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

12/22/1999

OFFICE OF
PREVENTION, PESTICIDES, AND
TOXIC SUBSTANCES

PC Code: 128712

MEMORANDUM

SUBJECT: Review of environmental fate studies, and environmental fate and ecological risk assessment for Section 3 proposed new uses for Carfentrazone-ethyl (DP Barcodes D250106, D256220, D259337, and D261660).

TO: Dianne Morgan, PM Team 23
Registration Division (7505C)

FROM: Jim Carleton, ERB II
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THRU: Jean Holmes, Chief (Acting)
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Two studies submitted by FMC Corporation to support registrations of carfentrazone-ethyl (F8426) on sweet corn, sorghum, and rice were reviewed by EFED. This memo presents DER reviews of these studies (an aquatic field dissipation study, and an aerobic soil degradation study on the major degradates), and an assessment of the environmental fate and effects, and potential ecological risks associated with proposed new uses on sweet corn, sorghum, and rice. The following table summarizes the DER results:

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GLN #	Study type	MRID #	Acceptability?	Data requirement fulfilled?	Additional information required?
162-1	Aerobic soil metabolism	44633504	Yes	Yes	No
164-2	Aquatic field dissipation	44654701	Yes	No	Yes

The aquatic field dissipation study (MRID 44633504) can be upgraded to acceptable if the registrant provides adequate storage stability information. Please refer to the attached Data Evaluation Record for the specific information needed.

The Agency requested that the registrant submit a special Early-Life Stage (ELS) study, guideline 70-1, on either a freshwater fish or frog, using full-spectrum lighting that simulates solar ultraviolet radiation (SUVR). In response, the registrant has submitted to EPA a fish early life stage study with simulated SUVR (MRID 449632-01). Based on review by a contractor, this study is supplemental and failed to establish an NOAEC. The DER for this study will be delivered once EFED completes a secondary review. This study will need to be replaced to help decrease the high level of uncertainty that currently exists in the chronic risk assessment for fish and invertebrates.

Attachments:

Data Evaluation Record: MRID 44633504, Guideline 162-1 (aerobic soil degradation of the F8426 acid metabolites), J. Carleton, 11/1/99.

Data Evaluation Record: MRID 44633504, Guideline 164-2 (aquatic field dissipation of F8426), J. Carleton, 11/1/99.

Carfentrazone-ethyl Herbicide Environmental Fate and Ecological Effects Assessment and Risk Characterization for a Section 3 for Use on Sweet Corn, Sorghum, and Rice, J. Carleton, N. Mastrota, 12/15/99.

Carfentrazone-ethyl

Herbicide

Environmental Fate and Ecological Effects

Assessment and Risk Characterization

for a Section 3 for Use on Sweet Corn, Sorghum, and Rice

Table 1. EECs for use in the human health risk assessment

Crop	App Rate (lbs ai/acre)	GENEEC Peak EEC (ppb)	GENEEC 56 Day EEC (ppb)	SCIGROW concentration (ppb)	Monitoring Data: Peak (ppb)	Monitoring Data: 365 Day Average (ppb)
sweet corn, sorghum	0.031	1.69	0.65	6.55	NA	NA
rice	0.3	NA	NA	NA	205	7

II. INTRODUCTION

A. Use Characterization

Carfentrazone-ethyl (F8426) is a foliar applied post-emergent herbicide currently registered for use on corn, barley, oats, wheat, sorghum, and soybeans, according to REFS (US EPA/OPP database). Proposed new use sites are sweetcorn, sorghum, and rice. According to the 1992 USDA Agricultural Census, the geographical areas corresponding to these crops include areas in the Midwest (especially in Illinois, Wisconsin, and Minnesota), the Northeast, Pacific Northwest, and the Southeast (especially in southern Louisiana and southern Florida).

B. Target Pests

Carfentrazone-ethyl is applied to control broadleaf weeds. The following table presents the target weeds listed on the proposed labels for carfentrazone-ethyl (Shark 40 DF™ and Aim 40 DF™ herbicide) application to sweetcorn, sorghum, and rice.

Table 2. Target weeds for carfentrazone-ethyl on proposed new use sites.

Weeds controlled	Weeds suppressed
black nightshade	common arrowhead
redroot pigweed	common bullrush
velvetleaf	duck salad
common lambsquarters	
morning glories	
ricefield bullrush	
California arrowhead	
annual arrowhead	
mexicanweed	
purple ammania	
redstem ammania	
rice flatsedge	
smallflower umbrellaplant	

C. Formulation Type

The formulations of carfentrazone-ethyl proposed for registration on sweetcorn, sorghum, and rice are as follows:

Shark 40 DF™:	a water dispersable granule product composed of 40% carfentrazone-ethyl and 60% inert ingredients.
Aim 40 DF™:	a water dispersable granule product composed of 40% carfentrazone-ethyl and 60% inert ingredients.

D. Method, Rate, and Timing of Application

The recommended application methods for Shark 40 DF™ and Aim 40 DF™ are groundboom and aerial broadcast. Aerial application is listed only on the labels for rice. For rice, the label recommends applying 0.2 lb a.i./acre per season post-emergence to control submerged weeds, and 0.1 lb a.i./acre per season post-emergence to control emergent weeds, with total applications not to exceed 0.3 lb a.i./acre per season. For sweet corn and sorghum, the label recommends applications of 0.0083 lb a.i./acre after emergence not to exceed a total of 0.031 lb a.i./acre per season.

III. INTEGRATED ENVIRONMENTAL RISK CHARACTERIZATION

Use of carfentrazone-ethyl on rice and other grains is not predicted to pose a threat to birds, mammals, or terrestrial invertebrates. Estimated risks to plants from carfentrazone-ethyl are high; however, they are lower than what is typically seen for many herbicides. Based on water monitoring data obtained from studies of carfentrazone-ethyl on rice paddies, the new use on rice may pose high chronic risk to fish and aquatic invertebrates, as well as acute risk to trigger concern for threatened and endangered species of fish and aquatic invertebrates. Aerial applications on sweet corn and sorghum, and both ground and aerial applications on rice are expected to pose a high risk to nontarget terrestrial plants (especially dicots) due to exposure from spray drift. These uses may harm threatened and endangered plants. Ground and aerial applications on rice are expected to pose high risks to aquatic plants.

