Preliminary Comments from Members of the Science Advisory Board (SAB) Animal Feeding Operations Emissions Review Panel As of April 5, 2012

Purpose: These are Preliminary Comments from Members of the SAB Animal Feeding Operations Emissions Review Panel, related to the Panel's review of the following two EPA documents associated with EPA's emissions estimating methodologies for Animal Feeding Operations: a) "Draft - Development of Emissions Estimating Methodologies for Broiler Animal Feeding Operations" - February 2012 draft; and b) "Draft - Development of Emissions Estimating Methodologies for Lagoons and Basins at Swine and Dairy Animal Feeding Operations" - February 2012 draft. The first SAB Animal Feeding Operations Emissions Review Panel Meeting occurred on March 14-16, 2012.

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Overarching Comments:

1. I applaud the US Environmental Protection Agency for undertaking this comprehensive exercise to develop emissions estimating methodologies for AFOs. This is a step in the right direction. However, US EPA can and must do better by taking advantage of USDA, and the AFO academic research community, and others.

2. My main concern stem from the fact that US Environmental Protection Agency did not have the NAEMS monitoring study and protocol scientifically peer reviewed prior to the commencement of the study to determine a host of issues including but not limited to:

    a) Determine that scientific and statistically valid data would be provided to EPA to meet the needs for the development of emissions estimating methodologies for broiler, swine and dairy AFOs.
    b) For lagoons, how does US EPA know that statistically developed EEMs are correct?
    c) The AFO industry for swine utilizes two kinds of barns for housing the animals-tunnel ventilated and natural ventilated. How will emissions of gases from naturally ventilated barns be determined?

3. In order to move forward the US EPA needs to take advantage of the published peer reviewed data sets and modeling together with the NAEMS data set.

<u>Executive summary</u>

<u>Combining lagoon and basin data</u>

Lagoons and basins are not the same and operate very differently. Lagoons conversion of manure is much greater than in a basin. Lagoons maintain a bacterial pool to aid in the breakdown of newly added manure while basins do not. Differences in concentration and composition between swine and diary lagoons make it difficult (if not erroneous) to combine the data from these two sources. Lumping them together overlooks the basic differences in microbial processes and waste characteristics and undermines the credibility of conclusions drawn from such analyses.

<u>Number and location of monitoring sites</u>

3 dairy lagoons (Indiana, Washington and Wisconsin
6 swine lagoons
    3 breeding/gestation (Iowa, North Carolina, Oklahoma)
    3 finish (Indiana, North Carolina, Oklahoma)

Indiana swine and dairy operations monitored continuously for 1 year (Perhaps it may be prudent to c*ompare lagoon and basins here to see similarities and differences*)
The rest: monitored up to 21 days (***what were actual monitoring times?)***

Extrapolate basin NH3 emissions to higher temperatures measured in lagoons

It appears now after the monitoring is done and the that the analysis is being undertaken by US EPA to develop EEMs, flawed approaches are being used to try to cover for flaws in the sample design.
EPA reports that basin and lagoon data were combined to allow the estimation of basin NH3 emissions in high temperature ranges only measured in lagoons. Extrapolating basin NH3 emissions to higher temperatures based upon lagoon NH3 emissions measured at higher temperatures is an example of such erroneous analytical practice. This extrapolation assumes that basin and lagoon NH3 emission dependency on temperature is the same. 1) this is not known. Sound scientific practice would require prior knowledge of basin NH3 emissions at high temperatures to support such an extrapolation. It is analogous to extrapolating to conditions beyond the range of a standard curve which is not sound science. 2) what other contributing factors to NH3 emissions are different between the lagoons and the basins that might affect NH3 emissions? For example, did the basins develop any crusts or other solids on the surface which might obstruct diffusion of NH3 across the liquid/atmosphere interface? What are the dimensions of the basins and lagoons? Are they sufficiently difference to affect the wind fetch and hence gas stripping effects of flow across the liquid/atmosphere interface? What are pH differences? Are redox potentials similar or do any of the basins have anoxic surface layers?

SUGGESTION: NAS Report on AFO emissions concluded that emissions should be estimated based upon a process-based model. If different treatment systems are going to be combined, the process-based approach will be even more important. To do this, first the microbial processes must be shown to be sufficiently similar. Once this is established, then it might be possible for lagoon and basin differences in waste N, S, C concentrations, residence time, temperature, pH and other characteristics to provide the range of data needed to develop process-based emission models. This would require taking into account how the microbial processes and the chemical and physical processes are controlled by dominant characteristics in each system.

EPA developed 3 types of EEMs based upon combinations of meteorological and farm characteristics. Different emissions were quantified for swine lagoons and dairy basins. ***When are swine and dairy data combined and when not. How does this influence the EEMs for swine and dairy?***

VOC data – ***statements confusing. Were VOC data (both total VOC and speciated VOCs) collected but not given to EPA? Why weren't upwind VOC's data measured?***

Introduction

The introduction should clearly point out the limited nature of the data. If no data was collected, it should be pointed out.

1.3 Emission-Estimating Methodology Development

Page 1-6: Due to the very limited amount of data received for N concentration, solid content and pH of the lagoon liquid, these data were not included in the EEM.

These are among the key parameters needed to estimate NH3 emission especially if the dairy basin and swine lagoon data are to be combined!

Page 2-11 The Indiana 1 year continuous monitoring of swine and dairy farms were not measured at the same time but rather back to back. This makes their comparison more difficult due to difference in weather over the 2 periods of measurement.

Page 2-12. Manure was collected by vacuum from cow barn and placed in lagoons.
Could vacuum system have removed NH3 and other gases during transport to the basin?

Page 2-13. The Washington State dairy removed all solids from basin every year with "clarified" liquid from solids separation stored in a large storage basin. Gaseous emissions were recorded in east lagoon – solids last removed in 2006.
Removal of solids would impact the NH3 concentration in the liquid and remove most of the microbial community (compared to a swine lagoon.) Surface area of "large storage basin" would influence analysis based upon lagoon (and basin) storage area. East lagoon (basin) may have been managed differently during study as solids were not removed annually. Was lagoon surface area measured for both lagoons on this dairy or just one? This is important because of the role lagoon surface area is playing as a determining factor for NH3 emissions.

Page 2-14

Wisconsin dairy used solids separator, three stage lagoon, pumped out twice yearly. First 2 stages were monitored for NH3 loss

The 3 dairy farms have very different types of treatment systems and lagoon (basin) systems. Without considering these differences, it will be impossible to discern the influence of farm size and lagoon size on NH3 emissions.

Swine farms
Page 2-16 Indiana farm – pull plug – emptied every 2 week to lagoon. Farrow to wean.

NC sow/farrowing op – pull plug – emptied once a week

Page 2-17 OK swine farm – pull plug. Emptied once/week sow to farrow farm

Page 2-18 Iowa swine farm – finish farm - deep pit barns, transferred every 10 days to concrete circular structure (55 m diameter)

Page 2-19 NC finish swine farm – pull plug – daily transfer to lagoon.

Page 2-20 OK finish swine farm – pull plug 3x/week removal to lagoon.

The swine farms had significant differences in their manure handling procedures which could affect the NH3 emissions from the lagoons. This needs to be explained.

Table 3-1 (page 3-3) pH, and solids content measured. ***This data should be used for EEMs.***

Page 3-5 Table 3-2 Reported emissions rates (for NH3 and H2S)
Of the 9 farms measured, valid NH3 emissions were not available at all for 2 farms and a third farm had only one day of valid measurements, essentially eliminating it as a data source.

The swine farm measured for a full year only had 1 day of valid data!
2 of the 3 dairy farms had no valid data!
Therefore the data analysis is really performed on 6 farms (only 2/3rds of that reported to be part of the study.) Given only 1 dairy farm, the dairy and swine data should not be combined. (EPA's plans to combine the lagoon and dairy basin means the dairy emissions would be dominated by emission data from swine.)

*******So in reality, the EEMs only have valid data from 5 swine farms for the analysis********

This lack of data brings into serious question the validity of the EEMs based on NAEMS data set for NH3 emissions certainly for dairy and but also for swine.

Page 4-3 Meteorological data recorded as 5 minute averages and emissions were reported as 30 minute averages

Page 4-4 For NH3 emissions calculated using the RPM model, the 75 percent completeness criteria was achieved at only site OK4A. The final reports to EPA do not discuss data completeness and do not provide detailed reasons for why the completeness goals were not achieved.
Didn't EPA ask why completeness goals were not met?

Page 5-6 In developing the NH3 EEMs, the EPA used the measurements obtained using the RPM model (Radial Plume Mapping)

Page 4-5, Table 4-1 Reported number of Valid Emission Days by Site
No. of valid Emission Days (RPM)

IN4A	1	
NC4A	4	1 fall, 3 summer
OK4A	30	no winter samples
IA3A	4	all summer
NC3A	3	2 winter, 1 summer
OK3A	9	no winter samples, 1 spring
IN5A	18	no winter sample, 2 summer (Dairy)
WA5A	0	
WI5A	0	

Total days besides OK4A and IN5A = 21 days
Total days swine 51 days; 30 at OK4A (60%)
Total swine + dairy = 69 days

The EEMs have been developed from 5 swine sites, 4 of which only had 21 days of valid emission data. Only 2 samples from winter.
If the 1 dairy site is eliminated (18days; 26% of samples; 1 site), 60% of the samples are from the summer. 60% of the samples are from OK4A

The data set is skewed seasonally, geographically and by animal type. EEMs developed from this data set would not be valid for dairies and are dominated by data from 1 swine farm in Oklahoma.

Page 4-13, (Table 4-6 and 4-7) The seasonal distributions of valid NH_3 and H_2S emissions were weighted towards the spring and summer.

Page 4-7, Considering alignment with NAEMS monitoring dates, the data completeness goal for liquid composition data of quarterly sampling was not achieved at any NAEMS monitoring sites

Page 4-11 (and page 5-6) Due to the very limited number of daily NH3 emission values reported, the EPA prepared a database of half hour values by combining the 30 minute emissions data and 5 minute meteorological data provided by the NAEMS researchers.
The statistics of this seem dubious to me. The 30 minute emission measurements are not independent measures but autocorrelated since they are a time series.

Page 4-12 Based upon its analysis, the EPA confirmed that the completeness goal for the two long term monitoring sites was not achieved. Additionally, the completeness goal for the short term monitoring sites was achieved only at site OK4A.

Page 5-1. Mentions 9 values (one from each site) for each farm-based predictor variable. However, only 7 sites had NH3 emission data and 1 site had only 1 day's worth of data. There was also only 1 dairy site which should not be combined with the swine data. Therefore there should only be 5 sites.

Page 5-6 emissions … data used to develop NH_3 EEMs for lagoons were collected … from 6 swine sites and 3 dairy sites.
Only 5 swine sites had data and 1 had only 1 day. Only 1 dairy farm had data.

Page 5-7, Table 5-2. ***Where did the NH_3 emission data to WA5A and WI5A come from? Table 4-1 show no valid NH_3 emission data from these dairy farms?***

Page 5-9 In determining which data and information … would be selected as candidate predictor variable for EEM development, the EPA's primary consideration was data completeness. … and readily available to farmers. Is this scientifically valid?

Page 5-13. NH3 emissions rate from lagoons is affected by air temperature, wind speed across the lagoon surface and relative humidity. …EPA included temperature as a candidate predictor variable but not wind speed and RH.

Solar radiation not used.

Page 5-15 – 16 Lagoon liquid data –although expected to affect NH3 emissions, pH, ORP lagoon liquid temperature, total N, NH_4^+ not used due to insufficient data.

20% of 30 minute data held out for model verification
This data is likely autocorrelated to the data within the model and therefore does not represent a true test of the model with independent data.

Page 5-24. To capture the skew-right nature of the NH3 emission data, EPA chose the gamma distribution.

Page 5-25. …Section 5.1.1 discusses the challenges of deciding how many and which of the static farm based predictors to include and shows how unbalanced coverage of meteorological conditions from site to site presents an obstacle to using NAEMS data to learn the effects of any farm based variable on NH3 emissions.

