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

MEMORANDUM

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SUBJECT: Thiobencarb New Use – Wild Rice in California. Ecological Risk Assessment (PC Code 108401)

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EFED has received a request to provide an ecological risk assessment for a section 3 registration of thiobencarb (Bolero™ 8 EC) for use on wild rice in California. This request was made by an IR-4 petition.

On September 30, 1997, the Agency issued a RED for thiobencarb that included an ecological risk assessment for use on rice in California. The application rate used in the RED is the same as the application rate for the proposed use on wild rice in California (2 to 4 pounds active ingredient per acre). Therefore, the ecological risk assessment in the RED will be referenced as much as is applicable in this assessment.

The assessment in the RED did not include aquatic Estimated Environmental Concentrations (EEC) due to the fact that at that time, a modeling scenario to predict EECs for use on rice was not available. For the current assessment on wild rice, the rice model, together with actual monitoring data will determine the EECs that will be used to calculate aquatic Risk Quotients (RQ).

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1.0 Executive Summary

1.1 Nature of Chemical Stressor

Thiobencarb is an herbicide used to control grasses and broadleaved weeds. It is currently proposed for registration for wild rice (in California only), as an application on soil in rice paddies to kill weeds before they emerge. Being a carbamothioate, its mode of action is inhibition of cell growth. In California, wild rice is "dry-seeded" in which seeds are sowed and grown in dry seed beds for several weeks before flooding. If there is no rainfall, fields are irrigated with a small volume of water (i.e. flushed) to promote seed germination.

1.2 Potential Risks to Non-target Organisms

There is potential risk to listed and non-listed species of non-target plants (aquatic and terrestrial), birds, mammals, aquatic invertebrates (freshwater and estuarine), and fish (freshwater and estuarine).

1.3 Conclusions – Exposure Characterization

Thiobencarb dissipates in the environment by binding to soil, by aerobic soil metabolism at the soil/H_2O interface, and by aqueous photolysis in the presence of photosensitizers. Ground water contamination is not likely from use on the primary crop, rice, and surface water is not likely to receive significant amounts of thiobencarb unless there is excess rainfall soon after application, leading to uncontrolled runoff. When used on the rice, thiobencarb is more likely to be found in the soil than in the paddy water. Furthermore, greater quantities of thiobencarb are associated with soil when applied preflood to soil rather than in standing water. The portion of thiobencarb associated with soil was approximately 10 times more when applied preflood to soil than when applied to standing water, primarily since thiobencarb has time to bind to soil prior to flooding. As a result, sensitized aqueous photolysis is expected to be more significant as a dissipation route when thiobencarb is applied to water than when it is applied to dry soil, due to a greater amount of thiobencarb remaining in paddy water containing natural photosensitizers.

Thiobencarb has a water solubility of 30 ppm, a vapor pressure of 1.476×10^{-6} Torr, and a Henry's Law Constant of 3.42×10^{-8} atm m^3/mol. It is stable to hydrolysis, **non-sensitized** aqueous photolysis, soil photolysis, anaerobic aquatic metabolism, and aerobic aquatic metabolism. In an aqueous photolysis study with and without the use of **photosensitizers**, the half-lives were 12 and 190 days, respectively. Since some humic substances in natural waters have been shown to act as photosensitizers, the 12-day half-life may be more relevant. Thiobencarb also degraded moderately slowly under aerobic conditions with calculated half-lives of 27-58 days in soils that typically support rice production.

Thiobencarb slowly mineralizes in soil without forming significant quantities of non-volatile degradates. The major degradate in both the aqueous photolysis and soil metabolism studies was 4-chlorobenzoic acid, reaching 56 and 5 % respectively. CO_2 and bound residues are the primary products from soil metabolism studies, occurring in proportions of 42-77 and 23-42 %, respectively. Aqueous residues did not exceed 4.5 % in soil metabolism studies.

Parent thiobencarb was moderately mobile to immobile in the tested soils with Freundlich K_{ads} values of 5.42-20. The K_{oc} values ranged from 384-1435. 4-Chlorobenzoic acid, a degradate of thiobencarb, was very mobile to moderately mobile in the tested soils with Freundlich K_{ads} values of 0.74-3.26. The corresponding K_{oc} values ranged from 84-416. Mobility generally decreased with increasing clay content, increasing organic matter content, and increasing cation exchange capacity.

Results from an aquatic field dissipation study in Louisiana, where thiobencarb was applied as a spray directly to soil and flooded 7 days later, show half-lives of 5.8 days in flood water and 36 days in hydrosol. The median ratio of soil:water thiobencarb residues was 63.5:1.

In two field studies in California where granules were applied into standing water, the half-lives in flood water were 8.7 days (guideline study) and 4.5 days (literature review, Ross and Sava, 1986). The half-lives in hydrosol were 153 and 56 days, respectively. The median ratios of soil:water thiobencarb residues were 5.6:1 and 6.6:1.

For more details please see previous RED for conclusions of exposure characterization.

1.4 Conclusions – Effects Characterization

Thiobencarb is practically nontoxic to avian species on an acute oral basis and on a subacute dietary basis. Avian reproduction data suggest that dietary concentrations greater than 100 ppm can impair reproduction in birds.

Thiobencarb is slightly toxic to mammals on an acute oral basis. In a reproductive study

(MRID 40446201), there were no reproductive effects observed at levels of 100 ppm. The NOEL was equal to or greater than 100 ppm (mg/kg/day).

Thiobencarb is moderately to highly toxic to freshwater fish. There are no chronic studies available for freshwater fish.

Thiobencarb is highly toxic to aquatic invertebrates on an acute basis. Concentrations of thiobencarb greater than 1 ppb can be detrimental to the survival and reproduction of freshwater invertebrates.

Thiobencarb is highly toxic to marine/estuarine fish on an acute basis. An estuarine fish early life stage study suggests that concentrations of 150 ppb or more can adversely affect the growth of juvenile fish.

Thiobencarb is highly toxic to marine/estuarine mollusks on an acute basis. Thiobencarb is also highly toxic to marine/estuarine shrimp on an acute basis. A chronic estuarine invertebrate study suggests that concentrations of 6.2 ppb or more can adversely affect the growth of estuarine invertebrates.

Terrestrial plants were found to be sensitive to thiobencarb at 0.019 lb ai/A for seedling emergence and 0.073 lb ai/A for vegetative vigor.

Green alga is the most sensitive aquatic plant species with an EC_{50} at 17 ppb. The vascular aquatic plant, duckweed, was found to have an EC_{50} of 770 ppb.

2.0 Problem Formulation

2.1 Nature of Regulatory Action

The proposal under consideration is for the use of thiobencarb (Bolero™ 8 EC) on wild rice in California (2 to 4 pounds active ingredient per acre). Application is to be made by ground or aerial methods to dry-seeded rice.

2.2 Stressor Source and Distribution

2.2.1 Nature of the Chemical Stressor

Table 2.1 Summary of Physical/Chemical and Environmental Fate Properties of Thiobencarb

Parameter	Value	Source	Comment
Chemical name	S-4-chlorobenzyl diethylthiocarbamate	Ahrens, 1994	
Molecular weight	257.78 g/mole	Ahrens, 1994	
Solubility	30 mg/L in water at 25º	Ahrens, 1994	
Vapor pressure	1.476×10^{-6} mm Hg at 20Cº	Ahrens, 1994	

Table 2.1 Summary of Physical/Chemical and Environmental Fate Properties of Thiobencarb			
Parameter	**Value**	**Source**	**Comment**
Henry's Law Constant	3.42 E-8 atm-m^3/mol		Calculated from vapor pressure and water solubility
Log K_{ow}	3.42	Ahrens, 1994	
pK_a	none	Ahrens, 1994	
Hydrolysis half-life	Stable	MRID 41609012	Stable at pH 5, 7, and 9
Aqueous photolysis half-life	190 days	MRID 422257801	In nonsensitized, sterile pH7 buffer at 25ºC; stable in dark control
Soil photolysis half-life	168 days (irradiated) 280 days (dark control)	MRID 41215312	Dark-corrected half-life is 420 days
Aerobic soil metabolism half-life	58 days (0-56 day data) Stockton Clay adobe soil (CA) 37 days (Clay soil, Biggs, CA) 27 days (Silty Clay Loam, Crowley, LA)	MRID 43300401 MRID 00040925	
Anaerobic aquatic metabolism half-life	Stable	MRID 43252001	
Aerobic aquatic metabolism half-life	Stable	MRID 42015301	
Soil organic carbon partition coefficient (K_{oc})	1084 (sandy loam) 384 (Loam) 618 (silty clay) 1027 (clay loam) 1435 (silt loam)	MRID 41215313	

2.2.2. Persistence and Mobility

Thiobencarb is generally nonpersistent in the water column but moderately persistent in soils and sediments. Thiobencarb dissipates in the environment by binding to soil, by aerobic soil metabolism at the soil/H_2O interface, and by aqueous photolysis in the presence of photosensitizers. Ground water contamination is not likely from use on the primary crop, rice, and surface water is not likely to receive significant amounts of thiobencarb unless there is excess rainfall soon after application, leading to uncontrolled runoff. When used on the rice, thiobencarb is more likely to be found in the soil than in the paddy water. Furthermore, greater quantities of thiobencarb are associated with soil when applied preflood to soil rather than in standing water. The portion of thiobencarb associated with soil was approximately 10 times more when applied preflood to soil than when applied to standing water, primarily since thiobencarb has time to bind to soil prior to flooding. As a result, sensitized aqueous photolysis is expected to be more significant as a dissipation route when thiobencarb is applied to water than when it is applied to dry soil, due to a greater amount of thiobencarb remaining in paddy water containing natural photosensitizers.

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Thiobencarb moderately accumulated in bluegill sunfish with maximum bioconcentration factors of 128x, 639x, and 411x for edible (muscle) tissue, nonedible tissue, and whole fish, respectively. Depuration is rapid, with 93-95% of the accumulated [^{14}C]residues being eliminated from the tissues in three days. The degradates 4-chlorobenzylmethylsulfoxide, thiobencarb sulfoxide, desethylthiobencarb, and 2-hydroxythiobencarb were identified in edible and nonedible tissue.

The summary of degradates found in the California and Louisiana aquatic field dissipation studies are found in Table 2.2 below.

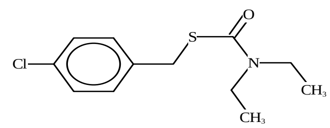
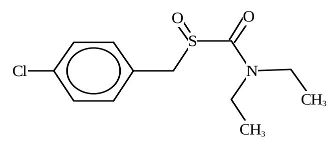
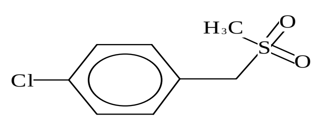
Table 2.2 presents the amounts of the degradates found in the California and Louisiana aquatic field dissipation studies.