The main concern following carfentrazone application to sorghum and sweet corn will be exposure not to the parent compound, but to the degradates. For application to field crops, the primary transport mechanism for most pesticide residues to surface waters is runoff, which typically carries a relatively small fraction (up to a few percent) of the total applied pesticide mass into receiving streams or water bodies adjacent to the field. Carfentrazone-ethyl is not persistent, but breaks down rapidly in the environment to several major degradates. These degradates are substantially more persistent than the parent compound, and are therefore more likely than the parent to end up in receiving waters as a result of runoff. Toxicity tests show that these degradates are much less toxic to fish and aquatic invertebrates than is parent carfentrazone-ethyl. Therefore, following application to sweet corn and sorghum fields, the occurrence of the degradation products in the aquatic environment, should pose minimal risk to fish and aquatic invertebrates. Although toxicity tests with freshwater algae show that the degradates exhibit significant phytotoxicity, risk to aquatic plants from use on sweet corn and sorghum is nevertheless low because of the relatively low application rate.

Unlike field crops such as sweet corn and sorghum, when pesticides are applied to rice paddies, the entire mass of pesticide is applied *directly* to water. This water is then typically held on-site for some period of time before the paddy is drained, and the water discharged directly into receiving waters (no minimum holding time for rice paddy water is currently required on the carfentrazone-ethyl label). Because 100% of the pesticide is applied to water, at a given application rate aquatic concentrations are substantially higher than those which might result from edge-of-field runoff after application to field crops. For carfentrazone-ethyl, it should also be noted that **the application rate for rice is ten-fold higher than the rate for field crops**, thus substantially higher aquatic concentrations will result from application to rice than from applications to sweet corn and sorghum. Therefore, carfentrazone-ethyl may be expected to impact aquatic plants as a result of applications to rice. In addition, once paddy drainage waters merge with receiving waters, the amount of dilution expected is a major source of uncertainty. In some rice-growing areas of the U.S., drainage channels exist in which the majority of the water consists at times of rice-paddy drainage. These streams or bayous are hydrologically connected to downstream waters which may contain sensitive fish or aquatic invertebrates that can migrate upstream into the high-concentration paddy drainage waters. For this reason, the carfentrazone-ethyl rice use has substantially higher aquatic exposure potential than the sweet corn and sorghum uses, and is therefore of special concern. As the water drains into larger bodies of water and becomes mixed with uncontaminated water, residues would be greatly diluted and the risks of carfentrazone-ethyl would diminish. In order to mitigate the aquatic risks for the most sensitive aquatic organisms (plants) resulting from the rice use, EFED calculates that a minimum holding time of at least 69 days would be needed after application of carfentrazone-ethyl, before paddy waters are released into the environment.

The chronic risk of carfentrazone-ethyl to fish and aquatic invertebrates is highly uncertain. The chronic NOAEC for fish has not been established. In a fish early life-stage study with solar ultraviolet radiation (MRID 44963201), a significant reduction in wet weight of fry was observed at the minimum test concentration of 16.4 ppb ai. This reduction in wet weight was not very large (15%), and there was no significant reduction at this test level in length, percent hatch, or percent survival. These results indicate that the NOAEC is not much lower than the minimum test concentration. The 56-day average EEC for use on corn and sorghum is 0.2 ppb ai, which is far less than the minimum test concentration Thus, it is likely that future testing would establish the NOAEC at a level greater than the chronic EEC for these uses, leading to a conclusion of minimal chronic risk. On the other hand, the 56-day average EEC for rice is 12.3 ppb, which is only slightly less than the minimum test concentration. Thus, it is quite possible that future testing will establish an NOAEC less than the chronic EEC for rice, leading to a conclusion of high chronic risk.

Besides the uncertainty in the chronic NOAEC, other factors increase the uncertainty of the chronic risk assessment for fish and invertebrates. First, aquatic concentrations in water leaving a rice paddy soon after application will be well above levels known to be chronically toxic. Concentrations will then decline however, due to degradation and downstream dilution. Whether high short-term exposure pulses will result in chronic effects on growth is unknown. Second, toxicity of phototoxic chemicals like carfentrazone-ethyl will depend on the duration and intensity of solar ultraviolet light to which fish are exposed, which is unknown. The toxicity test was performed with a photoperiod of 18 hours light:6 hours dark, which is probably more than that to which most aquatic organisms would be exposed. Finally, the extent to which the toxicities of the degradation products are enhanced by solar ultraviolet light is unknown. In conclusion, chronic risk to fish and aquatic organisms is probably minimal for use on corn and sorghum, whereas it is potentially high but uncertain for use on rice.

IV. ENVIRONMENTAL FATE ASSESSMENT

A. Chemical Profile

Common Name:	Carfentrazone-ethyl
Trade Names:	Shark 40 DF™, Aim 40 DF™
Manufacturer's Code Numbers:	F8426
Chemical Name:	Ethyl 2-chloro-3-[2-chloro-4-fluoro-5-[4-(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl]phenyl] propanoate
Chemical Class:	Protoporphyrin
Mode of Action:	Protoporphyringen oxidase (prototox) inhibition
Formulation:	Water Dispersable Granule Active Ingredient: 40% Inert Ingredients: 60%
Molecular weight:	412.19 g/mol
Aqueous solubility:	12 ppm (20°C)
Vapor pressure:	1.2×10^{-7} mm Hg (25°C)
Henry's Law constant	3×10^{-9} atm. m^3/mol
Octanol/Water Partition Coefficient:	log Kow = 3.36
Density:	1.457 g mL^{-1} (20°C)