Page 5-26. Fig 5-6 shows ln(NH_3) increases with increasing air temperature points corresponding to very low emissions (near zero) … do not follow the same pattern with respect to air temp and brings their validity into question. Perhaps plotting Ln NH_3 vs (air –lagoon)Temp may provide a better insight (Aneja et al. JAWMA, 2008)

Page 5-46 **– *degree of freedom discussion should be based upon 5 data points not 9.***

Page 5-47 EPA chose to use the farm-based predictor variables in table 5-9 as surrogates for those describing differences in lagoon liquid and thereby accounting for any differences in emission from dairy and swine lagoons
there is no evidence that this is a valid assumption.

page 5-48 At this point, no conclusion can be drawn from plots or summary statistics regarding difference in NH3 emission from lagoons for different animal types because the met conditions under which the data were collected for the different sites are so different. The emission differences among animal types appear to be driven by the differences in the NAEMS sampling schedule across sites, with higher emissions occurring in the summer months and lower emission in the colder months across all animal types. While seasonal data availability is different among sites, the NAEMS data collectively provide coverage of all seasons when all sites are combined, though the data are quite sparse for January.

Page 5-69 - …EPA has concluded that additional analysis is needed to develop the lagoon EEMs due to some confounding factors in the available data. “The EPA is seeking recommendations from SAB on the additional proposed analyses.”
My conclusion is that the data is too skewed in animal type, location and season to produce useful conclusions. It is clear to me that the NAEMS monitoring process fell far short of expectations and is unable to deliver the desired product, i.e. EEMs. Perhaps the other sources of data collected from published studies can be mined to improve the NAEMS data set for analysis.

<u>References that should be included or considered to ensure a comprehensive understanding of AFO broiler and/or swine and dairy lagoon/basin operations:</u>

A) The following are some of my recent publications that US Environmental Protection Agency may benefit from. They deal with emissions of ammonia from swine lagoons and barns, and development of a process model for lagoons.

Aneja, Viney P.; S. Pal Arya; D.S. Kim; I.C. Rumsey; H.L. Arkinson; H. Semunegus; K.S. Bajwa; D.A. Dickey; L.A. Stefanski; L. Todd; K. Mottus; W.P. Robarge; and C.M. Williams. Characterizing Ammonia Emissions from Swine Farms in Eastern North Carolina: Part 1—Conventional Lagoon and Spray Technology for Waste Treatment. 2008. *J. Air & Waste Manage. Assoc.* 58:1130–1144.

Aneja, Viney P.; S.P. Arya; I.C. Rumsey; D.S. Kim; K. Bajwa; H.L. Arkinson; H. Semunegus; D.A. Dickey; L.A. Stefanski; L. Todd; K. Mottus; W.P. Robarge; and C.M. Williams. Characterizing Ammonia Emissions from Swine Farms in Eastern North Carolina: Part 2—Potential Environmentally Superior Technologies for Waste Treatment. 2008. *J. Air & Waste Manage. Assoc.* 58:1145–1157.

Aneja, Viney P.; S.P. Arya; I.C. Rumsey; D-S. Kim; K.S. Bajwa; and C.M. Williams. Characterizing ammonia emissions from swine farms in eastern North Carolina: Reduction of emissions from water-holding structures at two candidate superior technologies for waste treatment. 2008. *Atmospheric Environment* 42: 3291–3300.

Aneja, Viney P.; J.P. Chauhan; and J.T. Walker. Characterization of atmospheric ammonia emissions from swine waste storage and treatment lagoons. 2000. J. of Geophysical Research 105 (No. D9): 11535–11545.

Aneja, Viney P.; W.H. Schlesinger; and J. Willemerisman. Effects of agriculture upon the air quality and climate: research, policy, and regulations. 2009. *Environ. Sci. Technol.* 43, 4234–4240.

Bajwa, Kanwardeep S.; V.P. Aneja; and S.P. Arya. Measurement and estimation of ammonia emissions from lagoon–atmosphere interface using a coupled mass transfer and chemical reactions model, and an equilibrium model. 2006. *Atmospheric Environment* 40: S275–S286.

B) The following are some of my recent publications that US Environmental Protection Agency may benefit from. They deal with H2S emissions from swine operations:

Blunden, Jessica; and V.P. Aneja. Characterizing ammonia and hydrogen sulfide emissions from a swine waste treatment lagoon in North Carolina. 2008. *Atmospheric Environment* 42: 3277–3290.

Blunden, Jessica; V.P. Aneja; and J.H. Overton. Modeling hydrogen sulfide emissions across the gas– liquid interface of an anaerobic swine waste treatment storage system. 2008. *Atmospheric Environment* 42: 5602– 5611.

Blunden, Jessica; V.P. Aneja; and P.W. Westerman. Measurement and analysis of ammonia and hydrogen sulfide emissions from a mechanically ventilated swine confinement building in North Carolina. 2008. *Atmospheric Environment* 42: 3315–3331.

C) The following are some of my recent publications that US Environmental Protection Agency may benefit from. They deal with VOCs emissions:

Blunden, Jessica; V.P. Aneja; and W.A. Lonneman. Characterization of non-methane volatile organic compounds at swine facilities in eastern North Carolina. 2005. *Atmospheric Environment* 39: 6707–6718.

Rumsey, Ian C.; V.P. Aneja; and W.A. Lonneman. Characterizing non-methane volatile organic compounds emissions from a swine concentrated animal feeding operation. 2012. *Atmospheric Environment* 47: 348-357.

Preliminary Comments from Dr. Peter Bloomfield, Dr. Alicia Carriquiry, Dr. Paul Sampson, and Dr. Eric Smith

Discussion of response to Charge Question 1: *Please comment on the statistical approach used by the EPA for developing the draft EEMs for broiler confinement houses and swine and dairy lagoons/basins. In addition please comment on the approach for developing draft EEMs for egg-layers, swine and dairy confinement houses.*

Development and Structure of the broiler Emissions Estimating Models (Section 7)

1. The panel recommends the EPA develop a modeling approach that is more consistent with the sampling design structure and data limitations. Model development needs to consider effects of location, house within location and flocks within house in model inference and prediction. Model uncertainty needs to recognize the limitations in using a small number of locations. The panel is concerned that any model developed from information on two sites is not applicable to all sites in the US.

2. The panel further recommends the EPA carefully consider the process for developing the statistical model, paying attention to the mean and variance components of the model. In particular, the approach for evaluating random effects requires attention. The panel also expressed concern about using a polynomial model for estimating the relationship between animal mass and concentrations.

3. The panel recommends the EPA consider other approaches to the crossvalidation method used to evaluate the model. K-fold crossvalidation methods are preferable to simple data splitting. Splitting of data based on factors related to model usage (such as flock, house and location) should be considered as a way to evaluate model predictive ability.

4. The panel recommends that residual analyses have more importance in the report and modeling process. It is preferable to plot residuals to look for oddities, lack of fit, serial correlation and lack of support for the probability model rather than histograms of the data. The mean and variance specifications should be assessed in an extensive analysis of residuals. The covariance structure, especially the possible contemporaneous correlation among residuals for different houses at a single site, should also be assessed using the same residuals.

General comments

1. The modeling approach generally ignores the sampling/design structure of the data and implications. It is not clear from the model development process if the overall goal is prediction or inference. The sampling design determines the ability to make statements about the collection of potential samples. In this design, there are locations, sites/houses within locations and flocks within houses. These factors, which might be called design factors are mostly

ignored. They are however rather important when it comes to making inferences about what factors and interactions are important as they affect the variance estimates and degrees of freedom for testing. While it would be useful to add factors associated with year and season, I suspect that the imbalance in the data will cause limitations when the model is applied to new sites.

The EPA attempts to remove problems due to inadequate sample design by combining the information from separate sets into a single data set. While this may be required to develop a model, the inference may be limited to the locations and houses that are available. From a broad inference perspective the model involves N=3 sites. This is a rather small sample for developing models for use in other locations. It is also difficult to estimate variance components with this number of sites.

2. The process of developing the statistical model for predicting each pollutant should begin with finding appropriate specifications of:

- the mean, as a function of the predictor variables;
- the variance, as a function of the mean and/or the predictor variables.

The distributional form of the observations, identification of which is the first step in the process described in the Draft, is generally accepted as less important than the mean and variance specifications. The panel expressed concern about the both deterministic and stochastic components of the model. Specifically

- Nonlinear models: Polynomial regression, such as the use of cubic functions to represent nonlinear dependence in average mass of animals, leads to poor predictions near the extremes of the experimental conditions, and can lead to disastrous extrapolations only just beyond those extremes. It would be useful to plot the model to see the values that might occur for maximum bird mass. Use of a nonlinear model may be a possibility here although there are potential problems with these models as well. The restriction on the range of mass should be reported if the cubic model is used. Plots of individual flocks suggest that a different models might be appropriate for different flocks or that a random effect due to flock is needed. Alternative strategies to polynomials for nonlinear relationships: perhaps low degree of freedom splines that are linear at the boundaries? If polynomials are to be used, the panel recommends us of orthogonal polynomials. With these one can arguably consider eliminating some interaction terms rather than keeping all three polynomial terms in any interaction considered.

- Correlation structure: It is not clear that the very high temporal correlation structure has been adequately modeled. Usual time series tools (ACF and PACF) should be considered to assess the adequacy of the AR(1) model. The defense of the current model seems to be based entirely on the coverage of predictive intervals. While this is important, this does not guarantee a good model (overall coverage near 95% does not necessarily mean that coverage conditional on other factors is also 95%). The extremely high autocorrelation suggests that perhaps there are some other temporal trend features that could/should be identified.

- Random effects: The analysis approach must consider random effects for flocks. It is possible that other factors (such as buildup) may account for most of the flock effects, but it is still necessary to consider a flock random effect to account for what must otherwise be considered dependent observations (beyond the temporal dependence). Although house and location are also considered as potentially random, there are too few levels of the house and site factors to analyze them as random effects. They should be modeled and tested as fixed effects. We would hope that the house and site factors would act like additive blocking effects in addition to other predictors, but it could be necessary to consider interaction effects permitting other predictors to have different coefficients at different sites.

2. Crossvalidation is a useful tool for model selection and for evaluating predictive ability. It's value is constrained by the method for selecting the test set for model evaluation. By selecting a random sample of observations, the results concerning predictive ability are limited. It is not clear if the method will give a good measure of the predictive ability for a site in Florida, or another state or another location within Kentucky. It should be possible to estimate prediction error for different flocks, for different houses and for different locations by running exercises using these factors to select holdout samples. The crossvalidation exercise could help identify the limitations to the model and to obtain a better estimate of the prediction error at new locations or new flocks.

The exercise described in the Draft as “cross-validation” is not what most statisticians understand by that description. Five-fold cross-validation would involve a similar division of the data set into fifths, but each would be held out in turn, and predicted using a model fitted to the other four fifths. The exercise described in the Draft is also not a true validation, because the performance of candidate models in predicting the hold-out data was used in the model selection process. In a true validation, the test data would be held out of the entire model selection and estimation process. Model and analysis must incorporate the factors in the experimental design. That is, the “house”, “site” and “flock” factors must be part of any analysis.

3. The panel recommends that residual analyses be part of the report. Histograms are used to indicate that the data are skewed however, these plots are rather limited, as the authors point out. It is preferable to plot residuals; to look for oddities, lack of fit, serial correlation and lack of normality. The mean and variance specifications should be assessed in an extensive analysis of residuals. The covariance structure, especially the possible of contemporaneous correlation among residuals for different houses at a single site, should also be assessed using the same

residuals. Table 7-9 is definitely not a good way to assess mean-variance relationship as the constant range of NH3 values in the rows of the table constrain the SDs to be similar.

