UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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OFFICE OF
PREVENTION, PESTICIDES, AND
TOXIC SUBSTANCES

MEMORANDUM

SUBJECT: EFED Science Chapter for Pendimethalin (Case # ~~0817~~ 0167)

FROM: C. Renée Costello, Task Team Leader B. Quinn for Renée 4/15/96
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THRU: Elizabeth M. Leovey, Chief
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TO: Jane Mitchell, CRM Team Reviewer
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Attached to this memorandum is the EFED Reregistration Eligibility Decision (RED) Science Chapter (Attachment 1) for pendimethalin. The EFED Science Chapter, which can be directly merged into the RED document, contains the environmental assessment divided into four sections: Environmental Fate and Transport; Ecological Effects; Ecological Exposure and Risk Assessment; and Environmental Risk Characterization. Attachment 2 is the physicochemical data for amitrole and the DERs for the environmental fate and transport guideline studies. Attachment 3 is the Groundwater Assessment.

Pendimethalin is a dinitroaniline herbicide registered for use on annual grasses and broadleaf weeds in terrestrial food crop and terrestrial non-food crop use groups. It is a cell growth inhibitor that prevents seedling development and is herbicidally active on the roots and coleoptiles of susceptible weeds. Pendimethalin does not control weeds postemergence and must be soil applied. Formulations include a 3.3 emulsifiable concentrate, a 4.0 emulsifiable concentrate, a 60DG water dispersible granule, and a fertilizer formulation. Application rates range from 1.0 to 4.0 lbs ai/A. Total pendimethalin use ranges from 14 to 25 million pounds active ingredient annually, with the largest usage occurring on soybeans, cotton, and corn.

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Environmental Risk Characterization Conclusions:

o Pendimethalin dissipates in the environment by binding to soil, microbially-mediated metabolism and volatilization. It is essentially immobile in soil.

o Based on laboratory studies and limited field study information, pendimethalin is slightly to moderately persistent in aerobic soil environments. Persistence decreases with increased temperature, increased moisture and decreased soil organic carbon.

o Additional terrestrial field dissipation studies for major pendimethalin uses (cotton and soybeans) are requested to fully characterize the fate of pendimethalin.

o Pendimethalin may contaminate surface water from spray drift associated with aerial and ground spray application, or in runoff from rainfall events and through irrigation waters (chemigation). However, the high affinity for pendimethalin to bind to soil and sediment particles should limit concentrations of pendimethalin in surface waters.

o Although pendimethalin has been detected in ground water (at very low levels), the potential for ground water contamination from pendimethalin residues is low.

o Pendimethalin would not represent a high acute risk to birds or a high acute or chronic risk to mammals. The chronic risk to birds could not be determined because avian reproduction studies have not been submitted. These studies are requeted.

o Chronic risk LOCs for fish were exceeded by a small margin. But it is presumed that overall, pendimethalin does not represent a high risk to aquatic animals and plants, including estuarine organisms.

o The use of pendimethalin may adversely effect endangered species of terrestrial and semi-aquatic plants, aquatic plants and invertebrates including mollusks, fish, and birds (specifically grazers).

o The risk to nontarget terrestrial and semi-aquatic plants is expected to be moderate. However any impact to floral communities, should it occur, could be extensive because of the high poundage used.

Recommendations

1. Avian Reproduction studies (71-4) preferably with a bobwhite quail and a mallard duck are requested on the technical grade of the active ingredient.

An avian chronic risk assessment cannot be completed without these studies. Pendimethalin has been shown to be persistent in both field and laboratory studies. It has a high potential to bioaccumulate in fish. Pendimethalin is a widely used agrochemical with up to 25 million pounds active ingredient per year applied nationwide. According to the label, several applications may be applied per use season for most major crops,

including cotton and rice.

2. Additional terrestrial field dissipation studies (164-1) for major use sites (cotton and soybeans) uses under typical use conditions are requested.

Only one terrestrial field study for pendimethalin has been submitted (almond site in California). The field dissipation results from this site would not be characteristic of major use sites such as cotton and soybeans. These studies will provide information on dissipation routes and potential for off-site drift.

The study design should incorporate air sampling. The depth of sampling can be limited to 12 inches. ERCB is willing to work with the registrant to develop the study design.

3. Aquatic field dissipation (GLN 164-2) is unsatisfied at this time since no study has been submitted to the agency. However, the registrant has conducted an aquatic field dissipation study in dry-seeded rice in Arkansas that has not yet been submitted.

4. Droplet size spectrum (GLN 201-1) and drift field evaluation (GLN 202-1) studies are required for pendimethalin, since the different formulations may be applied by aircraft and it is estimated that there will be detrimental effects to non-target terrestrial and semi-aquatic plants due to drift. However, to satisfy these requirements the registrant, in conjunction with other registrants of other pesticide active ingredients, formed the Spray Drift Task Force (SDTF).

5. EFED does not recommend any risk reduction measures at this time.

Labeling Requirements and Endangered Species

All pesticides with outdoor, terrestrial uses are required to have the following statement in the Environmental Hazards section of the label:

> "This pesticide is toxic to fish and aquatic invertebrates. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark."

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

ERCB TASK TEAM MEMBERS:

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C. Environmental Assessment

The environmental assessment consists of four sections: Environmental Fate; Ecological Toxicity; Ecological Exposure and Risk Assessment; and Environmental Risk Characterization. The first section depicts the environmental fate and transport data from field and laboratory studies, analyzes the impact to water resources, and details the environmental fate assessment. The second and third sections report the ecological toxicity data from laboratory studies, estimates ecological exposure and assesses the effects to nontarget terrestrial and aquatic organisms. The section on environmental risk characterization integrates the exposure and effects assessments to determine the extent and potential for risk to the environment.

1. Environmental Fate

a. Environmental Fate Assessment

Pendimethalin dissipates in the environment by binding to soil, microbially-mediated metabolism, and volatilization. Persistence decreases with increased temperature, increased moisture and decreased soil organic carbon. Pendimethalin residues are tightly bound to soil and sediment particles. Field dissipation information on the major use sites (cotton and soybeans) that would more clearly describe the environmental fate of pendimethalin has not been submitted.

Pendimethalin is stable to sterile hydrolysis, soil photolysis, and anaerobic soil metabolism, but degrades slowly under aqueous photolysis conditions with a calculated half-life of 21 days. Aerobic soil metabolism half-lives range from 42-1322 days with 172 days used for the purpose of exposure assessment. Pendimethalin forms many minor (< 10% of applied) degradates that are primarily an intact benzene ring with rearranged alkyl groups. Anaerobic aquatic metabolism half-lives ranged from 6 to 105 days. Aqueous residues of parent pendimethalin and its degradates bind to sediment in anaerobic aquatic metabolism and soil mobility studies. This is consistent with mobility studies indicating that pendimethalin is essentially immobile in all soils studied.

The calculated half-life of pendimethalin in a field study (almond orchard in California) was 34 days. Although the orchard site is not a major use site for pendimethalin, the resulting half-life is consistent with the results from the soil metabolism studies.

Pendimethalin accumulated readily in bluegill sunfish with BCFs of 1400X in edible, 5800X in non-edible and 5100X in whole fish, however, depuration was rapid.

Pendimethalin may contaminate surface water from spray drift associated with aerial and ground spray application, or in runoff from rainfall events and through irrigation waters (chemigation). However, the high affinity for pendimethalin to sorb to soil and sediment particles should limit concentrations of pendimethalin in surface waters. Pendimethalin was detected in surface water samples at a maximum of 3.66 μg/L in selected Lower Great Lake Tributaries during 1982-1985. In a study of the spatial and temporal distributions of pesticides and nutrients in the

Mississippi River and its tributaries, dissolved pendimethalin was not detected in surface water sample above the reporting limit of 0.018 μg/l. Surface water monitoring results found in the STORET database are a compilation of various states' monitoring data. The maximum concentration of pendimethalin was 17.6 μg/L (ppb) for a surface water sample collected in Ohio; the next highest reported concentration was 10 μg/L with a range of 1-10 μg/L. From the STORET data (excluding the highest Ohio sampling results), the maximum concentrations of pendimethalin in surface water samples range from 0.01 to 3.2 μg/L.

Pendimethalin has a low potential to leach to ground water in most soils. Pendimethalin has a history of high use over a wide geographic area on several major crops, however, EFED has few reports of detections in ground water. Residues of pendimethalin have been found in ground water in limited areas in two states. The concentrations in ground water were relatively low, ranging from 0.2 to 0.9 ppb.

b. Environmental Fate and Transport

(1) Degradation

Abiotic Hydrolysis

Pendimethalin did not degrade in sterile aqueous buffer solutions (pH 5, 7, and 9) that were incubated in darkness at 25°C for 30 days. The guideline requirement (GLN 161-1) is fulfilled. MRID 00106777

Abiotic and Biotic Hydrolysis

Calculated half-lives were 10-11 days (average of 10.6 days) in water containing different soil fungi and 354 days in sterile water. Three degradates were formed, which were ring rearrangements and ring additions. Zimdahl et al., 1990.

Photodegradation in Water

The calculated half-lives were 16.5 days at pH 5, 7, and 9 (MRID 43808201), and in an older study, 21 days at pH 7 (MRID 00153763). When corrected for the distance between the light source and the water in the most recent study (40 cm vs 80 cm for the older study), the 3.5 day half-life reported by the registrant becomes 16.5 days, which is consistent with the 21-day half-life in the older study. The artificial light intensity for the new study was for September 13, 1990 at Princeton, New Jersey and Chicago, Illinois on June 30 and the temperature was set at 25°C. Up to 37 minor degradates were isolated, but only one degradate was identified, 2,6-dinitro-3,4-dimethyl aniline (a ring-rearrangement of parent pendimethalin with an ethylpropyl group removed from an amine group). However, the degradate did not exceed 9.3% of applied, and no other degradate reached this amount. Pendimethalin was stable in the dark controls, which is consistent with the hydrolysis study. The guideline requirement (GLN 161-2) is fulfilled. MRIDs 00153763;43808201

Photodegradation on Soil

Pendimethalin did not degrade on sandy loam exposed to artificial light at 25°C. The guideline requirement (GLN 161-3) is fulfilled. MRID 00153764.

Photolysis in Air

This study is not required because pendimethalin is tightly bound to soil and its toxicity is in Class 3. Gln. 161-4, waived on 6/27/91.

Aerobic Soil Metabolism

Pendimethalin degraded with a calculated half-life of 1322 days in sandy loam soil in a study submitted for registration. This half-life was considered an outlier and was not used in assessing the environmental fate of pendimethalin. The identified minor degradates were 2,6-dinitro-3,4-xylidine, 4-[(1-ethylpropyl)amino]-2-methyl-3,5-dinitro benzyl alcohol, and 4-[(1-ethylpropyl)amino]-3,5-dinitro-o-toluic acid. All of these degradates were ring rearrangements of parent pendimethalin.

