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WASHINGTON D.C., 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

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MEMORANDUM **DATE:** April 21 2008

SUBJECT: Revised Ecological Risk Assessment for Reregistration Eligibility Decision (RED) for Naphthalene

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The Environmental Fate and Effects Division (EFED) has completed the environmental fate and ecological risk assessment in support of the re-registration of the repellent, Naphthalene (CAS Registry Number: 91-20-3); End Use Products - ENOZ® Skat! – white solid flakes/crystals (granular) containing 99.45% active ingredient (a.i.) [EPA Reg. No. 1475-146]; Snake-A-Way – white solid flakes/crystals (granular) containing 7.0% ai [EPA Reg. No. 58630-1]; Shotgun® Rabbit & Dog Repellent – white solid flakes/crystals (granular) containing 15.0% ai [EPA Reg. No. 4-465]; and Bat-A-Way Bird, Squirrel, Rabbit & Bat Repellent - white solid

flakes/crystals (granular) containing 99.95% active ingredient [EPA Reg. No. 58630-2], for use to repel unwanted animal visitors from flowering beds, buildings, and gardens in non-cropped and domestic outdoor areas. Conclusions regarding the environmental fate, ecological effects, and ecological risks associated with the proposed use in residential areas can be found in the Executive Summary of the attached document.

Data Gaps

Table A.1. identifies the status of environmental fate and transport study requirements and **Table A.2.** identifies the status of ecological effects study requirements.

Table A.1 Environmental Fate Data Requirements for Naphthalene

Guideline #	Data Requirement	MRID #	Study Classification	Are more data needed?
161-1	Hydrolysis	Not available	Not available	No. Published literature suggests this is an insignificant route of dissipation.
161-2	Photodegradation in Water	Not available	Not available	No. Published literature suggests this is an insignificant route of dissipation.
161-3	Photodegradation on Soil	Not available	Not available	No. Published literature suggests this is an insignificant route of dissipation and this is not a model input.
161-4	Photodegradation in Air	Not available	Not available	No
162-1	Aerobic Soil Metabolism	Not available	Not available	Yes. Model assumptions based on the supplemental data from the open literature. Submission of acceptable data can provide for confirmation of assumptions or inputs for refined modeling.
162-2	Anaerobic Soil Metabolism	Not available	Not available	No
162-3	Anaerobic Aquatic Metabolism	Not available	Not available	No
162-4	Aerobic Aquatic Metabolism	Not available	Not available	Yes. Lack of data led to the assumption of half life at two times the aerobic soil metabolism value. Submission of data can remove uncertainty in this assumption.

Table A.1 Environmental Fate Data Requirements for Naphthalene				
Guideline #	**Data Requirement**	**MRID #**	**Study Classification**	**Are more data needed?**
163-1	Soil Column Leaching (Aged) Adsorption/Desorption (parent)	Not available	Not available	Yes. Supplemental data from open literature. Model assumptions were based on these supplemental data. Submission of acceptable data can provide for confirmation of assumptions or inputs for refined modeling.
163-2	Laboratory Volatility	Not available	Not available	No
163-3	Field Volatility	Not available	Not available	No
164-1	Terrestrial Field Dissipation	Not available	Not available	No.
164-2	Aquatic Field Dissipation	Not available	Not available	No
164-3	Forestry Dissipation	Not available	Not available	No
165-4	Accumulation in Fish	Not available	Not available	No
165-5	Accumulation in aquatic non-target organism (crayfish)	Not available	Not available	No
166-1	Ground Water-small scale prospective	Not available	Not available	No

Table A.2 Ecological Effects Data Requirements for Naphthalene					
Guideline	**Data Requirement**	**Test Material**	**MRID**	**Study Classification**	**Are More Data Needed?**
71-1	Avian Oral LD_{50}	Naphthalene	148176	Supplemental	Yes. The purity of the active ingredient needs to be reported to upgrade the study to acceptable from supplemental.
71-2	Avian Dietary LC_{50}	Naphthalene	148175 Not available	Supplemental Not available	Yes. The purity of the active ingredient in the bobwhite quail test needs to be reported to upgrade the study to acceptable from supplemental. A subacute dietary study with the mallard duck is required to determine the toxicity of

Table A.2 Ecological Effects Data Requirements for Naphthalene					
Guideline	**Data Requirement**	**Test Material**	**MRID**	**Study Classification**	**Are More Data Needed?**
					naphthalene to waterfowl. Together the studies would fulfill the 72-1 guideline (subacute avian dietary toxicity tests with an upland game bird and waterfowl) for an outdoor noncrop use.
71-4	Avian Reproduction	Naphthalene	Not available	Not available	No
72-1	Freshwater Fish LC_{50}	Naphthalene	45030801 44302701	Supplemental Acceptable	No. Even though the study is not repairable, the 72-1 guideline has been fulfilled for a toxicity test with a warm water and cold water fish. No
72-2	Freshwater Invertebrate Acute LC_{50}	Naphthalene	44302702	Acceptable	No
72-3(a)	Estuarine/Marine Fish LC_{50}	Naphthalene	Not available	Not available	No
72-3(b)	Estuarine/Marine Mollusk EC_{50}	Naphthalene	Not available	Not available	No
72-3(c)	Estuarine/Marine Shrimp EC_{50}	Naphthalene	Not available	Not available	No
72-4(a)	Freshwater Fish Early Life-Stage	Naphthalene	46220970	Supplemental	No. However, the non-guideline study was conducted with salmon fry instead of eggs.
72-4(b)	Aquatic Invertebrate Life-Cycle (freshwater)	Naphthalene	Not available	Not available	No
123-1(a)	Seedling Emergence (Tier I)	Naphthalene	Not available	Not available	Yes. Product labels, summary reviews of available open literature data, and toxicity tests with green algae suggest naphthalene is phytotoxic to plants. A Tier I seedling emergence toxicity test is recommended to determine the toxicity of naphthalene to terrestrial plants. If plants are sensitive to

Table A.2 Ecological Effects Data Requirements for Naphthalene					
Guideline	**Data Requirement**	**Test Material**	**MRID**	**Study Classification**	**Are More Data Needed?**
					naphthalene, there might be direct effects to plants and possible indirect effects to animal taxa due to loss of cover or food sources. However, the likelihood for plants to be at risk from naphthalene is low but cannot be precluded at this time.
123-1(b)	Vegetative Vigor (Tier I)	Naphthalene	Not available	Not available	Yes. Product labels, summary reviews of available open literature data, and toxicity tests with green algae suggest naphthalene is phytotoxic to plants. A Tier I vegetative vigor toxicity test is recommended to determine the toxicity of naphthalene to terrestrial plants. If plants are sensitive to naphthalene, there might be direct effects to plants and possible indirect effects to animal taxa due to loss of cover or food sources. However, the likelihood for plants to be at risk from naphthalene is low but cannot be precluded at this time.
123-2 Aquatic Plant Growth (Tier I and II)	Green Algae	Naphthalene	Not available	Not available	No

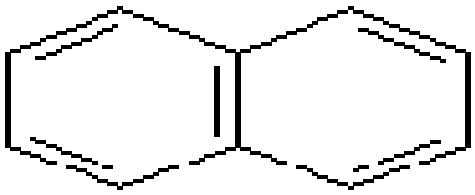
Table A.2 Ecological Effects Data Requirements for Naphthalene					
Guideline	**Data Requirement**	**Test Material**	**MRID**	**Study Classification**	**Are More Data Needed?**
	Duckweed, Lemna gibba	Naphthalene	Not available	Not available	Product labels, summary reviews of available open literature data, and toxicity tests with green algae suggest naphthalene is phytotoxic to plants. A Tier I aquatic vascular plant toxicity test is recommended to determine the toxicity of naphthalene to vascular plants. If plants are sensitive to naphthalene, there might be direct effects to plants and possible indirect effect to animal taxa due to loss of cover or food sources. However, the likelihood for plants to be at risk from naphthalene is low but cannot be precluded at this time.
	Freshwater Diatom, Navicula	Naphthalene	Not available	Not available	Reserved. A Tier II toxicity test with a freshwater diatom is recommended if testing with terrestrial plants raises any concerns and/or if open literature data with freshwater diatoms are unavailable. If plants are sensitive to naphthalene, there might be direct effects to plants and possible indirect effect to animal taxa due to loss of cover or food sources. However, the likelihood for plants to be at risk from naphthalene is low but cannot be precluded at this time.
	Marine Diatom	Naphthalene	Not available	Not available	Reserved. A Tier II toxicity test with a marine diatom is recommended if testing with terrestrial plants raises any concerns and/or if open literature data with marine diatoms are unavailable. If plants are sensitive to naphthalene, there might be direct effects to plants and possible indirect effect to animal taxa due to loss of cover or food sources. However, the likelihood for plants to be at risk from naphthalene is low but cannot be precluded at this time.

Table A.2 Ecological Effects Data Requirements for Naphthalene					
Guideline	**Data Requirement**	**Test Material**	**MRID**	**Study Classification**	**Are More Data Needed?**
	Blue-green algae	Naphthalene	Not available	Not available	Reserved. A Tier II toxicity test with a blue-green alga is recommended if testing with terrestrial plants raises any concerns and/or if open literature data with blue-green algae are unavailable. If plants are sensitive to naphthalene, there might be direct effects to plants and possible indirect effect to animal taxa due to loss of cover or food sources. However, the likelihood for plants to be at risk from naphthalene is low but cannot be precluded at this time.
141-1	Honey Bee Acute Contact LD_{50}	Naphthalene	N/A	N/A	Naphthalene is volatile. It is uncertain if there is a direct effect to pollinators visiting flowers and gardens treated with naphthalene or if there are indirect effects to flowers when bees are prevented from visiting/pollinating the area. An acute contact test with honeybees is recommended.

ECOLOGICAL RISK ASSESSMENT

Re-Registration

Naphthalene
CAS Registry Number: 91-20-3
U.S. EPA Pesticide Code Number: 055801



Repellent Proposed for Outdoor Uses on Non-Cropped and Domestic Outdoor Areas

CAS Name: Naphthalene
IUPAC Name: Naphthalene

Proposed End-use Products: "ENOZ® Skat!", "Snake-A-Way", "Shotgun® Rabbit & Dog Repellent", and "Bat-A-Way Bird, Squirrel, Rabbit & Bat Repellent" (7.0-99.95% naphthalene as the single active ingredient in white solid flakes/crystals).

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Executive Summary

A. Nature of Chemical Stressor

The Environmental Fate and Effects Division (EFED) have assessed the potential ecological risks associated with the use of naphthalene. Naphthalene is a repellent used to control both indoor and outdoor moth and mammal infestations. The labeled indoor uses for naphthalene are not expected to result in exposure to non-target terrestrial and aquatic organisms. Thus, indoor uses (i.e. mothballs) are not considered in this assessment. Of the registered uses, four labels currently specify outdoor use and products are formulated as granular formulations, technically naphthalene crystals or flakes. The outdoor labels state that the products are to be used as repellents for snakes, mammals, and birds from ornamental plants, gardens, and the perimeters of structural buildings. With the exception of statements that the product should be applied in bands of at least one inch wide (ENOZ Skat!; EPA Reg # 1475-146) and up to 12 inches wide (Snake-A-Way; EPA Reg #58630-1), the outdoor use labels generally contain a non-specific application description. In addition, the existing labels indicate that multiple applications may be required for effective repellency, but do not limit the number of applications.

B. Conclusions – Exposure Characterization

In order to provide an assessment of potential exposure to non-target organisms from the terrestrial non-crop use of naphthalene, several assumptions were made regarding the amount applied per acre and the total number of applications expected to be used. According to information provided by the registrants, naphthalene is typically applied outdoors with application rates of 10.8 lbs/acre for use as a rabbit and dog repellent and 0.56 lbs/acre as a snake repellent. Typically, naphthalene is applied in bands of 4 to 12 inches in width, which will limit the total pounds per acre applied. For the purpose of this assessment, it is assumed that a single application will represent a band of 12 inches surrounding a planted bed or the perimeter of a house/garden. The registrant also indicates that applications should be repeated as needed with a typical application interval of 2 to 3 months. Given this, it is assumed, for the purpose of this assessment, naphthalene will be applied up to six times per year. Since naphthalene will not be applied to the entire target site but is applied in a band, an adjustment factor of 4.1% has been applied to GENEEC2 model output to account for this aspect of the products' applications.

Aquatic exposures were estimated using the Tier 1 model, GENEEC2, and terrestrial exposures were estimated using the Tier 1 model, T-REX v. 1.3.1. For GENEEC2 and T-REX modelings, granules are used as a surrogate for flakes or crystals.

C. Conclusions – Effects Characterization

Based on the data requirements for a terrestrial non-crop/domestic outdoor use as a repellent, all data except terrestrial and aquatic vascular plants were submitted and reviewed for the naphthalene risk assessment using the granular banded application and incidental ingestion exposure methods. Available acute toxicity data with aquatic species indicate that naphthalene is moderately toxic to freshwater fish and invertebrates with LC_{50} values of 2.0 and 1.6 mg ai/L, respectively. Toxicity data with aquatic nonvascular plants indicate that naphthalene is slightly

toxic to green algae with EC_{50} values of 33 and 34 mg/L. Following chronic exposure, a reduction in survival, feeding behavior, and growth were observed in Coho salmon; the LOAEC and NOAEC were 0.67 and 0.37 mg ai/L, respectively. The results of an embryo-larval toxicity test with the Fathead minnow demonstrated adverse effects at a concentration of 0.85 mg/L, the NOAEC was 0.62 mg/L.[1] Toxicity data were not available for aquatic vascular plants; consequently, the toxicity of naphthalene to aquatic vascular plants is unknown.

Available acute toxicity data with terrestrial species indicate that naphthalene is practically non-toxic to upland game birds (acute oral LD_{50} = 2690 mg ai/kg bw; acute dietary LC_{50} >5620 mg ai/kg diet). Acute dietary toxicity data with the mallard duck was not available; the toxicity to waterfowl exposed to granular naphthalene is unknown. Available acute toxicity data also indicate that naphthalene is practically non-toxic to mammals (acute oral LD_{50} = 2649 mg ai/kg bw).

Two-generation reproductive toxicity studies evaluating reproductive performance of mammals exposed to naphthalene are not available, although the occurrence of hemolytic anemia in the neonates of anemic, naphthalene-exposed mothers demonstrates that naphthalene and/or its metabolites can cross the placental barrier. Following chronic exposure, rat studies involving naphthalene exposure during gestation reported that doses of 150 mg/kg/day and greater were maternally toxic to rats with a decrease in number of live mouse pups per litter with a dose of 300 mg/kg/day given during gestation. *In vitro* studies of naphthalene embryotoxicity in the presence of liver microsomes support the concept that naphthalene metabolites may be harmful to the developing embryo.[2] Toxicity data were not available for honeybees and terrestrial plants; consequently, the toxicity of naphthalene to beneficial insects and terrestrial plants is unknown.

No chronic studies with freshwater and marine/estuarine invertebrates and birds were available. Summary reviews of available open literature data concerning the toxicity of naphthalene degradation products were identified; however, those data were unavailable for this assessment.

D. Potential Risks to Non-target Animals and Plants

Based on the available ecotoxicity information and the estimated environmental exposures, naphthalene may pose an acute risk to birds, mammals, terrestrial-phase amphibians and reptiles. Acute risk is not expected for freshwater animals, aquatic-phase amphibians and aquatic nonvascular plants. Due to lack of toxicity data, risks to honey bees, and terrestrial and aquatic vascular plants are unknown. Lack of toxicity data does not preclude potential risk to these taxa. Tables 1 and 2 provide summaries for the environmental risk conclusions for aquatic and terrestrial animals and plants.