B. Persistence

Carfentrazone-ethyl (F8426) (Ethyl 2-chloro-3-[2-chloro-4-fluoro-5-[4-(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl]phenyl] propanoate)) is an N-phenyl heterocyclic compound which contains a 2,4,5-substitution on the phenyl ring. The Environmental Fate and Effects Division (EFED) has determined that carfentrazone-ethyl breaks down rapidly in the environment (aerobic soil half-life <1 day) to carfentrazone-ethyl chloropropionic acid (F8426-ClPAC) (MRID 44165034). The chloropropionic acid degradate subsequently breaks down to cinnamic acid, propionic acid, benzoic acid, and 3-hyroxymethyl benzoic acid at slower rates than the parent compound degrades (K. McCormack, R. Hitch 3/31/98). No information on the identity of the ultimate degradates in areobic soil is available. In an aerobic soil metabolism study, degradate residues degraded much more slowly (MRID 44633504). For example, the slowest degradation was observed for F8426-benzoic acid, which had an average half-life for three soils of 1878 days. Although no aerobic or anaerobic aquatic laboratory data were available to evaluate the degradation of F8426 and its degradates in water, an aquatic field dissipation study was available. In that study (MRID 44654701), carfentrazone-ethyl was applied to flooded rice fields at a nominal application rate of 0.3 lb/acre, at sites in California and Louisiana. At each site, half-lives were separately calculated for F8426, its degradate F8426-chloropropionic acid, and F8426 + total degradates (F8426-chloropropionic acid, F8426-propionic acid, F8426-cinnamic acid, F8426-benzoic acid, and 3-hydroxymethyl-F8426-benzoic acid) in water and sediments. Total toxic residues of carfentrazone (parent plus degradates) in water degraded with half-lives of 10 and 4 days at the California and Louisiana sites respectively, indicating that residues are fairly short-lived in water. However, based on the aerobic soil metabolism data, residues in the subsurface may be much more persistent than residues in surface waters. Hydrolysis of carfentrazone-ethyl is pH-dependent (MRID 43189231), with rapid hydrolysis occurring at alkaline pH's (half-life 3.6 hours) and moderate hydrolysis at neutral pH's (half-life 8.6 days); at acidic pH's the parent is stable. The degradate chloropropionic acid is stable to hydrolysis at neutral and alkaline pH's. Hydrolysis data for the other major degradates were not available. No acceptable aqueous or soil photolysis data were available for carfentrazone-ethyl or its degradates.

C. Mobility

Carfentrazone-ethyl is moderately soluble in water (12-30 ppm) with the solubility varying with pH. Its K_{oc} value in soil could not be determined because of its rapid breakdown. The major degradate chloropropionic acid has a high water solubility (910 ppm) and is very mobile in soil ($K_{ads} = 0.4$; $K_{oc} = 6\text{-}48$) (MRID 43189233). The other major degradates (benzoic acid, cinnamic acid, propionic acid, and 3-hydroxymethyl benzoic acid) are also very mobile with K_d's less than 10 (MRID 44165036, 44165037).

D. Bioaccumulation

Rainbow trout were exposed to uniformly phenyl ring-labeled ^{14}C carfentrazone-ethyl at concentrations of 16 ug/L for 41 days and 160 ug/L for 28 days. Maximum bioconcentration factors for the 16 ug/L concentration exposure were 49X for the edible tissue, 397X for the nonedible tissue, and 186X for the whole fish tissues. Maximum bioconcentration factors for the 160 ug/L concentration exposure were 49X for the edible tissue, 413X for the nonedible tissue, and 183X for the whole fish tissue. F8426-chloropropionic acid, 3-hydroxymethyl-F8426-chloropropionic acid (conjugate), and two polar unknowns were isolated in the edible and nonedible fish tissues. Depuration was rapid in the 16 ug/L concentration exposure, with 98.4%

of the accumulated residues eliminated by day 14. In the 160 ug/L concentration exposure, depuration was also rapid with 99.1% of the accumulated residues eliminated from the

E. Volatilization

Based on the low vapor pressure and Henry's Law constant of parent carfentrazone-ethyl (1.2×10^{-7} mmHg at 25°C, and 3×10^{-9} atm. m^3/mol, respectively), volatilization is not expected to be an important route of dissipation.

V. AQUATIC EXPOSURE AND RISK ASSESSMENT

A. Toxicity Summary

Carfentrazone-ethyl is moderately toxic to freshwater and estuarine fish on an acute basis (96-hour LC_{50}'s 1.1 to 1.6 mg ai/L). For chronic exposure, carfentrazone-ethyl reduces fish growth at 0.242 mg ai/L, with an NOAEL established at 0.118 mg ai/L. Carfentrazone-ethyl is slightly to moderately toxic to freshwater invertebrates ($EC_{50} > 9.8$ mg ai/L) and moderately toxic to marine/estuarine invertebrates (EC_{50}'s 1.2 to 2.1 mg ai/L). Data have not been submitted on the chronic toxicity of carfentrazone-ethyl to aquatic invertebrates. Carfentrazone-ethyl is quite toxic to aquatic plants, with EC50's ranging from 5.9 mg AI/L to 16.2 mg ai/L. It appears to be equally toxic to vascular and nonvascular aquatic plants.

Toxicity testing with degradation products of carfentrazone-ethyl with the rainbow trout and the water flea indicate that they all are slightly toxic to practically nontoxic to aquatic animals. Toxicity tests with freshwater algae, however, show that the three degradation products tested (F4826-cinnamic acid, F4826-chloroproionic acid, and F4826-propionic acid) exhibit significant phytotoxicity. F4826-chloroproionic acid was the most toxic to green algae, with an EC_{50} of 26.2 mg AI/L.

A detailed compilation of ecotoxicity data is provided in Appendix A.

B. Aquatic Exposure Summary

The Tier I screening model GENEEC was used to generate EECs of carfentrazone-ethyl (parent only) and carfentrazone-ethyl plus degradates in surface water resulting from application to sweet corn and sorghum (*i.e.* row crops). For parent modeling, a K_{oc} value for the chloropropionic acid degradate was used, since no value was available for the parent, due to its rapid breakdown. For the combined parent + degradates modeling, maximally conservative K_{oc} and half-life values were obtained from available data on the degradates.

1. **Surface Water EECs: Parent Only** (for fish and aquatic invertebrates)

Carfentrazone-ethyl is rapidly converted in the environment into various degradation products. Tests conducted with the rainbow trout, the waterflea, and the mysid shrimp show that the major degradates have very low toxicity to fish and aquatic invertebrates. Since the degradates contribute little to the total toxicity of carfentrazone ethyl, acute and chronic exposure values for fish and aquatic invertebrates were based on aquatic EEC's of the parent compound only.