The half-lives for aerobic soil metabolism ranged from 42-563 days in the literature studies referenced below with a guideline study reporting a half-life of 1322 days for a total of 27 total observations. Because of the range of values, statistical analyses of the available data were performed. The mean, median, and modal half-lives are 126, 122, and 122 days, respectively, with a standard deviation of 66 days (n=24). The half life values of 409, 563, and 1322 days were not included in the final statistical analyses because they were greater than three standard deviations from the mean. Based on soils and crops that are normally treated with pendimethalin, the reviewer assumed that temperatures would likely range from 20-30°C and soil moisture contents from 50-75% Field Capacity (FC). The range of observed half-lives in the above experimental conditions were 72-172 days. The 172-day half-life was used for GENEEC calculations since it was the longest half-life for the observed range. Although some of the studies were conducted using foreign soils, the half-lives for foreign soils fall within the range of values seen in studies using U.S. soils. Gln. 162-1, MRID 40185104.

Half lives were affected by study conditions. Walker and Bond (1977) evaluated the effect of moisture, temperature and different soils on soil persistence.

As indicated in Table 1, persistence decreased about 5 days for every one percent increase in moisture.

Table 1. Calculated Half-Lives of Parent Pendimethalin in Sheeps Pen Loam Soil (1.2% OC, 18.3% clay) at 25°C (Walker and Bond, 1977).

% Moisture (Field Capacity, FC)	Half-Life (days)
12.5	563
25	261
37.5	225
50	239
62.5	166
75	122

As indicated in Table 2 below, persistence decreased about 15 days for every degree of temperature increase.

Table 2. Calculated Half-Lives of Parent Pendimethalin in Sheeps Pen Loam Soil (1.2 % OC, 18.3 % clay) at 75 % Field Capacity (Walker and Bond, 1977).

Temperature (°C)	Half-life (days)
30	98
25	122
20	168
15	265
10	409

As indicated in Table 3 below, the persistence of pendimethalin generally increased with increasing soil organic carbon and clay content.

Table 3. Half-Lives of Parent Pendimethalin in Different Soils at 25°C and 75% FC (Walker and Bond, 1977).

Soil *	% OC	% clay	Half-life (days)
Soakwaters	0.87%	27.6%	72
Gravel Pits	1.08%	20.4%	87
Gallas Leys	1.12%	37.8%	132
Sheeps Pen	1.2%	18%	129
Big Cherry	1.33%	20%	139
Pump Ground	1.75%	20.5%	127
Water Meadows	6.8%	60.4%	172

* Incomplete soil characterization information was provided.

The following aerobic soil metabolism half-lives are from Zimdahl, et al., 1984:

Table 4. Calculated Half-Lives of Parent Pendimethalin in Different Soils (Zimdahl, et al., 1984).

Soil	% OC	% FC	Temperature (°C)	Half-Life (days)
Clay loam	0.76%	50%	30	73
Clay loam	0.76%	75%	35	61
Clay loam	0.76%	75%	30	54
Clay loam	0.76%	75%	20	77
Clay loam	0.76%	75%	10	101
Clay loam	0.76%	100%	30	56
Clay	1.0%	75%	30	42
Sandy loam	0.76%	75%	30	45

In a study by Zimdahl, et al., as shown in Table 4, persistence generally increased with increasing clay and organic carbon content. The calculated half-lives were 42-101 days in a range of soils with 0.76 and 1.0% Organic Content (OC) at 50-100% Field Capacity (FC) and 10-35°C. Persistence decreased with increasing moisture and temperature.

Anaerobic Soil Metabolism

Pendimethalin is stable to anaerobic soil metabolism. Ninety-eight percent of parent remained after 60 days of anaerobic conditions. The identified minor degradates were 2,6-dinitro-3,4-

xylidine, 4-[(1-ethylpropyl)amino]-2-methyl-3,5-dinitro benzyl alcohol, and 4-[(1-ethylpropyl)amino]-3,5-dinitro-o-toluic acid. The guideline requirement (GLN 162-2) is fulfilled. MRID 40185105

Anaerobic Aquatic Metabolism

The calculated half-lives were 6, 30, 33, 45, 52, 59, 62, 63, and 105 days.

A half-life of 105 days was calculated in silt loam soil (1.2% OC) that was incubated for one week under aerobic conditions and for 8 weeks under anaerobic conditions. Only minor degradates (<2.5%) were isolated; none were identified. Less than 3% was associated with the flood water at any time in the study. (GLN 162-3) MRID 40813501, reviewed on 6/27/91.

A half-life of 6 days was calculated for non-sterilized sandy loam pond sediment from Ontario, Canada (1.8% OC) at 25°C incubated for 39 days under anaerobic aquatic conditions. In all conditions (5°C non-sterile, 5°C, sterile, 25°C, non-sterile, and 25°C, sterile), aqueous residues decreased rapidly to form soil-extractable residues, followed by a rapid increase in soil-bound residues. At 5°C and 25°C under non-sterile conditions, aqueous residues declined to about 11.8% by 16 days and remained constant until the end of the study at 39 days. Extractable residues decreased from 60.8-70.9% at 5°C (non-sterile) to 27% by 39 days. Many minor (<10%) degradates were isolated, and none were identified. Gln. 162-3, MRID 43154702, reviewed for reregistration.

The calculated half-lives for 30 kPa (100% FC), continuous flood, and alternate wet/dry treatments were 59, 63, and 30 days, respectively, in Crowley silt loam soil (5% sand, 74% silt, 21% clay, pH 5.5, 1% OC). Soil persistence decreased with increasing soil moisture content. Alternating wet/dry conditions decreased persistence presumably by increasing the volatility during the wet cycle. Barrett and Lavy, 1983.

The calculated half-lives were 62, 52, 45, and 33 days in sterile, non-flooded; non-sterile, non-flooded; sterile, flooded; and non-sterile, flooded sandy loam soil with 60% sand, 21% silt, 19% clay, 0.35% OC, and Ph 8.2. Persistence decreased with flooded conditions regardless of sterility. Three minor degradates with ring rearrangements were formed. Kulshrestha and Singh, 1992.

As reported in another study, between 45-59% of pendimethalin was bound to sediment (Matapeake silt loam, pH 5.3, 0.87% OM, 38.4% sand, 49.4% silt, and 12.2% clay) by 30 days. Only 11-13% of residues were associated with tne aqueous phase throughout the study. Polar residues reached 54% by 2 days and >90% by 9-30 days. A total of 32% of soil residues was extractable. Isensee and Dubey, 1983.

The guideline requirement (GLN-162-3) is fulfilled. MRIDs 40813501;43154702).

(2) Mobility

Unaged Mobility (Batch Equilibrium)

Parent pendimethalin was essentially immobile in loamy sandy (0.46% OC), sandy loam (0.93% OC), silt loam (2.73% OC), loam (2.21% OC), and silty clay loam (2.91% OC), and sandy clay loam (1.5% OC) soils from the U.S. with Freundlich K_{ads} values of 30, 110, 380, 301, and 854, respectively. Desorption coefficients were not provided. K_{ocads} were 15000, 13000, 14100, 13700, and 29400, respectively. The N values were 1.05, 1.08, 0.89, 1.20, and 0.83, respectively. The guideline requirement (GLN 163-1) is fulfilled. MRID 00153765

Parent pendimethalin was essentially immobile in loamy sandy (0.87% OC), sandy loam (0.44% OC), sandy clay loam (0.67% OC), and sandy clay loam (1.5% OC) soils from Japan with Freundlich K_{ads} values of 61, 193, 153, and 285, respectively. Freundlich K_{des} values were 124, 284, 323, and 556, respectively. K_{ocads} were 7011, 43863, 22835, and 19000 and K_{ocdes} values were 14252, 64545, 48208, and 37066, respectively. The N values ranged from 1.03-1.13. Gln 163-1, MRID 43041901

Aged Mobility

Waived for reregistration since there are no significant transformation products of pendimethalin. Gln. 163-1.

Laboratory Volatility

Volatility can be significant under warm, moist conditions. The maximum volatility rate for air-dried sandy loam soil (0.8% OC) was 5.4 x 10^{-5} $\mu g/cm^2/hr$ and the maximum air concentration was 0.54 ug/m^3. The maximum volatility rate for moist (80% FC) sandy loam soil was 2.1 x 10^{-3} cm^2/hr and the maximum air concentration was 31 ug/m^3. The moist soil volatility rate and air concentration were approximately 38 times and 57 times that of the dry soil (respectively). The guideline requirement (GLN 163-2) is fulfilled. MRID 00153766

Table 5. Volatility Half-lives (Walker and Bond, 1977).

Surface*	Half-life (days)
Bare Metal (aluminum)	6
Dry Sheeps Pen (1.2% OC, 18% clay)	96
Moist Sheeps Pen (1.2% OC, 18% clay)	37

* Incomplete soil characterization information was provided.

Volatilization of pendimethalin may be responsible for some of the accelerated rate of loss as the soil moisture increases.

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(3) Accumulation

Bioaccumulation in Fish

Pendimethalin residues accumulated in bluegill sunfish exposed to 3 ppb of pendimethalin, with BCF's of 1400X for edible, 5800X for non-edible, and 5100X for whole fish. Pendimethalin comprised 68-81% of the recovered radioactivity, and the degradate 4-[(1-ethylpropyl-amino]-2-methyl-3,5-dinitro-benzyl alcohol (CL 202,347) was 2-3.1% of the recovered radioactivity. Many other minor degradates were formed up to 32% of the applied radioactivity. Depuration was rapid, with 87-91% of the ^{14}C-residues eliminated from the fish tissues by 14 days of depuration. The guideline requirement (GLN 165-4) is fulfilled. MRIDs 00158235;00156726

(4) Field Dissipation

Terrestrial Field Dissipation

No acceptable field dissipation studies were submitted for the major crops treated with pendimethalin (cotton and soybeans). The registrant should provide studies for these crops, since the orchard study in CA is not necessarily representative of soybeans and cotton. These studies can be modified to include volatility information.

The calculated half-life of pendimethalin in sandy loam soil in an almond orchard in California was 34 days. No leaching was observed below 6 inches of depth. Gln. 164-1, MRID 41722504

Walker and Bond (1977) observed that volatilization occurred more rapidly with warmer soil temperatures in English Sheeps Pen and Big Ground soils. In the field, up to 50% volatilized in 30-40 days from the first surface application, and in 12-14 days from the second surface application. Pendimethalin was lost more rapidly from surface treatments than in incorporated treatments. When incorporated, between 65-80% remained in field soil 20-23 weeks after application. Walker and Bond, 1977.

