Risk Assessment on Scourge[R] and Punt[TM] 57-0S

Materials used by the Metropolitan Mosquito Control District for the Control of Adult Mosquitos

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Introduction

The Metropolitan Mosquito Control District (MMCD) controls mature flying mosquitos (adults) to supplement larval mosquito control. Adult mosquito control involves treating parks and recreation areas with two commercial pesticides, Scourge[R] and Punt[TM] 57-0S. The MMCD treats athletic fields, camps, zoos, and areas designated for civic events. The MMCD may also treat residential areas within a quarter mile radius of parks and recreation areas.

Scourge[R] and Punt[TM] 57-0S contain the synthetic pyrethroid insecticides resmethrin and permethrin respectively. Pyrethroids disrupt the insect nervous system. These insecticides were first isolated from chrysanthemum flowers. Researchers later developed synthetic pyrethroids, which are more potent and more stable in sunlight than naturally occurring pyrethroids.

People[1] could be exposed to Scourge[R] and Punt[TM] 57-0S by three main pathways: 1) incidental ingestion of treated soil or vegetation, 2) inhalation of the pesticide during or after treatment, and 3) direct skin contact with treated soil or foliage.

The following risk assessment estimates the potential toxicity to humans from exposure to Scourge[R] and Punt[TM] 57-0S, and discusses the uncertainties in this estimation. To assure an adequate margin of safety, the risk estimations incorporate protective assumptions and near worst case exposure scenarios. It should be emphasized that risk assessment does not provide a precise quantitation of exposure and safety. Instead risk assessment indicates types of exposures that might be cause for concern and estimates safe levels of exposure with a wide margin for protection.

Conclusion

Exposure to Scourge[R] or Punt[TM] 57-0S through ingestion or skin contact should not pose a health risk to humans under the scenarios described in this document. Brief inhalation exposure to the pesticides should not pose a health risk. Nevertheless, children should be prevented from having prolonged inhalation exposure to the pesticides. For example, children should not be permitted to follow the pesticide applicators as they work. The risk assessment of these pesticides may be revised if new toxicologic data, air monitoring data, or other types of data are received.

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[1]This risk assessment only considers people who do not work with Scourge[R] and Punt[TM] 57-0S. If the pesticide applicators who work with Scourge[R] and Punt[TM] 57-0S wear the recommended safety equipment, which includes gloves, longsleeves, goggles and a respirator, they should avoid hazardous exposure to the pesticides.

Summary

The intent of this risk assessment is to determine whether exposure to the pesticides Scourge[R] and Punt[TM] 57-0S could be toxic to humans. Four main questions are addressed for each pesticide. First, are any of the ingredients in the pesticides potentially harmful to humans? Second, how much of these ingredients could a human be exposed to without suffering harmful effects? Third, how much of these ingredients might humans be exposed to under the treatment conditions described by the MMCD? Fourth, does the estimated level of exposure to these compounds exceed the estimated level of safety?

Due to various uncertainties in the calculations, this risk assessment should not be interpreted as a precise quantitation of exposure and safety, but instead as an indicator of the types of exposures that might be cause for concern. Uncertainties arise from a number of sources. For example, if the amount of a chemical in the air or soil has not been measured, it must be estimated. Sometimes the amount or quality of toxicologic data on a chemical is not adequate to accurately predict what toxic effects it might have in humans. In addition, exposure can vary greatly among individuals throughout a population. The amount of exposure depends on many factors including age, size, residence, and activities.

To account for various types of uncertainty, some general assumptions are made. In all cases, we try to make assumptions that err on the side of protecting human health. For example, we assume that people are exposed to almost as much of the pesticide as possible, even if the average person would be exposed to less. This gives a measure of protection to people who are sensitive to the pesticides, and provides a margin of safety for the average person. Most of the assumptions and equations used to estimate exposure follow United States Environmental Protection Agency guidelines.

The estimation of a safe level of exposure to a chemical can be expressed in different ways. In this document it is referred to as either a **reference dose (RfD)** expressed in units of milligrams of a substance ingested per kilogram of body weight per day (mg/kg/day), an **estimated safe air concentration** expressed in milligrams of the chemical inhaled per cubic meter (mg/m^3), or a **Maximum Daily Allowable Intake (MDA)**, expressed in milligrams of a chemical ingested each day (mg/day). A more detailed explanation of RfDs and MDAs is given in Appendix B.

Scourge®

Three tables summarizing the risk assessment of Scourge® follow. Please refer to the full risk assessment for a detailed explanation of the calculations and assumptions that yielded these results.

The potentially hazardous chemicals contained in Scourge® are the pesticide resmethrin, piperonyl butoxide, and an aromatic petroleum solvent (APS). Scourge® also contains a mineral oil-type material.

Exposure to these chemicals could come from eating, inhaling, or having skin (dermal) contact with Scourge®. Exposure is estimated for a child and an adult, and compared to the estimated safe level of exposure. Due to lack of toxicity data, piperonyl butoxide is only evaluated for oral and inhalation exposure, the aromatic petroleum solvent is only evaluated for inhalation exposure, and no risk assessment is done for the inert ingredients.

Scourge[R]

Ingestion	MDA (mg/day)	Estimated Daily Intake (mg/day)
Resmethrin (child)	3.2	5.3×10^{-6}
Resmethrin (adult)	14	2.6×10^{-6}
Piperonyl Butoxide (child)	13	1.5×10^{-5}
Piperonyl Butoxide (adult)	59	7.0×10^{-6}

Inhalation	Estimated Safe Air Concentration (mg/m^3)	Estimated Air Concentration (mg/m^3)
Resmethrin (child)	0.57	1.4
Resmethrin (adult)	2.0	1.4
Piperonyl Butoxide (child)	16	4.0
Piperonyl Butoxide (adult)	57	4.0
APS (child)	7.8	1.7
APS (adult)	27	1.7

Dermal	MDA (mg/day)	Estimated Daily Intake: Soil (mg/day)	Estimated Daily Intake: Foliage (mg/day)
Child	80	1.2×10^{-4}	0.12
Adult	350	3.3×10^{-4}	0.34

Conclusion: Oral and dermal exposure to Scourge[R], under the conditions described in this document, should not pose a health risk. Brief inhalation exposure to Scourge[R] should not pose a health risk. Nevertheless, children should be prevented from having prolonged inhalation exposure to Scourge[R]. For example, children should not be permitted to follow the pesticide applicators as they work. See the full risk assessment on Scourge[R] (part II, section C) for a detailed explanation of the uncertainties in the estimation of inhalation exposure.

Punt™ 57-0S

Three tables summarizing the risk assessment of Punt™ 57-0S follow. Please refer to the full risk assessment for a detailed explanation of the calculations and assumptions that yielded these results.

The potentially hazardous chemicals contained in Punt™ 57-0S are the insecticide permethrin and a xylene range aromatic solvent. Before applying Punt™ 57-0S, the MMCD dilutes it with soybean oil or a food grade mineral oil.

Exposure to these chemicals could come from eating, inhaling, or having skin (dermal) contact with Punt™ 57-0S. Exposure is estimated for a child and an adult, and compared to the estimated safe level of exposure. This risk assessment evaluates the oral, inhalation and dermal routes of exposure to permethrin. Due to lack of data, no risk assessment is done for the xylene range aromatic solvent.

Punt™ 57-0S

Ingestion	MDA (mg/day)	Estimated Daily Intake (mg/day)
Child	0.8	1.5×10^{-4}
Adult	3.5	7.0×10^{-5}

Inhalation	Estimated Safe air concentration (mg/m^3)	Estimated air concentration (mg/m^3)
Permethrin (child)	1.6	4.1
Permethrin (adult)	5.6	4.1

Dermal	$^2MDA_{tox}$ (mg/day)	$^3MDA_{irr}$ (mg/day)	Estimated Daily Intake: Soil (mg/day)	Estimated Daily Intake: Foliage (mg/day)
Child	160	1.6	3.4×10^{-3}	3.5
Adult	700	7.0	9.1×10^{-3}	9.8

Conclusion:

Oral and dermal exposure to Punt™ 57-0S, under the conditions described in this document, should not pose a health risk.

Brief inhalation exposure to Punt™ 57-0S should not pose a health risk. Nevertheless, children should be prevented from having prolonged inhalation exposure to Punt™ 57-0S. For example, children should not be permitted to follow the pesticide applicators as they work.

Although the estimated dermal exposure to permethrin from foliage exceeds the MDA for irritation, incidental contact with foliage probably would not result in significant irritation. The calculation of estimated daily intake assumes that there is 100% transfer of permethrin from foliage to the hands, arms, and legs. Under most conditions, contact with treated foliage should not result such a large exposure. See full risk assessment on Punt™ 57-0S [part IV, section (4)] for an explanation of the uncertainties in the estimation of dermal exposure.

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[2]This represents the RfD for toxicity.

[3]This represents the RfD for skin irritation.

Risk Assessment of Scourge[R]

I. General Comments

Scourge[R] contains 4.14% resmethrin[4], 12.42% piperonyl butoxide, and 5% of an aromatic petroleum solvent. Resmethrin is an insecticide. Piperonyl butoxide is not an insecticide, but serves to increase the potency of resmethrin in mosquitos. The remaining components of Scourge[R] are listed as inert ingredients, which are mainly composed of a mineral oil-type material[5].

The MMCD applies Scourge[R] using truck-mounted foggers. Fogging is done 1 to 2 hours before sunrise or at 8 or 9 o'clock at night, when mosquitos become active. The MMCD treats parks and recreation areas, and residences within a quarter mile radius of these areas. In high use parks, treatments occur a maximum of 5 times during the summer, at 10 day intervals. Scourge[R] is applied at a rate of approximately 0.0035 pounds of resmethrin and 0.01 pounds of piperonyl butoxide per acre. Resmethrin degrades in sunlight with a half life[6] of approximately 45 minutes[7]. It is completely degraded from plants within 5 days and 98% degraded from soil in 16 days (WHO, 1989).

One source of uncertainty that runs throughout this risk assessment concerns the potential difference in potency between the resmethrin used in toxicologic studies, which are used to estimate safe exposure levels, and the resmethrin contained in Scourge[R]. Resmethrin is usually made up of a mixture of cis and trans isomers. The cis isomer is more toxic than the trans isomer. A mixture of cis and trans isomers is less toxic than either alone (Miyamoto, 1976). The difference in toxicity between the most potent pure cis isomer and a 4:1 trans:cis mixture is less than 5 fold (Miyamoto, 1976). Scourge[R] contains resmethrin that is a

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[4]The chemical name for resmethrin is [5-(phenylmethyl)-3-furanyl]methyl 2,2-dimethyl-3-(2-methyl-1-propenyl)cyclopropanecarboxylate.

[5]Personnel Communication. Letter from John R. De Prospo, Manager, Toxicology Services, Roussel Bio Corporation, May 29, 1992.

[6]**Half-life** is the time it takes for half of a compound to degrade. For example, compound A has a half-life of 10 days. If there are 8 grams of A on day 1, there will be 4 grams of A on day 10. On day 20 there will be 2 grams of A, etc.

[7]Personal Communication. John De Prospo, Manager, Toxicology Services, Roussel Bio Corporation, May 28, 1992, 201-628-7200.

maximum of 30% cis isomer and a minimum of 70% trans isomer. Most toxicity studies use technical grade resmethrin, which is a mixture of cis and trans isomers. Unfortunately, these studies usually do not state the ratio of the cis and trans isomers of the resmethrin used in the experiments. Because of the limited information, we cannot be certain that the potency of the resmethrin used in the toxicology studies is the same as that of the resmethrin contained in Scourge[R].

A second source of uncertainty concerns the effect of piperonyl butoxide on the potency of resmethrin in humans. Piperonyl butoxide increases the potency of resmethrin in insects by inhibiting resmethrin metabolism. It is unclear how piperonyl butoxide affects resmethrin metabolism in mammals.

Three studies suggest that piperonyl butoxide may not increase the potency of resmethrin in humans to the extent it does in insects. A chronic toxicity study by Sarles and Vandergrift found that a preparation of 6 parts piperonyl butoxide to 1 part pyrethrins was no more toxic than piperonyl butoxide alone (Sarles and Vandergrift, 1952). This study is not definitive because it was conducted with a mixture of pyrethrins and not resmethrin alone. Furthermore the ratio of pyrethrins to piperonyl butoxide in the Sarles and Vandergrift study was 1 to 6, and the ratio of resmethrin to piperonyl butoxide in Scourge[R] is 1 to 3. In a study by Conney et al., 8 volunteer men were given 50 mg (0.7 mg/kg) of piperonyl butoxide. This dose of piperonyl butoxide did not appear to affect the metabolism of antipyrine. Both resmethrin and antipyrine are metabolized by microsomal enzymes. Microsomal enzymes are a mixture of different enzymes and isoenzymes. One weakness in this study is that it does not provide evidence that antipyrine and resmethrin are metabolized by the same enzyme or isoenzyme. A third study showed that piperonyl butoxide increases the potency of resmethrin less than two fold in rats (Roussel Bio A). In this study, the [8]LD_{50} for resmethrin in rats was 4250 mg/kg. A preparation of Scourge[R] containing 18% resmethrin and 54% piperonyl butoxide yielded an LD_{50} of 2700 mg/kg (Roussel Bio A).

The degree to which piperonyl butoxide might increase the potency of resmethrin in humans is unknown. The Roussel Bio study indicates that piperonyl butoxide could increase the potency of resmethrin in mammals by approximately 1.6 fold. To account for the potential of piperonyl butoxide to increase the potency of resmethrin in humans, the risk estimations for resmethrin incorporate an uncertainty factor of 2.

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[8]The LD_{50} is the dose at which half of the animals treated with the chemical die.

The Material Safety Data Sheet for Scourge[R] lists resmethrin, piperonyl butoxide and the aromatic petroleum solvent under hazardous ingredients. A risk assessment for the oral, inhalation and dermal routes of exposure to resmethrin follows. Due to lack of toxicity data, piperonyl butoxide is only evaluated for oral and inhalation exposure, the aromatic petroleum solvent is only evaluated for inhalation exposure, and no risk assessment is done for the inert ingredients.

