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

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

MEMORANDUM

PC Code: 122804
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SUBJECT: Tier I Drinking Water EECs for Abamectin on Leafy and Fruiting Vegetables and Plums; Recalculated Tier II Drinking Water EECs for Abamectin on Strawberries in Florida Incorporating the Index Reservoir and the Percent Cropped Area

FROM: Stephanie Syslo, Environmental Scientist Stephanie Syslo 4/20/2000
and
James Carleton, Chemist/Peer Reviewer Jim Carleton 4/20/00
Environmental Risk Branch II
Environmental Fate and Effects Division (7507C)

TO: Kelly O'Rourke, RAB 3
Health Effects Division (7509C)

THRU: Jean Holmes, Branch Chief (Acting) Jean Holmes 4/20/00
Environmental Risk Branch 11, EFED (7507C)

As requested, a Tier I screening assessment of estimated environmental concentrations (EECs) for abamectin in drinking water resulting from the proposed label uses for leafy and fruiting vegetables and plums was performed. The product considered was Agri-Mek ® 0.15 EC (EPA Reg.No. 100-898) containing the active ingredient abamectin, which itself is a mixture of avermectins containing $\geq$80% avermectin B_{1a} (5-0-demethyl avermectin A_{1a}) and $\leq$20% avermectin B_{1b} (5-0-demethyl-25-de(l-methylpropyl)-25-(I-methylethyl) avermectin A_{1a})]. Use sites modeled using GENEEC for predicting surface water concentrations and SCI-GROW for predicting ground water concentrations were done for leafy and fruiting vegetables and plums; EFED did not perform a Tier II surface water drinking water assessment for the vegetable or plum scenarios because strawberries were considered a higher exposure scenario (4 applications per season @ 0.01875 lb ai/A [the highest national use rate for abamectin] vs. 3 applications for vegetables @ 0.01875 lb ai/A, and 2 applications for plums @ 0.0234 lb ai/A).

Because previous dietary assessments indicated that there was a concern for residues in drinking water resulting from this use, a Tier II assessment following the Index Reservoir and Percent Cropped Area policy in place in EFED (Denise Keeher, EFED policy memo dated December 1, 1999) was performed on strawberries grown on black plastic mulch in Florida. This assessment replaces the one performed last year for strawberries (DP Barcode 251775; dated 1/11/99).

PRZM-EXAMS simulations were conducted for abamectin use on strawberries to evaluate the cumulative probability distribution for peak and annual mean EECs. Previous modeling with GENEEC did not take the use of plastic mulch on Florida strawberries into account, and as a result PRZM-EXAMS modeling shows higher predicted values than did modeling with GENEEC. Drinking water EECs for parent abamectin on strawberries in Florida, incorporating the Index Reservoir and Percent Cropped Area adjustments, are presented below..

Estimated drinking water concentrations to be used for exposure to Abamectin in drinking water derived from Surface Water

Toxicity Endpoint	Model EEC Value (µg/L)	Use Modeled	PCA Modeled
Acute	1.47*	Strawberries in Florida; 4 ground applications @ 0.01875 lb ai/A; application intervals of 7 days, 21 days, 7 days (per label instructions for strawberries)	The default PCA factor of 0.87 was used because at this time no PCA specific for strawberries has been developed
Chronic non-cancer	0.71		
Cancer	0.71		

* EECs rounded to 2 significant figures; one-in-ten-year value reported.

The recalculated EECs are higher than previously reported for PRZM-EXAMS due to the four applications and using the default value for the PCA. Because strawberries are a minor use crop, the use of the PCA default value increases the uncertainty of these estimates. In addition, the certainty of the concentrations estimated for strawberries is low, due to uncertainty on the amount of runoff from plant beds covered in plastic mulch and uncertainty on the amount of degradation of abamectin on black plastic compared to soil. At this time, no further refinement of this assessment is possible. However, EFED is in discussions with the registrant (Novartis) concerning the estimation of degradation factors that may affect the risk characterization for this chemical. When those factors become available, they will be incorporated into EFED's drinking water assessment for the strawberry use.

Background

Abamectin (also known as avermectin) is the active ingredient in the miticide/insecticide Agri-mek ® 0.15, which is proposed for control of a number of insect pests, specifically mites and leafminers in leafy vegetables, fruiting vegetables, and plums.

Groundwater and surface water monitoring data are not available to the Environmental Fate and Effects Division (EFED) for abamectin at this time. Tier I Screening models were used to determine estimated concentrations for abamectin in groundwater and surface water for leafy vegetables, fruiting vegetables, and plums.

Ground Water

The SCI-GROW model is based on scaled ground water concentration from ground water monitoring studies, environmental fate properties (aerobic soil half-lives and organic carbon partitioning coefficients-K_{oc}'s) and application rates. The model is based on permeable soils that are vulnerable to leaching and on shallow ground water (10-30 feet).

The SCI-GROW model (Version 1.2; executable file dated 11/12/97) was used to estimate concentrations of abamectin that could be found in drinking water derived from ground water, using the input values listed in the table below. EECs were not calculated for degradates of abamectin.