Table 3. GENEEC Inputs, Carfentrazone-ethyl (parent only)

Parameter	Input	Source/Rationale.
Solubility (ppm)	12	MRID 43939203
Aerobic soil $t_{1/2}$ (days)	1.3	MRID 43189232: maximum value available
Aerobic aquatic $t_{1/2}$ (days)	12.3	MRID 44654701: maximum value available
Hydrolysis $t_{1/2}$ (days)	8.6	MRID 43189231: value for pH 7
K_{oc}	6	MRID 43189233: minimum value for F8426-chloropropionic acid used, since value for parent not available
Application rates (lb a.i./Acre)	0.031	Label - max. annual rate (sweet corn, sorghum)

Using the GENEEC model and available environmental fate data for carfentrazone-ethyl, EFED calculated the following Tier 1 Estimated Environmental Concentrations (EECs) for residues of carfentrazone-ethyl (parent only) in surface water after application to sweet corn and sorghum:

Acute or peak EEC:	0.6 µg/L
Chronic (21-day average) EECs:	0.4 µg/L
Chronic (56-day average) EECs:	0.2 µg/L

Modeling was not necessary for the rice scenario, because EFED had data from an aquatic field dissipation study (MRID 44654701) in which carfentrazone-ethyl was applied to rice paddies in California and Louisiana. Because no minimum holding time for the rice paddy water is required on the labels, and because released paddy water can constitute the bulk of the water in receiving streams and bayous in some areas, no dilution has been assumed in extrapolating ecological EECs from the aquatic field dissipation study. Based on an aerobic aquatic field study (application to a rice field) on carfentrazone-ethyl, EFED calculated the following concentrations for residues of carfentrazone-ethyl (parent only) in surface receiving waters after application to rice:

Acute or peak EEC:	189 µg/L
Chronic (21-day time-weighted-average) concentration:	28.5 µg/L

Chronic (56-day time-weighted-average) concentration: 12.3 μg/L

2. Surface Water EECs: Parent Plus Degradates (for aquatic plants)

Unlike for aquatic animals, tests conducted with a green algae show that the major degradation product of carfentrazone-ethyl, F4826–chloroproionic acid, shows a high level of toxicity to plants. F4826-cinnamic acid and F4826-propionic acid were also shown to be somewhat phytotoxic. Since the degradation products contribute contribute significantly to the total toxicity of carfentrazone ethyl, acute and chronic exposure values for aquatic plants were based on aquatic EEC's of the parent compound plus degradation products.

Table 4. GENEEC Inputs, Carfentrazone-ethyl (parent plus degradates)

Parameter	Input	Source/Rationale
Solubility (ppm)	910	Solubility of chloropropionic acid degradate
Aerobic soil $t_{1/2}$ (days)	3631	90% upper C.L. on mean value for degradate with longest half-life (benzoic acid)
Aerobic aquatic $t_{1/2}$ (days)	16	90% upper C.L. on mean value for total residues (parent + degradates)
Hydrolysis $t_{1/2}$ (days)	N/A	No data available for degradates
K_{oc}	6	MRID 43189233: minimum value for F8426-chloropropionic acid used, since value for parent not available
Application rates (lb a.i./Acre)	0.031	Label - max. annual rate (sweet corn, sorghum)

Using the GENEEC model and available environmental fate data for carfentrazone-ethyl and its degradates, EFED calculated the following Tier 1 Estimated Environmental Concentrations (EECs) for residues of carfentrazone-ethyl (parent plus degradates) in surface water after application to sweet corn and sorghum:

Acute or peak EEC: 1.69 μg/L
Chronic (21-day average) EECs: 1.14 μg/L
Chronic (56-day average) EECs: 0.65 μg/L

Based on an aerobic aquatic field study (application to a rice field; MRID 44654701) on carfentrazone-ethyl, EFED calculated the following concentrations for total residues of carfentrazone-ethyl (parent plus degradates) in surface receiving waters after application to rice:

Acute or peak EEC: 409 μg/L
Chronic (21-day time-weighted-average) concentration: 160.1 μg/L
Chronic (56-day time-weighted-average) concentration: 73.8 μg/L

C. Quantitative Risk Assessment

Acute risk quotients were calculated for fish based on the acute toxicity of parent carfentrazone-ethyl to the tidewater silverside. This species is an estuarine fish, but since the LC50 is slightly less than those of freshwater species, these risk quotients are protective of freshwater species as well. The chronic risk quotient was based on an early life-stage study with rainbow trout in which fish were exposed to solar ultraviolet radiation (SUVR). This study found greater chronic toxicity than did a similar test without SUVR, showing that carfentrazone-ethyl is phototoxic. Chronic toxicity testing has not been conducted with an estuarine or marine fish.

Table 5. Risk quotients for freshwater and saltwater fish from the use of carfentrazone-ethyl.

Use Site, Application Method	Max. Per Season Rate (lb/A)	LC50 (ppb)	NOAEC (ppb)	EEC[a] Peak (ppb)	EEC[a] 56-Day Ave. (ppm)	Acute RQ (EEC/LC50)	Chronic RQ (EEC/NOAEC)
Sweet corn & sorghum, ground application	0.031	1140	< 16.4[b]	0.6	0.2	< 0.01	> 0.01
Rice, application to water	0.3	1140	<.16.4[b]	189	12.3	0.17	> 0.75

[a] EECs from section B.1

[b] The NOAEC was not established. A significant reduction in wet weight was observed at the lowest test concentration.of 16.4 ppb ai.

The risk quotients for the new use on grains do not exceed any aquatic acute level of concern for freshwater or saltwater fish. For use on rice, the acute risk quotients exceed the restricted use and endangered species levels of concern for freshwater and saltwater fish. Therefore, these results indicate that the new use on rice is predicted to pose a minor risk to freshwater and saltwater fish that could be mitigated by restricted use registration. This assessment might underestimate the acute risk of carfentrazone-ethyl because the acute toxicity tests were not performed with exposure to SUVR. Based on chronic tests, SUVR enhances the toxicity of carfentrazone-ethyl.

Definitive chronic risk quotients could not be calculated because the fish early life-stage study performed with SUVR failed to establish an NOAEC. Since there were significant adverse effects observed at the lowest test concentration of 16.4 ppb AI, the NOAEC must be less than this level. The chronic risk assessment for carfentrazone-ethyl is currently very uncertain. It appears that there is a low risk of chronic effects from use on corn and sorghum, but a potentially high risk from use on rice (see Section 3 for further discussion). A new chronic toxicity study using SUVR is needed to increase the confidence of the chronic risk assessment.