4. The variable selection approach in the model building is likely suboptimal with respect to the goal of accurate prediction. We would recommend a modern text focusing on prediction, such as "The Elements of Statistical Learning" by Hastie, Tibshirani and Friedman. Because the primary aim is prediction there is no reason to base variable selection on backward elimination with a conservative p<.001 criterion. The apparent significance of individual predictors is not a primary concern, especially in the context of (somewhat) correlated predictors. While the final choice of model was not completely automatic according to the backward elimination algorithm, there seems no reason not to consider the results of an all subsets regression procedure rather than backward elimination (although this would only be possible without all the interaction effects) using a BIC criterion. Uncertainty in the "best" model could be assessed with cross-validation (see below).

Miscellaneous:

Page 7-29 Bottom of second paragraph - centering does not produce data where 50% are below zero and 50% above unless you are centering by the median.

Page 7-31 is there any justification for using a change in R2 for adding interaction terms?

Page 7-37 (2nd paragraph) Can three sites really be representative of all sites? Consider rewriting the sentence.

Figure legends could contain more information. For example, Table 7-16, mention this is standardized data.

Diets can have a large impact but are not included.

Season is not in the model. The data cover somewhat different time periods. It may however be difficult to include season in a simple manner. The California sites are sampled from Sept 2007-Oct 2009 while Kentucky sites were sampled from February 2006 to March 2007. There is confounding between location and time of sampling (year of sampling). This may affect inference for seasonality.

Table 7-2 parameters picked based on chemistry and knowledge - additional variables should have been in the model.

The use of the regression of predicted versus observed is potentially difficult as one may obtain an R^2 of 1.0 when there is a biased model.

Check calculations of LL and BIC - these seem to be based on REML rather than ML

It is generally not clear how different results will be when they are applied to new sites.

A relevant variable that should be include is the nitrogen inputs.

Some of the variables exhibit measurement error (number of birds and average bird weight are estimates). Consider accounting for the error because if it is not accounted for the relationship between the concentration and predictors is attenuated.

In Table 7.8 it appears that the variance component for house is significant (or this is a typo).

It might be useful to consider a method such as quantile regression for estimating the percentiles of the distribution rather than the average values.

There is clear lack of constant variance. As is common in data of this kind, the variance and the mean are correlated, so that, e.g., the variance in the response increases as the mean response also increases. A simple solution to this problem is to transform the response variable since transformation sometimes disentangles the mean and the variance. One possibility is to just use a square root of a log transformation (assuming that we report the zeros as censored).

Table 7-2 refers to selected variables, which were based on knowledge of chemistry (p. 7-14). Air flow, temperature, and time variables are related to chemistry. However, feed rate and composition, water management, and manure composition (moisture and N) also relate to the chemistry.

Table 7-3. Note that more than half of data is missing in fall, 79% missing in California.

Centering and scaling the predictor variables (usually termed “standardization”) has no effect on collinearity, except between a predictor and the constant term.

When a model estimated using “base” data is evaluated by comparing its predictions for “hold-out” data, the rmse (root mean squared prediction error) is the most important summary. The R^2 in the regression of the hold-out data on the predictions is less relevant; testing that the regression has a slope of 1 and an intercept of 0 gives some information about possible differences between base and hold-out data.

In Section 7.4.3: “a small p-value indicates that the estimated value of the parameter is not significantly different from zero ” is the opposite of the correct interpretation; a small p-value indicates that the estimated value of the parameter *is* significantly different from zero.

It is not clear how important some factors are since tests are not reported. It does appear that animal mass seems to be most important.

All relevant variables were not used. More consideration to mass balance and process-based models is needed.

The panel thought that there might be evidence for variance heterogeneity and requests that this be given additional attention.

There is a lack of data/modeling of correlation between houses on a farm which is necessary in order to put confidence limits on a total farm emission estimate. Future data collection should include information on multiple houses. The report shows concern at the end of section 7.4 (p. 7-37) for making predictions at sites not included in the NAEMS. Unfortunately, if there are any significant differences between the sites available, whether in variance and auto-correlation parameters or other fixed effect parameters, any such predictions cannot be justified. It is a limitation of the study design that collected data on only 3 sites in 2 states. One cannot ignore heterogeneity across sites and rely on predictions assuming no heterogeneity, as suggested at the end of section 7.4.

Consider a joint test of significance of the slope and intercept in the model that compares predictions and actual values (p 7-42). . Also a plot of these values is warranted.

Negative values

About negative/zero values: I am not sure whether I completely understand what is going on here, but here is what I think I understand.

- There is no such thing as a negative emission. If a negative value is recorded, this MUST be due to measurement error.
- If we know the minimum detection level of the instrument that made the measurement, then any measurement below that detection limit is CENSORED (it something between 0 and the MDL) and should be treated as such in the analysis. This would include any value below the MDL, including negative values, zeros, etc.
- The simple solution is to use half of the MDL in place of the measurement, as Wendy (I think) suggested.
- The not-so-simple but statistically more correct approach is to toss the standard regression model and fit a model that allows for the presence of censoring. SAS can handle that, for example, but it requires a bit of an overhaul of the statistical models in Section 7.
- If a calculated value such as measurement – background is negative, we will cannot report a negative value, it seems to me. I would probably again just report that the emission is below background and either leave it at that or again treat it as censored, although this is a bit more difficult because the background is also an estimated value and using it as a fixed censoring threshold is difficult.

Section 8

- Plots in section 8 really suggest analysis on a log scale would be appropriate, although this is not certain without diagnostics. Log scale not strongly suggested for VOC.

Preliminary Comments from Dr. Nichole Embertson

Responses to Charge Questions from Meeting on March 14-16, 2012

Question 1

Please comment on the statistical approach used by EPA for developing the draft EEM's for broiler confinement houses and swine and dairy lagoons.

Please refer to comment summary submitted by panel for comments. My views are in line with those comments.

Question 2

Please comment on the agency's decisions to combine the swine and dairy dataset to ensure that all seasonal meteorological conditions are represented. In addition, the agency also seeks the SAB's comments on whether the agency should combine lagoon and basin data.

Combining the swine and dairy lagoon/basins is not a valid approach if accurate EEM want to be developed. Swine and dairy lagoons/basins are *significantly* different biologically and nutrient wise. Some supporting reasons: swine and monogastric and dairy ruminant and thus have very different manure profiles; dairy has a much high solids content which precludes sunlight and surface aeration, and provides more material for methane, hydrogen sulfide, and anaerobic biological process to take place; dilute swine lagoons are more apt to foster populations of purple sulfur bacteria, which can significantly reduce hydrogen sulfide production; and lastly, because of differences in housing, dairy lagoons, unlike very controlled swine housing, tend to collect more slab runoff water than swine, transfer carbon rich bedding to lagoon, and have more pre-lagoon treatment via solids separation, all of which greatly affect the emission potential. Extrapolating results from swine lagoons onto a dairy lagoon, or vise-versa, is not accurate and will not be supported by either industry, nor the scientific community.

The combination of swine and dairy lagoons to increase the dataset to ensure all meteorological conditions are represented is not a valid methodology. Not only for the reasons mentioned above, but the seasonal weather patterns in the areas lagoon/basin data were collected (IN, WA, WI, IA, NC, OK) are very different. This was acknowledged on page 2-10 in the lagoon report, "*The sites selected also represent the broad geographical extent of dairy production to also represent different climatological settings for farm and any regional differences in farm practices*." Combining datasets does not offer any additional validity or support, but rather undermines the relevance by comparing "apples to oranges". Patterns in each individual season can be assessed and compared across species and site, but combination of all species and seasonal data into one set for seasonal representation is not advised.

Lagoon and basis data should not be combined. Even though EPA combined these two in the report (page 1-6), they are actually very different and should be assessed separately. A lagoon is used to provide biological treatment and long term storage. A basin is for short term storage and does not provide biological treatment. Basins include technologies such as earthen pits, weeping walls, leaky dams, gravitational solids separators, pits, and tanks. Additionally, lagoon systems can come in overflow multi-stage systems with multiple lagoons, each with a very different nutrient, biological and thus, gas emission profile. The combination of multi-stage lagoon system into one is also not recommended. Each should be evaluated separately. Overall, it is recommended that lagoons and basis <u>not</u> be combined.

Question 3

Please comment on the agency's decision to use static predictor variables as surrogates for data on lagoon/basin conditions. Given the uncertainties in that approach, does the SAB recommend that EPA consider specific alternative approaches for statistically analyzing the data that would allow for the site specific lagoon liquid characteristics to be used as predictor variables?

Of the static variables suggested as surrogates for data on lagoon conditions, none are valid for representation of factors that correctly effect emissions rates. The suggested variables do not take into consideration nutrient values of lagoon, biological activity, or parameters that effect potential emission rates. Neither is it able to account for improvements with best management practices, digester use, or other management and treatment options. Using a predictor such as "surface area" to predict the rate of ammonia emissions from a lagoon has no basis in any parameter that would account for actual emissions. A value such as "milk production" instead of "animal body weight" would be more accurate in predicting total manure output and potential nutrient values, but that doesn't account for differences in nutrition, breed, housing type, or treatment system, all of which have been shown in scientific studies to greatly effect emission potential.

Instead of a purely statistical approach, it is suggested that EPA move toward a process based model to predict potential emissions or provide a better predictor variable to use in a statistical-based model. The variability between lagoons, basins, and area weather patterns is far too great to use one emission rate or non-representative predictor variables.

Question 4

Does the SAB recommend the EPA consider alternative approaches for developing the draft NH3 EEM that balances the competing needs for a large dataset (to reflect seasonal meteorological conditions) verses incorporating additional site specific factors that directly affect lagoon emissions. If so, what specific alternative approaches whole be appropriate to consider?

It is recommended that EPA move toward a parallel, process based model approach for developing EEM's for lagoons and basins. The current dataset can be used to validate the model to ensure it is meeting the needs of the EPA methodology. Additionally, the EPA should consider using literature values, or data taken from other similar studies to add robustness to the data set.

Question 5

Please comment on the EPA's approach for handling negative and zero emission measurements.

There are two types of negative data in the dataset that need to be considered separately: calculated (emission) and raw (concentration).

For **calculated data**, negative values should be included. This is because the background values, used to create the calculated values (measured – background), were measured either intermittently (twice a day for gas), or continuously without correction for lag time in the barn (PM data). This could lead to a bias either up or down, potentially creating negative data values. Additionally, if an event occurred outside the barn (i.e., other barn cleanout, manure movement, etc.), or meteorological conditions created the exhaust air to come back into the barn, these events may create a spike or change in measured values that effect the calculated values. If negative values are excluded due to calculated error, then there is a bias toward those values that were overestimated on the positive side (these values were not taken out of the data set). If the calculated value is negative, the raw data can be consulted to discover if it is a calculated effect or other.

For **raw data**, if the instrument produces a negative concentration value that is due to a "below detection" or "minimum detection limit (MDL)" reading, but within instrument limits, the number should be used. Suggestions on the use of negative values: 1) Convert negative value, that is within the instrument error to 0 and use. 2) Use the negative value produced if it is within instrument error. Often times values fall below the standard curve as part of the variation of equipment, error, etc. 3) The values can be corrected by using the EPA method of using half of the MDL when observed value is below limit of detection.

If the measured concentration value is below lowest detection limit for the instrument *and* out of instrument error, limits, or uncertainty, then the value should be removed from data set. Data should be qualified individually.

If raw data is deemed negative after adjustment due to calibration, the value should be included in the data set. If not, there is a bias to those data that are positive due to the same process.

Concentration data should be qualified on an individual basis to remove any outliers prior to assessment as a negative emission value.

The model should include negative values to be valid. There is already a lot of uncertainty in the measurements, which speaks to inclusion of negative values that qualify. There is no statistical problem with inclusion of negative values into the model.

Question 6

In the interest of maximizing the number of available data values for development of the draft H2S EEM for swine and dairy lagoons/basins, does SAB recommend any alternative approaches for handling negative and zero data other than the approach used by the agency.