[1] www.epa.gov/waterscience/pc/ambientwqc/naphthalene80.pdf
[2] http://www.atsdr.cdc.gov/toxprofiles/tp67.pdf

TABLE 1. Summary of Environmental Risk Conclusions for Aquatic Organisms		
Assessment Endpoint	**Use Patterns with LOC Exceedances**	**Summarized Risk Characterization**
Acute Risk to Freshwater Fish and Aquatic-phase Amphibians from Granular Application	None	At the peak EECs, there are no exceedances of the Acute Risk, Acute Restricted Use, or Acute Endangered Species LOCs for freshwater fish. EFED currently uses surrogate data (freshwater fish) for aquatic-phase amphibians. Since the fish risk assessment indicates no acute LOC exceedances, consequently, there are no risk concerns for aquatic-phase amphibians.
Acute Risk to Freshwater Invertebrates from Granular Application	None	At the peak surface water EECs, there are no exceedances of the Acute Risk, Acute Restricted Use, or Acute Endangered Species LOCs for freshwater invertebrates.
Acute Risk to Estuarine/marine Fish and Invertebrates from Granular Application	None	At the peak surface water EECs, there are no exceedances of the Acute Risk, Acute Restricted Use, or Acute Endangered Species LOCs for estuarine/marine fish and invertebrates.
Risk to Aquatic Vascular Plants from Granular Application	No information available	No aquatic vascular plant (e.g., duckweed) toxicity studies were submitted; therefore, risk to aquatic vascular plants receiving runoff from granular naphthalene is unknown. Label and summary reviews of open literature data suggest possible phytotoxicity to plants.
Risk to Aquatic Nonvascular Plants from Granular Application	None	At the peak surface water EECs, there are no exceedances of the Acute Risk or Acute Endangered Species LOCs for green algae.

TABLE 2. Summary of Environmental Risk Conclusions for Terrestrial Organisms		
Risk Conclusion	**Use Patterns with LOC Exceedances**	**Summarized Risk Characterization**
Acute Risk to Birds (including terrestrial-phase amphibians and reptiles) from Granular Application	Terrestrial non-crop use (10.8 lbs ai/A x 6 appls with 60 day reapplication interval)	Using the LD_{50}/ft^2 exposure method for assessing risk from granular banded applications, Acute, Acute Restricted use, and Endangered Species LOCs are exceeded for 20, 100, and 1000 g birds using the dose-based LD_{50} value. Although there is exceedance of LOCs from the LD_{50}/ft^2 analysis, the potential for risk to birds is based on the assumption that birds are feeding exclusively within the 12-inch-wide banded application around the house or garden perimeters. The likelihood for risk to birds is low because: 1) It is anticipated that birds may likely be repelled away from the treated band; 2) It is unlikely birds will obtain all dietary items from within the treated band; and, 3) The EECs calculated in the T-REX analysis may be overestimated (e.g., a minimum row [banded] length of 209 feet long around gardens and houses is unlikely).
	Terrestrial non-crop use (0.56 lb ai/A x 6 appls with 60 day reapplication interval)	Using the LD_{50}/ft^2 exposure method for assessing risk from granular banded applications, the Acute, Acute Restricted Use and Acute Endangered Species LOCs are exceeded for 20 and 100 g birds using the dose-based LD_{50} value. Acute Restricted Use and Acute Endangered Species LOCs are exceeded for 1000 g birds using the dose-based LD_{50} value. Although there is exceedance of LOCs from the LD_{50}/ft^2 analysis, the potential for risk to birds is based on the assumption that birds are feeding exclusively within the 12-inch-wide banded application around the perimeter of a house or garden. The likelihood for risk to birds is low because: 1) It is anticipated that birds may likely be repelled away from the treated band; 2) It is unlikely birds will obtain all dietary items from within the treated band; and, 3) The EECs calculated in the T-REX analysis may be overestimated (e.g., a minimum row [banded] length of 209 feet long around gardens and houses is unlikely).
Acute Risk to Mammals from Granular Application	Terrestrial non-crop use (both 10.8 and 0.56 lb ai/A)	Using the LD_{50}/ft^2 exposure method for assessing risk from granular applications, the Acute, Acute Restricted Use and Acute Endangered Species LOCs are exceeded for 15, 35, and 1000 g mammals ingesting naphthalene granules at both application rates. Although there is exceedance of LOCs from the LD_{50}/ft^2 analysis, the potential for risk to mammals is based on the assumption that mammals are feeding exclusively within the 12-inch-wide banded application around the house or garden perimeters. The likelihood for risk to mammals is low because: 1) It is anticipated that mammals will likely be repelled away from the treated band; 2) It is unlikely mammals will obtain all dietary items from within the treated band; and, 3) The EECs calculated in the T-REX analysis is overestimated, since a row (banded) length of 209 feet long around garden and houses is unlikely.

TABLE 2. Summary of Environmental Risk Conclusions for Terrestrial Organisms		
Risk Conclusion	**Use Patterns with LOC Exceedances**	**Summarized Risk Characterization**
Risk to Non-target Beneficial Insects from Granular Application	No information available	No honeybee data were provided; risk to honeybees visiting treated areas is unknown. In addition, it is unknown if plants will be indirectly affected from the absence of pollinators visiting the area.
Risk to Terrestrial Plants from Granular Application	No information available	No terrestrial plant toxicity studies were submitted; risk to terrestrial plants receiving runoff from granular naphthalene is low but cannot be precluded at this time. Labels and a summary review of open literature data suggest possible phytotoxicity to plants.
Risk to Terrestrial Animals from Incidental Ingestion of Granules	Terrestrial non-crop use (both 10.8 and 0.56 lbs ai/A x 6 appls with 60 day reapplication interval)	To exceed the endangered species LOC, only $1/10^{th}$ and nine naphthalene granules ingested are needed for a 20-g and 1000-g species, respectively, to pose a risk from incidental ingestion. To exceed the acute restricted use LOC, ½ and 46 naphthalene granules ingested are needed for a 20-g and 1000-g species, respectively, to pose a risk from incidental ingestion. To exceed the acute risk LOC, 1 and 92 naphthalene granules ingested are needed for a 20-g and 1000-g species, respectively, to be potentially at risk from incidental ingestion.

E. Conclusions – Endangered Species

Direct effects LOCs were exceeded for birds, terrestrial-phase amphibians, reptiles and mammals. Therefore, there is potential for indirect effects to all terrestrial animal and plant taxa that depend on those animals as pollinators or seed dispersers, mammal or reptile burrows for habitat, feeding, or cover requirements, and for survival, growth, or reproduction. In addition, no terrestrial plant toxicity data are available; if plants are found to be sensitive to naphthalene, there might be direct effects to plants and possible indirect effect to animal taxa due to loss of cover or food sources. The animal and plant species that reside in those areas, and the basis for the designation, are in Appendices H and I and are summarized in Table 3, below.

Table 3. Listed taxonomic groups potentially at risk associated with direct or indirect effects due to applications of naphthalene on areas where ornamental plants, flowering beds and gardens are grown nationwide				
Listed Taxon	**Direct Effects**	**Basis for Direct Effects Concern**	**Indirect Effects**	**Basis for Indirect Effects Concern**
Terrestrial and Semi-Aquatic Plants – monocots and dicots	Yes	Since the product labels state, "Do not apply the product directly to foliage or stems," this statement indicates that there is a possibility of phytotoxicity. In addition, a summary review of open literature data suggests naphthalene is selectively phytotoxic to plants. However, toxicity data are not available for terrestrial plants exposed to naphthalene. If plants are sensitive to naphthalene, there might be direct effects to plants. The likelihood for	Yes	Potential concerns for monocots and dicots that depend on birds, reptiles, terrestrial-phase amphibians and mammals as pollinators or seed dispersers. If pollinators such as honeybees, beneficial insects, and birds/mammals are repelled from naphthalene, there might be indirect effects to plants due to loss of pollinators for flower fertilization.

		plants to be at risk from naphthalene is low but cannot be precluded at this time.		
Honeybees	Yes	No data on honeybees are available. Since naphthalene is volatile, it is uncertain if honeybees will be impacted from pollinating the treated areas or if flowers will be indirectly affected from the absence of pollinators. The likelihood of direct effects to honeybees is low but cannot be precluded at this time.	Yes	Potential concerns for honeybees that depend on mammal or reptile burrows for habitat, feeding, or cover requirements.
Birds and Reptiles[1]	Yes	The endangered species LOC is exceeded for both high and low application rates.	Yes	Potential concerns for birds and reptiles that eat mammals as a food resource.
Terrestrial-phase Amphibians[1]	Yes	The endangered species LOC is exceeded for both high and low application rates.	Yes	Potential concerns for terrestrial-phase amphibians that eat birds, reptiles and mammals as a food source or depend on mammal or reptile burrows for habitat and shelter.
Mammals	Yes	The endangered species LOC is exceeded for both high and low application rates.	Yes	Potential concerns for mammals that eat birds, reptiles and terrestrial-phase amphibians and depend on reptile burrows for habitat and shelter.
Aquatic Vascular Plants	Yes	Since the product labels state, "Do not apply the product directly to foliage or stems," this statement indicates that there is a possibility of phytotoxicity. In addition, a summary review of open literature data suggests naphthalene is selectively phytotoxic to plants. However, toxicity data are not available for aquatic plants exposed to naphthalene. If plants are sensitive to naphthalene, there might be direct effects to plants. The likelihood for plants to be at risk from naphthalene is low but cannot be precluded at this time.	Yes	Potential concerns for aquatic vascular plants that depend on birds, reptiles, terrestrial-phase amphibians and mammals as pollinators or seed dispersers. If pollinators such as honeybees, beneficial insects, and birds/mammals are repelled by naphthalene, there might be indirect effects to plants due to loss of pollinators for flower fertilization.
Freshwater Invertebrates, Fish and Aquatic-phase Amphibians[2]	No	No LOC exceedances	Yes	If plants are directly or indirectly affected from exposure to naphthalene, freshwater fish and amphibians may be indirectly affected due to loss of cover or food sources.
Estuarine/marine Fish and Invertebrates	No	No LOC exceedances	Yes	If plants are directly or indirectly affected from exposure to naphthalene, estuarine/marine fish and invertebrates may be indirectly affected due to loss of cover or food.
Aquatic Nonvascular Plants – algae and diatoms	No	No LOC exceedances	Yes	Potential concerns for aquatic nonvascular plants that depend on birds, reptiles, terrestrial-phase amphibians and mammals as pollinators and seed dispersers. If pollinators such as honeybees, beneficial insects, and birds/mammals are repelled by naphthalene,

				there might be indirect effects to plants due to loss of pollinators for flower fertilization.
1 Birds are used as surrogate species for terrestrial-phase amphibians and reptiles; therefore, potential direct and indirect effects to endangered avian, terrestrial-phase amphibians and reptilian species are considered equivalent.				
2 Fish are used as a surrogate for aquatic phase amphibians; therefore, potential direct and indirect effects to endangered fish and aquatic-phase amphibian species are considered equivalent.				

F. Identification of Uncertainties and Their Impact on the Risk Assessment

There are a number of areas of uncertainty in the terrestrial and aquatic species risk assessments that could potentially cause an underestimate or overestimate of risk. First, this assessment accounts only for exposure to non-target animals and plants to naphthalene, but not to its degradation products. The risks could be underestimated if degradates also exhibit toxicity under the conditions of use as stated on the labels. Summary reviews of available open literature data concerning the toxicity of naphthalene degradation products were searched; however, those data were unavailable for this assessment. Second, the risk assessments only consider the most sensitive species tested and only considers a subset of possible use scenarios. Third, for screening terrestrial risk assessments, a generic bird or mammal is assumed to occupy the treated site, and to consume 100% of its diet as the pesticide. The actual habitat requirements of any particular terrestrial species are not considered, and it is assumed that species occupy, exclusively and permanently, the treated area being modeled. This assumption leads to a maximum level of exposure in the risk assessment. Since naphthalene is a repellent used to control unwanted species from habiting the treated area, the risk estimations for birds, terrestrial-phase amphibians, reptiles, and mammals exposed to naphthalene granules may be overestimated. Fourth, the aquatic exposure assessment relies on GENEEC2 to provide screening level estimates of exposure using a limited data set of environmental fate data. In general, GENEEC2 provides high end exposure estimates that likely over-estimate exposure in aquatic systems. The potential impacts of uncertainties are detailed in section III.D of this document.

Additional uncertainty results from lack of information and/or data in several components of this ecological risk assessment, as follows:

- The T-REX model is designed to calculate risk indices from pesticide applications on an entire one-acre agricultural field by broadcast spray/granular application or by rows/bands. Since naphthalene is proposed for an application of a 12-inch-wide band around the perimeter of a flowering bed, house, or garden to repel unwanted species, T-REX assumptions may over-estimate the risk indices for birds, terrestrial-phase amphibians, reptiles, and mammals exposed to naphthalene flakes. Even though there is an exceedance of the levels of concern for acute risk to those species, the exceedance is based on the assumption that the species occupy, exclusively and permanently, the 12-inch-wide band around the perimeter of a house or garden. To the extent that a repelled species does not reside exclusively and permanently within the 12-inch banded area(s), exposure will be less and risk will presumably be less.

- No data are available for honeybees to assess the risk to pollinators visiting flowering beds or gardens. Naphthalene is volatile, and it is unknown if honeybees will be discouraged from pollinating the treated area or if plants will be indirectly affected from the absence of pollinators

visiting the area.

- There are a number of uncertainties associated with the environmental fate data. No acceptable environmental fate studies have been submitted to support this risk assessment. A single summary review of available open literature data was provided for aerobic soil metabolism and adsorption/desorption. However, these data have not been fully reviewed and are used as supplemental information for risk assessment purposes. No additional data for other important environmental fate processes (hydrolysis, photolysis, aerobic aquatic metabolism) have been submitted, although some open literature data is available from other sources (US NPS, 1997) although much of this data is limited and has not been thoroughly reviewed. Where data are missing, an assumption of stability has been incorporated into the exposure modeling which likely over-estimates predicted exposures, particularly aqueous photolysis which has been shown to be rapid in some studies. In addition, volatility is unaccounted for in Tier I modeling conducted for this assessment. It is uncertain whether the aerobic soil metabolism data includes losses due to volatility (which would be expected in an open system) and thus it is uncertain whether the lack of accounting for volatility in the modeling results in an over-estimation of exposure. There is some suggestion from the open literature that naphthalene degrades rapidly in aerobic aquatic conditions but these data are suspect as they may represent lumped dissipation processes and not true degradation (US NPS, 1997).

- No terrestrial or aquatic vascular plant studies are available. While the product labels state specifically for terrestrial non-crop/domestic outdoor uses, “Do not apply the product directly to foliage or stems,” this statement indicates that there is a possibility of phytotoxicity; in addition, a summary review of open literature data suggest that naphthalene is selectively phytotoxic to plants. If plants are sensitive to naphthalene, there might be direct affects to plants and possible indirect affects to animal taxa due to loss of cover or food sources. The likelihood of risk to plants may be low but cannot be precluded at this time.

- No preliminary analysis was performed for non-food uses of naphthalene because the LOCATES tool does not include county-level location information for the proposed non-food use of naphthalene. Consequently, based on the information available at this step in the assessment process, it is presumed that all listed animal species are potentially directly affected from the broad range of naphthalene proposed uses which include areas around houses, cabins, trailers, garages, utility houses, barns, woodpiles, sand piles, trash cans, flower beds, plants (ornamentals, roses, spring bulbs), around the periphery of gardens, and garbage bags placed near residences and other buildings, streets or alleys for garbage collection. Additional analysis of listed animal locations, refinement of the action area associated with naphthalene regulatory decisions, and the biology of the potentially affected species would be needed before an effects determination can be made for any of the co-located species identified by this assessment.

- Currently, the T-REX model does not have the capability to estimate chronic exposure to terrestrial animals from banded granular applications.

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Appendices

Tables

I. PROBLEM FORMULATION

The purpose of this ecological risk assessment (ERA) is to assist the Agency in evaluating the actions needed, if any, to address the ecological risks in terrestrial and aquatic environmental settings associated with the reregistration of the repellent, the active ingredient, naphthalene, that is used to repel animals from ornamental plants, gardens and the perimeters of buildings.