Table 2.2.
Maximum Amounts of Thiobencarb and Metabolites Found in Flood Water in Field Dissipation Studies

Study Type	Metabolite (Maximum in Flood Water)	MRID
Louisiana Aquatic Field Dissipation (dry-seeded rice) 4 lb/acre, aerial, spray, flooded to 4.5 inches at 7 days post-application	Parent Thiobencarb **Max. 12.2-14.1 ppb at 3 days post-flood (PF)** 5.6-10.5 ppb at 7 days PF Less than 1 ppb 28-70 days PF Thiobencarb sulfoxide **Max. 16-13.4 ppb at 1 day PF** 2.6-5.2 ppb at 3 days PF 0.8-1.5 ppb at 7 days PF Less than 0.9 ppb at 14 to 70 days PF 4-chlorobenzylmethylsulfone **Max. 4.8-5.8 ppb at 5 days PF** 1.4-1.8 ppb at 14 days PF Less than 0.5 ppb 21-70 days PF	MRID 42003404
California Aquatic Field Dissipation (wet-seeded rice) 4 lb/acre, aerial, granular, flooded to 6 inches at time of application	Parent Thiobencarb 266 ppb at zero days **Max. 438 ppb at 3 days** 1.0 ppb at 92 days Thiobencarb sulfoxide 4.4 ppb at zero days **Max. 22 ppb at 3 days** Non-detectable at 33 days 4-chlorobenzylmethylsulfone 1.11-3.14 ppb at day zero **Max. 6.38-10.0 ppb (avg. 8.3) at day 10** 5.15-6.95 ppb at day 21 Nondetect-1.52 ppb at day 33 Nondetect-1.1 ppb at day 92	MRID 43404005
Ross and Sava, 1986 (wet-seeded) 4 lb/acre, aerial, spray, water depth 10.4 inches	Parent Thiobencarb **Max. 576 ppb at 4 days** No Degradates measured	none

Structures of the parent and degradates are given in **Table 2.3.**

Table 2.3. The Chemical Structure of Thiobencarb and its Metabolites

Thiobencarb	
Thiobencarb sulfoxide	
4-chlorobenzylmethylsulfone	

2.2.3. Overview of Pesticide Usage

Proposed registration is for wild rice (in California only) as an application of an EC formulation to soil in rice paddies to kill weeds before they emerge. In California, wild rice is “dry-seeded” in which seeds are sowed and grown in dry seed beds for several weeks before flooding. Thiobencarb should be the last chemical to be applied prior to flooding. If there is no rainfall, fields are irrigated with a small volume of water (i.e. flushed) to promote seed germination. Aerial or ground applications of 2 to 4 pounds active ingredient per acre may be made. Application is to be done only once per season.

2.3 Receptors

2.3.1 Aquatic and Terrestrial Acute Effects

The receptor is the biological entity that is exposed to the stressor (EPA, 1998.)

Consistent with the process described in the Overview Document (EPA, 2004), this risk assessment uses a surrogate species approach in its evaluation of Thiobencarb. Toxicological data generated from surrogate test species, which are intended to be representative of broad taxonomic groups, are used to extrapolate to potential effects on a variety of species (receptors) included under these taxonomic groupings.

Acute and chronic toxicity data from studies submitted by pesticide registrants along with the available open literature are used to evaluate the potential direct effects of thiobencarb to the aquatic and terrestrial receptors identified in this section. This includes toxicity data on the technical grade active ingredient, degradates, and when available, formulated products (e.g. "Six-Pack" studies).

Table 2.1 provides a summary of the taxonomic groups and the surrogate species tested to help understand potential acute ecological effects of pesticides to these non-target taxonomic groups. In addition, the table 2.4 below provides a preliminary overview of the potential acute toxicity of thiobencarb by providing the acute toxicity classifications.

Table 2.4 Test Species Evaluated for Assessing Potential Ecological Effects of Associated Acute Toxicity Classification

Taxonomic Group	**Example(s) of Surrogate Species**	**Acute Toxicity Classification**
Birds[1]	Mallard (*Anas platyrhynchos*) Bobwhite (*Colinus virginianus*)	Practically non-toxic
Mammals	Laboratory rat (*Rattus norvegicus*)	Slightly toxic
Freshwater fish[2]	Bluegill sunfish (*Lepomis macrochirus*) Rainbow trout (*Onchorhynchus mykiss*)	Moderately to highly toxic
Freshwater invertebrates	Water flea (*Daphnia magna*)	Highly toxic
Estuarine/marine fish	Sheepshead minnow (*Cyprinodon variegatus*)	Highly toxic
Estuarine/marine invertebrates	Mysid shrimp (*Americamysis bahia*) Eastern oyster (*Crassostrea virginica*)	Highly toxic
Terrestrial plants[3]	Monocots: corn (*Zea mays*) Dicots: soybean (*Glycine max*)	No classification available
Aquatic plants and algae	Vascular: Duckweed (*Lemna gibba*) Nonvascular: marine diatom (*Skeletonema costatum*)	No classification available

[1] Birds represent surrogates for terrestrial-phase amphibians and reptiles.
[2] Freshwater fish may be surrogates for aquatic-phase amphibians.
[3] Four species of two families of monocots, of which one is corn; six species of at least four dicot families, of which one is soybeans.

2.3.2. Chronic Effects

The most sensitive chronic avian study submitted by the registrant produced a NOAEL of 100 ppm based on number of eggs laid and number of normal hatchlings. Other avian reproductive studies showed effects on 14-day survivor weight, normal hatchings eggs laid and eggs set.

There were no mammalian reproductive effects observed up to levels of 100 mg/kg/day (2000 ppm).

There are no chronic studies available for freshwater fish.

The NOAEC for freshwater aquatic invertebrate's was 1.0 ppb for number of offspring produced.

The NOAEC for estuarine fish was <150 ppb for weight loss.

The NOAEC for estuarine invertebrates was 3.2 ppb for survival of offspring.

2.4 Ecosystems Potentially at Risk

The ecosystems at risk are often extensive in scope, and as a result it may not be possible to identify specific ecosystems during the development of a baseline risk assessment. However, in general terms, terrestrial ecosystems potentially at risk could include the treated field and areas immediately adjacent to the treated field that may receive drift or runoff. Areas adjacent to the treated field could include cultivated fields, fencerows and hedgerows, meadows, fallow fields or grasslands, woodlands, riparian habitats and other uncultivated areas.

Aquatic ecosystems potentially at risk include water bodies adjacent to, or down stream from, the treated field and might include impounded bodies such as ponds, lakes and reservoirs, or flowing waterways such as streams or rivers. For uses in coastal areas, aquatic habitat also includes marine ecosystems, including estuaries.

2.5 Assessment Endpoints

Assessment endpoints represent the actual environmental value that is to be protected, defined by an ecological entity (species, community, or other entity) and its attribute or characteristics (EPA, 1998). For thiobencarb, the ecological entities may include the following: birds, mammals, freshwater fish and invertebrates, estuarine/marine fish and invertebrates, terrestrial plants, insects, and aquatic plants and algae. The attributes for each of these entities may include growth, reproduction, and survival. (See Table 2.5 in section 2.7.2 for further discussion.)

2.6 Conceptual Model

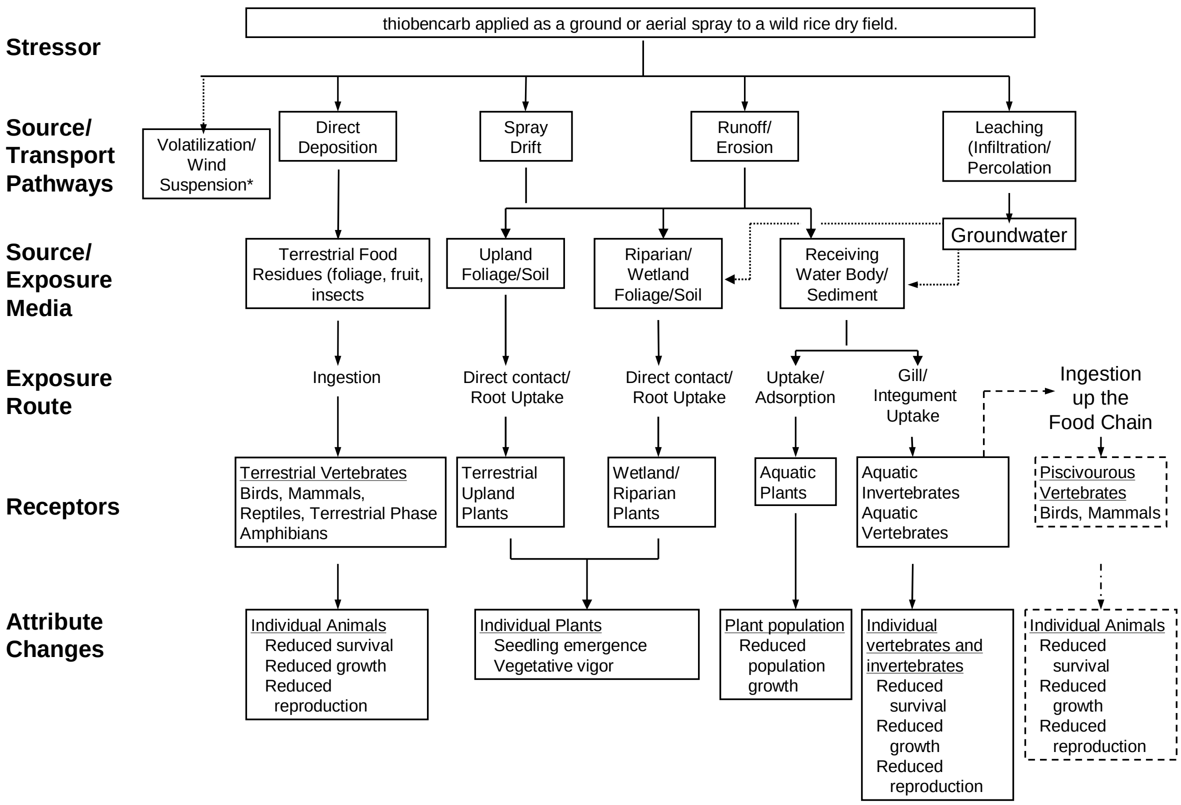
For a pesticide to pose an ecological risk, it must reach ecological receptors in biologically significant concentrations. An exposure pathway is the means by which a pesticide moves in the environment from a source to an ecological receptor. For an ecological pathway to be complete, it must have a source, a release mechanism, an environmental transport medium, a point of exposure for ecological receptors, and a feasible route of exposure.

A conceptual model provides a written description and visual representation of the predicted relationships between thiobencarb, potential routes of exposure, and the predicted effects for the assessment endpoint.

2.6.1. Conceptual Diagram

A conceptual model (CM) consists of a written description/risk hypothesis and visual representation of the predicted relationships between a stressor, the potential routes of exposure, and the attribute changes of concern for the assessment endpoint. Visual representations of the risk hypothesis assessed in this screening level risk assessment are provided for thiobencarb injection in **Figure 2.1.**

Figure 2.1 Conceptual Diagram for Exposure Route of Thiobencarb Applied by Ground or Aerial Spray to Wild Rice Fields.



2.7 Analysis Plan

This assessment focuses on adverse acute and chronic effects to terrestrial and aquatic wildlife associated with the proposed new uses for thiobencarb. This analysis plan identifies the approach, methods, specific models, information, and data that will be used to estimate and evaluate risks from proposed labeled uses of thiobencarb based on the conceptual model and risk hypotheses.

2.7.1 Preliminary Identification of Data Gaps

Freshwater Fish Early life Stage (72-4).

2.7.2 Measures of Effects and Exposure

Table 2.5 provided below provides a summary of the assessment endpoints previously identified as measure of effects.

