PEER REVIEW OF EPA'S HAZARDOUS WASTE IDENTIFICATION RULE RISK ASSESSMENT MODEL

Farm Food Chain Module: Background and Implementation for the Multimedia, Multipathway and Multiple Receptor Risk Assessment (3MRA) Model for HWIR 99

Prepared for:
Dr. Zubair Saleem
OSW/EMRAD
U.S. Environmental Protection Agency
2800 Crystal Drive
Arlington, VA 22202

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Prepared by:
Eastern Research Group, Inc.
2200 Wilson Boulevard, Suite 400
Arlington, VA 22201-3324

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NOTE

This report was prepared by Eastern Research Group, Inc. (ERG), an EPA contractor, under Contract Number 68-W-99-001. The report presents comments provided by peer reviewers on the *Farm Food Chain Module: Background and Implementation for the Multimedia, Multipathway and Multiple Receptor Risk Assessment (3MRA) Model for HWIR 99* and *Data Collection for the Hazardous Waste Identification Rule: Section 10.0 Farm Food Chain and Terrestrial Foodweb Data* documents that are part of EPA's Hazardous Waste Identification Rule risk assessments.

The comments presented in this report have been compiled by topic and by individual peer reviewer. As EPA requested, this report provides the peer review comments exactly as they were submitted to ERG. Also attached are the original comments submitted by each individual reviewer.

Peer Review Charges for the HWIR Farm Food Chain Module

Background

The multi-media, multi-pathway and multiple receptor risk assessment (3MRA) model was designed to establish safe, constituent-specific exit levels for low risk hazardous wastes under the Hazardous Waste Identification Rule (HWIR). Wastes to be assessed under HWIR are those currently designated as hazardous because they were listed, or had been mixed with, derived from, or contained listed wastes. One of the intended outcomes of HWIR is to reduce possible over-regulation arising from application of the "mixture" and "derived-from" rules that were promulgated as part of the first comprehensive regulatory program for the management of hazardous wastes under RCRA in May of 1980. Both of these rules remain important in reducing risk to human health and the environment associated with the management of hazardous wastes; however, because they apply regardless of the concentration or mobility of hazardous constituents in the wastes, they also open the possibility of over-regulation. Therefore, one of the primary purposes of 3MRA is to provide a tool for identifying possible instances of over-regulation, and to provide an avenue for the safe relief from Subtitle C disposal regulations.

In December of 1995, the Agency proposed a methodology designed to identify the exposure pathway associated with the highest predicted risks to both human and ecological receptors. This methodology constituted the first multi-media risk assessment tool developed to support risk-based exit levels (i.e., acceptable chemical concentrations in wastes), and was referred to as the Multiple Pathway Receptor Analysis (MPRA). It utilized the revised EPACMTP modeling approach for the groundwater pathway analysis, and the indirect exposure methodology for other pathways. The MPRA was designed to simulate each exposure pathway independent of other pathways, and the model was parameterized such that the contaminant fate and transport favored one pathway for each simulation. That is, the parameters to which each pathway was most sensitive were set to high end values, and the model was executed to drive risks to one pathway at a time (i.e., contaminant losses to other environmental media were not tracked). During an extensive series of reviews of the MPRA, the EPA Science Advisory Board (SAB) and others urged the Agency to consider using a simultaneous, mass-constrained analysis that would account for dispersal, transport and transformation of contaminant mass through all media and exposure routes. This was perhaps the most important and strongly expressed element in all of the review comments received.

The goal of the 3MRA is to identify wastes currently listed as hazardous that could be eligible for exemption from hazardous waste management requirements. The 3MRA risk assessment predicts chemical-specific potential risks to human and ecological receptors living within a radius of 2 kilometers of industrial nonhazardous waste sites that could manage HWIR-exempted waste. These risk estimates, along with other information, may be used to identify the chemical-specific concentrations for exempted waste that would be protective of human health and the environment at selected sets of risk protection criteria.

The 3MRA assessment strategy provides a methodology to evaluate multiple exposure pathway risks to human and ecological receptors at a statistically representative sample of waste management units (WMUs) and associated environmental settings to estimate the distribution of risk nationally. It is a forward-calculating approach that begins with selected concentrations of a chemical in waste, and estimates the associated hazards and risks to human and ecological receptors.

The risk assessment is designed to produce chemical-specific distributions of cancer risks or hazards to humans and ecological receptors living in the vicinity of industrial waste sites that could manage HWIR-exempted wastes throughout their operating life. For each site and waste concentration, the model generates risks for each receptor location and then sums the number of receptors that fall within a specified risk range (bin) to get the distribution of risks for the population at each site. We can use the distribution of risks for a setting to determine whether the setting is protective based on the percentage of the population protected, a specified cancer risk or hazard level, and the initial concentration in waste. The model then uses these data to generate a percentile distribution based on the number of settings protected at a specified risk level for each waste concentration to generate the national distribution.

The 3MRA model consists of 17 media-specific pollutant fate, transport, exposure, and risk modules; 6 data processors to manage the information transfer within the system; and 3 databases that contain the data required to estimate risk.

As shown in Figure 1, the 3MRA Model incorporates the following interacting modules:

- Source modules, which estimate the simultaneous chemical mass losses to the different media and maintain chemical mass balance of the releases from the waste management unit into the environment

- Fate/transport modules, which receive calculated releases from waste management units and distribute the mass through each of the media to determine the chemical concentrations in air, groundwater, soil, and surface water across space and time

- Food chain modules, which receive the outputs from the fate and transport modules and estimate the uptake of chemicals in various plants and animals

- Exposure modules, which use the media concentrations from the fate and transport modules to determine exposure to human and ecological receptors from inhalation (for humans only), direct contact (for ecological receptors only), and ingestion (for both receptor types)

- Risk modules, which predict the risk/hazard quotient for each receptor of concern.

Farm Food Chain Module

The Farm Food Chain module (FFC) module calculates the concentration of a chemical in homegrown produce (fruits and vegetables), farm crops for cattle (forage, grain, and silage), beef, and milk. The concentrations in homegrown produce, beef, and milk are inputs to the Human Exposure Module and are used to calculate the applied dose to human receptors who consume

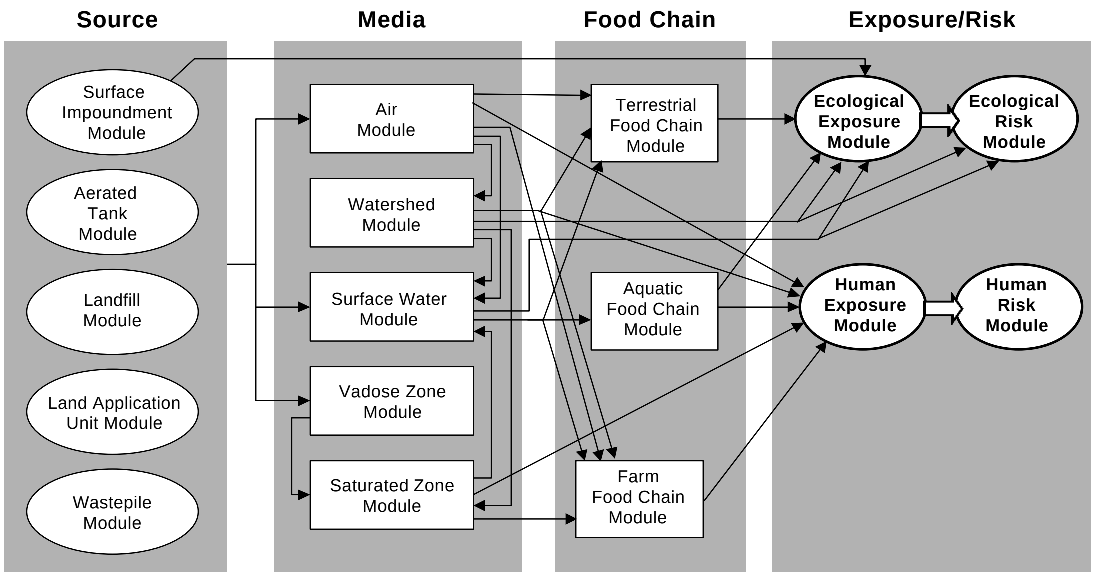

Figure 1. Source, fate, transport, exposure, and risk modules of the 3MRA Model

them. The modeling construct for the FFC module is based on recent and ongoing research conducted by the U.S. Environmental Protection Agency (EPA) Office of Research and Development (ORD).