The number of times the MMCD treats a given area differs depending on the type of activity that takes place there. Some areas are only treated once for a special event, such as a parade or festival. The MMCD may treat high use parks up to 5 times a season at 10 approximately day intervals.

To be protective, this risk assessment uses an exposure scenario for a high use park. In other words, it assumes that Scourge[R] is applied for 50 days during the summer (5 applications at 10 day intervals), and that a child and an adult use that park everyday for those 50 days.

The following calculations incorporate assumptions and uncertainty factors that should err on the side of protecting public health. The scenarios assume near maximum exposure in order to protect sensitive individuals and provide an adequate margin of safety for the average person.

II. Ingestion Exposure to Resmethrin and Piperonyl Butoxide

Exposure to resmethrin and piperonyl butoxide could occur through incidental ingestion of contaminated soil and contaminated vegetation. For example, a child might place his/her hands in his/her mouth during play at a park. There is also a chance of exposure through ingestion of unwashed homegrown vegetables. For example, fogging of residential neighborhoods within a quarter mile radius of a park or recreation area could result in the inadvertent treatment of gardens.

Due to the short half life of resmethrin, it is assumed that significant exposure to resmethrin will not occur after the day of application. Since there is a 10 day interval between treatments, it is assumed that each day of exposure is independent. Therefore a risk assessment is done for an acute (one day) exposure to resmethrin.

Since the half life of piperonyl butoxide was not available, it is assumed that piperonyl butoxide persists in the soil and on vegetation for the whole 50 day treatment period. The risk assessment for piperonyl butoxide assumes that exposure occurs every day for the 50 day treatment period.

Exposure to resmethrin and piperonyl butoxide through ingestion of soil and homegrown vegetables is estimated for a 1-6 year old child and an adult. Appendix A provides the general equations and assumptions for ingestion exposure.

Note: Section A estimates ingestion exposure to resmethrin, section B estimates ingestion exposure to piperonyl butoxide, and section C provides a table summarizing the results, and a conclusion.

A. Resmethrin:

(1) Estimation of the amount of resmethrin in and on soil and vegetation:

0.0035 lb of resmethrin applied per acre (information provided by the MMCD).

$(0.0035\ lb/acre)(450\ g/lb) = 1.575\ g/acre$
$(1.575\ g/acre)(acre/43{,}560\ ft^2) = 3.6 \times 10^{-5}\ g/ft^2$
$(3.6 \times 10^{-5}\ g/ft^2)(ft^2/929\ cm^2) = 3.9 \times 10^{-8}\ g/cm^2$
$(3.9 \times 10^{-8}\ g/cm^2)(10^3\ mg/g) = 3.9 \times 10^{-5}\ mg/cm^2$

- **3.9×10^{-5} mg/cm^2 resmethrin deposited on soil and vegetation**
- **2.6×10^{-5} mg resmethrin per gram of soil** (see Appendix A)

(2) Oral Reference Dose (RfD) for Resmethrin:

Appendix B explains how to calculate an RfD, the use of uncertainty factors, and how to calculate a Maximum Daily Allowable Intake (MDA).

The World Health Organization's environmental criteria document for resmethrin cites a 90-day rat study that suggests a NOAEL of 66 mg/kg/day (WHO, 1989). This document also cites a study that reports a NOAEL for fetotoxicity of 40 mg/kg/day (WHO, 1989). To be protective, the lower NOAEL for fetoxicity is used to calculate the RfD. Long term exposure studies in rats and mice indicate that the synthetic pyrethroid insecticide resmethrin is not carcinogenic (WHO, 1989).

NOAEL = 40 mg/kg/day
UF_1 = 10 for extrapolation from animals to humans
UF_2 = 10 for sensitive subpopulations
UF_3 = 2 for potential of piperonyl butoxide to increase resmethrin toxicity

$$\text{Oral RfD} = \frac{40 \text{ mg/kg/day}}{(10)(10)(2)} = \mathbf{0.2 \text{ mg/kg/day}}$$

$$\mathbf{MDA_{child} = (0.2 \text{ mg/kg/day})(16 \text{ kg}) = 3.2 \text{ mg/day}}$$

$$\mathbf{MDA_{adult} = (0.2 \text{ mg/kg/day})(70 \text{ kg}) = 14 \text{ mg/day}}$$

The confidence in this RfD is medium. The NOAEL for the fetoxicity study should be protective for subchronic effects.

Note: This is an RfD for subchronic exposure. Due to lack of adequate data, an acute RfD was not calculated. Using a subchronic RfD to assess acute exposure is less accurate than using an acute RfD, but provides a greater margin of safety.

(3) Estimation of Exposure to Resmethrin through Soil Ingestion:

See Appendix A for an explanation of equations and assumptions.

Soil ingestion for a child:

$$\frac{(2.6 \times 10^{-5}\ mg/g)(10^{-3}\ g/mg)(200\ mg/day)}{(16\ kg)}$$

$Intake_{child} = 3.3 \times 10^{-7}$ mg/kg/day

Daily $Intake_{child}$ = $(3.3 \times 10^{-7}$ mg/kg/day$)(16$ kg$)$ = **5.3×10^{-6} mg/day**

Soil ingestion for an adult:

$$\frac{(2.6 \times 10^{-5}\ mg/g)(10^{-3}\ g/mg)(100\ mg/day)}{(70\ kg)}$$

$Intake_{adult} = 3.7 \times 10^{-8}$ mg/kg/day

Daily $Intake_{adult}$ = $(3.7 \times 10^{-9}$ mg/kg/day$)(70$ kg$)$ = **2.6×10^{-6} mg/day**

(4) Ingestion of Homegrown Vegetables:

Assume 3.9×10^{-5} mg/cm^2 resmethrin is deposited on the surface of the vegetables (see (1) above). This factor is used to convert the MDA for resmethrin from mg/day to cm^2 vegetable surface area/day:

MDA_{child} = $(0.2$ mg/kg/day$)(16$ kg$)/(3.9 \times 10^{-5}$ mg/cm^2)

= **82,000 cm^2/day** vegetable surface area

MDA_{adult} = $(0.2$ mg/kg/day$)(70$ kg$)/(3.9 \times 10^{-5}$ mg/cm^2)

= **360,000 cm^2/day** vegetable surface area

B. **Piperonyl Butoxide:**

(1) Estimation of the amount of piperonyl butoxide in and on soil and vegetation:

0.01 lb of piperonyl butoxide is applied per acre (information provided by the MMCD).

$(0.01\ lb/acre)(450\ g/lb) = 4.5\ g/acre$
$(4.5\ g/acre)(acre/43{,}560\ ft^2) = 1.0 \times 10^{-4}\ g/ft^2$
$(1.0 \times 10^{-4}\ g/ft^2)(ft^2/929\ cm^2) = 1.1 \times 10^{-7}\ g/cm^2$
$(1.1 \times 10^{-7}\ g/cm^2)(10^3\ mg/g) = 1.1 \times 10^{-4}\ mg/cm^2$

- **1.1×10^{-4} mg/cm^2 piperonyl butoxide is deposited on foliage and soil.**

- **7.3×10^{-5} mg piperonyl butoxide per gram soil** (see Appendix A)

(2) Oral Reference Dose (RfD) for Piperonyl Butoxide:

Appendix B explains how to calculate an RfD, the use of uncertainty factors, and how to calculate a Maximum Daily Allowable Intake (MDA).

Sarles and Vandegrift performed a wide range of toxicity studies on technical grade piperonyl butoxide, including chronic toxicity in rats and dogs, and reproductive studies (Sarles and Vandegrift, 1952). These studies suggest a NOAEL of 84 mg/kg/day for both piperonyl butoxide alone and a mixture of 1 part pyrethroids and 6 parts piperonyl butoxide.

NOAEL = 84 mg/kg/day
UF_1 = 10 for extrapolation from animal to human
UF_2 = 10 for sensitive subpopulation

$$\text{Oral RfD} = \frac{84\ mg/kg/day}{(10)(10)} = 0.84\ mg/kg/day$$

This RfD is supported by a study by Conney et al., in which 8 volunteer men were given 50 mg (0.7 mg/kg) of piperonyl butoxide. This dose of piperonyl butoxide did not have any affect on the metabolism of antipyrine.

The confidence in this RfD is medium due to the limited data base. The study looked at a wide range of parameters and included a chronic study in more than one species. The RfD is supported by a limited study in humans. Because of limited data, this RfD is calculated from **chronic** exposure data. Using a chronic RfD to assess acute exposure is less accurate than using an **subchronic** RfD, but provides a greater margin of safety.

Oral RfD = 0.84 mg/kg/day

MDA_{child} = (0.84 mg/kg/day)(16 kg) = 13 mg/day

MDA_{adult} = (0.84 mg/kg/day)(70 kg) = 59 mg/day

(3) Estimation of Exposure to Piperonyl Butoxide through Soil Ingestion:

See Appendix A for an explanation of equations and assumptions.

Soil ingestion for a child:

$$\frac{(7.3 \times 10^{-5}\ mg/g)(10^{-3}\ g/mg)(200\ mg/day)}{(16\ kg)}$$

$Intake_{child}$ = 9.1×10^{-7} mg/kg/day

Daily $Intake_{child}$ = $(9.1 \times 10^{-7}$ mg/kg/day)(16 kg) = **1.5×10^{-5} mg/day**

Soil ingestion for adult:

$$\frac{(7.3 \times 10^{-5}\ mg/g)(10^{-3}\ g/mg)(100\ mg/day)}{(70\ kg)}$$

$Intake_{adult}$ = 1.0×10^{-7} mg/kg/day

Daily $Intake_{adult}$ = $(1.0 \times 10^{-7}$ mg/kg/day)(70 kg) = **7.0×10^{-6} mg/day**

(4) Ingestion of Homegrown Vegetables:

Assume 1.1×10^{-4} mg/cm^2 piperonyl butoxide is deposited on the surface of the vegetables (see (1) above). This factor is used to covert the MDA for piperonyl butoxide from mg/day to cm^2 vegetable surface area/day:

MDA_{child} = (0.84 mg/kg/day)(16 kg)/$(1.1 \times 10^{-4}$ mg/cm^2)

= **120,000 cm^2/day** surface area of vegetables

MDA_{adult} = (0.84 mg/kg/day)(70 kg)/$(1.1 \times 10^{-4}$ mg/cm^2)

= **530,000 cm^2/day** surface area of vegetables

C. Summary and Conclusion for Ingestion Exposure to Resmethrin and Piperonyl Butoxide

Soil Ingestion

	MDA (mg/day)	Estimated Daily Intake (mg/day)
Resmethrin (child)	3.2	5.3×10^{-6}
Resmethrin (adult)	14	2.6×10^{-6}
Piperonyl Butoxide (child)	13	1.5×10^{-5}
Piperonyl Butoxide (adult)	59	7.0×10^{-6}

Ingestion of Vegetation

	MDA - Child	MDA - Adult
Resmethrin	82,000 cm^2/day	360,000 cm^2/day
Piperonyl Butoxide	120,000 cm^2/day	530,000 cm^2/day

For point of reference, an 8.5" x 11" piece of paper is approximately 603 cm^2. A tomato that is 8 cm high (appr. 3 inches), assuming that it is spherical, would have a surface area of approximately 200 cm^2. A green pepper that is 13 cm high (appr. 5 inch), assuming that it is a sphere, would have a surface area of approximately 530 cm^2. A lettuce leaf that is 5 cm by 15 cm (appr. 2" x 6") would have a surface area of 75 cm^2.

Conclusion:

Exposure to resmethrin or piperonyl butoxide through ingestion of soil or vegetation should not pose a health risk. The estimated exposure to resmethrin or piperonyl butoxide through soil ingestion is well below the estimated maximum daily allowable intake for either chemical. These calculations suggest that even if exposure to resmethrin occurred every day for 50 days, the health risk would be insignificant. Likewise significant exposure to either resmethrin or piperonyl butoxide from vegetation would entail consumption of a huge quantity of unwashed garden vegetables each day.

III. Inhalation Exposure to Scourge[R]

Inhalation exposure to Scourge[R] could occur during or after pesticide treatment. Because data on the air concentration of Scourge[R] were not available, the air concentration was estimated using a computer model.

According to the MMCD, Scourge[R] is applied in small particles so that it can be dispersed by the wind.[9] The MMCD estimates that Scourge[R] will be dispersed from the point of treatment by 30 minutes.[10]

Since Scourge[R] disperses rapidly from the air, inhalation is calculated as an acute (short term) exposure. Because treatments occur at 10 day intervals, each exposure is assumed to be independent. Inhalation exposure to resmethrin, piperonyl butoxide and the aromatic petroleum solvent is estimated for a 1-6 year old child and an adult. The general equations and assumptions used for these calculations are found in Appendix C.

NOTE: Section A estimates air concentrations, Section B estimates safe exposure levels, and Section C provides a table summarizing the results, and a conclusion.

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[9]Letters from the MMCD to the Minnesota Department of Health dated November 30, 1992 and February 12, 1993. Letter from Roussel Uclaf to the MMCD dated February 16, 1993.

[10]See footnote 9 above.

A. Estimation of Air Concentration

(1) Resmethrin:

Air concentration modeling was performed by Dr. Gregory Pratt, Program Development Unit, Division of Air Analysis, Minnesota Pollution Control Agency (MPCA). See attachment 1.

Assumptions for air concentration modeling:

a. 0.159 g resmethrin sprayed per second (calculated from information provided by the MMCD)

b. 404.7 m^2 is covered per second (calculated from information provided by the MMCD)

c. Treatment is done at a height of 8 feet (information provided by the MMCD)

d. Wind Speed is between 2.2 and 6.6 MPH

e. The model incorporates the size and settling velocity of the pesticide particles and the nonvolatile nature of resmethrin.

f. Air concentration at a 5 foot breathing height of a person standing approximately 20 meters downwind of the treatment. Although the air concentration below 5 feet should be slightly lower[11], to be protective, the risk estimation assumes the concentration at the breathing height of a child is the same as at 5 feet.

This model estimates that within a minute of pesticide application, the air concentration of resmethrin would be approximately 1.4 mg/m^3.

[11]Personal Communication with Dr. Gregory Pratt of the MPCA.

(2) Piperonyl Butoxide:

Piperonyl butoxide, like resmethrin, has low volatility (Roussel Bio B). Therefore, the results from the air concentration modeling for resmethrin can be adjusted to estimate the air concentration of piperonyl butoxide.