The guideline requirement (164-1) is not fulfilled. Additional studies are needed.

Aquatic Field Dissipation

Aquatic field dissipation is unsatisfied at this time since no study has been submitted to the agency. However, the registrant has conducted an aquatic field dissipation study in dry-seeded rice in Arkansas that has not yet been submitted. The guideline requirement (GLN-164-2) is not fulfilled.

(5) Spray Drift

Spray Drift

No pendimethalin specific studies were reviewed. Droplet size spectrum (GLN 201-1) and drift field evaluation (GLN 202-1) studies are required for pendimethalin, since the different formulations may be applied by aircraft and it is estimated that there will be detrimental effects to non-target terrestrial and semi-aquatic plants due to drift. However, to satisfy these requirements the registrant, in conjunction with other registrants of other pesticide active ingredients, formed the Spray Drift Task Force (SDTF). The SDTF has completed and submitted to the Agency its series of studies which are intended to characterize spray droplet drift potential due to various factors, including application methods, application equipment, meteorological conditions, crop geometry, and droplet characteristics. During 1996 the Agency plans to evaluate these studies. In the interim, and for this assessment of pendimethalin, the Agency is relying on previously submitted spray drift data and the open literature for off-target drift rates. The estimated drift rates at 100 feet downwind of the treated sites are 1% at the applied spray volume from ground applications and 5% from aerial applications. After review of the new studies the Agency will determine whether a reassessment is warranted of the potential risks of the application of pendimethalin products.

c. Water Resources

(1) Ground Water

EFED concludes that pendimethalin has a low potential to leach to ground water in most soils. Pendimethalin exceeds all of the ground water persistence triggers, however, the high K_d and K_{oc} values demonstrate that pendimethalin will bind strongly to soil organic matter and is not mobile. There is no indication that pendimethalin would exceed any ground water LOC. Residues of pendimethalin have been found in ground water in limited areas in two states. The concentrations were relatively low, ranging from 0.2 to 0.9 ppb (μg/L). However, considering its history of high use over a wide geographic area on several major crops, there are relatively few detections in ground water.

(2) Surface Water

Pendimethalin may contaminate surface water from spray drift associated with aerial and ground spray application, or in runoff from rainfall events and through irrigation waters (chemigation). Transport of pendimethalin during runoff events which occur soon after application could be considerable due to its persistence and extensive use. The intermediate to high soil/water partitioning coefficients for pendimethalin (Freundlich K_{ad}s of 30-854 ml/g; K_{oc}s of 7011-64545) indicate pendimethalin would be transported in runoff adsorbed onto eroding soil or entrained sediment. The anaerobic aquatic metabolism and soil mobility studies both reported partitioning of pendimethalin primarily with the soil or sediment phase, and it is not partitioned into the aqueous phase.

Surface waters may be contaminated through drift from aerial and ground spray applications. Pendimethalin is aerially applied to $\approx$50% of the treated rice fields, $<$15% of the treated cotton acres, and $<$5% for all other treated crops (Registrant use information). Based on the environmental fate assessment, volatilization losses of pendimethalin following aerial applications may also be important. At this time, spray drift information is unavailable; however, the registrant is a participating member of the SDTF and data from the SDTF will be available in 1996.

In receiving surface water bodies, pendimethalin is moderately persistent (anaerobic aquatic metabolism half-life of 60 days). Pendimethalin is stable to hydrolysis; however it degrades by aqueous photolysis (half-lives of 17-21 days) and should dissipate fairly rapidly in shallow water exposed to sunlight. Volatilization of pendimethalin from well-mixed surface waters may be an important transport process because greater volatilization was observed under moist field conditions (maximum of 50% volatilized from moist soils in field studies) than for dry soils. The reported vapor pressure of 2.9×10^{-6} Torr at 20°C and estimated Henry's Law Constant of 2.2×10^{-5} atm-m^3-mol^{-1} support the conclusion of volatility as a significant transport mechanism.

Pendimethalin is not regulated under the Safe Drinking Water Act (SDWA); therefore, a Maximum Contaminant Level (MCL) has not been established for it. Pendimethalin is classified

in Toxicity Category III based on the Oral LD_{50} from a rat study and has been classified as a Group C nonquantifiable carcinogen by the HED Carcinogenicity Peer Review Committee (RCAB risk assessment summary, 1/17/96).

Monitoring Data

Baker (1988) studied sediment, nutrient, and pesticide transport in selected Lower Great Lake Tributaries during 1982-1985. Pendimethalin was detected in surface water samples from numerous river transport stations. Maximum concentrations of pendimethalin were 3.66 μg/L (Upper Honey Creek) for 1983; 1.25 μg/L (Honey Creek) for 1984, and 0.31 μg/L (Lost Creek) for 1985. The maximum concentrations for pendimethalin in stream water samples for selected Lower Great Lakes Tributaries are summarized in Table 6 (Baker, 1988).

Table 6. Maximum Concentrations of Pendimethalin for 1982-1985 (Baker, 1988)

SAMPLING LOCATION	1982	1983 (μg/L)	1984 (μg/L)	1985 (μg/L)
Maumee River	n/a	0.269	0.666	0.0
Sandusky River	n/a	0.371	0.570	0.130
Honey Creek	n/a	0.623	1.248	0.230
Rock Creek	n/a	0.470	0.276	0.0
U. Honey Creek	n/a	3.660	0.055	0.0
Lost Creek	n/a	3.455	0.346	0.310
River Raisin	n/a	0.333	0.080	0.0
Cuyahoga River	n/a	1.057	0.139	0.0

Note: data for 1984 and 1985 were corrected for recoveries less than 100%.

In a study of the spatial and temporal distributions of pesticides and nutrients in the Mississippi River and its tributaries, Coupe et al. (1993) did not detect dissolved pendimethalin in surface water samples above the reporting limit of 0.018 μg/L. These study results suggest pendimethalin would not be present in public drinking water. The sampling period was April, 1991 to September, 1992 for eight sampling stations (three on the Mississippi, and one each on the Ohio, Illinois, Missouri, Platte, and White Rivers). The USGS study focused on selected pesticides associated with agriculture row crop production and employed extensive field and laboratory quality assurance procedures to generate high-quality monitoring data.

A summary of the pendimethalin detections in the STORET database are shown in Table 7. The surface water monitoring results found in the STORET database are a compilation of various states' monitoring data. The STORET data does not have strict quality assurance criteria. The maximum concentration of pendimethalin was 17.6 μg/L (ppb) for a surface water sample collected in Ohio; the next highest reported concentration was 10 μg/L with a range of 1-10

μg/L. From the STORET data (excluding the highest Ohio sampling results), the maximum concentrations of pendimethalin in surface water samples range from 0.01 to 3.2 μg/L.

Table 7. Summary of Pendimethalin Detections in STORET database

STATE	MONITORING PERIOD	DETECTIONS/ SAMPLES	MAXIMUM CONCENTRATION -- μg/L --
AR	1995	12/35	0.08
CA	1992-94	20/291	0.30
CO	1993-94	32/92	3.2
CT	1993-94	2/2	0.12
KS	1993	1/1	0.01
LA	1995	2/2	0.06
NE	1992-93	17/71	0.07
OH	1981-87	650/2436	17.6
OR	1992-95	8/64	0.25
PA	1993-95	56/207	0.24
TX	1995	1/1	0.04
WA	1993-94	26/81	0.19
WI	1993-94	16/122	0.05

2. Ecological Toxicity

a. Toxicity to Terrestrial Animals

(1) Birds, Acute and Subacute

An oral (LD_{50}) study (preferably mallard duck 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 acute and subacute toxicity of a pesticide to birds. Results of these tests are tabulated below.

Table 8: Avian Acute Oral Toxicity Findings (LD_{50})

Species	% A.I.	LD_{50} (mg/kg)	Accession No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Mallard Duck	Technical	1,421	00059739 Fink/1976	Slightly toxic	Yes

Table 9: Avian Subacute Dietary Toxicity Findings (LC_{50})

Species	% A.I.	LC_{50} (ppm)	Accession No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Northern Bobwhite Quail	Technical	4,187	00026675 Fink/1973	Slightly toxic	Yes
Mallard Duck	Technical	4,640	00026674 Fink/1973	Slightly toxic	Yes

These results indicate that pendimethalin is slightly toxic to avian species on an acute oral and subacute dietary basis. The guideline requirements (71-1(a) and 71-2(a) & (b)) are fulfilled (Accession No. 00059739, 00026675, 00026674).

(2) Birds, Chronic

Avian reproduction studies using the technical grade of the active ingredient are required because pendimethalin has been shown to have a half-life of 4 days in both field and laboratory studies. It has a high potential to bioaccumulate in fish. Pendimethalin is a widely used agrochemical with up to 25 million pounds per year applied nationwide and may be applied several times per use season on various crops. Therefore, avian reproduction studies are requested for all use sites. An avian chronic hazard assessment cannot be completed without these studies. The guideline (71-4) is not fulfilled.

(3) Mammals

Data from available mammalian studies which are used for human health risk assessment will be used to estimate toxicity to wild mammalian species. A rat acute oral LD_{50} study (81-1,

MRID# 00026657) resulted in an LD_{50} of 1050 mg/kg for female rats and 1250 mg/kg for male rates. These results indicate that pendimethalin is slightly toxic to small mammals on an acute oral basis.

A two-generation rat reproduction study (83-4, MRID # 41725203) reported a reproductive NOEL of 2500 ppm and an LOEL of 5000 ppm.

(4) Insects

A honey bee acute contact LD_{50} study using the technical grade of the active ingredient is required for pendimethalin because of the extensive agricultural use patterns. The result of this test is provided below.

Table 10: Nontarget Insect Acute Contact Toxicity Findings

Species	% A.I.	LD_{50} (μg/bee)	MRID No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Honey Bee	Tech	>49.7	00099890 Atkins/1974	Practically nontoxic	Yes

The results indicate that pendimethalin is practically nontoxic to bees on an acute contact basis. The guideline requirement (141-1) is fulfilled (MRID 00099890).

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 tabulated below.

Table 11: Freshwater Fish Acute Toxicity Findings for Technical Pendimethalin

Species	% A.I.	LC_{50} (ppm)	Accession No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Rainbow trout	93.2	0.138	106764 Sleight/1973	Highly toxic	Yes
Bluegill sunfish	93.2	0.199	106764 Sleight/1973	Highly toxic	Yes
Channel catfish	93.2	0.418	106764 Sleight/1973	Highly toxic	Yes

The results indicate that technical pendimethalin is highly toxic to fish on an acute basis. The guideline requirement (72-1(a) & (c) is fulfilled (Accession No. 106764).

