August 9, 1995

EPA-SAB-EEC-95-010

Honorable Carol M. Browner
Administrator
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

RE: SAB Review of EPA's Composite Model for Leachate Migration with Transformation Products - EPACMTP

Dear Ms. Browner:

The Science Advisory Board (SAB) has completed its review of the Office of Solid Waste and Emergency Response (OSWER) Composite Model for Leachate Migration with Transformation Products (hereafter the model is referred to as EPACMTP). This review was part of a continuing effort by the Environmental Engineering Committee to promote improvements in the development and external peer review of environmental regulatory models. The OSWER Exposure Model Subcommittee (OEMS) met on March 8, 1995 in Washington, DC to conduct this review.

EPACMTP is designed to predict human exposure to groundwater pollutants in a domestic drinking water receptor well that is impacted by releases from land disposal sites. This model is applied nationally in support of development of regulations for management and control of hazardous wastes, and it is not intended for site-specific applications. The Subcommittee commends the Agency for making enhancements to earlier models, responding, in part, to SAB suggestions and recommendations. The EPACMTP modeling approach incorporates greater flexibility and versatility in the simulation capability than its predecessor (EPA's Composite Model for Landfills). EPACMTP model explicitly considers: a) chain transformation reactions and transport of daughter products, b) effects of water-table mounding on groundwater flow and contaminant migration, c) finite source, as well as continuous source, scenarios, and d) metals transport by linking EPACMTP with the MINTEQ metals speciation model outputs. The Subcommittee also identified a few important deficiencies in EPACMTP that should be addressed by the Agency in completing the model development and verification before it is widely used.

The charge for this review consisted of the following four questions:

a) Is the mathematical formulation in the EPACMTP of the subsurface fate and transport of daughter products from degrading organic chemical constituents appropriate for EPA to use in establishing nation-wide exit levels for hazardous waste in future regulations?

b) Is the regional approach, using hydrogeologic data from specific sites within regions, better or should OSW continue to use inputs based on national distributions?

c) Is the finite-source approach adequate for regulatory purposes?

d) Should the metal speciation model (MINTEQ) be linked to the EPACMTP model to assess the subsurface fate and transport of metals as part of EPA's national rulemaking efforts?

The incorporation of the daughter products into the model makes it more complete and the mathematical formulation appears to be correct. However, EPA should verify that the software works properly by further testing and documenting how these daughter products are used in the simulation analysis. In addition, the Agency should document known instances where very toxic daughter products are formed from multiple parent chemicals (i.e., exposure and risks may be underestimated) as well as instances where biodegradation or inhibiting factors may affect the transformation rate (i.e., exposure may be overestimated by the model).

The regional approach, using a stratified sample, which allows the incorporation of inherent correlations and trends, is scientifically superior to the previous nation-wide approach, and it responds directly to an earlier SAB recommendation (SAB, 1990). The Subcommittee recommends that EPA compare the differences in results obtained by using the two approaches, document the sensitivity of the key variables that affect the time to achieve a peak concentration, and derive the additional insights necessary to ensure that site- and region-specific values are available for the most sensitive parameters.

The finite-source approach is very appropriate for EPA to use. However, clear and precise definition of the source terms must be developed to insure that the approach is used properly. For example the definition for C_w, the waste concentration, is imprecise. In addition to the definitions, it is important to explain how the source terms are related to mass transfer, time dependence, and the availability of the source. The model should also be run under contrasting scenarios: liners versus no liners and under different closure alternatives that are specified in existing regulations. It is important that all options offered by EPACMTP are tested to verify that they perform properly before the model is released.

The MINTEQ model used for metal speciation was not evaluated as part of this review. While the addition of metal speciation to the EPACMTP model is valuable, the accuracy of the model estimates must be verified and the documentation of this use needs to be clarified. For example, the pH difference between the soil and the leachate could cause significant errors. These possible errors need to be evaluated to be sure that the MINTEQ-generated curves are being properly generated and appropriately used in the EPACMTP model. Geochemical data on chromium (VI), selenium, and cadmium are available which should be incorporated in the MINTEQ code for use with EPACMTP.