A. Stressor Source and Distribution

The primary chemical stressor is naphthalene, formulated to repel snakes, mammals, and birds from ornamental plants, gardens, and the perimeters of structural buildings. Naphthalene (not to be confused with naphtha) (also known as naphthalin, naphthaline, tar camphor, white tar, albocarbon, or naphthene), is a crystalline, aromatic, white, solid hydrocarbon, best known as the primary ingredient of mothballs. Naphthalene is volatile, forming a flammable vapor. Its molecules consist of two fused benzene rings. It is manufactured from coal tar, and converted to phthalic anhydride for the manufacture of plastics, dyes and solvents. It is also used as an antiseptic and insecticide, especially in mothballs (for indoor uses) and flakes (for outdoor uses). Naphthalene ($C_{10}H_8$) is known among polycyclic aromatic hydrocarbon class of chemicals as a "benzenoid" polycyclic aromatic hydrocarbon (PAH), an alternant PAH.[3,4]

1. Mode of Action

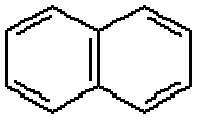
The toxicological mode of action of naphthalene is poorly understood; however, published literature indicates that exposure to naphthalene may induce cataracts, histological changes associated with pneumotoxicity, glutathione depletion, lipid peroxidation, DNA fragmentation and the production of the active oxygen species as superoxide anion and hydroxyl radical. Toxic manifestations of naphthalene are associated with its oxidative metabolism to various products including quinones, specifically the naphthoquinone metabolite. The ability to protect against the toxic effects of naphthalene by using various antioxidants and free radical scavengers has been demonstrated.[5]

The repellent mode of action of naphthalene is to keep unwanted animals away from visiting the areas of interest. It is unclear if it is the odor of the volatilizing naphthalene that repels the organisms.

2. Chemical Identification of Naphthalene

Table I-1 presents the names and codes used to identify naphthalene in this assessment.

[3] http://en.wikipedia.org/wiki/Naphthalene
[4] http://en.wikipedia.org/wiki/Polycyclic_aromatic_hydrocarbons
[5] http://cat.inist.fr/?aModele=afficheN&cpsidt=13944427 and http://cat.inist.fr/?aModele=afficheN&cpsidt=1407090

TABLE I-1. CHEMICAL IDENTIFICATION FOR THE ACTIVE INGREDIENT NAPHTHALENE.[6]	
Common Name and Company Code	Naphthalene
USEPA Pesticide Code Number (PC #)	055801
CAS Registry Number	91-20-3
CAS Name	Naphthalene
IUPAC Name	Naphthalene
Empirical Formula and Smiles String	$C_{10}H_8$
Molecular Weight	128.18 g/mole
Molecular Structure	

3. Overview of Pesticide Usage

The proposed end-use products for terrestrial non-crop and domestic outdoor uses are "ENOZ® Skat!", "Snake-A-Way", "Shotgun® Rabbit & Dog Repellent" and "Bat-A-Way Bird, Squirrel, Rabbit & Bat Repellent" with naphthalene as the active ingredient in white solid crystals/flakes. The proposed uses are summarized in Table I-2. The products are labeled as a repellent for rabbits, rattlesnakes (*Genus crotalus*), checkered garter (*Thamnophis marcianus*), house mice (*Mus musclus*), Norway rats (*Rattus norvegicua*), roof rats (*R. rattus*), tree squirrels, bats, starlings, pigeons, and/or house sparrows from ornamentals, gardens, planting beds and areas around buildings.

Table I-2. Overview of Naphthalene Outdoor Uses	
Use grouping	**Representative Use**
Terrestrial Non-food + Domestic Outdoor (residential)	Areas around houses, cabins, trailers, garages, utility houses, barns, woodpiles, sand piles, trash cans, flower beds, plants (ornamentals, roses, spring bulbs), around the periphery of gardens, garbage bags placed near residences and other buildings, streets or alleys for garbage collection.

The labels state that the products may be applied as bands around the plants or periphery of gardens and buildings to reduce the frequency of visits by animals. However, the bandwidth of the bands is dependant on the product formulation and label statements. The four products identified above are for terrestrial non-crop or domestic outdoor uses only, even though there are other naphthalene products for indoor uses. The proposed application rates range from a maximum of 10.8 lbs/acre to a minimum of 0.56 lbs/acre for naphthalene uses on terrestrial non-food or domestic outdoor sites, with up to six applications per year with 60-day reapplication intervals.

[6] Information obtained from Naphthalene SMART meeting, March 28, 2007.

B. Receptors

For the screening level risk assessment on naphthalene and its transformation products, toxicological data generated on representative test species belonging to broad taxonomic groups are summarized, then utilized in an assessment of risk for each group. These data are obtained from registrant-submitted studies and published literature. Table I-3 lists the taxonomic groups and representative test species used for evaluation of potential ecological effects on terrestrial non-food and domestic outdoor uses. Within each of these very broad taxonomic groups, an acute endpoint is selected from the available toxicity data for use in risk estimation.

Table I-3. Taxonomic Groups and Test Species Evaluated for Ecological Effects in the Screening Level Risk Assessment for Naphthalene.

Taxonomic group	Example(s) of representative species
Birds, Terrestrial-phase Amphibians and Reptiles[a]	Mallard duck (*Anas platyrhynchos*) Bobwhite quail (*Colinus virginianus*)
Mammals	Laboratory rat (*Rattus norvegicus*)
Freshwater fish and Aquatic-phase Amphibians[b]	Bluegill sunfish (*Lepomis macrochirus*) Rainbow trout (*Oncorhynchus mykiss*) Coho salmon (*Oncorhynchus kisutch*)
Freshwater invertebrates	Water flea (*Daphnia magna*)
Estuarine/marine fish	Fathead minnow (*Pimephales promelas*)
Estuarine/marine invertebrates	Pacific oyster (*Crassostrea gigas*) Grass shrimp (*Palaemonetes pugio*)
Terrestrial plants[c]	Monocots – No data Dicots – No data
Aquatic vascular plants Aquatic non-vascular plants	Duckweed – No data Green algae (*Chlorella vulgaris*)

[a]Birds are used as surrogates for amphibians (terrestrial phase) and reptiles.
[b]Freshwater fish are used as surrogates for amphibians (aquatic phase).
[c]Four species of two families of monocots, of which one is corn; six species of at least four dicot families, of which one is soybeans.

No ecological effects data on terrestrial and aquatic vascular plants, or honeybees are available. The potential risks to terrestrial and aquatic vascular plants, and honeybees from exposure to naphthalene are unknown.

A complete discussion of all toxicity data available for this risk assessment and the resulting measurement endpoints selected for each taxonomic group are included in the Ecological Effects Characterization section and Appendix E.

1. Aquatic Effects:

For naphthalene, effects on aquatic organisms are estimated from acute laboratory studies either submitted to the Agency or found in the open literature (i.e., ECOTOX). Acute data are available

for freshwater fish, rainbow trout (*Oncorhynchus mykiss*) and bluegill sunfish (*Lepomis macrochirus*); freshwater invertebrates, water flea (*Daphnia magna*); estuarine/marine fish, Fathead minnow (*Pimephales promelas*); and estuarine/marine invertebrates, Pacific oyster (*Crassostrea gigas*) and Grass shrimp (*Palemonetes pugio*). These freshwater fish species also act as surrogates for aquatic-phase amphibians. Data is available for aquatic non vascular plants with one green algae species (*Chlorella vulgaris*). None is available for aquatic vascular plants.

Data were available to evaluate chronic effects of naphthalene on aquatic animals are an Early Life-Stage study with Coho salmon (*Oncorhynchus kisutch*) and Fathead minnow embryo-larval test to observe the chronic effect to freshwater and marine/estuarine fish.

2. Terrestrial Effects:

The effect of naphthalene on birds is estimated from acute and subacute studies on the upland game bird, northern bobwhite quail (*Colinus virginianus*). No studies are available for waterfowl. The bird studies also act as surrogates for reptiles and terrestrial-phase amphibians. Effects on mammals are estimated from acute data in rats reviewed by the Health Effects Division (HED) and effects on mammals from chronic data in rats from available open literature data.

3. Ecosystem at Risk

The terrestrial ecosystems potentially at risk include the treated area where the granules are applied in bands. For Tier I assessment purposes, risk will be assessed to terrestrial animals assumed to exclusively occur in the treated area directly exposed to naphthalene granules.

The use of naphthalene, as stated in the proposed label, could result in exposure to aquatic and terrestrial animals inhabiting flowing, non-flowing or transient freshwater water bodies. For Tier I assessment purposes, risk will be assessed to aquatic animals assumed to occur in small, static ponds receiving runoff from adjacent treated areas.

C. Assessment Endpoints

A summary of the assessment and measurement endpoints selected to characterize potential ecological risks associated with exposure to naphthalene is provided in Table I-4.

This ecological risk assessment considers the labeled maximum and minimum application rates, maximum number of applications and minimum reapplication intervals between applications for representative uses to estimate exposure concentrations. This assessment is not intended to represent a site or a time-specified analysis. Instead, this assessment is intended to represent high-end exposures at a national level. Likewise, the most sensitive toxicity endpoints are used from surrogate test species to estimate treatment-related direct effects on acute mortality/immobilization assessment endpoints. Toxicity tests are intended to determine effects of outdoor use exposure on birds, terrestrial-phase amphibians, reptiles, mammals, fish, aquatic-phase amphibians, aquatic invertebrates, and plants. These tests include short-term acute and subacute studies and are typically arranged in a hierarchical or tiered system that progresses from

basic laboratory tests to applied field studies. The toxicity studies are used to evaluate the potential of a pesticide to cause adverse effects, to determine whether further testing is required, and to determine the need for precautionary label statements to minimize the potential adverse effects to non-target animals and plants (40 CFR 158.202, 2002).

Table I-4. Summary of Assessment and Measurement Endpoints for Naphthalene as a Non-Food Use

Assessment Endpoint	Measures of Effect
1. Abundance (i.e., survival) of birds. Birds are surrogate for reptiles and terrestrial phase amphibians.	1a. Bobwhite quail acute oral LD_{50}. 1b. Bobwhite quail subacute dietary LC_{50}. 1c. Mallard duck subacute dietary LC_{50}.* 1d. Avian reproduction NOAEC* * Currently, no subacute dietary toxicity study with mallard ducks or a reproduction study have been submitted for naphthalene or found in open literature.
2. Abundance (i.e., survival) of mammals.	2a. Laboratory rat acute oral LD_{50}.
3. Survival and reproduction of individuals and communities of freshwater fish and invertebrates. Fish are surrogate for aquatic phase amphibians.	3a. Rainbow trout, bluegill sunfish acute LC_{50}. 3b. Coho salmon chronic (early-life) NOAEC. 3c. Water flea acute EC_{50}.
4. Survival and reproduction of individuals and communities of estuarine/marine fish and invertebrates.	4a. Fathead minnow acute LC_{50}. 4b. Pacific oyster and Grass shrimp acute EC_{50}. 4c. Fathead minnow chronic NOAEC.
5. Perpetuation of individuals and populations of non-target terrestrial and semi-aquatic species (crops and non-crop plant species).	5a. Monocot and dicot seedling emergence and vegetative vigor endpoints are not available.* *Currently, no Tier I terrestrial plants toxicity studies have been submitted or found in open literature for naphthalene.
6. Survival of beneficial insect populations.	6a. Honeybee acute contact LD_{50} is not available.* *Currently, no honeybee toxicity study has been submitted or found in open literature.
7. Maintenance and growth of individuals and populations of aquatic plants from standing crop or biomass.	7a. Alga EC_{50} and NOAEC values 7b. Vascular plant (i.e., duckweed) EC_{50} and NOAEC values for growth rate and biomass measurements are not available.* *Currently, no Tier I aquatic vascular plant toxicity studies have been submitted or found in open literature.

LD_{50} = Lethal dose to 50% of the test population.
NOAEC = No-observed-adverse-effect concentration.
LOAEC = Lowest-observed-adverse-effect concentration.
LC_{50} = Lethal concentration to 50% of the test population.
EC_{50}/EC_{25} = Effect concentration to 50/25% of the test population.

D. Conceptual Model

Naphthalene is insoluble and has high potential to volatilize from soil, so exposure from inhalation is possible. Potentially, soil particulates containing naphthalene could be transported

away from the treatment site by wind erosion. Naphthalene is not likely to leach to groundwater due to this use pattern but is expected to be transported via runoff to surface water bodies. The low Koc would suggest that naphthalene could leach to groundwater. However, for this assessment groundwater is not considered as a major route of exposure for aquatic organisms. This assumption is supported by the fact that in the USGS NAWQA groundwater data, a total of 6,977 groundwater samples were analyzed for naphthalene with only 37 positive detections, suggesting that leaching is not likely significant. Modeling with the SciGrow groundwater model suggests estimated concentrations are below those estimated for surface water and below those seen in the USGS NAWQA data. Naphthalene does not bioaccumulate in aquatic animals. With limited data available for naphthalene, only potential risks from exposure to parent naphthalene were quantified. It is uncertain if the transformation products are of toxicological concern.

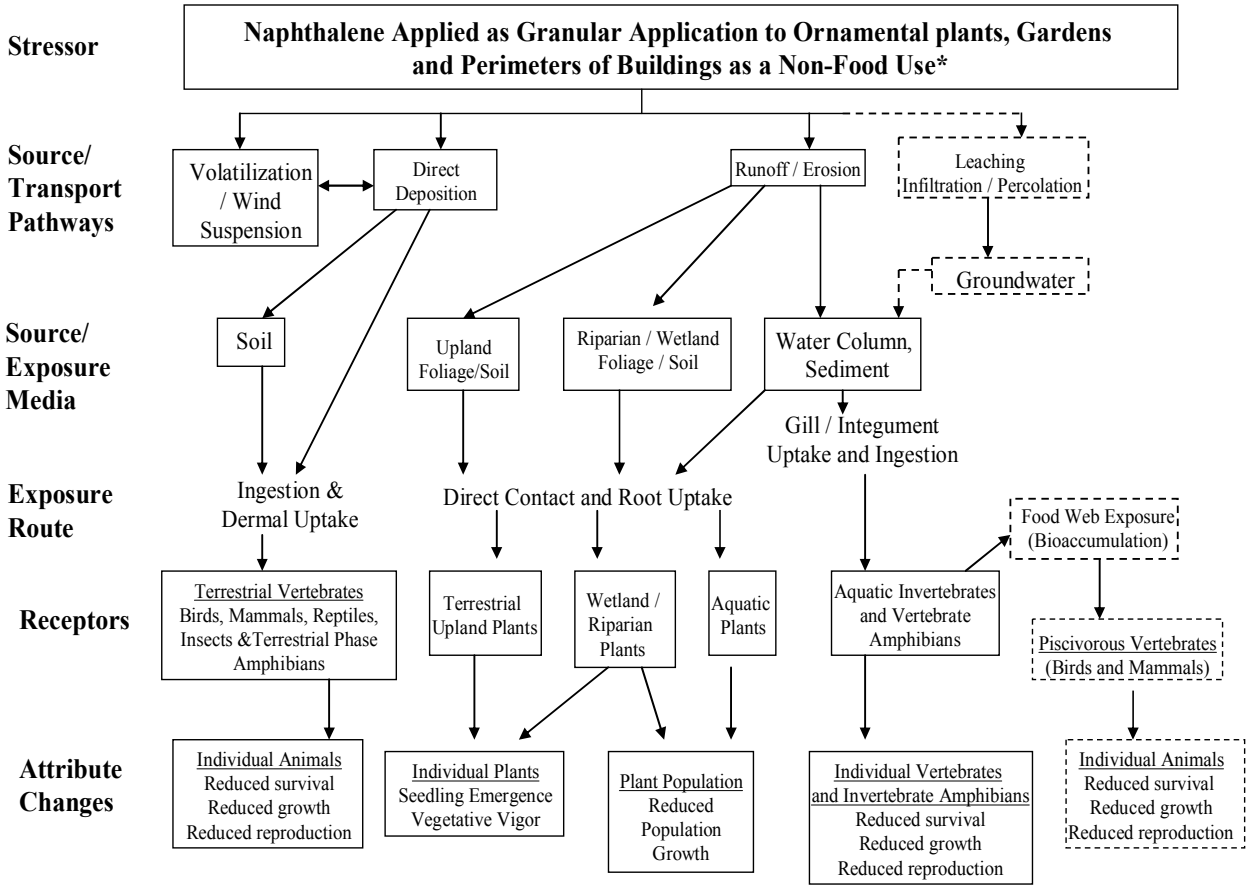
The initial emphasis of the risk assessment primarily addresses possible risks to aquatic vascular and non-vascular plants, fish, aquatic-phase amphibians and invertebrates and to terrestrial non-target plants, birds, reptiles, terrestrial-phase amphibians and mammals. Risk was evaluated for exposure of these organisms to naphthalene through ingestion of granules and water bodies receiving runoff following application.

