	70,000
Sugarbeets	1.0-5.0	3	1 at planting 2 post planting	not specified	51,000
Citrus (grapefruit, lemons and limes)	5.0-10	1	just prior to spring flush	N.A.	13,000
Beans(dried)	0.5-2.0	1	At planting	N.A.	18,000
Sweet Potatoes	1.5-3.0	1	At planting	N.A.	?
Sugarcane	2.0-3.0	1	Post Plant (Early Summer/Fall)	N.A.	?
Ornamental Sites					
Herbaceous, Woody shrubs, Trees and vines. (commercially field grown and nursery plantings)	5.0-10.0 lb ai/A	Repeat as needed			
Ornamental and Forest Greenhouse	5.0-10.0 oz/2500 sq ft				

(Other Ornamental uses are state registrations)

1 Source: Qualitative Use Analysis, BFSD, Ludvik (1983).
2 Method of application is ground.
3 $\leq$ 2.0 lb ai/A post-emergent soil application only in Maine and Wisconsin.

should be noted that among the environmental fate data requirements are photodegradation in water, aerobic and anaerobic aquatic metabolism studies, leaching and adsorption/desorption studies, and laboratory and field volatility studies.

Comparing the above fish and invertebrate acute triggers to estimated residue levels discussed above suggest that non-target fishes and invertebrates indigenous to small ponds (i.e., worst case situation) could be exposed to aldicarb residues from certain uses that exceed their respective triggers. Modeling for stream residues is forthcoming.

Chronic testing (life stage or life cycle) for the technical can be required if:

- the product is expected to be transported to water, and
- its presence in water is likely to be continuous, or
- any LC_{50} or EC_{50} is less than 1 ppm, or
- the estimated environmental concentration in water is equal to or greater than 0.01 of any LC_{50} or EC_{50}, or
- studies of other organisms indicate the reproductive physiology of fish and/or invertebrates may be affected. [72-4]

An embryo-larvae study with a freshwater fish (fathead minnow, Pickering and Gilliam, 1982, BOWOAL07) demonstrates that there was no adverse effect on embryo or larvae survival and growth at 78 ppb or less. At 156 ppb survival was significantly less (50 %) than controls after 30 days exposure. Life-cycle estuarine studies (U.S. EPA, 1981, 00066341) suggest that low aldicarb residues can produce adverse effects in certain of these organisms. The MATC for the mysid shrimp is 1.0 to 1.5 ppb. The MATC for the sheepshead minnow is 50 to 88 ppb. The residues discussed above may exceed these levels under certain conditions.

As stated in the Environmental Fate and Exposure Assessment, aldicarb did not move horizontally under the conditions of the studies reviewed. Maximum residues in runoff were found to be 0.08 ppm (EFB, 6-1-82). Those residues would be diluted upon reaching a body of water. In another study, irrigation water leaving aldicarb treated hops fields was found to contain 4 ppb or less of total aldicarb residues at distances 1/4 mile or greater from the edge of the treated field. In all cases residues would be composed of a mixture of parent aldicarb, aldicarb sulfoxide and aldicarb sulfone. All uses associated with the subject products involve soil incorporation of the granules which greatly diminishes potential for surface runoff. Leaching would be the overriding manifestation of soil mobility.

In conclusion, modeling suggests that surface runoff of total residues from aldicarb treated fields could result in residues up to 133 ppb. These residues can exceed aquatic organism acute and chronic triggers. Based on these indications chronic studies may be required. However, requirements for further chronic testing for aquatic organisms are reserved at this time. Certain environmental fate data contraindicate the need for further testing. We need the full compliment of environmental fate data in order to make an adequate assessment of the persistance of aldicarb relative to chronic exposure. We will wait for the registrant to satisfy the liability to fulfill environmental fate data requirements. Additionally, we need to solidify our thoughts regarding the estimated environmental concentrations generated by modeling.

Avian Exposure

Avian 8-day dietary toxicity values, when compared with a commonly used dietary toxicity rating scheme (Hill et al. 1975, 00022923), suggest that aldicarb is moderately toxic to mallards (LC_{50} = 594 ppm, Hill et al. 1975, 00022923) and highly toxic to bobwhite (LC_{50} = 71 ppm, Beavers and Fink, 1979, BOWOAL01). Given the fact that the registered formulations are granular, little dietary exposure is expected. The field study by Haines (1970, 00101962) showed that game farm raised pheasants and quail were not affected by ingesting aldicarb contaminated sugar beet foliage. Mortality in quail resulted when Temik 10G granules were ingested.