Table 2.5 Measures of Ecological Effects for Thiobencarb

Assessment Endpoint		**Selected Surrogate Species and Measure of Ecological Effect**	**Comments**
Birds	Survival	Bobwhite acute oral LD_{50} >1938 mg ai/kg-bw	MRID 42600201
		Mallard duck subacute dietary LC_{50} > 5000 ppm	MRID 44846206
	Reproduction and growth	Mallard duck Reproductive study NOEL = 100 ppm ai	MRID 00025778
Mammals	Survival	rat LD_{50} = 1033 mg ai/kg bw	MRID 42130701
	Reproduction and growth	Rat two-generation NOEC = 100 mg ai/kg bw-day diet	MRID 40446201
Freshwater fish	Survival	Bluegill sunfish acute 96-hr LC_{50} = 0.56 ppm ai	MRID 00050665
	Reproduction and growth	No data	
Freshwater invertebrates	Survival	*Daphnia magna* acute 48-hr EC_{50} = 0.10 ppm ai	MRID 00025788
	Reproduction and growth	*Daphnia magna* life cycle NOAEC = 0.001 ppm ai	MRID 00079098
Estuarine/marine fish	Survival	Sheepshead minnow 96-h LC_{50} = 0.66 ppm ai	MRID 00079112
	Reproduction and growth	Sheepshead minnow NOEC < 0.15 ppm	MRID 00079112
Estuarine/marine invertebrates	Survival	mysid shrimp 48-h LC_{50} = 0.15 ppm	MRID 00050667
	Reproduction and growth	mysid shrimp Life cycle NOAEC = 0.0032 ppm	MRID 43976801
Terrestrial plants	Survival and growth	Seedling Emergence EC_{25} = 0.019 lb ai/A Vegetative vigor EC_{25} = 0.073 lb ai/A	MRID 41690902
Insects	Survival	No data	

Assessment Endpoint		Selected Surrogate Species and Measure of Ecological Effect	Comments
Aquatic plants	Biomass and Growth Rate	green algae 5-day EC_{50} = 0.017 ppm ai duckweed EC_{50} = 0.770 ppm ai; NOEC = 0.140 ppm ai	MRID 41690901

LD_{50} = Lethal dose to 50% of the test population; NOEC = No observed effect concentration; NOEL = No observed effect level; LC_{50} = Lethal concentration to 50% of the test population; EC_{50} = Effect concentration to 50% of the test population; IC_{50}= inhibition concentration resulting in a 50% inhibition in the test population response (e.g., growth)

The environmental fate and transport properties of thiobencarb are well characterized. The physical/chemical and fate properties of thiobencarb are summarized in **Table 2.1** in section 2.2.1.

3.0 Analysis

3.1 Aquatic Exposure

The estimated surface water environmental concentrations (EEC) presented here are based on the Tier 1 Rice Model, which assumes flooded fields (wet seeding), and on Aquatic Field Dissipation studies conducted on rice fields in Louisiana (dry seeding).

The Louisiana aquatic field dissipation study was conducted at 4 lb/acre, followed by flooding after seven days. The maximum thiobencarb concentration in the flood water was 13 ppb (average) 3 days after flooding. The wild rice use specifies a 2 lb/acre use rate; thus, the approximate EEC based on this field study is 7 ppb.

Rice Model.

A Tier I aquatic exposure assessment was performed using the Tier I Rice Model for surface water sources. Based on the environmental fate data for thibencarb, input parameters used for the models are shown in **Table 3.1**.

Table 3.1. Chemical Specific Input Parameters for Thiobencarb

Parameter	Input Value and Unit	Source
Maximum application rate	4 lb/acre Also modeled 2.0 and 2.5 lb/acre	Product Label for Bolero 8EC
Maximum number of applications	1	Product Label for Bolero 8EC
Partition coefficient K_{oc}[b]	900 mL/g (average of 4 values, range 384-435)	MRID 41215313
Aerobic soil metabolism[c]	41 days (average of 3 values, range 27-58 days)	MRID 43300401, 00040925

The Tier 1 Rice Model v1.0 (May 8, 2007) estimates the peak concentration of pesticide in a 0.1 meter-deep rice paddy, and does not account for any dissipation processes, with the exception of partitioning to sediment. The relevant equation is:

$$Cw = m_{ai}' / (0.00105 + 0.0000013*Koc)$$

Where Cw is the paddy water concentration (ppb), m_{ai}' is the application rate (kg/hectare) and Koc is the organic-carbon normalized partition coefficient. The results for the selected application rates are given in Table 3.2.

Table 3.2. Results of Tier 1 Rice Model

Application Rate	Peak EEC, ppb
4 lb/acre (4.48 kg/hectare)	2018.
2.5 lb/acre (2.8 kg/ha)	1261.
2.0 lb/acre (2.24 kg/ha)	1009.

Since the Rice Model can not provide a 21-day and 50-day EEC for calculation of chronic RQ for aquatic invertebrate and fish, respectively, a spreadsheet was set up with a line for every day from 0 to 21 and 0 to 56. The concentrations were directly from a field dissipation study (MRID 43404005 and Ross & Sava), up to the day that the parent concentration peaked. On that day, the concentration entry was defined as the peak concentration, times an exponential decay function, using the slope of the data after the peak as the decay rate. The decay rate constants were k=0.1252 (halflife 5.54 days) for MRID 43404005, and k=0.1596 (halflife 4.34 days) for Ross & Sava. The time, t, was set to 0 for the peak day by subtracting the day of the peak concentration from the current day. So, if the peak was on day 3, then the time was 3-3=0, and the peak was reproduced exactly. On each subsequent day, the time went up by one day, and the concentration decayed accordingly. The estimated aquatic environmental exposure concentrations are below in Table 3.3.

Table 3.3. Aquatic Exposure using 4 lb/acre (4.48 kg/hectare)

Exposure reference	Peak EEC, ppb	21 day	60 day
Rice Model Tier I	2018	---	---
MRID 43404005	438	202	80
Ross & Sava	576	209	70

3.2 Terrestrial Exposure Assessment

The TREX model automates the calculation of dietary exposure according to the Hoerger-Kenaga nomogram, as modified by Fletcher (1994). The nomogram tabulates the 90th percentile exposure expected on various classes of food items, and scales the exposure (in dietary terms) to the size and daily food intake of several size classes of birds and mammals.

The results of the TREX model outputs are found in section 4.1.2.

4.0 Risk Charcterization

4.1 Risk Quotients (RQ)

Risk characterization integrates exposure and measure of effects data to evaluate the likelihood of adverse effects. For a screening level risk analysis, the Agency accomplishes this integration using a risk index approach, the risk quotient method. Risk quotients (RQs) are calculated by dividing estimates of exposure (EEC) by acute and chronic measures of effect.

RQ = EXPOSURE / MEASURE OF EFFECT

RQs are then compared to levels of concern (LOCs) to indicate the potential risk to non-target, listed (endangered or threatened), and non-listed organisms. The LOCs are presumptive risk values; a RQ that exceeds the LOC has a presumed risk to non-target organisms. LOCs currently address the following categories of presumed risk:

- acute - potential for acute risk is high and regulatory action beyond restricted use classification may be warranted
- acute restricted - the potential for acute risk is high, but may be mitigated through restricted use classification
- acute listed species - threatened and endangered species may be adversely affected
- chronic risk - the potential for chronic risk is high and regulatory action may be warranted.

The measures of effect used in calculating the acute and chronic risk quotients are derived from required laboratory toxicity studies. Table 4.1 lists the LOC value by taxonomic group associated with a given risk presumption and the specific associated RQ calculation. Each of the taxonomic groups corresponds to the risk hypotheses identified for this assessment in section II.D.

Table 4.1. Risk presumption LOC values and associated formulas for RQ calculations

Risk Presumption	RQ	LOC
Birds and Wild Mammals		
Acute Risk[1]	EEC[2] (ppm) / LC_{50} (ppm) or EEC (mg/kg-bw/d) / LD_{50} (mg/kg-bw/d)	0.5
Acute Restricted Use[1]	EEC (ppm) / LC_{50} (ppm) or EEC (mg/kg-bw/d) / LD_{50} (mg/kg-bw/d)	0.2
Acute Listed Species[1]	EEC (ppm) / LC_{50} (ppm) or EEC (mg/kg-bw/d) / LD_{50} (mg/kg-bw/d)	0.1
Chronic Risk[1]	EEC (ppm) / NOAEC (ppm) or EEC (mg/kg-bw/d) / NOAEL (mg/kg-bw/d)	1.0
Aquatic Animals		
Acute Risk	EEC (ppm) / (LC_{50} (ppm) or EC_{50} (ppm))	0.5
Acute Restricted Use	EEC (ppm) / (LC_{50} (ppm) or EC_{50} (ppm))	0.1
Acute Listed Species	EEC (ppm) / LC_{50} (ppm) or EC_{50}	0.05
Chronic Risk	EEC (ppm) / NOAEC (ppm)	1.0
Terrestrial and Plants Inhabiting Semi-Aquatic Areas		
Acute Risk	EEC (lbs ai/A) / EC_{25} (lbs ai/A)	1.0
Acute Listed Use	EEC (lbs ai/A) / (EC_{05} or NOAEC (lbs ai/A))	1.0
Aquatic Plants		
Acute Risk	EEC (ppm) / EC_{50} (ppm)	1.0
Acute Listed Species	EEC (ppm) / (EC_{05} or NOAEC (ppm))	1.0

[1] For mammals and birds, one can either calculate based on concentration of the ai in the diet (ppm) where the dietary level from the laboratory study is adjusted for the body weight of representative exposed mammals or birds or compare normalized dose values in terms of milligram of ai per kilogram body weight per day (mg/kg-bw/d).
[2] EEC = estimate environmental concentration

4.1.1. Non-Target Aquatic Animals and Plants

The EECs used to calculate aquatic risk are from section 3.1 which included values obtain from the Rice Exposure Model and field studies, specifically MRID 43404005 and Ross & Sava. The 576 ppb concentration peak value is from Ross and Sava since it is the greater peak value of the two dissipation studies. The 80 ppb value for chronic fish is the 60-day value from MRID

43404005 since it is the highest 60-day value from the two field studies and the 209 ppb concentration value is the 21-day value from Ross and Sava, again since it is the greater of the two field dissipation values. The aquatic RQs for fish and aquatic invertebrates are found in Table 4.2 below.

Table 4.2 RQ Values for Aquatic Animals

Taxa	Rice Model EEC (ppb)		Field Dissipation EEC (ppb)		Acute RQ		Chronic RQ (Field Dissipation)
	Peak	Chronic	Peak[1]	Chronic	Rice M	F. Dissipation	
Freshwater fish	2018	-----	576	80[2]	3.6	1.0	------
Freshwater invertebrates	2018	-----	576	209[1]	20.2	5.8	209
Estuarine fish	2018	-----	576	80	3.1	0.9	>0.5
Estuarine invertebrates	2018	-----	576	209	13.5	3.8	65.3

[1] from Ross and Sava
[2] from MRID 43404005
Freshwater fish surrogate = Bluegill sunfish acute 96-hr LC_{50} = 0.56 ppm ai
Freshwater invertebrate surrogate = *Daphnia magna* acute 48-hr EC_{50} = 0.10 ppm ai
Freshwater invertebrate surrogate = *Daphnia magna* life cycle NOAEC = 0.001 ppm ai
Estuarine fish surrogate = Sheepshead minnow 96-h LC_{50} = 0.66 ppm ai
Estuarine fish surrogate = Sheepshead minnow early life cycle NOEC < 0.15 ppm
Estuarine invertebrate surrogate = mysid shrimp 48-h LC_{50} = 0.15 ppm
Estuarine invertebrate surrogate = mysid shrimp Life cycle NOAEC = 0.0032 ppm

The Agency's LOC for freshwater and estuarine fish and invertebrates is exceeded for listed and non-listed species.

Table 4.3 below provides RQs for listed and non-listed non-target aquatic plants from runoff.

Table 4.3 RQ for Aquatic Non-Target Plant

TAXA	Rice Model EEC	Ross & Sava EEC	Non-Listed RQ		Listed Species RQ	
			Rice M	R & S	Rice M	R & S
green algae	2018 ppb	576 ppb	118.7	33.9	------	-------
duckweed	2018 ppb	576 ppb	2.6	0.75	14.4	4.1

Unicellular surrogate = green algae 5-day EC_{50} = 0.017 ppm ai
Vascular aquatic plant = duckweed EC_{50} = 0.770 ppm ai; NOEC = 0.140 ppm ai

The Agency's LOC for aquatic non-target plants is exceeded for listed and non-listed species.