1. Risk Hypothesis

The use of naphthalene as a repellent in terrestrial non-crop and domestic outdoor sites will result in either direct or indirect adverse effects to terrestrial and aquatic animals and plants. Based on the information, persistence, mode of action, direct toxicity and potential indirect effects, EFED assumes that naphthalene has the potential to cause reduced survival, and growth and reproduction impairment to both terrestrial and aquatic animals and plants as a result of the labeled uses of the pesticides.

2. Conceptual Model Diagram

Based on the potential behavior of naphthalene in the environment and the proposed method of application (e.g., ground granular application), a conceptual model (Figure ID-1) was developed that represents the possible relationships between the stressor, ecological endpoints, and the measurement endpoints.



* dotted line represents unlikely exposure pathways; bold line represents likely exposure pathways

Figure ID-1. Naphthalene Environment Risk Assessment Conceptual Model

E. Analysis Plan

Naphthalene is registered for use as an insect, invertebrate and mammal repellent for both indoor and outdoor uses. Naphthalene has a number of non-pesticidal uses (principally as a constituent of various petroleum products), which are not considered in this assessment. Indoor pesticidal uses are principally as mothballs and are not considered likely to result in exposure to non-target organisms (other than humans) and are therefore not considered in the ecological risk assessment. Currently, four registered products included outdoor uses for treatment of ornamentals, planting beds, and gardens to repel animals. Outdoor pesticidal uses are principally as flakes or crystals. Information on application and on the extent of expected outdoor use was provided at the registrant SMART meeting on March 28, 2007. Based on this information the exposure assessment will consider two exposure scenarios. The first is a high use rate at 10.8 lbs/acre with six applications per year for repelling rabbits and dogs. The second is a low use rate scenario with an application rate of 0.56 lbs/acre with six applications per year for repelling snakes. Aquatic exposure estimates were generated for each scenario using the Tier I exposure model, GENEEC2, which assumes an area is 100% treated.

Given the limited use of this compound and the fact that it is applied in a band around ornamentals, planting beds and gardens as a repellent, an adjustment to the modeled EEC was made. The percent of lot treated was derived from the United States 2000 Census data [http://www.census.gov/main/www/cen2000.html], which indicated that a typical lot size is ¼ acre (10,890 square feet) with a typical house having a footprint of 1000 square feet. If it is assumed that the house is symmetrical, then the perimeter would be 126.4 ft (31.6 ft on each side). If it is further assumed that the ornamental beds will be present in a 10 foot band around the house, then the perimeter would be 206.4 ft. If a typical application band is 1 foot (12 inches), then the treated area would be 206.4 square feet. If it is additionally assumed that a garden will typically be present, then an additional calculation was made to account for the potential treatment to the perimeter of the garden. In this case, it is assumed that a garden would be 20 feet by 100 feet for a perimeter of 240 feet. An assumption of a one-foot band of naphthalene around this garden yields a total treated area of 240 square feet. Adding these together and dividing by the total ¼ acre lot area yields a percent lot treated of 4.1%. The resultant GENEEC2 has been adjusted by this factor.

Ecological risk will be assessed to determine the potential for acute effects (*i.e.,* lethality) to mammals, birds, fish or invertebrates using screening-level risk assessment models. Risk will be assessed on the treated site for birds and mammals and in an adjacent pond for freshwater fish and invertebrates. Ecotoxicity data on sublethal (*e.g.,* reproductive, growth) effects were not available, so chronic risk is not addressed in this assessment.

Risk to aquatic animals will be assessed using GENEEC2, a Tier 1 model that estimates concentrations in a 1-hectare, 2-meter-deep water body adjacent to the 10-hectare treated site that drains into the water body. Since granular applications are assumed, this water body is also assumed to receive no drift from the treated site.

Terrestrial exposures from granular applications (mg ai/square foot)[7] for birds, terrestrial-phase amphibians, reptiles and mammals will be estimated using the Tier 1 model, T-REX Version 1.3.1 (T-REX, 2007). In addition, a banded granular application assumes that 100% of the granules are unincorporated on the ground. Risk to terrestrial animals from exposure to granules will be based on LD_{50}/ft^2 values. The LD_{50}/ft^2 values are calculated using a toxicity value (adjusted LD_{50} of the assessed animal and its weight classes) and the EEC (mg ai/ft^2) and are directly compared with Agency's levels of concern (LOCs). Since naphthalene is used only for granular applications, exposures to animals from foraging on food items with naphthalene residues (short and tall grass, broadleaves, seeds) are not estimated in this assessment. Details of the TREX model and EEC/RQ calculations are presented in Appendix D.

F. Data Gaps

For environmental fate there are no acceptable fate studies. However, a single supplemental study has been provided which summarizes open literature data on adsorption/desorption and aerobic soil metabolism data. Other fate parameters needed to conduct this assessment have either been extrapolated from the open literature data (aerobic aquatic metabolism half life) or conservatively assumed to be stable (photolysis and hydrolysis). The lack of these data provides uncertainty to this assessment (Table I-5). Elimination of this uncertainty would require submission of additional data for these fate processes.

Table I-5. Environmental Fate Data Requirements for Naphthalene

Guideline #	Data Gap	Value of Additional Testing
162-1	Aerobic Soil Metabolism	**Low**. Supplemental data from open literature. Model assumptions were based on these supplemental data. Submission of acceptable data can provide for confirmation of assumptions or inputs for refined modeling.
163-1	Adsorption Desorption	**Low**. Supplemental data from open literature. Model assumptions were based on these supplemental data. Submission of acceptable data can provide for confirmation of assumptions or inputs for refined modeling.
162-4	Aerobic Aquatic Metabolism	**Medium**. Lack of date led to assumption of half life at two times the aerobic soil metabolism value. Submission of data can remove uncertainty in this assumption.

[7] mg ai/ft^2 = $\frac{\text{application rate x \% active ingredient x 453,590 mg/lb}}{\text{no. of rows/acre x row length x bandwidth}}$ X % incorporation

Several ecotoxicity data gaps for naphthalene were also identified during problem formulation (Table I-6).

Table I-6. Ecological Toxicity Data Requirements for Naphthalene

Guideline #	Data Gap	Value of Additional Testing
71-2	Avian subacute dietary LC_{50} (mallard duck)	**High** – No study with mallard duck is available. Study is required to evaluate the toxicity to waterfowl. In the dietary study with upland game bird (bobwhite quail), body weight decreased while feed consumption increased when compared to controls.
122-1	Tier I Nontarget Terrestrial Plant Phytotoxicity: Seedling emergence and Vegetative vigor	**Low to Medium** – No studies are available. Since the product labels state specifically for terrestrial non-crop/domestic outdoor uses, "Do not apply the product directly to foliage or stems," this statement indicates that there is a possibility of phytotoxicity; in addition, summary reviews of open literature data indicate naphthalene is phytotoxic to plants. If plants are sensitive to naphthalene, there might be direct effects to plants and possible indirect effects to animal taxa due to loss of cover or food sources. The likelihood for risks to plants is low but cannot be precluded at this time.
122-2	Tier I Nontarget Aquatic Plant Growth	**Low to Medium** - No studies are available. Since the product labels state specifically for terrestrial non-crop/domestic outdoor uses, "Do not apply the product directly to foliage or stems," this statement indicates that there is a possibility of phytotoxicity; in addition, summary reviews of open literature data indicate naphthalene is phytotoxic to plants. If plants are sensitive to naphthalene, there might be direct effects to plants and possible indirect effects to animal taxa due to loss of cover or food sources. The likelihood for risks to plants is low but cannot be precluded at this time.
141-1	Acute honey bee contact LD_{50}	**Low** – No study is available. It is uncertain how pollinators will react to naphthalene when actively visiting gardens and flowers where naphthalene is applied frequently. Also, since naphthalene is volatile, it is uncertain how naphthalene fumes will impact honeybees. If honeybees are sensitive to naphthalene, there might be indirect effects to plants due to loss of pollinators. The likelihood for risks to honeybees is low but cannot be precluded at this time.

II. ANALYSIS

A. Use Characterization

Information provided by the registrant indicates that a significant proportion of naphthalene use is on ornamentals, planting beds, and gardens. Generally, naphthalene is applied for outdoor use as flakes in bands surrounding the site to be protected. Typically, these bands do not exceed 12 inches in width and are replenished as needed (typically, every two to three months). The use patterns assessed in the exposure assessment are summarized in Table II-1.

Table II-1 Naphthalene Application Information [A]					
Crop	**Formulation**	**Method of Application**	**Maximum Application Rate (lbs/acre)**	**Maximum Seasonal Rate**	**Minimum Application Interval**
Ornamentals for rabbit & dog repellent	Granules	Ground	10.8	64.8	2 months
Ornamentals for snake repellent	Granules	Ground	0.56	3.36	2 months

[A] Based on information provided at SMART Meeting on March 28, 2007

B. Exposure Characterization

1. Environmental Fate and Transport

Several environmental fate studies (aerobic soil and aqueous photolysis) were submitted but deemed to be unacceptable for risk assessment purposes due to poor material balances, inadequate sample intervals, and issues with volatile trapping and therefore have not been used in this assessment. A single overview of open literature data (MRID 45346801) provided supplemental data on the adsorption/desorption and aerobic soil metabolism properties of naphthalene. Possible degradation processes affecting naphthalene (and PAH's in general) include photo-oxidation and microbial degradation.

For sorption a total of 13 open literature studies were submitted and summarized and indicated that the solubility of naphthalene ranged from 30 to 31.7 mg/L and that the Koc ranged from 200 to 1470 for a variety of soils from North America, Europe and China. The study author concluded from this review that naphthalene was bound relatively rapidly to soils with a sustained desorption over days to weeks. For biodegradation a total of 15 open literature studies were submitted and reviewed and found that naphthalene degraded with aerobic soil metabolism half-lives between 3.5 and 40 days with no appreciable degradation under anaerobic conditions. Possible dissipation processes affecting naphthalene (and PAH's in general) include volatilization, bioaccumulation, adsorption, and leaching.

Additional open literature data (US NPS, 1997, US HHS, 2005) describes both aerobic soil degradation and adsorption values that are consistent with values described above, although under certain conditions degradation from soil may be somewhat longer. In addition, these data suggest that naphthalene degrades rapidly by aqueous photolysis. The data (US HHS, 2005) also suggest that under certain conditions naphthalene dissipates rapidly from open water systems although it is unclear whether the dissipation observed was due to degradation or lumped dissipation processes including transport out of the systems by flowing water. The additional data suggest that up to 30% of loss from soil can occur due to volatilization and also suggest that once in air, naphthalene should degrade rapidly (US NPS, 1997). Once in air, naphthalene tends to dissipate rapidly (US HHS, 2005). Finally, these data suggest that naphthalene is relatively stable under anaerobic conditions (US NPS, 1997).

A number of transformation products were identified in the various open literature studies. The study author proposed a degradation pathway for naphthalene, which ultimately resulted in catechol. Transitional transformation products included cis-1,2-dihydroxy-1,2-dihydronapthalene, 1,2-dihydroxy-napthalene, 2-hydroxchromene-2-carboxylate (HCCA), trans-o-hydroxy-benzylidenpyruvate (tHBPA), salicyladehyde, and salicylate. There are no registrant submitted environmental fate data on these degradation products that would allow for an approximation of environmental fate inputs, the available open literature data is sparse, and there is no available toxicity data for these compounds. Therefore, these degradates have not been quantitatively assessed in the exposure assessment.

A copy of the submitted summary along with the metabolic pathway, transformation product structures, results from individual studies, and bibliography of open literature data is presented in Appendix G.

2. Aquatic Exposure Modeling

EFED normally relies on an integrated approach for conducting exposure assessments that relies on an analysis of both monitoring data and modeling. In the case of naphthalene, no monitoring data are available. Therefore, this assessment relies solely on modeling.

EFED uses a tiered system of pesticide exposure modeling to assess risk of a pesticide to the environment. Each of the tiers is designed to screen out pesticides by requiring higher, more complex levels of investigation only for those that have not passed the next lower tier. In this case, EFED has conducted a Tier I aquatic exposure assessment relying on GENEEC2. GENEEC (*GEN*eric *E*stimated *E*nvironmental *C*oncentration, version 2) is a program to calculate acute as well as longer-term estimated environmental concentration (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[8].

The appropriate GENEEC2 input parameters were selected from the environmental fate data submitted by the registrant and in accordance with US EPA-OPP EFED water model parameter selection guidelines, Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides, Version 2.3, February 28, 2002. These parameters are summarized in **Table II-2**. Results of GENEEC2 modeling are presented in **Table II-3** and Appendix C**.**

[8] See http://www.epa.gov/oppefed1/models/water/index.htm for more details.

Table II-2 Summary of GENEEC2 environmental fate data used for aquatic exposure inputs for naphthalene		
Fate Property	**Value**	**MRID (or source)**
Solubility in Water	32 mg/L	Product Chemistry
Photolysis in Water	stable	Assumed
Aerobic Soil Metabolism Half-lives	32.6 days (90th % of 9 values)	MRID 45346801
Hydrolysis	stable	Assumed
Aerobic Aquatic Metabolism (water column)	65.2 days	Twice the aerobic soil metabolism rate constant
Koc	131 (lowest non-sand Koc)	MRID 45346801
Application Efficiency	99 % for ground*	default value
Spray Drift Fraction	1 % for ground	default value

* – Although not specified on labels it is assumed that only ground applications would be used.

Two scenarios were modeled to represent a high naphthalene use scenario and at low use scenarios. The high use scenario was modeled at 10.8 lbs/acre with six applications per year, while the low use scenario was modeled at 0.56 lbs/acre with six applications per year. The application method was modeled as ground application with a granular formulation. The results of the Tier I modeling is summarized in Table II-3.

Table II-3 Results of GENEEC2 Modeling for Naphthalene Use on Ornamentals*							
Use Site	**Application Rate (lbs/acre)**	**Number of Applications (interval)**	**Peak EEC (ppb)**	**4 day EEC (ppb)**	**21 day EEC (ppb)**	**60-day EEC (ppb)**	**90-day EEC (ppb)**
Ornamentals for rabbit & dog repellent	10.8	6 (2 months)	26.9	26.6	25.2	22.4	20.5
Ornamentals for snake repellent	0.56	6 (2 months)	1.4	1.4	1.3	1.2	1.1

* Note these EECs are adjusted by 4.1% to account for the fact that the product is only applied in a band around ornamental, planting beds, and gardens

Unaccounted for in this exposure assessment is the fact that naphthalene is volatile. No product chemistry data were available but an estimate of the vapor pressure was made using EpiSuite. EpiSuite reported an experimentally derived value for vapor pressure of 8.5 x10^{-2} mm Hg (which is consistent with the registrant reported value of 10.5 Pa, or 7.8 x 10^{-2} mm Hg) suggesting that naphthalene is volatile. Given the volatility of this compound and the fact that the Tier I model used to estimate exposure does not account for volatility as a route of dissipation it is likely that the exposure estimates derived above are over-predictions of potential exposure. However, it is unknown from the open literature data used in this assessment whether the systems were closed

or flow-through. If the aerobic metabolism data (and hence the half-life used in this assessment) were flow-through, then the degradation reported would include volatilization as a process. The impact of volatility on this assessment is uncertain.