It is understood that the dataset for H2S for swine and dairy lagoons/basins was small due to data summary methods and/or instrument deficiency in being able to record concentration/emission values and producing invalid data for H2S. Instrument deficiency was due to changes in wind direction, inadequate wind speeds, or other unknown variables. This cannot be corrected for after the fact; therefore, the methodology for assessing valid data should be considered. The summary methods used by EPA ended up precluding data if a 75% validation level for various time periods (i.e., hourly, daily, total) was not met. The 75% number seemed too stringent and unnecessary in this case and it is suggested that the number be evaluated for reduction or removal so that more data can be included. To maximize the dataset, it is recommended that all data meeting the criteria outlined in Question #5 above be included for analysis, regardless of the 75%.

Question 7

Please comment on the approach EPA used to develop the draft broiler VOC EEM.

Please refer to comment summary submitted by panel for comments. My views are in line with those comments.

Preliminary Comments from Dr. Brock Faulkner

<u>Response to Charge Questions</u>

Question 1*. *Comment on the statistical approach used by EPA for developing the draft EEMs for broiler confinement houses and swine and dairy lagoons/basins. In addition, please comment on using this approach for developing draft EEMs for egg-layers, swine, and dairy confinement houses.

General Comments

Under the Consent Agreement, EPA is required to develop emissions estimating methodologies (EEMs) from data collected during the National Air Emissions Monitoring Study (NAEMS) project. It was obvious from the outset of the NAEMS project that the basic design of the study was critically flawed and would make development of reliable EEMs from the collected data that could be applied to other operations nationwide difficult or impossible with any reasonable level of confidence. EPA has clearly worked diligently to salvage the results of this study and develop draft EEMs for broiler confinement houses and lagoons and basins from dairy and swine operations. Nonetheless, several aspects of EPA's analysis are concerning:

1. Given that EPA's EEMs are highly dependent on particular measurement methods and data availability, **several data collection and quality issues should be addressed by EPA as they further develop their methodology**:

   - Data available for development of EEMs should be described with more clarity. It is not apparent in the Draft EEMs for broilers and lagoons/basins how data were collected and what data are available. Section 1 of the broiler report describes how data were *supposed* to be collected in the NAEMS project, but many departures were made from the original study plan. These departures should be clearly explained, and data that were not collected should be clearly identified early in the reports.

   - It was apparent during the March meeting of the SAB Panel that there are significant volumes of data collected during the course of the NAEMS project that are in the possession of the Science Advisor, Dr. Heber, but that have not yet been made available to EPA. **Much of these data are critical to development of good EEMs.** EPA should work with Dr. Heber to inventory that data which were collected but have not yet been reported to EPA and should develop a timely plan for transferring the data to the Agency.

   - Confidence in the applicability of EEMs developed from study data is substantially limited by the limited number of sites from which data were collected. This is a major flaw in the NAEMS study and one that can no longer be rectified, but the implications of such a limited dataset should be clearly acknowledged so that state and regional regulatory agencies applying the EEMs clearly understand the limits of applicability for the final EEMs.

- Negative and zero data values must be treated carefully. Negative and zero values resulting from net concentration calculations (e.g. outlet concentrations minus inlet concentrations) should be treated differently than negative and zero values resulting from instrument calibration issues, etc. Eliminating all negative values of some measurements will inappropriately bias EEMs towards higher emissions estimates. However negative or zero values resulting from flaws in data reduction methods should be considered through a different lens. EPA's current method of eliminating all negative values is arbitrary and should be reconsidered, but no firm rules can be established across all measurement methods at all sources regarding the most appropriate manner in which to process negative and zero values.

- Data outliers should be identified and excluded carefully throughout the full range of data values. Methods for identifying and handling outliers are not currently described adequately.

2. **The statistical model EPA uses to estimate emissions of a given constituent should reflect, to a great degree, the physical, chemical, and biological processes involved in generating emissions of that constituent.** Many of the "surrogate" variables used by EPA to estimate emissions do not directly affect emissions from a given source. It is illogical, then, to utilize these variables when estimating emissions from a much larger suite of animal feeding operations than was used to develop the EEMs.

3. **EPA should carefully consider the range of data over which EEMs will be extrapolated beyond those captured at measurement sites.** Two issues are of primary concern related to extrapolation of EEMs beyond the range of data from which they were developed:

    a. EPA should check that EEM models yield **reasonable** emissions estimates, **commensurate with results of other studies**, at points beyond those from which EEMs were developed. For example, because a cubic function was used to represent the predictor variable "avem" in the broiler methodology, if the average bird mass gets large enough, the proposed EEM will predict "zero" emissions from the broiler house. Such a result is unreasonable and clearly results from applying the EEM to values of bird mass that exceed those at data collection sites but that are not unreasonable for some broiler production facilities in the US.

    b. Sites for the NAEMS study were chosen to collect data at facilities applying no emissions control strategies. Therefore, applying EEMs to facilities in which effective pollution control strategies have been applied will lead to overestimation of emissions. EPA should make state clearly in the EEM description that **the EEMs only predict emissions from facilities in which no control measures are**

applied so that producers implementing better management practices will be able to take credit for reducing emissions. The need to allow producers to take credit for good environmental stewardship practices further underscores the need for a regression model that parallels pollution generation processes so that the effects of control strategies might be more easily and accurately quantified.

4. **EPA should validate the results of their EEMs against emissions estimates available in scientific literature.** During EPA's call for information for both broiler and lagoon emissions, numerous studies were submitted that have used diverse measurement methodologies at numerous sites to characterize pollutant emissions from these sources. EPA has stated that most of these sources provide no valuable information for EEM development (see tables 4-4 and 4-5 of the broiler report and tables 3-3 and 3-4 of the swine and dairy lagoon/ basin report), but this is not true. While the data in these sources may not be sufficient or of the appropriate type to utilize when developing a regression model, comparing the results of EEMs derived from data collected at a few site with singular measurement techniques against data collected from multiple facilities using a host of measurement methodologies will serve to strengthen EPA's EEMs if the results are consistent with those found in the literature. If EPA's results are not consistent with the peer-reviewed literature, the Agency should critically question why such a departure exists and re-evaluate their EEM and/or the representativeness of data reported in the body of scientific literature.

Addressing each of these concerns in the present and soon-to-be-developed EEMs will greatly strengthen the quality and validity of EEMs developed.

Broiler EEM

Emissions estimating methodologies were developed for ammonia, hydrogen sulfide, particulate matter ($PM_{2.5}$, PM_{10}, and total suspended particulate (TSP)), and volatile organic compound (VOC) emissions from broiler operations.

Strengths

- EPA's proposal to develop three tiers of EEMs (I, IA, and IAC) for broilers, each requiring a different level of detail regarding inputs, is a good concept. However, given that:
  - Conditions within the confinement building rather than in the ambient air affect ventilation rates and biochemical processes at the point of generation, and
  - Growers regularly monitor conditions within the confinement buildings,

EPA may consider developing an "IC" methodology, in which inventory and confinement parameters may be used apart from ambient meteorological conditions.

- EPA's analysis of litter buildup and choice of the *build* function to indicate the absence (0 for first flock on new litter) or presence (1 for all subsequent flocks) of litter buildup is appropriate. Further differentiation for later flocks is unnecessary, as concluded by EPA.

- EPA's logic for including 2-way interactions but excluding 3-way interactions in the statistical analysis is reasonable.

- EPA's logic in assessing the need for random variables of "site" and "house" is sound, but the analysis is lacking in rigor given that only two sites were monitored, and only two houses per site were included in the study. Random variables for "flock" and "year" should also be included in the analysis to determine if they are significant.

Weaknesses

- As mentioned previously, **the statistical model EPA uses to estimate emissions of a given constituent should reflect, to some degree, the physical, chemical and biological processes involved in generating emissions of that constituent**. As applied to the broiler EEM, this means that some estimation of the nitrogen and sulfur contents of system inputs (i.e. feed, water, and bedding) should be included in the EEMs for ammonia and hydrogen sulfide, since these compounds are the precursors to estimated emissions. By using surrogate variables that do not directly affect emissions (e.g. "avem" for ammonia and hydrogen sulfide emissions), EPA is faced with two major dilemmas:

    1. The Agency incurs a greater risk that extrapolation of EEMs to production scenarios beyond those which were used to develop EEMs will result in erroneous emissions estimates, and

    2. The Agency precludes the use of the developed EEMs for estimating effects of improvements in production systems such as increases in feed conversion efficiency.

    In order to build a statistical model that better reflects actual generation mechanisms (e.g. concentration of precursors in the litter), EPA is limited by the data available to them through the NAEMS study. For gaseous emissions, estimates of the nitrogen and sulfur content of litter are critical, while for PM, estimates of bird activity are pertinent.

    In order to estimate the composition of the litter, estimates of feed composition and metabolic conversion could be used. Although he had not, at the time of the SAB Panel meeting in March, made the data available to EPA, Dr. Heber indicated that his research team collected samples of feed, water, and manure at project sites from which the nitrogen and sulfur contents of each of these components were characterized. Feed data could be combined with estimates of metabolic conversion efficiencies for broilers to determine nutrient excretion rates, which would be much more pertinent to emissions generation than simply using average bird mass. If such data are not forthcoming from Dr. Heber, EPA could utilize National Research Council (NRC) feed composition recommendations to estimate ration composition.

As an alternative approach, EPA could utilize an American Society of Agricultural and Biological Engineers (ASABE) standard that estimates typical manure (both urine and feces) characteristics excreted by various animals (ASAE D384.2 – Manure Production and Characteristics) to estimate litter composition. Values in this standard could be used to estimate the nitrogen additions to the original litter material, thereby providing a more realistic predictor variable for statistical regression than those utilized by EPA in their draft EEM for broilers.

- The limited datasets available for $PM_{2.5}$ and TSP emissions are especially problematic for developing EEMs to predict emissions from sources across all regions of the United States. According to Tables 8-22 and 8-35 of the draft broiler methodology, $PM_{2.5}$ and TSP concentrations were collected for less than 10% of the total sampling days at site CA1B, effectively limiting development of the EEMs for these pollutants to measurements from the Kentucky sites only. (Separately, it is unclear why EPA is developing an EEM for TSP, when TSP is no longer a regulated pollutant.)

- The dataset for developing an EEM for VOCs is critically limited. This issue is discussed in more detail in the response to Charge Question #7.

- EPA attempted to develop EEMs that utilize data easily accessible to producers, but the Agency falsely assumed that growers frequently measure bird mass. Most growers do not measure bird mass, and many growers do not know the weight of their birds until they receive a report of total mass of birds harvested. While birds are not routinely weighed, their weight can be predicted with a high level of confidence (e.g. Flood et al., 1992). In fact, at the Kentucky sites, bird weight was correlated to bird age with an R^2 value of 0.9935 (Figure 18 from Burns et al., 2009), and there was no significant difference in bird weight between the two Tyson sites that were monitored (Burns et al., 2009). During development of the EEMs for broilers, measured bird weights were collected and should be used, but during application of the EEMs to other facilities, EPA would be well served to allow producers to use predicted bird mass to estimate emissions rather than requiring producers to routinely measure bird mass.

Emission Factors for Decaking and Cleanout

EPA's proposal to develop emission factors for decaking and litter cleanout operations rather than a regressive EEM is well founded given the limited dataset. However, **emission factors for decaking and litter cleanout should be expressed on a "mass per unit weight of litter" basis** rather than in terms of the total mass of birds raised on litter since the last cleanout, particularly for facilities with more than three flocks between full cleanouts. After 3-4 flocks have been raised on a given litter material, the parent material is largely composted and will reach a quasi-steady-state composition. At this point, for example, the litter is unable to retain any more nitrogen per unit weight such that ammonia emissions per unit weight of litter would not increase even if more flocks were raised on the litter.

Coufal et al. (2006) demonstrated this phenomenon when conducting a full nitrogen mass balance over 18 flocks raised on the same litter. During the first four flocks, when the litter material was still relatively intact, nitrogen loss through volatilization was poorly described by ambient temperature (r = 0.27). However, for flocks five through 18, nitrogen volatilization was highly correlated to average temperature (r = 0.88). These data indicate that nitrogen retention per unit mass of litter was likely not increasing after four flocks and was most dependent on barn temperature (Figure 1).