Estimated air concentration of resmethrin - **1.4 mg/m^3**

Scourge^R contains 4.14% resmethrin and 12.54% piperonyl butoxide.

Scourge^R is applied at a rate of approximately 0.01 lbs piperonyl butoxide per acre or 1.1 x 10^{-4} mg/cm^2 [information from MMCD and see calculations under ingestion exposure, section II, part B, (1)].

404.7 m^2 is covered per second (calculated from information provided by the MMCD)

1.1 x 10^{-4} mg/cm^2 x (g/1000 mg)(100 cm/m)^2 x 404.7 m^2/s = 0.45 g/s

Approximately 0.45 g of piperonyl butoxide is applied per second.

$$\frac{0.45 \text{ g/s APS}}{0.159 \text{ g/s resmethrin}} \times 1.4 \text{ mg/m}^3 \text{ resmethrin} = 4.0 \text{ mg/m}^3 \text{ APS}$$

Estimated air concentration of piperonyl butoxide - **4.0 mg/m^3**.

(3) Aromatic Petroleum Solvent (APS):

APS, like resmethrin, has low volatility (MSDS, Exxon). Therefore, the results from the air concentration modeling for resmethrin can be adjusted to estimate the air concentration of APS.

Estimated air concentration of resmethrin - **1.4 mg/m^3**

Scourge^R contains 4.14% resmethrin and 5% APS.

Scourge^R is applied at a rate of approximately 0.0035 lbs resmethrin per acre (information from MMCD).

$$\frac{5_{APS}}{4.14_{resmethrin}} \times 0.0035 \text{ lb resmethrin/acre} = 4.2 \times 10^{-3} \text{ lb APS/acre}$$

Approximately 4.2 x 10^{-3} lb APS is applied per acre.

4.2×10^{-3} lb/acre x 450 g/lb = 1.9 g/acre
1.9 g/acre x acre/43,560 ft^2 = 4.4×10^{-5} g/ft^2
4.4×10^{-5} g/ft^2 x ft^2/929 cm^2 = 4.7×10^{-8} g/cm^2

404.7 m^2 is covered per second (calculated from information provided by the MMCD)

4.7×10^{-8} g/cm^2 x (100 cm/m)^2 x 404.7 m^2/s = 0.19 g/s

Approximately 0.19 g of APS is applied per second.

$$\frac{0.19 \text{ g/s APS}}{0.159 \text{ g/s resmethrin}} \times 1.4 \text{ mg/m}^3 \text{ resmethrin} = 1.7 \text{ mg/m}^3 \text{ APS}$$

The estimated air concentration of APS - **1.7 mg/m^3.**

B. Estimation of Safe Level of Exposure

Toxicologists at Roussel Bio exposed 5 female rats and 5 male rats to 5 mg/liter "Scourge^R 18% + 54%" for 4 hours (Roussel Bio A and personal communication[12]). The formulation used for this study contained 18% resmethrin, 54% piperonyl butoxide and 25% APS. At 140 minutes, one female rat displayed tremors. At 160 minutes one male rat displayed tremors. Tremors disappeared after exposure. No adverse effects or gross abnormalities were observed over the following 14 days. This study suggests a LOAEL for acute exposure of 5 mg/liter.

$5\ mg/liter = (5\ mg/1000\ cm^3)(100\ cm/m)^3 = 5000\ mg/m^3$

Since resmethrin, piperonyl butoxide and the aromatic petroleum solvent (APS) have low volatility, we assume that the ratio of these ingredients in the air is the same as their ratio in the liquid formulation.

(1) Resmethrin:

$LOAEL_{resmethrin} - (5000\ mg/m^3)(0.18) = 900\ mg/m^3$

Convert LOAEL (mg/liter) to LOAEL (mg/kg) (See Appendix C):

$$\text{Rat: } \frac{(900\ mg/m^3)(0.223\ m^3/day)(day/24\ hr)(4\ hr)}{0.35\ kg} = 96\ mg/kg$$

LOAEL = 96 mg/kg
UF_1 = 10 for use of LOAEL instead of NOAEL
UF_2 = 10 for extrapolation from animals to humans
UF_3 = 10 for sensitive subpopulations

Since the study used the total formulation of Scourge^R, which contains piperonyl butoxide, the safety factor of 2 for piperonyl butoxide will not be used to calculate the safe air concentration.

$$\frac{96\ mg/kg}{(10)(10)(10)} = \textbf{0.096 mg/kg resmethrin over a 4 hour exposure}$$

[12]Phone conversation with John de Prospo, Manager, Toxicology Services, Roussel Bio, March 12, 1993.

$\frac{96 \text{ mg/kg}}{(10)(10)(10)}$ = **0.096 mg/kg resmethrin over a 4 hour exposure**

The confidence in this estimated safe level is medium. There is a limited data base, but the data concerns the total formulation, which gives a better indication of toxicity than a study that looks at the individual ingredients. The uncertainty factor (1000) reflects the imprecision of the estimation. It is intended as a protective factor in light of uncertainty.

Convert to a safe 4 hour concentration level for a child:

let X (mg/m^3) = safe 4 hour concentration level for a child

breathing rate of a child = (16 m^3/day)(day/24 hrs) = 0.67 m^3/hr

$$\frac{[X \text{ mg/m}^3](0.67 \text{ m}^3/\text{hr})(4 \text{ hrs})}{(16 \text{ kg})} = 0.096 \text{ mg/kg}$$

solve for X:

$$X \text{ (mg/m}^3) = \frac{(0.096 \text{ mg/kg})(16 \text{ kg})}{(0.67 \text{ m}^3/\text{hr})(4 \text{ hrs})} = \mathbf{0.57 \text{ mg/m}^3}$$

Convert to a safe 4 hour concentration level for an adult:

breathing rate of an adult = (20 m^3/day)(day/24 hrs) = 0.83 m^3/hr

$$\frac{(0.096 \text{ mg/kg})(70 \text{ kg})}{(0.83 \text{ m}^3/\text{hr})(4 \text{ hrs})} = \mathbf{2.0 \text{ mg/m}^3}$$

Note: These concentrations reflect the estimated air concentration of resmethrin that could be safely inhaled for up to 4 hours. The air concentration of resmethrin that could be safely inhaled for only 30 minutes may be greater than these values. Due to the lack of data, it was not possible to calculate a safe 30 minute exposure level.

(2) Piperonyl Butoxide:

$LOAEL_{PB}$ - (5000 mg/m^3)(0.54) = 2700 mg/m^3

LOAEL = 2700 mg/kg
UF_1 = 10 for use of LOAEL instead of NOAEL
UF_2 = 10 for extrapolation from animals to humans
UF_3 = 10 for sensitive subpopulations

$$\frac{2700\ mg/kg}{(10)(10)(10)} = \textbf{2.7 mg/kg over a 4 hour exposure}$$

The confidence in this estimated safe level is medium. There is a limited data base, but the data concerns the total formulation, which gives a better indication of toxicity than a study that looks at the individual ingredients. The uncertainty factor (1000) reflects the imprecision of the estimation. It is intended as a protective factor in light of uncertainty.

Convert to a safe 4 hour concentration level for a child:

let X (mg/m^3) = safe 4 hour concentration level for a child

breathing rate of a child = (16 m^3/day)(day/24 hrs) = 0.67 m^3/hr

$$\frac{[X\ mg/m^3](0.67\ m^3/hr)(4\ hrs)}{(16\ kg)} = 2.7\ mg/kg$$

solve for X:

$$X\ (mg/m^3) = \frac{(2.7\ mg/kg)(16\ kg)}{(0.67\ m^3/hr)(4\ hrs)} = \textbf{16 mg/m}^3$$

Convert to a safe 4 hour concentration level for an adult:

breathing rate of an adult = (20 m^3/day)(day/24 hrs) = 0.83 m^3/hr

$$\frac{(2.7\ mg/kg)(70\ kg)}{(0.83\ m^3/hr)(4\ hrs)} = \textbf{57 mg/m}^3$$

Note: These concentrations reflect the estimated air concentration of piperonyl butoxide that could be safely inhaled for 4 hours or less. The air concentration of piperonyl butoxide that could be safely inhaled for only 30 minutes may be greater than these values. Due to the lack of data, it was not possible to calculate a safe 30 minute exposure level.

(3) Aromatic Petroleum Solvent (APS):

$LOAEL_{APS}$ - (5000 mg/m^3)(0.25) = 1250 mg/m^3

LOAEL = 1250 mg/kg
UF_1 = 10 for use of LOAEL instead of NOAEL
UF_2 = 10 for extrapolation from animals to humans
UF_3 = 10 for sensitive subpopulations

$\frac{1250\ mg/kg}{(10)(10)(10)}$ = **1.3 mg/kg APS over a 4 hour exposure**

The confidence in this estimated safe level is medium. There is a limited data base, but the data concerns the total formulation, which gives a better indication of toxicity than a study that looks at the individual ingredients. The uncertainty factor (1000) reflects the imprecision of the estimation. It is intended as a protective factor in light of uncertainty.

Convert to a safe 4 hour concentration level for a child:

let X (mg/m^3) = safe 4 hour concentration level for a child

breathing rate of a child = (16 m^3/day)(day/24 hrs) = 0.67 m^3/hr

$\frac{[X\ mg/m^3](0.67\ m^3/hr)(4\ hrs)}{(16\ kg)}$ = 1.3 mg/kg

solve for X:

X (mg/m^3) = $\frac{(1.3\ mg/kg)(16\ kg)}{(0.67\ m^3/hr)(4\ hrs)}$ = **7.8 mg/m^3**

Convert to a safe 4 hour concentration level for an adult:

breathing rate of an adult = (20 m^3/day)(day/24 hrs) = 0.83 m^3/hr

$\frac{(1.3\ mg/kg)(70\ kg)}{(0.83\ m^3/hr)(4\ hrs)}$ = **27 mg/m^3**

Note: These concentrations reflect the estimated air concentration of APS that could be safely inhaled for 4 hours or less. The air concentration of APS that could be safely inhaled for only 30 minutes may be greater than these values. Due to the lack of data, it was not possible to calculate a safe 30 minute exposure level.

C. Summary and Conclusion for Inhalation Exposure to Resmethrin and Aromatic Petroleum Solvent

	Estimated Safe Air Concentration (mg/m^3)	Estimated Air Concentration (mg/m^3)
Resmethrin (child)	0.57	1.4
Resmethrin (adult)	2.0	1.4
Piperonyl Butoxide (child)	16	4.0
Piperonyl Butoxide (adult)	57	4.0
APS (child)	7.8	1.7
APS (adult)	27	1.7

Conclusion:

Brief inhalation exposure to Scourge^R should not pose a health risk. Nevertheless, children should be prevented from having prolonged inhalation exposure to Scourge^R. For example, children should not be permitted to follow the pesticide applicators as they work.

The estimation of inhalation exposure incorporates assumptions that should err on the side of protecting health. Due to the uncertainties inherent in these calculations, the results should not be considered as an absolute quantitation of exposure, but rather as an indicator of potential health risk. All of the uncertainties should be taken into consideration when examining the results of these calculations.

There are two main sources of uncertainty in these calculations. First, because no air monitoring data was available, the air concentrations of resmethrin and APS were estimated using a computer model. The United States Environmental Protection Agency considers this computer model to be accurate within a factor of 2 (personal communication with Dr. Gregory Pratt). Air monitoring studies of Scourge^R during and after treatment would eliminate this source of uncertainty.

Second, due to the lack of toxicologic data, an accurate estimate of a safe air concentration for a 30 minute exposure could not be calculated. Only an air concentration that would be safe for exposures up to 4 hours could be estimated. The air concentration that would be safe for a only a 30 minute exposure could be higher than the 4 hour concentrations.

Given these uncertainties, we cannot say whether inhalation of Scourge[R] poses a significant health risk. Since the calculations all incorporate protective assumptions, it is likely that a brief inhalation exposure to Scourge[R] does not pose a health risk. Nevertheless, children should be prevented from having prolonged inhalation exposure to Scourge[R]. For example, children should not be permitted to follow the pesticide applicators as they work.

IV. Dermal Exposure to Resmethrin

Dermal exposure to resmethrin could occur through contact with soil or foliage. The following estimates the dermal exposure to resmethrin from soil or foliage for a 1-6 year old child and an adult.

Due to the short half life of resmethrin, it is assumed that significant exposure to resmethrin will not occur after the day of application. Since there is a 10 day interval between treatments, it is assumed that each day of exposure is independent. Therefore a risk assessment is done for an acute (one day) exposure to resmethrin.

Note: A table containing a summary of the results, and a conclusion appears at the end of this section in part (4).

(1) Dermal Reference Dose (RfD) for Resmethrin:

See Appendix B for the explanation and definition of a reference dose (RfD) and a Maximum Daily Allowable Intake (MDA).

The World Health Organization's environmental health criteria document for resmethrin cites a study on dermal toxicity in which 4 groups of 10 male New Zealand White rabbits were treated twice a week for three weeks with 1) 0.247 mg/ml resmethrin applied over 1 ml of imitation sweat; 2) 0.247 mg/ml resmethrin applied without sweat; 3) cotton cloth fixed to skin pretreated with 10 g of technical grade resmethrin; or 4) untreated cotton cloth fixed over skin pretreated with pyrax powder containing 1% resmethrin at a rate of 1 g/kg body weight. Controls were used for each group. No compound-related skin lesions were noted and dermal irritation scores for resmethrin were no higher in the treated groups than for controls. No significant changes were noted in rabbit body weight, or the organ-to-body weight ratios of liver, lung, kidney, testes, or spleen.

The results of this study are supported by an unpublished 21 day dermal rabbit study performed by Roussel Bio[13]. The Roussel Bio study indicated a NOAEL greater than 1 g/kg/day. Therefore a NOAEL of 1 g/kg/day is used to calculate the dermal RfD for resmethrin.

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[13]Personal communication: John De Prospo, Manager, Toxicology Services, Roussel Bio Corporation, May 28, 1992, 201-628-7200.

Calculation of Dermal RfD

See Appendix B for an explanation of the use of a NOAEL and uncertainty factors (UFs) to calculate an RfD.