Given the mobile nature of this compound, it is possible that naphthalene may leach to groundwater. A cursory review of USGS NAWQA groundwater data indicates that of 6,977 samples only 37 detections of naphthalene were found. While the maximum concentration detected was 70 ppb, there are a number of possible sources of naphthalene contamination of groundwater, including many with significantly higher use (e.g., industrial, jet fuel). Thus it appears that leaching is not likely a significant route of exposure for the pesticidal use of naphthalene. A quick check of groundwater leaching potential using SciGrow yields an estimated concentration in groundwater of 16.3 ppb at the highest application rate (10.8 lbs/acre x 6 applications) and 0.84 ppb at the lowest rate (0.56 lbs/acre x 6 applications). These values are below the surface water concentrations predicted by GENEEC2, are lower than the NAWQA values described above, and assume a much broader area of application than anticipated for this use pattern (bands surrounding gardens and planting beds). Given the lines of evidence described, it is expected that as an exposure route for ecological risk assessment ,naphthalene in groundwater resulting from pesticidal use is minimal.

3. Terrestrial Exposure Modeling

Naphthalene when applied outdoors is formulated as a granular formulation, technically as flakes or crystals. For T-REX modeling, granules are used as a surrogate for flakes or crystals.

Terrestrial exposures for naphthalene are estimated using the conceptual approach given in the Tier-1 model, T-REX Version 1.3.1[9]. A default foliar half-life of 35 days was assumed. The LD_{50}/ft^2 is used to estimate risk for granular formulations through row and banded applications. The appropriate T-REX input parameters were selected from the product labels. For the method of application using granules (flakes), one row length of 209 ft with row spacing of 2,500 inches, 1-foot bandwidth and 0% incorporation was assumed. For minimum foraging area estimates need to exceed the levels of concerns, a maximum mass of 38 mg naphthalene per flake is used.[10] These parameters are summarized in **Table II-4**.

Table II-4. Input Parameters for T-REX Analysis

Application Type	Formulation	Input	Guidance	Comments
Rows/Band	Granular	No. of Row, Length, and Spacing	Row spacing is the amount of space (inches) between crop rows and is obtained from the product label.	Only one row was assumed. A minimum row length of 209 foot with row spacing of 2,500 inches was used assuming application occurs on one side of an one-acre field.

[9] T-REX, 2005. See http://www.epa.gov/oppefed1/models/terrestrial/ for more information

[10] The exact mass of naphthalene per flakes was not provided; however, information obtained from Naphthalene SMART meeting, March 28, 2007 was used to estimate the weight.

Table II-4. Input Parameters for T-REX Analysis				
Application Type	**Formulation**	**Input**	**Guidance**	**Comments**
		Band width	Bandwidth is the width of the applied pesticide row (inches) and is obtained from the product label.	A foot bandwidth was obtained from labels.
		% incorporated	Value depends on the method of application: T-Banded – covered with specified amount of soil: 99% In-furrow, drill, or shanked-in: 99% Side-dress, banded, mix, or lightly incorporate with soil: 85% Broadcast, mix, or lightly incorporated: 85% Side-dress, banded, unincorporated: 0% Broadcast, aerial broadcast, unincorporated: 0%	0% incorporated was obtained from labels.
		Weight of granule	Data is obtained from registrant.	38 mg (from SMART meeting)

The T-REX model does not allow for multiple applications at different rates so the terrestrial exposures for this risk assessment were estimated assuming six ground applications at 10.8 lbs/acre with a reapplication interval of 60 days. A second lower use rate scenario was modeled assuming six ground applications at 0.56 lbs/acre. Results of T-REX modeling are presented in Tables II-5 and II-6.

Table II-5 Terrestrial EECs (mg ai/ft^2) on avian and mammalian ingesting granules following label-specified application of naphthalene at 10.8 lb ai/A; determined using the TREX model	
Intermediate Calculations	
# rows acre-1:	1.00
row length (ft):	208.71
lb ai/1000 ft row:	51.65
bandwidth (ft):	1.00
mg ai/ft^2 (EEC):	23429.24
exposed EEC (mg ai/ft^2):	23429.24

Table II-6 Terrestrial EECs (mg ai/ft^2) on avian and mammalian ingesting granules following label-specified application of naphthalene at 0.56 lb ai/A; determined using the TREX model	
Intermediate Calculations	
# rows acre-1:	1.00
row length (ft):	208.71
lb ai/1000 ft row:	51.65
bandwidth (ft):	1.00

Table II-6 Terrestrial EECs (mg ai/ft^2) on avian and mammalian ingesting granules following label-specified application of naphthalene at 0.56 lb ai/A; determined using the TREX model	
Intermediate Calculations	
mg ai/ft^2 (EEC):	1214.85
exposed EEC (mg ai/ft^2):	1214.85

C. Ecological Effects Characterization

Summaries of the available ecotoxicity studies can be found in **Appendix E.**

Following implementation of the Overview document (USEPA, 2004a), EFED has begun incorporating data from open literature into ecological risk assessments (USEPA, 2004b). Toxicity data from open literature are identified via the ECOTOX search engine and maintained by EPA/ORD. Open literature data presented in this risk assessment were obtained from the data provided to EFED by ORD on 11/6/2006. In order to be included in the ECOTOX database, papers must meet the following minimum criteria:

1. the toxic effects are related to a single chemical exposure;
2. the toxic effects are on an aquatic or terrestrial plant or animal species;
3. there is a biological effect on live, whole organisms;
4. a concurrent environmental chemical concentration/dose or application rate is reported; and
5. there is an explicit duration of exposure

Data that passes the ECOTOX screen is evaluated along with the registrant-submitted data, and may be incorporated qualitatively or quantitatively into the risk assessment. In general, effects data in the open literature that are less than or more conservative than the registrant-submitted data are considered. The degree to which open literature data is quantitatively or qualitatively characterized is dependent on whether the information is relevant to the assessment endpoints (i.e., maintenance of survival, reproduction, and growth) identified in the problem formulation. For example, endpoints such as behavior modifications are likely to be qualitatively evaluated, because it is unclear whether such modifications cause a reduction in species survival, reproduction, and/or growth. Specific open literature data that are considered include the following:

1. the endpoint is more sensitive than those identified in the registrant data;
2. the data is for under represented taxa (i.e., amphibians); and
3. the data includes endpoints not normally evaluated in registrant studies, but ecologically relevant

An examination of the studies found in the open literature (ECOTOX) did not provide any lower endpoints than the studies submitted by the Registrant; however, several open literature studies with other taxa groups were available for this assessment. Acute studies with the Fathead minnow, Pacific oyster, and Grass shrimp were available to observe the effect of naphthalene to estuarine/marine fish and invertebrates. A Freshwater Fish Early Life-Stage study with Coho salmon and embryo-larval test with fathead minnow were available to observe the effect to fish

from long-term exposure. For toxicity effects to aquatic plants, several green algae studies were available. Studies with soil invertebrates were available to observe the effect to terrestrial invertebrates. A summarized table of toxicity endpoints selected for aquatic and terrestrial risk assessment can be found in Tables II-7 and II-8, respectively.

1. Aquatic Effects

With the exception of the Pacific oyster, available freshwater and estuarine/marine fish and invertebrate acute toxicity data suggest that naphthalene is moderately toxic to aquatic animals (Table II-7). Chronic freshwater fish reproduction data indicates that survival and growth were affected; the NOAEC was determined to be 0.37 mg/L. For estuarine/marine fish, a chronic embryo-larval test indicates adverse effects at 0.85 mg/L; the NOAEC was determined to be 0.62 mg/L. Aquatic plant growth studies with green algae were less sensitive than animals with concentrations of 33 and 34 mg/L, which categorizes naphthalene as slight toxic to green alga. No toxicity study with aquatic vascular plants is available for this ecological risk assessment.

Table II-7. Toxicity of Naphthalene to Aquatic Organisms and Plants

Taxon	Test Organism	Endpoint	Value* (mg a.i./L)	Ecotoxicity Category	MRID Classification
Freshwater Fish	Rainbow trout *Onchorhynchus mykiss*	96-hr LC_{50} NOAEC (mortality) NOAEC (sublethal)	**2.0** 0.86 0.86	moderately toxic	45030801 supplemental
	Bluegill sunfish *Lepomis macrochirus*	96-hr LC_{50} NOAEC (mortality) NOAEC (sublethal)	3.2 1.4 1.4	moderately toxic	44302701 acceptable
	Coho salmon *Oncorhynchus kisutch*	40D NOAEC 40D LOAEC	**0.37** 0.67	None	127330 supplemental
Freshwater Invertebrate	Water flea *Daphnia magna*	48-hr EC_{50} NOAEC (mortality) NOAEC (sublethal)	**1.6** 0.48 >8.8	moderately toxic	44302702 acceptable
Estuarine/ marine Fish	Fathead minnow *Pimephales promelas*	96-hr LC_{50} NOAEC (mortality) NOAEC (sublethal)	**6.6** NR NR	moderately toxic	DeGraeve, et al. 1980
		Chronic NOAEC Chronic LOAEC	**0.62** NR	None	DeGraeve, et al. 1980
Estuarine / marine Invertebrates	Pacific oyster *Crassostrea gigas*	96-hr EC_{50} NOAEC (mortality) NOAEC (sublethal)	**199** NR NR	practically nontoxic	LeGore, 1974
	Grass shrimp *Palaemonetes pugio*	96-hr LC_{50} NOAEC (mortality) NOAEC (sublethal)	**2.35** NR NR	moderately toxic	Tatem, 1976
Vascular Plant	Duckweed *Lemna gibba*	7-day EC50 NOAEC	No data	No data	No data
Non-vascular Plant	Green algae *Chlorella vulgaris*	48-hr EC_{50} NOAEC LOAEC	**33** NR NR	slightly toxic	Kauss & Hutchinson, 1975

***Bolded** values indicate toxicity thresholds used to calculate risk quotients.
NR – not reported

Available avian acute toxicity data suggest that naphthalene is practically non-toxic to upland game bird species both on acute oral and dietary basis (**Table II-8**). No subacute dietary study with the mallard duck was available; consequently, it is unknown how toxic naphthalene is to waterfowl species. Naphthalene is practically non-toxic to mammals on an acute oral basis.

2. Terrestrial Effects

Table II-8 Toxicity of Naphthalene to Terrestrial Animals and Plants

Taxon	Test Organism	Test Type	Endpoint	Value[a]	Ecotoxicity Category	MRID Classification
Bird	Bobwhite quail *Colinus virginianus*	Acute Oral	LD_{50}	**2690 mg/kg bw**	practically nontoxic	148176 acceptable
		Subacute Dietary	LC_{50}	**>5620 mg/kg diet**	practically nontoxic	148175 acceptable
	Mallard duck *Anas platyrhynchos*	Subacute Dietary	LC_{50}	No data	Not available	Not available
Mammal	Rat *Rattus norvegicus*	Acute Oral	LD_{50}	**2649 mg/kg bw**	practically nontoxic	148174
Beneficial insects	Honey bee *Apis mellifera*	Acute Contact	LD_{50}	No data	Not available	Not available
Soil Invertebrates	*Folsomia candida*	Chronic Effects on Soil Invertebrates (reproduction and survival)	NOAEC LOAEC	**88 µmol/kg soil** 409 µmol/kg soil	None	S.T.J. Droge et al
	Enchytaeus crypticus		NOAEC LOAEC	220 µmol/kg soil 2045 µmol/kg soil	None	S.T.J. Droge et al
Terrestrial plants	Monocots and dicots	Seedling emergence and Vegetative vigor	EC_{25} NOAEC LOAEC	No data	Not available	Not available

[a] **Bolded** values indicate toxicity thresholds used to calculate risk quotients.

No terrestrial plant seedling emergence or vegetative vigor studies are available for this ecological risk assessment. However, the labels state specifically, "Do not apply the product directly to foliage or stems." This statement indicates that there is a possibility of phytotoxicity and open literature data suggest naphthalene is selectively phytotoxic to plants (Spencer, E. Y. Guide to the Chemicals Used in Crop Protection, 7th edition, publication 1093). Until terrestrial plant studies are available, it is uncertain which plant species is selectively affected when exposed to naphthalene. In addition, no beneficial insect studies are available; it is uncertain how pollinators will react to naphthalene when visiting ornamental flowers and gardens.

III. RISK CHARACTERIZATION

Risk characterization integrates EECs and toxicity estimates and evaluates the likelihood of adverse ecological effects to non-target species. In a deterministic approach, an exposure

estimate is divided by a single point estimate of toxicity to calculate a risk index (RQ or LD_{50}/ft^2). The RQ (for aquatic animals) or LD_{50}/ft^2 (for terrestrial animals) is then compared to Agency's levels of concern (LOCs) that serve as criteria for categorizing potential risk to non-target species.

A. Risks to Non-target Aquatic Organisms and Plants

Based on the available ecotoxicity information and the modeled aquatic exposures (from the GENEEC2 model), it appears that naphthalene poses minimal acute risk to aquatic animals and aquatic nonvascular plants (*i.e.*, fish, aquatic-phase amphibians, invertebrates, and alga) when used at six applications, 60 days apart, at a rate of 10.8 lbs/acre (**Table III-1**). Therefore, minimal acute risk also is expected from minimum use rate of 0.56 lbs/acre for freshwater animals, because EECs resulting from the lower use rate scenario to those aquatic species are lower than the maximum use rate scenario. Risks to aquatic vascular plants are also unknown due to lack of ecotoxicity data.

Table III-1. Risks to Aquatic Animals and Plants for Naphthalene Use on Ornamentals; 6 applications, 60 days apart at a rate of 10.8 lbs a.i./A

Taxon	Species	Toxicity Endpoint	EEC (µg/L)	RQ[1]	LOCs Exceeded[2]
Freshwater Fish	Rainbow trout *Onchorhynchus mykiss*	96-hr LC_{50} = 2.0 mg/L (or 2000 µg/L)	26.9 (peak)	0.013	None
	Coho salmon *Oncorhynchus kisutch*	40-day NOAEC = 0.37 mg/L (or 370 µg/L)	22.4 (60D)	0.06	None
Freshwater Invertebrate	Water flea *Daphnia magna*	48-hr LC_{50} = 1.6 mg/L (or 1600 µg/L)	26.9 (peak)	0.017	None
Marine/estuarine Fish	Fathead minnow *Pimephales promelas*	LC_{50} = 6.6 mg/L (or 6600 µg/L)	26.9 (peak)	<0.01	None
		NOAEC = 0.62 mg/L (or 620 µg/L)	22.4 (60D)	0.04	None
Marine/estuarine Invertebrate	Grass shrimp *Palaemonetes pugio*	LC_{50} = 2.35 mg/L (or 2350 µg/L)	26.9 (peak)	0.01	None
Vascular Plant	Duckweed *Lemna gibba*	No data	26.9 (peak)	Not available	
Freshwater Non-Vascular Plant	Green Algae *Chlorella vulgaris*	EC_{50} = 33 mg/L (or 33000 µg/L)	26.9 (peak)	<0.01	None

[1] Acute Risk Quotients are calculated using the following formula: EEC/LC_{50}; Chronic Risk Quotients are calculated using EEC/NOAEC.
[2] Acute LOC for aquatic animals >0.05 for endangered species, >0.1 for restricted use and >0.5 for non-listed species; LOC for aquatic plants >1; Chronic LOC for aquatic animals >1.