Ground Water Exposure Inputs for SCI-GROW for Parent Abamectin

MODEL INPUT VARIABLE	INPUT VALUE	COMMENTS
Application Rate (lbs. ai/A)	0.0234 (Plums) 0. 0188 (Leafy and fruiting vegetables; strawberries)	Current label ((EPA Reg.No. 100-898)
Maximum No. of Applications	2 (Plums) 3 (Leafy and fruiting vegetables) 4 (Strawberries)	Current label.
K_{oc}	2,531	Lowest non-sand K_{oc} of 2,531 in Three Bridges silt loam (1.22 % OC). Lowest K_{oc} was used since the K_{oc}'s differed by more than a factor of 3. MRID 40856301
Aerobic Soil Metabolic Half-life (days)	70	Mean of 70 days from individual half-lives of 34, 41, 72, and 131 days. Ku and Jacob, 1983, No MRID available, Review dated 3/28/84.

Results from the SCI-GROW screening model predict that the maximum chronic concentration of parent abamectin in shallow ground water is not expected to exceed 2.0 ng/L for the current maximum use rate on strawberries, 1.5 ng/L for the proposed use on leafy and fruiting vegetables, and 1.2 ng/L for the proposed use on plums. Please note that these EECs are well below the Limit of Quantitation for the analytical method (LOQ in water = 0. 1µg/L = 100 ng/L)

Limitations of this analysis

The SCI-GROW model (Screening Concentrations in Ground Water) is a model for estimating maximum concentrations of pesticides in ground water. SCI-GROW provides a screening concentration, an estimate of likely ground water concentrations if the pesticide is used at the maximum allowed label rate in areas with ground water exceptionally vulnerable to contamination. In most cases, a majority of the use area will have ground water that is less vulnerable to contamination than the areas used to derive the SCI-GROW estimate.

Surface Water

The GENEEC model (version dated 5/3/95) was used to determine estimated concentrations for abamectin in surface water for leafy vegetables, fruiting vegetables, and plums, using the input values listed in the table below. EECs were not calculated for degradates of abamectin.

Surface Water Exposure Inputs for GENEEC for Parent Abamectin

MODEL INPUT VARIABLE	INPUT VALUE	COMMENTS
Application Rate (lbs ai/A)	0.0188 (Leafy and fruiting vegetables) 0.0234 (Plums)	Current label (EPA Reg.No. 100-898)
Maximum No. of Applications	3 (Leafy and fruiting vegetables) 2 (Plums)	Current label
Application Interval (days)	7 (Leafy and fruiting vegetables) 21 (Plums)	Current Label
K_{oc}	2,531	Lowest non-sand K_{oc} of 2,531 in Three Bridges silt loam (1.22 % OC). MRID 40856301
Aerobic Soil Metabolic Half-life (days)	115	90% upper-bound confidence limit of mean half-life
Is the pesticide wetted-in?	No	Current label
Depth of Incorporation (in.)	0	Current label
Spray Drift	5 (leafy and fruiting vegetables) 1 (leafy and fruiting vegetables, plums)	Aerial = 5%; Ground = 1%
Solubility (µg/L)	7.8	At pH 9; EFGWI3 One-Liner Database
Aerobic Aquatic Metabolic Half-life (days)	230	No acceptable aerobic aquatic metabolism data were available. Therefore, since there were no data and the hydrolysis rate is stable, per current EFED guidance, use 2x aerobic soil metabolism half-life as input value.
Hydrolysis (pH 7) half-life (days)	0	Stable. No MRID available. Review dated 4/18/83.
Photolysis Half-life (days)	0.5	Dark-control adjusted half-life. Ku and Jacob, 1983, No MRID available, Review dated 3/28/84.

Results from the GENEEC screening model are presented below.

Tier I GENEEC EECs for Abamectin (µg/L)							
Crop	Application Rate	Application interval	Application method	Peak	4-Day	21-Day	60-day
Leafy and fruiting vegetables	3 app. @ 0.0188 lb ai/A	7 days	Ground	0.36*	0.34	0.23	0.14
			Aerial	0.46	0.43	0.30	0.18
Plums	2 app. @ 0.0234 lb ai/A	21 days	Ground	0.29	0.27	0.19	0.11

*EECs rounded to 2 significant figures.

Limitations of this analysis

There are certain limitations imposed when Tier I EEC's are used for drinking water exposure estimates. A single 10 hectare field with a 1 hectare pond does not reflect the dynamics in a watershed large enough to support a drinking water facility. A basin of this size would likely not be planted completely to a single crop nor be completely treated with a pesticide. Additionally, treatment with the pesticide would likely occur over several days or weeks, rather than all on a single day. This would reduce the magnitude of the concentration peaks, but also make them broader, reducing the acute exposure but perhaps increasing the chronic exposure. The fact that the simulated pond has no outlet is also a limitation as water bodies in this size range would have at least some flow through (rivers) or turnover (reservoirs). In spite of these limitations, a Tier I EEC can provide a reasonable upper bound on the concentration found in drinking water if not an accurate assessment of the true concentration. The EEC'S have been calculated so that in any given year, there is a 10% probability that the maximum average concentration of that duration in that year will equal or exceed the EEC at the site. Risk assessment using Tier I values can capably be used as refined screens to demonstrate that the risk is below the level of concern.