NOAEL = 1 g/kg/day = 1000 mg/kg/day
UF_1 = 10 for interspecies extrapolation
UF_2 = 10 for sensitive subpopulation
UF_3 = 2 for piperonyl butoxide

$$RfD = \frac{1000 \text{ mg/kg/day}}{(10)(10)(2)} = 5.0 \text{ mg/kg/day.}$$

The confidence in this RfD is medium. The results from the Roussel Bio study support the study cited by the World Health Organization. The RfD is medium because of the limited amount of published data.

Note: This is an RfD for subchronic exposure. Due to lack of adequate data, an acute RfD was not calculated. Using a subchronic RfD to assess acute exposure is less accurate than using an acute RfD, but provides a greater margin of safety.

Dermal RfD = 5.0 mg/kg/day

MDA_{child} = (5.0 mg/kg/day)(16 kg) = 80 mg/day

MDA_{adult} = (5.0 mg/kg/day)(70 kg) = 350 mg/day

(2) Estimation of Dermal Exposure from Soil:

See Appendix D for an explanation of the equations and assumptions used in this section. The estimated concentration of resmethrin in soil is 2.6×10^{-5} mg/g (see Appendix D).

$$\text{Intake}_{\text{child}} = \frac{(2.6 \times 10^{-5}\ \text{mg/g})(10^{-3}\ \text{g/mg})(3160\ \text{cm}^2\text{/day})(1.45\ \text{mg/cm}^2)}{(16\ \text{kg})}$$

$$= 7.4 \times 10^{-6}\ \text{mg/kg/day}$$

Daily Intake$_{\text{child}}$ = $(7.4 \times 10^{-6}$ mg/kg/day)(16 kg) = 1.2×10^{-4} mg/day

$$\text{Intake}_{\text{adult}} = \frac{(2.6 \times 10^{-5}\ \text{mg/g})(10^{-3}\ \text{g/mg})(8629\ \text{cm}^2\text{/day})(1.45\ \text{mg/cm}^2)}{(70\ \text{kg})}$$

$$= 4.7 \times 10^{-6}\ \text{mg/kg/day}$$

Daily Intake$_{\text{adult}}$ = $(4.7 \times 10^{-6}$ mg/kg/day)(70 kg) = 3.3×10^{-4} mg/day

(3) Estimation of Dermal Exposure from Foliage:

See Appendix D for an explanation of the equations and assumptions. Assume the concentration of resmethrin on foliage is 3.9×10^{-5} mg/cm^2 (see section I, part A above).

$$\text{Intake}_{\text{child}} = \frac{(3.9 \times 10^{-5}\ \text{mg/cm}^2)(3160\ \text{cm}^2\text{/day})}{(16\ \text{kg})}$$

$$= 7.7 \times 10^{-3}\ \text{mg/kg/day}$$

Daily Intake$_{\text{child}}$ = $(7.7 \times 10^{-3}$ mg/kg/day)(16 kg) = 0.12 mg/day

$$\text{Intake}_{\text{adult}} = \frac{(3.9 \times 10^{-5}\ \text{mg/cm}^2)(8620\ \text{cm}^2\text{/day})}{(70\ \text{kg})}$$

$$= 4.8 \times 10^{-3}\ \text{mg/kg/day}$$

Daily Intake$_{\text{adult}}$ = $(4.8 \times 10^{-3}$ mg/kg/day)(70 kg) = 0.34 mg/day

(4) Summary and Conclusion for Dermal Exposure to Resmethrin

	MDA mg/day	Estimated Daily Intake Soil mg/day	Foliage mg/day
Child	80	1.2×10^{-4}	0.12
Adult	350	3.3×10^{-4}	0.34

Conclusion:

Dermal exposure to resmethrin should not pose a significant risk of toxicity. The estimated intake of resmethrin from dermal contact to soil or foliage is well below the estimated MDA. These calculations suggest that even if exposure to resmethrin occurred every day for 50 days, the health risk would be insignificant.

Risk Assessment of Punt™ 57-0S

I. General Comments

Punt™ 57-0S is applied by backpack to bushes and vegetation around woods, where mosquitos rest during the day. The treatment usually takes place in parks and other recreational areas.

Concentrated Punt™ 57-0S contains 57% permethrin[14], 37% xylene range aromatic solvent, plus other inert ingredients. The MMCD dilutes one part concentrated Punt™ 57-0S in 9 parts soybean oil or a food grade mineral oil, and applies the diluted material at a rate of approximately 0.1 lb permethrin per acre.

According to the World Health Organization's environmental health criteria document on permethrin, the half-life of permethrin in soil is less than 28 days, and the half-life on plants is approximately 10 days (WHO, 1990).

One source of uncertainty that runs throughout this risk assessment concerns the potential difference in potency between the permethrin used in toxicology studies and the permethrin contained in Punt™ 57-0S. Permethrin is usually a mixture of cis and trans isomers. The cis isomer of permethrin is more toxic than the trans isomer (Miyamoto, 1976; WHO, 1990). A mixture of cis and trans isomers is less toxic than pure cis isomer, but is usually more toxic than pure trans isomer. The World Health Organization's environmental health criteria document cites a study showing that a 80:20 cis:trans mixture is approximately 7 times as potent in rats as a 20:80 cis:trans mixture. The 80:20 cis:trans mixture is approximately twice as potent as a 50:50 mixture of the isomers (WHO, 1990).

According to the label, Punt™ 57-0S contains a minimum of 35% of the cis isomer and a maximum of 65% of the trans isomer. Most of the toxicology studies used in this risk assessment do not state the ratio of the cis and trans isomers of permethrin used in the experiments. Because of the limited information, we cannot be certain that the potency of the permethrin used in the toxicology studies is the same as that of the permethrin contained in Punt™ 57-0S.

A second source of uncertainty concerns the potential of permethrin to cause cancer in humans. Permethrin has been tested for carcinogenicity in both rats and mice. According to the United States Environmental Protection Agency (USEPA), "Definite evidence

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[14]The chemical name for permethrin is (3-phenoxyphenyl) methyl(+/-) cis/trans 3-(2,2-dichloroethenyl) 2,2-dimethyl, cyclopropanecarboxylate.

of oncogenicity was not observed in any of the [three] long-term rat studies (Federal Register, 1982)." The World Health Organization concluded that, "No evidence of oncogenicity was observed in the rat studies (WHO, 1990)."

In contrast to the rat studies, three long term mouse studies suggest that permethrin might be carcinogenic. One study showed an increase in lung adenomas in male mice at the highest experimental dose. According to the World Health Organization, it was not clear whether this increase was related to permethrin ingestion (WHO, 1990). A second study showed an increased incidence of bronchio-alveolar adenomas in female mice only. According to the World Health Organization, the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) Scientific Advisory Panel expressed some doubt about the conduct of this study (WHO, 1990). A third study showed a dose-related increase in lung tumors in female mice (WHO, 1990). The significance of lung tumors in mice for predicting carcinogenic potential in humans is questionable (Federal Register, 1982). According to the USEPA, "The biological evidence produced by long-term mouse and rat studies, and other toxicological studies leads the EPA to conclude, based on the Agency risk assessment, that the likelihood of oncogenic effects in humans from exposure to low levels of permethrin is non-existent or extremely low (Federal Register, 1982)."

The Material Safety Data Sheet for Punt™ 57-0S lists permethrin and a xylene range aromatic solvent under hazardous ingredients. This risk assessment evaluates the oral, inhalation and dermal routes of exposure to permethrin. Due to lack of available data, no risk assessment is done for the xylene range aromatic solvent or the inert ingredients.

The number of times the MMCD treats a given area differs depending on the type of activity that takes place there. Some areas are only treated once for a special event, such as a parade or festival. The MMCD may treat high use parks up to 5 times a season at 10 approximately day intervals.

To be protective, this risk assessment uses an exposure scenario for a high use park. In other words, it assumes that Punt™ 57-0S is applied for 50 days during the summer (5 applications at 10 day intervals) and that a child and an adult use the park every day for the 50 day treatment period.

The following calculations incorporate assumptions and uncertainty factors that should err on the side of protecting public health. The scenarios assume near maximum exposure in order to protect sensitive individuals and provide an adequate margin of safety for average citizens.

II. Ingestion Exposure

Exposure to permethrin could occur through incidental ingestion of contaminated soil and contaminated vegetation. For example, a child might place his/her hands in his/her mouth during play at a park. There is also a chance of exposure through ingestion of unwashed homegrown vegetables. For example, pesticide application to residential neighborhoods within a quarter mile radius of a park or recreation area could result in the inadvertent treatment of gardens.

Exposure to permethrin through ingestion of soil and homegrown vegetables is estimated for a 1-6 year old child and an adult. The general equations for ingestion exposure and the assumptions that go into the calculation of ingestion exposure are given in Appendix A.

Note: A table containing a summary of the results and a conclusion appears at the end of this section in part E.

A. Estimation of the amount of permethrin in and on soil and vegetation:

- 0.1 lb of permethrin is applied per acre. (Information provided by the MMCD).

0.1 lb/acre x 450 g/lb = 45 g/acre
45 g/acre x acre/43,560 ft^2 = 0.001 g/ft^2 x 1000 mg/g = 1 mg/ft^2
1 mg/ft^2 x ft^2/929 cm^2 = 1.1 x 10^{-3} mg/cm^2

- **1.1 x 10^{-3} mg/cm^2 permethrin deposited on soil and vegetation**

- **7.3 x 10^{-4} mg of permethrin per gram of soil** (See Appendix A)

B. Oral Reference Dose (RfD):

Refer to Appendix B for the definition and calculation of a Reference Dose and Maximum Daily Allowable Intake (MDA).

The World Health Organization's environmental health criteria document on permethrin summarizes a number of subchronic studies, reproductive studies, and developmental studies (WHO, 1990). One 90 day rat study suggests a LOAEL of 100 mg/kg/day and a NOAEL of 20 mg/kg/day. The results of another 90 rat study suggests a LOAEL of 270 mg/kg/day and a NOAEL of 85 mg/kg/day. A 3 month dog study suggests a LOAEL of 50 mg/kg/day for liver effects and a NOAEL of 5 mg/kg/day. In addition, a teratogenicity study in rats suggests a LOAEL of 50 mg/kg/day and a NOAEL of 20 mg/kg/day. As an extra measure of protection, the lowest NOAEL of 5 mg/kg/day from the 3 month dog study is used to calculate the RfD. This NOAEL should be protective for both teratogenic effects and liver damage.

NOAEL = 5 mg/kg/day
UF_1 = 10 for interspecies extrapolation
UF_2 = 10 for sensitive subpopulation

$$RfD = \frac{5 \text{ mg/kg/day}}{(10)(10)} = 5.0 \times 10^{-2} \text{ mg/kg/day.}$$

The confidence in this RfD is medium. The studies cited by the World Health Organization document indicate that this RfD is protective for both teratogenic effects and general subchronic toxicity.

Oral RfD = 5×10^{-2} mg/kg/day

MDA_{child} = $(5 \times 10^{-2}$ mg/kg/day)(16 kg) = 0.8 mg/day

MDA_{adult} = $(5 \times 10^{-2}$ mg/kg/day)(70 kg) = 3.5 mg/day

C. Estimation of Exposure through Soil Ingestion:

Refer to Appendix A for an explanation of equations and assumptions.

Soil ingestion for a child:

$$\frac{(7.3 \times 10^{-4}\ mg/g)(10^{-3}\ g/mg)(200\ mg/day)}{(16\ kg)}$$

Intake = 9.1×10^{-6} mg/kg/day

Daily $Intake_{child}$ = $(9.1 \times 10^{-6}\ mg/kg/day)(16\ kg)$ = **1.5×10^{-4} mg/day**

Soil ingestion for an adult:

$$\frac{(7.3 \times 10^{-4}\ mg/g)(10^{-3}\ g/mg)(100\ mg/day)}{(70\ kg)}$$

Intake = 1.0×10^{-6} mg/kg/day

Daily $Intake_{adult}$ = $(1.0 \times 10^{-6}\ mg/kg/day)(70\ kg)$ = **7.0×10^{-5} mg/day**

D. Ingestion of Homegrown Vegetables:

Assume 1.1×10^{-3} mg/cm^2 permethrin is deposited on the surface of the vegetables (see A above). This factor is used to convert the MDA for permethrin from mg/day to cm^2 vegetable surface area/day:

MDA_{child} = $(5 \times 10^{-2}\ mg/kg/day)(16\ kg)/(1.1 \times 10^{-3}\ mg/cm^2)$
= **730 cm^2/day**

MDA_{adult} = $(5 \times 10^{-2}\ mg/kg/day)(70\ kg)/(1.1 \times 10^{-3}\ mg/cm^2)$
= **3200 cm^2/day**

E. Summary and Conclusion for Ingestion Exposure to Permethrin

Soil Ingestion

	MDA (mg/day)	Daily Intake (mg/day)
Child	0.8	1.5×10^{-4}
Adult	3.5	7.0×10^{-5}

Ingestion of Vegetation

	MDA_{child}	MDA_{adult}
Permethrin	730 cm^2/day	3200 cm^2/day

For point of reference, an 8.5" x 11" piece of paper is approximately 603 cm^2. A tomato that is 8 cm high (appr. 3 inches), assuming that it is a sphere, would have a surface area of approximately 200 cm^2. A green pepper that is 13 cm high (appr. 5 inches), assuming that it is a sphere, would have a surface area of approximately 530 cm^2. A lettuce leaf that is 5 cm by 15 cm (appr. 2" x 6") would have a surface area of 75 cm^2.

Conclusion:

Exposure to permethrin through soil ingestion appears negligible. The estimated exposure to permethrin through soil ingestion is well below the estimated maximum daily allowable intake of permethrin.

Since permethrin has a half life of 10 days on plants, the concentration of permethrin will decrease over the 10 day interval. The MDAs for ingestion of foliage are protective, since they are calculated assuming a constant concentration of permethrin on vegetation over a 10 day interval. Nevertheless, homegrown vegetables should be washed before they are eaten and consumption of other foliage, especially by children should be avoided.

III. Inhalation Exposure to Permethrin

Punt™ 57-0S is applied by backpack directly to vegetation. In contrast to Scourge®, which is applied so that it disperses with the wind, Punt™ 57-0S is applied so that it deposits on vegetation.

