September 11, 2015 [filed via www.regulations.gov]

Dr. Fred Jenkins, DFO
Office of Science Coordination and Policy (7201M)
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460-001

RE: Comments of CropLife America on *EPA's Scientific Advisory Panel (FIFRA SAP) to consider and review Development of a Spatial Aquatic Model (SAM) for Pesticide Risk Assessment*. 80 FR 43086. July 21, 2015. Docket No. EPA-HQ-OPP-2015-0424.

Dear Dr. Jenkins:

CropLife America ("CLA") appreciates the opportunity to review and provide the attached comments on the project to *consider and review Development of a Spatial Aquatic Model (SAM) for Pesticide Risk Assessment*, proposed by the United States Environmental Protection Agency ("EPA" or the "Agency"). Established in 1933, CLA represents the developers, manufacturers, formulators and distributors of crop protection chemicals and plant science solutions for agriculture and pest management in the United States. CLA's member companies produce, sell and distribute virtually all the crop protection and biotechnology products used by American farmers.

CLA represents the interests of its member companies by, among other things, monitoring legislation, federal agency regulations and actions and litigation that impact the crop protection and pest control industries, and participating in such actions when appropriate. CLA is committed to working with EPA, as the primary federal agency responsible for the regulation of pesticides, to encourage practical, science-based regulation of its members' products. CLA would welcome the opportunity to discuss these comments in greater detail. Feel free to contact me at 202-833-4474 or jcollins@croplifeamerica.org.

Sincerely,

Janet E. Collins

Janet E. Collins, Ph.D., R.D.
Senior Vice President, Science and Regulatory Affairs
Attachment: CLA's comments to Docket No. EPA-HQ-OPP-2015-0424-0001

Review of the USEPA Spatial Aquatic Model (SAM)

Waterborne Environmental, Inc.

897-B Harrison Street, S.E.

Leesburg, Virginia 20175

and

Stone Environmental, Inc.

535 Stone Cutters Way

Montpelier, VT 05602

Sponsored by CropLife America

September 11, 2015

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1 EXECUTIVE SUMMARY

The Spatial Aquatic Model (SAM) represents a long-needed advancement in pesticide aquatic exposure modeling by accounting for the spatial variability in key environmental conditions, including soils, topography, land use, and weather, in estimating pesticide concentrations at the watershed scale. The spatial resolution at which exposure predictions can be generated is far superior to the current approach used by the US EPA's Office of Pesticide Programs (OPP) in making pesticide exposure predictions for ecological and human health risk assessments. While SAM's concept of a spatially distributed watershed scale model for both screening level and refined exposure modeling moves OPP in the right direction, there are several aspects associated with the model's development approach, current assumptions, and functionality that should be addressed.

1. In developing SAM, OPP has taken a single field scale model (PRZM) and transformed it into a spatially distributed watershed scale model designed to simulate watersheds ranging in size from tiny headwater catchments to the Mississippi River. It is unclear why it was necessary for OPP to develop a new watershed scale water quality model from the ground up when multiple such models have been in use and under continued development and support by academic, government, and private industry scientists for several decades. Spatially distributed watershed scale models, such as SWAT, HSPF, and MIKE-SHE, have been in use and under continued development and support by academic, government, and private industry scientists for several decades. These models simulate both land surface and in channel chemical and sediment transport processes and have fully developed hydrologic components that simulate the dynamic responses of surface runoff, lateral flow, and baseflow. Hydrologic flow routing, which accounts for connectivity of catchments and channel characteristics (geometry, slope, roughness) in determining travel times and flow volumes, is also a fully developed component of these models. These existing models have also been used in the simulation of pesticides in flowing water systems and reservoirs. As part of the justification for building SAM, a thorough review of the existing state of the art science and comparisons of SAM to the existing watershed scale models should have been conducted. If currently available tools did not meet OPP's requirements, then consideration should have been given to the option of building upon the sound foundation of these models to meet the requirements. Alternatively, the standard PRZM used in current assessments has been used in loading to other surface water systems models (VVWM, RIVWQ, SWAT, EXAMS) and methods could have been explored that maintained the field level functionality and familiarity with a more robust routing and transport model system.
2. To meet the requirements of a refined pesticide exposure modeling assessment, the available options for simulating pesticide applications both spatially and temporally should be expanded. This includes the ability to specify multiple application methods per crop per season, specifying different application patterns on different crops in a single simulation, and more flexible options for defining pesticide application windows to cover multiple applications per crop. Weather and

field conditions should also be considered in refining the application timing. Some of the key tools required for pesticide management, such as best management practices and complex labels, should not be excluded reduced for the sake of computational simplicity.

3. Several important pesticide transport and environmental fate processes are currently not accounted for in SAM. These processes include, erosion, sediment transport, pesticide spray drift, and aquatic degradation and benthic layer deposition and re-suspension. These processes will need to be incorporated into the model and validated against monitoring data before final conclusions concerning the suitability of the model can be made.
4. Rigorous comparison of model predictions at appropriate scales and with best available representation of the agronomic, soil, weather, and application data for the corresponding monitoring data should be made at each phase of model development. . We recommend following the best practices for model evaluation described in the 2009 Agency-wide guidance on the development, evaluation, and application of environmental models to make this comparison.
5. How SAM will be used in ecological and human health risk assessments has not been well defined at this point in time. Until this is better understood, it is difficult to assess whether further improvements in model representations (increasing model complexity) will lead to better performance in meeting modeling objectives (uses) and/or the outputs provided by SAM will be sufficient for such assessments. However, the outputs available from the currently available alpha 1.0 version would need to be expanded upon if SAM is to be useful in refined aquatic exposure risk assessments. In particular, a written statement of modeling objectives for all intended regulatory uses, including endangered species assessments, should be developed.
6. The detailed comments and recommendations on the SAM model interface, spatial data compilation, conceptual model assumptions, and outputs provided in this review of the SAM SAP documents are intended to improve the eventual implementation of a spatially explicit watershed scale pesticide fate and transport model used by OPP in aquatic pesticide exposure risk assessments.

2 BACKGROUND

The objective of this document is to evaluate the current US Environmental Protection Agency (USEPA) Spatial Aquatic Model (SAM) tool. The SAM tool is currently available online and is described to be in the alpha stage of development. This indicates that many functions may not be present and the tool may not be fully functional or perhaps not include appropriate hydrologic and chemical transport processes that are critical for a higher-tier modeling approach.

This evaluation of the SAM tool includes an evaluation of the existing User Interface, the model documentation materials, and comments and recommendations on the assumptions the Agency is using with the spatial data in the system. The currently available documentation that exists for SAM dates from the October 2014 workshop hosted by EPA, with limited additional materials (recorded presentations) from the April 2015 workshop, Exposure Modeling Public Meeting (EMPM) from April 28th, 2015, and a presentation at the ACS National Meeting in Boston (August 2015), and the Federal docket leading to the September SAP meeting. Missing in the docket were some of the identified spreadsheets that would have allowed a more detailed quality assurance focused review as well. This document provides comments on the user interface, underlying assumptions and equations as documented, data sources, and output concluding with general recommendations. Each section generally contains comments and recommendations for refinements felt to improve the eventual tool implemented by USEPA for pesticide exposure assessments. Finally, although potentially premature given the current state of model development, an example comparison of appropriate monitoring data and modeling results is provided to add to the examples found in the official documentation.

3 EVALUATION OF THE SAM INTERFACE (VERSION ALPHA 1.0)

3.1 SAM OVERVIEW PAGE – DESCRIPTION TAB

- Review reference: http://qed.epa.gov/ubertool/sam
- Comments:
  - Too much information on one page
- Recommendation:
  - Organize information into sections for clarity and easy understanding

3.2 SAM USER LOGIN PAGE

- Review reference: http://qed.epa.gov/ubertool/login?next=/ubertool/sam/input
- Current status:
  - The SAM tool currently can be accessed with a username and password that is available only thru request
  - Current username and password is generic
- Recommendation:
  - Provide an option for new user to signup
  - Runs should be confidential and only available to the specific user. This is critical, because otherwise it is viewed as a potential tool that can be used to review ongoing efforts by users. This is considered undesirable.

3.3 SAM INPUTS PAGE – CHEMICAL INPUTS SCREEN

- Review reference: http://qed.epa.gov/ubertool/sam/input
- Current status:
  - Only Koc (Kd) and aerobic soil half-life chemical properties can be input into the current version.
- Comments:
  - The user can choose a scenario or make a custom scenario. Currently the default stored scenarios are all related to a chemical and crop. It seems counter-intuitive that the crop would be relevant during the chemical properties description. The use of stored chemical data suggests an authoritative source for this information. What will be the process to update the stored parameters when new studies are completed?
  - Sorption coefficient (mL/g) accepts text input for character “e”; should limit to only ‘numeric’ input
  - The ‘Clear’ button does not work. What is its use in comparison with ‘Defaults’ button?
  - User Manual notes: “Note: Half-life does not include soil photolysis (which usually is not an important degradation pathway), pH-dependent hydrolysis (which can be important for some pesticides, such as organophosphorus or N-methyl carbamates), or foliar interception or dissipation.”
- Recommendation:

- The selection of a crop to determine the extent of application use site is available as an input under the Application/Crop Groups input and need not be part of the chemical inputs.
- Allow user to provide foliar degradation and water degradation half-lives
- Check for errors with data inputs (error handling)
- Set lower bounds for Sorption coefficient and Soil metabolism half-life input values so a value less than 0 cannot be entered.
- Have 'clear' button empty the custom values entered

3.4 SAM INPUTS PAGE – APPLICATION CHOICES SCREEN

- Review reference: http://qed.epa.gov/ubertool/sam/input
- Current status:
  - Total number of crop groups used in simulation varies by each crop and is fixed.
  - Only 13 crops listed for simulation: corn, cotton, soybeans, wheat, vegetables, orchards, ground fruit, grapes/vineyards, pasture/hay/forage/grass, other grains, other row crops, other trees, and other crops. The total number of individual crops represented by the selected groups is updated based on selections.
  - User can choose multiple crops
  - Only ground and foliar application method options are available, the User Manual acknowledges that additional methods may be added in subsequent versions. Only one method may be selected even though there may be different methods required for different crops or for the first app versus subsequent apps.
  - User can input number of application per year, application rate, first application date, time window, three choices of application window (uniform, uniform step, triangular application), and percent applied.
  - The application tab does not include application timing intervals if multiple applications are made.
  - Only one application rate is allowed so this would apply to all crops and all applications in a series.