Comparison of avian LD_{50} values (Mallard LD_{50} = 1 mg/kg, Hill, 1983, BOWOAL04; bobwhite LD_{50} = 2 mg/kg, Beavers and Fink, 1979, BOWOAL02) with a commonly used acute oral toxicity rating scheme (Matsumura, 1975) indicate that technical aldicarb is highly toxic to birds. Similarly, the 15G formulation is highly toxic to birds based on the bobwhite LD_{50} of 2.5 mg/kg (Hill, 1983, BOWOAL04). Aldicarb's single dose oral LD_{50} exceeds the Agency's classification trigger (LD_{50} < 50 mg/kg) for a restricted use pesticide. However, classification procedures for soil incorporated granular products is under Agency review.

Acute oral exposure is perhaps the principle route of pesticide uptake for outdoor applications of granular formulations, principally through the accidental ingestion of granules left on the soil surface either from incomplete incorporation or spillage. Field studies and use history bear this out. Granular formulations of aldicarb have been responsible for at least eight documented bird kills in England and Germany. Field studies under artificial conditions (Haines, 1970, 00101961 and Clarkson et al., 1969, 00101960) have demonstrated that granular aldicarb applications can be hazardous to birds.

The toxicological hazard posed by aldicarb granules to seven species of birds known to utilize cultivated fields is shown in Table 2. These calculations suggest that as few as 12 granules of the 15% formulation could exceed the LD_{50} for birds weighing as much as 1.2 kilograms. Birds that would most likely be affected are small birds that ingest one or two granules. Calculations for maximum weight for birds likely to exceed their LD_{50} by ingesting one or two granules are shown below:

$$\text{Weight} = \frac{(\text{Granule Weight [mg]} \times \text{Percent Active}) \times 1000}{LD_{50}}$$

		1 Granules	2 Granules
For 15G:	$\frac{(0.6 \text{ mg} \times .15) \times 1000}{1.0 \text{ mg/kg}}$ =	90 g.	180 g.
For 10G:	$\frac{(0.6 \text{ mg} \times .10) \times 1000}{1.0 \text{ mg/kg}}$ =	60 g.	120 g.

Table 2.

Aldicarb's (10G/15G) Hazard to Seven Species of Non-Target Birds.

Species	Body Weight (g)	MG/ Animal (g)[2]	Number of Granules equal to LD_{50}[1] 10G Granules	15G Granules
Mallard (14-day)	200	0.20	3.3	2.2
Mallard (adult)	1200	1.20	20.0	13.3
Robin	80	0.08	1.3	0.9
Mourning Dove	100	0.10	1.7	1.1
House Sparrow	20	0.02	0.3	0.2
Redwing-Blackbird	50	0.05	0.8	0.6
Grasshopper Sparrow	13.9	0.01	0.2	0.1
Attwater's Prairie Chicken (adult)	1000	1.00	16.7	11.1
(14-day)	50	0.05	0.8	0.6

Footnotes

1 Assumed weight of one granule = 0.6 mg. Also, assuming equal sensitivity among all species (mallard LD_{50} = 1.0 mg/kg).

> mg a.i./10G granule = 0.6 mg X 10% = 0.06 mg aldicarb/granule.

> mg a.i./15G granule = 0.6 mg X 15% = 0.09 mg aldicarb/granule.