In the course of this review, the Subcommittee has referred to the Agency's "Guidance for Conducting External Peer Review of Environmental Regulatory Models" which was itself reviewed by the SAB (SAB, 1993d).

We appreciate the opportunity to review the improvements that EPA has made to develop the EPACMTP model for analyzing the transport and fate of chemical releases to groundwater from land disposal facilities. Again, we commend the Agency for its progress, and we appreciate EPA's efforts to respond directly to our past recommendations. We look forward to your response to our recommendations on the EPACMTP.

Sincerely,

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Executive Committee

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Dr. Ishwar P. Murarka, Chair
Environmental Engineering Committee

James W. Mercer

Dr. James W. Mercer, Chair
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ABSTRACT

The OSWER Exposure Modeling Subcommittee (OEMS) of the Environmental Engineering Committee of the Environmental Protection Agency's Science Advisory Board (SAB) reviewed the Agency's Office of Solid Waste and Emergency Response (OSWER) Composite Model for Leachate Migration with Transformation Products (EPACMTP) on March 8, 1995. The review examined the mathematical formulation, a site-based approach using hydrogeologic regions, and the metal speciation model (MINTEQ) linked to the EPACMTP model to assess the subsurface fate and transport of metals.

The Subcommittee concluded that the mathematical formulation incorporating daughter products into the model appeared to be correct and quite useful. The regional site-based approach is better than the national distribution approach used in the previous model. In addition, the finite-source approach will be appropriate for regulatory analysis once the definition of the source term has been clarified and validated. The Subcommittee encourages the Agency to improve its documentation of the performance of its modules and to document how they had responded to past peer reviewer comments. The MINTEQ model for metal speciation is a valuable addition, but it needs to have further testing and other databases need to be consulted. Overall, the Subcommittee commends OSWER for its improvements to the EPACMTP model and its responsiveness to previous SAB suggestions.

KEY WORDS: Groundwater Modeling, Transport and Fate, RCRA

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1. EXECUTIVE SUMMARY

The OSWER Exposure Model Subcommittee (OEMS)of the Environmental Engineering Committee of the Science Advisory Board of EPA has reviewed the EPA's Composite Model for Leachate Migration with Transformation Products (EPACMTP). The OEMS began this review process through a consultation with OSWER staff and consultants on March 2-3, 1994 on the concepts for the determination of soil screening levels. Following further development by OSWER, OEMS reviewed changes that OSWER made to the model on March 8, 1995. The charge for this review was based on four questions:

a) Is the mathematical formulation in the EPACMTP of the subsurface fate and transport of daughter products appropriate for EPA to use in establishing nation-wide exit levels for hazardous waste in future regulations?

b) Is the regional approach, using hydrogeologic from specific sites within regions, better or should OSW continue to use inputs based on national distributions?

c) Is the finite source approach adequate for regulatory purposes?

d) Should the metal speciation model (MINTEQ) be linked to the EPACMTP model to assess the subsurface fate and transport of metals as part of EPA's national rulemaking efforts?

The Subcommittee concluded that the mathematical formulation incorporating daughter products into the model appeared to be correct and useful. The regional approach is better than the national distribution approach used in the previous model. However, variability and sensitivity of the input variables need to be clarified. The finite-source approach is appropriate, but the definitions of the source terms must be clarified to assure proper use of the approach. The MINTEQ model is a valuable addition, but it needs to have further testing to verify its accuracy in this context. Overall, the Subcommittee commends OSWER for its improvements to the EPACMTP model and its responsiveness to previous SAB suggestions.