- Comments:
  - Number of crops is based on crop selected, the 'total number of crops' value cannot be changed. It's confusing that this looks like a field that can be edited but it is locked. It would also be nice to know which crops (CDL classes) are included in a group.
  - 'Number of apps per year', 'app rate', 'time window (days)' and 'percent applied' – input boxes accepts text input for character "e", should limit to only 'numeric' input
  - 'Percent applied' accepts input value greater than 100
  - Currently, only one application timing method "Uniform step application over window" can be simulated. When any other application timing is selected, it defaults to using "Uniform step application over window".
  - The number of windows do not correspond to the number of apps or an interval between apps. The percent applied in the two windows is supposed to add up to 100 but is not enforced or validated. The option is limited in that it assumes that window

#2 begins immediately following window #1, when in reality, there may be periods of time between windows where no applications are occurring.
    - The number of applications should be straight-forward but it is unclear how this information is actually used when the only refinement available is a uniform step window. With uniform applications, the number of apps is conceptually infinite because the apps are applied all day every day.
    - The 'Clear' button does not work.
    - The default button clears the crop, total number of crops time window and percent applied but resets the number of applications, application rate, first application date, and application method.
- Recommendation:
    - Make apparent to the user the significance of the 'total number of crops' value. It's in the documentation that it refers to the CDL classes but not obvious to the user. Make the user aware of what included in the grouped crops (e.g. vegetables or ground fruit).
    - Change total number of crops formatting so it does not look like a model input, provide information about which crops belong to a group, could be in a separate link.
    - Different application methods (incorporation, soil injection, t-band, etc.), and granular application method should be included.
    - More input flexibility should be included for specifying which methods apply to each crop and application when there are multiple in a series. Additionally, different types of application may be made to the same crop depending on the timing.
    - Applications on specified dates or relative to crop growth dates options, and application refinements like applying once every other year should be provided
    - Provide more flexibility in the rate input options. This would include specifying different application rates for different crops simulated, and for different applications made to the same crop (such as a pre-plant application and a post-emergent application).
    - In order to allow multiple applications per year, an input for the application interval must be added. Furthermore, some pesticide use patterns with multiple applications per year have different intervals between each application. The interface will need to be modified to accommodate these types of use patterns with variable application intervals.
    - Random sampling of application dates within the specified window would better simulate reality, in which unique pulse applications occur on different days and different fields from year to year, and would better satisfy label requirements for interval, number of apps, and pre-harvest interval. An even more flexible option would be to allow the user to enter in multiple windows and assign a probability of application to each of those dates. Application dates across the watershed can then be selected based on the probability of each window and then random sampling of dates within each window. An intermediate improvement to the step window option would be to calculate and update the percent applied in the second window based on the percent applied in the first window and allow the user to define an interval between the two windows.

- The lumped categories (e.g. vegetables, orchards, etc.) should have further refinement in the future since the crop timing can be very different for individual crops.
- Irrigation is not available yet so it's not clear which input screen would allow this input. Provide the user with the option to turn on irrigation.
- Fix the clear and default buttons

3.5 SAM INPUTS PAGE – SIMULATION CHOICES SCREEN

- Review reference: http://qed.epa.gov/ubertool/sam/input
- Current status
  - State/Region choice is only Ohio Valley at this time
  - Three choices for simulation type: Eco, DW Reservoirs, DW Flowing
  - Start date starts 01/01/1984 and default end date should be on 12/31/2013, but the end date could be extended to 06/02/2014.
- Comments:
  - It appears that the State/Region will be a drop down list. If not, how will the user know the names that are recognized?
  - 'Sim type' options grayed out – only ecological assessment option is available in the current version. Placeholders for drinking water assessment exist for future enhancements.
  - For custom chemical, the interface allows the start dates to be entered that correspond to dates far in the future (e.g., 1/1/2020_ or in the distant past (1/1/1900). The user can't go beyond 06/02/2014 on the end date or before 01/01/1984.
  - The user can choose an ending date that's before the start date.
  - The 'Clear' button does not work.
  - The 'Defaults' button reset the start and end dates but unchecked the "Sim Type" and the user can't select a "Sim Type" anymore
- Recommendation:
  - Have 'Simulation type' option show which simulation is being run by default
  - Fix the clear and default buttons
  - Provide reasons for the bounds set for start and end dates.
  - Do not allow user to choose an end date prior to the start date. Error checking should be added to guard against this and potential errors that may result.

3.6 SAM INPUTS PAGE - OUTPUT CHOICES SCREEN

- Review reference: http://qed.epa.gov/ubertool/sam/input
- Current status:
  - For default scenario, all the choices are locked down.
  - Output preference choices include daily concentrations and time-average results. Currently the daily concentrations are grayed out for custom users.
  - Custom user can select the average period but can't choose between time-average concentrations or toxicity exceedance.
  - In the custom run, the averaging period can be changed

  - Custom user can input a threshold value and select different threshold options but can only select one.
  - Custom user can check multiple output formats (generate CSVs, generate map, or plots/histograms)
  - User can input number of concurrent processes and number of process multiplier

- Comments:
  - If default chemical is chosen, no options are available to choose or change on this screen
  - Only time-averaged concentrations are available for output. A placeholder for daily concentrations exists, but does not run.
  - The user can input "0" as an averaging period. However, when the submit button is hit, an error message is given that the value has to be greater or equal to 1. It automatically changes this number to '4' and won't let the user change it to another number.
  - For pre-set runs, the option for averaging period on the interface is grayed out and defaulted for 4-day but the results (CSV) are only generated for 21-day and 60-day averages
  - There are currently four options for the type of threshold. Only one can be selected at a time.
  - What does 'Number of concurrent processes' and 'number of processes multiplier' mean? This input is currently not functional.
  - The 'Clear' button does not work. What is its use in comparison with 'Defaults' button?
  - Option to save metadata exists in the custom run only. If that button is checked, the user is asked to enter metadata to be saved with model run. It's not clear what metadata choices are available.
  - Output options include CSVs, maps, plots or histograms – works only with pre-set runs, but not with custom runs.
  - It is not clear from the interface what information the CSVs, maps, or plots/histograms contain prior to running the model.
  - Submit button for a default chemical scenario
    - runs very fast and provides results quickly
    - results available for visualization on map, but map legend is missing
    - results also available as charts, but chart legend is missing
    - can download a ZIP file with model results as CSV
    - user can drill down on map for more details in table form on smaller catchments on an annual basis
  - Submit button for a custom chemical scenario
    - a message comes up indicating the model is running successfully and not to refresh the page to prevent duplicate results
    - without page refresh, the tabular data (for download), map and charts do not show up
    - even after a considerable wait time, the results do not show up on the page

    - Cannot download PDF and HTML results. Clicking the links for both options show a "File not found – Interstate 404" error page (http://qed.epa.gov/ubertool/sam/html)

- Recommendation:
    - CSV output should include metadata on fields and what each tabular field represents
    - Daily concentrations should be made available.
    - The interface and model output processing should be modified to allow all exposure durations to be reported in a single set of output.
    - Map and chart outputs do not have a legend
    - If the user has the .csv with the concentrations or thresholds then may want to quickly see the location on the map. Therefore, an option should be made to allow the user to type in catchment ID of interest for zooming in on the map.
    - Allow user to select multiple outputs at a time (e.g., both daily concentrations AND time-averaged results).
    - The ability to select multiple threshold types to be included as the model output would be desirable, as would more than a single threshold level.
    - Some help buttons or tool tips that describe the contents of each of the output formats (CSV, plots/histograms, and maps) would be helpful.
    - 'Number of concurrent processes' and 'number of processes multiplier' should not be user input. The processing load required by the job submitted should be managed server-side and designed to optimize the performance for each user given the computational resources available.

3.7 SAM ALGORITHMS PAGE

- Review reference: http://qed.epa.gov/ubertool/sam/algorithms
- Current Status:
    - Nothing on this page
- Recommendation:
    - Select key algorithms from the documents and add here
    - Add a section demonstrating model verifications done to assure model components are correctly assembled into SAM model

3.8 SAM REFERENCES PAGE

- Review reference: http://qed.epa.gov/ubertool/sam/references
- Current status:
    - Has only the user manual dated 04/21/2015
- Recommendation:
    - Post all SAM related documents and presentations from EPA workshops and conference presentations here
    - Any peer review publications (e.g., Carleton, 2015) related to SAM could be posted here

3.9 SAM QA/QC PAGE

- Review reference: http://qed.epa.gov/ubertool/sam/qaqc
- Current status:
  - Only has "Run QAQC" listed
- Comments:
  - If you click on 'Run QAQC' text on this page, the user it's a message that it's running QA/QC and then the text "Run QAQC" goes away and the page is blank.
  - .pdf and .html download buttons don't work
- Recommendation:
  - Details of QA/QC of SAM results (e.g., flow, concentrations) presented at USEPA workshops could be posted here

3.10 SAM BATCH PAGE

- Review reference: http://qed.epa.gov/ubertool/sam/batchinput
- Current status:
  - The text says to 'Please download, fill, and upload this CSV file for batch calculation and allows the user to browse files to upload then submit the batch.
- Comments:
  - The link to 'Please download, fill, and upload this CSV file for batch calculation.' does not work and takes to a "404 not found" page
  - User can browse a file to upload – no guidance on the contents and format of this file
  - With no standard file or guidance on input file, 'Submit Batch' button is irrelevant at this time
- Recommendation:
  - Provide a 'template' file that could be used to provide model inputs
  - Provide guidance on what could be run in 'batch' mode and how

3.11 SAM USER HISTORY PAGE

- Review reference: http://qed.epa.gov/ubertool/sam/history
- Current status:
  - No description on the table of run history is provided, just user, time and run type and a link to view (download or open) data.
- Comments:
  - This tab takes a long time to load and appears to show all runs from all users with a download link.
  - When the view link is hit, sometimes there is a .csv file and sometimes it's empty.
  - The contents of this file could not be validated because there are no descriptions of the data or metadata provided.
  - 'View' button launches only one of the CSV outputs provided by the model, the other three CSV outputs that are part of standard output download is missing
- Recommendation:
  - Provide information on how to identify and retrieve historical runs made by a user
  - Inconsistency in the available files for download

- Make sure all available runs can be downloaded
- Have user label each run, so it can be identified and downloaded from this site
- This should be "secure" in the future so that only the user has access to these data. How will privacy be ensured for all the different users of the tool? Will EPA have access to runs submitted by registrants? Users should have private accounts for running the tool that allow them to return to view their completed results.

3.12 SITE NAVIGATION

- Comments:
  - The user needs to remain on the same page with the browser open and cannot refresh it in order to obtain results. It is not clear how the user is notified when results are ready. It is also not clear whether parameters submitted with the job were valid and the model execution is being carried out properly.
- Recommendation:
  - Users need more feedback from the app and should not be required to stay on the page for results. Users should also be given an estimate of the time it will take for processing to complete along with confirmation that they have submitted a job with valid parameters. Users could provide an email address to receive notification for when results are ready.

3.13 OVERALL INTERFACE COMMENTS

- Need unique user login permissions
- Need to set bounds (upper and lower) for input parameter values
- The up/down arrows for changing input values are cumbersome. The values are not validated for obviously impossible values such as negative numbers. The down arrow can be used to get negative application rates and number of apps, for example. Validation against simple ranges of possible values should be added to save the user from making a costly mistake and not realizing until results are returned.
- Need error handling to check for errors in data entry.
- Provide a "help" or "?" link beside each input field that provides brief information on the variable with an example value, such as 'tooltip' help.
- User should be able to name and save his/her simulation runs for easy retrieval.
- Have the SAM model version number on each output, so user knows what version was used for the simulation run. Users will also need access to older versions of SAM to be able to reproduce EPA results.
- Not sure if the "system administrator" has access to all runs made by user
- User should be able to delete his/her run(s). If the run(s) are deleted, are they completely removed from USEPA and user's servers?
- Outputs generated from default runs should have metadata and legends for maps/charts
- Outputs are not generated when custom chemical simulation run is made
- Provide an option to download all input data (spatial and tabular) used by SAM to create the final results, will help user better understand the data and put the results to context. If this is

technically challenging then provide an option to download all input data for the priority catchments (those falling in the 90%ile range).