Acute risk quotients were calculated separately for freshwater invertebrate, mollusks, and marine/estuarine invertebrates based on the acute toxicity of the waterflea, eastern oyster, and mysid, respectively. The chronic toxicity of carfentrazone-ethyl to aquatic invertebrates could not be assessed because no chronic toxicity data are available for these species.

Table 6. Acute risk quotients for freshwater and saltwater invertebrates based on a mysid EC_{50}

Use Site, Application Method	Max. Per Season Rate (lb/A)	LC50 (ppb)	EEC* Peak (ppb)	Acute RQ (EEC/LC50)
		Freshwater Invertebrates		
Sweet corn and sorghum, ground application	0.031	>9800	0.6	<0.01
Rice, application to water	0.3	>9800	189	<0.02
		Marine and Estuarine Invertebrates		
Sweet corn and sorghum, ground application	0.031	1160	0.6	<0.01
Rice, application to water	0.3	1160	189	0.16
		Mollusks		
Sweet corn and sorghum, ground application	0.031	2050	0.6	<0.01
Rice, application to water	0.03	2050	189	0.09

*EECs from section B.1

The risk quotients for the new use on grains do not exceed any acute levels of concern for freshwater or saltwater invertebrates. For use on rice, the acute risk quotient for freshwater invertebrates does not exceed the high risk level of concern; however, acute risk quotients for mollusks and saltwater invertebrates do exceed the level of concern for presuming risk to threatened and endangered species. The risk quotient for saltwater invertebrates also exceeds the LOC for presuming risk that may be mitigated through restricted use registration. Therefore, the new use of carfentrazone-ethyl on grains is expected to pose minimal acute risk to freshwater and saltwater invertebrates, but the new use on rice is predicted to pose a minor acute risk to mollusks and saltwater invertebrates that could harm some threatened and endangered species.

Toxicity findings show that degradation products of carfentrazone-ethyl are much less toxic to fish and aquatic invertebrates than is parent carfentrazone-ethyl. Thus, the occurrence of the degradation products in the aquatic environment should pose minimal risk to aquatic organisms.

Both parent carfentrazone-ethyl and its degradates exhibit significant toxicity to aquatic plants. Acute risk quotients for vascular and non-vascular plants exposed to carfentrazone-ethyl and its degradates are tabulated below.

Table 7. Acute risk quotients for aquatic plants (nonendangered species) from total carfentrazone residues.

Use Site, Application Method	Max. Per Season Rate (lb/A)	Species	EC50 (ppb)	EEC* (ppb)	RQ (EEC/EC50)
Grains, ground application	0.031	duckweed	5.9	1.69	0.29
	0.031	algae or diatom	6.5	1.69	0.26
Rice, application to water	0.20	duckweed	5.9	409	69.3
	0.20	algae or diatom	6.5	409	62.9

*EECs from section B.2

Endangered species risk quotients for vascular aquatic plants exposed to total carfentrazone residues are tabulated below. (No species of non-vascular plant have been listed as endangered or threatened at this time).

Table 8. Acute risk quotients for threatened and endangered species of aquatic plants from total carfentrazone residues.

Use Site, Application Method	Max. Per Season Rate (lb/A)	Species	NOAEC (ppb)	EEC* (ppb)	RQ (EEC/NOAEC)
Grains, ground application	0.031	duckweed	1.9	1.69	0.89
	0.031	algae or diatom	2.2	1.69	0.77
Rice, application to water	0.30	duckweed	1.9	409	215
	0.30	algae or diatom	2.2	409	186

*EECs from section B.2

For the new use on grains, risk quotients from total carfentrazone residues do not exceed any level of concern for aquatic plants. However, risk quotients for rice exceed aquatic plant acute high risk and endangered species levels of concern for vascular and nonvascular plants. Therefore, the new use on rice is predicted to pose a high risk to nontarget aquatic plants when the water is discharged from the field.

D. Threatened and Endangered Species

Based on the available data, the new use of carfentrazone-ethyl on grains is not expected to pose a risk to any threatened or endangered species of aquatic organism. However, the new use on rice is predicted to pose a risk to threatened and endangered fish, mollusks, marine/estuarine crustaceans, and aquatic plants. Most of the threatened or endangered species of fish that occur in areas with rice production would not be at risk. Some are restricted to the larger rivers where residues of carfentrazone-ethyl would be diluted well below toxic levels. In California, other threatened or endangered fish inhabit cool-water streams of mountainous regions, which would be far removed from rice-production areas in the valley. Andromous salmon would transvers through rice-production areas but mainly breed in the cool mountain streams. Only two fish species in California, the steelhead trout population of the Central Valley and the delta smelt, may be at risk since they inhabit the smaller streams and drains of the lowland areas.

Several threatened or endangered mussels occur in counties with rice production in the Southeast. Carfentrazone-ethyl is not highly toxic to mollusks, but could pose a slight threat to species that live in small shallow water bodies that receive a large percentage of their flow from the drainage from rice fields. Concentrations of carfentrazone-ethyl in larger rivers would be too dilute to cause a hazard. The mussel species that possibly could be at risk are the fat pocketbook pearly mussel (*Potamilus capax*), the Arkansas Fatmucket (*Lampsilis powelli*), the Ouachita Rock-Pocketbook (*Arkansia wheeleri*), and the Louisiana Pearlshell (*Margaritifera hembeli*), and the Curtis Pearlymussel (*Epioblasma florentina curtisi*).

Currently, according to the EPA endangered species database, no threatened or endangered species of aquatic plant or marine/estuarine crustacean occurs in counties with rice production.

VI. DRINKING WATER ASSESSMENT

Screening models were used to determine estimated concentrations of carfentrazone-ethyl (F8426) in ground water and surface water for sweet corn and sorghum uses. Data from an aquatic field dissipation study were used for estimates of total residues in water following application to rice fields. Total residues includes parent carfentrazone-ethyl and several degradates which may be of concern: F8426- chloropropionic acid, F8426-cinnamic acid, F8426-propionic acid, F8426-benzoic acid, and 3-hyroxymethyl F8426-benzoic acid.