Currently, adequate air monitoring data for Punt™ 57-0S is not available. Therefore, Dr. Gregory Pratt of the Minnesota Pollution Control Agency estimated the air concentration for permethrin using a computer model that incorporates data on concentration, dispersal rate and particle size.

Punt™ 57-0S should settle out of the air faster than Scourge® because Punt™ is applied in larger particles (AMCAB, 1952). The MMCD estimates that Scourge® is dispersed from the point of treatment by 30 minutes[15].

Punt™ 57-0S is applied approximately five times per year at ten day intervals. Inhalation exposure to permethrin is estimated for a 1-6 year old child and an adult exposed 5 times per year for 30 minutes. Because Punt™ 57-0S disperses so rapidly from the air, inhalation is calculated as an acute (short term) exposure. The general equations and assumptions used for these calculations are found in Appendix C.

Note: A table containing a summary of the results, and a conclusion appears at the end of this section in part (4).

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[15]Letters from the MMCD to the Minnesota Department of Health dated November 30, 1992 and February 12, 1993. Letter from Roussel Uclaf to the MMCD dated February 16, 1993.

(1) Estimation of Air Concentration:

Air concentration modeling was performed by Dr. Gregory Pratt, Program Development Unit, Division of Air Analysis, Minnesota Pollution Control Agency. See attachment 2.

Assumptions for air concentration modeling for permethrin:

a. 0.0945 g permethrin sprayed per second (calculated from information provided by the MMCD)

b. 8.36 m^2 is covered per second (calculated from information provided by the MMCD)

c. Treatment is done at a height of 6 feet (information provided by the MMCD)

d. Low winds (6.6 - 8.8 MPH)

e. The model incorporates the size and settling velocity of the pesticide particles and assumes that permethrin is not volatile.

f. Air concentration at a 5 foot breathing height of a person standing approximately 20 meters downwind of the treatment. This is a conservative exposure scenario, assuming exposure occurs at the time of treatment, with minimal dispersal of pesticide.

g. Assume the concentration of permethrin is the same at the breathing height of a child as it is at the breathing height of an adult.

This model estimates that within a minute of application, the air concentration of permethrin would be approximately 4.1 mg/m^3.

(2) Estimation of a Safe Level of Exposure to Permethrin through Inhalation:

The World Health Organization's environmental health criteria document on permethrin cites a subchronic inhalation study in which rats were exposed to 125, 250 or 500 mg/m^3 technical grade permethrin for 6 hours per day, 5 days per week for 13 weeks (WHO, 1990). This study suggests a NOAEL of 250 mg/m^3 for subchronic exposure. This NOAEL will be considered to calculate a safe air concentration for a six hour exposure. This is protective, since the rats in the study were repeatedly exposed to permethrin.

Convert NOAEL (mg/m^3) to NOAEL (mg/kg) (See Appendix C):

$$\text{Rat: } \frac{(250\ mg/m^3)(0.223\ m^3/day)(day/24\ hr)(6\ hr)}{0.35\ kg} = 40\ mg/kg$$

NOAEL = 40 mg/kg.
UF_1 = 10 for extrapolation from animals to humans
UF_2 = 10 for sensitive subpopulations

$$\text{Estimated Safe Intake} = \frac{40\ mg/kg}{(10)(10)} = \textbf{0.4 mg/kg over 6 hours}$$

The confidence in estimated safe intake is medium. It should be noted that this safe intake is estimated from a subchronic exposure and not an acute exposure. This adds a measure of protection.

Convert to a safe 6 hour concentration level for a child:

let X (mg/m^3) = safe 6 hour concentration level for a child

breathing rate of a child = (16 m^3/day)(day/24 hrs) = 0.67 m^3/hr

$$\frac{[X\ mg/m^3](0.67\ m^3/hr)(6\ hrs)}{(16\ kg)} = 0.4\ mg/kg$$

solve for X:

$$X\ (mg/m^3) = \frac{(0.4\ mg/kg)(16\ kg)}{(0.67\ m^3/hr)(6\ hrs)} = \mathbf{1.6\ mg/m^3}$$

Convert to a safe 6 hour concentration level for an adult:

breathing rate of an adult = (20 m^3/day)(day/24 hrs) = 0.83 m^3/hr

$$\frac{(0.4\ mg/kg)(70\ kg)}{(0.83\ m^3/hr)(6\ hrs)} = \mathbf{5.6\ mg/m^3}$$

Note: These concentrations reflect the estimated air concentration of permethrin that could be safely inhaled for up to 6 hours. The air concentration of permethrin that could be safely inhaled for only 30 minutes may be greater than these values. Due to the lack of data, it was not possible to calculate a safe 30 minute exposure level.

(3) Summary and Conclusion for Inhalation Exposure to Permethrin

	Estimated Safe air concentration (mg/m^3)	Estimated air concentration (mg/m^3)
Permethrin (child)	1.6	4.1
Permethrin (adult)	5.6	4.1

Conclusion:

Brief inhalation exposure to Punt™ 57-0S should not pose a health risk. Nevertheless, children should be prevented from having prolonged inhalation exposure to Punt™ 57-0S. For example, children should not be permitted to follow the pesticide applicators as they work.

The estimation of inhalation exposure incorporates assumptions that should err on the side of protecting health. Due to the uncertainties inherent in these calculations, the results should not be considered as a precise quantitation of exposure, but rather as an indicator of potential health risk. All of the uncertainties should be taken into consideration when examining the results of these calculations.

There are two main sources of uncertainty in these calculations. First, because no air monitoring data was available, the air concentration of permethrin was estimated using a computer model. The United States Environmental Protection Agency considers this computer model to be accurate within a factor of 2 (personal communication with Dr. Gregory Pratt). Air monitoring data would eliminate this source of uncertainty.

Second, due to the lack of toxicologic data, an accurate estimate of a safe air concentration for a 30 minute exposure could not be calculated. Only an air concentration that would be safe for exposures up to 6 hours could be estimated. The air concentration that would be safe for only a 30 minute exposure could be higher than the 6 hour concentration. Because adequate data were not available, we were unable to do an inhalation risk assessment on the xylene range aromatic solvent in Punt™ 57-0S.

Given these uncertainties it is difficult to determine whether inhalation of Punt™ 57-0S poses a significant health risk. Since the calculations all incorporate protective assumptions, it is likely that a brief inhalation exposure to Punt™ 57-0S does not pose a health risk. Nevertheless, children should be prevented from having prolonged inhalation exposure to Punt™ 57-0S. For example, children should not be permitted to follow the pesticide applicators as they work.

IV. Dermal Exposure to Permethrin

Dermal exposure to permethrin could occur from contact with soil or foliage. The following estimates dermal exposure from contact with soil or foliage for a 1-6 year old child and an adult.

Note: A table containing a summary of the results, and a conclusion appears at the end of this section in part (4).

(1) Dermal Reference Dose (RfD):

See Appendix B for an explanation and definition of a reference dose (RfD).

Medical studies suggest that permethrin has low dermal toxicity. For example, permethrin creams are being considered as a treatment for humans with scabies and head lice (Hogan, et al., 1991; Bowerman, et al., 1987).

The World Health Organization's environmental health criteria document for permethrin cites a study of dermal toxicity in which 0, 0.1, 0.32 or 1.0 g/kg body weight of technical grade permethrin was applied to the clipped skin of New Zealand White rabbits each day for 21 consecutive days (WHO, 1990). Blood samples were drawn weekly for clinical chemistry samples, and various tissues and organs were examined for microscopic lesions. Aside from moderate skin irritation, no significant changes in body weight, organ weight, or clinical chemistry were evident. No compound related skin lesions were noted. This study suggests a NOAEL of 1.0 g/kg/day, for toxicity, and a LOAEL of 0.1 g/kg/day (100 mg/kg/day) for irritation.

The results of the rabbit study cited by the World Health Organization are supported by two studies carried out with human volunteers. In one study, 659 patients, (92% under 20 old, and 39% male, 61% female) were treated once with a 1% permethrin (25:75, cis:trans) creme rinse hair conditioner (Bowerman et al., 1987). A median value of 50 mls of 1% rinse was applied to hair and scalp and then rinsed. Patients were observed 30-60 minutes, 24 hours, 7 days, and 14 days after treatment. They were evaluated for erythema, edema, rash, itching, burning/stinging, pain, numbness and tingling. 1.2% of the patients reported dermal reactions, such as itching or erythema. These reactions were mild and transient. There were no reports of neurologic effects or allergic conjunctivitis. Assuming that the youngest child weighed 16 kg and the oldest, 70 kg, and a median dose of 0.5 g (50 mls x 1 g/100 mls = 0.5 g), the dose of permethrin would range between approximately 7 mg/kg and 31 mg/kg. In addition, the World Health Organization's environmental health criteria document for permethrin cites a study in which 10 male volunteers wore clothes impregnated with permethrin for 48 hours, resulting in a dose of 0.054 mg/kg/day. There were no complaints of irritation.

Calculation of Dermal RfD for Toxicity:

See Appendix B for the calculation of an RfD and use of a NOAEL, a LOAEL, and uncertainty factors (UFs).

NOAEL = 1 g/kg/day = 1000 mg/kg/day
UF_1 = 10 for extrapolation from animal to human
UF_2 = 10 for sensitive subpopulations

$$RfD = \frac{1000 \text{ g/kg/day}}{(10)(10)} = 10 \text{ mg/kg/day}$$

The confidence in the RfD for toxicity is medium. The uncertainties include no LOAEL for toxicity from the study and no factor to account for the difference between the absorption of permethrin in rabbits and humans.

RfD_{tox} = 10 mg/kg/day

MDA_{child} = (10 mg/kg/day)(16 kg) = 160 mg/day

MDA_{adult} = (10 mg/kg/day)(70 kg) = 700 mg/day

Calculation of Dermal RfD for Irritation:

LOAEL = 100 mg/kg/day
UF_1 = 10 for LOAEL
UF_2 = 10 for extrapolation from animal to human
UF_3 = 10 for sensitive subpopulations

$$RfD = \frac{100 \text{ mg/kg/day}}{(10)(10)(10)} = 0.1 \text{ mg/kg/day}$$

The confidence in the RfD for irritation is medium. Although the studies indicate that permethrin is not a strong irritant, the human studies are limited. The large uncertainty factor reflects the imprecision of the RfD. It is intended to be a protective factor in light of uncertainty.

RfD_{irr} = 0.1 mg/kg/day

MDA_{child} = (0.1 mg/kg/day)(16 kg) = 1.6 mg/day

MDA_{adult} = (0.1 mg/kg/day)(70 kg) = 7.0 mg/day

(2) Estimation of Dermal Exposure from Soil:

See Appendix D for an explanation of the equations and assumptions for dermal exposure. Assume that the concentration of permethrin in the soil is 7.3×10^{-4} mg/g (see Appendix D).

Dermal Exposure from Soil for a Child:

$$\frac{(7.3 \times 10^{-4} \text{ mg/g})(10^{-3} \text{ g/mg})(3160 \text{ cm}^2\text{/day})(1.45 \text{ mg/cm}^2)}{(16 \text{ kg})}$$

$$= 2.1 \times 10^{-4} \text{ mg/kg/day}$$

Daily $\text{Intake}_{\text{child}}$ = $(2.1 \times 10^{-4}$ mg/kg/day)(16 kg) = **3.4×10^{-3} mg/day**

Dermal Exposure from Soil for an Adult:

$$\frac{(7.3 \times 10^{-4} \text{ mg/g})(10^{-3} \text{ g/mg})(8620 \text{ cm}^2\text{/day})(1.45 \text{ mg/cm}^2)}{(70 \text{ kg})}$$

$$= 1.3 \times 10^{-4} \text{ mg/kg/day}$$

Daily $\text{Intake}_{\text{adult}}$ = $(1.3 \times 10^{-4}$ mg/kg/day)(70 kg) = **9.1×10^{-3} mg/day**

(3) Estimation of Dermal Exposure from Foliage:

See Appendix D for an explanation of the equations and assumptions for dermal exposure. Assume that the concentration of permethrin deposited on vegetation is 1.1×10^{-3} mg/cm^2 (see section I, part A above).

Dermal Exposure from Foliage for a Child:

$$\frac{(1.1 \times 10^{-3} \text{ mg/cm}^2)(3160 \text{ cm}^2\text{/day})}{(16 \text{ kg})} = 0.22 \text{ mg/kg/day}$$

Daily $\text{Intake}_{\text{child}}$ = (0.22 mg/kg/day)(16 kg) = **3.5 mg/day**

Dermal Exposure from Foliage for an Adult:

$$\frac{(1.1 \times 10^{-3} \text{ mg/cm}^2)(8620 \text{ cm}^2\text{/day})}{(70 \text{ kg})} = 0.14 \text{ mg/kg/day}$$

Daily $\text{Intake}_{\text{adult}}$ = (0.14 mg/kg/day)(70 kg) = **9.8 mg/day**

(4) Summary and Conclusion for Dermal Exposure to Permethrin:

	MDA_{tox} (mg/day)	MDA_{irr} (mg/day)	Estimated Daily Intake: Soil (mg/day)	Estimated Daily Intake: Foliage (mg/day)
Child	160	1.6	3.4×10^{-3}	3.5
Adult	700	7.0	9.1×10^{-3}	9.8

Conclusion:

Dermal exposure to permethrin does not pose a significant risk of toxic effects. The estimation of intake of permethrin from dermal contact with soil or foliage is below the estimated dermal RfD for toxicity.

The estimated intake of permethrin from dermal contact with soil exceeds the MDA for irritation. The calculation for exposure to the foliage incorporates near worst case assumptions. For example, it assumes that hands, arms and legs are covered with the same concentration of permethrin that is sprayed on the foliage. In other words, the assumption is that there is 100% transfer of permethrin from foliage to skin. Because no data was available on how much permethrin would actually be transferred from foliage to skin, 100% transfer was assumed. It is likely that transfer of permethrin from foliage to skin is below 100%. This is an extremely protective assumption. In addition, these calculations assume that exposure occurs every day for 50 days. Occasionally brushing up against treated foliage should not result in such extensive exposure. Finally, since the half life of permethrin in plants is 10 days, the concentration of permethrin will decrease over the 10 day intervals. These calculations do not take that into consideration. Therefore it is unlikely that incidental dermal exposure to permethrin would be irritating.