4 EVALUATION OF ASSUMPTIONS USED IN SAM

4.1 HYDROLOGY ASSUMPTIONS

- Review reference: SAM Background Document (2015) and Thurman et.al.(2014)
- Comments:
    - NHDPlus version 2 dataset (termed NHDPlus subsequently) is used in SAM for river/stream networks, waterbodies, catchment boundaries, and mean monthly flow and velocity data associated with the stream network.
    - SAM alpha 2.0 uses NHDPlus catchment boundaries as the spatial unit of analysis, in comparison to the larger HUC-12 boundaries used in SAM alpha 1.0
    - In SAM alpha 2.0, Super PRZM Hydro aggregates daily runoff and pesticide loadings at the NHDPlus catchment level, weights it by area, and estimates daily pesticide concentrations in receiving waterbodies (at pour point).
    - In SAM, Super PRZM Hydro processes each NHDPlus catchment by summing the scenarios' daily runoff, weighted by area, to produce a daily time series of total runoff
    - Daily mean pesticide concentrations in receiving water bodies are calculated by SAM using the daily mass transported by runoff, receiving waterbody volume (at pour point) and flow rate.
    - SAM model simplifies the top 2 cm of the soil profile as a single compartment with uniform flow and mass distributions. This is in contrast to PRZM3 and PRZM5 which utilize a multi-compartment conceptual model with non-uniform flow and pesticide mass distributions. The SAM Background Document (2015) states that the pesticide transport results were insensitive to these two conceptualizations of the surface soil layer. Some evidence to support this is provided through graphical comparisons in Appendix 2-B. However, no quantitative or statistical analyses are provided to allow reviewers to judge the stated insensitivity.
    - For lotic waterbodies (e.g., streams, rivers), waterbody volume is estimated as reach cross-sectional area (derived from NHDPlus version 2) multiplied by a representative length of 40 meters. This value of 40 meters is based on a "mixing cell" concept to account for longitudinal dispersion in rivers. The 40 meter length is several orders of magnitude smaller than the actual stream lengths for NHDPlus catchments (the watershed scale of the SAM pilot project). The SAM Background Document (2015) acknowledges the small water body volume that results from this assumption relative to the daily flow rate. However, the effects of this assumption on simulated pesticide concentrations are not clearly presented for watersheds of different drainage sizes, and are only partly addressed in the discussion on water body concentration calculations and the washout dissipation rate constant.
    - For lentic waterbodies (e.g., reservoirs, lakes) waterbody volume estimates were developed by EPA's Office of Research and Development. Information on the reservoir volume estimation method, or a table of reservoir volumes versus drainage areas were not provided for review.

- Monthly mean base flows in receiving water bodies are estimated as the difference between monthly mean flows (from NHDPlus) and long term average daily watershed runoff (from Super PRZM Hydro). Daily runoff values are added back to monthly mean base flows, generating a daily hydrograph at each modeled location. The hydrographs account for peaks and lulls in daily flow which is not captured in the monthly variability. Example hydrographs demonstrating the combining of NHDPlus-derived base flow and PRZM-based daily surface runoff were not provided. Comparisons of predicted daily hydrographs to measured stream flow data were not provided.
- SAM alpha 1.0 predicts exposure concentrations at individual HUC-12 watershed as a discrete unit, i.e. each watershed is considered separately. There is no downstream routing of flows and pesticide mass in this version of SAM.
- In SAM alpha 2.0, stream routing is set for a daily time step due to the PRZM model temporal scale limitations (i.e., based on the CN method at daily time steps) and lack of comprehensive stream data (e.g., cross section, hydraulic and stream properties, etc.). The proposed approach (Carleton, 2015) is based on a hybrid method (data- driven and conceptual) using an impulse response function (IRF; defined from a probability density function -pdf), and then routed in space and time based on an exponential decay process. This approach may fit well on non-reactive constituents (or low sorbing constituents) where the IRF pdf is well known under hydrological conditions that fit within the model time step (daily expected travel time). However, it is well known that travel-time estimations are problematic and the equations were originally derived to target problems where hydrograph peak responses were important (e.g., design of hydraulic structures, flooding assessment, etc.) for land-uses commonly outside agricultural dominated watersheds.
- It was unclear whether the IRF approach to routing flow and pesticide mass to downstream catchments would also be applied to temporally distribute loads within individual headwater catchments, assuming a model daily time step, would be relevant to headwater catchments with travel times of greater than 1 day.
- A risk assessment of dissolved chemicals may be a function of different processes due to the fact that routing of water flow and chemical mass transport at any single point in the watershed stream are governed by mechanisms that are dissimilar. In addition, in the approach used in SAM alpha 2.0, there are unaccounted for transport drivers (i.e., model structural uncertainty) that may result in undesired simulated concentrations (under or over estimation) to specific daily aggregated watershed outlets. To overcome all of these issues, the routing time step may need to be shorter than the model time step (daily) and should incorporate simulation of other important processes (e.g., surface-subsurface water interaction; pools) which implies new model inputs and possibly adjusted computational processes and structure.

- Recommendations:
  - Pesticide loadings from sediment transport and spray drift are not taken into account in both versions of SAM (alpha 1.0 and alpha 2.0). Additionally, pesticide fate in waterbody (e.g., in stream degradation, sorption to sediment, and other removal mechanisms) is not taken into account in these versions. It is important to identify efficient and representative approaches corresponding to the expected temporal and spatial model scale. Since erosion

and spray drift are expected to be more important near receiving water bodies, landscape (slope, erodability, soil type, etc.), management (presence and type of BMP, application technology, etc.), and environmental factors (rainfall, crop presence/absence, sediment burial, etc.) should be considered in the development and implementation of these two processes.

- Provide quantitative/statistical comparisons of results from SAM (using a single mixing cell) and PRZM5 (using 10 sub-compartments) that show the similarity discussed in SAM Background Document (2015) to supplement the graphical comparisons provided in Appendix 2-B.
- The 40 meter representative length for flowing water bodies is not analogous to an actual stream length within an NHDPlus catchment. The conceptual differences need to be better described. Because the 40-meter length is used in the water body volume calculation and the subsequent pesticide concentration calculations, the sensitivity of concentrations to a range of values for this length should be provided, as well as additional justification for selecting 40 meters.
- Spatial aggregation of runoff and pesticide load at the daily time-step seems logical, but may over-estimate exposure if overland flow and stream routing within a given sub-basin require a temporal lag. The daily time-step assumes that hydrologic processes and associated chemical transport are adequately represented; however, for smaller catchments, this may not be an adequate assumption – especially in low dilution, rapidly flowing systems. Careful examination of appropriate model temporal and spatial scale should be done to better interpret cases when exposure estimates may be less reliable.
- The SAM Background Document (2015) references a US EPA ORD dataset of reservoir volumes estimated from surrounding topographic data. We suggest that this volume estimation approach be described in more detail and that the ORD dataset be made publically available for review.
- Daily hydrographs are constructed from a monthly base flow volume plus a surface runoff component from PRZM. Some examples of these daily flow times series compared to observed hydrographs (e.g., from USGS gage stations) should be provided in order to assess the appropriateness of the method.
- The NHDPlus dataset used in SAM alpha 2.0 is available nationwide, but has limited accuracy – especially for lower-order watersheds. This uncertainty should be accounted for in some fashion when incorporating mean monthly flow and velocity into the modeling process. Additionally, the use of mean monthly flow and velocity is a step in the right direction, but variance around this mean value would be helpful to understand the potential impact of the temporal scale and associated potential effects.
- SAM alpha 2.0 uses NHDPlus catchments compared to the larger HUC-12 watersheds used in SAM alpha 1.0. The decision to change spatial scale is not explained. Furthermore, it is not clear how the spatial scale affects SAM output exposure estimates.
- As the IRF routing used in SAM alpha 2.0 is similar to a tank conceptual model ($Q = Q_o e^{-tk}$) commonly used in flow problems (e.g., tank cascade models), improvements can be achieved by the addition of a second exponential decay term to represent photo- or bio-degradation as well as an additional sorption/desorption term (additional tanks). Another approach may be to incorporate other routing models such as RIVWQ (Waterborne

Environmental, 2015) or SWAT (USDA), both physically-based hydrodynamic river models that account for flow routing and in-channel chemical processes, or a cell to cell conceptual aggregation.

- Routing in reservoirs is not accounted for in the proposed SAM alpha 2.0 and will result in disagreements for watersheds in which lakes and reservoirs are present. Reservoirs and lakes are hydrological stream flow "circuit breakers" with problematic dynamics (flow, chemical, and biological processes) acting as potential constituent pool or sinks. Sediment deposition in lakes/reservoir is an important source of constituent sorbed mass to benthic zones even if K_{oc} is small. On the other hand, along streams, this phenomenon may be less important as most of the sorbed constituent commonly travel attached/sorbed to fine soil sediments (organic/inorganic particles) as suspended loads and bed load resuspension is common during rainfall events. Note that in SAM, benthic constituent pools are not accounted, and that degradation/transformation/contribution is not simulated within streams/lakes/reservoirs. A reservoir routing model that takes into account these hydrologic, sediment, and chemical processes will need to be added to SAM in order to correctly model pesticide fate in these types of water bodies and in flowing water systems that contain them.
- The current implementation of SAM, includes daily-varying surface runoff contributions at the NHDPlus catchment scale, and monthly varying base flow contributions to total streamflow. Depending upon geographic region, base flow (shallow groundwater contributions to streamflow) accounts for between 20% and 65% of total annual streamflow. This base flow component, plus shallow sub-surface flow (interflow or lateral flow), represents the majority or total flow in many regions, and because its dynamics are driven by storm events, can vary significantly on a daily time scale. Because simulating pesticide concentrations is heavily dependent on simulating accurate water volume, incorporating of a time-varying base flow/interflow component to the flow predictions in SAM would be a valuable addition to the approach.

4.2 Pesticide Application Assumptions

- Review reference: SAM Background Document (2015)
- Comments:
  - Application Rate: Based on the alpha 1.0 version and the SAM Background Document (2015), it appears that only a single application rate is possible for a given simulation. For many pesticides, applications at different rates may occur in the same year.
  - Application Interval/Number of Applications: The alpha 1.0 version allows users to define the number of applications per year, but there is no input for the application interval (days between applications). An application interval is necessary to accurately describe the pesticide application pattern allowed on the label.
  - Application Method:

- In the alpha 1.0 version, only two types of application methods are available as options (ground or foliar). Some pesticides will require additional application methods in order to simulate labeled uses properly.
- Only 1 application method can be selected at a time for a given simulation, however, multiple application methods may be used for the same pesticide at different times during the season.

- Application Extent:
  - In the alpha 1.0 version, multiple crop groups can be selected to receive applications, however, the same application characteristics (rate, number of applications, timing) is the same for all crops. For many pesticides, when conducting a multi-crop assessment, the application characteristics will vary by crop.
  - The alpha 1.0 version and SAM Background Document (2015) appears to assume that 100% of a selected crop(s) receives the defined pesticide application pattern. At the watershed scale, this will be a false assumption for even the most widely used pesticides.
- Application Timing: The SAM model acknowledges that at the watershed scale, pesticide applications will occur at different times on different fields. The SAM alpha 1.0 version provides 3 methods by which applications can be spread across an application "window". These include a uniform distribution, step distribution, and triangular distribution. An additional method to define an application window based on empirical crop progress date reports (CPRs) and a growing degree day (GDD) crop growth model has been proposed as a future enhancement to SAM. This proposed method is suited to pesticides that are applied relative to crop management/crop growth stages. Spreading applications over a range of dates is necessary to capture the appropriate agronomic variability across a watershed, however how this variability is captured in the modeling needs careful consideration.
  - Although not stated explicitly in the SAM Background Document (2015), it appears that the application window is incorporated into the simulation by applying the pesticide at a reduced rate over all of the target crop(s) area. This is in contrast to applying pesticide at the intended application rate to a fraction of the crop(s) in the watershed on each day during the application window. The later example (applications at intended rate over a fraction of the crop(s) each day) is how applications happen in reality. The apparent SAM approach is a convenient simplification, and it is not known how this simplification affects the resulting concentration simulations.
  - The application window methods in both the alpha version and the proposed methods based on CPRs and a GDD model seem to be designed to simulate a single application per year. For cases where multiple applications are allowed (e.g., a pre-plant and a post-emergent), multiple application windows will be required.
  - The current application window method does not account for restricting applications on rainy days. Some pesticide labels include rainfall restrictions, and for

all pesticides, applications on days with significant rainfall are less likely. Adding options for constraining application based on daily rainfall would be a valuable and practical improvement.