Tier II Assessment for Drinking Water Derived from Surface Water

On the basis of the results from the Tier I surface water screening assessment for strawberries conducted last year, a refined assessment was requested at that time. The PRZM/EXAMS model was used to estimate surface water concentrations for avermectin used on strawberries in Florida (D251775; EFED memo to HED dated 1/11/99). In the interim, the Index Reservoir and Percent Cropped Area policy was put in effect within EFED. As a result, it was necessary to recalculate the Tier II EECs to replace the ones previously reported. Details on the input parameters used in PRZM-EXAMS to generate these replacement EECs and the limitations and uncertainties of the models are included in Appendices A, B, C, and D (attached).

cc: Tom Harris, RD

Tier I SCI-GROW Values for Avermectin in Ground Water

Plums - Ground application

```
 INPUT VALUES
--------------------------------------------------------------
 APPL (#/AC) APPL.  URATE    SOIL   SOIL  AEROBIC
 RATE          NO.  (#/AC/YR) KOC    METABOLISM (DAYS)
--------------------------------------------------------------
   .023         2     .047    2531.0     70.0

GROUND-WATER SCREENING CONCENTRATIONS IN PPB
----------------------------------------------------
              .001225
----------------------------------------------------
A=   65.000 B= 2536.000 C=    1.813 D=    3.404 RILP=    1.080
F=   -1.582 G=     .026 URATE=    .047 GWSC=        .001225
```

Leafy and fruiting vegetables - Ground and aerial application

```
 INPUT VALUES
--------------------------------------------------------------
 APPL (#/AC) APPL.  URATE    SOIL   SOIL  AEROBIC
 RATE          NO.  (#/AC/YR) KOC    METABOLISM (DAYS)
--------------------------------------------------------------
   .019         3     .056    2531.0     70.0

GROUND-WATER SCREENING CONCENTRATIONS IN PPB
----------------------------------------------------
              .001476
----------------------------------------------------
A=   65.000 B= 2536.000 C=    1.813 D=    3.404 RILP=    1.080
F=   -1.582 G=     .026 URATE=    .056 GWSC=        .001476
```

Strawberries - Ground application

```
 INPUT VALUES
--------------------------------------------------------------
 APPL (#/AC) APPL.  URATE    SOIL   SOIL  AEROBIC
 RATE          NO.  (#/AC/YR) KOC   METABOLISM (DAYS)
--------------------------------------------------------------
   .019         4     .075    2531.0     70.0

GROUND-WATER SCREENING CONCENTRATIONS IN PPB
----------------------------------------------------
              .001969
----------------------------------------------------
A=   65.000 B= 2536.000 C=    1.813 D=    3.404 RILP=    1.080
F=   -1.582 G=     .026 URATE=    .075 GWSC=        .001969
```

Tier I GENEEC Values for Avermectin in Surface Water

Leafy and fruiting vegetables - Aerial application

```
INPUT VALUES
--------------------------------------------------------------------
 RATE (#/AC)   APPLICATIONS  SOIL  SOLUBILITY  % SPRAY  INCORP
  ONE(MULT)    NO.-INTERVAL  KOC     (PPB)       DRIFT  DEPTH(IN)
--------------------------------------------------------------------
 .019(  .054)     3      7   2531.0    7.8          5.0        .0

FIELD AND STANDARD POND HALFLIFE VALUES (DAYS)
--------------------------------------------------------------------
METABOLIC  DAYS UNTIL  HYDROLYSIS  PHOTOLYSIS  METABOLIC  COMBINED
 (FIELD)   RAIN/RUNOFF   (POND)    (POND-EFF)    (POND)    (POND)
--------------------------------------------------------------------
 115.00        0          N/A       .50-  61.35   *****     48.43

GENERIC EECs (IN PPT)
----------------------------------------------------
  PEAK    AVERAGE 4   AVERAGE 21   AVERAGE 56
  GEEC    DAY GEEC    DAY GEEC     DAY GEEC
----------------------------------------------------
 456.66    425.83      288.67       173.11
```

Leafy and fruiting vegetables - Ground application

```
INPUT VALUES
--------------------------------------------------------------------
 RATE (#/AC)   APPLICATIONS  SOIL  SOLUBILITY  % SPRAY  INCORP
  ONE(MULT)    NO.-INTERVAL  KOC     (PPB)       DRIFT  DEPTH(IN)
--------------------------------------------------------------------
 .019(  .039)     3      7   2531.0    7.8          1.0      .0

FIELD AND STANDARD POND HALFLIFE VALUES (DAYS)
--------------------------------------------------------------------
METABOLIC  DAYS UNTIL  HYDROLYSIS  PHOTOLYSIS  METABOLIC  COMBINED
(FIELD)    RAIN/RUNOFF   (POND)    (POND-EFF)    (POND)    (POND)
--------------------------------------------------------------------
 11.00         0          N/A       .50-  61.35   *****     48.43

GENERIC EECs (IN PPT)
----------------------------------------------------
  PEAK    AVERAGE 4   AVERAGE 21   AVERAGE 56
  GEEC    DAY GEEC    DAY GEEC     DAY GEEC
----------------------------------------------------
 362.48    335.29      229.08       139.22
```

Plums - Ground application

```
INPUT VALUES
--------------------------------------------------------------------
RATE (#/AC)   APPLICATIONS  SOIL   SOLUBILITY  % SPRAY INCORP
 ONE(MULT)    NO.-INTERVAL  KOC     (PPB)       DRIFT   DEPTH(IN)
--------------------------------------------------------------------
.023(  .044)      2      21    2531.0     7.8          1.0       .0

FIELD AND STANDARD POND HALFLIFE VALUES (DAYS)
--------------------------------------------------------------------
METABOLIC  DAYS UNTIL  HYDROLYSIS  PHOTOLYSIS  METABOLIC  COMBINED
 (FIELD)   RAIN/RUNOFF  (POND)     (POND-EFF)   (POND)     (POND)
--------------------------------------------------------------------
115.00          0          N/A      .50-  61.35    *****      48.43

GENERIC EECs (IN PPT)
--------------------------------------------------------
  PEAK     AVERAGE 4    AVERAGE 21   AVERAGE 56
  GEEC     DAY GEEC     DAY GEEC     DAY GEEC
--------------------------------------------------------
 294.43     272.33       186.08       113.09
```