2. INTRODUCTION

EPA's Composite Model for leachate Migration with Transformation Products (EPACMTP) computer code is a simulation model for subsurface fate and transport of contaminants released from land disposal sites. EPACMTP (EPA, 1994a) is designed to predict human exposure to groundwater pollutants in a domestic drinking water receptor well impacted by such releases. The model is applied to support development of regulations for management and disposal of hazardous wastes. Simulations are performed using probabilistic input specifications, where the model is designed to be used for generic, nationwide assessments using Monte Carlo simulation techniques. It is not intended for site-specific applications. EPACMTP extends and enhances the modeling approach adopted for the 1990 Toxicity Characteristic (TC) Rule promulgated by the U.S. Environmental Protection Agency in March 1990. For that rule, the Agency used EPACML (EPA's Composite Model for Landfills) (EPA, 1990) to estimate the potential human exposure to hazardous chemicals leaching from land disposal facilities. EPACML accounts for first-order decay and linear equilibrium sorption of chemicals, but disregards the formation and transport of transformation products (also known as daughter products). The analytical groundwater transport solution technique employed in EPACML further imposes certain restrictive assumptions; specifically, the solution can handle only uniform, unidirectional groundwater flow and thereby ignores the effects of groundwater mounding on contaminant migration and groundwater flow. To address the limitations of EPACML, the modeling approach has been enhanced and implemented in EPACMTP. The EPACMTP modeling approach incorporates greater flexibility and versatility in the simulation capability; i.e., the model explicitly can take into consideration:

a) chain transformation reactions and transport of daughter products,
b) effects of water-table mounding on groundwater flow and contaminant migration,
c) finite source, as well as continuous source, scenarios, and
d) metals transport by linking EPACMTP with outputs from the MINTEQ metals speciation model.

To facilitate the use of the model, interactive pre- and post-processors have been developed to assist in problem set-up and analysis.

EPACMTP contains a vadose zone module called Finite Element Contaminant

Transport in the Unsaturated Zone (FECTUZ), a saturated zone module called Combined Analytical-Numerical SAturated Zone in 3-Dimensions (CANSAZ-3D), and a Monte Carlo module for nationwide uncertainty analysis. The FECTUZ module is designed to simulate vertically downward steady-state flow and contaminant transport through the unsaturated zone above an unconfined aquifer. FECTUZ is based on the EPA's numerical unsaturated zone simulator, VADOFT, but with extensions and enhancements to optimize the computational efficiency for Monte Carlo analyses (McGrath and Irving, 1973), and to handle multi-species decay chains. The transport simulator of FECTUZ can accommodate advection, longitudinal dispersion (in the vertical direction), first-order degradation with daughter product formation, and linear or nonlinear Freundlich equilibrium sorption. In cases where the transformation products are of concern, FECTUZ can handle either straight or branched decay chains with up to seven different chemical species, i.e., a parent and up to six daughter products. FECTUZ predicts concentrations at the water table, which provides the input for CANSAZ-3D. The CANSAZ-3D module simulates 3-D steady-state groundwater flow and transient or steady-state contaminant transport. The flow simulator of CANSAZ-3D accounts not only for ambient groundwater flow, but also for leakage from a land disposal unit and regional recharge. The transport simulator of CANSAZ-3D accounts for 3-D advection and dispersion, first-order decay with daughter product formation, and linear or non-linear Freundlich equilibrium sorption. In cases where daughter product formation is of interest, CANSAZ-3D can accommodate up to seven different species, i.e., a parent with up to six daughter products.

2.1 Background and Prior SAB Reviews of Related Documents

The U.S. Environmental Protection Agency (EPA), Office of Solid Waste and Emergency Response (OSWER) has been using and improving mathematical models since the early 1980s when the Vertical Horizontal Spread (VHS) model (Domenico and Palciauskas, 1982) was used. This model was replaced by the Combined Analytical-Numerical SAturated Zone (CANSAZ) flow and transport model used in the EPA Composite Model for Surface Impoundments (EPACMS). The CANSAZ model was reviewed by the Science Advisory Board (SAB) in 1990 (SAB, 1990). Earlier in 1988, the SAB had reviewed the Unsaturated Zone Code (FECTUZ) (SAB, 1988). In 1989, the SAB issued a resolution on use of mathematical models by EPA for regulatory assessment and decision-making (SAB, 1989), which was directed, in part, at OSWER. In 1991, the SAB provided a review of OSWER's draft report on the usage of computer models in the hazardous waste/Superfund programs (SAB, 1991b). As recently as March 2-3, 1994, the SAB provided a consultation on EPACMTP (SAB, 1994). OSWER has been receptive to previous SAB review comments and consultation. Thus, this SAB review of EPACMTP represents a peer review of groundwater models developed and significantly improved by OSWER for use in RCRA/Superfund regulations. This current review followed EPA guidance (EPA, 1994b) that was reviewed by the SAB (SAB, 1993c). There are also four additional SAB publications on groundwater modeling by the EEC that are listed in section 5 of this report.