4.1.2. Non-Target Terrestrial Animals and Plants

Birds

Since the current information and data have not changed significantly from what was included in RED, the terrestrial risk assessment for the proposed use on wild rice in California is covered by the assessment done in the RED. Below in Table 4.4 is a summary of the terrestrial risk assessment in the RED:

- The acute risk to birds from all uses of *liquid* thiobencarb is minimal. No acute effects to threatened and endangered species are expected.

Table 4.4 Avian Chronic Risk Quotients (RQs) for Liquid Applications Based on a Mallard Duck NOEC and Maximum EECs

Crop	Maximum Application Rate (lbs a.i./A)	Food Items	Maximum EEC (ppm)	NOEC (ppm)	Chronic RQ (EEC/NOEC)	Number of Days EEC > NOEC
Rice	4	Short grass	960	100	9.6	29
		Long grass	440	100	4.4	19
		Broadleaf plants and insects	540	100	5.4	21
		Fruit	60	100	0.6	0

- The avian chronic RQs exceed the Agency's Level of Concern for chronic risk to birds.

Mammals

The previous RED indicates acute and chronic risk to mammals.

Acute oral LD_{50} data for laboratory rats submitted to the Health Effects Division (HED) for evaluation of human toxicity were used to assess the mammalian acute toxicity of thiobencarb. The LD_{50} for male and female rats are 1033 and 1130 mg ai/kg, respectively (MRID 42130701). These results classify thiobencarb as slightly toxic to mammals on an acute basis.

Results from chronic mammalian studies (two generation rat) were discussed in section B.f. of the 1997 revised HED Chapter of the Rereregistration Eligibility Decision document for thiobencarb. In a reproductive study (MRID 40446201), there were no reproductive effects observed at levels of 100 ppm. The NOEL was equal to or greater than 100 mg/kg/day.

The previous RED used the parental/systemic endpoints for determining chronic risk to small mammals. For parental/systemic toxicity (MRID 40446201), the NOEL was 2 mg/kg/day and the LOEL was 20 mg/kg/day based on histopathological changes of the liver and kidney. The changes are enlargement of centrolobular hepatocytes (both generations) and hepatocyte single cell necrosis observed in both sexes of both sexes in both generations including renal atrophic tubule consisting of regenerated epithelium.

There were increased liver and kidney weights in the high dose group. EFED does not currently uses these parental/systemic endpoints for determining reproductive risk to small mammals. Therefore the NOEL of greater than 100 ppm will be used for risk assessment purposes.

Below in Table 4.5 to 4.7 is the output from a TREX spreadsheet model.

Table 4.5. Upper Bound Kenaga, *Acute* Mammalian Dose-Based Risk Quotients

Size Class (grams)	Adjusted LD50	EECs and RQs									
		Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/Seeds/ Large Insects		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	2270.36	915.3	0.40	419.5	0.18	514.8	0.23	57.2	0.03	12.7	0.01
35	1836.96	632.6	0.34	289.9	0.16	355.8	0.19	39.5	0.02	8.8	0.00
1000	794.54	146.7	0.18	67.2	0.08	82.5	0.10	9.2	0.01	2.0	0.00

Table 4.6 Upper Bound Kenaga, Chronic Mammalian Dietary Based Risk Quotients

NOEC (ppm)	EECs and RQs							
	Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/Seeds/ Large Insects	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
2000	960.0	0.48	440.0	0.22	540.0	0.27	60.0	0.03

Size class not used for dietary risk quotients

Table 4.7 Upper Bound Kenaga, Chronic Mammalian Dose-Based Risk Quotients

Size Class (grams)	Adjusted NOEL	EECs and RQs									
		Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	219.78	915.3	4.16	419.5	1.91	514.9	2.34	57.2	0.26	12.7	0.06
35	177.83	632.6	3.56	289.9	1.63	355.8	2.00	39.5	0.22	8.8	0.05
1000	76.92	146.7	1.91	67.2	0.87	82.50	1.07	9.2	0.12	2.0	0.03

The results show that the LOC is exceeded for acute and chronic risk to mammals. However, it should be noted that the mammalian reproductive study did not find any reproductive effects up to 2000 ppm. Thus the NOEL is greater than 2000 ppm (100 mg/kg/day). There is uncertainty in reproductive risk to small mammals from the use of thiobencarb in that the reproductive study was not tested at higher than 2000 ppm ai. Therefore it is not known whether there is a reproductive effect at concentrations above 2000 ppm.

Terrestrial Plants

The terrestrial plant endpoint for calculating RQs for potential risk to non-target plants is Seedling Emergence EC_{25} = 0.019 lb ai/A and Vegetative vigor EC_{25} = 0.073 lb ai/A and are found in section 2.7.2. Tables 4.8, 4.9 and 4.10 below provide RQs for listed and non-listed non-target terrestrial plants from runoff and spray drift.

Table 4.8 Input parameters used to derive EECs.

Input Parameter	Symbol	Value	Units
Application Rate	A	4	lb ai/A
Incorporation	I	1	none
Runoff Fraction	R	0.02	none
Drift Fraction	D	0.05	none

Table 4.9 EECs for pesticide Thiobencarb. Units in lb ai/A.

Description	Equation	EEC
Runoff to dry areas	(A/I)*R	0.08
Runoff to semi-aquatic areas	(A/I)*R*10	0.8
Spray drift	A*D	0.2
Total for dry areas	((A/I)*R)+(A*D)	0.28
Total for semi-aquatic areas	((A/I)*R*10)+(A*D)	1

Table 4.10 RQ values for plants in dry and semi-aquatic areas exposed to thiobencarb through runoff and/or spray drift.*

Listed Status	Dry Area	Semi-Aquatic	Spray Drift
non-listed	14.74	52.63	10.53
listed	54.90	196.08	39.22

*If RQ > 1.0, the LOC is exceeded, resulting in potential for risk to that plant group.

The Agency's LOC for terrestrial non-target plants is exceeded for listed and non-listed species.

4.2 Risk Description

4.2.1. Aquatic Animals and Plants

Acute risk to animals

Based on the RQ calculations from the Rice Model, there are listed and non-listed exceedances of the LOC for acute risk to fish and aquatic invertebrates. The Rice Model's exposure to aquatic animals may be overestimated since the application of thiobencarb estimates the peak concentration of pesticide in a 0.1 meter-deep rice paddy, assumes direct application to water, and does not account for any dissipation processes, with the exception of partitioning to sediment.

The field dissipation monitoring data may provide a lower bound estimate of actual environmental concentrations. Even with the lower EECs from the field monitoring data, there are LOC exceedances for acute risk to fish and aquatic invertebrates with RQs ranging from 0.9 to 5.8 for freshwater fish and estuarine invertebrates, respectively. The aquatic invertebrates appear to be more sensitive than the fish species by a factor of at least 4-5 X. Freshwater species appear to be slightly more sensitive than the estuarine species.

Chronic risk to animals

The Agency's chronic LOC is exceeded for fish and aquatic invertebrates.

Since there are no chronic data for freshwater fish and the chronic study for the estuarine fish did not provide a NOEC, an acute to chronic ratio will be used to calculate the chonic toxicity for the fish and thereby estimate the potential chronic RQ. The EEC for determining the chronic RQ comes from the field dissipation studies (MRID 43404005 and Ross & Sava) since the Rice Model can not provide a 21-day and 50-day EEC for calculation of chronic RQs for aquatic invertebrates and fish as stated in section 3.1.

The formula for calculating the chronic freshwater fish toxicity is:

$$\frac{\text{acute fish tox (560 ppb)}}{\text{chronic fish tox (x)}} = \frac{\text{acute aquatic invertebrate (100 ppb)}}{\text{chronic aquatic invertebrate (1 ppb)}}$$

chronic freshwater fish toxicity = 5.6 ppb

The formula for calculating the chronic estuarine fish toxicity is:

$$\frac{\text{acute fish tox (660 ppb)}}{\text{chronic fish tox (x)}} = \frac{\text{acute aquatic invertebrate (150 ppb)}}{\text{chronic aquatic invertebrate (3.2 ppb)}}$$

chronic estuarine fish toxicity = 14.1 ppb

Using the new chronic fish toxicity values derived from the acute to chronic ratio, the freshwater fish chronic RQ is 14.3 (80/5.6). The estuarine fish chronic RQ is 5.7 (80/14.1). There are more sensitive estuarine fish species (Atlantic silverside (*Menidia menidia*)). The 14-day old Atlantic silverside has an LC_{50} of 410 ppb. Therefore, the potential acute risk to estuarine fish may be greater than what was stated.

Risk to aquatic plants

The Agency's LOC for aquatic plants (listed and non-listed) is exceeded. The Rice Model shows an RQ of 118.7 for alga/diatom species and 2.6 for aquatic vascular plant species. Using EECs derived from the field studies show RQs of 33.9 for alga species and below the LOC for aquatic vascular species.

The listed species LOC is exceeded from 14.4 to 4.1X for aquatic vascular species. There are currently no listed unicellular species.

4.2.2. Risk to Terrestrial Organisms

Risk to Birds

The acute risk to birds from all uses of *liquid* thiobencarb is minimal. No acute effects to threatened and endangered species are expected.

The Agency's chronic LOC for birds (1.0) is exceeded. The RQ's ranged from 0.6 to 9.6.

Acute Risk to Mammals

The acute RQs ranged from a high of 0.4 to below the LOC for listed species (0.1). There are no acute LOC exceedances for acute risk to non-listed species but only to listed species.

Chronic Risk to Mammals

Based on dietary EECs, the chronic LOC for mammals is not exceeded. However, based on the dose-based EECs the chronic LOCs are exceeded for mammals feeding on grass, broadleaf plants, and small insects. The RQs range from a high of 4.2 to below the Agency's chronic LOC for mammals. However, there is much uncertainty on whether the Agency's chronic LOC for mammals is exceeded in that the rat reproduction study did not find any reproductive effects up to 2000 ppm (100 mg/kg-bw).

The dose-based approach assumes that the uptake and absorption kinetics of a gavage toxicity study approximate the absorption associated with uptake from a dietary matrix. Toxic response is a function of duration and intensity of exposure and the importance of absorption kinetics across the gut. A gavage dose represents a very short-term high intensity exposure, where dietary exposure may be of a more prolonged nature. The dietary-based approach assumes that animals in the field are consuming food at a rate similar to that of confined laboratory animals. Energy content in food items differs between the field and the laboratory as does the energy requirements of wild and captive animals. The Wildlife Exposure Factors Handbook can provide insights into energy requirements of animals in the wild as well as energy content of their diets.

Risk to Terrestrial Plants

The Agency's LOC for terrestrial non-target plants is exceeded for listed and non-listed species.

Thiobencarb is a member of the thiocarbamate class of chemicals that have a common herbicidical mode of action in the inhibition of lipid synthesis and not ACCase inhibition. The emerging shoot growth is inhibited in the targeted plant. Therefore, the seedling growth would be the most sensitive part of the plant. Data from the seedling emergence and vegetative growth studies support this assertion. The seedling emergence study tends to be more sensitive than the vegetative vigor study by almost a factor of 4X. In addition, the greater risk quotients are not from spray drift but from runoff scenarios.

4.3.1 Review of Incident Data

There have been no adverse incidents to non-target animals or plants reported to the Agency.

4.4.1 Federally Threatened and Endangered (Listed) Species Concerns

There may be potential risk to listed species under the following taxa: birds (and reptiles), mammals, freshwater and estuarine fish (and amphibians), freshwater and estuarine aquatic invertebrates, and aquatic and terrestrial plants.

The list of Federally Threatened and Endangered (Listed) Species that may be potentially at risk from thiobencarb use on wild rice are in Appendix C.