Farm Food Chain Database

Data were collected to quantify parameters required to develop exposure profiles for human receptors that may occur through the ingestion of beef, dairy, and agricultural foods. These parameters include bioaccumulation factors, partitioning coefficients, and ingestion rates that the module uses to estimate movement of chemicals through the food chain. Two primary databases were constructed to support the module: the chemical-specific database and the exposure-related database. Data sources for databases included EPA documents and primary literature.

Materials to be Reviewed:

US EPA, 1999. Farm Food Chain Module: Background and Implementation for the Multimedia, Multipathway, and Multireceptor Risk Assessment (3MRA) For HWIR99.

U.S. EPA, 1999. Data Collection for the Hazardous Waste Identification Rule, Section 10.0 Farm Food Chain and Terrestrial Foodweb Data

Peer Review Charge

While reviewing the documents, please address the following general issues:

1. Comment on the organization of the review documents. Do the documents present the information in a clear, concise, and easy to follow format? If not, please provide suggestions to improve the presentation.

2. Is there an adequate description of the purpose and context for the Farm Food Chain module and its companion Data report? If not, please explain.

3. As with any risk assessment, there are always additional data and method development efforts that could be undertaken to reduce the level of uncertainty. Are you aware of any major methodological limitations or data gaps in the Farm Food Chain module or supporting database that have not been identified? If so, how could they be addressed in the near-term (for example, less than six months) and the longer-term?

In addition, the following specific issues should be addressed.

4. Several potential exposure pathways are not included in the module (that is, pork, chickens and eggs). There is limited information for ingestion rates of grain, silage, forage, and soil for these animals in addition to limited data on chemical-specific biouptake factors. Given what information is available to estimate exposures through these pathways, would you recommend that these pathways be added to the module or handled in a qualitative manner dealing with the uncertainty of the pathways?

5. A default factor of 1.0 was applied for chemical uptake into beef, dairy, pork, chicken, and eggs when chemical-specific data were not available. Would you recommend a different approach rather than assuming a default value of 1.0 which may likely lead to an over- or under-estimation of uptake into prey species and that

could be developed and implemented within a timeframe of from one to several months?

6. Are there data sources that you are aware of that would provide us additional data related to ingestion rates or biouptake factors that would improve the quality of the existing databases?

7. Currently, cattle exposures are based only on consumption of contaminated feed and water, and do not consider exposures through inhalation or dermal pathways. Would you recommend the inclusion of these pathways for calculating exposures via the beef and dairy pathways? If so, are you aware of any data sources or references to help parameterize these pathways?

8. Different approaches are used to estimate plant and animal biotransfer factors used in various equations depending on whether the chemical is a metal, an organic, a dioxin-like compound, or a special chemical such as polycyclic aromatic hydrocarbons (PAHs). Is this approach acceptable for a national-scale assessment? Would you recommend any other approaches that could be implemented in one to several months?

General Comments

Dr. Mackay: I hope you find these comments useful. Again I reiterate that the reports are done accurately. I could find no obvious mistakes. The presentation could be improved but admittedly this is a difficult subject with many variables and a proliferation of symbols. My major concerns are the biotransfer factor approach which I have discussed at some length and the need to improve the atmosphere - plant transfer equations to include a clear treatment of equilibrium considerations. In neither case is state of the art science exploited. This concerns me deeply and results, I suspect from excessive reliance by EPA on established contractors. The risk is that those parties who for their own reasons wish to discredit the HWIR process will use extreme examples of failure to express processes of air-plant partitioning and uptake by farm animals adequately to accomplish this. The use of poorly defensible "correction factors" should also be avoided. This is a difficult task which the authors have addressed fairly well, but I am convinced that it could be done better and presented better.

Dr. Travis: In general, I found the document to be well written, easy to understand, and to provide a comprehensive assessment of the risks posed to humans by the movement of chemicals through the agricultural food. The models employed to evaluate the uptake of chemicals in food items provide a realistic assessment of the probable concentrations of pollutants in food at points of human exposure. The pathways by which contaminates are assumed to by take up into food and the algorithms used to estimate biotransfer factors are similar to those used in other EPA assessments and, for the most part, are accepted as state-of-the-art by the scientific community. It is my belief that these methodologies provide an adequate basis for a national level assessment of the potential impact from contaminates released from industrial waste sites on nearby farms and home gardens. The exposure pathways selected for analysis represent pathways most likely to result in significant human exposure and thus provide a reasonable worse case analysis. The parameters used in the analysis are appropriate. I thus believe that the current document represents a complete and comprehensive analysis of reasonably anticipated concentrations in food items.

Responses to Specific Charge Questions

1. *Comment on the organization of the review documents. Do the documents present the information in a clear, concise, and easy to follow format? If not, please provide suggestions to improve the presentation.*

Dr. Mackay: Generally the documents are well organized and the reader has a fairly clear picture of the sequence. Section 1.2 "Summary of Functionality" is difficult to understand.

What are "module loops"?

The "overall duration" is not defined. The module seems to calculate a single concentration at a single point in time, so the purpose of this section is not clear.

The variable names are at times quite awkward. See equation 3-1 in where there seems to be sub, sub, subscripts. On p3-14 there is a variable called WBNRchConcWaterDiss. Surely this can be abbreviated. The use of a first symbol C for concentration would help. Concentrations are P... or PD... or PV... In 3-20 it is A.

The units vary a great deal and this makes it difficult to follow the logic and test the equations. For example after equation 3-7 concentrations of mg/kg and µg/g are used, then after 3-11 there is µg/mL. In 3-18 the RCF has µg/mL and µg/g. There's µg/L after 3-6. Times are variously days, years and in some cases seconds. I did not detect errors but there is potential for error when a diversity of units is used.

In some cases the symbol changes, e.g. in 3-20 there is CTss, but later it is Ctss.

There is no need to state that x is antilog [log x] as is done after 3-5 and elsewhere (e.g. 3-18).

The gas constant is now 8.314 Pa.m^3/mol K. The 82 atm m^3/mol K is obsolete.

(Eq 3-5). There seems to be a desire to calculate dry weight concentrations (e.g. 3-16) only later to convert them back to wet weight (3-17).

DW is subscripted, but WW is not (see after 3-17).

These problems are, in part, forced on the authors but they could do a better job of presenting the symbols and equations in easily interpreted quantities. The important aspect is to write <u>correct</u> equations and that seems to have been done.

Dr. Shull: *Farm Food Chain Module*
The structure of the general document outline is adequate and acceptable, and the basic information regarding the equations (structure, units) is adequately conveyed. However, in many parts of the document, description of the theory, purpose, background and backup for much of the technical information and the equations used in the module is confusing, lacks sufficient detail and is in many cases poorly written.

Section 1.1. What is meant by 'dual logic'?

Where code is presented in the text (e.g., Section 3.3), no explanation or walk-through of the code is presented. The code as presented is meaningless to any reviewer who is not versed in the code language. There are a number of parameters that are not clearly defined before they are used in the text (e.g., equation 3-2, " mg/kg DW").

There are statements in the documentation citing "evidence" for certain model approaches and assumptions (e.g., last sentence of first paragraph under Section 3.1.2), but no references are provided for these statements, making them impossible to review.

Equations are presented for "special chemicals", but there is no description in the text for what qualifies as a "special chemical."

Specifics as to how "empirical correction factors" are derived, used and applied should be added to the text, or the reader should be referred to where this discussion can be found. Information as to what these factors are specifically designed to account for in each equation should be added. It does not appear that empirical correction factors are used in any of the equations for inorganics, but peeling, cleaning, and volumetric differences in types of plants would seemingly apply. With the information presented in the review materials, the reviewer cannot determine what specific phenomena are being modeled/accounted for, how, and why, and the reviewer could not reproduce the values if they were presented.

Statements are made in text that indicate changes in methods under specific conditions, but the criteria that would generate a deviation from the initial method are not given. For example, on Page 3-10, first paragraph under equation 3-12, the text reads "If neither Equation 3-11 or 3-12 is appropriate calculates as shown in Equation 3-13" but the text does not define the criteria the model or the modeler would use to determine appropriateness of either equation. Similarly, Equations 3-11 and 3-13 are the same. Is presentation of the equation a second time necessary? This implies some structural difference in the equation, but there appears to be no difference whatsoever. Referring the reader back to equation 3-11 with mention of appropriate changes in input variables, where applicable, would suffice.