Freshwater fish toxicity studies using a typical end use product were conducted. Results of these tests are tabulated below.

Table 12: Freshwater Fish Acute Toxicity Findings for the Formulated product

Species	% A.I.	LC_{50} (ppm)	Accession No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Rainbow trout	45	0.52	00037927 Bentley/1974	Highly toxic	Yes, for formulation
Bluegill sunfish	45	0.92	00037927 Bentley/1974	Highly toxic	Yes, for formulation
Channel catfish	45	1.9	000251601 Sousa/1983	Moderately toxic	Yes, for formulation

The results indicate that this formulated product of pendimethalin is highly to moderately toxic to fish on an acute basis. The guideline requirement (72-1(b) & (d)) is fulfilled (Accession No. 00037927, 000251601).

(2) Freshwater Fish, Chronic

A fish life-cycle test using the technical grade of the active ingredient is required for pendimethalin because it can be aerially applied, it has extensive use sites, many of which may occur near water bodies and has a halflife of greater than 4 days. The preferred test species is the fathead minnow. Results of this test are tabulated below.

Table 13: Fish Life-Cycle Toxicity Findings

Species	% A.I.	NOEC/LOEC (ppb)	MATC (ppb)	Accession No. Author/Year	Endpoints Affected	Fulfills Guideline Requirement?
Fathead minnow	98.3	6.3/9.8	7.85	00096342 EG&G Bionomics/1975	Egg production reduced at 9.8 ppb; reduced hatch at 22 and 43 ppb.	Yes

The results indicate that reproductive effects to freshwater fish may occur at levels greater than 6.3 ppb (μg/L). The guideline requirement (72-5) is fulfilled (Accession No. 00096342).

(3) Freshwater Invertebrates, Acute

A freshwater aquatic invertebrate toxicity test using the technical grade of the active ingredient 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 14: Freshwater Invertebrate Toxicity for Technical Pendimethalin and the Formulated Product

Species	% A.I.	LC_{50}/EC_{50} (ppm)	Accession No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Daphnia magna	Technical	0.28	FAOPEN05 EG&G Bionomics/1976	Highly toxic	Yes
Daphnia magna	45.6	5.1	260404 Forbis/1985	Moderately toxic	Yes for formulated product
Procambarus simulans Crayfish	94.2	1.0	00099889 ABC Inc./ 1980	Highly toxic	No - supplemental

The results indicate that technical pendimethalin is highly toxic to aquatic invertebrates on an acute basis and a formulated product of pendimethalin is moderately toxic to aquatic invertebrates on an acute basis. The guideline requirement (72-2(a) & (b)) is fulfilled (Accession No. FAOPEN05 & 260404).

(4) Freshwater Invertebrate, Chronic

Data from an aquatic invertebrate life-cycle test using Daphnia magna are required because pendimethalin is toxic to Daphnia magna (EC_{50} of 0.28 ppm), is registered for uses that involve multiple applications and has a halflife of greater than 4 days. Results of this test are tabulated below.

Table 15: Aquatic Invertebrate Life-Cycle Toxicity Findings

Species	% A.I.	NOEC/LOEC (ppb)	MATC (ppb)	Accession No. Author/Year	Endpoints Affected	Fulfills Guideline Requirement?
Daphnia magna	92.2	14.5/35.8	22.78	247299 Gramey/1981	Mean brood size	Yes

The results indicate that aquatic invertebrate reproductive impairment may occur at levels greater than 14.5 ppb (μg/L). The guideline requirement (72-4(b)) is fulfilled (Accession No. 247299).

(5) Estuarine and Marine Animals, Acute

Acute toxicity testing with estuarine and marine organisms (fish, shrimp and oyster embryo-larvae or shell deposition) using the technical grade of the active ingredient is required for pendimethalin because of the extensive agricultural use patterns near estuarine and marine habitats and labeling permits aerial application. Results of these tests are tabulated below.

Table 16: Estuarine/Marine Acute Toxicity Findings for Technical Pendimethalin

Species	% A.I.	LC_{50}/EC_{50} (ppm)	Acc. No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Eastern oyster (embryo-larvae)	92.2	0.210	251601 Ward/1983	Highly toxic	Yes
Sheepshead minnow	92.2	0.707	251601 Ward/1983	Highly toxic	Yes
Pink shrimp	92.2	1.6	251601 Ward/1983	Moderately toxic	Yes

The results indicate that technical pendimethalin is moderately to highly toxic to estuarine/marine organisms on an acute basis. The guideline requirement (Gdln 72-3 (a), (b), & (c)) is fulfilled (Accession No. 251601).

Estuarine/marine toxicity studies using the typical end use product were provided. Results of these tests are tabulated below.

Table 17: Estuarine/Marine Acute Toxicity Findings for Formulated Product
Eastern oyster

Species	% A.I.	LC_{50}/EC_{50} (ppm)	Acc. No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Eastern oyster (embryo-larvae)	45	0.450	251601 Ward/1983	Highly toxic	Yes, for formulation
Sheepshead minnow	45	1.7	251601 Ward/1983	Moderately toxic	Yes, for formulation
Pink shrimp	45	11	251601 Ward/1983	Slightly toxic	Yes, for formulation

The results indicate that this formulated product of pendimethalin is slightly to highly toxic to estuarine/marine organisms on an acute basis. The guideline requirement (Gdln 72-3(d), (e), & (f)) is fulfilled (Accession No. 251601).

c. Toxicity to Plants

(1) Terrestrial

Terrestrial plant testing (seedling emergence and vegetative vigor) is required for pendimethalin because it is volatile (vapor pressure $\geq 1.0 \times 10^{-5}$mm Hg at 25°C), it can be aerially applied and because it may affect endangered plant species which are located near the use areas.

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 the second of which is a root crop, and (2) four species of at least two monocotyledonous families, one of which is corn (Zea mays).

Results of Tier II seedling emergence toxicity testing on the technical material are tabulated below.

Table 18: Nontarget Terrestrial Plant Seedling Emergence Toxicity Findings (Tier II)

Most Sensitive Species	% A.I.	Parameter Affected	NOEC (lbs a.i./A)	EC_{25} (lbs a.i./A)	MRID No. Author/Year	Fulfills Guideline Requirement?
Ryegrass	92.98	Percent emergence	0.02	0.03	42372201 Chetram & Gagne/1992	Yes
		Percent survival	0.02	0.06		
		Phytotoxicity rating	0.02	N/A		
		Plant height	0.01	0.05		
		Plant weight	0.01	0.02		

These results indicate that exposure levels of greater than 0.01 lbs a.i./A may cause significant detrimental effects on certain terrestrial plants. The guideline requirement (123-2) is fulfilled (MRID 42372201).

Results of Tier II seedling germination toxicity testing on the technical material are tabulated below.

Table 19: Nontarget Terrestrial Plant Seedling Germination Toxicity Findings (Tier II)

Most Sensitive Species	% A.I.	NOEC (lbs a.i./A)	EC_{25} (lbs a.i./A)	MRID No. Author/Year	Fulfills Guideline Requirement?
Ryegrass	92.98	0.25	0.82	42372202 White & Gagne/1992	Yes

These results indicate that exposure levels of greater than 0.25 lbs a.i./A may cause significant detrimental effects on the germination of certain terrestrial plants. The guideline requirement (123-2) is fulfilled (MRID 42372202).

Results of Tier II vegetative vigor toxicity testing on the technical material are tabulated below.

Table 20: Nontarget Terrestrial Plant Vegetative Vigor Toxicity Findings (Tier II)

Most Sensitive Species	% A.I.	Parameter Affected	NOEC (lbs a.i./A)	EC_{25} (lbs a.i./A)	MRID No. Author/Year	Fulfills Guideline Requirement?
Ryegrass and lettuce	92.98	Phytotoxicity rating	0.063	N/A	42372203 Canez & Gagne/1992	Yes - classified as supplemental but fulfills guideline requirement
Onion		Percent survival	1.0	1.4		
Ryegrass		Plant height	0.063	0.10		
Ryegrass		Plant dry weight	< .035	0.035		

These results indicate that exposure levels of greater than 0.063 lbs a.i./A may cause significant detrimental effects on the vigor of certain terrestrial plants. The guideline requirement (123-2) is fulfilled (MRID 42372203).

(2) Aquatic

Aquatic plant testing is required for pendimethalin. Results of Tier II toxicity testing on the technical material are tabulated below.

Table 21: 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*	92.98	5.8	3.2	42372206 Hughes et al/1992	Yes
Duckweed *Lemna gibba*	92.98	12.5	5.6	42137101 Hughes et al/1991	Yes
Green algae *Selenastrum capricornutum*	92.98	5.4	3.0	42372204 Hughes et al/1992	Yes
Marine diatom *Skeletonema costatum*	92.98	5.2	0.7	42372205 Hughes et al/1992	Yes
Blue-green algae *Anabaena flos-aquae*	92.98	> 174	98	42372207 Hughes et al/1992	Yes

These results indicate that exposure levels of greater than 0.7 ppb (μg/L) of pendimethalin may

cause detrimental effects to the growth and reproduction of certain aquatic plant species. The guideline requirement (123-2) is fulfilled (MRID 42372206, 42137101, 42372204, 42372205, 42372207).

3. Exposure and Risk Assessment

a. Ecological Exposure and Risk Assessment

Explanation of the Risk Quotient (RQ) and the Level of Concern (LOC): The Levels of Concern are criteria used to indicate potential risk to nontarget organisms. The criteria indicate that a chemical, when used as directed, has the potential to cause undesirable effects on nontarget organisms. There are two general categories of LOC (acute and chronic) for each of the four nontarget faunal groups and one category (acute) for each of two nontarget floral groups. In order to determine if an LOC has been exceeded, a risk quotient must be derived and compared to the LOC's. A risk quotient is calculated by dividing an appropriate exposure estimate, e.g. the estimated environmental concentration (EEC), by an appropriate toxicity test effect level, e.g. the LC_{50}. The acute effect levels typically are:

-EC_{25} (terrestrial plants),
-EC_{50} (aquatic plants and invertebrates),
-LC_{50} (fish and birds), and
-LD_{50} (birds and mammals)

The chronic test results are the:

-NOEL (sometimes referred to as the NOEC) for avian and mammal reproduction studies, and either the NOEL for chronic aquatic studies, or the Maximum Allowable Toxicant Concentration (MATC) which is the geometric mean of the NOEL and the LOEL (sometimes referred to as the LOEC) for chronic aquatic studies.

When the risk quotient exceeds the LOC for a particular category, risk to that particular category is presumed to exist. Risk presumptions are presented along with the corresponding LOC's.