2 Example: Mallard LD_{50} X Weight (kg) = 1.0 mg/kg X 0.200 kg = 0.200 mg/animal.

The number of 15G granules required to equal mallard LD_{50} $= \frac{0.200 \text{ kg}}{0.09 \text{ mg a.i./granule}} = 2.2$ granules

The agricultural use (re-registration) of Aldicarb on over 2 million acres of cultivated crop-land will result in significant exposure to non-target birds. Mortalities can be expected from accidental ingestion of pesticide granules. The likelihood of an avian species ingesting a lethal dose of aldicarb will increase if granules are not immediately or properly incorporated. Incorporation only serves, however, to reduce the potential for non-target wildlife exposure, not eliminate it. Erbach and Tollefson (1983), using the best conventional procedure, spring-tined incorporation in front of press wheels, incorporated 95% of pesticide granules applied. Under these conditions 5% of the granules remained on the soil surface and would be available to wildlife. Fink (1980) also examined the degree with which corn planters could incorporate granular pesticides. Counts conducted immediately after incorporation revealed that both row areas and end row turn areas contained large numbers of exposed granules (70 and 344 granules per sq. ft., respectively). Balcomb et al. (1982) also reported seeing exposed granules while conducting field searches for non-target mortality. Field studies with aldicarb and other granular pesticides have documented that non-target birds and mammals can ingest lethal doses of granular pesticides during the course of their normal feeding activites (Balcomb et al., 1982; Bunyan et al., 1981).

As stated, incidents and field studies indicate that aldicarb applications can pose a hazard to bird species that typically probe the soil surface for worms and grubs. Balcomb et al. (1982) noted that the majority of pesticide related mortality occurred in robins, a species known to repeatedly probe surfaces for earthworms. Avian mortalities are expected to occur primarily in small birds (less than 200 grams) and to be heaviest during the first week following product application. Mortality is expected to occur within a short time following application via acute toxicity and predation of temporarily paralysed individuals. The hazard to non-target avian wildlife should be significantly reduced following rainfall or irrigation of teated areas. Clarkson et al. (1970, 00101960) showed that mortality was more severe in non-irigated plots (76%) when compared with irrigated plots (13%).

In conclusion, the available data indicate that aldicarb applications may result in avian mortality. Hazards to wildlife cannot be estimated with certainty from laboratory tests, therefore, field studies when available should be the primary focus of risk assessment. The available field studies and use history for aldicarb (and other granular pesticides with comparable toxicity) provide sufficient information to indicate that granular pesticide treatments may result in some mortality if not local population reductions in certain bird species. Whether these effects are excessive, long-lasting, or likely to diminish wildlife resources cannot be said with any degree of certainty. Field studies that would further quantify non-target avian impact are needed. Such studies should be conducted with aldicarb treatments to sorghum and citrus.

Mammalian Exposure

Aldicarb is highly toxic to mammals (rat LD_{50} = 0.9 mg/kg, 7.0 mg/kg for 10G, FCH, 1981). Exposure to mammals is expected to occur through the accidental ingestion of granules during feeding, foraging and/or grooming. The rat LD_{50} was used to establish a mammalian classification trigger (1/5 LD_{50}) of 0.18 mg/kg. The toxicological hazards posed by aldicarb residues to four species of mammals known to frequent cultivated fields are shown in Table 3. These calculations indicate that as few as seven granules could exceed the LD_{50} value of heavier mammals (approximately 1 kg). However, considering that the major route of exposure to mammals is expected to occur accidentally, mammals that can exceed their LD_{50} by ingesting one or two granules are considered most at risk. Maximum weight calculations for this most susceptable group are shown below:

$$\text{Animal Weight (g)} = \frac{(\text{Granule Weight (mg)} \times \text{Percent Active}) \times 1000}{LD_{50}}$$

		1	2
For 15G:	Animal	Granule	Granules
Weight (g) =	$\frac{(0.6 \text{ mg} \times .15) \times 1000}{0.6 \text{ mg}}$ =	150 g	300 g
For 10G:	Animal		
Weight (g) =	$\frac{(0.6 \text{ mg} \times .10) \times 1000}{0.6 \text{ mg}}$ =	100 g	200 g

The use (re-registration) of aldicarb on over 2 million acres of cultivated crop-land will result in significant exposure to non-target mammals. Although exposure can be expected from accidental ingestion of aldicarb granules or predation, the hazard to mammals is not as readily apparent as it is for birds. There is no evidence of kills or long-lasting population reductions or impact resulting from direct granular exposure. Lund and Haines (1969, 00101959) reported no ill effects to deer and rabbits in a simulated spill of Temik 10G. Bunyan et al. (unreviewed field study, 1981) reports that non-target ground feeding mammals (mostly herbivores) had low residues of aldicarb. Rabbits and hares feeding on emerging sugarbeet had 0.005-0.4 ppm in stomach contents and 0.01-0.04 ppm in the liver. Overall, 16 mammals (27%) of all those shot or trapped had aldicarb residues. One woodmouse and one shrew trapped had 2 and 1 ppm aldicarb residues respectively. Still other small mammals contained nonquantifiable residues. The avian field stud by Haines (1970, 00101962) demonstrated that vegetative exposure to aldicarb residues by birds are not as likely to result in mortality as direct granular exposure can.