The approach to headings in inconsistent. Suggest more explicit headings for the initial equations (up through equation 3-19). For example, the identical heading is used to describe the derivation of "Concentrations in Root Vegetables-Metals" for both garden and farm analyses. Suggest using a format similar to that used for beef concentrations, "Beef Concentration-Regional Watershed" and "Beef Concentration-Local Watershed" for plant-related variables. For example: "Concentrations in Root Vegetables-Metals-Regional Watershed", "Concentrations in Root Vegetables-Metals-Local Watershed," etc.

In several of the equations, there are implicit unit conversions. While most risk assessors/scientists likely can follow the implicit conversion, depending on the intended audience, it may be necessary to discuss or identify these unit conversions.

Mercury is identified as a separate chemical class, but there is no discussion as to how this chemical will be treated differently than any other metal or metalloid.

Justification for the initial exclusion of translocation of substances through livestock exposed via dermal and inhalation routes should be provided.

Grain is mentioned explicitly in reference to food sources for livestock. It is not clear whether grains are included as a agricultural item for human consumption in the model. In this reviewer's experience, uptake of metals and metalloids into grain and subsequent human ingestion is an important pathway. Some explicit discussion as to the crop types included (or a reference to a citation that defines each of the crop types modeled) should be provided.

No discussion is presented regarding if or how naturally occurring background concentrations of inorganics or anthropogenic background concentrations of organics are dealt with or accounted for in the model or model results.

It is not clear whether direct vapor phase partitioning of volatile and semivolatile organics into plant lipid tissues is modeled. If this mechanism is not specifically addressed, some discussion as to why the pathway is not included should be presented. If the mechanism is not presented because data are lacking for most compounds and are only available for some, a methodology could be used wherein only those chemicals with such data are assessed via this plant uptake mechanism. If the mechanism is modeled, additional text should be included to make the mechanism-related equations easy to find and understand.

When equations are listed and discussed, the equation should be listed first, with the supporting text for the equation following directly after.

In Section 3.1.1, what are the determinants of the length of exposure? It is not clear why the amount of biomass is ‘the amount of standing crop' and not the ‘the amount of harvested crop'? Seems the latter would be more appropriate for risk assessment purposes.

Section 3.1 "bioaccumulate" (line 4) and "accumulation" are potentially inappropriate terms 'translocate' or ‘partition' would be better. Just because a pollutant is translocated from the environment into plants or food animals doesn't necessarily mean they ‘bioaccumulate' or ‘accumulate' in all cases. These terms imply the concentrations in plants and/or animals are greater than in environmental media (soil, water, air) in all cases, when they in fact may not.

In Section 3.1.2, additional discussion of the use of volume based versus mass-transfer based partitioning coefficients should be included. Second paragraph, last sentence. What proportion of the vegetation is ‘not contaminated due to vapor deposition onto plant surfaces', and how is that accounted for in the correction factor? Explain.

What types of soil/air/groundwater concentration data will be applied in the model? Will average concentrations be used, statistical estimates of the average (e.g., the 95% UCL concentration), or some percentile value? Could a probabilistic approach be employed to generate a distribution of soil input concentrations? According to USEPA guidance, the residential receptor exposure point concentration can be something other than a ‘point estimate.'

Equation 3-2: PDxxx-xxx-DW is the concentration ‘on' not ‘in' the plant, KpParxxx is defined here differently than in the second para of page 3-2.

In Equation 3-5, some explanation of the biotransfer factor is needed. Is the 'transfer' a transfer of VOC 'in air' to 'in plant', or to 'on to' the plant surface, or into plant.

In Section 3.3, how is surface soil defined?

In Section 3.3.1, the stated definition of 'soil bioavailability' is inconsistent with other definitions. The 'bioavailability' of a substance in soil is generally defined as 'the fraction of a dose available for absorption.' This generally accepted definition doesn't relate to the ratio between biotransfer factors for soil and vegetation. Suggest a different term be used to describe the process in this section.

Data Collection: Section 10.0 Farm Food Chain and Terrestrial Foodweb Data
The document's organization goes back and forth between two food webs and two database types. This is confusing because the food webs, and hence their associated data, have much in common. Suggest organizing the presentation into three categories: (1) data common to both food webs; (2) data exclusive to the farm food chain; and (3) data exclusive to the terrestrial food web. Also suggest minimizing the sub-headings. A suggested table of contents is attached.

The Introduction could be simplified. Suggest replacing both paragraphs with:

> "In this section, the parameters necessary to model chemical exposure though the Farm Food Chain (FFC) and the Terrestrial Food Web (TFW) are identified, followed by selection of a recommended default value for each parameter. Because the behavior of chemicals in each of these systems is so similar, it was not necessary to create different databases for each food chain. However, two databases were created. In he first database, chemical-specific factors that affect chemical mobility through the food-chain were compiled. While in the second database, receptor exposure specific factors that affect chemical mobility through the food chain, were compiled. Data from both of the databases are required to estimate chemical exposure doses to human or ecological receptors through the FFC or TFW."

Page 10-10, last paragraph of Section 10.3.1.1.1, last sentence. It is difficult to understand how a default value of 2E-05 d/g for metals was derived with insufficient data.

Throughout the document, sometimes the median of the data is used and sometimes the geometric mean of the data is used as the default value. Does this reflect the literature compendium reviewed or is there another reason for this inconsistency? And, why are means used versus the use of some other statistical measure? Justification for each of the default values selected should be provided.

Suggest providing all data points considered valid for each parameter for inclusion in probabilistic risk assessments.

Page 10-10, Section 10.3.1.1.1, Biotransfer Factors. Several statements and assumptions regarding dioxins biotransfer (""bioaccumulate") are made with no supporting references. Specific references or supportive information for all assumptions and conclusive statements should be included, professional judgment fully documented and described where applicable.

Page 10-16, Section 10.3.1.2.1 Bioaccumulation Factors, guideline #2. Throughout the document, calculation of biotransfer factors includes tissue concentrations in wet-weight and the soil concentrations in dry weight. The document is very consistent on this issue. Even when earthworm data are provided in dry-weight, the data are converted into wet-weight before calculating the transfer factor. It is the reviewer's opinion that transfer factors should be in wet-weight tissue/wet-weight soil. At a minimum, this approach adds more site specificity to the exposure assessment and also demonstrates awareness that the traditional units for transfer factors are in fact "unitless" values. It has been the reviewer's experience that in the literature most transfer factors are calculated wet-weight tissue/wet-weight soil, even if the risk assessment used dry-weight soil for the soil exposure point concentration. Thus, I suggest that the biotransfer factor equations include % moisture in the site soil. Since Section 10 only discusses the database, it is unclear whether the % moisture calculation is included in the modeling.

Dr. Travis: The document is clear and well organized. It is easy to follow the format. I have no suggestions for improvement other than the specific comments that follow.

2. *Is there an adequate description of the purpose and context for the Farm Food Chain module and its companion Data report? If not, please explain.*

Dr. Mackay: These are adequately described. I was confused for a while because the Data Collection document includes the terrestrial food web as well. Perhaps each module should have its own data report. A figure or picture displaying the various pathways would be useful to convey what is and is not included. Many references are EPA (in press) which is not very illuminating. It is not clearly stated why “organics” (O) are separated from “dioxin-like” (D) or “special” (S). What is “special”? A specimen calculation would be a big help.

Dr. Shull: No. The document presented provides only very broad, nebulous and somewhat generic discussion of the intent of the model to prevent over-regulation of certain classes of waste. It is unclear as to the exact use of the model, by whom, and for what specific purposes and under what specific circumstances. Significant additional discussion as to the planned use of the model, the specific audience for whom the model documentation, and code, is intended, and the specific intended users/audience of the results of the model is warranted.

Dr. Travis: The module overview of the Farm Food Chain module could be improved by providing a few words of context regarding HWIR. You might consider adding the following introductory paragraph:

"The multi-media, multi-pathway and multiple receptor risk assessment (3MRA) model was developed to establish chemical-specific exit levels for low risk hazardous wastes under the Hazardous Waste Identification Rule (HWIR). The goal of the 3MRA is to identify wastes currently listed as hazardous that could be eligible for exemption from hazardous waste management requirements. The 3MRA model contains source modules, fate/transport modules, food chain modules, exposure modules, and risk modules. The purpose of the current section is to describe the Farm Food Chain module."