B. Risks to Non-target Terrestrial Animals and Plants

Birds, reptiles and terrestrial-phase amphibians

Based on the available terrestrial ecotoxicity information and the predicted direct ingestion exposures (from the T-REX model); naphthalene appears to pose acute risk to birds, terrestrial-

phase amphibians and reptiles. For granular uses at the maximum application rate of 10.8 lbs/acre (Table III-2), the T-REX model indicates that the acute risk, restricted use and endangered species LOCs are exceeded for all bird weight classes. At 0.56 lbs/acre, only the restricted use and endangered species LOCs are exceeded for the 1000-g bird weight class exposed to naphthalene granules; all LOCs are exceeded for the 20- and 100-gram weight classes. A definitive acute dietary LC_{50} was not established for the bobwhite quail (*i.e.*, LC_{50} > 5620 mg/kg-diet), and the TREX model only allow dose-based RQs for granular applications; thus, acute dietary risk quotients were not calculated and excluded from assessment at this time.

Mammals

The acute LD_{50}/ft^2s to terrestrial mammals, as a result of the assessed uses of naphthalene at 10.8 (Table III-2) and 0.56 lbs/acre (Table III-3), exceed the LOCs for acute risk, restricted use and endangered species.

Table III-2 Granular LD_{50}/ft^2 (RQs) from Direct Ingestion of Flakes at 10.8 lb ai/A - EEC/Toxicity (adjusted mg/ft^2 / adjusted LD_{50})[A]

Taxa	Weight Class	LD_{50}/ft^2	LOCs Exceeded[B]
Avian	20 g	**604.48***	Acute Risk, Restricted Use, Endangered Species
	100 g	**94.97***	Acute Risk, Restricted Use, Endangered Species
	1000 g	**6.72***	Acute Risk, Restricted Use, Endangered Species
Mammal	15 g	**268.18***	Acute Risk, Restricted Use, Endangered Species
	35 g	**142.05***	Acute Risk, Restricted Use, Endangered Species
	1000 g	**11.49***	Acute Risk, Restricted Use, Endangered Species

[A] Bird LD_{50} = 2690 mg/kg, Mammal LD_{50} = 2649 mg/kg; mg/ft^2 = 23429.24
***** Exceed acute risk, restricted use, and endangered species LOCs of 0.5, 0.2 and 0.1, respectively.
[B] Acute LOC for terrestrial animals: >0.1 for endangered species, >0.2 for restricted use and >0.5 for acute risk

Table III-3 Granular RQs (LD_{50}/ft^2) from Direct Ingestion of Flakes at 0.56 lb ai/A - EEC/Toxicity (adjusted mg/ft^2 / adjusted LD_{50})[A]

Taxa	Weight Class	LD_{50}/ft^2	LOCs Exceeded[B]
Avian	20 g	**31.34***	Acute Risk, Restricted Use, Endangered Species
	100 g	**4.92***	Acute Risk, Restricted Use, Endangered Species
	1000 g	**0.35^**	Restricted Use, Endangered Species
Mammal	15 g	**13.91***	Acute Risk, Restricted Use, Endangered Species
	35 g	**7.37***	Acute Risk, Restricted Use, Endangered Species

Table III-3 Granular RQs (LD_{50}/ft^2) from Direct Ingestion of Flakes at 0.56 lb ai/A - EEC/Toxicity (adjusted mg/ft^2 / adjusted LD_{50})[A]			
Taxa	**Weight Class**	**LD_{50}/ft^2**	**LOCs Exceeded [B]**
	1000 g	**0.60***	Acute Risk, Restricted Use, Endangered Species
[A] LD_{50} = 2690 mg/kg, Mammal LD_{50} = 2649 mg/kg; mg/ft^2 = 1214.85 * Exceed acute risk, restricted use, and endangered species LOCs of 0.5, 0.2 and 0.1, respectively. ^ Exceed acute restricted use and endangered species LOCs of 0.2 and 0.1, respectively. [B] Acute LOC for terrestrial animals: >0.1 for endangered species, >0.2 for restricted use and >0.5 for acute risk			

Beneficial insects

No honeybee toxicity studies are available; consequently, it is uncertain if honeybees will be impacted when pollinating in the treated area.

Terrestrial plants

No seedling emergence or vegetative vigor studies are available; consequently, it is uncertain if terrestrial plants will be affected in the treated area.

C. Risk Description

1. Risks to Non-target Aquatic Organisms and Plants

In the conceptual model, surface runoff/erosion to adjacent bodies of water was predicted as the most likely sources of exposure of naphthalene to non-target aquatic animals and plants. Risks to aquatic organisms (i.e. fish, invertebrates, and plants) were assessed based on modeled estimated environmental concentrations (EECs) and available toxicity data. Aquatic EECs for the ecological exposure to naphthalene were estimated using GENEEC2 employing the standard ecological water body (Table II-2) and a percent area treated of 4.1% (Section 1.E).

The risk hypothesis stated that the use of naphthalene has the potential to cause adverse effects to aquatic animals and plants. For direct acute risk to freshwater and estuarine/marine animals and algae and direct risk following chronic exposure to freshwater and estuarine/marine fish, this assessment refutes this hypothesis. Risk of direct effects to aquatic animals and algae are below the Agency's LOC, but risk is unknown for aquatic vascular plants. Therefore, potential risk of indirect effects cannot be precluded for aquatic animals and plants until data on aquatic vascular plants are provided.

a. Fish and Aquatic Invertebrates

Available acute toxicity data for aquatic species indicate that naphthalene is moderately toxic to freshwater and estuarine/marine fish and invertebrates. A comparison of the GENEEC peak EEC of naphthalene in surface water of 26.9 µg/L to toxicity values for fish and invertebrates indicates that the toxicity values (between 1600 - 6600 µg ai/L) were 59 to 245-fold higher than the highest estimated EEC. Therefore, it is concluded that the acute risk to freshwater and estuarine/marine animals is expected to be minimal.

The chronic risk quotients calculated (freshwater and estuarine/marine fish) is less than the

chronic LOC of 1.0 for the proposed uses. For outdoor uses, the GENEEC2 60-day EEC was 22.4 µg/L. The NOAECs from chronic toxicity studies with the freshwater and marine/estuarine fish were 0.37 mg/L (370 µg/L) and 0.62 mg/L (620 µg/L). A comparison of the EEC with the NOAECs resulted in risk quotients that are several orders of magnitude below the LOC of 1.0. Therefore, potential risk to fish following chronic exposure is lower than the chronic level of concern for aquatic animals.

Consequently, the risks for acute and chronic adverse effects related to reproduction, growth, and survival are lower than the Agency's concern level for freshwater and estuarine/marine fish and invertebrates inhabiting surface waters adjacent to naphthalene treated site. Nevertheless, freshwater animals are as sensitive as estuarine/marine animals to naphthalene.

b. Aquatic-phase Amphibians

EFED currently uses surrogate data (fish) to estimate potential risks to non-target aquatic phase amphibians. Risks to fish species were discussed above. No aquatic-phase amphibian toxicity data was submitted or was located in the open literature. Therefore, based on conclusions for fish, risk to aquatic phase amphibians is also expected to be lower than the Agency's concern level.

c. Aquatic Plants

EFED currently uses aquatic plant data to estimate potential risks to non-target aquatic plants from surface water runoff. Available open literature toxicity data with green algae indicate naphthalene is slightly toxic to aquatic nonvascular plants with EC_{50} values of 33 and 34 mg/L. No aquatic vascular plant toxicity data with duckweed was submitted or located in the open literature. Therefore, it is uncertain if aquatic vascular plants inhabiting surface waters adjacent to a treated area would be at risk for adverse effects to growth and development as a result of naphthalene outdoor uses. In addition to the uncertainty, the proposed labels state that the products should not be applied directly to foliage or stems. This statement and summary reviews of open literature data indicate that there is a possibility of phytotoxicity to plants.

2. Risks to Non-target Terrestrial Animals and Plants

In the conceptual model, animals exposed to naphthalene granules as surrogate for flakes or crystals and wind erosion of soil particles are the most likely sources of naphthalene exposure to non-target terrestrial animals and plants. While terrestrial organisms may also be exposed by other routes, such as incidental ingestion of contaminated soil, dermal contact with treated granular surfaces and soil during activities in the treated areas, and preening activities, the primary route of exposure to naphthalene granules in this assessment will be via the oral route.

Acute risks to terrestrial animals (i.e. birds, terrestrial-phase amphibians, reptiles and mammals) and plants (i.e. dicots and monocots) were assessed based on modeled EECs and available toxicity data. As part of the terrestrial assessment, exposure concentrations of naphthalene granules to non-target terrestrial animals were modeled according to labeled maximum and minimum application rates. For terrestrial birds, terrestrial-phase amphibians, reptiles and

mammals, estimates of upper bound levels of naphthalene granules, which may expose wildlife, were determined using the Fletcher nomogram followed by a first order decline model TREX 1.3.1 (Details in appendix D). No terrestrial plant data were available; therefore, no risk assessment was conducted for terrestrial plants.

The risk hypothesis stated that the use of naphthalene has the potential to cause adverse effects to terrestrial animals and plants. The risk hypothesis is confirmed for birds, terrestrial-phase amphibians, reptiles and mammals, and for adverse effects to non-target terrestrial animals and plants via indirect effects resulting from potential effects to birds, terrestrial-phase amphibians, reptiles and mammals. However, for terrestrial plants, due to lack of data, it is uncertain if terrestrial plants inhabiting areas adjacent to a treated area would be at risk for adverse effects to growth and development from naphthalene uses. Furthermore, as stated previously, the proposed labels state that the products should not be applied directly to foliage or stems. This statement indicates that there is a possibility of phytotoxicity.

a. Birds

Naphthalene is categorized as practically nontoxic to upland game birds (Northern bobwhite quail) on an acute oral (2690 mg/kg bw) and subacute dietary (>5620 mg/kg diet) basis. No acute studies with the mallard duck are available; therefore, it is uncertain if naphthalene is toxic to waterfowl even though naphthalene is not toxic to upland game birds. In the oral study, sublethal effects of ruffled appearance, depression, reduced reaction to external stimuli, loss of coordination, lower limb weakness prostrate posture, lethargy and loss of righting reflex were more pronounced at the beginning of the test; at test termination, all surviving birds appeared normal. Based on LD_{50}/ft^2 exposure method and an avian oral LD_{50} of 2690 mg/kg bw, the Acute Risk, Acute Restricted Use, and Endangered Species LOCs were exceeded for all weight classes birds exposed to naphthalene granules at the maximum application rate of 10.8 lb/A (see Table III-2). At the minimum application rate of 0.56 lb/A (Table III-3), the Acute Risk, Acute Restricted Use and Endangered Species LOCs were exceeded for all weight classes birds, except for 1000 g birds which only the Acute Restricted Use and Endangered Species LOCs are exceeded.

LD_{50} (mg/kg-bw) values from acceptable or supplemental toxicity studies that are then adjusted for the size of the animal tested compared with the size of the animal being assessed (e.g., 20-gram bird). For the use of naphthalene on ornamentals, flowering beds and perimeter of buildings, the highest EEC is 23429.24 mg ai/sq. ft. The adjusted LD_{50} for a 20 g bird would be 1937.96 mg ai/kg-bw. The LD_{50}/sq ft for a 20 g bird would be 604.48.[11] The result Table III-4 summarizes this comparison. See Appendix D for T-REX modeling calculations and results following the application of 10.8 and 0.56 lbs/A for birds.

[11] **LD_{50} ft^{-2} =** EEC (mg a.i./ft^2) / (Adj. LD_{50} x bw (kg) of assessed animal) = (23429 mg ai/sq ft) / (1937 mg/kg bw x .02 kg) = 604

Table III-4. Comparison of Avian Acute Toxicity Values with Predicted EECs on Granule Consumption			
Application Rate	**Weight class (g)**	**Naphthalene Estimates**	
		Predicted EEC (mg ai/sq ft)	**Adjusted LD_{50} [a] (mg ai/kg-bw)**
10.8 lbs/A	20	23429.24	1937.96
	100	23429.24	2467.11
	1000	23429.24	3484.89
0.56 lbs/A	20	1214.85	1937.96
	100	1214.85	2467.11
	1000	1214.85	3484.89
[a] LD_{50} = 2690 mg/kg-bw			

To better characterize the risks to birds, this screening risk assessment also estimates the minimum foraging area (square feet) needed to allow for direct ingestion of sufficient mass of naphthalene to achieve a dose that exceeds the adjusted LD_{50} by assuming that a bird consumes 100%, 50% or 10% of the available granules depending on bird's weight class. In order to derive a first approximation of acute exposure and risk to granular naphthalene for birds that may directly consume granules, the TREX model takes into account that naphthalene granules do not repel but attract birds and that 100% of avian diet is comprised of naphthalene granules. By comparing this estimated concentration at 10.8 lb/A to the corresponding acute oral toxicity reference value for birds (LD_{50} = 2690 mg/kg-bw for birds (MRID 148176)); acute LD_{50}/ft^2s were calculated and compared to the Agency's LOCs. Subsequently, the LD_{50}/ft^2 for birds, in general, resulting from exposure to 10.8 lb/A granular naphthalene was 8.7; the Agency's LOCs for acute risk (0.5), acute restricted use (LOC 0.2), and acute endangered species (LOC 0.1) were all exceeded. The LD_{50}/ft^2 for birds, in general, resulting from exposure to 0.56 lb/A granular naphthalene was 0.45; the Agency's LOCs for acute restricted use and endangered species were exceeded.

Although it seems unreasonable to assume that naphthalene granules may be consumed by birds since it is not formulated as an attractant but as a repellent to terrestrial animals and is comprised of granules with a strong odor of coal tar, it is uncertain if the repellent nature of the compound will be sufficient to keep birds away. The reason of the uncertainty is based on the acute dietary study (MRID 148175) of naphthalene to 13-day old bobwhite quails, the 5-day LC_{50} was >5620 mg/kg-diet but the NOAEC was 1000 mg/kg-diet due to reductions in percentage of body weight while food consumption of treated birds were higher (9-15 g/bird/day) than the control birds (8.6 g/bird/day). Nevertheless, the TREX model assumes birds are exclusively attracted to naphthalene and their diets are 100% granules, which represents a conservative scenario due to species-specific feeding habits and dietary requirements. Therefore, EFED has taken further steps to characterize the potential for acute risk to avian species by evaluating how much area would need to be foraged to achieve the amount of naphthalene granules necessary to trigger the

Agency's Levels of Concern (LOCs). Table III-5 calculates the number of granules and minimum foraging area needed to exceed Agency's LOCs at 10.8 lb/A granular naphthalene.

Table III-5. Estimates of the number of granules, and minimum area foraged needed for a 20g, 100g, and 1000g bird to achieve the EEC that would trigger an exceedance of the adjusted LD50, acute risk LOC (0.5), and endangered species risk (0.5) levels of concern (LOCs) based on an application rate of 10.8 lb/A

		Bird Size (grams)		
		20	**100**	**1000**
No. of Consumed Granules Required to Reach the Specified LOC	Adjusted LD_{50}	1	7	92
	Acute Risk LOC (0.5)	0.51	4	46
	Endangered Species LOC (0.1)	0.1	0.65	10
Area of Field to be Foraged (square feet) to Achieve the Endangered Species LOC Based on Application Rate of 10.8 lb/A.*	Assuming a 100% Feeding Efficiency	0.03	0.22	3.1
	Assuming a 50% Feeding Efficiency	0.07	0.44	6.2
	Assuming a 10% Feeding Efficiency	0.34	2.19	31

* Immediate EEC = 112.46 mg/square feet (excluding row spacing, bandwidth, and # of rows input parameters)

For instance, it was estimated that a 20-g bird would need to consume 0.1 granules to exceed the endangered species LOC. Based on the maximum application rate of 10.8 lb/A, this number of granules could be gleaned from 0.03, 0.07, or 0.34 square feet (within the treated band) when assuming a 100%, 50%, or 10% feeding efficiency, respectively. To achieve an EEC equivalent dose that would result in an exceedance of the endangered species LOC, a 1000g bird would have to consume 10 granules. It was estimated that this number of granules could be consumed in an area of 3.1, 6.2, or 31 square feet when assuming a 100%, 50%, or 10% feeding efficiency, respectively.