5.0 References

Lai, J.C., 1991. Field Dissipation of Bolero 8ECin Rice. Laboratory Project ID: 1641/90/7538. Chevron Chemical Company, Richmond, Ca. MRID 42003404

Ho, B, 1990. Aquatic Field Dissipation of Bolero 10G in Rice. Laboratory Project ID: T-7230. Chevron Chemical Company, Richmond, Ca. MRID 43404005

Ahrens, W.H, ed., 1994. Herbicide Handbook, Seventh Edition. Weed Science Society of America, Champaign, IL.

Ross, L.J. and R.J. Sava, 1986. Fate of thiobencarb and molinate in rice fields. J. Environ. Qual. 15:220-225.

USEPA. 2003. Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides, Version II" dated February 28, 2002. U.S. Environmental Protection Agency, Washington, DC.

USEPA. 1993. Wildlife Exposure Factors Handbook. Volume I of II. EPA/600/R-93/187a. Office of Research and Development, Washington, DC 20460.

Appendix A TREX Model Output for Thiobencarb

Table A.1

Mammalian Class	Body Weight	Ingestion (Fdry) (g bwt/day)	Ingestion (Fwet) (g/day)	% body wgt consumed	FI (kg-diet/day)
Herbivores/ insectivores	15	3	14	95	1.43E-02
	35	5	23	66	2.31E-02
	1000	31	153	15	1.53E-01
Grainvores	15	3	3	21	3.18E-03
	35	5	5	15	5.13E-03
	1000	31	34	3	3.40E-02

Mammalian Class	Body Weight	Adjusted LD50	Adjusted NOAEL
Herbivores/ insectivores	15	2270.36	219.78
	35	1836.96	177.83
	1000	794.54	76.92
Grainvores	15	2270.36	219.78
	35	1836.96	177.83
	1000	794.54	76.92

Summary of Risk Quotient Calculations Based on Upper Bound Kenaga EECs

Table A.2. Upper Bound Kenaga, Acute Mammalian Dose-Based Risk Quotients

Size Class (grams)	Adjusted LD50	EECs and RQs									
		Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	2270.36	915.29	0.40	419.51	0.18	514.85	0.23	57.21	0.03	12.71	0.01
35	1836.96	632.59	0.34	289.93	0.16	355.83	0.19	39.54	0.02	8.79	0.00
1000	794.54	146.67	0.18	67.22	0.08	82.50	0.10	9.17	0.01	2.04	0.00

Table A.3. Upper Bound Kenaga, Acute Mammalian Dietary Based Risk Quotients

LC50 (ppm)	EECs and RQs							
	Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
0	960.00	#####	440.0 0	#####	540.00	#####	60.00	#####

Size class not used for dietary risk quotients

Table A.4. Upper Bound Kenaga, Chronic Mammalian Dietary Based Risk Quotients

NOAEC (ppm)	EECs and RQs							
	Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
2000	960.00	0.48	440.00	0.22	540.00	0.27	60.00	0.03

Size class not used for dietary risk quotients

Table A.5. Upper Bound Kenaga, Chronic Mammalian Dose-Based Risk Quotients

Size Class (grams)	Adjusted NOAEL	EECs and RQs									
		Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	219.78	915.29	4.16	419.51	1.91	514.85	2.34	57.21	0.26	12.71	0.06
35	177.83	632.59	3.56	289.93	1.63	355.83	2.00	39.54	0.22	8.79	0.05
1000	76.92	146.67	1.91	67.22	0.87	82.50	1.07	9.17	0.12	2.04	0.03

Appendix B Ecological Data Tables

1. Ecological Toxicity Data

a. Toxicity to Terrestrial Animals

(1) Birds, Acute and Subacute

An oral (LD_{50}) study (preferably mallard or bobwhite quail) and two subacute dietary (LC_{50}) studies (one species of waterfowl, preferably the mallard duck and one species of upland game bird, preferably bobwhite quail) are required to establish the toxicity of a pesticide to birds. Results of these tests are tabulated below.

Table B.1 : Avian Acute Oral Toxicity Findings (LD_{50})

Species	% A.I.	LD_{50} (mg a.i./kg)	MRID No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Northern bobwhite	96.9	> 1938[a]	MRID 42600201 S.M. Campbell and M. Jaber. 1992.	Practically nontoxic	Yes

[a] There were no mortalities in birds receiving a dose of 1938 mg ai/kg thiobencarb.

Table B.2 : Avian Subacute Dietary Toxicity Findings (LC_{50})

Species	% A.I.	LC_{50} (ppm ai)	MRID No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Northern bobwhite	"Technical"	>5620[a]	MRID 00034763 Fletcher, 1976.	Practically nontoxic	No, supplemental
Mallard duck	96.5	> 5000	MRID 44846206 Helsten, 1999	Practically nontoxic	Acceptable

[a] In this range-finding test for reproductive effects, there were no treatment-related mortalities in eight birds that were fed a diet containing 5620 ppm for eight weeks.

These results indicate that thiobencarb is practically nontoxic to avian species on an acute oral basis. A supplemental study (MRID 00034763) and acceptable study (MRID 44846206) suggests that thiobencarb is probably practically nontoxic to the bobwhite on a subacute dietary basis.

(2) Birds, Chronic

Avian reproduction studies using the technical grade of the active ingredient (TGIA) are required when birds may be exposed to a pesticide repeatedly or continuously through its persistence, bioaccumulation, or from multiple applications, or if mammalian reproduction tests indicate possible adverse reproductive effects. The preferred test species are the mallard duck and bobwhite quail. Avian reproduction studies are required for thiobencarb because it is persistent in the terrestrial environment and may bioaccumulate. Results of these tests are tabulated below.

Table B.3 : Avian Reproduction Findings

Species	% A.I.	NOEC (ppm ai)	LOEC (ppm ai)	Endpoints Affected	MRID No. Author/Year	Fulfills Guideline Requirement?
Northern bobwhite	97.5	267	930	Hatchling weight, number of hatchlings per live embryos	MRID 43075401 J. Beavers, K. Chafey, L. Mitchell, and M. Jarber. 1993.	Acceptable
Mallard duck	96.5	115	231	14-day survivor weight, normal hatchings eggs laid, eggs set	MRID 45140601 Helsten, 2000	Acceptable
Mallard duck	95.5	100	300	Number of eggs laid, number of normal hatchlings	MRID 00025778 Beavers, 1979	No, supplemental [a]
Japanese Quail	50.0 (Saturn EC)	750 formulation	350 formulation	fertility and hatchability	MRID 00080848 Chevron Chemical Co., 1974	No, supplemental [b]

[a] Supplemental due to temperature and humidity not controlled; photoperiod increased very rapid and at very high photoperiod; raw data provided is incomplete; and housing and feed not described well.
[b] Supplemental due to lack of information on procedures, raw data, housing, consumption data, and test environment.

The results indicate that dietary concentrations greater than 100 ppm can impair reproduction in birds.

(3) Mammals

Wild mammal testing may be required on a case-by-case basis, depending on the results of the lower tier studies such as acute and subacute testing, intended use pattern and pertinent environmental fate characteristics. This testing has not been required for thiobencarb. Acute oral LD_{50} data for laboratory rats submitted to the Health Effects Division (HED) for evaluation of human toxicity were used to assess the mammalian acute toxicity of thiobencarb. The LD_{50} for male and female rats are 1033 and 1130 mg ai/kg, respectively (MRID 42130701). These results classify thiobencarb as slightly toxic to mammals on an acute basis.

Smith 1 reports that the LD_{50} of technical grade thiobencarb is 920-1903 mg/kg in the rat, which supports the definitive findings reported above. Smith also reports the LD_{50} of technical grade thiobencarb for the mouse to be 2745 mg/kg, indicating that the mouse is less sensitive than the rat.

Results from chronic mammalian studies (two generation rat) were discussed in

1 Smith, G. J. 1993. Toxicology & Pesticide Use in relation to wildlife: Organophosphorus & Carbamate compounds. C. K. Smoley, Boca Raton, FL.

section B.f. of the 1997 revised HED Chapter of the Rereregistration Eligibility Decision document for thiobencarb (case number 2665). In a reproductive study (MRID 40446201), there were no reproductive effects observed at levels of 100 mg/kg/day. The NOEL was equal to or greater than 100 mg/kg/day.

For parental/Systemic toxicity (MRID 40446201), the NOEL was 2 mg/kg/day and the LOEL was 20 mg/kg/day based on histopathological changes of the liver and kidney. The changes are enlargement of centrolobular hepatocytes (both generations) and hepatocyte single cell necrosis observed in both sexes of both sexes in both generations including renal atrophic tubule consisting of regenerated epithelium. There were increased liver and kidney weights in the high dose group.

(4) Insects

A honey bee acute contact LD_{50} study using the technical grade of the active ingredient is required when the proposed use will result in honey bee exposure. A honey bee acute contact study is not required for this pesticide because its use sites are not expected to result in significant exposure to bees.

(5) Other terrestrial invertebrates

Toxicity data was submitted on apple snail (*Pomacea aludosa*).

Table B.4 Toxicity data on Apple Snail

Species	% A.I.	LC50 or EC50 (ppm ai)	MRID No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Apple snail *Pomacea aludosa*	85[a]	LC_{50} = 1.85	MRID 40031001 Rich, 1986	Moderately toxic	No, supplemental

[a]Bolero 8 EC

b. Toxicity to Aquatic Animals

(1) Freshwater Fish, Acute

Two freshwater fish toxicity studies using the technical grade of the active ingredient are required to establish the toxicity of a pesticide to freshwater fish. One study should use a coldwater species (preferably the rainbow trout), and the other should use a warmwater species (preferably the bluegill sunfish). Results of these tests are given below.

Table B.5: Freshwater Fish Acute Toxicity Findings

Species	% A.I.	LC_{50} (mg ai/L)	MRID No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Bluegill sunfish	10[a]	0.56	MRID 00050665 Thompson, 1980	Highly toxic	Yes, for TEP only
Rainbow trout	10[a]	1.5	MRID 00050664 Thompson, 1980	Moderately toxic	Yes, for TEP only
Rainbow trout	95.5	1.15	MRID 00080851 Johnson, U.S.D.I., 1973.	Moderately toxic	No, supplemental
Bluegill sunfish	95.5	2.48	MRID 00080851 Johnson, U.S.D.I., 1973.	Moderately toxic	No, supplemental
Channel catfish	95.5	2.28	MRID 00080851 Johnson, U.S.D.I., 1973.	Moderately toxic	No, supplemental
Rainbow trout	85.2 [b]	1.2	MRID 00139051 Sanders, 1982	Moderately toxic	No, supplemental
Bluegill sunfish	85.2 [b]	1.7	MRID 00139051 Sanders, 1982	Moderately toxic	No, supplemental
Channel Catfish	85.2 [b]	2.3	MRID 00139051 Sanders, 1982	Moderately toxic	No, supplemental
Bluegill sunfish	Technical	2.6	MRID 00080859 Wateri, 1974	Moderately toxic	No, supplemental
Carp	Technical	2.8	MRID 00080859 Wateri, 1974	Moderately toxic	No, supplemental
Bluegill sunfish	84.0[b]	1.66	MRID 00080851 Johnson, U.S.D.I., 1973.	Moderately toxic	No, supplemental
Rainbow trout	84.0[b]	1.05	MRID 00080851 Johnson, U.S.D.I., 1973.	Moderately toxic	No, supplemental
Channel catfish	84.0[b]	2.28	MRID 00080851 Johnson, U.S.D.I., 1973.	Moderately toxic	No, supplemental

[a] Bolero 10 G
[b] Bolero 8 EC

The majority of the results indicate that thiobencarb is moderately toxic to fish on an acute basis. The sole exception was an acute test of bluegill sunfish exposed to Bolero 10 G (10% ai) that determined the LC_{50} to be 0.56 ppm ai. This result is inconsistent with the results of two other acute tests which both determined that the LC_{50} for the bluegill sunfish was greater, in the range of 2.5 to 2.6 ppm ai. Results of tests with rainbow trout found that LC_{50}'s for this species are slightly greater than 1, putting it in the the moderately toxic range (>1-10 ppm) but close to the highly toxic range (0.1-1 ppm). The EFED therefore concludes that thiobencarb is moderately to highly toxic to freshwater fish.