I found the description of the Farm Food Chain module to be well written and easy to understand. The one place that I wondered about was section 3.1.2 and the necessity of introducing both the volume-based equation (3-5) and mass-based equation (3-6) for the air-to-plant biotransfer factor. The document might explain that it is necessary to have two formulas because different moisture contents are assumed for different categories of food items.

3. *As with any risk assessment, there are always additional data and method development efforts that could be undertaken to reduce the level of uncertainty. Are you aware of any major methodological limitations or data gaps in the Farm Food Chain module or supporting database that have not been identified? If so, how could they be addressed in the near-term (for example, less than six months) and the longer-term?*

Dr. Mackay: The document treats particle-bound and vapor phase contaminant as if they are two separate species. In reality there may be exchange between them.

The calculations use deposition rates from the atmosphere as input. In reality the foliage may approach an equilibrium or steady-state with the atmosphere at which deposition and loss rates are equal. For example Hiatt of EPA Las Vegas has shown that foliage comes to equilibrium with many vapor phase organics thus the rates of deposition and loss are not important (ES&T, 1999, 33, 4126). The extensive work by McLachlan (ES&T 1999, 33, 1799) and others such as Jones are totally ignored. As a result the calculations are not up to date and in some cases they are needlessly complex. There is also recent work by Chiou (USGS.Denver) on uptake from roots (ES&T 2001, 35, 1437) which makes reference to other models of root uptake. A related model is that of Hung (Chemosphere 1997, 35, 959).

The term “wet deposition” is not defined.

Why are “dissolved” water concentrations used? Cows consume dissolved and particle-bound contaminant.

On p2-1 it says “resuspension and redeposition” are not considered. On 3-6 it asserts that “Bv is assumed to account for possible resuspension and redeposition”. In reality many leafy vegetables receive a lot of contaminant by rain splash and soil dust adhesion.

For substances such as vinyl chloride and even benzene, inhalation is likely to be a major pathway for farm animals. It could be included with minimal difficulty. [p2-1]

p3-2 is “weathering” evaporation or chemical degradation or both?

The loss rate constant k_p is a critical quantity and it must vary greatly from chemical to chemical. From p10-39 it seems to be almost universally 18.07 $year^{-1}$. The implication is that the half-life for loss of benzene, benzo(a)pyrene and zinc are all 14 days. The time of exposure seems to be 0.164 year (60 days) and thus 4.3 half-lives. The net result is that the concentration in plants is calculated essentially as a ratio of an uptake rate (to which great effort is devoted) and a loss rate (which is arbitrarily set at a 2 week half-life). This is an unfortunate imbalance in effort.

In equation 3-2 the term ($1-exp^{kt}$) which is an “approach to equilibrium term” is applied to wet particles, but not dry particles. Why? Since kt is 2.97 this term is always 0.95. Note that the k term must apply to both wet and dry deposition because it is in the denominator of equation 3-3. This is mathematically wrong.

I see no justification for treating chemicals with log K_{OW} greater than or less than 5 differently when applying 3-3 and 3-4. Eq 3-4 is essentially an equilibrium calculation since Bvol is a partition coefficient calculated from the octanol-air partition coefficient.

After 3-6 it should be FW not F_W.

P3-6 line 1 constituents, not constitutes.

Bv is not a biotransfer factor which usually has units such as d/g. It is a partition coefficient.

Equation 3-8 is derived from the Travis & Arms paper which has been discredited. Best to ignore it. The source of this equation is not well documented and I am sceptical of it. Better to ask Hiatt (see earlier).

I am concerned about the frequent use of “correction factors”. For example VG_{bg} appears in 3-11 but is not explained quantitatively. After much searching I find that it is assigned a value of 0.01 (p10-41). The result is that the concentration in root vegetables is arbitrarily reduced by a factor of 100! This brings into question the need for accurate calibration of quantities such as RCF. This correction factor apparently “adjusts for peeling, cooking or cleaning”. No justification is presented for the selection of a factor of 0.01. Unfortunately the arbitrary inclusion of such correction factors reduces the credibility of the entire set of calculations.

I am confused about the sources of K_{OW}, K_{OC} and K_D. They are related. Why is K_D obtained from CPP after 3-12 but calculated from K_{OC} after 3-11. Is K_{DS} different from K_D?

I believe 3-18 and 3-19 are the Briggs correlations. They should be acknowledged as such.

P3-14 line 2 contaminant not contaminate.

Later (mid page) Eq 3-2 does not define the various P terms, as is stated.

Equation 3-20 uses biotransfer factors. B. The equation basically says

$$C_{BEEF} = C_{FOOD} \times Q_{FOOD} \times B$$

where C_{BEEF} is concentration in beef, C_{FOOD} is concentration in food (DW), Q_{FOOD} is mass of food (DW) consumed per day and B is the biotransfer factor (day/gram). $C_F Q_{FOOD}$ is the contaminant intake I (mg/day). If the residence time of the chemical in the animal is T days then the body burden will be ITmg. If the animal mass is Mg then the whole body concentration will be IT/M mg/g or 1000 IT/M µg/g. It follows that B is T/M. Since M is about 10^6g and T may be 10 days B is about 10^{-5} which is consistent with data on p10-36. Zinc has a very large B which implies a long T. The Hg species data are all the same which must be wrong since methyl mercury is longer retained because of its strong binding to sulfur groups. Lead has a remarkably small B suggesting that it is not retained. Is this true?

The uptake from soil is treated similarly except a "bioavailability factor" Bs is included which appears to be 1 for all substances except TCDD. (P10-37). After defining Ba for water separately it seems to be set equal to Ba for beef. Why not just include it as such in the equation 3-20?
I think there are extra unnecessary sets of square brackets in equation 3-20.

Section 3.3.1.
I find this confusing. Ba_{BEEF} for TCDD is about 5 x 10^{-5} from p10-36. This is inconsistent with equation 3-24, which for a substance of log K_{OW} 6.6 gives Ba of 10^{-1}. I am deeply sceptical about Eq 3-24. It does not take into account metabolism of the chemical. The situation is particularly bad when log K_{OW} is about 6.9. If log K_{OW} is 6.9 then logB is -0.7. If it is 7.0 B is set to zero, i.e. there is a step change at 6.9.

Again I note that only dissolved chemical in water is considered. I suspect that cows drink muddy water containing a lot of solids and their associated contaminant.

In my view biotransfer factors are a very crude way of estimating uptake. There has been a lot of work done on uptake of chemicals by farm animals and models have been developed by workers such as McLachlan, Sweetman and others, mostly in Europe. This work has been totally ignored in favor of flawed correlations. Serious consideration should be given to scrapping the entire biotransfer factor approach. A more honest approach for this program would be to state that given the present state of the art, these general calculations can not be done with sufficient accuracy to justify their present inclusion. This should not be interpreted as a criticism of the authors, who have done a valiant job. Clearly some of the current thinking on uptake by farm animals has not yet penetrated EPA. Better to admit inability to calculate biotransfer than do a bad job and generate results which are excessively conservative or otherwise.

Section 4.0

All I can glean from Fig. 4-1 is that the calculation is done repeatedly.

Appendix A is well done, but I am confused if a variable is called Chem Bs or just Bs.

The justification of biotransfer for factors in the data report p10-9 to 10-29 concerns me because it is quite dated and heavily dependent on internal EPA and ORNL documents. The metal work relies on a 1984 report. There is no mention of work such as that of McLachlan (ES&T 1996, 30, 252 or Douben (Environ. Poll. 95, 1997, p333.

This is a list of only a few papers on biotransfer published mostly in the last 10 years.

Furst, 1993 Chemosphere 27, 1349.
McLachlan, 1994 ES&T 28, 2407
McLachlan, 1993 J. Arg. Food Chem. 41, 474
Jensen, 1990 Chemosphere 20, 1013
Stevens, 1988 Risk Analysis 8, 329
Thomas, 1998 ES&T 32, 3522
Thomas 1999, ES&T 33, 104
Sweetman, 1999 Environ. Poll. 104, 261.
Thomas, 1999 Chemosphere 39, 1533,

Dr. Shull: Recommend where possible a discussion of the use of probabilistic methods to assess uncertainty in food chain modeling and exposure analysis. Also recommend use of any available field study information to validate equations that calculate biotransfer factors, or at least to provide some discussion of certainty/uncertainty in the calculated values.