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Appendix A

Calculation of Soil Ingestion

$$\text{Intake (mg/kg/day)} = \frac{CS \times CF \times IR \times FI \times EF}{BW \times AT}$$

Daily Intake (mg/day) = (Intake mg/kg/day)(BW kg)

CS = Concentration of Contaminant in Soil (mg/g)

CF = Unit Conversion Factor (10^{-3} g/mg)

IR = Ingestion Rate (mg soil/day)

FI = Fraction Ingested from Contaminated Source

EF = Exposure Frequency (days of exposure during treatment period)

BW = Body Weight (kg)

AT = Averaging Time (days)
(number of days over which exposure is averaged)

Note: This equation is consistent with the equation used by the USEPA for exposure assessments at Superfund sites (USEPA, 1989).

Continued on following page.

Appendix A continued Assumptions for the Calculation of Soil Ingestion:

1. Mixing level of soil is 1 cm (USEPA, 1990b). This is protective, since it assumes minimal dilution of the contaminant. Volume = (area)(height) = (cm^2)(cm) = cm^3. To estimate the concentration of the contaminant in the soil, the amount of the contaminant per unit of area (mg/cm^2) is divided by the depth of the soil (mixing level of 1 cm) to give mg/cm^3.

2. Density of soil is 1.5 g/cm^3. Soil densities range from 0.93-1.84 g/cm^3 (USEPA, 1990b). 1.5 g/cm^3 is used as a default value when the actual soil density is not known (USEPA, 1990b).

3. CS = (mg contaminant/g soil) = (mg contaminant/cm^3)(cm^3/1.5 g)
   CS(Resmethrin) = (3.9×10^{-5} mg/cm^3)(cm^3/1.5 g) = **2.6×10^{-5} mg/g**
   CS(Piperonyl butoxide) = (1.1×10^{-4} mg/cm^3)(cm^3/1.5 g) = **7.3×10^{-5} mg/g**
   CS(Permethrin) = (1.1×10^{-3} mg/cm^3)(cm^3/1.5 g) = **7.3×10^{-4} mg/g**

4. IR = 200 mg soil/day for 1-6 year olds (USEPA, 1989).

5. IR = 100 mg soil/day soil for those older than 6 (USEPA, 1989).

6. FI = 1

8. EF = 1 day for **resmethrin.** Resmethrin has a very short half life and therefore should not persist in soil between treatments. This assumes that each day of exposure is independent.
   EF = 50 days for **piperonyl butoxide.** Assume that piperonyl butoxide persists in the soil for the 10 days between treatments and that soil is ingested every day for the approximately 50 days adult control occurs (5 treatments at 10 day intervals).
   EF = 50 days for **permethrin.** Assume that permethrin persists in the soil between treatments and that soil is ingested every day for the approximately 50 days adult control occurs (5 treatments at 10 day intervals).

11. BW = 16 kg median weight for 1-6 year olds (USEPA, 1989)

12. BW = 70 kg for adult (USEPA, 1989)

13. AT = 1 day for resmethrin (assumes each day of exposure is independent)
    AT = 50 days for permethrin and piperonyl butoxide (5 treatments at 10 day intervals)

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Appendix A continued

Calculation of Soil Ingestion

$$\text{Intake (mg/kg/day)} = \frac{CS \times CF \times IR \times FI \times EF}{BW \times AT}$$

When the constants listed on the previous page are used, the above equation reduces to:

$$\text{Intake}_{child}\text{(mg/kg/day)} - \frac{(CS\ mg/g)(10^{-3}\ g/mg)(200\ mg/day)}{16\ kg}$$

$$\text{Intake}_{adult}\text{(mg/kg/day)} - \frac{(CS\ mg/g)(10^{-3}\ g/mg)(100\ mg/day)}{70\ kg}$$

Appendix B

Reference Dose (RfD)

Reference Dose (RfD): The USEPA defines a reference dose as, "...an estimate of the amount of a chemical that a person can be exposed to on a daily basis that is not anticipated to cause adverse systemic health effects over the person's lifetime" (USEPA, 1990a). In other words, daily exposure to a substance at its reference dose, even for a lifetime, should not result in toxic effects. The reference dose is usually expressed in units of milligrams of a substance per kilogram of body weight per day (mg/kg/day). The USEPA calculates a reference dose using the equation shown below:

$$\text{RfD} = \frac{\text{(NOAEL or LOAEL mg/kg/day)}}{\text{Uncertainty Factor}}$$

A. **NOAEL** stands for no-observed-adverse-effect-level. This number is usually derived from experimental animal data and reflects the highest dose at which no harmful effects of the agent are seen. **LOAEL**, the lowest-observed-adverse-effect-level, is the lowest dose at which harmful effects are noted. The use of a NOAEL or a LOAEL depends on the available data. Both the NOAEL and LOAEL are expressed in units of milligrams of the chemical per kilogram of body weight per day (mg/kg/day).

B. The **uncertainty factor** results from multiplying numbers which account for potential sources of uncertainty in the data. For example, a factor of 10 is included when animal data are used to derive values that are applied to human health. Another factor of 10 is incorporated to consider that some members of the population may be more sensitive to a chemical than others. These two common sources of uncertainty would result in an uncertainty factor of 100 (10 x 10). Numbers reflecting other sources of uncertainty, which can include the quality of data, and the use of a LOAEL instead of a NOAEL, can also contribute to the uncertainty factor. A large uncertainty factor indicates imprecision, but is a means of being protective in light of uncertainty.

Note: The RfDs calculated for this risk assessment are subchronic or acute RfDs. For this purpose the definition of RfD is modified so that a subchronic RfD reflects the safe dose of a substance that can be ingested daily for a less than lifetime exposure (in this case a 50 days) and an acute RfD reflects the safe dose of a substance that can be ingested for a short term exposure (in this case 1 day or less).

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Appendix B continued

Maximum Daily Allowable Intake (MDA)

MDA = mg of substance that can be safely consumed each day

MDA = (RfD mg/kg/day)(body weight kg) = mg/day

MDA for Ingestion of Homegrown Vegetables

The MDA for homegrown vegetables is expressed in terms of the surface area (cm^2) of the vegetables that can be consumed each day. To convert the MDA from mg/day to cm^2/day, the MDA is divided by the amount of the substance deposited on the vegetables (mg/cm^2):

$$MDA_{veg}\,(cm^2/day) = \frac{MDA\ (mg/day)}{deposition\ (mg/cm^2)} = \frac{(RfD\ mg/kg/day)(BW\ kg)}{deposition\ (mg/cm^2)}$$

Standard body weights recommended by the USEPA for exposure assessments at Superfund sites (USEPA, 1989):

1-6 year old child - 16 kg
Adult - 70 kg

Appendix C

Adjusting Animal Inhalation Data for Application to Humans
(Calabrese and Kenyon, 1991)

Acute Exposure

1. Convert NOAEL or LOAEL from mg/m^3 to mg/kg body weight.

$$\frac{(\text{NOAEL } mg/m^3)(\text{IR } m^3/day)(24 \text{ hr/day})(\text{ET hrs})}{\text{BW kg}}$$

IR = inhalation rate (mg/m^3)
ET = exposure time (hours)
BW = body weight (kg)

Assumptions for Conversion (Calabrese and Kenyon, 1991, p. 612)

IR_{rat} = 0.223 m^3/day
BW_{rat} = 0.35 kg

IR_{child} = 16 m^3/day
BW_{child} = 16 kg

IR_{adult} = 20 m^3/day
BW_{adult} = 70 kg

2. Estimate safe exposure level by dividing the adjusted NOAEL or LOAEL by uncertainty factors as described in Appendix B.

Appendix D Calculation of Dermal Exposure from Soil (USEPA, 1989)

$$\text{Intake (mg/kg/day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF}{BW \times AT}$$

Daily Intake (mg/day) = (Intake mg/kg/day) (BW kg)

CS = chemical concentration in soil (mg/g)
CF = conversion factor (10^{-3} g/mg)
SA = surface area available for contact (cm^2/event)
AF = soil to skin adherence factor (mg/cm^2)
ABS = absorption factor
EF = exposure frequency (days)
BW = body weight (kg)
AT = averaging time (days over which exposure is averaged)

Assumptions:

1. Mixing level of soil is 1 cm (USEPA, 1990b). This is a protective number, assuming minimal dilution of the contaminant (see Appendix A).

2. Density of soil is 1.5 g/cm^3. Soil densities range from 0.93 - 1.84 g/cm^3 (USEPA, 1990b). 1.5 g/cm^3 is used as a default value when the actual soil density is not known (USEPA, 1990b).

3. CS = $(mg/cm^2)(1/cm)(cm^3/1.5\ g)$
   CS(Resmethrin) = $(3.9 \times 10^{-5}\ mg/cm^3)(cm^3/1.5\ g) = 2.6 \times 10^{-5} mg/g$
   CS(Permethrin) = $(1.1 \times 10^{-3}\ mg/cm^3)(cm^3/1.5\ g) = 7.3 \times 10^{-4} mg/g$

4. SA = 3160 cm^2/day for arms, hands and legs of a child
   SA = 8620 cm^2/day for arms, hands and legs of an adult
   (USEPA, 1989)

5. AF = 1.45 mg/cm^2 This is the adherence factor for commercial potting soil (USEPA, 1989).

6. ABS = 1 This is very protective, since it assumes that all of the substance is absorbed through the skin.

7. EF = 1 day for resmethrin (see Appendix A)
   EF = 50 days for permethrin (see Appendix A)

9. BW = 16 kg for a child 1-6 years old, 70 kg for an adult

10. AT = 1 day for resmethrin (see Appendix A)
    AT = 50 days for permethrin (see Appendix A)

Note: This equation is consistent with the equation used by the USEPA for exposure assessments at Superfund sites (USEPA, 1989).

Appendix D continued

Calculation of Dermal Exposure from Foliage

$$\text{Intake (mg/kg/day)} = \frac{CS \times SA \times ABS \times EF}{BW \times AT}$$

Daily Intake (mg/day) = (Intake mg/kg/day)(BW kg)

CS = chemical concentration on surface of foliage (mg/cm^2)
SA = surface area available for contact (cm^2/day)
ABS = absorption factor
EF = exposure frequency (days)
BW = body weight (kg)
AT = averaging time (number of days over which exposure is averaged)

Assumptions:

1. Assume concentration on foliage is application rate

2. SA = 3160 cm^2/day for arms, hands and legs of a child
   SA = 8620 cm^2/day for arms, hands and legs of an adult (USEPA, 1989)

3. ABS = 1 This is very protective, since it assumes that all of the substance is absorbed through the skin.

4. EF = 1 for resmethrin (see Appendix A)
   EF = 50 for permethrin (see Appendix A)
   (note: the half life for permethrin in plants is approximately 10 days. 50 is a very protective estimate, since the concentration of permethrin will decrease by half during the ten day interval).

6. BW = 16 kg for a child 1-6 years old, 70 kg for an adult

7. AT = 1 day for resmethrin (see Appendix A)
   AT = 50 days (5 treatments at 10 day intervals)

When the constants listed above are used, the equation reduces to:

$$\text{Intake}_{child}\,(mg/kg/day) = \frac{(CS\ mg/g)(10^{-3}\ g/mg)(3160 cm^2/day)(1.45 mg/cm^2)}{16\ kg}$$

$$\text{Intake}_{adult}\,(mg/kg/day) = \frac{(CS\ mg/g)(10^{-3}\ g/mg)(8629 cm^2/day)(1.45 mg/cm^2)}{70\ kg}$$

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PPPPPPPP    RRRRRRRR      AAAAAA    TTTTTTTTTT  TTTTTTTTTT
PPPPPPPP    RRRRRRRR      AAAAAA    TTTTTTTTTT  TTTTTTTTTT
PP      PP  RR      RR   AA    AA      TT          TT
PP      PP  RR      RR   AA    AA      TT          TT
PP      PP  RR      RR   AA    AA      TT          TT
PP      PP  RR      RR   AA    AA      TT          TT
PPPPPPPP    RRRRRRRR     AA    AA      TT          TT
PPPPPPPP    RRRRRRRR     AA    AA      TT          TT
PP          RR  RR       AAAAAAAAAA    TT          TT
PP          RR  RR       AAAAAAAAAA    TT          TT
PP          RR    RR     AA    AA      TT          TT
PP          RR    RR     AA    AA      TT          TT
PP          RR      RR   AA    AA      TT          TT
PP          RR      RR   AA    AA      TT          TT
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Resmethrin
Receptor height = 5 ft (1.52 m)
max [] = 1402 µg/m³

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RRRR        M   M   000    SSSS   QQQ   U   U        RRRR        FFFFF  PPPP
R   R       MM MM  O   O  S      Q   Q  U   U        R   R       F      P   P
R   R       M M M  O   O  S      Q   Q  U   U        R   R       F      P   P
RRRR        M   M  O   O   SSS   Q   Q  U   U        RRRR        FFFF   PPPP
R R         M   M  O   O      S  Q Q Q  U   U        R R         F      P
R  R        M   M  O   O      S  Q  Q   U   U        R  R        F      P
R   R ____  M   M   000   SSSS    QQ Q   UUUUU ____  R   R ____  F      P
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      J   000   BBBB        4  4   999    222
      J  0   0  B   B       4  4   9   9  2   2
      J  0   0  B   B       4  4   9   9      2
      J  0   0  BBBB        44444   9999     2
   J  J  0   0  B   B          4       9    2
   J  J  0   0  B   B          4       9   2
    JJJ   000   BBBB           4    999   22222
```

Job R_MOSQU_R_FP (492) queued to AIR on 16-SEP-1992 16:02 by user PRATT, UIC [AQPDS,PRATT], under account AQPDS at priority 100, started on printer LTA9899: on 16-SEP-1992 16:02 from queue AIR.

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Attachment 1

AIR Concentration modeling for Resmethrin

```
CO STARTING
CO TITLEONE RESMETHRIN SPRAY STUDY - WORST CASE MET DATA
CO MODELOPT CONC   URBAN                          NOCALM
CO AVERTIME  1
CO POLLUTID OTHER
CO DCAYCOEF   0.000000E+00
CO FLAGPOLE 0.0
CO RUNORNOT RUN
CO ERRORFIL ERRORS.OUT
CO FINISHED