The only fully acceptable studies on the acute toxicity of thiobencarb to fish were conducted with Bolero 10 G.

(2) Freshwater Fish, Chronic

A freshwater fish early life-stage test using the TGAI is required for thiobencarb because the end-use product may be applied directly to water or expected to be transported to water from the intended use site (rice) and because the following conditions are met: (1) some aquatic acute LC_{50} and EC_{50} are less than 1 mg/l, (2) EECs in water (based on measured concentrations) were greater than 1% of acute LC_{50} and EC_{50} values, and (3) the half-life in water is greater than 4 days. No study with a freshwater fish species has been submitted. A study with a marine/estuarine species (sheepshead minnow) was submitted (MRID 00079112), but this study does not fulfill the guideline because it failed to determine the NOEC. The guideline for an early life-stage toxicity study with a fish species [GLN 72-4(a)] has not been fulfilled. However, the EFED does not request that the registrant submit a study for this guideline. Instead, the EFED requests that the registrant submit a core study that tests the effects of technical thiobencarb over the life-cycle of a fish (GLN 72-5). The Agency is justified in requiring a fish life-cycle test for thiobencarb because the end-use product is intended to be applied directly to water or is expected to transport to water from the intended use site (rice), and because the EEC is greater than one-tenth of the NOEC in the invertebrate life-cycle test. This test should be conducted with a freshwater fish, preferably the fathead minnow or rainbow trout.

(3) Freshwater Invertebrates, Acute

A freshwater aquatic invertebrate toxicity test using the TGAI is required to assess the toxicity of a pesticide to freshwater invertebrates. The preferred test organism is *Daphnia magna*, but early instar amphipods, stoneflies, mayflies, or midges may also be used. Results of this test are tabulated below.

Table B.6: Freshwater Invertebrate Toxicity Findings

Species	% A.I.	LC_{50} or EC_{50} (ppm ai)	MRID No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Daphnid *Daphnia magna*	94.4	EC_{50} = 0.10	MRID 00025788 Wheeler, 1978.	Highly toxic	Yes
Daphnid *Daphnia magna*	82.25[a]	0.173 ppm ai	MRID 00079118 Wheeler, 1980.	Highly toxic	Yes, for TEP
Daphnid *Daphnia magna*	10[b]	EC_{50} = 0.46[c] LC_{50} = 1.2 ai	MRID 00050666 Forbis, 1980.	Highly toxic	No, supplemental
Daphnid *Daphnia magna*	85.2	1.2	MRID 00139051 Sanders, 1982	Moderately toxic	Acceptable
Scud *Gammarus pseudolimimaeus*	85.2 [a]	1.0	MRID 00139051 Sanders, 1982	Moderately toxic	No, supplemental [d]
Red Crayfish *Procambarus clarki*	85.2 [a]	6.5	MRID 00139051 Sanders, 1982	Moderately toxic	No, supplemental [d]
Lumbriculus varirgatus	97.2	2.54	MRID 44628601 Ogle, 1998	Moderately toxic	Supplemental [d]
Chironomid tentans	97.2	0.364	MRID 44628602 Ogle, 1998	Highly toxic	Supplemental [d]
Scud *Gammarus pseudolimimaeus*	95.5	LC_{50} = 0.72	MRID 00080851 Johnson, U.S.D.I., 1973.	Highly toxic	No, supplemental [d]
Scud *Gammarus pseudolimimaeus*	85[a]	LC_{50} = 1.0	MRID 00080851 Johnson, 1973.	Moderately toxic	No, supplemental [d]
Crayfish *Procambarus clarkii*	95.5	LC_{50} = 2.0	MRID 00080851 Johnson, 1973.	Moderately toxic	No, supplemental [d]

[a]Bolero 8 EC
[b]Bolero 10G
[c]The effect used to determine the EC_{50} was clumping of organisms.
[d] Supplemental since this is not recommended species.

The results indicate that thiobencarb is highly toxic to aquatic invertebrates on an acute basis.

(4) Freshwater Invertebrate, Chronic

An aquatic invertebrate life-cycle test using *Daphnia magna* using the TGAI is required for thiobencarb because the end-use product may be applied directly to water or expected to be transported to water from the primary use site (rice) and because the following conditions are met: (1) some aquatic acute LC_{50}'s and EC_{50}'s are less than 1 mg/l, (2) EECs in water (based on measured concentrations) were greater than 1% of acute LC_{50} and EC_{50} values, and (3) the half-life in water is greater than 4 days. *Daphnia magna* is the preferred test species.

Table B.7 Chronic Toxicity on Freshwater Invertebrates

Species	% A.I.	NOEC (ppb ai)	LOEC (ppb ai)	Endpoints Affected	MRID No. Author/Year	Study Category
Daphnia magna	96.9	48	90	Offspring produced	MRID 42680401 Putt, 1993	Supplemental [a]
Daphnia magna	95.2-95.9	1.0	3.0	Number of young produced	MRID 00079098 Vilkas, 1979	Acceptable

[a] Supplemental due to solvent was switched during the study. Reviewer accepts study since the solvent switch did not appear to affect the results.

A life-cycle toxicity study measured the toxicity of thiobencarb (95.2-95.9 percent pure) to the daphnid, *Daphnia magna*. The NOEC and LOEC were 1.0 ppb and 3.0 ppb, respectively. Chronic effects observed were reduced number of young produced and adult mortality. These results indicate that concentrations of thiobencarb greater than 1 ppb can be detrimental to the survival and reproduction of freshwater invertebrates.

(5) Estuarine and Marine Animals, Acute

Acute toxicity testing with estuarine and marine organisms (fish, shrimp, and oysters) using the technical grade of the active ingredient is required when an end-use product is intended for direct application to the marine/estuarine environment or is expected to reach this environment in significant concentrations. The preferred test organisms are the sheepshead minnow, mysid shrimp and eastern oyster. Estuarine/marine acute toxicity testing is required for this pesticide because its use on rice is expected to result in significant exposure to marine and estuarine environments. Application of thiobencarb on rice fields will contaminate tailwater (i.e., water discharged from the water management system) which may flow into estuaries. The tables below show the results of these tests for fish and aquatic invertebrates.

Table B.8 : Acute Toxicity Findings for Marine/Estuarine Fish

Species	% A.I.	LC_{50} (ppm)	MRID No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Sheepshead minnow	95.1	0.66	MRID 00079112, Ward, 1979.	Highly toxic	Yes
Sheepshead minnow	95.1	0.9	MRID 00079110, Heitmuller, 1979.	Highly toxic	Yes
Sheepshead minnow	85.5[a]	1.4	MRID 00079111, Heitmuller, 1979.	Moderately toxic	Yes, for TEP only
Sheepshead minnow	90	> 0.9	MRID 00141967 Borthwick and Walsh, 1981.	Not more than "highly toxic"	Open literature, supplemental
California grunion *Leuresthes tenuis* (Static tests)	90	0.31 (0 d old) 0.48 (7 d old) 0.59 (14 d old) 0.50 (28 d old)	MRID 00141967 Borthwick et al., 1981.	Highly toxic	Open literature, supplemental
California grunion *Leuresthes tenuis* (Flow-through tests)	90	0.27 (0 d old) 0.24 (7 d old) 0.38 (14 d old) 0.33 (28 d old)		Highly toxic	
Atlantic silverside *Menidia menidia* (Static tests)	90	0.46 (0 d old) 0.45 (7 d old) 0.63 (14 d old) 0.75 (28 d old)		Highly toxic	
Atlantic silverside *Menidia menidia* (Flow-through tests)	90	0.39 (0 d old) 0.20 (7 d old) 0.41 (14 d old) 0.68 (28 d old)		Highly toxic	
Tidewater silverside *Media peninsulae* (Static tests)	90	0.53 (0 d old) 0.40 (7 d old) 0.51 (14 d old) 1.2 (28 d old)		Moderately to highly toxic	
Tidewater silverside *Media peninsulae* (Flow-through)	90	0.30 (0 d old) 0.46 (7 d old) 0.39 (14 d old) 0.82 (28 d old)		Highly toxic	

[a]Bolero 8 EC

The results indicate that thiobencarb is highly toxic to marine/estuarine fish on an acute basis.

Table B.9: Acute Toxicity Findings for Marine/Estuarine Invertebrates

Species	% A.I.	EC_{50} (ppm)	MRID No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Eastern oyster (embryo-larvae)	95.1	0.56	MRID 00079114, Hollister,1979.	Highly toxic	Yes
Eastern oyster (embryo-larvae)	85.5[a]	0.32	MRID 00079115, Hollister,1979.	Highly toxic	Yes, for TEP
Eastern oyster (embryo-larvae)	90	0.9 - 9.0	MRID 00141967 Borthwick and Walsh, 1981.	Moderately to highly toxic	Open literature, supplemental
Mysid shrimp (<1 day old)	94.6	0.15	MRID 00050667, Hollister, 1980	Highly toxic	Yes
Mysid shrimp (6-8 days old)	95.1	0.288	MRID 00079117, 43031701 Hollister, 1979.	Highly toxic	No, supplemental [b]
Mysid shrimp (<1 day old)	90	0.33	MRID 00141967 Borthwick and Walsh, 1981.	Highly toxic	Open literature, supplemental
Grass shrimp *Palaemonetes pugio*	85.5[a]	1.0 (adults), 0.38-0.57 (juveniles)	MRID 00080858 Ward, 1975	Highly toxic	No, supplemental
Pink Shrimp *Penaeus duorarum*		0.57		Highly toxic	
White Shrimp *Penaeus setiferus*		0.31		Highly toxic	
Brown shrimp *Penaeus azetecus*		0.47		Highly toxic	
Ghost shrimp		1.1		Moderately toxic	
Fiddler crab	85.5[a]	4.4	MRID 00079113 Heitmuller, 1979	Moderately toxic	No, supplemental

[a]Bolero 8 EC
[b] Supplemental due to mysids are older than recommended.

The results indicate that thiobencarb is highly toxic to marine/estuarine mollusks on an acute basis. The results indicate that thiobencarb is also highly toxic for marine/estuarine shrimp.

(6) Estuarine and Marine Animals, Chronic

Data from estuarine/marine fish early life-stage and aquatic invertebrate life-cycle toxicity tests are required if the product is applied directly to the estuarine/marine environment or expected to be transported to this environment from the intended use site, and when any **one** of the following conditions exist: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity; (2) any acute LC_{50} or EC_{50} is less than 1 mg/L; (3) the EEC in water is equal to or greater than 1% of any acute EC_{50} or LC_{50} value; or (4) the actual or estimated environmental concentration in water resulting from use is less than 0.01 of any acute EC_{50} or LC_{50} value *and* any of the following conditions exist: studies of other organisms indicate the reproductive physiology of fish and/or invertebrates may be affected, physicochemical properties indicate cumulative effects, or the pesticide has a half-life in water greater than 4 days. The preferred test organisms are the sheepshead minnow and mysid shrimp.

Chronic testing with thiobencarb is required because it has a primary use (rice) for which it is applied directly to water or is applied to land which is subsequently flooded with water. In addition, concentrations of thiobencarb measured in aquatic field studies are as great as 0.085 ppm, which is greater than 0.01 of the LC_{50} for marine/estuarine fish and aquatic invertebrates. Results of this test are given below.