Also, as stated under #1 above, there are some exposure pathways that have not been addressed and should be. For example, the direct vapor phase partitioning of volatile and possibly semivolatile organics into plant lipid tissues apparently is not included in the module. Similarly, the inhalation and dermal pathways associated with translocation of substances through livestock should be included.

Data do exist to evaluate exposure to birds.

Dr. Travis: The Farm Food Chain (FFC) module is designed to predict the accumulation of contaminants in the edible parts of plants and beef and milk. These are used to predict possible human exposure through the food chain resulting from contaminated crops. I found the methodology to be state-of-the-art and using the best theoretical approaches currently available. I believe that the methodology provides an adequate and scientifically defensible basis for performing national level assessments. I am not aware of additional existing data or methods development that would improve that current approach. For course, additional new data characterizing biotransfer factors for a broad range of chemicals would be useful in bounding and reducing uncertainties. However, it is unlikely that such data will be obtained, even in the next 10 years. Nevertheless, even without additional data, the current methodology is capable of making reasonably accurate predictions of the transfer of contamination through the food chain to man

4. *Several potential exposure pathways are not included in the module (that is, pork, chickens and eggs). There is limited information for ingestion rates of grain, silage, forage, and soil for these animals in addition to limited data on chemical-specific biouptake factors. Given what information is available to estimate exposures through these pathways, would you recommend that these pathways be added to the module or handled in a qualitative manner dealing with the uncertainty of the pathways?*

Dr. Mackay: I would not recommend adding animals such as pigs, chickens or calculating concentrations in eggs until such time as the calculations can be done more accurately. If the beef route proves to be important these routes will also be important. Beef can thus serve as a "test case."

Dr. Shull: Yes, I recommend they be added to the module. Clearly, some amount of uncertainty will remain, which is unavoidable.

It is not clear whether question #4 is related to information gaps associated with human consumption of these products (e.g., pork, eggs) or feed consumption rates of the animals (e.g., swine, poultry); I address both.

If the former, the consumption rate for poultry across the U.S. is comparable to the beef consumption rate; the mean consumption rate for poultry is approximately 73% of the beef consumption rate (Exposure Factors Handbook, 1997). Therefore, poultry consumption potentially represents an important contributor to overall meat consumption. Where feasible, the exposures to poultry should be estimated unless information can be presented to demonstrate that this pathway does not contribute significantly to overall exposure. The shortcomings in the pathway analysis, if assessed, can be described in an uncertainty analysis. The ingestion rates of pork and eggs appear to be small enough to indicate that they are not likely to be significant contributors to total meat and egg ingestion (less than 25% of beef ingestion rates; EFH, 1997) and probably need not be assessed, depending on the magnitude of the available biouptake factors. However, documentation for including or eliminating ANY pathway from the risk assessment should be adequately documented.

Regarding feed intake rates in farm animals, I do not agree that there is a shortage (or absence) of such information. Actually, there is a plethora of feed intake information generated by animal scientists for various food animals (e.g., swine, poultry, etc.) on virtually every form and type of feedstuff available in agriculture. USDA and other government organizations (e.g., NRC), as well as private organizations (e.g., American Society of Animal Scientists), as well as the scientific literature is a source of a wide range of manuals and handbooks documenting feed and water intake rates in farm animals. Moreover, these information sources are constantly updated because of the fact that commercial farm operators and their consultants (nutritionists) rely heavily on them for optimizing production of farm animals.

Dr. Travis: In recent years chicken consumption in the United States has increased relative to beef. In 1998, per capita consumption of beef was 63 pounds, while per capita consumption of chicken was 52 pounds (USDA, 2000). Thus chicken represents an important component of the American diet. On the other hand, the fat content of chicken is lower than beef, and thus, represents a smaller potential pathway of dietary exposure. Data on chemical-specific biotransfer factors for chicken and eggs are limited, making prediction of the concentration of contaminates in chicken and eggs highly uncertain. Since on a national level, chicken production is highly centralized and mechanized, it should be possible to find out the components of the diet of centrally produced chicken. At the home garden level, this would be difficult. An approach to estimating the biotransfer factors is to assume the same biotransfer as in beef, adjusted for the relative fat content of chicken. However, given the overall uncertainty in the entire process, it would probably be better to better just to include chicken and eggs in the uncertainty analysis. One could take the total estimated dose via beef consumption for a specific compound and adjust it for (1) the relative consumption of chicken to beef, (2) the relative fat content of chicken to beef, and (3) the relative concentration of the contaminate in the typical diet of chicken and beef. This would provide an approximation of the dose received from chicken and eggs.

5. *A default factor of 1.0 was applied for chemical uptake into beef, dairy, pork, chicken, and eggs when chemical-specific data were not available. Would you recommend a different approach rather than assuming a default value of 1.0 which may likely lead to an over- or under-estimation of uptake into prey species and that could be developed and implemented within a timeframe of from one to several months?*

Dr. Mackay: The use of the default factor of 1 is suspect, but I see no easy alternative. A program of research into uptake by farm animals is needed which can generate either chemical specific factors or empirical correlations. Ultimately a PBPK type of model is needed.

Dr. Shull: This is a confusing question. The material included in the review package does not contain equations, material or documentation of any kind that shows the pathways associated with transfer into pork, chicken, and eggs. Additionally, text in reviewer question #4 above states that these exposure pathways were intentionally omitted because of limited information, and that modeling for these pathways was not conducted or attempted. Did/does the module intend to model these pathways? However, if it is the intent to include these pathways, broad application of a default biotransfer factor of 1.0 seems appropriate for screening risk assessment only. The default factor of 1.0 for chemical uptake into the food chain seems especially conservative when chemicals with empirical data have a maximum factor of 0.6 and the most bioaccumulative chemicals have been identified and studied.

Dr. Travis: This question is unclear. The methodology currently states that pork, chicken and eggs will not be considered. Also the question mentions prey species. Beef, pork, and chicken are not prey items. I assume the question is in two parts. The first part is about using 1.0 as a default for uptake into beef, pork, chicken and the second part is about using 1.0 as a default for uptake into prey items in the ecological terrestrial food chain. The document specifies an equation to be used for beef for log Kow within the range 1.3 to 6.9. Outside of this range, the biotransfer factor is set to 1.0. I believe that this procedure is adequate given that data on beef biotransfer do not exist for Log Kow above 6.9 and the fact the majority of compounds that will be evaluated will have a log Kow less than 6.9.

The procedure of using a default biotransfer factor of 1.0 for prey items is more problematic. First, very few biotransfer factors for prey items are available. Thus, the default value of 1.0 will be used in almost all cases. Second, the limited data that do exist show that biotransfer factors for prey items can sometimes exceed 1.0. A better approach would be to bypass estimating uptake into prey items all together and use information on background soil concentrations and background concentrations in small mammals and birds to develop algorithms based on log Kow to predict concentrations in mammals and birds based on soil concentrations. This is an activity EPA should undertake. However, developing such a procedure would take longer than several months. In the mean time, it seems acceptable to use 1.0 as a default value.

6. *Are there data sources that you are aware of that would provide us additional data related to ingestion rates or biouptake factors that would improve the quality of the existing databases?*

Dr. Mackay: I have listed other data sources on biotransfer [in my response to question 3 above].

Dr. Shull: As related to quantitative information used directly in the various equations presented in the FFC module, this reviewer is not aware of any additional specific data that would assist in improving the scientific quality of the equations other than that discussed under question 4;the reviewer disagrees that there is insufficient information on livestock feed ingestion and inhalation rates.

Suggest consulting with staff at the USDA's Agriculture Research Service (ARS) for ingestion rate data on various types of food animals. I am unsure whether such data are organized into an available database, but would be somewhat surprised if not.

Dr. Travis: No. I am not aware of additional data related to ingestion rates or biouptake factors that could be used to improve the existing databases.

7. *Currently, cattle exposures are based only on consumption of contaminated feed and water, and do not consider exposures through inhalation or dermal pathways. Would you recommend the inclusion of these pathways for calculating exposures via the beef*

and dairy pathways? If so, are you aware of any data sources or references to help parameterize these pathways?

Dr. Mackay: I do believe that it would be useful to include inhalation uptake for cattle. It is easily done since it just adds another intake term. Respiration rates are well known.