A. Surface Water EECs

The drinking water assessment was based on carfentrazone-ethyl plus degradates. Because formation/decline curves for the carfentrazone degradates were not available, it was not possible to predict the concentration of parent compound and each degradate separately. Instead, the approach taken by EFED was to treat parent carfentrazone-ethyl plus the sum of its degradates as a single entity. The degradation rate of the longest-lived degradate (F8426-benzoic acid) was therefore selected to represent the overall degradation of this mixture.

Based on GENEEC modeling, the acute surface water Expected Environmental Concentration (EEC) for carfentrazone-ethyl plus degradates on sweet corn and sorghum is 1.69 µg/L. The estimated surface water concentrations for sweet corn and sorghum are 1.59, 1.14, and

0.65 µg/L for 4-day average, 21-day average, and 56 day average, respectively. The chronic surface water value (for sweet corn and sorghum) for use in HED's drinking water assessment is therefore 0.56 µg/L. Based on an aerobic aquatic (rice) field study, the acute surface water concentration for carfentrazone-ethyl (plus degradates) in paddy water, after application to rice is 409 µg/L. The time-weighted-average (TWA) annual concentration of carfentrazone-ethyl plus degradates in rice paddy water is 14.2 µg/L. Assuming a two-fold dilution of paddy water into receiving waters occurs, the acute and chronic EECs of carfentrazone-ethyl plus degradates are therefore 205 µg/L, and 7 µg/L, respectively.

Table 9. GENEEC Input Parameters

Parameter	Input*	Source/Rationale
Solubility (ppm)	910	Solubility of chloropropionic acid degradate (memo: McCormack, Hitch, 1998)
Aerobic soil $t_{1/2}$ (days)	3631	90% upper C.L. on mean value for degradate with longest half-life (benzoic acid)
Aerobic aquatic $t_{1/2}$ (days)	16	90% upper C.L. on mean value for total residues (parent + degradates)
Hydrolysis $t_{1/2}$ (days)	N/A	No data available for degradates
K_{oc}	6	MRID 43189233: minimum value for F8426-chloropropionic acid used, since value for parent not available
Application rates (lb a.i./Acre)	0.031	Label - max. annual rate (sweet corn, sorghum)

* Parameters were selected in accordance with the Proposed Interim Guidance for Input Values document, dated July 15, 1999.

Using the GENEEC model and available environmental fate data for carfentrazone-ethyl and its degradates, EFED calculated the following Tier 1 Estimated Environmental Concentrations (EECs) for total residues of carfentrazone-ethyl (parent plus degradates) in surface water after application to sweet corn and sorghum:

Acute or peak EECs:	1.69 µg/L
Chronic (56-day average) EECs:	0.65 µg/L

Based on an aerobic aquatic field study (application to a rice field) on carfentrazone-ethyl and its degradates, EFED calculated the following concentrations for total residues of carfentrazone-ethyl (parent plus degradates) in surface receiving waters after application to rice:

Acute or peak concentration:	205 µg/L
Chronic (365-day TWA) concentration:	7 µg/L

B. Groundwater EECs

The estimated ground water concentration for carfentrazone-ethyl plus degradates after application to sweet corn and sorghum is 6.55 µg/L. This estimate was derived using the EFED model SCI-GROW, and assuming application at the the maximum annual rates of 0.031 lb a.i. per acre. Because SCI-GROW is a screening level model, we have only moderate confidence in this result. Because it is a relatively new chemical, carfentrazone-ethyl is not one of the analytes in the Pesticides in Ground Water Database. No other monitoring information is available about carfentrazone-ethyl residues in ground water. The estimated ground water concentration after application to rice is expected to be negligible, since rice is grown in paddies that are designed not to allow substantial infiltration.

Using the SCI-GROW model to estimate concentrations in ground water for total residues of carfentrazone-ethyl plus degradates, the following EECs for both acute and chronic exposure were calculated:

Sweet corn, sorghum: 6.55 µg/L

Table 10. SCI-GROW input parameters

Parameter	Input	Source/Rationale
Aerobic soil $t_{1/2}$ (days)	1878	Mean value for degradate with longest half-life (benzoic acid)
K_{oc}	39.0	Median value for chloropropionic acid
Application rate (lb a.i./Acre)	0.031	Label - max. rate: sweet corn, sorghum

Groundwater numbers were not calculated for the rice use, since rice paddies are constructed to limit infiltration.

C. Drinking Water EEC Summary

Groundwater

Acute and chronic estimated concentrations: total residues (SCI-GROW)
0.031 lb a.i./acre/yr: 6.55 µg/L (sweet corn and sorghum)

Surface Water

Acute and chronic estimated concentrations: total residues (GENEEC)
Acute (0.031 lb a.i./acre/yr): 1.69 µg/L (sweet corn, sorghum)
Chronic (0.031 lb a.i./acre/yr): 0.65 µg/L (sweet corn, sorghum)

Acute and chronic estimated concentrations: total residues (field study data)

Acute (0.3 lb a.i./acre/yr):	205 µg/L (rice)
Chronic (0.3 lb a.i./acre/yr):	7 µg/L (rice)

D. MONITORING DATA

Because it is a relatively new chemical, carfentrazone-ethyl is not one of the analytes in the Pesticides in Ground Water Database (EPA, 1992), which includes data from 1971 through 1991. No other monitoring information is available about carfentrazone-ethyl residues in ground water or surface water.

VII. TERRESTRIAL EXPOSURE AND RISK ASSESSMENT

A. Toxicity Summary

Carfentrazone-ethyl is practically nontoxic on an acute basis to birds (Northern bobwhite LD_{50}>2250 mg ai/kg BWt, Northern bobwhite and mallard LC_{50}>5620 mg ai/L). Chronic toxicity to birds is also low. No impact on reproduction was observed in the Northern bobwhite or mallard at dietary concentrations up to 1000 ppm. Reduction in parental body weight was observed in Northern bobwhite at 1000 ppm (NOAEL=167 ppm). Carfentrazone-ethyl is practically nontoxic on an acute basis to mammals (rat LD_{50}>5000 mg ai/kg BWt). In chronic studies, relatively high doses of carfentrazone-ethyl cause toxicity to the liver. The dietary LOAEL for the rat is 800 ppm (males) and 200 ppm (females) based on damage to liver cells.