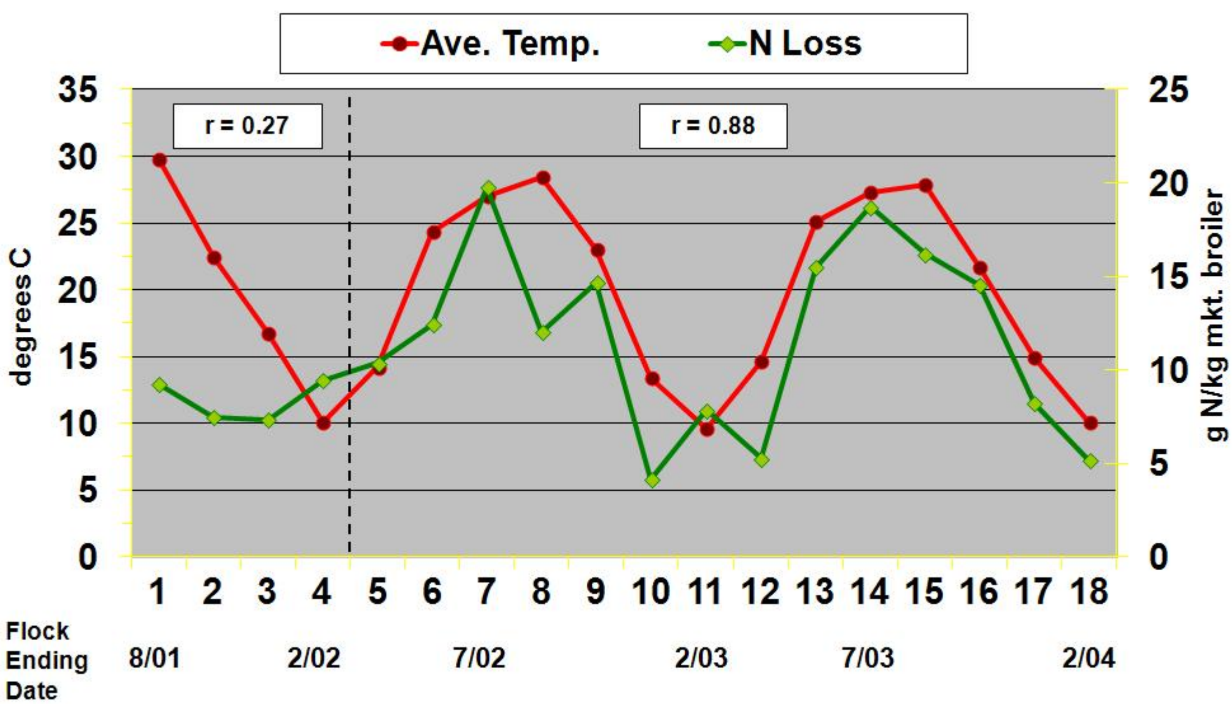

Figure 1. Ammonia loss over 18 flocks (adapted from Coufal et al., 2006)

Given that birds excrete a relatively predictable mass of manure, emissions in terms of "mass per unit weight of litter" and "mass per total mass of birds raised on litter since the last cleanout" could yield similar results <u>if</u> all litter was left in place between flocks, but this is not the case. Most growers decake between flocks, often removing litter from the building. The amount of litter removed during decaking varies dramatically as a function of litter age, bird health, ventilation, water management, etc. Coufal et al. (2006) reported that 6.3% of litter was removed during decaking after Flock 1 of his 18 flock study, while 81.6% was removed after Flock 18 (flock average = 39.8%). These data agree with data from Malone et al. (1992) and NRAES (1999). Furthermore, some producers use litter tillers or windrowers rather than conventional, thus altering the mass of litter removed during full cleanout compared to the study sites.

While the data from Coufal et al. (2006) are only for nitrogen, given the physical and biochemical processes that occur in litter to create emissions, it is likely that a similar approach could be taken for other pollutants as well.

While an emission factor approach is sound given the available data, a better approach to estimating emission from decaking and litter cleanout would include four steps:

1. Estimate the total mass of litter in the house by summing the mass of litter added to the house and the mass of manure produced (estimated using bird numbers and estimated manure production rates (e.g. ASAE D384.2)).

2. Estimate the fraction of litter removed during decaking.

3. Estimate the nitrogen (for NH_3), sulfur (for H_2S), and carbon (for VOCs) contents of the removed litter. These will likely vary between decaking and full cleanout operations and could be measured or estimated from previous research.

4. Use a process-based model or emission factors to predict total emissions from decaking or cleanout.

Such an approach is not drastically different in application than that proposed by EPA, but it better mirrors the physical and biochemical processes that lead to emissions generation and accounts for the litter reaching a quasi-steady-state chemical composition after the parent litter material is fully broken down. The result of this process would be an emission factor stated in more appropriate units (e.g. kg/ton litter removed) than those currently proposed by EPA.

Swine and Dairy Lagoon/Basin EEM

Liquid manure treatment is a chemically and biologically complex process. Here again, **the statistical model EPA uses to estimate emissions of a given constituent should reflect, to some degree, the physical, chemical and biological processes involved in generating emissions of that constituent.** Ammonia emissions from lagoons and basins are largely driven by five factors:

1. The concentration of nitrogen in the lagoon/basin,
2. Water temperature,
3. The pH of the lagoon,
4. Surface area, and
5. Manure residence time.

The dataset for lagoon emissions provided to EPA is substantially limited in scope, which led EPA to pursue several undesirable options when developing an EEM for ammonia from lagoons and basins from dairy and swine operations. **The draft EEMs do not effectively incorporate four of the five most important variables driving ammonia emissions from lagoons, and one of the three EEMs does not consider any of the five most important governing factors.**

If the EEMs developed by EPA are to be applied to other operations in the US with any confidence, the following considerations should be incorporated into a revised model:

1. **Some estimate of nitrogen concentrations in the lagoon must be made.** Dairy cattle have a relatively consistent mature weight (NRC assumes 1450 lbs. for Holstein cows; 900 lbs. for Jersey cows), and manure production rates and composition can be predicted with some confidence (see ASAE Standard D384.2 – Manure Production and Characteristics). Nitrogen excretion from dairy cattle is also related to milk production, which is documented by nearly all producers (values of which should be provided by Dr. Heber to EPA, especially since he stated at the meeting in North Carolina that he has these data). Therefore, animal size would not be required in the EEMs. However, the composition of the inputs to a lagoon varies significantly, being affected by factors such as:

    1. Type of manure handling system used (scrape v. flush v. open-lot dairy),
    2. Degree of solids separation,
    3. Amount of runoff received from precipitation, and
    4. Type of impoundment (primary lagoon, secondary lagoon, basin).

    These are important variables that affect nitrogen loading to a lagoon as much or more than animal size. Similarly, for swine, estimates of nitrogen loading into lagoons should be made based on production stage, manure management, etc.

EPA stated that the Agency will "Consider developing a single static variable that can represent NH_3 loading and lagoon surface area" (p 5-69 of dairy and swine lagoon/basin report). Such an analysis would likely represent an improvement over the current EEMs.

2. **Lagoon temperature and pH should be considered.** Partitioning between ammonia gas and ammonium cation is directly related to lagoon pH. Few emissions are expected from lagoons with pH < 6.8, while little nitrogen will be found as ammonium at pH > 11.0 (Metcalf and Eddy, 2003). Without considering this partitioning, an EEM for ammonia emissions will be plagued with exceptionally high uncertainties. At the SAB Panel meeting in North Carolina, Dr. Nail suggested that temperature and pH data are available for ~5,000 emissions measurements, whereas ~10,000 data points were used to generate the three proposed EEMs. **It would be far more preferable to develop EEMs with a more limited dataset that reflects those parameters that drive ammonia emissions than to use the larger dataset to develop an EEM that has little or no relation to the physical, chemical, and biological processes that drive emissions.**

3. **The response variable considered should be expressed in terms "emissions per unit area" or "emissions per unit N input" rather than "kg/30 minutes."** The current EEM expresses emissions in units that are inapplicable by other producers who use different manure management systems and/or have different animal populations than those sites used to develop the EEM.

4. **The necessity of two- and three-way interactions should be assessed.** Unlike the analysis conducted for broiler houses, in which the marginal improvement in modeled results arising from inclusion of three-way interactions was assessed, analyses of the importance of two- and three-way parameter interactions are not described for lagoons and basins (except for meteorological interactions). This analysis should be added.

Question 2. Comment on the agency's decision to combine the swine and dairy dataset to ensure that all seasonal and meteorological conditions are represented. In addition, the agency also seeks the SAB's comments on whether the agency should combine lagoon and basin data.

As currently analyzed, it is inappropriate for swine and dairy datasets for lagoons and basins to be combined. As the Agency stated on p. 5-28 of the draft EEM, the range of ammonia emissions varies drastically between animal types. On p. 5-48, the Agency also stated, "…the highest value of emissions for any dairy site is around 4 kg, but both swine sites have many values above 4 kg. The highest value of emissions for any swine growing and finishing site is around 9 kg, but the values for the breeding and gestation sites go as high as 16 kg." In fact, based on differences in nitrogen loading, the range of emissions would be expected to vary as or more drastically between lagoons and basins as it does between dairy and swine operations. Because EPA failed to analyze lagoons and basins in terms of the processes that generate emissions from these sources, combining datasets from these two diverse sources is inappropriate.

However, if EPA were more strategic in their methods of selecting predictor variables (as discussed in response to Charge Question 1), combining the swine and dairy datasets would not be problematic. Once nitrogen, sulfur, and carbon are dissolved into lagoon water, emissions are unaffected by the source of those compounds. Therefore, if the Agency used the more appropriate predictor variables of lagoon nitrogen content, temperature, pH, and surface area, datasets for dairy and swine lagoons could be combined, thereby ensuring that more seasonal and meteorological conditions are represented.

Question 3. Comment on the agency's decision to use static predictor variables as surrogates for data on lagoon/basin conditions. Given the uncertainties in that approach, does the SAB recommend that EPA consider specific alternative approaches for statistically analyzing the data that would allow for the site-specific lagoon liquid characteristics to be used as predictor variables?

Nitrogen loading is a critical predictor variable for estimating ammonia emissions. Given the drastic differences in manure production and composition from swine and dairy animals as well as the significant impact manure handling (scrape, flush, slatted floor, etc) and solids separation can have on the amount and concentration of nitrogen entering a lagoon, **the static variables "animal type" and "farm capacity" do not capture the necessary variability between sites and throughout the year.** The variables "animal type" and "farm capacity" could be combined with data on manure production characteristics (see ASAE Standard D384.2) to predict the total nitrogen excreted from the animals, but some estimate of the amount of nitrogen retained in the solids separated before entering the lagoon system would be required to predict the nitrogen load to any given lagoon. For dairies, a good predictor variable of nitrogen excreted would be milk production data, which, according to Dr. Heber's comments at the SAB Panel meeting, were collected during the course of the study but have not yet been given to EPA.

A static variable for "lagoon surface area" could be used if the surface area of the observed lagoons did not vary dramatically during periods of observation. Lagoon surface area is highly dependent on the side slope of the impoundment as well as precipitation and pumping schedules. Data on lagoon surface area variability are needed before judgment can be made as to the adequacy of a static predictor variable for surface area.

Even when additional data are obtained from Dr. Heber, the limited number of sites monitored during the NAEMS study, the sporadic nature of data collection at each site, and the failure to collect data per the NAEMS study plan makes development of lagoon and basin EEMs highly problematic. Unfortunately, these limitations are a result of the poor design of the NAEMS study, which can no longer be corrected.

Question 4. Does the SAB recommend that EPA consider alternative approaches for developing the draft NH3 EEM that balances the competing needs for a large dataset (to reflect seasonal meteorological conditions) versus incorporating additional site-specific factors that directly affect lagoon emissions. If so, what specific alternative approaches would be appropriate to consider?