In conclusion, aldicarb is highly toxic to mammals. The existing data base suggests limited exposure from a dietary standpoint. There are no reported incidents. A field study reports no effects to larger mammals from direct exposure to spilled granules. The registrant should conduct field searches (in conjunction with avian surveillance) that should help quantify the extent of non-target mammalian exposure resulting from the application of this product to sorghum and citrus.

Table 3.

Adicarb's (10G/15G) Hazard to Four Species of Non-Target Mammals.

Species	Body Weight (g)	Mg Animal (g)[2]	Number of Granules equal to LD_{50}[1] 10G Granules	15G Granules
Rat	200	0.12	2.0	1.3
Eastern Cottontail (Adult)	1100	0.660	11.0	7.3
Weaned Young 20 days old	85	0.051	0.9	0.6
Grey Squirrel (Adult-Female)	520	0.312	5.2	3.5
Weaned Young 10 weeks old	200	0.120	2.0	1.3
Delmarva Fox Squirrel (Adult Female)	795	0.477	8.0	5.3
Weaned Young 8-10 weeks old	454	0.272	4.5	3.0

Footnotes

1 Assumed weight of one granule = 0.6 mg.

> mg a.i./10G granule = 0.6 mg X 10% = 0.06 mg aldicarb/granule.

> mg a.i./15G granule = 0.6 mg X 15% = 0.09 mg aldicarb/granule.

2 Example: Rat LD_{50} X Animal Weight (kg) = 0.6 mg/kg X 0.085 kg = 0.051 mg/animal.

$$\text{Number of 10-G granules required to equal } LD_{50} = \frac{0.051 \text{ mg/kg}}{0.06 \text{ mg a.i./granule}} = 0.85 \text{ granules}$$

Endangered Species Concerns

Previous concerns for endangered species resulted in formal consultation with the Office of Endangered Species. As a result, the following Environmental Hazards Statement was added to aldicarb labels:

"NOTICE: Under the Endangered Species Act, it is a Federal Offense to use any pesticide in a manner that results in the death of a member of an endangered species. This act protects Attwater's Greater Prairie Chicken in the Texas counties of Aransas, Austin, Brazoria, Colorado, Galveston, Goliad, Harris, Refugio, and Victoria. Prior to making applications in these counties, the user must determine that this species is not located in or immediately adjacent to the area to be treated. If the user is in doubt whether or not the above named endangered species may be affected, he should contact either the regional U.S. Fish and Wildlife Service Office (Endangered Species Specialist) or personnel of the State, Fish and Game Office."

However, work is currently underway in the EEB "cluster" approach identifying may-effect situations to endangered species as a result of pesticide use on corn, cotton, soybeans, sorghum and small grains. Aldicarb is included in this work. EEB is working to develope mechanisms for implementing reasonable or prudent alternatives for protecting listed species.

References

Balcomb, R., C. Bowen, D. Wright and M. Law. 1982. Granular Carbofuran: Corn Applications Affect Wildlife. ~~Unpublished Manuscript.~~ In Press. J. Wildl. Manage.

Bunyan, P.J., M.J. Van Den Heuval, P.I. Stanley and E.N. Wright. 1981. An Intensive Field Trial and a Multi-site Surveillance Exercise on the Use of Aldicarb to Investigate Methods for the Assessment of Possible Hazards Presented by New Pesticides, Agric. Ecos., 7:239-262.

Erbach, D.C. and J.J. Tollefson. 1982. Granular Insecticide Application for Corn Rootworm Control. Trans. ASAE, 26(3):696-699.

Matsumura, F. 1975. Toxicology of Insecticides. Plenum Press, New York., 503 pp.