APPENDIX A

PRZM 3.12 and EXAMS 2.97.5 Chemical-Specific Input Parameters

The environmental fate database for abamectin is incomplete. However, based on the acceptable and supplemental data, the active ingredient abamectin, which itself is a mixture of avermectins containing ≥80% avermectin B_{1a} (5-0-demethyl avermectin A_{1a}) and ≤20% avermectin B_{1b} (5-0-demethyl-25-de(1-methylpropyl)-25-(1-methylethyl) avermectin A_{1a}), is not expected to persist in the environment under the experimental conditions of submitted studies.

EFED is requesting additional information on aerobic soil metabolism, aerobic aquatic metabolism, and terrestrial field dissipation in order to better assess the behavior of abamectin in the environment.

Results of reviewed studies indicate that abamectin should undergo photodegradation rapidly in the top 1-2 cm of the soil surface and in water, with half-lives of less than one day. Abamectin is also biodegraded in soil (90% upper bound confidence limit of the mean half-life = 115 days). Abamectin is stable to hydrolytic degradation. Based on the low reported vapor pressure (1.5 x 10^{-9} Torr), volatilization is not likely to be a significant transport process.

Abamectin is insoluble (7.8 μg/L at pH 9) and mobile (K_{ads} = 9.7 to 160) in the laboratory. Adsorption was correlated with soil organic matter content. However, there are no acceptable field dissipation studies available to determine if the behavior of abamectin in the laboratory is demonstrated in the field.

Based upon the laboratory data, ground water effects are expected to be minimal. Surface water contamination could occur from spray drift or runoff events that occur soon after application.

The data in Tables 1 and 2 were used for input into the PRZM-EXAMS modeling for **Parent Abamectin**. Below is a brief discussion of how the fate information was integrated.

Degradation: For PRZM-EXAMS environmental fate parameters from the submitted studies for abamectin were used as inputs according to approved parameter selection criteria[1]. The 90th percentile upper bound confidence limit of the mean metabolism half-life was found using four values from an acceptable study; this half-life value was then converted to a daily rate constant for PRZM using the formula Ln 2/($T_{1/2}$). Ten times the reported water solubility of 7.8 μg/L was used as an upper bound of solubility.

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[1] Draft Guidance for Chemistry and Management Practice Input Parameters For Use in Modeling the Environmental Fate and Transport of Pesticides. EFED Interim document dated April 6, 2000

Soil-Water Partition Coefficient. Data on soil adsorption and desorption are reported in Table 1. For strawberries, the K_{ads} value was set to 50, which was the average of the values measured for the two finer grained soils tested. This average was used because the organic matter content of the Myakka fine sand used in the model is much higher than the sand on which K_{ads} was measured. In addition, the effect of the black plastic mulch, used on strawberry beds in Florida, is unknown.

Soil and Foliar Volatilization. The soil volatilization routines in PRZM 3.12 were deactivated by setting the relevant parameters (Vapor diffusion rate, Henry's Law Constant and the enthalpy of Vaporization) to zero. The ability to estimate some of the necessary parameters, particularly the enthalpy of vaporization for abamectin, is very poor, and chemical-specific studies are generally not available for determining inputs for pesticide volatilization rate on plant foliage (PLVKRT), pesticide decay rate on plant foliage (PLDKRT), foliar extraction coefficient for pesticide washoff per centimeter of rainfall (FEXTRC), and the plant uptake efficiency factor (UPTKF). Default values selected for standard inputs are conservative.

Table 1. PRZM 3.12 input parameters for Avermectin used on strawberries

Input Parameter	Value	Source	Quality of Data
Foliar Volatilization (PLVKRT)	0 d^{-1}		Poor
Foliar Decay Rate (PLDKRT)	0 d^{-1}		Poor
Foliar Washoff Extraction Coefficient (FEXTRC)	0.5 cm^{-1}		Poor
Plant Uptake Fraction (UPTKF)	0		Poor
Soil-Water Partition Coefficient (KD) for modeled crops	50 L kg^{-1}	MRID 40856301	Poor - Fair
Dissolved Phase Decay Rate: Upper Horizons (DWRATE)	0.006027 d^{-1}	Ku and Jacob, 1983, No MRID available, Review dated 3/28/84.	Fair
Adsorbed Phase Decay Rate: Upper Horizons (DSRATE)	0.006027 d^{-1}	Ku and Jacob, 1983, No MRID available, Review dated 3/28/84.	Fair
Dissolved Phase Decay Rate: Lower Horizons (DWRATE)	no data		
Adsorbed Phase Decay Rate: Lower Horizons (DSRATE)	no data		
Vapor Phase Decay Rate (DGRATE) (all horizons)	0 d^{-1}		Poor