- The current implementation of the CPR/GDD application window treats all cropped areas in a given region (state) equivalently when distributing the pesticide application over time. However, in practice, field conditions dictate which fields will be worked earlier versus later in the season. To a large extent, soil moisture, driven by local weather, soil, and slope conditions, will determine how soon a field can be tilled, planted, and pesticide applied. Accounting for these factors will lead to a more accurate spatial and temporal distribution of pesticide application dates across watersheds of varying scales.

- Recommendations:
  - Application Rate: SAM should allow for different pesticide application rates for different applications and different crops during a single season.
  - Application Interval/Number of Applications: SAM should allow for one or more application intervals to be defined. Application intervals may vary for the different types of applications throughout a single season.
  - Application Method: Additional application methods, analogous to those available in the Surface Water Concentration Calculator (SWCC) should be added to SAM. In addition, multiple application methods should be allowed within a single season.
  - Application Extent:
    - SAM should allow pesticide application patterns to vary by crop.
    - The percent of a crop treated (PTA) should be an added input in order to run refined assessments.
  - Application Timing:
    - An evaluation of the effects of distributing a target application across all treated areas over an application window versus treating different areas at the full application rate at different times throughout the application window should be conducted.
    - The current application window concept in SAM should be extended to allow the definition of multiple windows for multiple applications within a single season (e.g., a pre-plant window and a post-emergent foliar window).
    - An application constraint for rainy days should be added. This constraint should include a daily rainfall depth threshold, where applications would not be allowed when rainfall exceeds the threshold depth for the day. Optionally, a probabilistic reduction factor could be incorporated that reduces the likelihood of an application on a rainfall day by a value less than 100%.

        - The use of application windows to define application timing can be refined to incorporate additional information on local weather, soils, and slope to prioritize which crop areas are planted and receive pesticide applications first. This priority would be driven by field workability, using soil moisture as a surrogate.

    - Additional recommendations concerning application inputs from a SAM user interface perspective are provided in Section 3.4.

4.3 Environmental and Chemical Fate

- Review reference: SAM Background Document (2015)
- Comments:
    - The SAM Background Document (2015) indicates that the landscape pesticide transport processes and conceptual model are similar to PRZM5 with the exception of the soil discretization which has been simplified. The SAM Background Document (2015) does not provide any calculations or references for the fate processes other than runoff so they were hard to evaluate.
    - The PRZM model being used in SAM has been reduced from a one-dimensional vertical soil profile to a zero dimensional box model of the first 2 cm. Processes in the first two centimeters determine how much pesticide mass will be available to runoff.
    - The status of erosion algorithms in SAM is unclear because several different sources provide conflicting information. In table 1 on p. 27 of the SAM Background Document (2015), the first row "Pesticide fate in catchment" indicates that erosion from the surface compartment is "Not yet implemented." In the same table, on p. 27, the fourth row "Pesticide inputs to water", indicates both pesticide mass flux in runoff and sediment are included. Under proposed updates, the SAM Background Document (2015), indicates the erosion algorithm currently used in SAM is MUSS (section 2.2.1, p.35), however different options are being considered that would be more scalable to the watershed level. On the other hand, the transport equation described in Appendix 2-A; Section 2 (SAM Federal Docket; 2015) does not include pesticide losses due to erosion.
    - Pesticide off-site transport to receiving water bodies due to spray drift is not currently accounted for in SAM.
    - The transport equation described in section 2 of Appendix 2-A (SAM Federal Docket; 2015) is an ordinary differential equation describing the pesticide losses from the soil surface compartment. There are no positive terms on the right hand side of the equation, i.e. no sources of pesticide only sinks. This simplification assumes that the applied pesticide mass arrives instantaneously and may be added into the initial concentration for the day. This simplification allows for an analytical solution to the transport equation. In reality, the pesticide source term is a time-varying function with unknown magnitude and frequency. The solution to this more realistic transport equation would require numerical integration.

- Land fate processes included in SAM are: degradation in soil (with sorbed and dissolved degradation rates equal), leaching, adsorption to soil, and runoff, all for the top 2 cm of soil. 75% of the applied pesticide mass is available for transformation and transport.
- The alpha 1.0 SAM version does not account for foliar degradation, aqueous photolysis, hydrolysis, or volatilization.
- Leaching in Super PRZM-hydro seems to be a one-way sink for pesticide out of the box model surface layer – note that a key recommendation from the Oct. 28-31, 2008 SAP on Risk Assessment for Pesticides with Persistent, Bioaccumulative, and Toxic Characteristics was for EPA to move away from box models.
- Water body fate processes included in SAM are first-order washout only.
- SAM does not account for in-water fate processes such as degradation, deposition or resuspension of sediment-sorbed chemical, adsorption to dissolved organic carbon, uptake by aquatic plants, or benthic/limnetic exchange by diffusion, wind stress, bioturbation or other mixing processes.
- Pesticide mass in runoff is delivered to the water body instantaneously.

- Recommendations:
  - Documentation of assumptions and algorithms should be expanded and clarified. In particular, key equations in addition to the transport equation should be provided. Processes in addition to runoff should be documented, including leaching and degradation calculations.
  - The issue of whether erosion has been implemented in the current version of SAM and to what extent should be clarified. Upland erosion and in-stream sediment transport are important processes for pesticide transport and need to be accounted for using best available scientific principles and models for those processes.
  - Spray drift should be included as a source of pesticide mass in water body concentrations. The spray drift contribution should be based on actual proximities of cropped areas to the water body in question.
  - An evaluation should be conducted to compare the effect of instantaneous applications versus more realistic applications made over a period of time on surface soil and runoff concentrations of pesticide.
  - SAM should account for soil and plant fate processes like foliar degradation, photolysis and volatilization.
  - SAM should account for in-water fate processes including: degradation, deposition and resuspension of sediment-sorbed chemical, adsorption to dissolved organic carbon, uptake by aquatic plants, and benthic/limnetic exchange by diffusion, wind stress, bioturbation or other mixing processes.

- SAM should account for degradation of pesticide while it is traveling over land to the water body.
- Pesticide mass should be delivered to the water body over time, not instantaneously, following correct hydrologic principles.

4.4 Representation of Crop

- Review reference: SAM Background Document (2015)
- Comments:
  - In the alpha 1.0 test version of SAM, 13 different crops are available for selection. Crop rotations for each crop with other crops are automatically selected for a particular crop.
  - For each crop, key crop-related inputs are planting and harvesting dates (to provide a reference point for pesticide applications and to simulate canopy cover), maximum canopy cover and crop interception (for rainfall and pesticide applications), depth of the active rooting zone (to define the zone of water extraction from soil), and crop-specific USLE inputs (C-factor).
  - The active planting (or blooming) and harvesting dates for field crops, vegetables and fruits and tree nuts were taken from USDA Usual Planting and Harvesting Dates publications (USDA NASS (2010), USDA NASS (2007) and USDA NASS (2006), respectively.
  - The USDA Plant Hardiness Zone (PHZ) Map15 is used to split up the range of planting, harvesting, and blooming dates in geographic subdivisions within each state. The beginning of the range in planting dates is assigned to the warmest PHZ. The initial planting date is then adjusted to progressively later dates through increasingly colder PHZs.
  - Other crop-related inputs including canopy cover, rainfall interception, active rooting depth, and USLE factor were taken from a variety of sources, including the PRZM Manual (Carousel et. al, 2005), existing USEPA OPP standard crop scenarios, and USDA Crop Profiles (http://www.ipmcenters.org//index.cfm/center-products/crop-profiles).
  - If pesticide application timing is related to crop growth stages, using a realistic estimate of the planting and harvesting dates of the crop is important, since timing of application is a sensitive parameter.
  - To vary crop growth stages spatially and temporally, USEPA is exploring options including using empirical data such as USDA Crop Progress reports, where available, or crop growth (phenology) models such as growing degree dates (GDD) where data are incomplete.
  - Impact of using empirical data and empirical data + GDD model was tested for corn in MO and OH. The timing of simulated concentrations was matched much closer to measured concentrations when using this approach.
- Recommendations:

- GDD method has its limitations and therefore, sensitivity of using this method should be explored for different crops and regions.
- The GDD for corn hybrid varieties have different growth cycles than regular corn varieties, therefore GDD methods may not be applicable for hybrid crops. In these cases, alternative methods should be explored.
- The GDD method does not take into account soil moisture or soil workability and therefore has limits on applicability in some cropping systems and locations. A comparison with alternative crop growth models should be considered.
- SAM uses one planting date for an entire watershed. In reality, planting days are spread out in a watershed (particularly as watershed size increases), therefore, a method should be explored where planting dates should be distributed (triangular or rectangular) over time in a watershed to explore the distribution of planting, and matched with application rate also distributed (triangular or rectangular) over time. This distribution of planting and application dates is important to consider even at the NHDPlus catchment scale. Pre-running watershed recipes makes it challenging to explore probability of planting over time.
- An option for users to change planting and harvesting dates should be provided in the model. Again, pre-run watershed recipe makes is impossible for providing this option, since curve numbers and depth of ET (based on root depth) associated with crop growth dates are also affected.
- An application window over a single planting date in a watershed, might be problematic, as some applications might end up being bare ground and some will be foliar. Therefore, probability of varying in planting dates in a watershed should be explored.
- Simulating wide application windows relative to spatially and temporally simulated crop growth dates, seems like a good approach. But it still does not take into account rainfall timing. A tool such as the Pesticide Application Timing calculator (PAT) (FOCUS, 2015) to avoid application on rainfall day should also be included along with the ability to vary planting and harvesting days.

4.5 Assembly of Output

- Review reference: SAM Background Document (2015), SAM alpha version 1.0
- Comments:
  - SAM is capable of generating massive amounts of data including: 30-year time series of pesticide concentrations in runoff for different land/soil/weather combinations and 30-year time-series of dissolved pesticide concentrations in each NHDPlus catchment. However, information on the outputs that will be available and how they will be used in risk assessments was not included in the SAM Background Document.

- Additional comments regarding the currently available model outputs, based on the interface design, are provided in Section 3.6

- Recommendations:
  - EPA should clearly explain which outputs will be evaluated and how outputs will be used/interpreted in risk assessments. Any statistical aggregation of outputs (for example, 4-day average concentrations, or annual maximum distributions) should also be explained and justified
  - Additional recommendations regarding the currently available model outputs, based on the interface design, are provided in Section 3.6 and Section 6

5 EVALUATION OF THE ASSUMPTIONS USED IN THE SPATIAL DATA ASSEMBLY

5.1 CROPPING DATA – CDL

- Overall Review Reference: (Appendix 3-B and Supplement to Appendix 3-B (SAM Federal Docket, 2015)

5.1.1 Census of Agriculture

- Review reference : Table 12 –CDL Class Data Tables – Thurman et.al.(2014)
- Summary: The 2007 NASS Census of Agriculture (from EPA LOCATES) will be used, however the 2012 version is currently available. In addition, it doesn't appear that the crosswalk relating Census of Agriculture crops to the NASS CDL crop has been made publically available.
- Recommendation: Update Census of Agriculture to the 2012 version and make the crosswalk relating CDL crops to Census of Agriculture publically available for review and comment.