Aldicarb Registration Standard - Nontarget Insects

Effects on Beneficial Insects

The following study received full review under this topic:

Author	ID
Atkins et al.	00036935

Study is outlined in Table 1.

Table 1. Toxicity studies on beneficial insects with aldicarb.

Species	Formulation	Results	Author	Date	MRID #
Honey bee (*Apis mellifera*)	Technical	LD_{50} = 0.285 micrograms per bee (highly toxic)	Atkins et al.	1975	00036935

There is sufficient information to characterize technical aldicarb as highly toxic to honey bees.

Aldicarb Registration Standard - Nontarget Insects

Effects on Nontarget Soil and Surface Invertebrates

The following study received full review under this topic:

Author	ID
Johansen and Eves	00060628

Study is outlined in Table 1.

Table 1. Toxicity studies on nontarget soil and surface invertebrates with aldicarb.

Species	Formulation	Results	Author	Date	MRID #
Lady beetle; Big-eyed bug; Pirate bug; Lacewing	10% G	Aldicarb reduced predator pops. in general, but only on a short-term basis	Johansen and Eves	1965	00060628

Available information indicates that aldicarb granular may reduce numbers of predaceous insects, on a short-term basis.

Aldicarb Registration Standard - Nontarget Insects

The following studies received abbreviated reviews:

Author	ID
Ridgway and Cowan	00091958
Hamlen	05009588
Elsey and Cheatham	05010420
Khalil et al.	05016155
Tyler et al.	05016510

Aldicarb Registration Standard - Nontarget Insects

Statements for Disciplinary Review

Effects of aldicarb on beneficial insects

Technical aldicarb is highly toxic to honey bees (Atkins et al. 1975.) It should be noted, however, that aldicarb is registered only as a granular insecticide. As such, aldicarb presents little or no hazard to honey bees.

Effects of aldicarb on nontarget soil and surface invertebrates

Results of a field study (Johansen and Eves 1965) indicate that use of aldicarb may cause temporary reductions in populations of insect predators.

References (for Disciplinary Review)

Atkins, E.L.; Greywood, E.A.; Macdonald, R.L. (1975) Toxicity of Pesticides and Other Agricultural Chemicals to Honey Bees: Laboratory Studies. By University of California, Dept. of Entomology, ?: UC, Cooperative Extension. (Leaflet 2287 published study.) Fiche/Master ID 00036935

Johansen, C.A. Eves, J. (1965) Bee Poisoning Investigations, 1965: Report No. G-1705; Report No. 17338. (Unpublished study, including letter dated June 12, 1973 from C.A. Johansen to A.D. Cohick, received March 27, 1974 under 4F1485; prepared by Washington State Univ., Dept. of Entomology, submitted by Chemagro Corp., Kansas City, Mo.; CDL:092011-I) Fiche/Master ID 00060628

GENERIC DATA REQUIREMENTS FOR ALDICARB

Data Requirement	Composition [1/]	Use Pattern [2/]	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)? [3/]
§158.155 Nontarget Insect					
NONTARGET INSECT TESTING - POLLINATORS:					
141-1 - Honey bee acute contact LD_{50}	TGAI	A,B	Yes	00036935	No
141-2 - Honey bee - toxicity of residues on foliage	TEP	A,B	No	_____	No [4/]
141-3 - Wild bees important in alfalfa pollination - toxicity of residues on foliage	TEP	A,B	No	_____	No [4/]
141-4 - Honey bee subacute feeding study	[Reserved] [5/]				
141-5 - Field testing for pollinators	TEP	A,B	No	_____	No [4]

1/ Composition: TGAI = Technical grade of the active ingredient; TEP = Typical end-use product.
2/ The use patterns are coded as follows: A=Terrestrial, Food Crop; B=Terrestrial, Non-Food; C=Aquatic, Food Crop: D=Aquatic, Non-Food; E=Greenhouse, Food Crop; F=Greenhouse, Non-Food, G=Forestry; H=Domestic Outdoor; I=Indoor.
3/ Data must be submitted no later than _____.
4/ As aldicarb is registered only as a granular formulation, there is no potential for bee exposure. Thus, testing beyond the first tier is not required.
5/ Reserved pending development of test methodology.
6/ Reserved pending Agency decision as to whether the data requirement should be established.