B. Terrestrial Exposure Summary

The model of Hoerger and Kenega (1972), as modified by Fletcher *et al.* (1994) was used to estimate pesticide concentrations on selected avian or mammalian food items. This model predicts the maximum concentrations that may occur immediately following a direct application at 1 lb ai/A. For 1 lb ai/A applications, concentrations on short grass, tall grass, broadleaf plants, and fruits are predicted to be as high as 240, 110, 135, and 15 ppm, respectively. The predicted maximum concentration for broadleaf plants and fruits are used to represent maximum concentrations that may occur on small and large insects, respectively. Linear extrapolation is then used to estimate maximum terrestrial EEC's for single applications at other application rates.

The peak terrestrial EECs resulting from multiple applications were estimated by summing the maximum EEC predicted for the last application with the remaining portions of the maximum concentrations predicted for all previous applications. After application, residues on food items are predicted to decline according to a first order exponential model.

For carfentrazone-ethyl, information was not available on the half-life of residues on foliage and other wildlife food. Therefore, based on current interim guidance, the half-life was assumed to be equal to the shortest half-life based on dissipation by hydrolysis, photolysis, or volatility, multiplied by an uncertainty factor of 3, or 30 days, whichever is shorter. The hydrolysis half-life for carfentrazone-ethyl is 8.6 days at pH 7, but it is stable at pH 5. Therefore, hydrolysis from foliage would be slow under even slightly acidic conditions. The rate of photolysis of carfentrazone is uncertain, but an unacceptable study determined it to be 67 days in soil, suggesting that it is not a rapid dissipation process. Carfentrazone-ethyl is not expected to volatilize rapidly. Therefore, the default value of 30 days was assumed as the half-life for dissipation from foliage and other wildlife food.

Carfentrazone-ethyl may be applied to rice twice in one season. According to the directions on the label, the first application is made as a water application to control submerged weeds when rice is at the 2-4 leaf stage. Although this application is made directly to water, foliage and other wildlife food on the edge of the rice fields could be exposed by spray drift. The rate at this application is 0.2 lb ai/A. A second application may be made at a rate of 0.1 lb ai/A to emerged weeds at 30-45 days after seeding. This application may be made to drained or flooded fields. We estimate that the second application will be made approximately 19 days after the first. The following formula was used to estimate the concentration of residues from the first application that would remain at the time of the second application:

$$C_t = C_0 e^{-\frac{t \ln 2}{t_{1/2}}}$$

where C_0 is the initial maximum concentration, t is the time after the first application (19 days), and $t_{1/2}$ is the half-life (30 days). The remaining concentration after 19 days is 0.645 times the initial concentration. This remaining amount was added to the initial maximum concentration from the second application to estimate the peak concentration from the two applications of carfentrazone-ethyl on rice. The peak concentration of carfentrazone-ethyl on wildlife food items are given below:

Table 11. Expected Environmental Concentrations on Food Items for Exposure to Terrestrial Wildlife.

Site, Application Method	Application Rate (lbs ai/A)	Terrestrial EEC (ppm)			
		Short Grass	Tall Grass	Broadleaf Plants & Small Insects	Fruit & Large Insects
Sweet corn & sorghum, ground application, max. per season rate	0.031	7.44	3.41	4.19	0.465
Rice, application to submerged weeds	0.20	48	22	27	3
Rice, application to emerged weeds	0.10	24	11	13.5	1.5
Rice, application to submerged weeds followed 19 days later by application to emerged weeds	0.03 (total)	54.9	25.2	30.9	3.43

C. Quantitative Risk Assessment

Acute risk quotients for birds were calculated based on the results of the dietary toxicity tests with the northern bobwhite and the mallard, both of which determined that the LC_{50}'s were greater than 5620 ppm ai. For the new uses on both grain and rice, acute risk quotients were very small (<0.01) for all types of wildlife food items. Therefore, risk to birds resulting from acute effects are predicted to be minimal.

Chronic risk quotients are given below.

Table 12. Chronic risk quotients for birds and mammals based on a northern bobwhite NOAEL.

Site, Method of Application	Appl. Rate (lbs ai/A)	Wildlife Food Items	Maximum EEC (ppm)	NOAEL (ppm)	Chronic RQ (EEC/NOAEL)
Sweet corn & sorghum, ground application, max. per season rate	0.031	Short grass	7.44	167	0.04
		Tall grass	3.41	167	0.02
		Broadleaf plants/Insects	4.19	167	0.03
		Seeds	0.47	167	<0.01
Rice, max. per season rate	0.3	Short grass	48.00	167	0.29
		Tall grass	22.00	167	0.13
		Broadleaf plants/Insects	27.00	167	0.16
		Seeds	3.00	167	0.02

Chronic risk quotients for new uses on both rice and sweet corn and sorghum are also less than the level of concern for high chronic risk. Therefore, we conclude that the new uses of carfentrazone will pose minimal acute and chronic risk to birds and will not pose a threat to endangered bird species.

As with birds, the toxicity of carfentrazone-ethyl to mammals is very low. The acute LD_{50} for the rat is greater than 5000 mg ai/kg. Acute risk quotients for mammals are all far below the levels of concern for high acute risk and risk to endangered species. Likewise, chronic toxicity studies with carfentrazone ethyl also indicate very low toxicity (NOAEL for ecological effects = 4000 ppm ai). Since the mammal NOAEL is greater than the bird NOAEL (167 ppm), chronic mammal risk quotients are less than those for birds. Therefore, we conclude that the new uses of carfentrazone-ethyl will pose minimal acute and chronic risk to mammals and will not pose a threat to endangered mammal species.

Carfentrazone-ethyl is practically nontoxic to the honeybee (LD_{50}>27.9 μg/bee). Therefore, the new uses are predicted to pose minimal risk to nontarget insects.

D. Exposure and Risk to Terrestrial Plants

The EFED does separate risk assessments for the two categories of nontarget plants (terrestrial and semi-aquatic). Non-target terrestrial plants inhabit non-aquatic areas which are generally well drained. Non-target semi-aquatic plants inhabit low-lying areas that are usually wet, although they may be dry during certain times of the year. Both the terrestrial and semi-aquatic plants are exposed to pesticides from runoff, drift, and volatilization. They differ, however, in that terrestrial plants are assumed to be subjected to sheet runoff, whereas semi-aquatic plants are assumed to be subjected to channelized runoff.