Dr. Shull: There is no justification for the initial exclusion of these pathways in the original document, though it is understood based upon the content of the review question that it is believed there is insufficient data to conduct these analyses.

Like any properly conducted and documented risk assessment, rationale for including or excluding a potential pathway should be described in a clear, concise manner that makes the rationale and process behind the decision completely transparent.

The reviewer is not aware of any data sources other than outlined above in question 4 and 6 to assist in the parameterization of these pathways.

Dr. Travis: I do not recommend inclusion of the inhalation and dermal pathways in estimating uptake into beef and milk. I believe that these are very minor pathways for exposure for beef and milk, and that addition of these pathways would complicate the methodology without adding more than 1 to 2 percent to overall predicted concentrations in beef and milk. Existing uncertainties in biotransfer from consumption for animal feed into beef and milk already outweigh these possible contributions.

8. *Different approaches are used to estimate plant and animal biotransfer factors used in various equations depending on whether the chemical is a metal, an organic, a dioxin-like compound, or a special chemical such as polycyclic aromatic hydrocarbons (PAHs). Is this approach acceptable for a national-scale assessment? Would you recommend any other approaches that could be implemented in one to several months?*

Dr. Mackay: The issue of using different approaches for different chemicals concerns me. Metals do deserve custom treatment as do organo-metals and metalloids like arsenic. Speciating organics such as PCP also require special treatment since their behavior is pH dependent. But all other organics such as dioxins, PAHs, alkanes and aromatics should be treatable by a common approach.

Dr. Shull: The equations presented for the derivation of biotransfer factors seem sufficient. The reviewer would suggest, where relevant data are available, the use of stochastic methods to complete any calculations that involve a range of potential values.

Dr. Travis: The use of different procedures for estimating biotransfer factors depending on whether the chemical is a metal, an organic, a dioxin-like compound, or a special compound is totally acceptable. One would not expect the algorithms to be the same for organic compounds and metals. Thus, these two cases require different approaches. For dioxin-like compounds and special chemicals the document recommends the use of actual measured values. Obviously, measured values, when available, should always have precedent over values predicted from mathematical algorithms. I find the approaches taken in the document to be totally acceptable and capable of making reasonable estimates of concentrations in food itmes.

Specific Comments

Dr. Mackay: [see comments to question 3 above.]

Dr. Shull: [see comments to question 1 above.]

Dr. Travis: Page 1-1, paragraph 1, line 2. The document says "contaminants in the edible parts plants". It should say "contaminants in the edible parts of plants".

Page 1-1, paragraph 1, line 3. The document says "direct deposition contaminants and particle-bound contaminants". It should say "direct deposition of contaminants and particle-bound contaminants".

Page 1-2, paragraph 1, line 2. The document would be clearer if it said "the FFC module uses equations to calculate chemical-specific values for the biotransfer factors used in estimating contaminant transfer…"

Page 1-2, paragraph 2. It is not clear what the source module represents. On page 2-1, the report says the report is considering "contaminants that have been emitted from the waste management unit (WMU)" However, the Source Modules description at the bottom of page 1-2 specifies "surficial soil and depth-averaged soil concentrations for each local watershed" What is the connection? Why is local watershed mentioned?

Page 2-1. I will comment on the assumptions in Section 2.0.
Study area is bounded by 2 km. The assumption of bounding the study area at 2 km from the source seems reasonable. The concentrations will drop off exponentially from the source and thus will be highest within the first 2 km. However, I will have to see later how the model handles mass balance and transport across the boundary at 2 km.

Homogeneous concentrations. This is a standard assumption and introduces no significant error. Since literature values for the biotransfer factors are estimated using this same assumption, there really is no other way to proceed. Moreover, since the methodology is primarily interested in chronic exposures, it is sufficient to compute exposures averaged over an exposure unit, for example, fruits and vegetables.

Resuspension and redeposition on plants. It is not clear how much of an under estimate of plant concentrations this assumption represents.

Inhalation and dermal exposure in cattle. I agree that this is a reasonable assumption. These two pathways do not represent significant pathways of exposure for cattle.

Page 3-1, paragraph 1. The document states "concentrations used for garden home produce are based on a single point estimate". It is not clear how this estimate is obtained. How is the location of gardens established and what soil concentration is used as representative of soils in the garden?

Page 3-1, paragraph 2. The separation of plant vegetation into three main categories (exposed, protected, and root) is standard and leads to reasonable estimates of concentrations in plants consumed by humans.

Page 3-1, paragraph 3. The document states that there are the three mechanisms by which contaminants can bioaccumulate in vegetation: direct deposition from the atmosphere of particle-bound containments onto plants surfaces, vapor-phase contaminant uptake from the atmosphere by exposed plant parts, and uptake of contaminates in the soil through the plant's roots. For root vegetables, there is also adsorption onto the outer parts of the root vegetable. These are the standard pathways generally considered in food chain models and are appropriate for use in the present model.

Page 3-2, equation 3-1. The equation is correct.

Page 3-3, equation 3-2. This equation is written incorrectly. The sum ParDDepAve + (Fwxx ParWDepAve) should be enclosed in a bracket. Other than this typographical error, the equation is correct and contains the standard terms for estimating plant concentration due to direct deposition.

Page 3-4, equation 3-3. It appears that this equation has the same typographical error as equation 3-2. the sum VapDDepAve + (FWxx VapWDepAve 365) should be inclosed in a bracket.

Page 3-4, line 13. The definition of VapDDepAve should be "average dry vapor phase- deposition rate". The definition of VapWDepAve should be "average wet vapor-phase deposition rate".

Page 3-4, line 18. It is not clear what "degradation loss of vapor phase constituents" means. Is this the plant surface loss of vapor phase contaminants or is it referring to chemical degradation rates, such as photo degradation rates? Arsenic Alters Function

Page 3-4, line 21. The equation for VapDDepAve appears to be correct. The use of a vapor phase dry deposition velocity of 1 cm/s seems reasonable. It is not clear how one will compute the average vapor phase wet deposition rate and the degradation loss constant for vapor phase constituents. This last constant seems particularly hard to estimate. Some discussion of it is needed in the text.

Page 3-4, Equation 3-4. This equation is used to describe vapor phase uptake by plants due to direct air-to-plant transfer. The equation appears to be correct.

Page 3-5, line 3. There is a typo in the spacing of this line.

Page 3-5, Equation 3-5. The equation has the correct form. The document should give some discussion of the derivation of this equation. From what empirical data are the constants in this equation derived? Also the document should make clear that the volume based Air-to-plant biotransfer factor gives the concentration based on wet weight of the leaf.

Page 3-5, line 14. The factor "L Fw leaf" in the definition of Bvol is not defined. What does the Fw stand for? On page 3-4, line14, Fw stands for the fraction of wet deposition that adheres to the plant. Does it stand for the same thing here? I do not believe so, but the document is not clear.

Page 3-5, Equation 3-6. Equation 3-6 describes the massed based air-to-plant biotransfer factor. It is a straightforward calculation to accomplish two things: 1) a transfer from leaf concentration based on amount of chemical in a unit volume of wet leaf to concentration based on amount of chemical in a unit weight of wet leaf and 2) a correction from wet weight of leaf to dry weight of leaf. The document is not clear as to why it is necessary to introduce these two concepts. Why not just derive equation 3-5 on a dry mass based basis? If there is not some overriding reason for introducing both of these concepts, it would be clearer to just introduce one.

Page 3-6, line 2. It is not clear what the Chemical properties Processor (CPP) is.

Page 3-6, line 9. The document should make clear the Br is the ratio of contaminant concentration in the "edible portion" of plants to the concentration is soil.

Page 3-6, equation 3-7. This equation is correct. However, the document should make clear that the concentration computed is for the concentration of contaminate in the edible portion of the plant.

Page 3-6, equation 3-7. The document is not clear as to the difference between equation 3-7 and equations 3-9 and 3-10. 3-9 is for root uptake in a local watershed, while 3-10 is for root uptake in a regional watershed. What is 3-6 for? Is it for root uptake at an individual farm? Another confusing point is the discussion in page 3-6, paragraph 3. It states that the depth-averaged soil concentration data comes from the watershed and source modules. Where does the soil concentration data for equation 3-7 come from? The document should be clear that equation 3-7 is for a farm area. How are the soil concentrations for the farm area computed? Do they represent averages across the whole watershed or averages on a local farm?