5.1.2 Five Years of CDL

- Review reference: Appendix 2 - CDL General Land Cover Class Groupings.xlsx spreadsheet; Table 1 – Thurman et.al.(2014)
- Summary:
  - There may be times when the five year CDL is appropriate, e.g., when one year vastly underestimates the acreage, such as vegetables in California.
  - Significant work has been conducted by various registrants, for instance, the Pyrethroid Working Group (PWG) and CLA committees, showing that five years of CDL is appropriate for identifying the "universe" of landscape level features associated with a crop such as soils, catchments or weather which fits nicely with the "watershed recipe" approach of preprocessing the spatial data.
  - The accuracy of "CDL program crops" like corn, cotton, wheat and soybean is high enough in a single year that a five year CDL is unwarranted and would inflate the acreage and over extend the geographic extent.
  - EPA's documentation does not discuss generating annual CDL crop acreages for the pre-processed "watershed recipe" data.
- Recommendation: EPA also should pre-process each CDL year independently so that a more realistic representative of actual crop acreage (for high confidence/accuracy in CDL) in any given year is available. Storing the individual years of CDL is simply a function of adding five additional columns of crop acreages to the current five year CDL lookup table.

5.1.3 The 11 Crop Groups

- Review reference: Appendix 2 - CDL General Land Cover Class Groupings.xlsx spreadsheet; Table 1 – Thurman et.al.(2014)
- Comments:

- It's important to recognize that the 11 multi-year crop groups were proposed by USEPA for use in the screening level, proximity assessment step with the intent of enabling the "Services" to conduct a 15 year assessment as part of a pesticide risk assessment under the Endangered Species Act.
- Grouping individual crops improves the accuracy of the classification but there may be a substantial increase in the crop acreage (i.e., for PCA needs) using the crop group (e.g., vegetables/ground fruit or orchards/vineyards) approach versus using an individual crop.
- Additional resolution may be afforded to specific crops and defended using the NASS CDL Accuracy Assessments published for each unique state year and crop. For example, the Oranges CDL class (code 212) in Florida which are lumped into the "Orchards and Grapes" crop group. Waterborne, Inc. communication with the developers of CDL (NASS Fairfax VA office) indicates that a high level of accuracy is associated with Florida oranges due to the contribution of extensive "training data" from the Florida NASS field office.
- Since CDL is processed at the state level (i.e., each state using its own separate set of training data), crop groups can optionally be refined regionally, such as the case with Florida oranges.
- Breaking the 11 crops into more detail, whether nationally or regionally, can be justified by comparing the CDL crop acreage against the Census of Agriculture (at the county level) and by verifying the CDL Accuracy Assessments.
- The "Other Crops" group (of the 11) consists of "miscellaneous" cropland groups that includes fallow, other crops (a catchall, though rarely used CDL category), clover/wildflower, sod/grass seed, and aquaculture. This group is rather broad and will add significant confusion and uncertainty to SAM modeling; this group should be reevaluated. Previous analysis conducted by Waterborne, Inc. indicates that the CDL fallow class (class 61) dominates the Other Crops group causing a misclassification of both the location and acreage for the remaining crops in this category. For instance, when SAM modeling is conducted for "clover/wildflower," all the soils, and weather and catchment information from sod/grass seed, aquaculture, and fallow will be selected to represent clover/wildflower.
- Sorghum and sugarcane (in Florida) of the "Other Grains" crop group (which contains 16 individual CDL crops) may have sufficient representation in the CDL to stand alone as their own crops (based on previous work by the authors).

Recommendation:

- Fallow should be removed from the Other Crops category entirely and placed in the "Miscellaneous land" group which consists of non-agriculture land cover types like barren, non-ag/undefined. Fallow is over-represented in some years of CDL and will dominant the "Other Crops" category both in location and acreage. Furthermore, the remaining crops in this category could be evaluated to determine whether they can stand alone or be incorporated into another crop group. It may not be appropriate to model these disparate crops as a single group; refinement options should be considered.
- For Florida oranges and Florida sugarcane, as well for sorghum nationally, the acreages in the CDL should be compared against Census of Agriculture and the Accuracy Assessments examined to assess feasibility of parsing these two crops out of the respective crop groups.

- EPA should compare the CDL acreage with the reported acreage in the Census of Agriculture, as well as the CDL Accuracy Assessments, to determine whether any other crops can be separated from their broad groups, whether regionally [state(s), or nationally]. It is not insurmountable to assess this and get the crop groupings right before proceeding with this model. The crop location data are the underpinning dataset used to select all other environmental parameters and define model needs and it is crucial that this step is completed properly.
- In cases where the spatial footprint of individual crops is still deemed uncertain, EPA should incorporate the county-level census of agriculture data to partition the acreage of the broader crop groups (e.g., vegetable/ground fruit and orchard/vineyard) down to individual crop acreages as a refinement option. This approach would be analogous to multiple soil components occurring within a single SSURGO map unit. Using this approach, the acreage associated with a particular scenario participating in a “watershed recipe” could be derived to represent only the specific crop(s) of interest, yet the spatial uncertainty would be covered by the footprint of the broader crop group.

5.2 SOILS DATA - SSURGO

- Review reference: SAM Background Document (2015) and Appendix 3-F (SAM Federal Docket, 2015)
- Comments
    - Soils Database Selection: The USDA SSURGO database (USDA NRCS, 2015) serves as the base soils dataset for SAM. SSURGO represents the best available, highest resolution spatial dataset for soils, covering the vast majority of the contiguous United States.
    - SSURGO Modifications for SAM: The SAM Background Document (2015), pg. 54 mentions that modifications were made to the SSURGO tabular data. These modifications mentioned include:
        - 1.) converting units to those used in the SAM model,
        - 2.) calculating USLE LS values,
        - 3.) processing soil horizon data to match SAM horizons, a process which included depth weighted averaging,
        - 4.) replacing missing, if needed, and
        - 5.) aggregating soil properties

        All details concerning how these modifications were made to the SSURGO database for use with SAM were not provided in the documentation and should be provided.
    - Non-Soil Map Units: The SAM Background Document (2015), pg. 54) states that "non-soil" map units (such as queries, pits, mines, urban land) were not included in the soils analysis for SAM, thereby excluding their potential runoff contributions, particularly, the water volumes that can reach surface water will thus be under estimated locally. While some of these types of areas may not produce significant amounts of runoff, others will contribute runoff, affecting the ultimate pesticide concentrations downstream.
    - Map Unit Soil Component Selection: The SAM Background Document (2015), pg. 54) describes that the highest percentage major component was taken to represent the map unit, unless that component had incomplete data. If data were incomplete, the next highest percentage component would be selected. The documentation also states that when two components have the same percentage, then the component with the higher hydrologic group is chosen. The Background Document does not specify how a soil component is selected for a map units when none of the components meet the data completeness criteria.
    - Soil Grouping Classes: The SSURGO soils have been aggregated into soil grouping classes based on the USDA NRCS Water Quality Index (WQI). These classes are based on four Soil Hydrologic Groups, five slope ranges, five soil erodibility (K-factor) ranges, and five soil organic matter (ranges). This results in a total of 600 possible soil groups that are evaluated for an assessment. The diversity in the soil characteristics that determine the pesticide runoff, erosion, and retention in the soil that these 600 groups represent is generally sufficient to represent variability found based on the complete set of all soils. Appendix 3-F (SAM Federal Docket, 2015) provides several sensitivity analyses aimed at evaluating the effects of lumping individual map units into soil groups. The overall conclusion was that the soil grouping methodology did not result in significant differences in simulated runoff volume, total pesticide mass, or annual peak pesticide concentrations based on 15 watersheds assessed. Runoff differences were generally less than 1%, pesticide mass differences were generally less than 2%, and annual peak pesticide concentration

differences were less than 5% for 11 out of 15 watersheds. In some cases, the pesticide concentrations based on the individual soils were higher and in other cases, concentrations based on the soil groups were higher. It should be noted that even within a single soil series, significant variability can exist (Hoogeweg and Hornsby, 1997). Map Unit Soil Group Assignment: It appears that each map unit was assigned to a single soil group based on the map unit's representative soil component (typically the dominant major component). This approach results in a fraction (often less than 50%) of the soils within the map units being accounted for. There are potentially multiple soil groups contained in a map unit that are unaccounted for in constructing the SAM watershed recipes based on only a single soil component per map unit.

- Soil Group Attributes: In the Appendix 3-F (SAM Federal Docket, 2015) contains a table that includes all of the soil related attributes associated with each scenario. The Background Document also states (pg. 60) that the scenario input values for soil groups represent the mean of the individual soil map units that fall within each group. It is unclear whether the mean attribute values are based on a simple arithmetic average or an area-weighted average based on map unit area. Also, the documentation does not describe how the approach of taking an average attribute value of many soils might be different from taking the actual attributes of a single dominant soil within each soil group. One difference is that the approach of taking the mean property value of all map units results in a "hypothetical" soil that has not actually been sampled in the environment.
- Hydrologic Soil Group Assignment: Appendix 3-A (SAM Federal Docket, 2015) provides some details on how PRZM scenario data were extracted from the spatial data sources. The Hydrologic Soil Group (HSG) for soils with both a "drained" and "un-drained" class (e.g., A/D, B/D, C/D) were assumed to have the "un-drained" class, "D," in all cases. For agricultural land in active production, not having drainage is unlikely.
- Horizon Data: In determining input values for scenarios, the SSURGO data, which can contain any number of horizons for a particular component, will be depth-weighted averaged into two soil horizons, a surface horizon between 0-10 cm, and a subsurface horizon > 10 cm. The exact calculations are not specified and the justification for using only two horizons in the modeling is not provided. In addition, it is not clear how the thickness of the subsurface horizon will be determined.
- Slope Input: For the slope parameter, Appendix 3-A (SAM Federal Docket, 2015) indicates the map unit average slope will be used as a scenario input, however for all other parameters, the majority component value is used. This difference seems to be inconsistent.

- Recommendations:
  - SSURGO Modifications for SAM: The details concerning how these modifications were made should be clearly described. This is especially important in order to make the approach reproducible for the public. In particular,
    - Item 2 (calculating USLE LS values): The USLE LS factor is based on slope and slope length. The Background Document describes that the slope length is derived from the SSURGO "SLOPELENUS_R' attribute. This SSURGO attribute is commonly

missing, so additional information on how this parameter is estimated in these situations should be provided.
    - Item 3 (processing soil horizon data to match SAM horizons): The mechanics of how SSURGO horizon attributes were weighted to assign attributes to SAM horizons should be discussed, including how missing data in portions of each SAM horizon were handled.
    - Item 4 (replacing missing values): It is common to find missing values in the SSURGO horizon attribute table. The approach (es) to replacing these missing values, needs to be defined explicitly for each parameter required by SAM, including how the missing data estimation carries over to the parameterization of the SAM horizons.
- Non-Soil Map Units: An approach needs to be developed that accounts for these areas in the SAM model watershed recipes. The primary importance is characterizing their runoff contribution potential.
- Map Unit Soil Component Selection: Information on how a soil component is selected to represent a map unit in cases where none of the soil meet the data completeness criteria should be provided.
- Soil Grouping Classes: The sensitivity analyses showed that for the majority of cases, differences in outputs between individual soils and grouped soils are small. However, there are cases where differences in annual maximums are higher than 10%. It would be useful to run additional output comparisons for watersheds located beyond the Midwest to see if the same patterns are observed. In addition, if the standard SAM approach is to use the soil groups, we would suggest that SAM include a modeling refinement option for running an assessment with all individual soils.
- Map Unit Soil Group Assignment: To be more accurate in soils characterization, the SSURGO "component percent" attribute can be used to represent all soils found within each map unit and account for their variability in pesticide runoff, erosion, and retention characteristics. Instead of map units being assigned to a single soil group, all components within the map unit can be accounted for by assigning each component to one of the 600 soil groups, resulting in multiple soil groups per map unit.
- Soil Group Attributes: Additional information should be provided on how "mean" soil attributes for each soil group were determined based on the individual soils contained in those groups. Also, it would be good to acknowledge that the "mean" property value approach results in a hypothetical soil, and mention how an alternative approach (such as selecting a dominant representative soil within the group) might impact modeling inputs and results.
- Hydrologic Soil Group Assignment: For agricultural land use, the "drained" hydrologic soil group should be assumed.
- Horizon Data: Provide justification for two soil horizons in the modeling. SSURGO can have over 10 horizons for selected soil profiles.
- Slope Input: Provide justification for using a map-unit average slope versus dominant component slope or use SRTM 10m data to derived locally correct slopes