Table B.10 Chronic Toxicity onEstuarine Fish and Invertebrates

Species	% A.I.	NOEC (ppb)	LOEC (ppb)	MRID No. Author/Year	Endpoints Affected	Fulfills Guideline Requirement?
Mysid	95.1	ND, EC_{05} = 9.8[b]	ND	MRID 00079117 Hollister, 1979	Reproduction, survival of offspring	No, supplemental
Grass shrimp	84.7	<21[c]	21[c]	MRID 00079097, Ward, 1977.	Adult mortality	No, supplemental [e]
Opossum Shrimp	"Technical"	3.2	6.2	MRID 43976801 Bailey, 1993	Survival of offspring	No, supplemental
Mysid	Not reported	22	35	McKenney, 1985	Number of young produced	Open literature, supplemental [d]
Sheepshead Minnow	95.1	<150	150	MRID 00079112, Ward, 1979.	Wet weight	No, supplemental

[a] ND designates that the value was not determined.
[b] The NOEC could not determined because the control had no replication. A nonlinear regression analysis (Bruce and Versteeg, 1992) was used to calculate the EC_{05} which can be used in lieu of the NOEC.
[c] Levels are highly uncertain because measured concentrations were highly variable.
[d] McKenney, C. L., Jr. 1985. Associations between physiological alterations and population changes in an estuarine mysid during chronic exposure to a pesticide. pp. 397-418. *In* Marine pollution and physiology: Recent advances. F. J. Vernberg, F. P. Thurberg, A. Calabrese, and W. Vernberg (eds.). University of South Carolina Press, Columbia, SC.
[e] Supplemental due to lack of raw data, measured concentrations were highly variable, and difficulty in accounting for all of animals.

The results indicate that a concentration of 150 ppb can adversely affect the growth of juvenile fish.

The EFED does not request that the registrant repeat the fish early life-stage study [GLN 72-4(a)]. Instead, the EFED requires that the registrant submit a core study that tests the effects of technical thiobencarb on the life-cycle of a fish (GLN 72-5). The Agency is justified in requiring a fish life-cycle test because the end-use product is intended to be applied directly to water or is expected to transport to water from the intended use site (rice), and because the EEC is greater than one-tenth of the NOEC in the invertebrate life-cycle test. This test should be conducted with a freshwater fish, preferable the fathead minnow or rainbow trout. The Agency reserves the right to require a second fish life-cycle study using a saltwater species at a later time.

The results indicate that a concentration of 6.2 ppb can adversely affect the growth of estuarine invertebrates. However, there are some uncertainties in the studies cited above in that none of the estuarine invertebrates were done in accordance with agency guidelines. Because the use of thiobencarb on rice in the Gulf Coast region may affect estuarine crustaceans, including economically important shrimp, core data on the chronic effects of thiobencarb on shrimp is essential for the risk assessment. The EFED therefore request that the registrant submit a study that tests the effects of thiobencarb over the life-cycle of a shrimp or mysid.

(7) Aquatic Field Studies

The conclusion of high risk to aquatic organisms, based on results from laboratory toxicity tests, triggered the requirement for aquatic field testing with thiobencarb (GLN 72-7). The following aquatic field studies have been conducted on the use of thiobencarb on rice.

Table B.11 Aquatic Field Studies

Title	Location and Date	Reference	Performed By	Sponsor	Fulfills Guideline Requirements?
Studies in Halls Bayou to Test the Effects of a Pre-Emergent Herbicide, Bolero, on Aquatic Organisms	Halls Bayou/ Chocolate Bay, Brazonia County, Texas 1979	MRID 00079986	Harper, 1979	Chevron Chemical Company	No, supplemental
Impact of Bolero Runoff on a Brackish Water Ecosystem	Matagorda, Texas 1982 - 1984	MRIDs 42130705 & 42130708	Fujie, 1983.	Chevron Chemical Company	Yes[1]
Thiobencarb: Studies on Residue Level and Behavior in Selected Irrigation Creeks in Agricultural Areas in Saga Prefecture,	Saga Prefecture, Kyushu, Japan 1975	MRID 00028183	Ishikawa, 1975	Unknown	No, supplemental

Southwestern Japan					

[1] Following the review of this study, an additional aquatic field study was requested to monitor aquatic residues in other localities where rice is grown. This additional study, however, was waived in December 1993. No further field studies are requested for thiobencarb at this time.

Hall's Bayou Study: The first field study conducted in the U.S, was in rice fields bordering Halls Bayou, a tidally influenced, narrow stream that empties into West Bay near Galveston, Texas. This study is also referred to as the Chocolate Bay study. This estuarine area is a complex and highly important ecosystem that supports many commercial species. . Contaminated water was released into the bayou when rice fields were irrigated with a small amount of water (i.e. flushed) to moisten the soil. Also, heavy rainfall occurring during the experiment resulted in two additional releases of contaminated water. Sampling sites were established 500 ft **downstream** and 500 ft upstream of the point of discharge from the rice fields. Water samples collected at the field outlets and in Halls Bayou were analyzed for residues of thiobencarb. Fish, nektonic macroinvertebrates, benthic organisms, and phytoplankton were also sampled in these areas before, during, and after discharge from the rice fields. Fish and macroinvertebrates were also held in cages in Halls Bayou to monitor their response to the discharge of thiobencarb.

Due to poor experimental design and experimental conditions that caused excessive stress to the caged organisms, the EFED concluded that the results of the caged tests with fish and shrimp were invalid. They thus yield no information which can be used for risk assessment. Other parts of the field study provided some information and were thus classified as supplemental

The highest concentrations of thiobencarb were measured on a day when heavy rainfall (3.23 inches) occurred on the same day that thiobencarb was applied, resulting in an unscheduled flush overflow. Peak thiobencarb concentrations were 8.9 ppm (8900 ppb) where the tailwater exited the rice field and 690 ppb at the point where the drainage water entered Halls Bayou. The highest concentrations measured in the Halls Bayou on days that were not associated with heavy rainfall were 83 ppb at the upstream station (E) and 64 ppb at the downstream station (F). The abundance of fish, invertebrates, and plankton sampled at the downstream station were similar to or greater than those sampled at the upstream station. Gillnet catches declined in only one of the two areas sampled after discharges from the rice fields. Seine and trawl sampling indicated a decline in abundance of fish and invertebrates occurred near the end of the study. All declines were observed at both the upstream and downstream stations. Some differences in species composition of fish and invertebrates were observed between the upstream and downstream stations, and some changes in the species composition of benthic organisms were observed over time. None of these differences, however, could be conclusively linked to the discharge of thiobencarb.

The biological findings of the Halls Bayou study were inconclusive since there were no significant differences in species abundance or clear trends in the changes in species composition between stations upstream and downstream of the point of discharge. The upstream stations, being only 500 feet upstream of the site of discharge, were likely close enough to be affected by contamination moving upstream as the result of tidal mixing. Also, the abundance and composition of species were probably influenced by other factors, including tidal cycles, salinity changes, and release of other pesticides from neighboring areas. Small samples sizes further limited the usefulness of this study. This study does not provide much useful information on the effects of thiobencarb on the estuarine environment.

Matagorda Study: A larger aquatic field study was conducted in 1982-1984 near Matagorda, Texas. The site consisted of a rice field that drained through a ditch into the tidal waters of the lower Colorado River of eastern Texas. As with Hall's Bayou, this estuarine area is a complex and highly important ecosystem that supports many commercial species. No thiobencarb applications were made in 1982; this year provided baseline data for the site. Baseline thiobencarb concentrations were as high as 9 ppb. In 1983 and 1984, approximately 500 acres of the field were treated with thiobencarb at a rate of 4 lbs ai per acre. Fields were flushed with water within 3 to 12 days after application. Data collected from 1982 through 1984 included (1) residues of thiobencarb in water, sediment, fish and shrimp; (2) catch per unit effort measurements of fish and aquatic invertebrates; and (3) percentages of grass shrimp (*Palaemonetes pugio*) that were gravid. While samples were collected during all three years of the study, the sampling effort on the third year was very poor.

A control station was also planned on the Colorado River upstream of the confluence with the drainage ditch. However, during the course of the study, the Agency and the registrants agreed that this station could not serve as a control for the field study because it contained preexisting residues of thiobencarb. It was therefore only possible to compare residues and biological samples collected during 1983 and 1984 to those collected during 1982, before the initial treatment. This represents a shortcoming of this study since the results could have been influenced by yearly fluctuations in environmental conditions that are unrelated to the applications of thiobencarb. Another shortcoming is that other pesticides (ordram, basegran, machette, and propanil) were applied to fields that drain into the test ditch during the period of this study. The toxicity of these pesticides could have contributed to the observed effects.

The results of the study were:

1. Residues of thiobencarb were transported into the estuary via runoff and drift. Residues in water exceeded the aquatic invertebrate MATC (1.7 ppb). Maximum residues measured in water, sediment, fish, and shrimp were 25.1 ppb, 50 ppb, 2400 ppb, and 970 ppb, respectively.

2. Although the overall population of fish was apparently not affected, marked

declines were observed during the treatment years in three species, *Gambusia affinis, Dormitator maculatus*, and *Poecilia latipenna*.

3. Several taxa of aquatic invertebrates showed substantial decline in numbers caught per unit effort. Species richness and diversity also declined significantly during treatment years.

4. The percentage of gravid shrimp decreased significantly in 1983 compared to 1982. The decline was about 50% at stations 1 and 2, and averaged 23% for all four stations. (Sampling was inadequate to assess the effect on the percentage of gravid shrimp in 1984.)

5. A kill of the fish menhaden (*Brevoortia patronus*) was observed in the area where the field runoff entered the drainage ditch. It occurred at the point of discharge from the drainage canal, one to two days after a post-application flush of the rice fields. Although other pesticides that were applied that year (ordram, basegran, and propanil) may have been present in the tailwater, this kill was attributed to thiobencarb contamination because the dead fish contained high residues of thiobencarb (mean of 3.56 ppm).

6. Field BCF for thiobencarb was estimated to be 109X for fish and 44X for shrimp.

Declines in fish, aquatic invertebrates, and gravid shrimp cannot conclusively be attributed to the use of thiobencarb. Nevertheless, the findings in the field were consistent with effects demonstrated in laboratory studies. They suggest that the application of thiobencarb to rice fields may result in significant environmental damage to the adjacent estuarine habitat. Possible effects include chronic effects to sensitive fish, acute and chronic effects to ecologically important aquatic invertebrates, chronic effects to grass shrimp and possibly to commercial shrimp, and indirect detrimental effects to organisms at higher trophic levels that depend on these organisms for food.

<u>Japan Study</u>: The EFED reviewed a study that measured residues of thiobencarb in creek water after application to rice paddies in Japan. Thiobencarb was applied in the form of 7% granules at a rate of 30 kg/ha, which is equivalent to 1.9 lb ai/A. Water samples were taken from ten stations along creeks that flow through the rice fields and drain into the Hayatsue River. Water sampling was conducted from March through November, with thiobencarb treatments being made from June 28 through July 2. The creeks served as storage for irrigation water until May, when the water is pumped onto the fields. The creeks resembled large ponds during the storage period.

Very low thiobencarb concentrations (0.2 ppb or less) were reported at all stations in March and April before applications were made. Concentrations peaked at the sampling period of July 1, when concentrations at most stations were between 20 and 40 ppb. The greatest concentration was measured was 40.5 ppb. Concentrations declined fairly rapidly thereafter; the half-life of thiobencarb in creek water was estimated to be 8.8 days. This rate of decline represents dilution as well as biological and physical degradation processes. EFED cannot interpret the significance of these results or extrapolate conclusions to other areas because of the lack of important information on the test conditions, such as flow rates within the creeks and rainfall during the study.