Table 2. EXAMS 2.97.5 Input parameters for Avermectin used on strawberries

Input Parameter	Value	Source	Quality
Aerobic Aqueous Metabolism Constant (KBACW)	0.000126 hr^{-1}	No acceptable guideline data available; used 0.5 x rate of aerobic soil metabolism	
Sediment Metabolism Constant (KBACS)	no data		
Neutral Hydrolysis Rate Constant (KNH)	stable		fair
Partition Coefficient (KPS)	50 mL g^{-1}	MRID 40856301	fair
Photodegradation in Water Rate Constant (KDP)	0.0578 h^{-1}		fair
Molecular Mass (MWT)	873 $g \cdot mol^{-1}$		good
Solubility (SOL)	78 $\mu g\ L^{-1}$	10x reported value	fair
Vapor Pressure (VAPR)	1.5 x 10^{-9} torr		good
Q10 For The water Column (QTBAW)	2		poor
Q10 For Sediment (QTBAS)	2		poor

Models Used

The EECs were calculated using two models: PRZM 3.12 (Carsel, et al., undated; executable dated May 7, 1998), to simulate the transport of the pesticide off the field, and EXAMS 2.97.5, (Burns, L.A., 1997; executable dated June 13, 1997), to simulate the fate of the chemical in the water body. The PRZM version used is an interim release that has been modified to provide improved pesticide extraction into runoff and additional application capacity. All post-processing analyses were handled by the program TABLE20 (executable dated May 27, 1998).

Procedure

PRZM 3.12 simulations were run from January 1 through December 31 for each year of meteorological data available for the Major Land Resource Areas (MLRA). EXAMS was run for all the simulations. The 10 year return EECs (or 10% yearly exceedence EECs) listed in Table 4 were calculated by linear interpolation between the third and fourth largest values using the Table20 program. The upper 90% confidence bound of the overall means were estimated by Table20.

Scenario

The scenario chosen represents the highest exposure site for abamectin. The weather data and agricultural practices are simulated at each site over multiple years (26 for strawberries) so that the probability of an EEC occurring at that site can be estimated. The modeled site consists of a 172.8 hectare field draining into a reservoir (based on the Shipman City Lake in Illinois). The site was selected so as to generate exposures to drinking water greater than for most sites (about 90%) used for growing the modeled crop. Table 4 provides a summary of the scenario. The simulations were made with a maximum application rate of 0.01875 lbs a.i./acre for four applications as a ground spray application. The EECs have been calculated so that in any given year there is a 10% probability the maximum average concentration of that duration in that year will equal or exceed the EEC at the site.

The Myakka fine sand used for strawberries is classified as hydrologic group D (but can be drained to group B) and was used because it is a major soil for strawberry production in Florida. Strawberries in Florida are cultivated on 6 in high beds measuring 2 ft by 4 ft. The beds are covered with a black plastic mulch during strawberry cultivation which covers about 60% of the soil surface. Runoff from fields using black plastic mulch has not been adequately studied and the patchwork of mulched areas is not something the PRZM model was designed for. Therefore we have had to approximate the effects of this mulch by assuming higher values of both curve numbers (CN) and lower Manning's N values than would be appropriate for a field with a bare Myakka soil. These assumptions, however, have had to be applied over the entire surface of the soil because PRZM cannot handle varying soil surface conditions. This is a refinement to our GENEEC modeling because GENEEC cannot handle the plastic mulch at all, but it makes runoff as simulated by the PRZM model higher than that previously simulated by the GENEEC, resulting in higher predicted surface water concentrations.

Table 4. Usage Practices used for modeling Avermectin

Location, (Soil), Hydrologic Group, and (MLRA)	Maximum Labeled Rate (lb ai/A), App. Dates, Pre-Harvest Interval (PHI)
Hillsborough County, FL (Myakka fine sand), Group D, MLRA U-154	0.01875 lb, four applications on 7 Dec, 14 Dec, 4 Jan and 11 Jan, PHI=NA

The PRZM 3.12 scenario parameters are provided in Appendix B. The EXAMS non-chemical specific parameters describing the index reservoir are listed in Appendix C.

PRZM-EXAMS RESULTS

Crop specific consecutive PRZM-EXAM simulations were conducted to evaluate the cumulative probability distribution for peak, 4-day, 21 day, 60 day, and 90 day EECs. The one-in-10 year PRZM-EXAMS Peak EECs for parent abamectin for the scenario modeled were then adjusted by the default Percent Cropped Area factor of 0.87, because at this time no PCA specific for strawberries has been developed. In addition, the overall 26 year mean value, along with the 90% confidence bound for the annual mean, were determined.

Table 4. Tier II upper tenth percentile EECs ($\mu g/L$) for Abamectin use on Strawberries in FL incorporating the Index Reservoir and Percent Croppped Area adjustments **

Peak	4-Day	21-Day	60-day	90-day	Overall 26-year mean	90% CL of mean*
1.47	1.37	1.17	0.86	0.71	0.28	0.30

*Upper 90th percent confidence bound on the overall mean concentration.
**EECs rounded to 2 significant figures.

The model simulations use historical precipitation as an input, and did not take into account irrigation which is often used in dry (e.g., California) regions to supplement rainfall. Modeled pond residues were distributed between the aqueous phase and the benthic phase approximately 1:10 due to the relatively high K_d chosen.

Transport with eroded sediment is the source of avermectin loading to aquatic environments in the modeled scenario. Runoff and spray drift were only small sources of loading for avermectin. Mitigation strategies need to consider the relative risks of ground water versus surface water contamination, and the relative risks of alternative pesticides to aquatic and terrestrial environments, as well as human health.