Table III-6 calculates the number of granules and minimum foraging area needed to exceed Agency's LOCs at the minimum application rate of 0.56 lb/A granular naphthalene.

Table III-6. Estimates of the number of granules, and minimum area foraged needed for a 20g, 100g, and 1000g bird to achieve the EEC that would trigger an exceedance of the adjusted LD50, acute risk LOC (0.5), and endangered species risk (0.5) levels of concern (LOCs) based on an application rate of 0.56 lb/A

		Bird Size (grams)		
		20	**100**	**1000**
No. of Consumed Granules Required to Reach the Specified LOC	Adjusted LD_{50}	1	7	92
	Acute Risk LOC (0.5)	0.51	4	46
	Endangered Species LOC (0.1)	0.1	0.65	10
Area of Field to be Foraged (square feet) to Achieve the Endangered Species LOC Based on Application Rate of 0.56 lb/A.*	Assuming a 100% Feeding Efficiency	0.66	4.2	60
	Assuming a 50% Feeding Efficiency	1.3	8.5	120
	Assuming a 10% Feeding Efficiency	6.7	42.3	598

* Immediate EEC = 5.83 mg/square feet (excluding row spacing, bandwidth, and # of rows input parameters)

For this screening risk assessment purposes, it is assumed that birds occupy, exclusively and permanently, the treated area being modeled. This assumption leads to a maximum level of exposure in the risk characterization. To the extent that a bird does not reside exclusively and permanently in the treated areas ingesting naphthalene granules as their only food source, exposure will be much less and presumably substantially less. Naphthalene is manufactured as a

repellent, so it is likely that birds will avoid consumption of the naphthalene flakes/crystals; however, incidental ingestion of naphthalene granules may be the most likely route of exposure.

a. Terrestrial-phase Amphibians and Reptiles

EFED currently uses data on surrogate species (birds) to assess non-target terrestrial-phase amphibians and reptiles. Based on the evaluation of potential risks to birds, potential risks to reptiles and terrestrial-phase amphibians are also higher than the Agency's levels of concern. Again, to the extent that a terrestrial-phase amphibian or reptile does not reside exclusively and permanently in the treated areas ingesting naphthalene crystals or flakes, exposure will be much less. Naphthalene is a repellent and it is manufactured to ensure that reptiles will avoid the naphthalene flakes (e.g., Snake-A-Way).

b. Mammals

Based on LD_{50}/ft^2 exposure method and mammal oral LD_{50} of 2649 mg/kg-bw, the Acute Risk, Acute Restricted Use and Endangered Species Risk LOC were exceeded for all weight classes (15-, 35- and 1000 g) mammals exposed to naphthalene granules at both maximum and minimum application rates (Tables III-2 and III-3). Mammalian species would be at risk to adverse effects from granular application of naphthalene. Currently, T-REX does not have the capacity to estimate the minimum foraging area needed to allow for direct ingestion of sufficient mass of naphthalene to achieve a dose that exceeds the LOC for mammals.

c. Beneficial Insects

No honeybee contact study has been submitted; therefore, the potential risks to beneficial insects are unknown.

d. Terrestrial Plants

EFED currently uses terrestrial plant data to estimate potential risks to non-target terrestrial plants from surface water runoff. No terrestrial plant studies have been submitted or located in published literature; therefore, the potential risks to terrestrial plants are unknown. Therefore, it is uncertain if terrestrial plants inhabiting areas adjacent to a treated area would be at risk for adverse effects to growth and development as a result of naphthalene uses. Furthermore, as stated previously, the proposed labels state that the products should not be applied directly to foliage or stems. This statement indicates that there is a possibility of phytotoxicity; in addition, open literature suggests that naphthalene is selectively phytotoxic to plants.

3. Review of Incident Data

The National Pesticide Information Center (NPIC) prepares summaries of information provided by individuals who have contacted the NPIC for information or to report a pesticide incident. None of this information has been verified or substantiated by independent investigations of NPIC staff, laboratory analysis, or any other means. Thus, if a person alleges/reports a pesticide incident, it will likely be recorded by NPIC. NPIC qualifies the information by assigning a

Certainty Index (CI), which is an indication of the degree of certainty that the purported incident was related to a pesticide exposure. CIs, range from 1 = "definite" to 5 = "unrelated". NPIC makes no claims or guarantees as to the accuracy of the CI or other information presented in its reports, other than that NPIC has done its best to accurately document/record the information provided to NPIC.

FIFRA 6(a)(2) incident data add lines of evidence to provide evidence that the risk predictions from the screening level assessment are substantiated with actual effects in the field. One incident resulting from naphthalene use has been recorded in the Ecological Incident Information System (EIIS) as of May 31, 2007. The incident reported includes possible impact to fish.

Formulation	Crop	Date and Location	Species Affected	Number Found	Residue and ChE Analysis	Miscellaneous, App. Rate, Method, etc.	Citation
Unknown	N/A	May 2003, Craven Co., NC	Unknown fish	2,000	No	Treated directly	IO14123-006

4. Endocrine Effects

One summarized study (Milton Fingerman, 1996) confirmed naphthalene is an endocrine disrupter. When elevated in water to 10 mg/L, naphthalene caused crawfish ovaries to shrink, resulting in fewer eggs and smaller offspring. However, the open literature data was unavailable for review for this assessment.

5. Federal Threatened and Endangered (Listed) Species Concerns

Acute endangered species and chronic risk LOCs are considered in this screening-level risk assessment of pesticide risks to listed species. Endangered species acute LOCs are a fraction of the non-endangered species LOCs or, in the case of endangered plants, RQs are derived using lower toxicity endpoints than non-endangered plants. Therefore, concerns regarding listed species within a taxonomic group are triggered in exposure situations where restricted use or acute risk LOCs are triggered for the same taxonomic group. The risk assessment also includes an evaluation of the potential probability of individual effects for exposures that may occur at the established endangered species LOC in both the risk characterization and the endangered species sections. This probability is calculated using the established dose/response relationship and assumes a probit (probability unit) dose/response relationship. This analysis is presented below.

a. Action Area

For listed species assessment purposes, the action area is considered to be the area potentially affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. At the initial screening-level, the risk assessment considers broadly described taxonomic groups and so conservatively assumes that listed species within those broad groups are co-located with the pesticide treatment area. This means that terrestrial plants and wildlife are assumed to be located on the treated site and aquatic animals are assumed to be located in a surface water body adjacent to the treated site. The assessment also assumes that the listed species are directly ingesting the granules or exposed to the wind-borne granules located on an

assumed area that has the relatively highest potential exposure to the pesticide. Section I.A.3 of this risk assessment presents the pesticide use sites that are used to establish initial collocation of species with treatment areas.

If the assumptions associated with the screening-level action area result in RQs that are below the listed species LOCs, a "no effect" determination conclusion is made with respect to listed species in that taxa, and no further refinement of the action area is necessary. Furthermore, RQs below the listed species LOCs for a given taxonomic group indicate no concern for indirect effects upon listed species that depend upon the taxonomic group covered by the RQ as a resource. However, in situations where the screening assumptions lead to RQs in excess of the listed species LOCs for a given taxonomic group, a potential for a "may affect" conclusion exists and may be associated with direct effects on listed species belonging to that taxonomic group or may extend to indirect effects upon listed species that depend upon that taxonomic group as a resource. In such cases, additional information on the biology of listed species, the locations of these species, and the locations of use sites and could be considered along with available information on the fate and transport properties of the pesticide to determine the extent to which screening assumptions regarding an action area apply to a particular listed species. These subsequent refinement steps could consider how this information would impact the action area for a particular listed species and may potentially include areas of exposure that are downwind and downstream of the pesticide use site.

b. Taxonomic Groups Potentially at Risk

The preliminary risk assessment for endangered species indicates that naphthalene exceeds the Endangered Species LOCs for the specified use scenario for the following taxonomic groups:

- Birds (all weight classes), reptiles and terrestrial-phase amphibians ingesting granules in the treated area at both high and low application rates.
- Mammals (all weight classes) ingesting granules in the treated area at both high and low application rates.

With limited data available, no LOCs were exceeded for freshwater fish, aquatic-phase amphibians and invertebrates. Data for estuarine/marine species, beneficial insects and terrestrial/aquatic plants are not available; it is uncertain if these species would be potentially at risk when exposed to naphthalene.

(1) Discussion of Risk Indices

For a screening-level risk assessment, EFED determines what endangered species may be affected by performing a screening level assessment. If the RQs and LD_{50}/ft^2s from this assessment do not exceed the listed species LOCs, endangered species may not be affected. However, the Agency's LOC for endangered and threatened birds, reptiles, terrestrial-phase amphibians and mammals is exceeded for the use of naphthalene as outlined in previous sections. Should estimated exposure levels occur in proximity to listed resources, the available screening level information suggests a potential concern for direct effects on listed species within these taxonomic groups listed above associated with the use of naphthalene as described in

Section I.A.3

(2) Probit Dose Response Relationship

A probit dose response analysis was performed for toxicity studies for which slopes with 95% confidence intervals were available; these include freshwater invertebrate (daphnid), freshwater fish (rainbow trout), and birds (bobwhite quail). The probit slope response relationship is evaluated to calculate the chance of an individual event corresponding to the listed species acute LOCs. To accomplish this interpretation, the Agency would use (1) the slope of the dose response relationship available from the toxicity study used to establish the acute toxicity measurement endpoints for each animal taxonomic group; (2) an assumption of a probit dose response relationship; (3) a mean estimate of slope consistent with current Agency statistical procedures; and (4) a lower limit to the estimate of individual effect chance based on what could be calculated by Excel spreadsheet "Normdist" function. In cases where dose-response curves are unavailable, event probabilities are calculated for the listed species LOC based on a default slope assumption of 4.5 as per original Agency assumptions of typical slope cited in Urban and Cook (1986).

Probability of an individual effect was estimated at the acute endangered species LOC for aquatic and terrestrial animals (Table III-7). Plants are not included in the probability analysis. This analysis is presented in the following table.

Table III-7 Probit Dose Response Relationship Analysis

Taxa	Probit Slope (95% confidence intervals)	Endangered Species LOC	Estimated Probability of an Individual Effect at the Endangered Species LOC	Comment
Birds, Reptiles and Terrestrial-phase Amphibians	2.13 (0.486-3.78) MRID 148176	0.1	1 in 6E1 (1 in 3.19 to 1 in 1.28E4)	None
Mammals	4.5 (2-9)	0.1	1 in 2.9E5 (1 in 44 to 1 in 9E18)	Data insufficient to allow for probit slope derivation; therefore, the default slope of 4.5 with lower and upper bounds of 2 – 9 was used.
Fish and Aquatic-phase Amphibians	12.9 (7.8 – 18) MRID 46030801	0.05	1 in 6E62 (1 in 5.9E23 to 1 in 7E120)	None
Aquatic Invertebrates	5.9 (1.4-10.3) MRID 44302702	0.05	1 in 1.2E14 (1 in 29 – 1 in 3.3E40)	None

(3) Data Related to Under-represented Taxa

Data are not available to evaluate effects to under-represented taxa.

(4) Implications of Sublethal Effects

The only sublethal effect observed in the acute terrestrial animal studies is a decrease in body

weight in the bobwhite quail acute oral study with a NOAEC of 1000 mg/kg-bw. No sublethal effects were reported in any of the acute studies conducted with aquatic species.

c. Indirect Effect Analysis

The endangered species LOC for non-target animals was exceeded for birds, reptiles, terrestrial-phase amphibians and mammals located in the treated areas ingesting granules for the scenarios analyzed. The guideline survival studies indicate direct adverse effects to 20-, 100-, and 1000-gram birds, reptiles, terrestrial-phase amphibians and 15-, 35-, and 1000-gram mammals.

Adverse effects to birds, reptiles, terrestrial-phase amphibians and mammals may be sufficient to prevent the animals from competing successfully with other animals for resources and water. Endangered species may be especially impacted by exposure to naphthalene because of the impact of the loss of a few individuals to the population. There is a potential concern for listed species with either broad or narrow dependencies on impacted bird, reptile, terrestrial-phase amphibian and mammal species/populations/communities for habitat, feeding, burrowing or cover requirements.

d. Critical Habitat

In the evaluation of pesticide effects on designated critical habitat, consideration is given to the physical and biological features (constituent elements) of a critical habitat identified by the U.S. Fish and Wildlife and National Marine Fisheries Services as essential to the conservation of a listed species and which may require special management considerations or protection. The evaluation of impacts for a screening level pesticide risk assessment focuses on the biological features that are constituent elements and is accomplished using the screening-level taxonomic analysis (risk indices, RQs or LD_{50}/ft^2s) and listed species levels of concern (LOCs) that are used to evaluate direct and indirect effects to listed species.

The screening-level risk assessment has identified potential concerns for indirect effects on listed species for those animals and plants dependant upon birds, reptiles, terrestrial-phase amphibians and mammals. In light of the potential for indirect effects, the next step for EPA and the Services is to identify which listed species and critical habitat are potentially implicated. Analytically, the identification of such species and critical habitat can occur in either of two ways. First, the agencies could determine whether the action area overlaps critical habitat or the occupied range of any listed species. If so, EPA would examine whether the pesticide's potential impacts on non-endangered species would affect the listed species indirectly or directly affect a constituent element of the critical habitat. Alternatively, the agencies could determine which listed species depend on biological resources, or have constituent elements that fall into, the taxa that may be directly or indirectly impacted by the pesticide. Then EPA would determine whether use of the pesticide overlaps the critical habitat or the occupied range of those listed species. At present, the information reviewed by EPA does not permit use of either analytical approach to make a definitive identification of species that are potentially impacted indirectly or critical habitats that is potentially impacted directly by the use of the pesticide. EPA and the Service(s) are working together to conduct the necessary analysis.

This screening-level risk assessment for critical habitat provides a listing of potential biological features that, if they are constituent elements of one or more critical habitats, would be of potential concern. These correspond to the taxa identified above as being of potential concern for indirect effects and include the following: birds, reptiles, terrestrial-phase amphibians and mammals. This list should serve as an initial step in problem formulation for further assessment of critical habitat impacts outlined above, should additional work be necessary.

e. Direct Effect Co-occurrence Analysis

Because the Endangered Species LOC for birds, reptiles, terrestrial-phase amphibians and mammals is exceeded for the proposed use of naphthalene, LOCATES was run for all listed birds, reptiles, terrestrial-phase amphibians and mammals to determine the potential for co-occurrence of listed animal species location with areas of expected pesticide use. However, no preliminary analysis was performed for non-food uses of naphthalene because the LOCATES tool does not include county-level location information for the proposed non-food use of naphthalene. The animal taxa that reside in those areas, and the basis for the designation, are in Appendix G. Consequently, based on the information available at this step in the assessment process, it is presumed that all listed animal species are potentially directly affected from the broad range of naphthalene proposed uses which include areas around houses, cabins, trailers, garages, utility houses, barns, woodpiles, sand piles, trash cans, flower beds, plants (ornamentals, roses, spring bulbs), around the periphery of gardens, and garbage bags placed near residences and other buildings, streets or alleys for garbage collection. Additional analysis of listed animal locations, refinement of the action area associated with naphthalene regulatory decisions, and the biology of the potentially affected species would be needed before an effects determination can be made for any of the co-located species identified by this assessment.

LOCATES listed 500 endangered/threatened birds, reptiles, terrestrial-phase amphibians, and mammals found nationwide. Consequently, based on the information available, it is presumed listed species reside in areas of expected pesticide use (Table III-8).