2.2 Charge to the Subcommittee

The areas listed below were identified for SAB review in a request from the Office of Solid Waste and Emergency Response.

a) EPACMTP is the latest and most advanced of the OSW subsurface fate and transport models designed to be computationally efficient for usage in Monte Carlo analysis for national rule-making. Is the mathematical formulation in EPACMTP for the subsurface fate and transport of daughter products from degrading organic chemical constituents sound, and is it appropriate for EPA to use this approach to establish nationwide exit levels for hazardous waste in future regulations?

b) The OSW has been using a national Monte Carlo procedure in which national distributions of parameters are used as input to the model. An alternative approach has been developed using a regional site information in which hydrogeologic model input parameters are selected from specific sites within hydrogeologic regions and, in general, have cross-correlations. Is this regional approach better, or should EPA continue to use the approach based on national distributions of input parameters?

c) The OSW's most recently-used approach is based on an infinite source steady-state model. EPA has developed a finite-source approach for use with EPACMTP. Is this approach adequate for regulatory purposes?

d) MINTEQ (metal speciation model) was developed by EPA. EPA has recently developed the linkage of the output of the model with EPACMTP to assess the subsurface fate and transport of metals. Is this linkage for metals appropriate for national rule-making efforts?

3. RESPONSE TO THE CHARGE QUESTIONS

OSWER has been responsive to SAB comments on prior modeling efforts and has developed an improved model and approach to simulate transport and fate of contaminants released to the subsurface. Because of the nature of the review and Subcommittee charge, the focus is on recommendations to improve the model further. Comments that follow address ways that the model and/or its documentation and use can be enhanced. Generally the comments include a brief discussion followed by recommendations. Each question from the charge is addressed in separate subsections below.

3.1 Daughter Products

Incorporation of daughter products into EPACMTP makes the model more complete. The treatment of degradation with a first-order decay rate is consistent with available scientific information. The mathematical formulation appears to be correct. Degradation is an important process that should be considered and, therefore, its incorporation into EPACMTP is conceptually appropriate. The SAB cannot comment on information/data input on degradation because these were not reviewed. These data are an important aspect of proper implementation of modeling degradation. Although parameters and data associated with hydrolysis tend to be fairly well defined (given pH and temperature conditions), it should be recognized that parameters and data associated with biodegradation are more imprecise, vary over a wide range, and are site specific. Because of this uncertainty associated with the biodegradation of certain chemicals, the three following recommendations are made.

<u>Recommendation 1</u> - EPA should carefully consider whether to use biodegradation and associated data when applying EPACMTP on a national basis to certain chemicals that are known to only be moderately (or possibly) biodegradable (see, e.g., Wilson and McNabb, 1983).

Although the omission of biotransformation term from the model may yield conservative predictions for some chemicals (e.g., BTEX), this omission will not yield conservative predictions for other chemicals that have more toxic daughter products (e.g., trichloroethene degrading anaerobically to vinyl chloride). In addition, EPACMTP does not consistently account for multiple parent compounds that produce the same daughter compound. From the mathematical formulation (see Equation 2.16 in EPA, 1994a, p. 1-14), it appears that the code has the capacity to deal with multiple source compounds. However, in the presentation to the Subcommittee, OSWER consultants suggested that all daughter products are treated "independently" in the Monte Carlo analysis. Such an approach could significantly underestimate the amount of a daughter compound that is formed. There is not enough documentation on how the model is actually implemented to determine whether this aspect of daughter formation is properly addressed, and more clarification is required. Furthermore, there appears to be inadequate numerical verification of the daughter products modules (particularly those which are coupled with nonlinear sorption).