Limitations and Uncertainties of the Models

It should be remembered in interpreting these results that they represent the upper limit for possible exposure from these use patterns to aquatic environments at a single high exposure site. In actual practice, the true environmental concentrations will probably be less than indicated by this analysis because most sites will produce less loading to aquatic environments than this scenario.

The index reservoir represents potential drinking water exposure from a specific area (Illinois) with specific cropping patterns, weather, soils, and other factors. Use of the index reservoir for areas with different climates, crops, pesticides used, sources of water (e.g. rivers instead of reservoirs, etc), and hydrogeology creates uncertainties. In general, because the index reservoir represents a fairly vulnerable watershed, the exposure estimated with the index reservoir will likely be higher than the actual exposure for most drinking water sources. However, the index reservoir is not a worst case scenario; communities that derive their drinking water from smaller bodies of water with minimal outflow or with more runoff prone soils would likely get higher drinking water exposure than estimated using the index reservoir. Areas with a more humid climate that use a similar reservoir and cropping patterns may also get more pesticides in their drinking water than predicted using this scenario.

A single steady flow has been used to represent the flow through the reservoir. Discharge from the reservoir also removes chemical so this assumption will underestimate removal from the reservoir during wet periods and overestimates removal during dry periods. This assumption can both underestimate or overestimate the concentration in the pond depending upon the annual precipitation pattern at the site.

The index reservoir scenario uses the characteristics of a single soil to represent the soil in the basin. In fact, soils can vary substantially across even small areas, and this variation is not reflected in these simulations.

The index reservoir scenario does not consider tile drainage. Areas that are prone to substantial runoff are often tile drained. Tile drainage contributes additional water and in some cases, additional pesticide loading to the reservoir. This may cause either an increase or decrease in the pesticide concentration in the reservoir. Tile drainage also causes the surface soil to dry out faster. This will reduce runoff of the pesticide into the reservoir. The watershed used as the model for the index reservoir (Shipman City Lake) does not have tile drainage in the cropped areas.

EXAMS is unable to easily model spring and fall turnover. Turnover occurs when the temperature drops in the fall and the thermal stratification of the reservoir is removed. Turnover occurs again in the spring when the reservoir warms up. This results in complete mixing of the chemical through the water column at these times. Because of this inability, the Index Reservoir has been simulated without stratification. There is data to suggest that Shipman City Lake, upon which the Index Reservoir is based, does indeed stratify in the deepest parts of the lake at least in some years. This may result in both over and underestimation of the concentration in drinking water depending upon the time of the year and the depth the drinking water intake is drawing from.

Tier 2 modeling using PRZM and EXAMS is a field-scale simulation which treat watersheds as large fields. They assume that the entire area of the watershed is planted with the crop of interest (i.e., 100% crop coverage). This assumption may not hold for areas larger than a few hectares, such as watersheds containing drinking water reservoirs. Therefore, pesticide concentrations (peak and/or long-term average) were estimated with PRZM and EXAMS (the index reservoir modification changes the surface water body parameters used in EXAMS) and estimated environmental concentrations were adjusted by a factor that represents the maximum percent crop area found for the crop or crops being evaluated.

The PCA is a watershed-based modification. Implicit in its application is the assumption that currently-used field-scale models reflect basin-scale processes consistently for all pesticides and uses. In other words, we assume that the large field simulated by the coupled PRZM and EXAMS models is a reasonable approximation of pesticide fate and transport within a watershed that contains a drinking water reservoir. If the models fail to capture pertinent basin-scale fate and transport processes consistently for all pesticides and all uses, the application of a factor that reduces the estimated concentrations predicted by modeling could, in some instances, result in inadvertently passing a chemical through the screen that may actually pose a risk.

Some preliminary assessments made in the development of the PCA suggest that PRZM/EXAMS may not be realistically capturing basin-scale processes for all pesticides or for all uses. A preliminary survey of water assessments which compared screening model estimates to readily available monitoring data suggest uneven model results. In some instances, the screening model estimates are more than an order of magnitude greater than the highest concentrations reported in available monitoring data; in other instances, the model estimates are less than monitoring concentrations. Because of these concerns, the SAP recommended using the PCA only for "major" crops in the Midwest. For other crops, development of PCA's will depend on the availability of relevant monitoring data that could be used to evaluate the result of the PCA adjustment.

The PCA adjustment is only applicable to pesticides applied to agricultural crops. Contributions to surface waters from non-agricultural uses such as urban environments are not well-modeled. Currently, non-agricultural uses are not included in the screening model assessments for drinking water.

The PCA does not consider percent crop treated because detailed pesticide usage data are extremely limited at this time. Detailed pesticide usage data are currently available for only a few states.

Appendix B
PRZM 3.1 Scenario Parameters

This section provides a brief description of the crop site used to produce the Tier II EECs for avermectin. The soil description is a summary of the Official Soil Series Description provided on-line by Iowa State University[2]. The PRZM 3.1 parameters that describe the sites more fully are provided in Tables B-1 through B-6.

Scenario Site - Strawberries

The field used to grow strawberries is located in Hillsborough county, Florida. The soil is a Myakka fine sand, a sandy siliceous, hyperthermic Aeric Haplaquod, in MLRA U-154. The Myakka fine sand is a deep, poorly drained soil formed on sandy marine sediments. The soil has slopes of less than two percent and a seasonal high water table within ten inches of the soil surface for between one and four months of the year. They are found on flatwoods, high tidal areas, flood plains, depressions, and gently sloping barrier islands. They have rapid permeability in the A horizon, but have slow internal drainage and a high water table. The mean annual temperature is about 70 to 74°F and rainfall averages about 50 to 60 inches per year.