5.3 HYDROLOGY DATA – NHDPLUS

- Review reference: Appendix 3-A (SAM Federal Docket, 2015) and NHDPlus hydrology network
- Comments:
    - NHDPlus version 2 dataset provides the best available data, at a national scale, on stream networks, flow data and flow direction, and associated drainage areas for use in modeling
    - SAM uses the NHDPlus catchments (spatial unit of analysis) that represent the spatial watershed boundaries and the NHDPlus flowlines that represent the spatial stream/river network for lotic waterbodies (e.g., streams, rivers) within the catchments.
    - Per SAM Background Document (2015), for flowlines representing streams and rivers, the cross-sectional area is estimated using the mean monthly flow and mean monthly velocity data provided by NHDPlus. SAM calculates waterbody volume as the cross-sectional area multiplied by a representative length (e.g., 40 meters), to define a 'mixing cell' concept in the waterbody.
    - The mean monthly flow, mean monthly velocity and cross-sectional area are obtained from the most downstream flowline intersecting the catchment boundary (pour point).
    - Total daily flow in a lotic waterbody is calculated as the sum of base flow and daily runoff flow. For lentic water bodies (e.g., reservoirs, lakes) that are part of the drainage network, flows are also obtained from NHDPlus and volumes are preliminary estimates developed by USEPA.
    - NHDPlus catchment, which is the spatial unit of analysis for SAM, is the smallest nationally available watershed boundary dataset with a 1:1 relationship with the flowline network
    - Although the "NHD High Resolution" dataset provides higher resolution spatial hydrology data than NHDPlus, it does not provide the catchments, flow and velocity attributes for the stream network
    - Mean monthly flow (Q0001E) and mean monthly velocity (V0001E) data attributes provided by NHDPlus and used for SAM represent 'gage adjusted' values and are the best available data at this time scale and spatial resolution covering the entire conterminous US.
    - Per SAM Background Document (2015), monthly mean base flows in receiving water bodies are estimated as the difference between the estimated NHDPlus monthly mean flows and the long term average daily watershed runoff (from PRZM). It is unclear if, for non-headwater catchments, whether the surface runoff is the sum of the PRZM-based surface runoff from all upstream catchments or only the local catchment.
    - NHDPlus flowlines are attributed as either 'uninitialized' or 'with digitized', while only 'with digitized' flowlines contain flow and velocity data.

- Recommendation:
    - Provide a more complete discussion of the "uninitialized" and "with digitized" NHDPlus flowlines describing the differences in what these features represent and how they are used within the context of SAM.
    - Additional discussion should be provided on how NHDPlus catchments with no flow and velocity data are being used. In such case, consider using default values by NHDPlus region to account for local and regional differences in flow and velocity.
    - The 40 meter representative length for flowing water bodies is not analogous to an actual stream length of a HUC12 watershed. The conceptual differences need to be better

described. Because the 40m length is used in the water body volume calculation and the subsequent pesticide concentration calculations, the sensitivity of concentrations to a range of values for this length should be provided, as well as additional justification for selecting 40m.

- Use the latest updates to spatial and tabular information from NHDPlus dataset

5.4 WEATHER DATA - NCAR/NCEP REANALYSIS & NOAA CPC U.S. PRECIPITATION

- Review reference: Appendix 3-C (SAM Federal Docket, 2015) and NCAR/NCEP Reanalysis & NOAA CPC U.S. Precipitation, 1984 – 2014 (daily): 0.25◦x0.25◦ grid resolution.
- Comments:
    - EPA is moving away from the discrete SAMSON weather stations (Burns et al., 2007) which are no longer maintained by the NOAA National Climatic Data Center (NCDC) toward the more expansive, higher resolution, and recent (1/1/1948 – present) gridded data sets from NOAA Climate Prediction Center (CPC), and NCEP/NCAR. The increase in spatial resolution of weather data and the update to more recent years represents a potential improvement for modeling that should lead to more spatially accurate and representative of weather conditions in SAM. The weather input parameters derived from these datasets for SAM are precipitation, wind speed, temperature, solar radiation, and pan evaporation. The required variables (precipitation, temperature, solar radiation, horizontal wind velocity) are available at different spatial resolutions so a hybrid meteorological dataset was developed for SAM. Solar radiation, temperature, wind speed, and pan evaporation were derived from the 2.5 x 2.5 degree gridded NCAR reanalysis data. Precipitation was obtained from the 0.25 x 0.25 degree NOAA CPC dataset. We assume the appropriate conversion factors needed to unpack the data from netCDF files were applied correctly using standard functions in the NCAR command language (NCL)
    - Based on the available information provided during the workshops and the documentation, we believe that the re-gridding of the lower-resolution reanalysis data to the higher resolution CPC grid was conducted appropriately using standard NCAR command language tools.
    - The re-gridded (higher resolution) data was mapped to the SAM scenarios. The grid used for this mapping was not adequately described – was it an EPA derived grid using Thiessen polygons or was it the actual 0.25 degree NOAA grid taking into account the curvature of the earth?
    - The pan evaporation data input needed for SAM is not directly available from NCAR reanalysis data. The potential evapotranspiration will be estimated using the Hargreaves-Samani method, a calculation involving downward solar radiation flux at the top of the atmosphere, daily mean air temperature, and daily temperature range data from NCAR reanalysis data. It is unclear in the documentation, but the assumption is the crop coefficients and/or pan factors as used will be adjusted to match the use of evaporation source (Pan or ETo).
    - In Appendix 3-C of the Background Document, EPA indicated its intention to update the weather files annually as new data is made available. Updates with this frequency will be a challenge in a regulatory setting where reproducibility of results is extremely important. How will users know when weather files have changed, and will they be able to run the model with older weather data?
    - While references for the sources of the weather datasets are provided, the uncertainty associated with the data products is not addressed. For example, the density of stations over more remote geographical regions will be much lower than more heavily populated regions, requiring greater use of model data in the analysis and leading to greater uncertainty.

  - The NCAR/NCEP Reanalysis dataset is known to have several issues. An issue list dated Nov 2012 can be found at: http://www.esrl.noaa.gov/psd/data/reanalysis/problems.shtml. A wide variety of problems have been reported and solutions have been addressed.
  - The weather datasets chosen for SAM were not compared against other potential weather data sources. For example, since the early 1990s, radar-based precipitation datasets have been archived by NOAA. Some radar products include gauge-based corrections, and with a higher spatial resolution, make them a viable candidate dataset for a model such as SAM.
  - The new weather data was not compared to the SAMSON weather data. Only SWCC results were compared for both datasets. There are clearly scenarios on the 1:1 plots (Appendix 3-C of SAM Background Document (US EPA, 2015) that resulted in differences in concentrations by up to an order of magnitude. No explanation was provided for these outliers. Pearson's correlation coefficients were all in the range of 0.858 – 0.907.
- Recommendation:
  - The pre-processed meteorological inputs (including individual PRZM met files) should be provided to the public for review. The vector grid and grid centroids and the raster grid should be provided to the public so that the domain assumed to correspond to each weather file is clear and can be used to interpret results and conduct additional spatial analyses consistent with the approach used by EPA.
  - The process used to obtain and unpack reanalysis data should be made more transparent so that it can be properly validated. It should be confirmed that the scale and offset factors remained the same for the variables across all files, since it is possible for these to vary even for the same variable from the same dataset.
  - The process for maintaining this dataset, documenting revisions, and preserving backward compatibility for reproducible results should be clarified. The schedule for weather file updates and previous and current versions of the files should be made publically accessible.
  - A summary of how the uncertainties associated with the selected weather datasets may impact exposure modeling results should be provided.
  - A justification for the use of the NOAA CPC gauge-based re-analysis precipitation products over higher-resolution radar-based products should be provided.
  - EPA should conduct an analysis to determine how the SAMSON dataset compares to the combined NCEP/NCAR-CONUS dataset using data for the same time period. Similarly, an assessment should be conducted to see how the NCEP/NCAR-CONUS data compare with the high resolution NEXRAD rainfall data.
  - EPA should statistically compare the SAMSON weather data to the new gridded data at the SAMSON locations, especially PET and precipitation, to better understand why there are biases in the exposure modeling results for certain scenarios. Slope of the regression line should be included when applicable.

6 RECOMMENDATIONS FOR ADDITIONAL OUTPUT

- Recommendations for additional outputs:
  - Allow PRZM input and output (.ZTS) files, daily stream flow rate and flow volume (or depth) data, and weather files along with metadata to be downloaded/available as an output option. This would create transparency and flexibility for the user.
  - Provide an output option for daily exposure estimates. This option is not currently functioning, but could be very useful for the user to have as an output.
  - Provide an output for recovery/duration in graphical and tabular form. Frequency of exceedance is documented in the current output of SAM; however, recovery/duration of effect is not captured but is an important metric to interpret the impact of exceedance.
  - Daily edge-of-field mass loadings would be a helpful output, as this might be used to understand impact of potential mitigation strategies related to some edge-of-field BMPs.
  - Output of spray drift and soil-bound chemical transport – when incorporated into SAM.
  - A single threshold value to determine exceedance probability is likely too simplistic for this tier of exposure/risk refinement. The user should have the ability to insert multiple toxicology thresholds that might represent a species distribution or multiple species.
  - Cumulative probability distributions of the daily exposure estimates for each catchment would allow the user to understand the entire spectrum of exposure results rather than limiting results to specific toxicity thresholds.
  - Provide summary results with temporal information, for example, minimum, maximum, and mean concentrations by month or by week for each catchment
  - Provide a summary of all inputs and version numbers of files and source code needed to recreate a simulation.

- General Considerations related to outputs:
  - Reproducibility of results is critical for use of SAM or any model in exposure assessments. All of the input data, both provided by the user and pre-processed by EPA that is used to generate model results needs to be published as output with the model results. Everything that would be needed to recreate the run should be documented explicitly. This would include a complete list of input parameters, version numbers of pre-processed files, the version number of the SAM source code, and how to access these files.
  - Having access to underlying PRZM input files would make it easier to understand problems or figure out if mitigation BMPs are needed, especially for “hot spot” areas predicted by SAM. It would be helpful to make the interface more flexible so that the user can turn off/on options to make runs with alternative soils, user-derived weather data, etc. Functionality around quantifying the impact of certain BMPs is important because it helps address mitigation and landscape features and corresponding management practices that differ geographically.

7 General Comments and Summary of Recommendations

The authors applaud the direction of moving past a scenario based modeling framework to a spatially distributed system that will allow for a greater understanding of pesticide exposures in the environment and a more focused and complete risk assessment process. The comments should be viewed in the spirit of a desire to partner towards these common goals in a way that provides the best available science and tools for decision making. The limitations in this or other model systems can be overcome in time and the continued open dialogue is welcome during this development process.