Page 3-6, paragraph 3. The last sentence in this paragraph raises an interesting question. The sentence states that for contaminants that are highly lipophilic (and thus root uptake is not an issue), Br is assumed to account for possible resuspension and redeposition. The question that

arises is does not Br already account for Air-to-Plant transfer also? Br is determined using experiments where plants are grown in contaminated soils. However, the concentrations of contaminates in plant parts measured in these experiments results for transfer through plant roots, resuspension and redeposition, and also volatilization from the soil and air-to-plant transfer. Unless only experiments in which the above ground plant parts are protected from soil vapors are used in determining Br, Then the Br in equation 3-7 already accounts for air-to-plant transfer and equations 3-5 and 3-6 are not needed. This issue needs discussion in the document.
Page 3-6, paragraph 4. The document states that the fraction of the farm or home garden located in the watershed is multiplied by the soil concentration. This procedure gives average exposure in the watershed rather than maximum exposure. However, I believe it is the correct way to do these calculations.

Page 3-7, equation 3-8. This equation is correct.

Page 3-7, equation 3-9. This equation is correct.

Page 3-7, equation 3-10. This equation is correct. The document is not clear as to the need for three separate equations (3-7, 3-9, 3-10) to compute root uptake. Why not just have one equation and point out the CTda can be computed three different ways depending on the application? Also, there is a typo in the term "CtdaR" following equation 3-10. It should read CTdaR.

Page 3-7, general comment. The document introduces three different terms for the depth-averaged soil concentration: CTdaAve, CTda, and CTdaR. I think it would be clearer to use CTdaF for the depth-averaged soil concentration in a farm area, CTdaL for the depth-averaged soil concentration in a local watershed, and CTdaR for the depth-averaged soil concentration in a regional watershed.

Page 3-8, line 3. The term Pxxx is not defined. One can guess at the definition from what appears on this page below, but the definition should be explicitly given.

Page 3-8, line 7. The entire section describing the Subroutine WAVEda is confusing. First, all of the terms used should be defined. Second, the document should provide a written description of what in general is being accomplished. What is Nyr? Is there more than one regional watershed? Is there more than one local watershed?

The document says "Get FarmWSSubFrac". This term should be defined. The meaning of WSS is not clear. It is clear from below that there is a farm fraction for both the local watershed and the regional watershed. This should be made clear in the document. Also the document uses the same notation for both.

Page 3-8, line 9. What is the summation sign in this equation summing over? The CTdaR is the soil concentration in regional watershed. Is there more than one regional watershed?

Page 3-8, paragraph 2. This paragraph mentions Pxxx. As noted above, the definition is not given. However, more important, the document does not tell how to compute the biotransfer factor Br that goes with Pxxx. Is it computed with equation 3-8? If it is, why the need for different notation: Pxxx vs PRxxx?

Page 3-8, paragraph 3. The Home Garden section is not clear. The text says "The module obtains CTda (either CTdaR or CTda)" I take from this that CTda is either CTdaR or CTda. The document should give some explanation of this. Again, some general written overview is necessary at the start of the section to explain what is going on.

Page 3-8, paragraph 4. The document says "Kd reflects the degree to which contaminant can be absorbed in combination with the soil". What does this sentence mean? Kd is the ratio of the contaminate concentration in soil to the contaminate concentration in soil water.

Page 3-8, paragraph 4, line 6. The document says "The focSAve is determined by performing a subroutine with the fraction of organic carbon and the fraction of the farm that is located in the watershed". This might be more clearly said as "FocSAve is the sum over all watersheds of the fraction of the farm in each watershed times the fraction of organic carbon in the soil of that watershed".

Page 3-9, line 1. It would be clearer if the line read "Two equations for RCF are defined,…"

Page 3-9, paragraph 1, line 4. Why is it necessary to have a correct factor for volumetric differences among roots of different plants? A volumetric adjustment was not used in above plants parts. Why is it necessary for roots?

Page 3-9, Paragraph 2, lines 1 and 2. Proot is not defined at this point in the document. It should be.

Page 3-9, equation 3-11. This equation appears to be correct. However, there is a typo. VGbg should be Vgbg.

Page 3-9, Subroutine WAVEfocS. It would help if the document explained what this subroutine was doing. For example, the document could say: for each farm (specified by FarmNumWSub), look up the fraction of the farm located in a watershed (specified by FarmWSSubFrac) and the fraction of organic carbon in the soil of that watershed (specified by focS), then focSave is calculated as…

Page 3-10, equation 3-12. This equation appears correct.

Page 3-10, equation 3-13. This equation is the same as equation 3-11. It is not clear why it is repeated.

Page 3-11. The text should explain that equations 3-14, 3-15, and 3-16 are for gardens and are the same as equations 3-11, 3-12, and 3-13, except that soil-water partition coefficient and fraction of organic carbon are for a single garden plot rather than averages over several watersheds.

Page 3-12, equation 3-17. This equation is correct.

Page 3-12, Root Concentration Factor. This equation has the correct form. Some explanation should be given as to where the coefficients in this equation come from.

Page 3-13, Equation 3-19. This equation has the correct form. Again, some explanation should be given as to the origin of this equation. Also explain why equation 3-13 is the same (has the same coefficients) as equation 3-18 except for the coefficient - 0.82. In other words, why is the line describing log RCF vs log Kow for organics with log Kow less than 2.0 parallel to the one for Kow greater than 2.0?

Page 3-13, Farm. The document states: "if the chemical type is O or S,…" What does type O or S mean?

Page 3-13, Home Garden, line 1. This might be clearer is the document said "If the human receptor location (HumRepLocxy) is in a local watershed, …"

Page 3-14, Subroutine WAVEss. It would help if the document said what this subroutine was doing. Use English words along with the symbols for the parameters. For example, say "Calculate the chemical concentration in surficial soil averaged over the farm area (CtssAve) as:"

Page 3-14, equation 3-20. This equation is correct. However, the document does not say how to estimate Bs, the bioavailability fraction of contaminant in soil relative to vegetation.

Page 3-15, equation 3-21. This equation is correct.

Page 3-15, equation 3-22. This equation is correct. Again, the document does not say how to estimate Bs, the bioavailability fraction of contaminant in soil relative to vegetation.

Page 3-16, equation 3-23. This equation is correct.

Page 3-16, Beef Biotransfer Factor. The first three sentences under beef biotransfer deal with soil bioavailability. For clarity, these three sentences should be placed in another section titled "Soil Biobioavailability". In addition, this sectionshould have some statement about where to find information of selecting a value for Bs, the bioavailability fraction of contaminant in soil relative to vegetation.

Page 3-16, Beef Biotransfer Factor. The first sentence in this section is unclear. The document has not defined a biotransfer factor for soil. Thus to say that soil bioavailability is the ratio between biotransfer factors for soil and vegetation is confusing.

Specific Comments on Farm Food Chain and Terrestrial Food Web Data

Page 10-1, introduction. The introduction is clear.

Page 10-2, Table 10-1. I will list the various parameters that I have comments on.

ChemBs. The description is unclear. What does "relative to vegetation" mean? The units for this parameter are listed as fraction. Below the units of other fractions are as unitless. The document should be consistent.

ChemBr. This parameter is listed as the "Fraction of constituents in soil taken up into plant tissues". This is an incorrect definition. If it were indeed a fraction, then it would be unitless. A better mane would be plant tissue/ soil partition coefficient.

ChemBr. This parameter is listed twice.

ChemRFC. This parameter is listed as a fraction. A better definition would be root tissue/ soil pore water partition coefficient.

ChemBAF. These are bioaccumulation factors relative to what medium? Soil? Food items of the prey?

Page 10-4, Section 10.2.1. The sources used to obtain the Farm Food Chain parameters appear adequate. The use of the "Methodology for Assessing Health Risks Associated with Multiple Exposure Pathways to Combustor Emissions" as the primary data source is justified and acceptable.

Page 10-5, table 10-3. The references used in selecting chemical-specific parameters appear adequate. As the document acknowledges, these is a shortage of information on the uptake of chemical into the food chain. However, the references listed are state of the art and I am not aware of additional information.

Page 10-7, table 10-4. The data sources used in selecting exposure-related parameters appear adequate.

Page 10-9, section 10.3.1.1.1. The use of predictive methods to estimate biotransfer factors based on log Kow when experimental values are not available is expectable. This is a standard approach. It is also acceptable to use a biotransfer factor for drinking water equal to the biotransfer factor for beef or milk when the biotransfer factor for water is not available.