SO STARTING

** Source Location Cards:
**          SRCID SRCTYP        XS            YS            ZS

SO LOCATION     1 AREA        -10.0500      -10.0500      244.0000

** Source Parameter Cards:
** POINT:   SRCID       QS             HS         TS          VS         DS
** AREA:    SRCID       QS             HS       SYINIT      SZINIT
** VOLUME:  SRCID       QS             HS        XINIT

SO SRCPARAM     1   0.39400000E-03     2.4400    20.1000

SO MASSFRAX     1  0.00973  0.24915  0.46942  0.20346  0.06824
SO SETVELOC     1  0.00120  0.00750  0.01980  0.03790  0.06200
SO REFLCOEF     1  0.95000  0.80000  0.73000  0.66000  0.59000
SO EMISUNIT   0.100000E+07 (GRAMS/SEC)          (MICROGRAMS/CUBIC-METER)
SO SRCGROUP ALL
SO FINISHED


RE STARTING
RE GRIDPOLR POL STA
RE GRIDPOLR POL ORIG       0.0       0.0
RE GRIDPOLR POL DIST      10.0      20.0      30.0      40.0      50.0
RE GRIDPOLR POL DIST      60.0      70.0      80.0      90.0     100.0
RE GRIDPOLR POL DDIR    0.00
RE GRIDPOLR POL FLAG     0.00    1.52    1.52    1.52    1.52    1.52    1.52
RE GRIDPOLR POL FLAG     0.00    1.52    1.52    1.52    1.52
RE GRIDPOLR POL END
RE FINISHED


ME STARTING
ME INPUTFIL worst_case.met                          (4I2,2F9.4,F6.1,I2,2F7.1)
ME ANEMHGHT   10.000 METERS
ME SURFDATA  99999  1990            SURFNAME
ME UAIRDATA  99999  1990            UAIRNAME
ME WINDCATS    1.54    3.09    5.14    8.23   10.80
ME FINISHED


OU STARTING
OU MAXTABLE ALLAVE  50
OU FINISHED

**********************************
*** SETUP Finishes Successfully ***
**********************************
```

*** MODELING OPTIONS USED: CONC URBAN FLAT FLGPOL NOCALM

*** MODEL SETUP OPTIONS SUMMARY ***

**Model Is Setup For Calculation of Average CONCentration Values.

**Model Uses URBAN Dispersion.

**Model Uses User-Specified Options:
1. Final Plume Rise.
2. Stack-tip Downwash.
3. Buoyancy-induced Dispersion.
4. Not Use Calms Processing Routine.
5. Not Use Missing Data Processing Routine.
6. Default Wind Profile Exponents.
7. Default Vertical Potential Temperature Gradients.

**Model Assumes Receptors on FLAT Terrain.

**Model Accepts FLAGPOLE Receptor Heights.

**Model Calculates 1 Short Term Average(s) of: 1-HR

**This Run Includes: 1 Source(s); 1 Source Group(s); and 10 Receptor(s)

**The Model Assumes A Pollutant Type of: OTHER

**Model Set To Continue RUNning After the Setup Testing.

**Output Options Selected:
Model Outputs Tables of Overall Maximum Short Term Values (MAXTABLE Keyword)

**Misc. Inputs: Anem. Hgt. (m) = 10.00 ; Decay Coef. = 0.0000E+00 ; Rot. Angle = 0.0
Emission Units = (GRAMS/SEC) ; Emission Rate Unit Factor = 0.10000E+07
Output Units = (MICROGRAMS/CUBIC-METER)

**Detailed Error/Message File: ERRORS.OUT

*** MODELING OPTIONS USED: CONC URBAN FLAT FLGPOL NOCALM

*** AREA SOURCE DATA ***

SOURCE ID	NUMBER PART. CATS.	EMISSION RATE (USER UNITS /METER**2)	COORD (SW CORNER) X (METERS)	Y (METERS)	BASE ELEV. (METERS)	RELEASE HEIGHT (METERS)	WIDTH OF AREA (METERS)	EMISSION RATE SCALAR VARY BY
1	5	0.39400E-03	-10.1	-10.1	244.0	2.44	20.10	

*** MODELING OPTIONS USED: CONC URBAN FLAT FLGPOL NOCALM

*** SOURCE IDs DEFINING SOURCE GROUPS ***

GROUP ID	SOURCE IDs
ALL	1 ,

*** SOURCE PARTICULATE DATA ***

*** SOURCE ID = 1 ; SOURCE TYPE = AREA ***

MASS FRACTION =
 0.00973, 0.24915, 0.46942, 0.20346, 0.06824,

SETTLING VELOCITY(METERS/SEC) =
 0.00120, 0.00750, 0.01980, 0.03790, 0.06200,

SURFACE REFLECTION COEFFICIENT =
 0.95000, 0.80000, 0.73000, 0.66000, 0.59000,

*** MODELING OPTIONS USED: CONC URBAN FLAT FLGPOL NOCALM

*** GRIDDED RECEPTOR NETWORK SUMMARY ***

*** NETWORK ID: POL ; NETWORK TYPE: GRIDPOLR ***

*** ORIGIN FOR POLAR NETWORK ***
X-ORIG = 0.00 ; Y-ORIG = 0.00 (METERS)

*** DISTANCE RANGES OF NETWORK ***
(METERS)

10.0, 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0,

*** DIRECTION RADIALS OF NETWORK ***
(DEGREES)

360.0,

*** MODELING OPTIONS USED: CONC URBAN FLAT FLGPOL NOCALM

*** NETWORK ID: POL ; NETWORK TYPE: GRIDPOLR ***

* RECEPTOR FLAGPOLE HEIGHTS IN METERS *

DIRECTION (DEGREES)	DISTANCE (METERS) 10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00
360.00	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52

*** NETWORK ID: POL ; NETWORK TYPE: GRIDPOLR ***

* RECEPTOR FLAGPOLE HEIGHTS IN METERS *

DIRECTION (DEGREES)	DISTANCE (METERS) 100.00
360.00	1.52

*** MODELING OPTIONS USED: CONC URBAN FLAT FLGPOL NOCALM

* SOURCE-RECEPTOR COMBINATIONS LESS THAN 1.0 METER OR 3*ZLB *
IN DISTANCE. CALCULATIONS MAY NOT BE PERFORMED.

SOURCE ID	- - RECEPTOR LOCATION - - XR (METERS)	YR (METERS)	DISTANCE (METERS)
1	0.0	10.0	-1.34

*** MODELING OPTIONS USED: CONC URBAN FLAT FLGPOL NOCALM

*** METEOROLOGICAL DAYS SELECTED FOR PROCESSING ***
(1=YES; 0=NO)