Levels of Concern (LOC) and associated Risk Presumption

Mammals, Birds

IF THE	LOC	PRESUMPTION
acute RQ>	0.5	Potentially high acute risk
acute RQ>	0.2	Risk that may be mitigated through restricted use
acute RQ>	0.1	Endangered species may be affected acutely
chronic RQ>	1	Chronic risk, endangered species may be affected chronically,

Fish, Aquatic invertebrates

IF THE	LOC	PRESUMPTION
acute RQ>	0.5	Potentially high acute risk
acute RQ>	0.1	Risk that may be mitigated through restricted use
acute RQ>	0.05	Endangered species may be affected acutely
chronic RQ>	1	Chronic risk, endangered species may be affected chronically

Plants

IF THE	LOC	PRESUMPTION
RQ>	1	Potentially high risk
RQ (using the NOEC or EC05) >	1	Endangered plants may be affected

Currently, there are no separate criteria for restricted use or chronic effects for plants.

Pendimethalin use patterns addressed in risk assessment: Pendimethalin is used on a wide variety of agricultural crops as well as many non-agricultural use sites. The following application rates and use patterns were assessed. These were based on labels and registrant information:

Terrestrial Animals and Terrestrial and Semi-aquatic Plants: The majority of use sites have a maximum use rate of 2.0 lbs ai/A or less. This includes such sites as corn, cotton, beans, grain sorghum, peanuts (1 lb ai/A), soybeans, rice (1 lb ai/A) and some others. These use sites make up over 90% of pendimethalin usage based on pounds applied annually. Risk based on this rate is considered to be typical for pendimethalin. However, there are some use sites that have higher single application rates and higher maximum seasonal rates. Although these make up less than 10% of pendimethalin usage, they still represent several million pounds of ai applied annually. These include:

Turf (max. single = 3 lb ai/A, max. seasonal = 5 lbs ai/A),
Onions (max. single = 2 lbs ai/A, max. seasonal = 6 lbs ai/A),
Sugarcane (max. single = 4 lbs ai/A, max. seasonal = 6 lbs ai/A) and
Ornamentals, landscape sites, non-cropland and alfalfa grown for seed (max. single = 4 lbs ai/A, max. seasonal = 4 lbs ai/A).

Aquatic Animals and Plants: Aquatic EECs were calculated using GENEEC for the following use rates and patterns

1) 1.0 lb ai/A - typical application rate applied once on a variety of agricultural crops including cotton, corn, and soybeans, both ground and aerial,

2) 2.0 lbs ai/A - maximum single application rate for cotton, soybeans, corn and other use patterns having a maximum application rate of 2 lbs ai/A, both ground and aerial,

3) 1.0 lbs ai/A - typical application rate for cotton, applied twice, with a two week application interval, both ground and aerial application,

4) 4 lbs ai/A for alfalfa grown for seed and sugarcane, applied once per season, both ground and aerial application, and

5) 2 lbs ai/A for onions applied 3 times per season at two week intervals, both ground and aerial application.

Aquatic EEC's were not estimated for rice (1.0 lb ai/A), turf, ornamental, landscape & grounds maintenance, non-cropland, and nonbearing nuts and vines (use rates of 3 and 4 lbs ai/A, ground application only). GENEEC is a model designed specifically to model runoff from certain agricultural fields and the risk assessment team did not consider it appropriate for sites such as these. It is assumed, for assessment purposes, that exposure from these use patterns would not be higher than exposure from other uses where GENEEC was used to estimate exposure. Exposure from the rice use is not expected to be greater than from the cotton use at 1.0 lb ai/A. Rationale for this is provided in Section 4 Environmental Risk Characterization.

(1) Exposure and Risk to Nontarget Terrestrial Animals

(a) Birds

Residues found on dietary food items following application are compared to LC_{50} values to predict hazard to birds. Day 0 residues on vegetation were estimated based on the work of Hoerger and Kenaga (1972) as modified by Fletcher et al. (1994) for application rates of 4.0 lbs, 3.0 lbs and 2.0 lbs ai/A. For cotton (1.0 lb ai/A), the highest (peak) residues after the second application were estimated using a computerized dissipation program that calculates daily estimated residues after repeated applications and first-order dissipation kinetics at an assumed rate. The use rate per application is 1.0 lb ai/A with an between application interval of two

weeks (14 days), during which time the residues from the first application would partially degrade. The aqueous photolysis half-life of 21 days was used to estimate the degradation of pendimethalin on vegetation.

The predicted 0 day maximum of pendimethalin that may be expected to occur on different avian food items following various applications of pendimethalin, and their corresponding risk quotients, are presented in the table below:

Table 22: Estimated Environmental Concentrations and Dietary Risk Quotients for Birds (Based on an LC_{50} = 4,187 ppm)

Food items	EEC - ppm 4.0 lbs ai/A	RQ Acute	EEC - ppm 3.0 lbs ai/A	RQ Acute	EEC - ppm 2.0 lbs ai/A	RQ Acute	EEC - ppm 1.0 lbs a.i./A	RQ Acute
Short Grasses	960	0.2	720	0.2	480	0.1	391	<0.1
Long Grasses	440	0.1	330	0.08	220	<0.1	180	<0.1
Broadleaf Plants and insects	540	0.1	405	0.1	270	<0.1	220	<0.1
Fruits and pods	60	<0.1	45	<0.1	30	<0.1	24	<0.1

Pendimethalin has low acute toxicity to birds, therefore, the risk quotients are small. The LOC for endangered species (0.1) has been slightly exceeded for the turf use (3.0 application rate) and smaller acreage use sites (4.0 lbs ai/A). Therefore, a may effect for endangered species, specifically grazers, has been identified. The risk quotients at 3.0 and 4.0 lbs ai/A are approximate to the restricted use LOC (0.2). However, the use of pendimethalin is expected to pose minimal overall acute risk to avian species, as further described in Section 4 Environmental Risk Characterization.

Chronic risk to avian species cannot be determined at this time due to lack of data.

(b) Mammals

Mammals are assumed to be exposed to dietary residues similar to birds. The EEC's calculated in Table 22 will be used to estimate exposure to mammals.

Small mammal acute risk is usually addressed using acute oral LD_{50} values converted to estimate an LC_{50} value for comparison with dietary exposure. However, in the case of pendimethalin, it was determined that the 2-generation reproductive toxicity study with rats which reported no mortality at 2500 ppm (NOEL for acute and subacute effects) was a better indicator of potential for acute toxicity from dietary exposure. The maximum estimated concentration on mammalian food items is 960 ppm. Because the maximum EEC is much less than the NOEL, where no effects, either sublethal or lethal, occurred, it is unlikely that mammals, including endangered

mammal species, would be exposed to enough pendimethalin to cause adverse effects.

Based on the same 2-generation reproductive toxicity study in rats minimal chronic risk to mammalian species, including endangered species, is expected. The NOEL of 2500 ppm is much higher than the maximum EEC of 960 ppm.

(c) **Insects**

Pendimethalin is practically non-toxic to honeybees. Honeybees are not likely to be adversely affected by the use of pendimethalin.

(2) **Exposure and Risk to Nontarget Aquatic Animals**

Expected Aquatic Concentrations: EFED calculated Generic Estimated Environmental Concentrations (GEECs) for pendimethalin application to a variety of crops at several different rates and application patterns. These GEECs are designed as a coarse screen and depends on basic chemical parameters and pesticide label application information. The GENeric Expected Environmental Concentration Program (GENEEC) which was used to calculate the GEECs is a Tier I model which uses a chemical's soil/water partition coefficient and degradation half-life values to estimate runoff from a ten hectare field into a one hectare by two meter deep pond. GENEEC was designed to specifically model runoff from agricultural fields.

GENEEC calculates both acute and chronic generic EEC values. It considers reduction in dissolved pesticide concentration due to adsorption of pesticide to soil or sediment, incorporation, degradation in soil before washoff to a water body, direct deposition of spray drift into the water body, and degradation of the pesticide within the water body. Review of the Spray Drift Task Force data has not been completed, so spray drift is assumed to be 1% of the application rate for ground applications and 5% of the application rate for aerial applications.

The following values were used for input into the GENEEC program:

Soil organic carbon partitioning coefficient:	7011
Soil aerobic metabolic half-life	172 days
Hydrolysis half-life:	Stable
Photolysis half-life:	Stable
Aquatic aerobic metabolic half-life	Stable

Water solubility: 375 ppb

Table 23: Generic EECs for Pendimethalin

Crop	Application Method	Application Rate in lbs a.i./A (number of apps.)	Peak EEC (ppb)	4-day EEC (ppb)	21-day EEC (ppb)	56-day EEC (ppb)
Soybeans, Cotton, Corn	Broadcast - ground	1.0 (1) typical rate	3	3	2	1
Soybeans, Cotton, Corn	Aerial	1.0 (1) typical rate	5	4	2	1
Soybeans, Cotton, Corn	Broadcast - ground	2.0 (1) maximum rate	7	6	3	2
Soybeans, Cotton, Corn	Aerial	2.0 (1) maximum rate	10	8	4	3
Cotton	Broadcast - ground	1.0 (2) typical rate - 2 week application interval	7	6	3	2
Cotton	Aerial	1.0 (2) typical rate - 2 week application interval	10	9	5	3
Sugarcane, Alfalfa (grown for seed)	Broadcast-ground	4.0 (1) maximum rate	13	12	6	4
Sugarcane, Alfalfa (grown for seed)	Aerial	4.0 (1) maximum rate	19	17	9	5
Onions	Broadcast - ground	2.0 (3) maximum rate - 2 week application interval	20	17	9	6
Onions	Aerial	2.0 (3) maximum rate - 2 week application interval	31	27	14	9

Peak exposure levels range from 3 to 31 ppb (μg/L), with 56-day average values ranging from 1 to 9 ppb (μg/L).

Since one application at 2.0 lbs ai/A yielded essentially the same GEEC as that from two applications at 1.0 lb ai/A, both of these scenarios will be combined in the risk quotient tables.