Recommendation 2 - EPA should perform further verification (to ensure proper coding) and document how the daughter products modules of EPACMTP are implemented.

Recommendation 3 - EPA should document known instances in which more toxic daughter products are formed from multiple parent chemicals and, in the EPACMTP modeling process, allow for special postprocessing of those chemicals to ensure that every degradation pathway is counted, with consideration of rate limiting steps.

3.2 Regional Approach

The regional approach for describing national variability in site conditions represents improvement over the previous approach in which groundwater fate and transport parameters were independently sampled from national distributions. That approach fails to account for the correlation which occurs between parameters at a site due to physical relationships among soil properties and regional trends in climate and geohydrology. The sampling of parameter sets from actual sites, based on a regionally stratified sample, allows these inherent correlations and trends to be properly incorporated by using a more localized data set. This modification in approach responds to a specific recommendation that was made by the SAB in reviewing CANSAZ (SAB, 1990), and it should be implemented instead of the national approach in the EPACMTP. The EPA has provided good documentation on the national distribution of hydrologic parameters that result. It should be noted, however, that some parameters are still sampled independently based on a national estimate, because the data for these parameters are not yet generally available for the sites included in the regional site data base. EPA has recently published guidance on documenting the costs and performance of remediation projects (EPA, 1995), which includes site-specific data that might be useful for this purpose.

The following recommendations concern data and the sensitivity of the calculation to that data.

Recommendation 4 - EPA should compare the variability distributions of the dilution and attenuation factors (DAFs) that result from the regional (new) and independent national sampling (old) approaches, and document the differences and the reasons for those differences.

Recommendation 5 - EPA should determine and document the sensitivity of computed DAFs to key hydrologic and chemical variables. This analysis should include varying distributions and documenting how DAFs are impacted. Discussions should be provided to help clarify how much of the variation in DAFs is associated with parameter variability from site to site, and how much is associated with uncertainty in the parameter values. An example of such a study is provided in Chiang et al. (1995).

Recommendation 6 - EPA should perform the necessary additional data collection of uncertain parameters and parameters that are currently unavailable on a site-specific basis, especially parameters that are found to have major effects on DAFs. If data cannot be obtained, then EPA should attempt to identify correlations that can be used on a regional basis to estimate these parameters in a manner that can account for the physical conditions at sites.

3.3 Finite-Source Approach

EPACMTP model predictions of concentrations at a receptor well are closely tied to source term concentration inputs to the code. The previous version of the model, EPACML, was designed to handle only a constant and continuous source concentration. Such an approach implies an infinite contaminant mass within the waste, and may lead to unrealistic and overly conservative model predictions. In response to this recognized limitation of EPACML, the new EPACMTP model has a number of refinements that are directed towards the improvement of the representation of the source term. The model can now handle a source of limited mass and finite duration. Options also have been incorporated to treat a time-varying source concentration. This variation in time may be the consequence of first order decay, or production or desorption from the waste solids, or continuous loading. Although these model refinements in the source term treatment represent a substantial conceptual improvement for the model, the Subcommittee has identified a number of concerns with the source term documentation and mathematical development which should be addressed.

Insufficient information is given in the background documents and user guide for EPACMTP to identify underlying assumptions in source term quantification, to precisely define important source term parameters, or to understand how the parameters will be evaluated for code implementation in the Monte Carlo analysis. In general, more attention needs to be directed to the definition and evaluation of source term parameters and the validation of the appropriateness of the underlying model assumptions for the description of contaminant leaching. Some additional Subcommittee concerns relating to the above issues are summarized below.

a) The EPACMTP background documents fail to precisely define C_w, the "waste concentration." An analysis of the source term governing equations suggests that the units of this parameter are mass of a particular waste constituent per total mass of waste (wet waste mass). It is unclear whether the term is meant to account for the total mass of the contaminant in the waste or only that portion which may enter the aqueous phase and be transported into the unsaturated zone (the leachable portion). The latter definition would appear to be more consistent with the intended model use. Clarification is needed on this point. Guidelines and references also need to be supplied in the documentation as to how this waste concentration can be precisely measured for a specific waste.