A dataset that reflects all possible seasonal and meteorological conditions is important, but perhaps more critical than seasonal representativeness is that the response variable (NH_3 emission rate) be properly related to predictor variables that would be expected to affect emissions in the same way at all sites across the country. For lagoons and basins, those predictor variables are nitrogen loading, lagoon temperature, pH, and surface area. **It would be far preferable to develop EEMs with a more limited dataset that reflects those parameters that drive ammonia emissions than to use the larger dataset to develop an EEM that has no direct relation to the physical, chemical and biological processes that drive emissions from lagoons.**

Question 5. Please comment on the EPA's approach for handling negative or zero emission measurements.

Negative or zero emission measurements can arise from negative or zero concentration measurements or from subtraction of background concentrations that exceed concentrations at the point of interest (i.e. outlet concentrations minus inlet concentrations). The following guidelines are suggested for handling negative or zero emission measurements:

- A better description is needed in both the broiler and swine/dairy lagoon EEM documents regarding how EPA identified outliers in the data. Before analyzing the data any further, these outliers should be identified using sound statistical techniques, and the reason for their inclusion or omission should be documented.

- If a negative emission rate was due to negative measured concentrations, clearly the concentration was below the minimum detection limit (MDL) of the instrument. Any measurement below the MDL is censored (i.e. a value equal to one-half the MDL is used, per standard EPA practice) and should be treated as such in the analysis. This treatment should be applied to any value below the MDL, including negative values, zeros, etc.

- After elimination of outliers, if a calculated emission value is zero, it should be included in the dataset. There are many cases in which emissions of a given pollutant may not be generated from a particular source. These are important points of the production cycle and should be included in any analysis.

- In cases where background concentrations, used to calculate net concentration increases (measured concentrations minus background concentrations), were measured either intermittently (twice a day for gas) or continuously without correction for lag time in the barn, negative emission rates may arise. Intermittent measurement of background concentrations could lead to a bias either up or down, potentially creating negative data values. Because this bias could occur in either the positive or negative direction, such negative values should be retained in the dataset. Omitting these data would bias models in the upward direction.

Negative emission rates can be used to develop a model that never predicts negative emissions. In fact, in some cases, these negative emission rates may be necessary to appropriately describe the uncertainty of the model. Therefore, **EPA's proposed approach of omitting all negative values is inappropriate**.

Question 6. In the interest of maximizing the number of available data values for development of the draft H2S EEMs for swine and dairy lagoons/basins, does SAB recommend any alternative approaches for handling negative and zero values other than the approach used by the agency?

More information is needed regarding the cause of negative and zero values for swine and dairy lagoons/basins before any recommendations can be made.

Question 7. Please comment on the approach used to develop draft broiler VOC EEM.

As written in the draft EEM, it is unclear how EPA developed the draft broiler VOC EEM. The Agency spared few details about how data were **supposed** to be collected, but details of how and what data were **actually** collected is incomplete and unclear. **EPA should state early in the document what data were actually used in developing the EEMs and how/where they were collected.**

Based on clarifications made during discussions at the Panel meeting in North Carolina in March, it became clear how data were collected, that VOC data from the California measurement site were unusable, and that the usable data from the Kentucky measurement sites were not robust. At this time, **EPA does not have enough data to establish an EEM for VOCs from broiler production systems.**

References:

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Flood, C. A., J. L. Koon, R. D. Trumbull, and R. N. Brewer. 1992. Broiler growth data: 1986–1991. *Trans. ASAE* 35(2): 703–709.

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Metcalf and Eddy. 2003. *Wastewater Engineering: Treatment and Reuse*. 4th ed. New Tork: McGraw-Hill.

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Responses to Draft EEMs for Broiler Operations and Swine/Dairy Lagoons/Basins

Broiler Operations

Section 1. Introduction

- I appreciate the development of three EEMs (I, IA, and IAC methodologies) with increasing degrees of refinement.

- Statements should be made up front where departures were made from the proposed plan of work (e.g. Section 1.2.1 – $PM_{2.5}$ was measured using TEOMs and a beta-gauge rather than FRM samplers; this is just one of MANY examples).

- Stated limitations of the data used are desperately needed.
    - Data from poultry sites were collected for typical bird grow-out periods, but there are birds that are grown for much shorter periods (Cornish hens) and much longer periods (large roasters). These limitations should be clearly stated because the current EEMs for ammonia would not fit some of the situations well at all (i.e. emissions would be estimated to go to zero for some of the largest birds).

    - Sites were chosen that employed no emissions controls measures, so estimates of emissions from facilities employing these measures should be adjusted accordingly.

- Descriptions of the physical/biological mechanisms that result in generation of estimated emissions are needed. What provides the N for ammonia generation? What causes volatilization of that N? Etc.

- Several key parameters that would affect emissions generation, such as animal activity (PM), feed composition (all gaseous pollutants), etc. were supposed to be measured but were not utilized in during EEM development. It was apparent from the meeting in March that Dr. Heber has much of these data and had not yet transmitted these data to EPA. This situation needs to be rectified, and EPA should consider these data when improving the proposed EEMs.

Section 2. Overview of Broiler Industry

- This would be a good place to describe the physical, chemical, and biological processes involved in generation of each pollutant of interest.

- Ventilation system and control operation need more clarification given how important ventilation rate calculation is to measuring emissions.

Section 3. NAEMS Monitoring Sites; Section 4: Data Available for EEM Development

- **During the March 2012 meeting, it became apparent that Dr. Heber has a lot of data that EPA does not have. This issue desperately needs to be resolved!**

- Great lengths are taken to describe measured parameters that are never considered seriously in the EEM development process (e.g. animal activity). EPA should:
    - Make clear up front what parameters were used for developing EEMs and
    - Significantly shorten descriptions of parameters that have no chance of making it into the EEMs (such as those that a producer will never measure).

- From p. 4-2: "The amount of measured negative values is low (less than 1.7 percent) compared to the total number of emissions records for H_2S and PM_{10}, which indicates that the steps taken to calibrate and maintain instrumentation and to minimize the influence of other on-site sources on ambient H_2S and PM_{10} emissions were reasonably effective." I don't follow this logic. Because you did not have a lot of negative values, all of the calibration and maintenance was okay? This is quite a leap in logic.

- Last paragraph on p. 3-10 says, "Each exhaust location was sampled and measured continuously for 10 minutes. The inlet air location was monitored for 20 minutes twice daily. After approximately four months of data collection, the gas concentration data were evaluated at each sampling location to determine whether equilibrium occurred within the sampling periods. A statistical analysis confirmed that 10 minutes was sufficient for the exhaust GSLs, but that 30 minutes was required for the house inlet. Consequently, the sampling period for the inlet air was increased from 20 minutes to 30 minutes." How were data collected in the first four months (with shorter sampling periods) used when determining EEMs?

- The description of VOC sampling is really poorly written and very confusing. Among other things, through, EPA took great lengths to describe the gas sampling process for California (e.g. describing the relative bias of tolulene checks), but data from California were not used to develop the EEM. The Agency should make very clear up front that the data were not used and why.

- Only 60% of sampling days in CA were valid. Given that the entire US industry is to be regulated off these two sites, that is disconcerting.

- **Diet formulation, the biggest factor affecting how much N is available to be excreted, is not included in the EEMs.**

- The hottest summer flocks also had the oldest litter in all cases, leading to highest possible emissions in terms of both concentrations and ventilation rates.

- How well does house CA1B, built in the 1960s (according to Table 3-1 but not apparent why in the text), represent modern industry practices? I'm guessing not very well.

- Pancake brooders (used in KY) are outdated and are primarily used by one integrator (Tyson). They lead to inconsistent floor heating, which can alter ammonia emissions during the brooding stage

- H_2S data for CA1B, H12 in Table 4-3 are highly suspect. If there wasn't a major flood due to drinker mismanagement recorded, it is likely that someone mis-entered the data as this number is identical to the adjacent number for NMHC from the same house.

- $PM_{2.5}$ emissions range for CAB1,H12 is much higher than other houses (Table 5-11). Is that data valid? The range in Table 5-11 doesn't match that given in Table 5-12.

- The use of TEOMs to collect PM data presents multiple problems. Biases in TEOM measurements relative to FRM measurements have been extensively documented:
    - Wanjura et al. (2008) found TEOM samplers under-sampled TSP relative to FRM samplers. Under-sampling was correlated to PM concentrations and size distribution

    - Hitzenberger et al. (2004) found that TEOM measurements of $PM_{2.5}$ were up to 18% lower than comparable gravimetric measurements, likely due to evaporation of volatile materials before entering sensor unit

  - Vega et al. (2003) found that TEOMs oversampled PM_{10} around Mexico City, and the degree of oversampling varied with concentration

  - The Texas Commission on Environmental Quality collocated FRM and TEOM samplers run for multiple years at stations in El Paso, Laredo, and Mission. The TCEQ found that adjusting the slope and intercept of the TEOM sampler made it invalid as a reference sampler but made it match FRM data very well ($R^2 = 0.93$)

- What type of TSP inlet was used for measurement (Section 3.3.1.2; p. 3-11)? Using a low-volume TSP inlet may lead to aspiration issues for large particles, and the PIs were supposed to be gravimetric/isokinetic samplers (per section 1.2.1) but actually used TEOMs and beta-gauges

- **Contrary to EPA's assertion, growers do not routinely record bird weight. In most cases, bird weights are not known until birds are removed from the farm for harvesting.**

- Figures are helpful and the section is well organized.

- Regarding EPAs call for information, EPA's review of articles received in response to EPA's Call for Information is amazing in terms of the lack of respect given to other scientists who used different measurement methods than those specified for the NAEMS study (indicated by the number of "None" statements in the column entitled "Possible Application for NAEMS" in Table 4-4). **There are no perfect measurement techniques for assessing the concentrations of a number of the pollutants monitored in the NAEMS project**, especially given the high levels of water vapor that are present in an enclosed AFO. To say that all of the studies that used alternate measurement techniques (e.g. flux chambers, Drager tubes, etc.) are not useful is baffling to me.

  Emissions estimated using EPA's EEMs should be compared to most of these studies, which provide valuable resources for "book ending" the true emissions from these operations. The implications of the results of the EEMs will be sweeping. It is foolish to base all emissions estimates off of measurements from two sites and then ignore the data from many other studies with such a tacit arrogance.

Section 5. Data Preparation

- A better description is needed in both the broiler and swine/dairy lagoon EEM documents regarding how EPA identified outliers in the data. Before analyzing the data any further, these outliers should be identified using sound statistical techniques, and the reason for their inclusion or omission should be documented.

- If a negative emission rate was due to negative measured concentrations, clearly the concentration was below the minimum detection limit (MDL) of the instrument. Any measurement below the MDL is censored (i.e. a value equal to one-half the MDL is used, per standard EPA practice) and should be treated as such in the analysis. This treatment should be applied to any value below the MDL, including negative values, zeros, etc.

- After elimination of outliers, if a calculated emission value is zero, it should be included in the dataset. There are many cases in which emissions of a given pollutant may not be generated from a particular source. These are important points of the production cycle and should be included in any analysis.

- In cases where background concentrations, used to calculate net concentration increases (measured concentrations minus background concentrations), were measured either intermittently (twice a day for gas) or continuously without correction for lag time in the barn, negative emission rates may arise. Intermittent measurement of background concentrations could lead to a bias either up or down, potentially creating negative data values. Because this bias could occur in either the positive or negative direction, such negative values should be retained in the dataset. Omitting these data would bias models in the upward direction.

- Negative emission rates can be used to develop a model that never predicts negative emissions. In fact, in some cases, these negative emission rates may be necessary to appropriately describe the uncertainty of the model. Therefore, **EPA's proposed approach of omitting all negative values is inappropriate**.

Section 6. Measured Emissions

- Emissions should be expressed in more appropriate units. Emissions in terms of "g/d" are meaningless to any production scenario apart from the single house where such emissions were measured. Express in terms of "g/bird/d" or "g/AU/day" instead.

- Measured emissions should be compared with other published values to validate their reasonableness.