- A detailed written statement of modeling objectives for all intended regulatory uses of SAM should be developed as recommended in Agency-wide guidance on the development, evaluation, and application of environmental models (US EPA, 2009).
- The SAM Background Document does not include a literature review of the "state of the science" of watershed scale water quality modeling. This is an area of significant international research and application that includes numerous water quality constituents, including pesticides. Prior to embarking on the development of a new model, a thorough evaluation of exiting models and approaches should have been undertaken to minimize duplication of effort and make best use of limited government resources.
- SWAT (USDA), HSPF (EPA/Aqua Terra) and MIKE-SHE (DHI)(EPA) are existing watershed-scale hydrologic and chemical transport models with the capability to simulate agricultural chemicals. How does the SAM model compare to these existing models in terms of efficiency, quality of prediction, calibration potential, incorporation of BMPs, flowing water bodies and routing, etc.? Are there advantages to including these other models to evaluate finer resolution, low-order watersheds within HUC12 or NHDPlus watersheds for further refinement?
- The EPA Office of Water has developed a national water quality modeling system called the Hydrologic and Water Quality System (HAWQS, https://epahawqs.tamu.edu/). This modeling system has been designed to run water quality simulations across the entire contiguous US at the HUC8, HUC10, and HUC12 resolutions using the Soil and Water Assessment Tool (SWAT). The HAWQS homepage lists pesticides as one of the water quality constituents that can be simulated. The SWAT model has an extensive international user base and is one of the most widely published watershed water quality models of the past two decades, with over 2000 publications (https://www.card.iastate.edu/swat_articles/). Has the US EPA OPP consulted with the US EPA Office of Water on the use of HAWQS (or a modified version of HAWQS) in pesticide modeling? The development of SAM from the "ground up" as a watershed scale model for predicting pesticides in flowing water bodies is somewhat surprising given that developmentally mature models such as SWAT and others already exist, and that other divisions of the US EPA have invested in a national water quality modeling system like HAWQS which is built upon these well-vetted, internationally recognized models.
- The monitoring comparison should not have been conducted until spray drift deposition, an important potential pathway for pesticides entering water bodies, and other key environmental fate and transport processes have been included in the model. Spray drift may significantly increase predicted concentrations and therefore result in even greater overestimations of the modeled concentrations compared to the observed concentrations than were already demonstrated in the comparison of Section 2.4.

- The monitoring comparison shows that the ranges of SAM predictions are biased high compared to observed data (the predicted maxima exceed the observed maxima but the predicted minima are not as low as or lower than the observed minima). This means that the range and frequency of results do not provide enough information to determine "the likelihood of exposures that may exceed toxicity thresholds of concern and, should such exposures occur, how often, how long, and where adverse impacts from pesticides in water overlap with populations (human and ecological) at potential risk," the main objective of SAM. EPA should ensure that SAM captures the full range of pesticide concentrations (including the minimums) so that this tool can be used as a higher tier modeling approach. With the current bias, SAM would be a screening tool. SAM predictions should be compared to the range of predictions obtained from the SWCC screening approach to ensure that value is added.
- The individual sections of this document provide many recommendations that can be categorized as a desire for more transparency (more available input, output), flexibility (more application options, environmental fate parameters) and a desire to match and even increase transport processes represented in established tools rather than simplifications.

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9 SUPPORTING MATERIAL

9.1 EVALUATION OF SAM IN COMPARISON WITH BEST-AVAILABLE PUBLIC MONITORING DATA

9.1.1 Introduction

EPA has presented examples of comparisons of the SAM results against selected monitoring data in mid-west watersheds (EPA, 2015. Test version of the spatial aquatic model (SAM) to estimate spatial and temporal pesticide exposures in water. 250th American Chemical Society National Meeting. August 19, 2015). So far, detailed model input and monitoring comparison data has not been made publicly available. Furthermore, the example comparisons do not purport to represent a typical result from a larger effort to understand and characterize the predictive quality of SAM. In this benchmarking exercise, a comparison between publicly available monitoring datasets and default SAM outputs is presented to investigate how SAM might perform against substantially more comparison points.

9.1.2 Methodology

From the list of available public monitoring data sources, the USGS National Water Quality Assessment Data Warehouse (NAWQA) was identified as a best available source due to the program's extensive monitoring data available for a wide variety of chemicals over an extended period of time. While the data in the NAWQA database would likely be considered as ambient for the most part, the range exposure durations might be from chronic to acute. A complete analysis and characterization of the probable exposure duration of the NAWQA data used in this comparison was not done because this exercise was meant to benchmark the range of possible exposure durations against the available, default SAM results.

EPA developed the SAM alpha version for the Ohio River Basin (NHDPlus region 05). EPA has made public the SAM alpha 1.0 simulation model runs for Atrazine, Chlorpyrifos, Fipronil, and Metolachlor. SAM generates predicted concentrations for pesticides for a 30-year time period, i.e.1984-2014. For the Ohio River Basin and for the same time period, all available surface water monitoring data was obtained from NAWQA for all four chemicals used in SAM. Due to limited availability of Fipronil data (due to its limited use in the Ohio River Basin) it was not considered for the current comparison, but the other three pesticides were included. SAM model results used for this comparison are at HUC-12 watershed scale which was the spatial unit of analysis used for SAM alpha version 1.0. This version of the model is available for the public at the EPA Uber tool website (http://qed.epa.gov/ubertool/sam/description). From documents recently released by EPA for the SAP, it was understood that a more recent SAM alpha version 2.0 is available, though not public yet, which uses the NHDPlus catchments as the spatial unit of analysis. For the comparison presented here, SAM model results from alpha version 1.0 and HUC-12 watershed boundaries were used. Figure 1 below shows the extent of available NAWQA monitoring locations within the Ohio River Basin for the three chemicals.

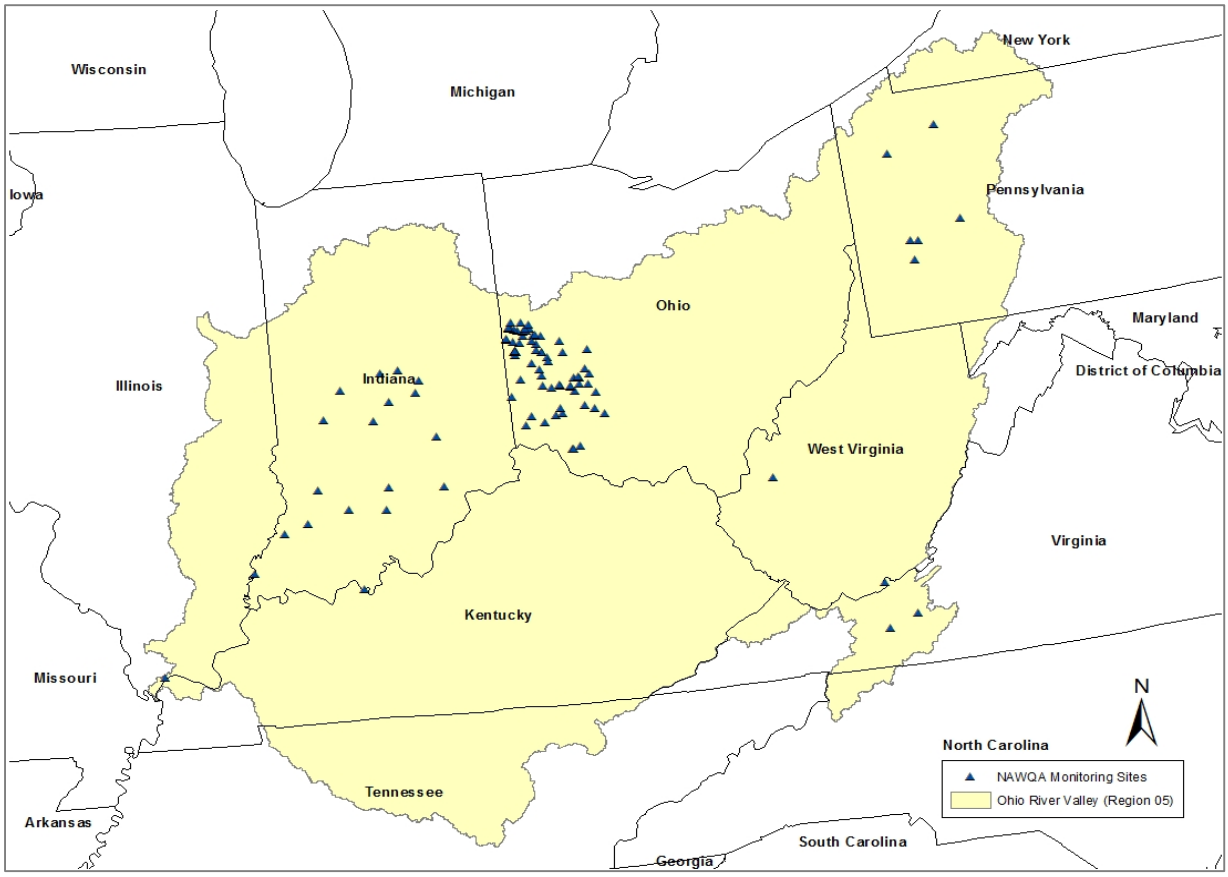

Figure 1. Ohio River Basin with NAWQA monitoring locations for the three pesticides

Several steps were involved in this comparison. First, SAM alpha 1.0 model was run with the available, default scenarios for Atrazine-Corn, Chlorpyrifos-Corn, and Metolachlor-Corn. As daily concentrations are not part of the available outputs from SAM, the 21-day 90th percentile concentration data for the three scenarios was obtained as they were "closest" to the daily concentrations predicted by SAM. The 30-year model simulation results were available as annual and monthly values for HUC-12 watersheds within the Ohio River Basin, but data was not available for all watersheds within the pilot area. NAWQA data for the Ohio River Basin for the three chemicals was obtained at individual sampling location points. There were 68 HUC-12 watersheds where the NAWQA sampling locations were uniquely represented within the 4,650 SAM watersheds.

9.1.3 Results

For this preliminary analysis, 68 watersheds were identified and used where NAWQA data was available within the Ohio River Basin area for the 30-year period, aggregating to the HUC-12 scale.

Mean concentrations were calculated from the NAWQA watersheds when multiple data sets were available within that same watershed to compare against mean monthly 21-day SAM output over the same 30-year simulation period for atrazine, chlorpyrifos, and metolachlor (Figure 2 through Figure 4)

This bench-marking preliminary analysis indicated that 21-day SAM exposure concentration estimates fall within the same order of magnitude as available NAWQA data from the Ohio River Valley for atrazine and chlorpyrifos. These preliminary results show that SAM may be over-predicting mean concentrations. While it may be unreasonable to calibrate every watershed, it is important to understand the behavior of the model as it relates to observations.

SAM 21-day exposure concentrations were aggregated at individual HUC-12 watershed, i.e. each watershed is considered separately. NAWQA measured concentrations depend entirely on the location of the sampling point. Measured concentrations could be effected by pesticide loadings from a single (head-water) watershed, or from contributions over a series of watersheds if the sampling point is located downstream on a major stream or river.

Beyond this, there may be a computational or parameterization issue across some watersheds, as they are currently set up. For example, the maximum SAM 21-day results for one watershed (HUC-12 ID = 051201090103) and all three compounds was two orders of magnitude larger than the 99.99th percentile value across all years of SAM results (no matching NAWQA data was available for this watershed – thus not shown in subsequent figures). This type of apparent error in watershed/model parameterization might lead to excessively high results.