Most areas are used for commercial forest production or rangeland. Areas with adequate water control measures are used to grow citrus, improved pasture, and truck crops. The weather data used was from MLRA 154 between 1948 and 1973.

Table B-1 PRZM 3.12 climate and time parameters for Florida strawberries.

Parameter	Value	Source	Quality
Starting Date*	January 1, 1948		
Ending Date*	December 31, 1973		
Pan Evaporation Factor (PFAC)	0.77	PIC	good
Snowmelt Factor (SFAC)	0.15 cm · K^{-1}	PIC	good
Minimum Depth of Evaporation (ANETD)	25.0 cm	PIC	good
Average Duration of Runoff Hydrograph (TR)	5.8 h	PIC	good

* These values are in the RUN file rather than the INP file.

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[2] Official Soil Series Descriptions, USDA-NRCS Soil Survey Division; Iowa State University; WEB Page: http://www.statlab.iastate.edu/soil/osd. 1998.

Table B-2. PRZM 3.12 model state flags for modeled scenarios.

Parameter	Value
Pan Factor Flag (IPEIND)	0
Foliar Application Model Flag (CAM); foliar application	2
Bulk Density Flag (BDFLAG)	0
Water Content Flag (THFLAG)	0
Kd Flag (KDFLAG)	0
Drainage model flag (HSWZT)	0
Method of characteristics flag (MOC)	0
Irrigation Flag (IRFLAG)	0
Soil Temperature Flag (ITFLAG)	0
Thermal Conductivity Flag (IDFLAG)	0
Biodegradation Flag (BIOFLAG)	0
Erosion Calculation Flag (ERFLAG)	4

Table B-3. Erosion and landscape parameters for strawberries in Florida.

Parameter	Value	Source	Quality
USLE K Factor (USLEK)	0.02 tons EI^{-1*}	PIC	good
USLE LS Factor (USLELS)	1.0	PIC	fair
USLE P Factor (USLEP)	1.0	**	fair
Field Area (AFIELD)	10 ha	standard	
NRCS Hyetograph (IREG)	4		good
Slope (SLP)	2.0%		fair
Hydraulic Length (HL)	345 m		good

* EI = 100 ft-tons * in/ acre*hr

** P Factor represent compromise for 1 year of conventional tillage and two years of no till.

Table B-4. PRZM 3.12 crop parameters for strawberries in Florida.

Parameter	Value	Source	Quality
Initial Crop (INICRP)	1	PIC	good
Initial Surface Condition (ISCOND)	2	PIC	fair
Number of Different Crops (NDC)	1	**	fair - good
Number of Cropping Periods (NCPDS)	26	Standard	
Maximum rainfall interception storage of crop (CINTCP)	0.1	PIC	fair
Maximum Active Root Depth (AMXDR)	8 cm	PIC	fair
Maximum Canopy Coverage (COVMAX)	90%	PIC	fair
Soil Surface Condition After Harvest (ICNAH)	3	PIC	fair
Date of Crop Emergence (EMM/EMD)	9/30	U. FL extension	fair - good
Date of Crop Maturity (MAM/MAD)	10/31	U. FL extension	fair - good
Date of Crop Harvest (HAM/HAD)	4/01	U. FL extension	fair - good
Maximum Dry Weight (WFMAX)	0.0	PIC	fair
SCS Curve Number (CN)	94-97	PIC	poor
Manning's N Value (MNGN)	0.015-0.023	PRZM Manual	poor
USLE C Factor (USLEC)	0.5	PIC	poor

Table B-5. PRZM 3.12 soil parameters for a strawberry field in Florida.

Parameter	Value	Source	Quality
Total Soil Depth (CORED)	150 cm	PIC	good
Number of Horizons (NHORIZ)	3	PIC	good
	First, Second and Third Soil Horizons (HORIZN = 1, 2, 3)		
Horizon Thickness (THKNS)	15 cm (HORIZN = 1) 75 cm (HORIZN = 2) 60 cm (HORIZN = 3)	PIC	good
Bulk Density (BD)	1.25 g $\cdot$cm^{-3} (HORIZN = 1) 1.45 g $\cdot$cm^{-3} (HORIZN = 2) 1.33 g $\cdot$cm^{-3} (HORIZN = 3)	PIC	good
Initial Water Content (THETO)	0.251 cm^3-H_2O $\cdot$cm^3-soil (HORIZN = 1) 0.267 cm^3-H_2O $\cdot$cm^3-soil (HORIZN = 2) 0.133 cm^3-H_2O $\cdot$cm^3-soil (HORIZN = 3)	PIC	good
Compartment Thickness (DPN)	0.1 cm (HORIZN = 1) 1.0 cm (HORIZN = 2) 1.0 cm (HORIZN = 3)	standard	
Field Capacity (THEFC)	0.251 cm^3-H_2O $\cdot$cm^3-soil (HORIZN = 1) 0.267 cm^3-H_2O $\cdot$cm^3-soil (HORIZN = 2) 0.133 cm^3-H_2O $\cdot$cm^3-soil (HORIZN = 3)	PIC	good
Wilting Point (THEWP)	0.101 cm^3-H_2O $\cdot$cm^3-soil (HORIZN = 1) 0.067 cm^3-H_2O $\cdot$cm^3-soil (HORIZN = 2) 0.033 cm^3-H_2O $\cdot$cm^3-soil (HORIZN = 3)	PIC	good
Organic Carbon Content (OC)	1.160% (HORIZN = 1) 0.116% (HORIZN = 2) 0.058% (HORIZN = 3)	PIC	good