The use of the Travis and Arms model for predicting biotransfer factor for beef and milk is acceptable. The EPA should continue to look for alternative approaches. However, data in this area are limited.

Page 10-10. Equations 10-1 and 10-2 are correct. The justifications given on their range of applicability are good. The EPA has decided to use a default value of 1 d/g animal tissue for constituents with Kow values outside the range of applicability. This value appears to be too large, especially for constituents with log Kow less than 2.8.

The document recommends a biotransfer factor for dioxin into milk of 1E-05 d/g. A similar transfer factor for dioxin into beef is not available. To obtain a number for beef, the document takes the ratio of percent fat in beef and milk to obtain an estimate that the biotransfer factor for beef is 5.4 times higher than that for milk. However, if one looks at equations 10-1 and 10-2, one sees that the biotransfer factor for beef is 3.1 times higher than the biotransfer factor for milk. It would thus appear that the choice of a factor of 5.4 for dioxin might be too high.

The use of beef and milk biotransfer factors for metals as developed by Baes et al. is appropriate.

Page 10-10, section 10.3.1.1.2. The document defines the bioavailability fraction for soil as the bioavailability of a contaminant in the soil relative to it bioavailability in vegetation. It would be better to define it as "the bioavailability of a contaminant in soil via the ingestion pathway relative to its bioavailability in vegetation via the ingestion pathway". The document goes on to say "This parameter indicates the fraction of the total chemical concentration in soil that is predicted to be in a chemical form that is not bioavailable". The document is unclear as to whether the bioavailability fraction for soil is for the fraction that is available or nonavailable.

Page 10-11, paragraph 1. The use of a default value of 1 for the bioavailability fraction for soil is reasonable.

Page 10-11, paragraph 2. The document says that "the fraction of dioxin that remains bioavailable as it moves from soil to plant ranged from 0.5 to 0.8". It is not clear what this sentence means. Does it mean that 50 to 80 percent in soil is taken up by vegetation? Does it mean that when contaminated vegetation is eaten, 50 to80 percent of the contamination is available for absorption into the body? If it means the latter, then the statement in the document should say "the fraction of dioxin in vegetation that is available for absorption following ingestion ranged from 0.5 to 0.8". One more point. This statement is discussing the fraction of dioxin that is available following ingestion. The last sentence on page 10-10 defines the bioavailability fraction for soil as the fraction that is NOT available! The document needs to be clear on this point.

Page 10-11, section 10.3.1.1.3, line 4. The document says "The root concentration factor is the ratio of contaminant concentration in the root tissue of plants (on a fresh weight basis) to those in soil". This statement is inconsistent with other definitions given in the document where RCF is defined as the ratio of contaminant concentrations in the root tissue of plants to those in soil water.

Page 10-11, last paragraph. The use of measured uptake factors for metals is appropriate. For a given metal, the use of the geometric mean of the compiled uptake factors is appropriate. Multiple studies have shown that concentrations in environmental media tend to be geometrically distributed.

Page 10-12, paragraph 1. The justification for not using metal uptake factors derived from studies on the application of sewage sludge to soil is appropriate. I agree with not using these values as they will tend to underestimate plant uptake of metals.

Page 10-12, paragraph 2. Is this paragraph discussing plant uptake for metals or both metals and organics? The justification for using greenhouse and pot studies is weak. The stated reason: "because the level of uncertainty in pot studies has not been quantified for uptake studies, it is more desirable to work with a larger data set within the constraints of the uncertainty", does not make sense. How can the fact that the level of uncertainty in pot studies has not been quantified be a justification for considering these data? It would be better just to state that because there tends to be a shortage of data from field studies, it was decided to use the larger data set consisting of both greenhouse and field data.

Page 10-12, paragraph 3. It is appropriate to use the regression equation for metals developed by Baes et al. when no other data are available.

Page 10-12, paragraph 4. The document says data from both soil and sludge-amended soil were used to develop uptake factors for mercury and methylmercury. Some justification should be given for the use of the data from sludge-amended soils. Earlier, the document says it is inappropriate to use such data since it provides an under estimate of uptake.

Page 10-13, equation 10-3. The use of this equation is appropriate.

Page 10-13, root concentration factors. The justification for developing root concentration factors seems inappropriate. The document states, "in some cases (e. g., dioxins) most of the constituent remains in plant roots and is not translocated to other tissue. For these constituents, an RCF is a more appropriate uptake factor". The reason for developing a root concentration factor is that the concentration of contaminates in edible roots can be different than that in the above ground parts. Thus, different equations are needed to predict bioconcentration in roots and above ground plant parts.

The document says, "For dioxin, the EPA-recommended RCF of 5,200 was used. These values were calculated using Equation 10-4, as follows". This seems to imply that the dioxin RCF was calculated using Equation 10-4, which cannot be true since the formula is valid for organics with a log Kow less than 2. This needs to be made clearer.

Page 10-14, paragraph 1. The document says, "Air-to-plant transfer is likely to be important for exposed produce but not for protected produce or root crops, because only aboveground exposed vegetation encounters deposition from the air". This is not true. Protected produce also encounters deposition from the air. You might want to say that the edible portion of protected produce does not encounter direct deposition from the air.

Page 10-14, equation 10-6. The form of this equation appears to be correct. I cannot tell if the specific parameters in the equation are correct.

Page 10-15, paragraph 4 and 5. The default values for the plant surface loss coefficient of particle-bound contaminants of 18.7 yr-1 for all constituents, 40.41 and 27.06 yr-1 for mercury and dioxin seem reasonable. However, the latter tow should probably be rounded to one decimal place, that is, 40.4 and 27.1. The last sentence in paragraph 5 states "these values were derive as the mean of a data range... " This sentence should say "the geometric mean of a data range…"

Page 10-15, vapor deposition. Following the first sentence, a new sentence should be inserted stating that this parameter is only used for nonmetals with log Kow less than 5. The last sentence in this paragraph states that "For metals and mercury, this vapor-related parameter was not required; hence, in the database, a placeholder value of 1 was substituted". It would probably be better to use a large placeholder value such as 1.0 E+6 in case the placeholder value is accidentally used.

Page 10-16, paragraph 2, subsection 1. The paragraph is not clear if a combination of field and laboratory exposures were used in all cases or only those cases where there was not sufficient field data.

Page 10-18, equation 10-9. This equation appears to be incorrect. I believe it should be BCF = (1 + Flipid Kow)/ Pworm. Then concentration in earthworms = BCF Fwater = (Fwater + Flipid Kow Fwater)/ Pworm.

Page 10-20, biotransfer factors. I agree that the values used are the standard for estimating biotransfer relationships in the FFC.

Page 10-21, paragraph 1. The document says "In spite of the added conservatism generated by including greenhouse studies, the plant uptake database was referred because it contains measured uptake factors that more likely reflect typical exposure scenarios for terrestrial plants". This sentence does not make sense. How can including greenhouse studies make the database more reflective of typical exposure scenarios for terrestrial plants? Greenhouse studies tend to over estimate the soil-to-plant bioconcentration factor.

Page 10-23, soil consumption rate. The soil consumption rates recommended seem reasonable.

Page 10-24. The values for water intake recommended seem reasonable.

Page 10-25. A default value of 1 for the fraction of food items grown in contaminated soil seems overly conservative. It is highly unlikely that any farm in the United States grows all of the grain and silage that cattle on the farm eat. I believe that data on this parameter are available. However, this parameter is unlikely to make more than a factor of three difference in the final predicted concentrations in beef and milk.

A value of 0.6 for the fraction of wet deposition that adheres to plants seems overly conservative. It is difficult to believe that 60% of contaminates (with Kow less than 5) that fall on vegetation during rainfall events stay on the vegetation. The methodology already assumes that vapor contaminates with Kow less than 5 do not accumulated in vegetation. Why would contaminates in rainwater with a low Kow accumulate in vegetation? I realize this is a difficult issue because of the lack of data on the uptake of contaminates during wet deposition.

Page 10-26. All the recommended parameters on this page seem reasonable.

Page 10-27. The aboveground and belowground correction factors seem reasonable.

Page 10-28. All of this discussion seems appropriate.

Page 10-29. I agree that the most appropriate data are those on U, S. EPA (in press) and U. S. EPA (1997a).