Section 7. Development of EEMs for Grow-out Periods

- **The statistical model EPA uses to estimate emissions of a given constituent should reflect, to a great degree, the physical, chemical, and biological processes involved in generating emissions of that constituent.**

- EPA's analysis of litter buildup and choice of the *build* function to indicate the absence (0 for first flock on new litter) or presence (1 for all subsequent flocks) of litter buildup is appropriate. Further differentiation for later flocks is unnecessary, as concluded by EPA.

- EPA's logic for including 2-way interactions but excluding 3-way interactions in the statistical analysis is reasonable.

- EPA's logic in assessing the need for random variables of "site" and "house" is sound, but the analysis is lacking in rigor given that only two sites were monitored, and only two houses per site were included in the study. Random variables for "flock" and "year" should also be included in the analysis to determine if they are significant.

- **EPA should carefully consider the range of data over which EEMs will be extrapolated beyond those captured at measurement sites.** EPA should check that EEM models yield reasonable emissions estimates, commensurate with results of other studies, at points beyond those from which EEMs were developed. For example, because a cubic function was used to represent the predictor variable "avem" in the broiler methodology, if the average bird mass gets large enough, the proposed EEM will predict "zero" emissions from the broiler house. Such a result is unreasonable and clearly results from applying the EEM to values of bird mass that exceed those at data collection sites but that are not unreasonable for some broiler production facilities in the US.

- I agree with EPA's approach to pulling random data to establish the cross-validation set, and I am glad to see that 20% of the data were used as such. I also support their decision to not use entire flocks for cross-validation. However, the last sentence on p. 7-10 is unclear. From what dataset were the "two additional cross-validation datasets with corresponding base datasets" made? Was the full dataset simply divided differently and analyzed three different times? If so, how were results from these three "non-independent" datasets compared and analyzed?

- **Contrary to EPA's current approach, models should also be tested against values available in the literature. This analysis would significantly strengthen the credibility of the EEM estimates.** Validation needs to be against other operations, not just 20% of "full" dataset from the four measured barns.

- The 12x12 matrix labeled "Ω" is the covariance matrix generated when conducting the regression analysis (p. 7-53). Surely the values in the "omega matrix" are not "random variables" as asserted on p. (7-53).

    1. The covariance matrix cannot be reproduced from the raw data without knowing which data was set-aside for validation.

    2. Given the importance of the "uncertainty" accounted for in the confidence interval, these "omega" matrices should be made available to the public.

Section 8. Results of Grow-out Period EEM Development

- With less than 10% data completeness for the CA sites, the $PM_{2.5}$ EEM is effectively based on measurements from two houses at one site and is, therefore, highly suspect with regards to representativeness. I do not recommend that emissions estimated using this methodology be given much (if any) confidence. The uncertainty in this EEM should be high due to the lack of data available, but without access to the covariance matrix, it is not possible to evaluate this.

- The issues for TSP are identical to those for $PM_{2.5}$.

- M**odeled should be tested against values available in the literature.** This analysis would significantly strengthen the credibility of the EEM estimates. Validation needs to be against other operations, not just 20% of "full" dataset from the four measured barns.

- Emissions should be reported based on standard air flow rates rather than actual airflow rates. (See AAQTF White Paper "Methodologies and Protocols for Analysis of Raw Data to Minimize Uncertainty of Resultant Aerial Emissions Estimation" submitted by Sally Shaver and Robert Burns and developed after a joint meeting of the AAQTF at EPA with EPA's input.

Section 9. Development of Decaking and Full Litter Clean-out Period EEMs

- EPA's decision to develop emission factors for decaking and full litter clean-out is sound. However, emission factors should be stated in terms of "mass of emissions per mass of litter removed" (e.g. g NH_3/ton) rather than in terms of the total mass of birds raised on the litter since the last full cleanout, as currently proposed.

- EPA proposes to estimate emissions by using an emission factors in terms of "g pollutant/kg-bird-day" multiplied by a calculation of litter buildup. These emission factors increase with increasing numbers of flocks (days) on given litter. An "infinitely increasing" emission factor <u>**does not**</u> match available data in the literature.

- Other research has shown that the nitrogen content of litter reaches a balance after 3 to 5 flocks.

    - During the first four of 18 flocks, Coufal et al. (2006) reported little correlation between nitrogen volatilization and average temperature (R^2 = 0.27)

    - After 3-5 flocks, nitrogen volatilization is highly correlated to average temperature (R^2 = 0.88 in Coufal et al., 2006).

  - o Experience shows that after 3-4 flocks, most of the litter material is effectively composted and has reached capacity to retain any more nitrogen per unit mass, thus the mechanism regulating ammonia emissions changes at this point, and the pool of available ammonia remains relatively consistent.

- **Therefore, a more appropriate method of estimating NH_3 emissions (for litter on which $\geq$3-4 flocks have been raised) would be in terms of "mass of pollutant per unit mass of litter removed"** (e.g. lb NH_3/ton litter removed). For litter on which < 3-4 flocks have been raised, an emission factor for ammonia in terms of "g pollutant/kg-bird-d" may be appropriate (per EPA's approach).

- To my knowledge, no similar information exists for constituents of interest to EPA aside from ammonia. However, it is expected that similar generation mechanisms would govern emissions of other gaseous constituents, so a similar emission factor units would be appropriate. PM emissions would be expected to correlate with the mass of litter handled and litter age.

- EPA proposed emission factors calculated based on three different estimates of birds weight (i.e. cumulative weight, total shipped weight, or maximum weight). Litter production (for $\geq$ 3-4 flocks on litter) or total mass of birds raised on litter (for < 3-4 flocks) should be based on cumulative mass of birds raised on litter, as:

    1. This is the unit most pertinent to quantifying litter production,
    2. Bird inventory numbers are regularly collected by producers, and
    3. Bird mass is well modeled and can easily be predicted using growth curves.
    4. The market weight of birds is variable across the industry and is not fully represented in the data collected.

<u>Swine and Dairy Lagoons/Basins</u>

Section 1. Introduction

- From p. 1-3, "The NH_3 and H_2S emissions were to be calculated from the difference in upwind and downwind concentration measurements using two different methods: an Eulerian Gaussian approach [computed tomography (CT)], and a Lagrangian Stochastic approach [backward Lagrangian stochastic method (bLS)]." Later in the report, it is stated that only radial plume mapping is used for EEM and that bLS data were collected to confirm it compares to RPM method (p. 5-6).

  1. Why not use bLS data? (according to Table 4-1, there are many more "valid test days" for bLS than for RPM)

2. If bLS results were not used, that should be stated here.

- From p. 1-6, "Due to the very limited amount of data received for the nitrogen concentration, solid content and pH of the lagoon liquid, these data were not included in the EEM."
    1. This is a problem! These are the very factors that determine lagoon emissions.
    2. **It would be better to make the EEM on a limited dataset with these variables than force other parameters that do not directly affect emissions into the model.**

But instead… From p. viii, "The EPA developed three types of EEMs that include as predictor variables a combination of ambient meteorological data (e.g., temperature, relative humidity) that were continuously monitored and categorical (i.e., static) data that characterize the farm and lagoon configuration (i.e., animal type, farm capacity, lagoon surface area)."

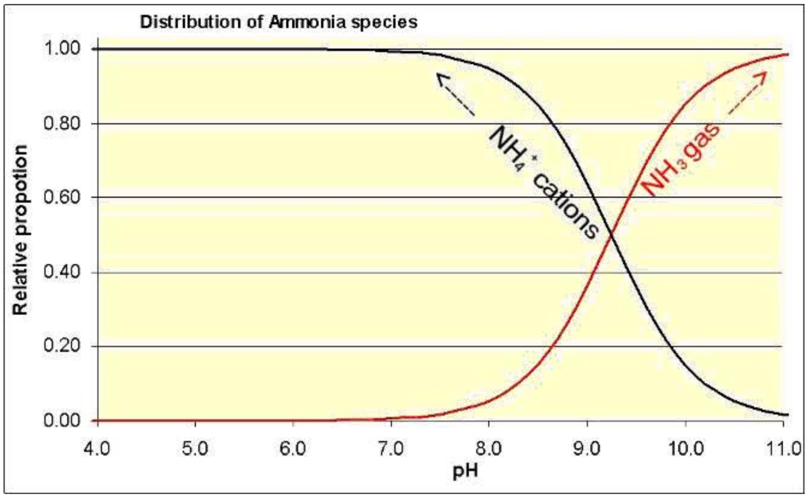
The most important considerations for ammonia emissions are:

3. **Lagoon temperature**
    - Measured but not used (limited data)
    - Could use ambient temperature as surrogate (as EPA did), but a long-term temperature trend would be better than instantaneous air temperature if doing this

4. **N content** of lagoon
    - Not measured in NAEMS – this is a big problem!
    - Could at least be estimated by looking at primary v. secondary lagoon and rather or not a facility uses a solids separator
        - It is highly inappropriate for EPA to not differentiate between "primary" and "secondary" lagoons or between "lagoons" and "basins" as these sources will have substantially different N loadings
    - Should consider how much runoff is channeled into lagoon/basin
5. **Surface area** (used in two of three EEMs but only as a static variable)

6. **pH**
    - Measured but not used (limited data)
    - No ammonia emissions are expected when pH > 6.8 (see Metcalf and Eddy, 2003)
    - From p. 2-9, "Emissions of NH_3 and H_2S are influenced by pH. The manure pH affects the partitioning between these compounds and their

ionized forms (NH_4^+ and HS^-), which are nonvolatile." Even so, EPA did not use this information.



Ammonia gas v. ammonium cations.

Section 2. Overview of Open Sources

- From p. 2-9, "Long periods of **manure residence time** in, either confinement, storage or stabilization facilities, provide greater opportunities for anaerobic breakdown and volatilization to the air. In addition, masses emitted will increase with time. The amount of **sulfur ingested by an animal** will affect the potential for H_2S production in manure. Sulfur can be present in feed additives and, in some cases, from water supplies. The amount of **nitrogen in feed** (proteins and amino acids) affects NH_3 and nitrous oxide emission potential. The amount of **carbon** affects CH_4 and CO_2 potential. Ensuring that the composition of feedstuffs does not exceed the nutritional needs of the animal will reduce emissions." Yet most of these inputs were not quantified as part of NAEMS. **How can EPA expect to predict emissions from lagoons with any modicum of accuracy when they did not measure the very parameters they know to affect emissions?**

Section 3. Data Available for EEM Development

- **During the March 2012 meeting, it became apparent that Dr. Heber has a lot of data that EPA does not have (e.g. milk production data). This issue desperately needs to be resolved!**

- As with the broiler EEM, the data in the papers submitted as part of the Call for Information should be used as part of the model validation. It is not sufficient to cross-validate a dataset from such a few sources with a fraction of the total dataset from the same sources.

- From p. 3-14, "As shown in the Table 3-5 and Table 3-6, none of the articles previously obtained by the EPA to support emissions factor development used remote sensing techniques to measure lagoon emissions. Consequently, none of the articles were applicable for EEM development."
    1. **Why is remote sensing considered a superior measurement methodology?** Flux chambers, wind tunnels, etc. have their limitations, but remote sensing does as well.

- Did EPA exclude data that failed to meet the "valid test days" test?
    1. From table 4-1, it is apparent that there are MANY more "valid test days" for bLS modeling (276 for NH_3) than there are for NH_3 RPM methods (69 days) or H_2S ratio methods.

        - However, on p. 5-6, EPA says, "In developing the NH_3 EEMs, the EPA used the measurements obtained using the RPM model. The EPA used the RPM data because these measurements were obtained using instrumentation and procedures that were similar to EPA's developmental test method OTM-10 (Optical Remote Sensing for Emission Characterization from Non-Point Sources). The EPA did not use the bLS emissions measurements because these data were collected under the NAEMS to conduct a validation study of the bLS model performance relative to the RPM model. Furthermore, because the RPM emissions dataset is much larger than the bLS dataset, including the bLS measurements in the EEM development dataset would not provide any additional information on lagoon emissions."