(a) Freshwater Fish

Table 24: Acute Risk Quotients (RQ) for Freshwater Fish based on Testing with Technical Pendimethalin

Crop and application method	Application Rate in lbs a.i./A (number of apps.)	Peak EEC (ppb)	Species	96 hour LC_{50} (ppb)	Acute RQ
Soybeans, Cotton and Corn - ground	1.0 (1) - typical	3	Rainbow trout	138	0.02
Soybeans, Cotton and Corn - aerial	1.0 (1) - typical	5			0.04
Soybeans, Cotton and Corn - ground	2.0 (1) - maximum rate	7			0.05
Soybeans, Cotton and Corn - aerial	2.0 (1) - maximum rate	10			**0.07**
Sugarcane, Alfalfa - ground	4.0 (1) - maximum rate	13			**0.09**
Sugarcane, Alfalfa - aerial	4.0 (1) - maximum rate	19			**0.14**
Onions - ground	2.0 (3) - maximum rate 14 day appl. interval	20			**0.14**
Onions - aerial	2.0 (3) - maximum rate 14 day appl. interval	31			**0.22**

Acute

The majority of pendimethalin use is represented by the 1.0 and 2.0 lb ai/A application rates. At the typical rate of 1.0 lb ai/A, no LOCs are exceeded. This suggests fish are not typically at acute risk from pendimethalin.

When using maximum application rates, all use patterns except 2.0 lbs ai/A, ground application, result in acute risk quotients for fish that exceed the endangered species LOC (0.05). Thus pendimethalin may affect endangered fish species under there conditions.

Use patterns involving higher application rates such as sugarcane and alfalfa and onions result in acute risk quotients for fish that exceed the restricted use LOC (0.1) by a small margin.

The EFED assumes that aquatic risk from turf (1.5 to 3.0 lbs ai/A, label indicates ground application only) and landscaping, ornamentals and non-cropland (2.0 to 4.0 lbs ai/A, label indicates ground application only) is not higher that risk from other "ground application" use patterns with similar application rates. Therefore, it is assumed turf, landscaping, ornamentals and noncropland could effect endangered fish species but would not exceed the restricted use LOC.

Aquatic EEC's were not estimated for rice since GENEEC was not designed to estimate aquatic exposure from this use pattern. Aquatic risk from rice (1.0 lb ai/A) is expected to be less than from the cotton use at 1.0 lb ai/acre as discussed in the Environmental Risk Characterization

Section.

None of the use patterns for pendimethalin result in acute risk quotients for fish that exceed 0.5. Thus, high acute risk to fish is unlikely.

Chronic

Based on the MATC from the fathead minnow full life-cycle study (7.85 ppb (μg/L)) and the 56-day average GEECs, most use sites represent minimal chronic risk to fish.

The 56-day average GEEC for *Onions* (4.0 lbs ai/acre, aerial), 9 ppb (μg/L), exceeds the MATC by a small margin indicating potential for chronic risk to fish.

Turf, landscape, ornamental, non-cropland and rice uses are expected to result in minimal chronic risk to fish.

(b) Freshwater Invertebrates

Table 25: Acute Risk Quotients (RQ) for Freshwater Aquatic Invertebrates based on Testing with Technical Pendimethalin

Crop and application method	Application Rate in lbs a.i./A (number of apps.)	Peak EEC (ppb)	Species	96 hour LC_{50} (ppb)	Acute RQ
Soybeans, Cotton and Corn - ground	1.0 (1) - typical rate	3	*Daphnia magna*	280	0.01
Soybeans, Cotton and Corn - aerial	1.0 (1) - typical rate	5			0.02
Soybeans, Cotton and Corn - ground	2.0 (1) - maximum rate	7			0.02
Soybeans, Cotton and Corn - aerial	2.0 (1) - maximum rate	10			0.04
Sugarcane, Alfalfa - ground	4.0 (1) - maximum rate	13			0.05
Sugarcane, Alfalfa - aerial	4.0 (1) - maximum rate	19			0.07
Onions - ground	2.0 (3) - maximum rate 14 day appl. interval	20			0.07
Onions - aerial	2.0 (3) - maximum rate 14 day appl. interval	31			0.11

Acute

Use patterns such as cotton, corn and soybeans involving an application rate of 1.0 to 2.0 lbs ai/A (aerial or ground) do not result in acute risk quotients for aquatic invertebrates that exceed any LOCs. These use patterns represent minimal acute risk to aquatic invertebrates.

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Sugarcane and alfalfa, when treated by aerial equipment at 4 lbs ai/A and onions when treated three times at 2.0 lbs ai/A result in acute risk quotients for aquatic invertebrates that exceed the endangered species LOC (0.05) by a small margin.

Aerial application to onions (three times at 2.0 lbs ai/A) results in acute risk that exceeds the restricted use LOC (0.1) by a small margin.

The EFED assumes that aquatic risk from turf (1.5 to 3.0 lbs ai/A, label indicates ground application only) and ornamentals and non-cropland (2.0 to 4.0 lbs ai/A, label indicates ground application only) is not greater than risk from other use patterns with similar application rates. Therefore, it is assumed these use patterns may effect endangered aquatic invertebrates but would not be expected to exceed the restricted use LOC.

Aquatic EEC's were not estimated for rice since GENEEC was not designed to estimate aquatic exposure from this use pattern. Aquatic risk from rice (1.0 lb ai/A) is expected to be less than from the cotton use at 1.0 lb ai/A as discussed in the Environmental Risk Characterization Section. The rice use does not exceed the aquatic invertebrate endangered species LOC.

None of the use patterns for pendimethalin result in acute risk quotients that exceed 0.5. Thus high acute risk to aquatic invertebrates is unlikely.

Chronic

Based on the aquatic invertebrate MATC from the *Daphnia magna* life-cycle study (23 ppb (μg/L)) and 21-day average Generic EECs, the use of pendimethalin represents minimal chronic risk to aquatic invertebrates.

Turf, landscape, ornamental, non-cropland, and rice uses are expected to result in minimal chronic risk to aquatic invertebrates.

(c) Estuarine and Marine Animals

Table 26: Acute Risk Quotients (RQ) for Eastern Oyster based on Testing with Technical Pendimethalin

Crop and application method	Application Rate in lbs a.i./A (number of apps.)	Peak EEC (ppb)	Species	48-hour EC_{50} (ppb)	Acute RQ
Soybeans, Cotton and Corn - ground	1.0 (1) - typical rate	3	Eastern oyster	210	0.01
Soybeans, Cotton and Corn - aerial	1.0 (1) - typical rate	4			0.02
Soybeans, Cotton and Corn - ground	2.0 (1) - maximum rate	7			0.03
Soybeans, Cotton and Corn - aerial	2.0 (1) - maximum rate	10			0.05
Sugarcane, Alfalfa - ground	4.0 (1) - maximum rate	13			0.06
Sugarcane, Alfalfa - aerial	4.0 (1) - maximum rate	19			0.09
Onions - ground	2.0 (3) - maximum rate 14 day appl. interval	20			0.09
Onions - aerial	2.0 (3) - maximum rate 14 day appl. interval	31			0.14

Acute

Risk quotients shown are only for the eastern oyster, which had the lowest EC50 of the three estuarine species tested. Risk quotients using the acute toxicity for shrimp and fish would not have exceeded any LOCs. Minimal acute risk to **shrimp** and **estuarine fish** is expected from all pendimethalin uses.

Use patterns such as cotton, corn and soybeans involving an application rate of 1.0 to 2.0 lbs ai/A (aerial or ground) do not result in risk quotients for oysters that exceeds any LOCs. These use patterns represent minimal acute risk to estuarine species.

Sugarcane and alfalfa, when treated by air at 4 lbs ai/A and onions when treated three times at 2.0 lbs ai/A result in acute risk quotients for oysters that exceed the endangered species LOC (0.05) by a small margin.

Aerial application to onions (three times at 2.0 lbs ai/A) results in acute risk quotients that exceed the restricted use LOC (0.1) by a small margin.

The EFED assumes that aquatic risk from turf (1.5 to 3.0 lbs ai/A, label indicates ground application only) and ornamentals and non-cropland (2.0 to 4.0 lbs ai/A, label indicates ground application only) is not greater than risk from other use patterns with similar application rates. Therefore, these use patterns may effect endangered mollusk species but would not be expected to exceed the restricted use LOC.

Aquatic EEC's were not estimated for rice since GENEEC was not designed to estimate aquatic exposure from this use pattern. Aquatic risk from rice (1.0 lb ai/A) is expected to be less than from the cotton use at 1.0 lb ai/A as discussed in the Environmental Risk Characterization Section.

None of the use patterns for pendimethalin result in acute risk quotients that exceed 0.5. Thus high acute risk to estuarine fish or invertebrates is unlikely.

Chronic

No chronic data with estuarine species were reviewed.

(3) Exposure and Risk to Nontarget Plants

(a) Terrestrial and Semi-Aquatic

EFED does separate risk assessments for nontarget terrestrial and semi-aquatic plants. Nontarget terrestrial plants inhabit non-aquatic areas which are generally well drained. Nontarget semi-aquatic plants inhabit low-lying areas that are usually wet, although they may be dry during certain times of the year. Semi-aquatic plants are not obligatory aquatic plants in that they do not live in a continuously aquatic environment. Both the terrestrial and semi-aquatic plants are exposed to pesticides from runoff and drift. They differ, however, in that terrestrial plants are assumed to be exposed via sheet runoff, whereas semi-aquatic plants are assumed to be exposed via channelized runoff. Calculating runoff exposure is done using a simple model which assumes that a certain percent of that which is applied transports with run off. The percent is based on solubility. Since the solubility is 0.375 ppm, it is assumed no more than 1% of the applied pendimethalin would runoff. Drift from aerial applications is assumed to be 5%, while drift from ground applications would not be expected to exceed 1% of the applied.

Volatilization is also a potential route of exposure, however ecological risk assessment techniques are not currently available to determine risk from such exposure.

Nonendangered Terrestrial and Semi-aquatic Plants

Risk quotients for terrestrial and semi-aquatic plants are derived by dividing an exposure estimate, in lb ai/A, by an EC_{25}, also expressed in lb ai/A. The total loading rate (runoff plus spray drift) is used with the EC_{25} of the most sensitive species in the seedling emergence study to determine the risk quotient for exposure to emerging seedlings. The loading from spray drift alone is used with the EC_{25} value of the most sensitive species in the vegetative vigor study to determine the risk to adult plants from foliar exposure.

The following table outlines the acute risk quotients to terrestrial and semi-aquatic plants using results from toxicity testing with technical pendimethalin.