Table III-8. Number of Listed Species Located in Non-Food Areas in the United States of America

Non-food Use	Affected Counties	Affected States	No. of Species
Ornamentals, gardens, and the perimeters of structural buildings	All	50	500

f. Indirect Effect Co-occurrence Analysis

The screening-level risk indices for birds, reptiles, terrestrial-phase amphibians and mammals exceed the LOC for endangered species. In accordance with established procedures such findings suggest a potential concern for indirect effects to listed animal and plant species with both narrow (i.e., species that are obligates or have very specific habitat or feeding requirements) and general dependencies (i.e., cover type requirements) on plants or animals as a resource or important habitat component. LOCATES was used to preliminarily identify listed animal and plant species that are located within the counties in USA where naphthalene could be used. This analysis considered all animal and plant taxonomic groups (i.e., conifers/cycads, monocots,

dicots, ferns, lichens, insects and arachnids) that eat birds or mammals, plants that requires birds or mammals as pollinators or seed dispersers, or species that require reptile or mammal burrows for shelter or breeding habitats. However, no preliminary analysis was available for non-food use of naphthalene because the LOCATES tool does not include county-level location information for the proposed non-food use of naphthalene. Consequently, based on the information available at this step in the assessment process, it is presumed that these animal and plant species are potentially indirectly affected from the broad range of naphthalene uses which include areas around houses, cabins, trailers, garages, utility houses, barns, woodpiles, sand piles, trash cans, flower beds, plants (ornamentals, roses, spring bulbs), around the periphery of gardens, and garbage bags placed near residences and other buildings, streets or alleys for garbage collection. The animal and plant species that reside in those areas, and the basis for the designation, are in Appendix H and are summarized in Table III-9, below. Such potential concerns are limited by the true potential for exposures of critical animal and plant species resources to modeled naphthalene levels and the relationship between 'directly effected' listed species and 'indirectly effected' listed species. Consequently, additional analysis of listed species locations, refinement of the action area associated with naphthalene regulatory decisions, and the biology of the potentially affected species would be needed before an effects determination can be made for any of the co-located species identified by this assessment for potential indirect effects.

Table III-9. Listed taxonomic groups potentially at risk associated with direct or indirect effects due to applications of naphthalene on areas where ornamental plants, flowering beds and gardens are grown nationwide

Listed Taxon	Direct Effects	Basis for Direct Effects Concern	Indirect Effects	Basis for Indirect Effects Concern
Terrestrial and Semi-Aquatic Plants – monocots and dicots	Yes	Since the product labels state, "Do not apply the product directly to foliage or stems," this statement indicates that there is a possibility of phytotoxicity. In addition, open literature suggests naphthalene is selectively phytotoxic to plants. However, toxicity data are not available for terrestrial plants exposed to naphthalene. If plants are sensitive to naphthalene, there might be direct effects to plants. However, the likelihood for plants to be at risk from naphthalene is low but cannot be precluded at this time.	Yes	Potential concerns for monocots and dicots that depend on birds, reptiles, terrestrial-phase amphibians and mammals as pollinators or seed dispersers. If pollinators such as honeybees, beneficial insects, and birds/mammals are repelled from naphthalene, there might be indirect effects to plants due to loss of pollinators for flower fertilization.
Honeybees	No	No data on honeybees are available. Naphthalene is volatile, so it is uncertain if honeybees will be impacted from pollinating the treated areas or if flowers will be indirectly affected from the absent of pollinators. The likelihood of direct effect to honeybees is low but cannot be precluded at this time.	Yes	Potential concerns for honeybees that depend on mammal or reptile burrows for habitat, feeding, or cover requirements.
Birds and Reptiles[1]	Yes	The endangered species LOC is exceeded for both high and low application rates.	Yes	Potential concerns for birds and reptiles that eat mammals as a food resource.
Terrestrial-phase	Yes	The endangered species LOC is	Yes	Potential concerns for terrestrial-phase

Table III-9. Listed taxonomic groups potentially at risk associated with direct or indirect effects due to applications of naphthalene on areas where ornamental plants, flowering beds and gardens are grown nationwide

Listed Taxon	Direct Effects	Basis for Direct Effects Concern	Indirect Effects	Basis for Indirect Effects Concern
Amphibians[1]		exceeded for both high and low application rates.		amphibians that eat birds, reptiles and mammals as a food source or use mammals and depend on reptile burrows for habitat and shelter.
Mammals	Yes	The endangered species LOC is exceeded for both high and low application rates.	Yes	Potential concerns for mammals that eat birds, reptiles and terrestrial-phase amphibians and depend on reptile burrows for habitat and shelter.
Aquatic Vascular Plants	Yes	Since the product labels state, "Do not apply the product directly to foliage or stems," this statement indicates that there is a possibility of phytotoxicity. In addition, open literature suggests naphthalene is selectively phytotoxic to plants. However, toxicity data are not available for aquatic plants exposed to naphthalene. If plants are sensitive to naphthalene, there might be direct effects to plants. However, the likelihood for plants to be at risk from naphthalene is low but cannot be precluded at this time.	Yes	Potential concerns for aquatic vascular plants that depend on birds, reptiles, terrestrial-phase amphibians and mammals as pollinators or seed dispersers. If pollinators such as honeybees, beneficial insects, and birds/mammals are repelled from naphthalene, there might be indirect effects to plants due to loss of pollinators for flower fertilization.
Freshwater Invertebrates, Fish and Aquatic-phase Amphibians[2,3]	No	No LOC exceedances	Yes	If plants are directly or indirectly affected from exposure to naphthalene, freshwater fish and amphibians may be indirectly affected due to loss of cover or food sources.
Estuarine/marine Fish and Invertebrates	No	No LOC exceedances	Yes	If plants are directly or indirectly affected from exposure to naphthalene, estuarine/marine fish and invertebrates may be indirectly affected due to loss of cover or food.
Aquatic Nonvascular Plants – algae and diatoms	No	No LOC exceedances	Yes	Potential concerns for aquatic nonvascular plants that depend on birds, reptiles, terrestrial-phase amphibians and mammals as pollinators and seed dispersers. If pollinators such as honeybees, beneficial insects, and birds/mammals are repelled from naphthalene, there might be indirect effects to plants due to loss of pollinators for flower fertilization.

1 Birds are used as surrogate species for terrestrial-phase amphibians and reptiles; therefore, potential direct and indirect effects to endangered avian, terrestrial-phase amphibians and reptilian species are considered equivalent.

2 Fish are used as a surrogate for aquatic phase amphibians; therefore, potential direct and indirect effects to endangered fish and aquatic-phase amphibian species are considered equivalent.

D. Assumptions, Uncertainties, Strengths and Limitations of the Naphthalene Assessment.

Maximum use scenario

This screening-level risk assessment relies on labeled statements of the maximum rate of naphthalene applications, the maximum number of applications, and the shortest interval between applications. Together, these assumptions constitute a maximum use scenario and can overestimate risk. However, the maximum use scenario must be considered because it is a reflection of the allowable use of naphthalene. The frequency at which actual uses approach these maximums is dependent on the number and timing of applications, and market forces. In addition, rates of application less than the maximum rate are also considered.

Lack of data on degradates

There are several areas of uncertainty in the terrestrial and the aquatic species risk assessments that could potentially cause an underestimation of risk. First, this assessment accounts only for exposure of non-target species to naphthalene, but not to its degradates. The risks presented in this assessment could be underestimated if degradates also exhibit toxicity under the conditions of use proposed on the label. Review of available open literature data concerning the fate and toxicity of the transformation products of naphthalene was limited to which degradates were observed but did not provide information on the conditions under which degradates were formed, the timing of formation, and what amounts were observed, and how quickly (if at all) the degradates degraded.

Uncertainties with GENEEC 2 model

Extrapolating the risk conclusions from the standard pond scenario modeled by GENEEC2 may either underestimate or overestimate the potential risks. Major uncertainties with the standard runoff scenario are associated with the physical construct of the watershed and representation of vulnerable aquatic environments for different geographic regions. The physicochemical properties (pH, redox conditions, etc.) of the standard farm pond are based on a Georgia farm pond. These properties are likely to be regionally specific because of local hydrogeological conditions. Any alteration in water quality parameters may impact the environmental behavior of the pesticide, depending upon the specific properties of a given chemical (for example, pH and dependant hydrolysis). The farm pond represents a well-mixed, static water body. Because the farm pond is a static water body (no flow through), it does not account for pesticide removal through flow through or accidental water releases. However, the lack of water flow in the farm pond provides an environmental condition for accumulation of persistent pesticides. The assumption of uniform mixing does not account for stratification due to thermoclines (e.g., seasonal stratification in deep water bodies). Additionally, the physical construct of the standard runoff scenario assumes a watershed:pond area ratio of 10 to 1. This ratio is recommended to maintain a sustainable pond in the Southeastern United States. The use of higher watershed:pond ratios (As recommended for sustainable ponds in drier regions of the United States) may lead to higher pesticide concentrations when compared to the standard watershed:pond ratio.

Location of wildlife species

For screening terrestrial risk assessments for listed species, a generic bird or mammal is assumed to occupy either the treated field or adjacent areas receiving or ingesting pesticide at a rate commensurate with the treatment rate on the field. Model predictions suggest that this assumption leads to an overestimation of exposure to species that do not occupy the treated field or do not ingest naphthalene granules (crystals/flakes). The actual habitat requirements of any particular terrestrial species are not considered, and it is assumed that species occupy, exclusively and permanently, the treatment area being modeled. This assumption leads to a maximum level of exposure in the risk characterization. To the extent that a species does not reside exclusively and permanently in treated areas, exposure will be less, and presumably less. As for the case with naphthalene used as a repellent to keep species away from treated areas, it is likely that terrestrial species will not occupy the treatment area permanently or attempt to ingest naphthalene granules. However, incidental ingestion of the naphthalene granules is likely.

Routes of exposure

Screening-level risk assessments for granular applications of pesticides consider dietary exposure alone. Other routes of exposure, not considered in this assessment, are discussed below:

- Incidental soil ingestion exposure

This risk assessment does not consider incidental soil ingestion; however, since naphthalene repels unwanted species to the treated sites, incidental soil ingestion may not need to be considered.

- Inhalation exposure

The screening risk assessment does not consider inhalation exposure. Such exposure may occur through two potential sources: (1) vapor phase pesticide volatilizing from treated surfaces and (2) airborne particulate (soil, vegetative material, and pesticide dusts/crystals/flakes).

Theoretically, inhalation of pesticide active ingredient in the vapor phase may be another source of exposure for some pesticides under some exposure situations. However, considering its moderate vapor pressure value (8.5×10^{-2} mm Hg), it is uncertain that naphthalene will exist in the gaseous phase at any considerable amount to cause any adverse effects via inhalation.

The impact from exposure to dusts/flakes/crystals contaminated with the pesticide cannot be assessed generically as partitioning issues related to application site soils and chemical properties render the exposure potential from this route highly situation specific.

- Dermal exposure

The screening assessment does not consider dermal exposure, except as it is indirectly included in calculations of risk indices based on lethal doses per unit of pesticide treated area. Dermal exposure may occur through three potential sources: (1) direct application of flakes/crystals to

terrestrial wildlife in the treated area, (2) incidental contact with contaminated vegetation, or (3) contact with contaminated water or soil.

The available measured data related to wildlife dermal contact with pesticides are extremely limited. The Agency is actively pursuing modeling techniques to account for dermal exposure via direct application of granules and by incidental contact with vegetation.

Dietary Intake – The Differences between Laboratory and Field Conditions

The acute and chronic characterization of risk rely on comparisons of wildlife dietary residues with LC_{50} or NOAEC values expressed in concentrations of pesticides in laboratory feed. These comparisons assume that ingestion of granules in the field occurs at rates commensurate with those in the laboratory. Although the screening assessment process adjusts dry-weight estimates of food intake to reflect the increased mass in fresh weight wildlife food intake estimates, it does not allow for gross energy and assimilative efficiency differences between wildlife food items and laboratory feed.

On gross energy content alone, direct comparison of a laboratory dietary concentration- based effects threshold to a fresh-weight pesticide residue estimate would result in an underestimation of field exposure by food consumption by a factor of 1.25 – 2.5 for most food items. Only for seeds would the direct comparison of dietary threshold to residue estimate lead to an overestimate of exposure.

Differences in assimilative efficiency between laboratory and wild diets suggest that current screening assessment methods do not account for a potentially important aspect of food requirements. Depending upon species and dietary matrix, bird assimilation of wild diet energy ranges from 23 – 80%, and mammal's assimilation ranges from 41 - 85% (U.S. Environmental Protection Agency, 1993). If it is assumed that laboratory chow is formulated to maximize assimilative efficiency (e.g., a value of 85%), a potential for underestimation of exposure may exist by assuming that consumption of food in the wild is comparable with consumption during laboratory testing. In the screening process, exposure may be underestimated because metabolic rates are not related to food consumption.

Finally, the screening procedure does not account for situations where the feeding rate may be above or below requirements to meet free-living metabolic requirements. Gorging behavior is a possibility under some specific wildlife scenarios (e.g., bird migration) where the food intake rate may be greatly increased. Kirkwood (1983) has suggested that an upper-bound limit to this behavior might be the typical intake rate multiplied by a factor of 5.

In contrast is the potential for avoidance, operationally defined as animals responding to the presence of noxious chemicals in their food by reducing consumption of treated dietary elements. This response is seen in nature where herbivores avoid plant secondary compounds or in this case, avoid chemicals that specifically repel unwanted species visiting the treated site.

Use of the most sensitive species tested

A small number of surrogate species were used in this screening level risk assessment. It is not possible to determine whether the species tested are more or less sensitive than species that may be exposed to naphthalene. Also, it was assumed that fish are approximately as sensitive as aquatic-phase amphibians and that bird are approximately as sensitive as terrestrial-phase amphibians and reptiles. However, no data are available to support these conclusions.

Lack of field studies

Although not required, field studies would assist in determining the actual extent of potential indirect effects to plants that depends on mammals and birds as pollinators and to animals that depends on reptile or mammal burrows for shelter and habitat.

Age class and sensitivity of effect thresholds

It is generally recognized that test organism age may have a significant impact on the observed sensitivity to a toxicant.

The screening risk assessment acute toxicity data for fish are collected on juvenile fish between 0.1 and 5 grams. Aquatic invertebrate acute testing is performed on recommended immature age classes (e.g., first instar for daphnids, second instar for amphipods, stoneflies and mayflies, and third instar for midges).

Acute dietary testing with birds is performed on juveniles, with mallard being 5-10 days old and bobwhite quail 10-14 days old.

Testing of juveniles may overestimate toxicity at older age classes for pesticidal active ingredients because younger age classes may not have the enzymatic systems associated with detoxifying xenobiotics. The screening risk assessment has no current provisions for a generally applied method that accounts for this uncertainty. In so far as the available toxicity data may provide ranges of sensitivity information with respect to age class, the risk assessment uses the most sensitive life-stage information as the conservative screening endpoint.

Acute and Chronic LOCs

The risk characterization section of this assessment includes an evaluation of the potential for individual effects at an exposure level equivalent to the LOC. This evaluation is based on the median lethal dose estimate and dose/response relationship established for the effects study corresponding to each taxonomic group for which the LOCs are exceeded. The dose-response curve representing a given taxa is generated from one study using one species. It is likely that the resulting dose-response relationship does not represent the response of all species within a taxa.

The risk estimates are based on acute and chronic effects in the laboratory; therefore, these risk estimates do not directly take into account uncertainties such as laboratory-to-field sensitivity differences. These include uncertainty regarding the error introduced when extrapolating from

laboratory to field effects at a given concentration. For example, mortality in the field could be greater in populations previously stressed by other pesticide exposures, temperature stress, habitat loss, predation, or competition for limited resources. Field mortality and reduction in growth and reproduction could be lower if the laboratory population were to represent an unusually sensitive species.

IV. LITERATURES CITED

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