A difficulty with all three of the field studies was that water flow measurements were not made, making it impossible to discern effects of dissipation versus dilution. While water residues were generally short-lived, it is not clear whether thiobencarb residues were broken down by chemical or biological forces, or they were swept away and diluted by tidal flow. Because it is possible that dilution was the primary mode of dissipation in all three studies, the rate at which thiobencarb degrades by chemical or biological means in estuaries remains unknown. Thiobencarb residues thus may persist longer in other areas where dilution is of less importance in the dissipation of residues.

The three biological field studies demonstrate that application of thiobencarb on rice can cause significant contamination to water, sediments, and aquatic organisms in off-site aquatic habitats. Harm to estuarine and freshwater ecosystems is possible when thiobencarb is used in southeastern United States. Although shortcomings of these studies make it impossible to identify thiobencarb as the sole cause of observed adverse effects, the studies fail to refute the Agency's presumption that the use of thiobencarb on rice results in severe effects on aquatic ecosystems.

c. Toxicity to Plants

(1) Terrestrial

Terrestrial plant testing (seedling emergence and vegetative vigor) is required for herbicides which have terrestrial non-residential outdoor use patterns and which may move off the application site through volatilization (vapor pressure $\geq 1.0 \times 10^{-5}$ mm Hg at $25^{o}C$) or drift (aerial or irrigation), and/or which may have endangered or threatened plant species associated with the application site. Terrestrial plant testing is required for thiobencarb because it is an herbicide with a terrestrial nonresidential use pattern (rice) and because aerial applications may result in drift.

For the seedling emergence and vegetative vigor testing the following plant species and groups should be tested: (1) six species of at least four dicotyledonous families, one species of which is soybean (*Glycine max*), and another of which is a root crop, and (2) four species of at least two monocotyledonous families, one species of which is corn (*Zea mays*).

Results of Tier II seedling emergence toxicity testing on technical thiobencarb are given below.

Table B.12 : Nontarget Terrestrial Plant Seedling Emergence Toxicity Findings (Tier II)

Species	% AI	Parameter Affected	EC_{25} (lb ai/A)	NOEC (lb ai/A)	MRID No. Author/Year	Fulfills Guideline Requirement?
Monocot--Corn	96.6	Shoot length	>1.7	1.7	MRID 41690902 Hoberg, J.R. 1990	Yes
Monocot--Oat		Shoot length	0.086	0.055		Yes
Monocot--Onion		Shoot length	2.0	0.94		Yes
Monocot--Ryegrass		Mortality	0.019	0.0051[1]		Yes[2]
Dicot/Root Crop--Carrot		Shoot length	>3.1	2.1		Yes
Dicot--Cabbage		Shoot length	0.082	0.071		Yes
Dicot-Cucumber		Shoot length	>1.7	0.16		Yes
Dicot--Lettuce		Mortality	0.27	--		No, supplemental
Dicot--Soybean		Shoot length	>1.7	0.94		Yes
Dicot--Tomato		Shoot length	1.1	0.94		Yes

1 This NOEL is based on 17% mortality of plants occurring at the next higher test level, 0.011 lb ai/A.
2 Seedling emergence data for ryegrass is upgraded from supplemental to core.

In the tier II seedling emergence test, mortality of test plants occurred in the tests with ryegrass, cabbage, and lettuce. Mortality was the most sensitive toxic endpoint for these species (plants tended to die shortly after emerging). The most sensitive species was ryegrass, a monocot, for which the EC_{25} based on mortality (i.e. LC_{25}) was 0.019 lb ai/A. The most sensitive dicot was cabbage. The cabbage EC_{25} based on shoot length was estimated to be 0.082 lb ai/A.

Results of Tier II seedling vegetative vigor toxicity testing on the technical thiobencarb are given below.

Table B.13 : Nontarget Terrestrial Plant Vegetative Vigor Toxicity Findings (Tier II)

Species	% A.I.	Parameter Affected	EC_{25} (lb ai/A)	NOEC (lb ai/A)	MRID No. Author/Year	Fulfills Guideline Requirement?
Monocot- Corn	96.6	Shoot length, shoot weight, and root weight	>2.2	2.2	MRID 41690902 Hoberg, J.R. 1990	Yes
Monocot--Oat		Shoot weight	0.17	0.12		Yes
Monocot--Onion		Shoot length	1.2	0.80		Yes
Monocot--Ryegrass		Shoot length	0.073	0.020		Yes
Dicot/ Root Crop--Carrot		Shoot length, shoot weight, and root weight	>2.2	2.2		Yes
Dicot--Cabbage		Root weight	1.2	1.4		Yes
Dicot--Cucumber		Shoot weight and root weight	--[a]	<0.12		Yes
Dicot--Lettuce		Root weight	1.3	0.80		Yes
Dicot--Soybean		Shoot weight	1.2	0.80		Yes
Dicot--Tomato		Root weight	1.8	2.2		Yes

[a]Greater than a 25% reduction was recorded at some or all exposure levels, but the EC_{25} could not be determined because no dose-response relationship was apparent.

In the Tier II vegetative vigor tests, soybean was the most sensitive dicot and ryegrass was the most sensitive monocot.

(2) Aquatic

Aquatic plant testing is required for any herbicide which has outdoor non-residential terrestrial uses in which it may move off-site by runoff (solubility >10 ppm in water), by drift (aerial or irrigation), or which is applied directly to aquatic use sites (except residential). The following species should be tested: *Kirchneria subcapitata*, *Lemna gibba*, *Skeletonema costatum*, *Anabaena flos-aquae*, and a freshwater diatom. Aquatic plant testing is required for thiobencarb because it may be applied directly to water, it may be applied aerially, and it is applied to rice paddies where it is expected to contaminate the tailwater that leaves the field.

Results of Tier II toxicity testing on technical thiobencarb are given below.

Table B.14 : Nontarget Aquatic Plant Toxicity Findings (Tier II)

Species	% A.I.	EC_{50} (ppb)	NOEC (ppb)	MRID No. Author/Year	Fulfills Guideline Requirement?
Freshwater diatom *Navicula pelliculosa*	96.6	380	65	MRID 41690901 Giddings, J.M. 1990.	Yes
Duckweed *Lemna gibba*		770	140		Yes
Green algae *Selenastrum capricornutum*		17	13		Yes
Marine diatom *Skeletonema costatum*		73	18		Yes
Blue-green algae *Anabaena flos-aquae*		>3100	3100		Yes
Marine diatom *Skeletonema costatum*	95.5	327-459[a]	--	MRID 00141967 Borthwick and Walsh, 1981.	Open literature, supplemental

[a]96-hour EC_{50}

The Tier II results indicate that green algae is the most sensitive aquatic plant species. A thiobencarb concentration of 17 ppb ai is predicted to cause a 50% reduction in the growth and reproduction of this species.

Appendix C Listed Species Listing

Species in Counties by State and Taxa

No species were excluded; Minimum of 99 Acre; All Medium Types Reported

Mammal, Bird, Amphibian, Reptile, Fish, Crustacean, Bivalve, Gastropod, Dicot, Monocot, Ferns, Conf/cycds, Coral, Lichen

rice – wild; California

California

Amphibian

Frog, California Red-legged
Rana aurora draytonii

Butte
Shasta
Yolo

Salamander, California Tiger
Ambystoma californiense
Yolo

Bird

Murrelet, Marbled
Brachyramphus marmoratus marmoratus
Lake

Owl, Northern Spotted
Strix occidentalis caurina
Lake
Lassen
Shasta

Crustacean

Crayfish, Shasta
Pacifastacus fortis

Fairy Shrimp, Conservancy Fairy
Branchinecta conservatio
Butte

Fairy Shrimp, Vernal Pool
Branchinecta lynchi
Butte
Shasta

Tadpole Shrimp, Vernal Pool
Lepidurus packardi
Sutter
Butte
Shasta

Fish

Dicot

Bird's-beak, Palmate-bracted
Cordylanthus palmatus

Yolo

Coyote-thistle, Loch Lomond
Eryngium constancei
Lake

Goldfields, Burke's
Lasthenia burkei
Lake

Grass, Hairy Orcutt
Orcuttia pilosa
Butte

Grass, Slender Orcutt
Orcuttia tenuis
Shasta
Modoc
Butte
Lake
Lassen

Meadowfoam, Butte County
Limnanthes floccosa ssp. Californica
Shasta

Spurge, Hoover's
Chamaesyce hooveri
Butte

Tuctoria, Green's
Tuctoria greenei
Butte

Fish

Chub, Hutton Tui
Gila bicolor ssp.
Lassen

Fish

Salmon, Chinook (Central Valley Spring Run)
Oncorhynchus (=Salmo) tshawytscha

Butte
Sutter
Shasta

Salmon, Chinook (Sacramento River Winter Run)
Oncorhynchus (=Salmo) tshawytscha
Yolo
Butte
Shasta
Sutter

Salmon, Coho (Southern OR/Northern CA Coast)
Oncorhynchus (=Salmo) kisutch
Lake

Smelt, Delta
Hypomesus transpacificus
Yolo

Steelhead, (California Central Valley population
Butte

Oncorhynchus (=Salmo) mykiss
Shasta
Sutter
Butte
Yolo

Steelhead, (Northern California population)
Oncorhynchus (=Salmo) mykiss

Lake

Sturgeon, green
Acipenser medirostris
Sutter
Yolo

Sucker, Lost River
Deltistes luxatus

Modoc

Sucker, Modoc
Catostomus microps

Lassen
Modoc

Sucker, Shortnose
Chasmistes brevirostris

Modoc

Monocot

Grass, Colusa
Neostapfia colusana

Yolo

Grass, San Joaquin Valley Orcutt
Orcuttia inaequalis

Butte

Grass, Solano
Tuctoria mucronata

Yolo

Reptile

Snake, Giant Garter
Thamnophis gigas

Butte
Sutter
Yolo

31 Species Affected:

Inverse Name:	Taxa:	Co. occurence:	Status:
Bird's-beak, Palmate-bracted	Dicot	1	Endangered
Coyote-thistle, Loch Lomond	Dicot	1	Endangered
Crayfish, Shasta	Crustacean	1	Endangered
Fairy Shrimp, Conservancy Fairy	Crustacean	1	Endangered
Goldfields, Burke's	Dicot	1	Endangered
Grass, Hairy Orcutt	Dicot	1	Endangered
Grass, Solano	Monocot	1	Endangered
Meadowfoam, Butte County	Dicot	1	Endangered
Salamander, California Tiger	Amphibian	1	Endangered
Salmon, Chinook (Sacramento River Winter Run)	Fish	4	Endangered
Sucker, Lost River	Fish	1	Endangered
Sucker, Modoc	Fish	2	Endangered
Sucker, Shortnose	Fish	1	Endangered
Tadpole Shrimp, Vernal Pool	Crustacean	4	Endangered
Tuctoria, Green's	Dicot	2	Endangered
Chub, Hutton Tui	Fish	1	Threatened
Fairy Shrimp, Vernal Pool	Crustacean	2	Threatened
Frog, California Red-legged	Amphibian	2	Threatened
Grass, Colusa	Monocot	1	Threatened
Grass, San Joaquin Valley Orcutt	Monocot	1	Threatened
Grass, Slender Orcutt	Dicot	5	Threatened
Murrelet, Marbled	Bird	1	Threatened
Owl, Northern Spotted	Bird	3	Threatened
Salmon, Chinook (Central Valley Spring Run)	Fish	4	Threatened
Salmon, Coho (Southern OR/Northern CA Coast)	Fish	1	Threatened
Smelt, Delta	Fish	1	Threatened
Snake, Giant Garter	Reptile	3	Threatened
Spurge, Hoover's	Dicot	1	Threatened
Steelhead, (California Central Valley population)	Fish	4	Threatened
Steelhead, (Northern California population)	Fish	1	Threatened
Sturgeon, green	Fish	2	Threatened

No species were selected for exclusion.

Dispersed species included in report.