Table 27: Exposure and Risk Quotients for Terrestrial and Semi-aquatic Plants

Application scenario & rate	Plant type	Exposure scenario	Exposure (lb ai/A)	EC_{25} (lb ai/A)	Risk Quotient
Ground, 2.0 lb ai/A (corn, soybeans and cotton, onions*)	Terrestrial	Sheet runoff + spray drift (1%)	0.04	0.02 (seedling emergence)	2
	Semi-aquatic	Channelized runoff + spray drift (1 %)	0.22	0.02 (seedling emergence)	11
	Terrestrial & semi-aquatic	Spray drift (1%)	0.02	0.035 (veg. vigor)	<1
Aerial, 2.0 lb ai/A (corn, soybeans and cotton, onions*)	Terrestrial	Sheet runoff + spray drift (5%)	0.12	0.02 (seedling emergence)	6
	Semi-aquatic	Channelized runoff + spray drift (5 %)	0.30	0.02 (seedling emergence)	15
	Terrestrial & semi-aquatic	Spray drift (5%)	0.10	0.035 (veg. vigor)	2.8
Ground, 3 lb ai/A (turf)	Terrestrial	Sheet runoff + spray drift (1%)	0.06	0.02 (seedling emergence)	3
	Semi-aquatic	Channelized runoff + spray drift (1 %)	0.33	0.02 (seedling emergence)	16.5
	Terrestrial & semi-aquatic	Spray drift (1%)	0.03	0.035 (veg. vigor)	<1
Ground, 4 lb ai/A (Ornamentals, landscape sites, non-cropland, nonbearing nuts and vines, alfalfa grown for seed, sugarcane)	Terrestrial	Sheet runoff + spray drift (1%)	0.08	0.02 (seedling emergence)	4
	Semi-aquatic	Channelized runoff + spray drift (1 %)	0.44	0.02 (seedling emergence)	22
	Terrestrial & semi-aquatic	Spray drift (1%)	0.04	0.035 (veg. vigor)	1
Aerial, 4 lb ai/A (alfalfa grown for seed, sugarcane)	Terrestrial	Sheet runoff + spray drift (5%)	0.24	0.02 (seedling emergence)	12
	Semi-aquatic	Channelized runoff + spray drift (5 %)	0.60	0.02 (seedling emergence)	30
	Terrestrial & semi-aquatic	Spray drift (5%)	0.20	0.035 (veg. vigor)	6

*Cotton and onion use involves multiple applications, however, the model used to estimate exposure does not handle multiple applications well. It is expected that the risk numbers could be higher with more applications at 2 lbs ai/A.

The LOC (1) for risk to terrestrial and semi-aquatic plant species has been exceeded for both ground and aerial application. This indicates that pendimethalin poses a risk to the vegetative vigor and emergence of nontarget terrestrial and semi-aquatic plants.

Endangered Terrestrial and Semi-aquatic Plants

Risk quotients for endangered terrestrial and semi-aquatic plants are derived by dividing an exposure estimate, in lb ai/A, by an NOEC, also expressed in lb ai/A. The lowest NOEC for terrestrial plants is 0.01 lb ai/A (ryegrass, seedling emergence). The risk quotients for endangered plants based on this NOEC compared to the range of exposures predicted would be from 4 to 60. This indicates that pendimethalin may affect threatened and endangered terrestrial and semi-aquatic plants.

b. Aquatic Plants

The same aquatic exposure values used to estimate risk to fish and invertebrates will be used to estimate risk to aquatic plants.

Nonendangered Aquatic Plants

Risk quotients for nonendangered plants are calculated for aquatic plants by dividing the GEEC by the aquatic plant EC_{50} values. A risk quotient for aquatic vascular plants is based on the EC_{50} of 12.5 ppb (μg/L) for duckweed (*Lemna gibba*). A risk quotient for nonvascular aquatic plants is based on the most sensitive algal or diatom species tested. For pendimethalin, the most sensitive nonvascular plant tested was the marine diatom *Skeletonema costatum* with an EC50 of 5.2 ppb (μg/L).

The following table outlines the risk quotients for nonendangered aquatic plants using results from toxicity testing with technical pendimethalin.

Table 28: Risk Quotients (RQ) for Vascular Aquatic Plants

Crop and application method	Application Rate in lbs a.i./A (number of apps.)	Peak EEC (ppb)	Species	EC_{50} (ppb) [NOEC]	RQs [End Spec]
Soybeans, Cotton and Corn - ground	1.0 (1) - typical rate	3	*Lemna gibba*	12.5 [5.6]	0.2 [0.5]
Soybeans, Cotton and Corn - aerial	1.0 (1) - typical rate	5			0.4 [0.9]
Soybeans, Cotton and Corn - ground	2.0 (1) - maximum rate	7			0.6 [1.2]
Soybeans, Cotton and Corn - aerial	2.0 (1) - maximum rate	10			0.8 [1.8]
Sugarcane, Alfalfa - ground	4.0 (1) - maximum rate	13			1.0 [2.3]
Sugarcane, Alfalfa - aerial	4.0 (1) - maximum rate	19			1.5 [3.4]
Onions - ground	2.0 (3) - maximum rate 14 day appl. interval	20			1.5 [3.6]
Onions - aerial	2.0 (3) - maximum rate 14 day appl. interval	31			2.5 [5.5]

Table 29: Risk Quotients (RQ) for non-vascular plants (representing algae and diatoms)

Crop and application method	Application Rate in lbs a.i./A (number of apps.)	Peak EEC (ppb)	Species	EC_{50} (ppb) [NOEC]	RQs [End Spec]
Soybeans, Cotton and Corn - ground	1.0 (1) - typical rate	3	*Skeletonema costatum*	5.2 [0.7]	0.6 [4.3]
Soybeans, Cotton and Corn - aerial	1.0 (1) - typical rate	5			0.1 [7.1]
Soybeans, Cotton and Corn - ground	2.0 (1) - maximum rate	7			1.3 [10.0]
Soybeans, Cotton and Corn - aerial	2.0 (1) - maximum rate	10			2.0 [14.3]
Sugarcane, Alfalfa - ground	4.0 (1) - maximum rate	13			2.5 [18.6]
Sugarcane, Alfalfa - aerial	4.0 (1) - maximum rate	19			3.6 [27.1]
Onions - ground	2.0 (3) - maximum rate 14 day appl. interval	20			3.8 [28.6]
Onions - aerial	2.0 (3) - maximum rate 14 day appl. interval	31			6.0 [44.3]

Typical application rates for many of the large acreage crops for which pendimethalin is registered do not represent a risk to aquatic plants. However, uses of pendimethalin at maximum rates are expected to result in risk to aquatic plants for all sites.

Endangered Aquatic Plants

Risk quotients for endangered aquatic plants are calculated dividing the GEEC by the aquatic plant NOEC or EC05 values. Risk quotients for endangered aquatic vascular plants are based on the NOEC of 5.6 ppb (μg/L) for duckweed (*Lemna gibba*) and the NOEC of 0.7 for *Skeletonema costatum*. The risk quotients for endangered aquatic plants range from less than 1 (*L. gibba*, soybeans, cotton and corn, 1.0 lbs ai/A, ground) to a high of 44 (*S. costatum*, onions, three applications of 2 lbs ai/A, aerial). All uses of pendimethalin may affect endangered aquatic plants.

(4) Endangered Species

The use of pendimethalin may adversely effect endangered species of terrestrial and semi-aquatic plants, aquatic plants and invertebrates including mollusks, fish, and birds (specifically grazers).

When the Endangered Species Protection Program becomes final, limitations in the use of

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

4. Environmental Risk Characterization

Introduction:

Pendimethalin is a dinitroaniline herbicide registered for use on annual grasses and broadleaf weeds in terrestrial food crop and terrestrial non-food crop use groups. It is a cell growth inhibitor that prevents seedling development and is herbicidally active on the roots and coleoptiles of susceptible weeds. Pendimethalin does not control weeds postemergence and must be soil applied. Formulations include a 3.3 emulsifiable concentrate, a 4.0 emulsifiable concentrate, a 60DG water dispersible granule, and a fertilizer formulation. Application rates range from 1.0 to 4.0 lbs ai/A. Total pendimethalin use ranges from 14 to 25 million pounds active ingredient annually, with the largest usage occurring on soybeans, cotton, and corn.

Summary of Conclusions:

o Pendimethalin dissipates in the environment by binding to soil, microbially-mediated metabolism and volatilization. It is essentially immobile in soil. Although pendimethalin has been detected in ground water (at very low levels), the potential for ground water contamination from pendimethalin residues is low.

o Based on laboratory studies and limited field study information, pendimethalin is slightly to moderately persistent in aerobic soil environments. Persistence decreases with increased temperature, increased moisture and decreased soil organic carbon.

o Pendimethalin may contaminate surface water from spray drift associated with aerial and ground spray application, or in runoff from rainfall events and through irrigation waters (chemigation). However, the high affinity for pendimethalin to bind to soil and sediment particles should limit concentrations of pendimethalin in surface waters.

o Additional terrestrial field dissipation studies for major pendimethalin uses (cotton and soybeans) are requested to fully characterize the fate of pendimethalin.

o Pendimethalin would not represent a high acute risk to birds or a high acute or chronic risk to mammals. The chronic risk to birds could not be determined because avian reproduction studies have not been submitted. These studies are requested.

o Chronic risk LOCs for fish were exceeded by a small margin. But it is presumed that overall, pendimethalin does not represent a high risk to aquatic animals and plants, including estuarine organisms.

o The use of pendimethalin may adversely effect endangered species of terrestrial and semi-aquatic plants, aquatic plants and invertebrates including mollusks, fish, and birds (specifically grazers).

o The risk to nontarget terrestrial and semi-aquatic plants is expected to be moderate. However any impact to floral communities, should it occur, could be extensive because of the high poundage used.

o After evaluating all the data, EFED believes that pendimethalin poses the greatest risk to endangered nontarget organisms and terrestrial and semi-aquatic plants as discussed above, however, this risk is expected to be less than the risk from other herbicides.

Environmental Fate and Water Resources:

Pendimethalin dissipates in the environment by binding to soil, microbially-mediated metabolism, and volatilization. Persistence decreases with increased temperature, increased moisture and decreased soil organic carbon. Pendimethalin forms many minor (< 10% of applied) degradates. Residues are tightly bound to soil particles and in aquatic environments, pendimethalin and its degradates are primarily associated with the sediment and not the aqueous phase. Pendimethalin accumulates readily in bluegill sunfish, however, depuration is also rapid. Field dissipation studies on the major use sites (cotton and soybeans) that would more clearly describe the environmental fate of pendimethalin in the field have not been submitted and are requested. The purpose of these studies is to determine the dissipation routes of pendimethalin and the potential for off site effects from its use.

Pendimethalin may contaminate surface water from spray drift associated with aerial and ground spray application, or in runoff from rainfall events and through irrigation waters (chemigation). Pendimethalin is not regulated under the Safe Drinking Water Act (SDWA), therefore, an MCL has not been established for it. Pendimethalin has been classified as a Group C nonquantifiable carcinogen by the HED Carcinogenicity Peer Review Committee (RCAB risk assessment summary, 1/17/96). Pendimethalin has been detected in surface water samples at concentrations of <0.01 ppb (μg/L) to approximately 3 ppb (μg/L), and two additional higher values of 10 and 17.6 ppb (μg/L). The high affinity for pendimethalin to bind to soil and sediment particles, should limit concentrations of pendimethalin in surface waters.