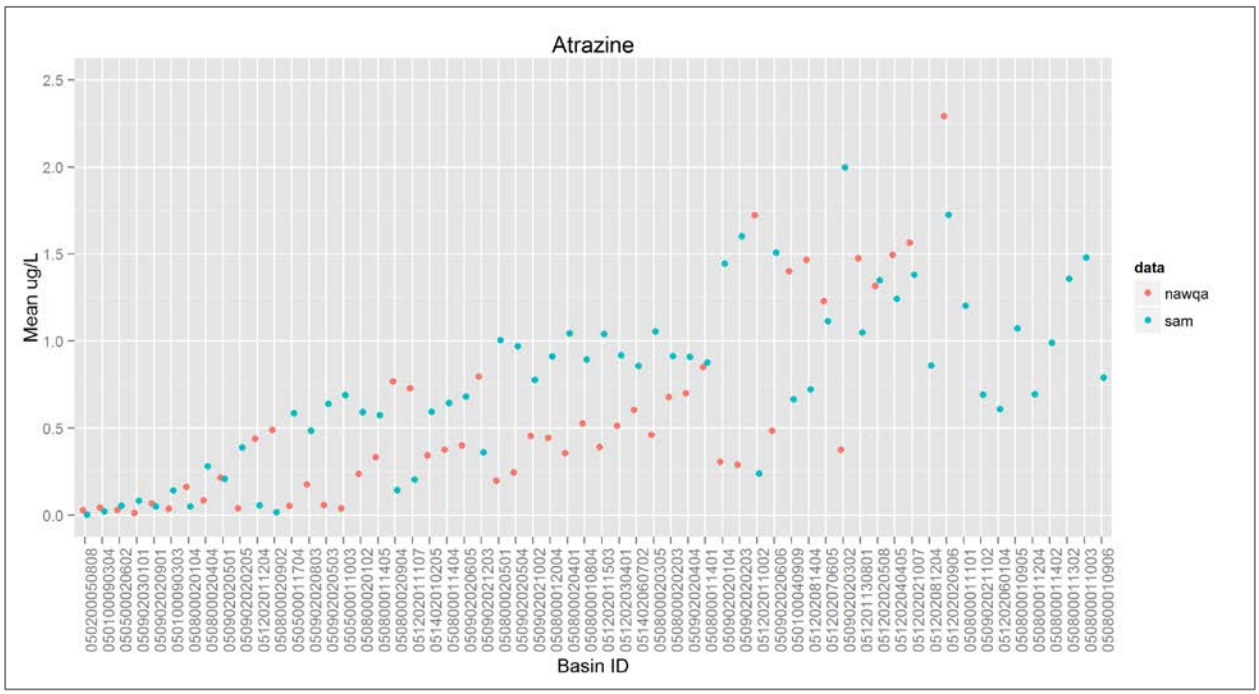

Figure 2. Atrazine comparison: Rescaled axis with points representing mean. NAWQA data compared to SAM output by HUC-12 watershed (Basin ID). NAWQA points represent watershed-wide mean. SAM points represent mean of monthly 21-day exposure estimates for any given watershed.

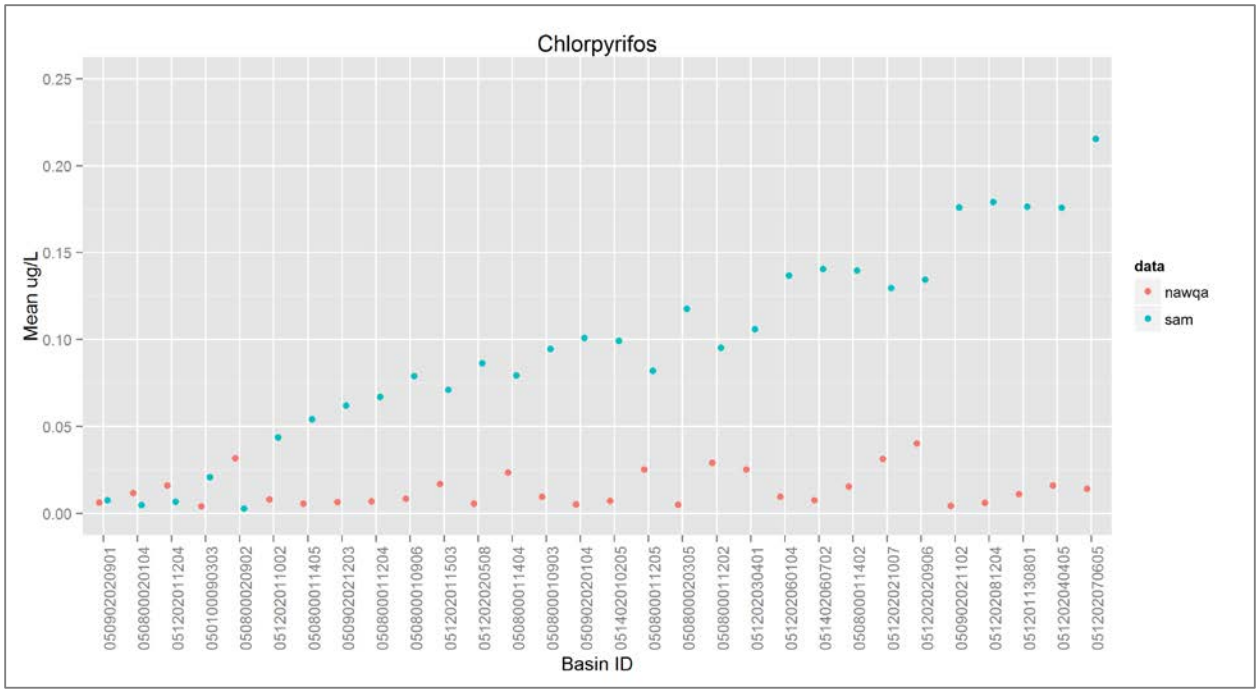

Figure 3. Chlorpyrifos comparison: Rescaled axis with points representing mean. NAWQA data compared to SAM output by HUC-12 watershed (Basin ID). NAWQA points represent watershed-wide mean. SAM points represent mean of monthly 21-day exposure estimates for any given watershed.

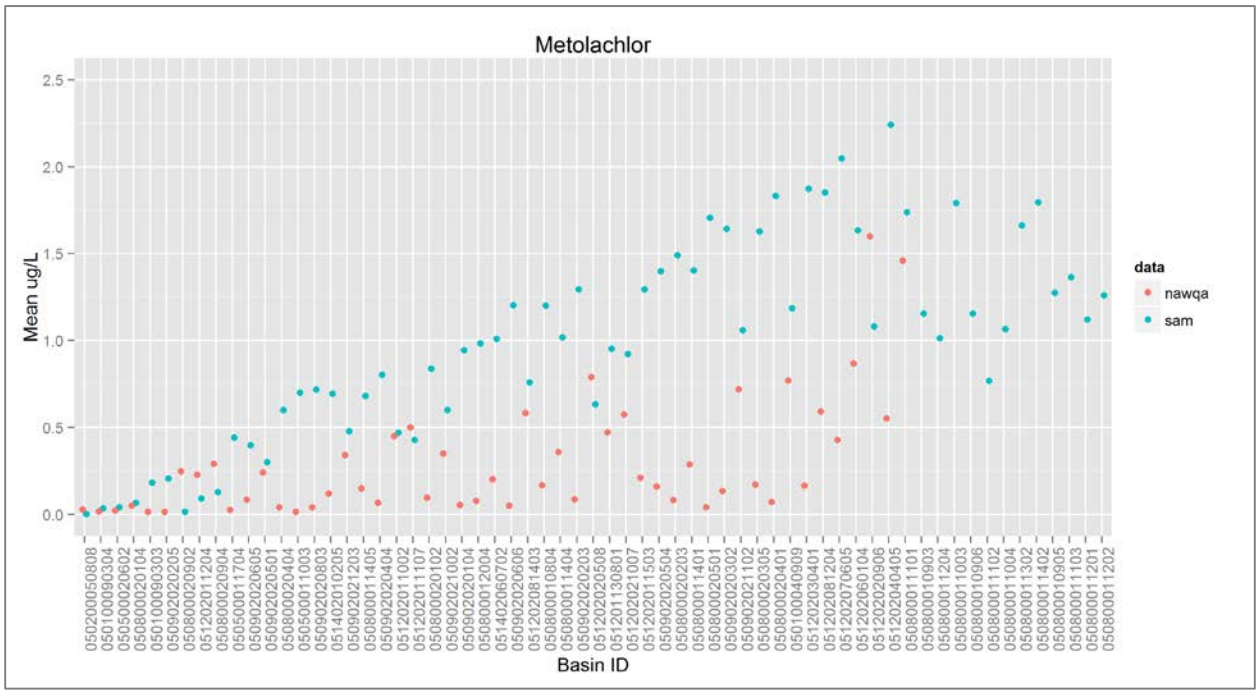

Figure 4. Chlorpyrifos comparison: Rescaled axis with points representing mean. NAWQA data compared to SAM output by HUC-12 watershed (Basin ID). NAWQA points represent watershed-wide mean. SAM points represent monthly 21-day exposure estimates for any given watershed.

9.1.4 Conclusions and Recommendations

The examples that were presented by EPA (ACS, 2015) imply that correlation between SAM results and monitoring data is consistent. While there is not enough information currently available to support that claim, the benchmarking exercise presented in this document provides a broader, preliminary analysis of additional data.

The results from SAM are largely dependent on the default parameterization that is currently available. The default scenarios assume an application rate that is, in most cases, much lower than the maximum label rate (seasonal):

Compound	Maximum label use rate (lb/ac)	SAM default use rate (lb/ac)
Metolachlor	4 (Corn)	0.93
Chlorpyrifos	3 (Corn)	0.98
Atrazine	2.5 (Corn)	1.16

As the current version of SAM alpha 1.0 does not allow for custom scenarios with alternative rates, it is difficult to assess the outcome of the tool if it were used with the most conservative estimate of application rate. As SAM tool is positioned to be a higher-tier exposure estimation effort, using the maximum use rate (seasonal) in SAM would ignore strategies that appear to be built into the tool to address the range of rates and application pattern. Thus, more validation effort would be ideal to fully take advantage of the model potential instead of defaulting to a most conservative assumption.

From this preliminary benchmarking exercise, the following conclusions and recommendations can be suggested:

Conclusions:

- SAM predicts within an order of magnitude of NAWQA across 68 HUC-12 watersheds.
- SAM default rates are lower than label rates (corn was used as an example), which skews the perception of validation success.
- SAM runs likely over-predict in the 99.99th percentile due to a probable error in model input data. Further testing of individual watershed results is needed.

Recommendations:

- SAM predictions are for a single combination of pesticide-crop use rate while NAWQA includes grab samples that could constitute use across multiple crops. Further work is needed to adjust the analysis to pair SAM estimates with NAWQA data that are most likely representative of associated use patterns – SAM and NAWQA have disparagingly large differences in “catchment” as well.
- SAM concentrations are predicted at each HUC-12 watershed as a discrete unit. Comparison with NAWQA and similar measured data could possibly be relevant if SAM has the ability to accumulate pesticide loadings from contributing upstream watersheds.
- Additional work around sensitivity of model parameters such as application rate, spatial distribution of application throughout different watersheds, effects of spatial rainfall patterns, and likelihood of crop percent area is recommended. Sensitivity analysis would improve

understanding of the hydrologic and chemical fate/transport processes that are important for the spectrum of chemistries.

- Further SAM testing is necessary, compared with NAWQA or best-available monitoring data, to validate model predictions and better understand how exposure estimates at a relatively arbitrary spatial scale are representative of likely scenarios of potential risk.
- More validations of SAM results with best-available data should be conducted before the tool can be used to support regulatory decisions as indicated in the SAM Background Document (2015). Future validation exercises should follow the best practices for model evaluation described in Agency-wide guidance on the development, evaluation, and application of environmental models (US EPA, 2009).

9.1.5 References

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