b) New model options in EPACMTP permit computation of a varying C_L at the source. Here C_L represents the mass of a waste constituent per volume of leachate solution. Two alternative models for the functional time dependence of C_L are incorporated in the simulator. A number of fundamental assumptions appear to be critical to the mathematical representation of these source models, but they are not explicitly stated nor justified in the documentation. One mathematical model describes a waste in which a portion of the contaminant mass is associated with the waste solids (EPA, 1994a, p. 20-21). An assumption of equilibrium partitioning between the solid and aqueous phases results in an exponentially decaying source term. Here an implicit but unstated assumption is that the sorption is linear.

The second model is designed to model a source constituent, which is subject to first-order reaction (decay and/or production). The source concentration expression, as given by Equations 18a and 18b (EPA, 1994a), however, does not appear to represent a correct mass balance expression. No accounting is made of the waste that may be associated with the solids, nor is there a term to account for the mass that leaches out of the system. The intended assumptions should be explicitly stated and justified. The mass associated with the waste solids should also be considered, as well as its potential for reaction. For microbial reactions, such bound mass is typically unavailable to the organisms. The expression for source term duration given by Equation 19 (EPA, 1994a) would appear to represent a minimum duration. This expression should be justified.

c) The modeling approach also implicitly assumes that the transformation rate is constant, unaffected by inhibition or other limiting factors. While this may be reasonable for an abiotic chemical degradation process, it may not be so for a biologically-mediated process.

As a result of this discussion, the following recommendations are made.

<u>Recommendation 7</u> - EPA should carefully define C_W and C_L and indicate how decay, including a decaying source, impacts these parameters and t_p.

<u>Recommendation 8</u> - A validation/verification of calculated DAFs from a "fresh" finite source would be helpful. Most validation studies presented are ones that have been used historically, but these do not test new code features.

The assumptions that underlie the source terms included in the EPACMTP model are almost exclusively relevant to situations in which the contaminant source is uncontained. Currently, containment systems such as liners, covers, and slurry walls have been implemented at contaminated sites on a national basis. The design (configuration, material properties, and dimensions) of a containment system influences the source term for contaminant transport.

Thus the application of the EPACMTP model to contaminant transport from contained wastes, without modification of the source term can result in overestimation of the rate of contaminant migration from a source. More work needs to be performed to relate source term decay or growth (with time) to the design and performance of barriers.

<u>Recommendation 9</u> - A scenario analysis of the source term is appropriate. This analysis should include the remediation options of liners versus no liners and cap/closure versus no closure that are specified in existing regulations. An example of such a study is provided in Chiang et al. (1995).

3.4 Metal Speciation Model

For metal speciation, EPA is using MINTEQ. In MINTEQ, precipitation and sorption reactions are treated using a two-step process; they are not considered simultaneously. As a result of the two-step process, an initial leachate concentration and distribution coefficient isotherms (as a function of concentration) are generated. The pH difference between the leachate and the environment could cause the initial concentration to exceed the chemical solubility, which would impact solute transport and DAF calculations. This issue is not considered in the present EPACMTP model.

Recommendation 10 - EPA should ensure that initial concentrations do not exceed the chemical solubility. EPA should make sure the MINTEQ approach is consistent with the leachability phenomena discussed in the SAB report EPA-SAB-EEC-92-003.

The MINTEQ code is composed largely of chemical data bases. The SAB did not review MINTEQ and thus cannot comment on the inputs to EPACMTP for metals. The version that EPA is using does not contain the latest data available for cadmium, chromium (VI), and selenium, which will impact calculations for these chemicals. Additional useful information on metals availability may be available from the Office of Water through its Contaminated Sediment Research program.

Recommendation 11 - EPA should update MINTEQ using the latest chemistry data available. This is especially true for chromium (VI), and may be true for other metals such as selenium and cadmium.

For sorption processes, more discussion is necessary to justify the approach. Sorption in the vadose zone is treated as nonlinear, whereas that in the saturated zone is assumed to be linear. Data need to be provided supporting the different approaches used above and below the water table.