The high Kd and Koc values demonstrate that pendimethalin will bind strongly to soil organic matter and is not mobile. EFED concludes that pendimethalin has a low potential to leach to ground water in most soils. Pendimethalin has a history of high use over a wide geographic area on several major crops, however the number of reported detections in ground water is small and the concentrations are relatively low. Pendimethalin residues in drinking water do not appear

to be a human health concern. Pendimethalin residues originating from ground water also do not appear to be a concern to organisms such as aquatic plant, terrestrial plants, birds, fish and most aquatic invertebrates. The potential for ground water contamination from pendimethalin residues is low and the potential risk from residues in drinking water is low.

Risk to Nontarget Species:

According to the registrant, the typical application rate for the major uses of pendimehtalin is 2 lbs ai/A. Except for the avian chronic risk which could not be determined, generally at this rate there is expected to be minimal acute risk to birds, minimal acute and chronic risk to fish and aquatic invertebrates, minimal acute risk to estuarine organisms and moderate risk to plants. Use rates higher than 2 lb ai/A are less than 10% or 2,000,000 lbs of pendimethalin total usage. These use rates did result in some LOC exceedances.

Birds: The *acute* risk to birds from pendimethalin is low. The risk quotients (RQs) do not exceed the levels of concern (LOCs) for potentially high acute risk or restricted use. The avian endangered species LOC has been slightly exceeded for the turf and other uses with application rates of 3.0 lbs ai/A or higher. The slight exceedance (RQ of 0.2 compared to LOC of 0.1) was based on the maximum residues from the application rates of 3.0 and 4.0 lbs ai/A on short grasses. The species that may be affected would be primarily grazers (e.g. geese).

According to the registrant, the typical application rate for most usages of pendimethalin is 2 lbs ai/A. The avian acute RQs from this rate does not exceed any LOCs. Thus the typical usage of pendimethalin is considered to represent minimal acute risk to birds.

Chronic risk to avian species cannot be determined because avian reproduction studies have not been submitted. Avian reproduction studies (preferably with the bobwhite quail and the mallard duck) are requested.

Mammals: Both the *acute* and *chronic* risk to mammals, including endangered species, is expected to be minimal. In a 2-generation reproductive toxicity study in rats a NOEL of 2500 ppm was reported. This NOEL is much higher than the maximum EEC of 960 ppm, therefore, it is unlikely that animals would be exposed to pendimethalin residues high enough to cause adverse effects.

Fish and Aquatic Invertebrates: The overall risk to nontarget aquatic animals from pendimethalin is low.

Fish: The LOC for *acute* effects to endangered freshwater fish species was equalled, or exceeded by small margins, by all use sites that are treated aerially at 2 lbs ai/A or higher (RQs ranged from 0.05 to 0.22 compared to the LOC of 0.05), indicating a possibility of effects. All use sites with applications greater than 2.0 lbs ai/A would exceed the endangered fish LOC. A single ground application of pendimethalin at 2 lbs ai/A or lower would not exceed any LOCs and represents minimal acute risk to fish. Application to rice (1.0 lb ai/A) by either air or

ground would not exceed any fish LOCs.

Application to onions (three time at 2 lbs ai/A) by air results in RQs that exceeds the restricted use LOC for fish.

The *chronic* risk LOC for fish was exceeded by a small margin (RQ of 1.1 compared to the LOC of 1) by aerial use of pendimethalin on onions. This exceedance was based the 56-day average GEEC of 9 ppb (μg/L). Pendimethalin use on onions is considered to represent a low chronic risk to fish. All other use patterns represent minimal chronic risk to fish.

Freshwater invertebrates: *Acute* risk to freshwater aquatic invertebrates tends to be lower than for fish since pendimethalin is less acutely toxic to these organisms. Applications at 2 lbs ai/A, whether by air or ground, did not exceed any LOCs. Applications greater than 2 lbs ai/A, or multiple applications of 2 lbs ai/A yielded RQs that exceeded the endangered invertebrate LOC by a small margin indicating the possibility of effects to endangered invertebrates, including mollusks. Aerial treatment of onions (three applications at 2 lbs ai/A) resulted in an RQ that exceeded the restricted use LOC by a small margin (0.14 compared to an LOC of 0.1).

Chronic risk to freshwater aquatic invertebrates is expected to be minimal since the chronic Rqs did not exceed the LOC for chronic effects for all uses.

Estuarine organisms: Pendimethalin represents minimal acute risk to estuarine fish and shrimp. Based on toxicity to the eastern oysters, the endangered species LOC is exceeded by small margins (0.06 to 0.14 compared to and LOC of 0.05) from application rates greater than 2 lbs ai/A, or multiple applications at 2 lbs ai/A. Currently, there are no endangered estuarine species of mollusks.

Terrestrial and Semi-aquatic Plants: The risk to nontarget terrestrial and semi-aquatic plants is predicted to be moderate. The RQs are as high as 30 for emerging seedlings. The LOCs have been exceeded for both ground and aerial applications based on the application rate of 2.0 - 4.0 lbs ai/A. This indicates that exposure of pendimethalin from runoff and spray drift will pose risk to the emergence of nontarget plants. Spray drift from aerial applications above 2 lbs ai/A represent a risk to the vigor of mature plants (RQ of 2.8 to 6 compared to LOC of 1). Pendimethalin may also affect endangered terrestrial and semi-aquatic plant species.

Pendimethalin, because of its extensive usage has the potential to exert impact on a large area of nontarget flora. This risk identified would be confined to areas around application sites, i.e. within the drift and runoff zone. Offsite movement from volatilization may also result in risk to plants, but the exposure levels could not be estimated.

It is also noteworthy that the magnitude of RQs, while exceeding the LOC by sizeable margins, are not as high as other herbicides.

Thus, it is presumed that pendimethalin represents a moderate risk to nontarget terrestrial and

semi-aquatic plants. This is a balance of LOC exceedances that are not particularly high and extensive usage.

Aquatic Plants: The LOC for risk to nontarget aquatic plants has been exceeded. Risk may be a little higher for nonvascular aquatic plants (diatoms and algae; RQs from 1.3 to 6) than for vascular plants (*L. gibba*; RQs from 0.6 to 2.5). However, based on the magnitude of RQs, the overall risk to aquatic plants is considered to be moderate.

Additional Discussion on Aquatic Risk of Pendimethalin

Additional information on pendimethalin that affects the determination of risk to aquatic organisms include its tendency to bind to sediment and suspended particulates, monitoring results, and typical application rates.

Because of its environmental fate characteristics, once pendimethalin reaches surface water habitats, it will tend to bind to sediment and suspended particulates. The strength of this binding increases with time as is evidenced by the methods required to extract pendimethalin from soil or sediment. This should limit long term concentrations in solution in surface waters.

The presumption that concentrations in surface water systems are limited is supported by monitoring results. In a study of the spatial and temporal distributions of pesticides and nutrients in the Mississippi River and its tributaries, Coupe et al. (1993) did not detect dissolved pendimethalin in surface water samples above the reporting limit of 0.018 μg/L. These study results suggest pendimethalin may not be present in the aqueous phase in concentrations above 0.018 ppb (μg/L). In monitoring reported by Baker (1988) from 1982 to 1985, the residues in Ohio creeks and rivers did not exceed 3.6 ppb (μg/L), and were typically less than 1 ppb (μg/L). The lowest toxicological endpoints for freshwater aquatic organism are the fish full life cycle MATC of 7.85 ppb (μg/L) and the EC50 for Duckweed (*Lemna gibba*) of 12.5 ppb (μg/L). The reported levels from monitoring do not represent a high risk to aquatic organisms.

Finally, it is noted that while several use sites are labeled for use rates greater than 2 lbs ai/A, the typical application rate for most sites is 2 lbs ai/A, according to the registrant. The exceptions are ornamentals (3.0 lbs ai/A), landscape and grounds maintenance, non-cropland (4.0 lbs ai/A) and a few agricultural crops that have higher seasonal rates (e.g. onions; 6 lbs ai/A per season). According to the registrant information, less than 200,000 lbs of pendimethalin are applied to these "higher application rate" use sites annually. Thus, less than one percent of pendimethalin usage is typically at rates greater than 2 lbs ai/A.

Monitoring information indicates that pendimethalin residues are present in surface water. However, EFED concludes that these concentrations do not represent a high risk to aquatic animals and plants, including estuarine organisms.

Discussion of aquatic risk from other use sites for which GENEEC was not used.

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Rice: Although pendimethalin is labelled for use on rice, EECs were not calculated for this use since GENEEC was not intended for rice use. The use rate for rice is 1.0 lbs ai/A, which is less than for cotton. Thus, the EECs calculated for cotton would probably be greater than the maximum exposure expected from rice. Pendimethalin is applied directly to the soil of the rice fields; there is no application to water. Labelling specifically states that no floodwater should be on the field at time of application. Once it has been applied, the labeling recommends either rainfall or irrigation to occur within 7 days for pendimethalin to be most effective. The field is then flooded within 5-7 days after seeding and is flushed approximately 90 days later. Virtually all of the water is contained within the rice field, except that which is lost during storm/rainfall events. What is lost during these events constitutes mainly water, with little or no sediment. Based on the environmental fate characteristics, pendimethalin is expected to be sorbed to the sediment and soil particles, and would not be found in the water column. If any soil is lost during these events, the pendimethalin in the water column would tend to sorb to the sediment and soil with which it comes into contact. Therefore, there are reasons to conclude the EECs from rice would be less than those calculated for cotton.

Other use sites: Aquatic EEC's were not estimated for *turf, ornamental, landscape & grounds maintenance, non-cropland, and nonbearing nuts and vines* (use rates of 3 and 4 lbs ai/A, ground application only). GENEEC is a model designed specifically to model runoff from certain agricultural fields and the risk assessment team did not consider it appropriate for sites such as these. It is assumed, for assessment purposes, that exposure from these use patterns would not be higher than exposure from other uses where GENEEC was used to estimate exposure. This is because these use sites are typically composed of uniformly treated areas much smaller than the 10 hectare watershed used for GENEEC. On turf, where treated sites could be larger than 10 hectares, soil erosion is expected to be minimal. When pendimethalin moves in runoff, it is primarily with suspended soil particles, therefore, surface water exposure from turf is predicted to be less than from agricultural fields. Therefore, aquatic risk from turf, ornamental, landscape & grounds maintenance, non-cropland, and nonbearing nuts and vines (use rates of 3 and 4 lbs ai/A,, ground application only) is not expected to be greater than from agricultural use sites with similar application rates.

Environmental Fate Assessment Biobliography

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