Appendix C
EXAMS Input Parameters for the Standard Index Reservoir

The water body used to generate the Tier II EECs for abamectin (the index reservoir) is intended as a drop-in replacement for the standard pond for use in drinking water exposure. It is used in a similar manner to the standard pond except that flow rates have been modified to reflect local weather conditions (the standard pond is static; i.e., no flow). The flow rate parameter is estimated using PRZM and the weather files for the local weather where the scenario is located. The mean runoff from the watershed is then used to estimate the flow through the reservoir. The use of the mean overall discharge is justified on the basis that the variation in daily flows is small relative to the reservoir storage (residence time is long compared with the duration of runoff pulses) and the reservoir volume is constant over the long term. (This ignores volume losses due to silting-in of the reservoir.)

Since EXAMS assumes that the volume of the water body is constant, flow out of the reservoir is equal to the flow into the reservoir and the discharge rate is set by setting the flow rate in. The STFLO (or STream FLows) parameter is used to set the flow into the reservoir from upstream. STFLO can be set into each segment for each month during the year. All the flow is set to enter the water column (segment 1). Currently all monthly flow values are set to the same value. The units on STFLO are $m^3 \bullet hr^{-1}$.

The index reservoir is based on Shipman City Lake in Illinois. Parameters for the Standard Index Reservoir follow.

Table C-1. EXAMS II geometry for Index Reservoir.

	Littoral	Benthic	Source
Area (AREA)	52,609 m^2	52,609 m^2	Jones *et al.*, 1998
Depth (DEPTH)	2.74 m	0.05 m	Jones *et al.*, 1998
Volume (VOL)	144,000 m^3	2630 m^3	Jones *et al.*, 1998
Length (LENG)	640 m	640 m	estimated from map
Width (WIDTH)	82.2 m	82.2 m	estimated from map
Stream Flow (STFLO)	136.2 m^3h^{-1}	0 m^3h^{-1}	estimated from cumulative runoff from FL strawberry scenario in PRZM

Table C-2. EXAMS II dispersive transport parameters between benthic and littoral layers in the Index Reservoir.		
Parameter	Path 1*	Source
Turbulent Cross-section (XSTUR)	52609 m^2	Burns, 1997
Characteristic Length (CHARL)	1.395 m	Burns, 1997
Dispersion Coefficient for Eddy Diffusivity (DSP)**	3.0 x 10^{-5}	standard pond
* JTURB(1) = 1, ITURB(1) = 2; ** each monthly parameter set to this value.		

Table C-3. EXAMS II sediment properties for the Index Reservoir.			
Parameter	Littoral	Benthic	Source
Suspended Sediment (SUSED)	30 mg L^{-1}		standard pond
Bulk Density (BULKD)		1.85 g cm^{-3}	standard pond
Per cent Water in Benthic Sediments (PCTWA)		137%	standard pond
Fraction of Organic Matter (FROC)	0.04	0.04	standard pond

Table C-4. EXAMS II external environmental and location parameters for the Index Reservoir.		
Parameter	Value	Source
Precipitation (RAIN)	0 mm ·$month^{-1}$	
Atmospheric Turbulence (ATURB)	2.00 km	standard pond
Evaporation Rate (EVAP)	0 mm $month^{-1}$	
Wind Speed (WIND)	1 m ·sec^{-1}	standard pond
Air Mass Type (AMASS)	Rural (R)	
Elevation (ELEV)	54.9 m	USGS map
Latitude (LAT)	39.12° N	USGS map
Longitude (LONG)	90.05° W	USGS map

Table C-5. EXAMS II biological characterization parameters for the Index Reservoir.			
Parameter	Limnic	Benthic	Source
Bacterial Plankton Population Density (BACPL)	1 cfu cm^{-3}		see text
Benthic Bacteria Population Density (BNBAC)		37 cfu $(100\ g)^{-1}$	see text
Bacterial Plankton Biomass (PLMAS)	0.40 mg L^{-1}		standard pond
Benthic Bacteria Biomass (BNMAS)		6.0×10^{-3} g m^{-2}	standard pond

Table C-6. EXAMS water quality parameters for the Index Reservoir.

Parameter	Value	Source
Optical path length distribution factor (DFAC)	1.19	Standard pond
Dissolved organic carbon (DOC)	5 mg $\cdot L^{-1}$	standard pond
chlorophylls and pheophytins (CHL)	$5x10^{-3}$ mg L^{-1}	standard pond
pH (PH)	7	standard pond
pOH (POH)	7	standard pond

Table C-7. EXAMS mean monthly water temperatures (TCEL) for the Index Reservoir. (See text for development of values.)

Month	Temperature (Celsius)
January	0
February	1.09
March	6.26
April	13.21
May	18.61
June	23.73
July	26.09
August	25.04
September	20.91
October	14.5
November	7.04
December	0.99

Appendix D
Input File Names

Table D-1. Input files archived for Avermectin Tier 2 EECs.

File Name	Date	Description
MET154.MET	March 22, 1991	MLRA 154 weather data for strawberries in Florida
Input Data File Sets		
IRFLATRW.exv	February 22, 2000	Environment file for strawberries in FL; modified fron Index Reservoir to set STFLO as derived from IRAVSTRW.inp

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