```
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1   1 1 1 1 1 1
```

NOTE: METEOROLOGICAL DATA ACTUALLY PROCESSED WILL ALSO DEPEND ON WHAT IS INCLUDED IN THE DATA FILE.

*** UPPER BOUND OF FIRST THROUGH FIFTH WIND SPEED CATEGORIES ***
(METERS/SEC)

1.54, 3.09, 5.14, 8.23, 10.80,

*** WIND PROFILE EXPONENTS ***

STABILITY CATEGORY	WIND SPEED CATEGORY 1	2	3	4	5	6
A	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00
B	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00
C	.20000E+00	.20000E+00	.20000E+00	.20000E+00	.20000E+00	.20000E+00
D	.25000E+00	.25000E+00	.25000E+00	.25000E+00	.25000E+00	.25000E+00
E	.30000E+00	.30000E+00	.30000E+00	.30000E+00	.30000E+00	.30000E+00
F	.30000E+00	.30000E+00	.30000E+00	.30000E+00	.30000E+00	.30000E+00

*** VERTICAL POTENTIAL TEMPERATURE GRADIENTS ***
(DEGREES KELVIN PER METER)

STABILITY CATEGORY	WIND SPEED CATEGORY 1	2	3	4	5	6
A	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
B	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
C	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
D	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
E	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01
F	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01

*** MODELING OPTIONS USED: CONC URBAN FLAT FLGPOL NOCALM

*** THE FIRST 24 HOURS OF METEOROLOGICAL DATA ***

FILE: worst_case.met FORMAT: (4I2,2F9.4,F6.1,I2,2F7.1)
SURFACE STATION NO.: 99999 UPPER AIR STATION NO.: 99999
NAME: SURFNAME NAME: UAIRNAME
YEAR: 1990 YEAR: 1990

YEAR	MONTH	DAY	HOUR	FLOW VECTOR	SPEED (M/S)	TEMP (K)	STAB CLASS	MIXING HEIGHT (M) RURAL	MIXING HEIGHT (M) URBAN
90	3	23	1	0.0	1.00	293.0	1	5000.0	5000.0
90	3	23	2	0.0	2.00	293.0	1	5000.0	5000.0
90	3	23	3	0.0	3.00	293.0	1	5000.0	5000.0
90	3	23	4	0.0	1.00	293.0	2	5000.0	5000.0
90	3	23	5	0.0	2.00	293.0	2	5000.0	5000.0
90	3	23	6	0.0	3.00	293.0	2	5000.0	5000.0
90	3	23	7	0.0	4.00	293.0	2	5000.0	5000.0
90	3	23	8	0.0	5.00	293.0	2	5000.0	5000.0
90	3	23	9	0.0	1.00	293.0	3	5000.0	5000.0
90	3	23	10	0.0	2.00	293.0	3	5000.0	5000.0
90	3	23	11	0.0	3.00	293.0	3	5000.0	5000.0
90	3	23	12	0.0	4.00	293.0	3	5000.0	5000.0
90	3	23	13	0.0	5.00	293.0	3	5000.0	5000.0
90	3	23	14	0.0	8.00	293.0	3	5000.0	5000.0
90	3	23	15	0.0	10.00	293.0	3	5000.0	5000.0
90	3	23	16	0.0	1.00	293.0	4	5000.0	5000.0
90	3	23	17	0.0	2.00	293.0	4	5000.0	5000.0
90	3	23	18	0.0	3.00	293.0	4	5000.0	5000.0
90	3	23	19	0.0	4.00	293.0	4	5000.0	5000.0
90	3	23	20	0.0	5.00	293.0	4	5000.0	5000.0
90	3	23	21	0.0	8.00	293.0	4	5000.0	5000.0
90	3	23	22	0.0	10.00	293.0	4	5000.0	5000.0
90	3	23	23	0.0	15.00	293.0	4	5000.0	5000.0
90	3	23	24	0.0	20.00	293.0	4	5000.0	5000.0

*** NOTES: STABILITY CLASS 1=A, 2=B, 3=C, 4=D, 5=E AND 6=F.
FLOW VECTOR IS DIRECTION TOWARD WHICH WIND IS BLOWING.

*** MODELING OPTIONS USED: CONC URBAN FLAT FLGPOL NOCALM

*** THE MAXIMUM 50 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 1 ,

** CONC OF OTHER IN (MICROGRAMS/CUBIC-METER) **

RANK	CONC	(YYMMDDHH) AT	RECEPTOR (XR,YR) OF TYPE			RANK	CONC	(YYMMDDHH) AT	RECEPTOR (XR,YR) OF TYPE		
1.	1402.18457	(90032401) AT	(0.00,	20.00)	GP	26.	536.60876	(90032316) AT	(0.00,	50.00)	GP
2.	1402.18457	(90032406) AT	(0.00,	20.00)	GP	27.	535.34814	(90032402) AT	(0.00,	40.00)	GP
3.	1250.09717	(90032401) AT	(0.00,	30.00)	GP	28.	535.34814	(90032407) AT	(0.00,	40.00)	GP
4.	1250.09717	(90032406) AT	(0.00,	30.00)	GP	29.	516.94604	(90032401) AT	(0.00,	90.00)	GP
5.	1100.96338	(90032401) AT	(0.00,	40.00)	GP	30.	516.94604	(90032406) AT	(0.00,	90.00)	GP
6.	1100.96338	(90032406) AT	(0.00,	40.00)	GP	31.	501.15808	(90032317) AT	(0.00,	20.00)	GP
7.	1012.57397	(90032316) AT	(0.00,	20.00)	GP	32.	470.48965	(90032402) AT	(0.00,	50.00)	GP
8.	962.97833	(90032401) AT	(0.00,	50.00)	GP	33.	470.48965	(90032407) AT	(0.00,	50.00)	GP
9.	962.97833	(90032406) AT	(0.00,	50.00)	GP	34.	466.55334	(90032301) AT	(0.00,	30.00)	GP
10.	832.22644	(90032401) AT	(0.00,	60.00)	GP	35.	466.55334	(90032304) AT	(0.00,	30.00)	GP
11.	832.22644	(90032406) AT	(0.00,	60.00)	GP	36.	452.93942	(90032403) AT	(0.00,	20.00)	GP
12.	819.12939	(90032316) AT	(0.00,	30.00)	GP	37.	452.93942	(90032408) AT	(0.00,	20.00)	GP
13.	767.81512	(90032309) AT	(0.00,	20.00)	GP	38.	449.10162	(90032309) AT	(0.00,	40.00)	GP
14.	711.57367	(90032401) AT	(0.00,	70.00)	GP	39.	443.25482	(90032401) AT	(0.00,	100.00)	GP
15.	711.57367	(90032406) AT	(0.00,	70.00)	GP	40.	443.25482	(90032406) AT	(0.00,	100.00)	GP
16.	684.99365	(90032402) AT	(0.00,	20.00)	GP	41.	425.95959	(90032316) AT	(0.00,	60.00)	GP
17.	684.99365	(90032407) AT	(0.00,	20.00)	GP	42.	408.75467	(90032402) AT	(0.00,	60.00)	GP
18.	668.65350	(90032316) AT	(0.00,	40.00)	GP	43.	408.75467	(90032407) AT	(0.00,	60.00)	GP
19.	648.79034	(90032301) AT	(0.00,	20.00)	GP	44.	404.92816	(90032317) AT	(0.00,	30.00)	GP
20.	648.79034	(90032304) AT	(0.00,	20.00)	GP	45.	399.92133	(90032403) AT	(0.00,	30.00)	GP
21.	606.64496	(90032402) AT	(0.00,	30.00)	GP	46.	399.92133	(90032408) AT	(0.00,	30.00)	GP
22.	606.64496	(90032407) AT	(0.00,	30.00)	GP	47.	381.85565	(90032310) AT	(0.00,	20.00)	GP
23.	605.98279	(90032401) AT	(0.00,	80.00)	GP	48.	352.87735	(90032403) AT	(0.00,	40.00)	GP
24.	605.98279	(90032406) AT	(0.00,	80.00)	GP	49.	352.87735	(90032408) AT	(0.00,	40.00)	GP
25.	592.84619	(90032309) AT	(0.00,	30.00)	GP	50.	351.25446	(90032402) AT	(0.00,	70.00)	GP

*** RECEPTOR TYPES: GC = GRIDCART
GP = GRIDPOLR
DC = DISCCART
DP = DISCPOLR
BD = BOUNDARY

*** MODELING OPTIONS USED: CONC URBAN FLAT FLGPOL NOCALM

*** Message Summary For ISC2 Model Execution ***

---------- Summary of Total Messages ----------

A Total of 0 Fatal Error Message(s)
A Total of 0 Warning Message(s)
A Total of 0 Informational Message(s)

******** FATAL ERROR MESSAGES ********
*** NONE ***

******** WARNING MESSAGES ********
*** NONE ***

****
*** ISCST2 Finishes Successfully ***
****

ROUSSEL UCLAF

TECHNICAL CENTER:
170 BEAVER BROOK ROAD
LINCOLN PARK, NEW JERSEY 07035
TELEPHONE: (201) 628-7200
FAX NO. (201) 628-9367

August 3, 1992

Mr. Ross Green
Metropolitan Mosquito Control District
2380 Wycliff Street
St. Paul, MN 55114

Dear Mr. Green:

We have calculated the amount of Scourge 18%/54% or Punt 57 OS which would be required to equal the acute lethal dose values (LD50 or LC50) representing accidental or one-time exposure situations. Additionally, we have calculated the level representing the U.S. Environmental Protection's Agency Reference Dose (RfD), formerly called the Allowable Daily Intake (ADI), which is the level associated with long term or chronic (usually low-dose lifetime) exposure.

The LD50 (or LC50) can be defined as "the statistically derived single dose [or concentration] of a substance that can be expected to cause death in 50% of a population (Hayes, 1984). This value is commonly calculated for each probable route of exposure, ingestion, skin absorption (dermal) or inhalation. These exposures typically represent worst case accidental, one-time exposures. On the other hand, the Reference Dose is defined by US-EPA as "an estimate of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk or deleterious effects during a lifetime. The RfD's are based on an assumption of lifetime exposure and may not be appropriately applied to less-than-lifetime exposure situations" (EPA, 1988). Therefore, the RfD is considered to be an amount of material in which the population may be safely exposed on a daily basis for a lifetime (70 years).

The risk assessment assumptions and calculations for acute and chronic exposure to Scourge or Punt 57 OS are presented below.

SCOURGE

SOME GENERAL FACTS

70 Kg Adult Male = 154 lbs. 1 Kg = 2.2 lbs.

10 Kg Child = 22 lbs. 1 lb. = 453.6 grams

Respiration Rate - No. of liters of air breathed/min.

Rat = 0.073 l/min.

Man = 20 l/min. during light work

1,000 Mg = 1 gram

1 Acre = 43,560 sq. ft.

Lifetime = 70 yrs.

a.i. = active ingredient (actual pesticide

1 Acre = Approximately 400 9x12 rugs

TOXICITY DATA	SCOURGE	PUNT 57 OS*
Oral LD50 (rat)	2,700 mg/kg	> 4,000 mg/kg
Dermal LD50 (rabbit)	> 2,000 mg/kg	> 2,000 mg/kg
4-Hour Inhalation LC50 (rat)	> 5 mg/kg	N/A
Reference Dose (RfD)	.03 mg/kg/day **	.05 mg/kg/day
Recommended Label Application Rate (AI/Acre)	.007 lb/A	.116/A
Absorption Rate of A.I.	5%	2%

* Based on active ingredient - permethrin
** Based on active ingredient - resmethrin

NOTE: Inhalation of Punt 57 OS is not applicable because the application is a coarse spray directed at foliage and the spray particles are of non-respirable size.

Acute (Accidental or Single) Exposure

Ingestion:

The acute oral LD50 for Scourge 18/54 = 2,700 mg/kg

Conversion of AI application rate to formulation (Scourge) application rate:

$$\frac{3.18 \text{ grams AI/Acre}}{18\% \text{ AI in } 18/54} = 17.7 \text{ g Scourge } 18/54/A$$

Equivalent LD50 for 10 Kg (22 lb) Child:

10 Kg x 2,700 mg Scourge/Kg = 27,000 mg or 27 grams Scourge

$$\frac{\text{27 grams}}{\text{17.79 Scourge/A}} = \text{1.5 Acres}$$

Therefore, a 22 lb. child would have to ingest 1.5 acres (600 9x12 rugs) of treated foliage in one sitting to equal the oral LD50 value.

Equivalent LD50 for 70 kg (154 lb) Adult Male:

70 Kg x 2,700 mg Scourge/Kg = 189,000 mg or 189 grams Scourge

$$\frac{\text{189 grams}}{\text{17.79 Scourge/A}} = \text{10.7 Acres}$$

Therefore, a 154 lb. adult male would have to ingest 10.7 acres (4,280 9x12 rugs) of treated foliage in one sitting to equal the oral LD50 value.

Skin Absorption:

The acute dermal LD50 for Scourge 18/54 = > 2,000 mg/kg

Equivalent LD50 for 10 Kg Child:

10 kg x 2,000 mg/kg = 20,000 or 20 grams Scourge 18/54

$$\frac{\text{20 grams}}{\text{17.7 grams Scourge/A}} = \text{1.13 Acres}$$

Therefore, a 22 lb. child would have to be exposed to (roll around in) 1.13 acres (452 9x12 rugs) of treated foliage as a single event to equal the dermal LD50 value.

Equivalent LD50 for 70 kg Adult Male:

70 kg x 2,000 mg/kg = 140,000 mg or 140 grams Scourge 18/54

$$\frac{\text{140 grams}}{\text{17.7 grams Scourge/A}} = \text{7.9 Acres}$$

Therefore, a 70 kg adult male would have to be exposed to (roll around in) 7.9 acres (3,160 9x12 rugs) of treated foliage as a single event to equal the dermal LD50 value.

Inhalation:

The acute inhalation LC50 (lethal concentration) for Scourge 18/54 equals > 5 mg/l.

To convert from concentration to dose (mg/l to mg/kg), the following is necessary:

Respiration rate for rat = .073 l/min

Average body weight of rat in LC50 study is approximately 250 grams or .25 kg.

The LC50 is for a 4-hour exposure.

$$\frac{(5 \text{ mg/l}) \times (.073 \text{ l/min}) \ (60 \text{ min./hr}) \ (4 \text{ hrs})}{.25 \text{ kg}} = 87 \text{ mg/kg}$$

87 mg/kg is the dose of Scourge which is equivalent to 5 mg/l, the acute inhalation LC50 of Scourge 18/54 in rats. The conversation from mg/l (concentration in air) to mg/kg (amount of product taken into the body per kg of body weight) allows us to make direct extrapolation from animal to man.

Respiration rate for man (during light work) = 20 l/min

Assume fog is evenly dispersed over each treated acre at a height of 5 feet for 1 hour (overexaggeration of worst case scenario).

At the recommended label application rate of 0.007 lb resmethrin/Acre, the equivalent rate for Scourge would be 0.039 lb Scourge/Acre.

Therefore:

$$\frac{0.039 \text{ lb Scourge}}{\text{Acre}} \times \frac{1}{(5 \text{ ft spray height})} \times \frac{1 \text{ Acre}}{(43{,}560 \text{ ft}^2)} \times \frac{454 \text{ g}}{1 \text{ lb.}} \times \frac{1 \text{ cu. ft}}{1{,}728 \text{ m}^3} \times \frac{1{,}000 \text{ cm}^3}{1 \text{ lb.}} =$$

2.9×10^{-6} grams = .003 mg Scourge/l of concentrated fog/ac.

The dose obtained from breathing a fog containing .003 mg Scourge/l air/acre for 1 hour is:

$$\frac{(.003 \text{ mg/l})\ (20 \text{ l/min})\ (60 \text{ min.})}{70 \text{ kg}} = .05 \text{ mg/kg/acre}$$

Therefore, an adult male would have to inhale the amount of Scourge 18/54 fog suspended over 1,740 acres to equal the acute inhalation LC50 value.

Chronic (Repeated over Lifetime) Exposure:

The RfD for Resmethrin = .03 mg/kg/day, every day over 70 years.

The amount of Resmethrin applied/sq.ft. at the recommended label rate of .007 lb./acre is:

$$\frac{(.007 \text{ lb})}{(\text{ Acre })} \frac{(453.6 \text{ g})}{(\text{ 1 lb. })} \frac{(\quad 1 \text{ Acre} \quad)}{(\text{ 43,560 sq.ft})} = 0.1 \text{ mg/sq. ft.}$$

Chronic Ingestion:

The amount of foliage treated with Scourge 18/54 to be ingested daily for a 70 kg adult male over a lifetime (to 70 years) that would be equivalent to the RfD would be:

$$(.03 \text{ mg/kg/day})\ (70 \text{ kg}) = \frac{2.1 \text{ mg/day}}{0.1 \text{ mg/sq.ft.}} = 21 \text{ sq. ft/day}$$

Chronic Dermal Absorption:

The absorption rate for Resmethrin is approximately 5% which means that only 5% of the total amount of material applied to the skin is absorbed into the body.

Therefore, the amount of foliage treated with Scourge 18/54 for a 70 kg adult male in which to roll around on a daily basis over a lifetime (70 years) that would be equivalent to the RfD would be:

$$(0.03 \text{ mg/kg/day})(70 \text{ kg})\ \frac{(100\%)}{5\%} = \frac{42 \text{ mg/day}}{0.1 \text{ mg/sq.ft}} = 420 \text{ sq. ft/day}$$

PERMETHRIN

Conversion of AI application rate to formulation (Punt 57 OS) application rate:

$$\frac{(\ 1\ lb.\ )}{(\ 1\ Acre\ )}\ \frac{(\ 454\ g\ )}{(\ 1\ lb.\ )} = 45.4\ g\ Permethrin/Acre$$

$$\frac{(45.4\ g\ )}{(\ 1\ Acre)}\ \frac{(\ 1\ Acre\ \_\_\_\_)}{(43,560\ sq.ft)} = 1\ mg/sq.\ ft.$$

Acute (Accidental or Single) Exposure

Ingestion:

Equivalent LD50 for 10 kg (22 lb.) Child:

(10 kg) (4,000 mg/kg Permethrin) = 40,000 mg Permethrin

$$\frac{40,000\ mg}{1\ mg/sq.\ ft.} = \frac{40,000\ sq.\ ft.}{(43,560\ sq.\ ft/Acre)} = 0.92\ Ac.$$ treated with Punt 57 OS

Therefore, a 22 lb. child would have to ingest 0.92 acres of foliage treated with Punt 57 OS in one sitting to equal the acute oral LD50.

Equivalent LD50 for 70 kg (154 lb.) Adult Male:

(70 kg) (4,000 mg/kg) = 280,000 mg Permethrin

$$\frac{280,000\ mg}{1\ mg/sq.\ ft.} = \frac{280,000\ sq.\ ft.}{(43,560\ sq.\ ft/Acre)} = 6.43\ Ac.$$ treated with Punt 57 OS

Therefore, an adult male (70 kg) would have to ingest 6.43 acres of foliage treated with Punt 57 OS at one sitting to equal the acute oral LD50.

Skin Absorption:

The acute dermal LD50 of Permethrin is > 2,000 mg/kg.

Equivalent LD50 for 10 kg (22 lb.) Child:

(10 kg) (2,000 mg/kg) = 20,000 mg Permethrin

$\frac{20{,}000 \text{ mg}}{1 \text{ mg/sq. ft.}} = \frac{20{,}000 \text{ sq. ft.}}{(43{,}560 \text{ sq. ft/Acre})} = 0.46$ Ac. treated with Punt 57 OS

Therefore, a 22 lb. child would have to roll around in about 0.5 acres of foliage treated with Punt 57 OS in a single event to equal the dermal LD50.

Equivalent LD50 for 70 kg (154 lb.) Adult Male:

(70 kg) (2,000 mg/kg) = 140,000 mg Permethrin

$\frac{140{,}000 \text{ mg}}{1 \text{ mg/sq. ft.}} = \frac{140{,}000 \text{ sq. ft.}}{(43{,}560 \text{ sq. ft/Acre})} = 3.2$ Ac. treated with Punt 57 OS

Therefore, a 154 lb. adult male would have to roll around in 3.2 acres of foliage treated with Punt 57 OS in a single event to equal the dermal LD50.

Chronic (Repeated over Lifetime) Exposure:

The RfD for Permethrin = 0.05 mg/kg/day, every day over 70 years.

The amount of Permethrin applied/sq. ft. at the recommended label rate is 1 mg/sq. ft.

Chronic Ingestion:

The amount of foliage treated with Punt 57 OS to be ingested daily for a 70 kg adult male over a lifetime (to 70 years) that would be equivalent to the RfD would be:

(.05 mg/kg/day) (70 kg) = 3.5 mg/Permethrin/day

since there is only 57% Permethrin in Punt 57 OS,

$(3.5 \text{ mg/day}) \left(\frac{100\%}{57\%}\right) = 6.14$ mg Punt 57 OS/day

$\frac{6.14 \text{ mg}}{1 \text{ mg/sq.ft.}} = 6.14$ sq. ft/day

Chronic Dermal Absorption:

The absorption rate of Permethrin is approximately 2%.

Therefore, the amount of foliage treated with Punt 57 OS for a 70 kg adult male in which to roll around on a daily basis over a lifetime (70 years) that would be equivalent to the RfD is:

$$(.05 \text{ mg/kg/day})\ (70 \text{ kg})\ \left(\frac{100\%}{57\%}\right)\left(\frac{100\%}{5\%}\right) = \frac{122.8 \text{ mg/day}}{1 \text{ mg/sq. ft.}} = 122.8 \text{ sq.ft/day}$$

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