For non-target terrestrial plants, EFED assumes a scenario in which plants are exposed from sheet runoff. A treated site of 1 acre is assumed to drain into an adjacent area of 1 acre where terrestrial plants may be impacted. In the scenario used for non-target semi-aquatic plants, exposure from runoff is assumed to be from channelized runoff. A treated site of 10 acres is assumed to drain into a distant low-lying area of 1 acre where semi-aquatic plants may be impacted. The EFED assumes that runoff will expose nontarget plants to a fixed percentage of the application rate. This percentage is estimated based on the water solubility of the active ingredient:

Water Solubility	% Runoff Assumed
< 10 ppm	1%
10 - 100 ppm	2%
> 100 ppm	5%

Carfentrazone-ethyl rapidly breaks down into the major degradate, F8426–chloroproionic acid, which is highly soluble (910 ppm) and highly mobile in soil. Since this degradation product is also phytotoxic (based on phytotoxicity data), the percent runoff for exposure to plants is assumed to be 5% of the amount applied. No runoff is assumed for rice because rice fields are surrounded by a levee and all runoff would be directed into a drainage canal or natural waterway. Therefore, runoff from rice fields would not expose terrestrial plants.

Exposure from spray drift was assumed to be 1% and 5% of the application rate for ground and aerial applications, respectively. Exposure from spray drift is compared to toxicity observed in the vegetative vigor test to assess risk from foliage exposure. Spray drift exposure is also added to runoff exposure, and the total loading to soil in nontarget areas is compared to toxicity results of the seedling emergence test to assess risk from soil exposure. The following table gives estimated exposure values for spray drift and total loading to nontarget soils.

Table 13. Estimated exposure (lbs ai/A) in nontarget areas from drift and runoff.

Use site, Application Method	Max. Appl. Rate (lb ai/A)	Sheet Runoff (lbs ai/A)	Channelized Runoff (lbs ai/A)	Spray Drift (lbs ai/A)	Total Loading	
					Adjacent Area (Sheet Run-off+Drift)	Semi-aquatic Area (Channel Run-off+Drift).
Sweet corn & sorghum, aerial application	0.031	0.00093	0.0093	0.00155	0.00248	0.0109
Sweet corn & sorghum, ground application	0.031	0.00155	0.0155	0.00031	0.00186	0.0158
Rice, aerial application	0.3	0[a]	0[a]	0.01500	0.0150	0.0150
Rice, ground application	0.3	0[a]	0[a]	0.00300	0.0030	0.0030

[a] No runoff is expected from rice fields into adjacent or semiaquatic areas.

The above exposure values were used to calculate the risk quotients for plants shown in the following table.

Table 14. Risk quotients for nonendangered nontarget plants.

Use site, Application Method	Max. Appl. Rate (lb ai/A)	EC_{50} for Most Sensitive Test Species		Risk Quotients		
		Seedlin Emergence	Vegetative Vigor	Seedling Emergence		Vegetative Vigor
				Adjacent Areas	Semi-aquatic Areas	
Sweet corn & sorghum, aerial application	0.031	0.022	0.0012	0.11	0.50	1.30
Sweet corn & sorghum, ground application	0.031	0.022	0.0012	0.085	0.72	0.26
Rice, aerial application	0.3	0.022	0.0012	--	--	12.50
Rice, ground application	0.3	0.022	0.0012	--	--	2.50

For all new uses with aerial application, the risk quotients exceeds the high risk LOC for effects on vegetative vigor from spray drift exposure. Ground applications also exceed the high risk LOC, but only for use on rice. Risk quotients for effects on seedling emergence do not exceed the high risk LOC. Risk quotients for threatened and endangered species are given in the table below.

Table 15. Risk quotients for threatened and endangered plants

Use site, Application Method	Max. Appl. Rate (lb ai/A)	NOAEL for Most Sensitive Test Species		Risk Quotients		
		Seedlin Emergence	Vegetative Vigor	Seedling Emergence		Vegetative Vigor
				Adjacent Areas	Semi-aquatic Areas	
Sweet corn & sorghum, aerial application	0.031	0.007	0.0006	0.35	1.16	2.58
Sweet corn & sorghum, ground application	0.031	0.007	0.0006	0.27	2.26	0.52
Rice, aerial application	0.3	0.007	0.0006	--	--	25.00
Rice, ground application	0.3	0.007	0.0006	--	--	5.00

Risk quotients for all new uses,except for ground application to sweet corn and sorghum,exceed the LOC for risk to threatened and endangered species. Dicotolydonous plants would be most at risk.

In conclusion, aerial application on sweet corn and sorghum and both ground and aerial applications to rice pose a high risk to nontarget plants due to exposure through spray drift. These uses may harm threatened and endangered plants. Ground applications on sweet corn and sorghum at up to 0.031 lb ai/A do not pose a high risk or a risk to threatened or endangered species. The greatest risk is posed by aerial applications to rice. Because of the selective toxicity of carfentrazone-ethyl, these risks will mainly be to dicotyledonous plants.

E. Threatened and Endangered Species

Use of carfentrazone-ethyl on rice and other grains is not predicted to pose a threat to threatened or endangered species of birds, mammals, or terrestrial invertebrates. However, aerial application to sweet corn or sorghum, and all applications to rice, pose a risk to threatened and endangered terrestrial plants due to exposure to spray drift. Risks from aerial applications to sweet corn or sorghum and ground applications to rice are relatively small and may not be significant if care is taken to avoid spray drift, such as by using application equipment used does not produce very small droplets that are prone to drift. Aerial applications to rice, in contrast, may pose a serious risk to threatened and endangered plants. Because of the selective toxicity of carfentrazone-ethyl, dicotyledonous plants (i.e., plants other than grasses and sedges) would be at greatest risk.

Appendix B gives a county-by-county list of threatened and endangered species that occur in counties with rice production. Not every plant on this list would be at risk. Some species may not be a risk because they are not sensitive to carfentrazone-ethyl (e.g., grasses and sedges) or do not occur close to fields of sweet corn, sorghum, or rice.