Recommendation 12 - EPA should better document the choice of vadose versus saturated zone distribution coefficient isotherms, and explain differences where they occur.

For some chemicals, especially some metals, transport times to reach peak concentrations may be on the order of centuries or longer. It is unclear if and how EPA factors this time frame to reach peak concentrations into the DAF calculation.

4. ADDITIONAL COMMENTS

During the review, discussions indicated that certain portions of EPACMTP are used more frequently than other portions, and that certain code options have had only limited testing and some have none at all. For example, in the metals background document (p. 5-4), the statement is made that, "The numerical nonlinear isotherm scheme works only for mildly nonlinear cases." It is important, before releasing EPACMTP, that all options offered should be tested to ensure that they work as designed.

Having independent reviewers review EPACMTP was good, and consistent with EPA external peer review guidance. These reviewers raised a number of important questions concerning the model assumptions and formulations. As part of the ensuing guidance, a response to reviewer comments should be adequately documented. Such documentation was missing or inadequate in this case. To provide a complete record and be consistent with peer review guidance, better documentation needs to be provided on all responses to reviewer comments.

There is a large family of EPA codes, many of which have similar origins. That is, many of the codes have subcodes that are the same. Examples include EPACMS, EPACML, EPACMTP, MULTIMED, and MMSOILS. It would be helpful for EPA to discuss and document the relationship among these codes. This would represent the first step in an ongoing communication that should occur within EPA. These various codes are undergoing continual testing and errors are noted and corrected in some of these codes. It appears that documentation of corrected errors does not occur and is not distributed to other portions of EPA where similar codes with the same subcode are being used.

Recommendation 13 - EPA should establish a central location where this debugging (code correction) information is contained and distributed. This function should be coordinated with the Agency working group on regulatory models and peer review to promote consistency and advise the users about enhancements.

The validation studies provided by EPA are good and are designed to test standard flow and transport conditions. Interestingly, the three validation studies are site-specific applications, for which EPACMTP is not designed as stated by the Agency. Unfortunately, the studies provided by OSWER do not test the new features in EPACMTP. EPA needs to perform confirmation testing of a) daughter products, b) metals speciation, and c) finite-source. EPA should also explore ways to confirm the regional distribution approach. One approach is to present various scenarios and examples, and check for reasonableness. This effort should include a discussion on the sensitivity of DAFs to different parameters and scenarios.

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APPENDIX A. GLOSSARY OF SELECTED TERMS

1. CANSAZ-Combined Analytical-Numerical Saturated Zone (CANSAZ) a two-dimensional flow and transport model.

2. CANSAZ-3D-Combined Analytical-Numerical SAturated Zone in 3-Dimensions (CANSAZ-3D), a module in EPACMTP for the saturated zone of groundwater.

3. DAF-Dilution and attenuation factors.

4. EPACML-EPA's Composite Model for Landfills (EPA, 1990), an earlier OSWER computer model used to estimate the potential human exposure to chemicals leaching from land disposal facilities.

5. EPACMS-EPA Composite Model for Surface Impoundments, the precursor to EPACML.

6. EPACMTP-EPA's Composite Model for leachate Migration with Transformation Products. This computer simulation model is intended to predict the subsurface fate and transport of contaminants released from land disposal sites.

7. FECTUZ-Finite Element Contaminant Transport in the Unsaturated Zone, a module in EPACMTP for the vadose or unsaturated zone of groundwater.

8. OSWER-the Office of Solid Waste and Emergency Response

9. MINTEQ (metal speciation model) was developed by EPA whose output is used by EPACMTP.

10. OSW-Office of Solid Waste

11. TC- Toxicity Characteristic, this attribute, defined by a 1990 EPA rule is one criterion used to classify wastes as hazardous or non-hazardous.

12. VHS-Vertical and Horizontal Spread (VHS) model (Domenico and Palciauskas, 1982), the first EPA groundwater contaminant model reviewed by SAB.

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AN SAB REPORT: REVIEW OF EPA'S COMPOSITE MODEL FOR LEACHATE MIGRATION WITH TRANSFORMATION PRODUCTS - EPACMTP

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