        - These two statements do not seem to match.

        - bLS results should be analyzed for consistency with radial plume mapping data before it is completely excluded. Multiple methods should be used "bookend" emissions from lagoons.

- **If N loading is not considered in the regression analysis, lagoons and basins should not be combined and should be differentiated. There is certainly less emissions from a basin than from a lagoon.**

Section 4. NAEMS Data Preparation

- From p. 4-7, "Considering alignment with the NAEMS monitoring dates, the data completeness goal for liquid composition data of quarterly sampling was **not achieved at any of the NAEMS monitoring sites.** Liquid composition data were not collected at site WA5A and the data for sites IN4A, IN5A and WI5A were reported as ranges and the sampling dates were not provided."

    1. This is a major limitation that should have been addressed as the project was being executed. There seems to be insufficient data to do even a mediocre job of developing a statistical EEM at this point.

    2. Further confounding the issue, from Table 4-5, 14% and 21% of the H_2S emissions values were negative using the Ratiometric and bLS methods, respectively. 17% of the NH_3 emissions values were negative using the bLS method.

    3. This is problematic! These are major limitations to the dataset for lagoons!

- EPA disregarded negative measurement values but kept zero values (first paragraph on p. 4-11). Similar rules should be applied to this dataset as was discussed regarding the broiler dataset (i.e. keep negative values if they are vetted). Was a process used to ensure that a "zero" value was not measured as the instruments drifted from positive to negative readings?

- With only one scraped dairy site (IN5A) and such different management practices between the other sites, how can you differentiate between emissions from each of these systems? In the EEM, there is a variable to differentiate between species, but this would only have one degree of freedom.

- Lagoon temperature data were not available for IA3A and WA5A for any of the NAEMS monitoring periods, further reducing the total data available for a proper analysis.

- How much lagoon pH data were available? Was surface area measured? These data should be included in Table 4-10.

- **"Data preparation" seems to have largely consisted of eliminating the most important variables governing emissions from lagoons and basins due to a lack of data.**

Section 5. Overview of NH_3 EEM

- Especially given the number of negative and zero values recorded, use of the EEMs should be restricted to ranges in which measured concentrations were above the minimum detection limits of the instruments used to generate the datasets from which the EEMs were derived. What are those minimum limits?

- From p. 5-1, "The amount of time-varying data (e.g., nitrogen content, ammonia content, pH) available to characterize the lagoon liquid at each site was very limited and including these limited data as predictor variables would have significantly reduced the overall size of the dataset available for EEM development. To maximize the number of NH_3 emissions measurements used to develop the EEM, the EPA considered a suite of static, farm-based predictor variables as surrogates for the time-varying data."

  1. The chosen substitutions were ill-advised, especially if no attempt was made to analyze nitrogen or manure loading rates (or at least estimate using manure production rates, accepted chemical values, and some estimate of the effect of solids separation)

  2. Also, since the chosen predictor variables are static (i.e. don't change with time, they are wholly inadequate to substitute for time-varying data that actually affect emissions.

- From p. 5-1, "To address this data limitation, the EPA decided to allow the EEMs to learn about effects of meteorological and farm-based predictor variables on NH_3 emissions simultaneously from swine and dairy."

  1. It is inappropriate to combine these datasets unless some attempt is made to characterize manure production rates and nutrient contents of manure between species.

  2. The categorical variable "species" is insufficient, as manure production rates will vary between different swine species, and interactions with this term do not capture differences in both animal weight and manure composition.

- From p. 5-6, "In developing the NH_3 EEMs, the EPA used the measurements obtained using the [radial plume mapping] model. The EPA used the RPM data because these measurements were obtained using instrumentation and procedures that were similar to EPA's developmental test method OTM-10 (Optical Remote Sensing for Emission Characterization from Non-Point Sources)."
  1. Why was this more limited dataset used without analysis of the bLS data?

- According to Table 5-2, Dairy IN5A had by far the most number of measurements and likely, therefore, dominated the model. However, it was the only scraped dairy. How much influence did measurements from this dairy have on the final model, particularly compared to sites like WI5A and IN4A which contributed very few data points?

- Table 5-6. Selected Candidate Predictor Variables.

  1. Lagoon temperature and pH should be among the variables considered as well as some estimate of N loading!

  2. There should be high correlation between animal type and average adult animal weight

  3. Lagoon cover information should be included (but was not because insufficient data was collected)

  4. Without an estimate of lagoon loading, lagoons and basins should certainly not be combined

- Response variables should be in units of "emissions per unit area" or "emissions per unit of N input" rather than "kg/30-min"

- Were data excluded if not more than 75% of measurements in a day were valid? Why does this matter if EEMs are to predict 30-minute averages?

- From p. 5-14, "The EPA also expected that increases in atmospheric pressure above the lagoon surface would tend to decrease NH_3 emissions. Higher atmospheric pressure will decrease the gradient between the partial pressure of NH_3 gas dissolved in the lagoon liquid and the atmosphere above the lagoon surface, thereby reducing diffusion of gas molecules from the liquid. However, the EPA did not use atmospheric pressure as a predictor variable because to do so would have significantly reduced the size of the dataset."

  1. Was atmospheric pressure significant within the dataset for which you had these data? If so, then it should likely be in the final model.

  2. However, **without N loading, pH, and lagoon temperature, EPA is focusing on the minor while ignoring the major predictor variables.**

- From p. 5-15, "Although the pH, ORP and temperature of the lagoon liquid were expected to affect NH_3 emissions from lagoons, the EPA did not include these data as candidate predictor variables due to the limited number of data values and because data were not provided for sites IA3A and WA5A." This is an inadequate justification when the mechanistic model certainly calls for these factors to be included. As I would tell my graduate students, **if you don't have the data to generate a reasonable EEM, then don't try publish an EEM until you go collect more data.**

- From p. 5-15, "Because the organic and ammoniacal nitrogen present in the lagoon liquid are precursors to NH_3 emissions, the EPA expected that NH_3 emissions would be higher at lagoons with higher total nitrogen concentrations. Nitrogen compounds can be bound to lagoon solids thereby preventing the release of ammonia precursors into the bulk lagoon liquid; therefore, the EPA also considered using the solids content of lagoon liquid in EEM development. However, the EPA did not include data for the nitrogen or NH_3 content of the lagoon liquid as candidate predictor variables due to the limited number of data values (see Table 5-4)." Again, **if you don't have the data to generate a reasonable EEM, then don't try publish an EEM until you go collect more data.**

- From p. 5-17, "The EPA considered using the following design specifications as predictor variables to assess whether lagoon design was related to NH_3 emissions: impoundment type (i.e., lagoon or basin), configuration, loading rates, volume, surface area, liquid depth and sludge depth. However, the EPA did not include lagoon loading rates, liquid depth and sludge depth because these data were not available for all sites. Also, the EPA did not consider using a predictor variable for single- or multiple-stage lagoons. Only site WI5A had a multi-stage lagoon, based on the descriptions provided in the SMP and final report. However, the emissions from each of the three stages were not measured independently. The monitoring equipment was located such that the total emissions from stages 1 and 2 were measured. Emissions from the 3rd stage, which was used to supply flush water, were not measured under the NAEMS. Consequently, the EPA decided to use the total emissions and total surface area from stages 1 and 2 as representative of a single-stage lagoon, rather than exclude site WI5A due to the different lagoon configuration. Therefore, a predictor variable for lagoon stages was not used."

  Essentially what is said here is, "EPA considered using appropriate metrics but did not because there was not enough data." I would like to see how a model developed on these more appropriate (albeit more limited) variables works.

- From p. 5-18, "The presence of a natural cover (i.e., crust, scum or ice) on the lagoon surface tends to reduce emissions because the cover inhibits diffusion of NH_3 from the lagoon liquid to the atmosphere. Observations regarding the type (e.g., crust, ice) and degree of cover (percent of surface area) were provided for select days at each site. Although the presence of natural lagoon cover (i.e., crust, scum or ice) was expected to affect NH_3 emissions, the EPA did not use it as a candidate predictor variable because of the limited number of recorded observations."

1. Were the degree and type of crust significant in models for just the sites in which they occurred (and were recorded)?

2. If so, they should be considered in the full model, even if it reduces the number of data points.

- **If sub-sets of data for which limited but important inputs were recorded span most of the ranges of temperature, animal type, etc., EPA should run sub-models on datasets to assess how important these factors are.**

- From p. 5-18, "The EPA also did not use the type of impoundment (i.e., lagoon or basin), as a predictor variable. For impoundment type, the QAPP, SMPs and the final reports do not define the design and operational differences between a "lagoon" and "basin" and the documents tend to use the terms interchangeably. Based on discussions with the NAEMS Science Advisor, dairies tend to use basins which have a lower degree of microbial activity than lagoons. Using this information, all of the dairy sites would be assigned a basin for impoundment type and all of the swine sites would be assigned a lagoon."

  This is a ridiculous conclusion! Dairies can have lagoons or basins, and swine facilities can have lagoons or basins. The relative microbial activity between species may differ, but it is silly to assert that all dairies have basins because their microbial activity is less than that of swine lagoons.

- From p. 5-28, "The axes in three plots of Figure 5-6 were scaled to fit the data for the different animal types. This scaling makes it clear that the range of NH_3 emissions is quite different for the different animal types."

  1. Unless nitrogen loading is considered in the EEM, this indicates that the data should not be combined if the datasets do not even cover the same ranges.

  2. From p. 5-48, "Notice that the highest value of emissions for any dairy site is around 4 kg, but both swine sites have many values above 4 kg. The highest value of emissions for any swine growing and finishing site is around 9 kg, but the values for the breeding and gestation sites go as high as 16 kg."

- There is **clearly** an issue with the timestamps of the data if emissions and ambient temperatures both increase at night and decrease during the day (section 5.3.4). This issue should have been resolved before doing any further analysis.

- From p. 5-46, "In developing the EEMs from the NAEMS data, if the EPA were to attempt to develop a separate EEM using only data from the dairy sites, there would be only three data points. Consequently, at most, only one farm-based predictor variable could be used. The resulting EEM would perfectly fit the three dairy sites, with no degrees of freedom for error, but it would be inappropriate to use it for predicting other sites due to the inability to adequately quantify uncertainty."
    1. This is insufficient justification for combining the datasets for dairies with those from swine, which are very different.
        - Dairy cattle are mature while swine are growing animals (manure production not constant)
        - Manure production (quantity and N content) are different
        - Amounts of urinary N production are different

- From p. 5-47, "However, because using both of these variables would use up two degrees of freedom, the EPA created the variable *size*, which was defined as the product of *capacity* and *adultwt*." **The use of "adultwt" is inappropriate for growing pigs.**

- In section 5, EPA should provide emission rates (kg/unit time) rather than just "kg".

- The necessity of two- and three-way interactions for the lagoon datasets should be assessed in a similar manner to that used for the broiler data. Unlike the analysis conducted for broiler houses, in which the marginal improvement in modeled results arising from inclusion of three-way interactions was assessed, analyses of the importance of two- and three-way parameter interactions are not described for lagoons and basins (except for meteorological interactions). This analysis should be added.

- Using the centering and scaling values given in Table 5-9, for the "Animal/Surface Area" EEM, the calculated value for "ha" (-0.95) does not match the value shown in Table 5-16 (-1.0)

- In Table 5-12 wind speed coefficient is negative but figure 5-13 shows a positive slope (which is what would be expected).

- From p. 5-69, "Emissions from dairy lagoons during the summer when lagoon emissions are typically higher than the rest of the year are under-represented in the NAEMS. This factor likely causes dairies to appear to have lower emissions than swine." "Lower emissions" based on what? Animal weight? Time? Per unit N input?

- From p. 5-69, "Also, during our evaluation of the three draft EEMs, we concluded that the emissions and surface areas at two of the dairy sites were likely under-represented because all stages of the multi-stage treatment systems at each site were not monitored." Then of what use is this data?

Preliminary Comments from Dr. April Leytem

<u>Response to Charge Questions</u>

Question 1: Please comment on the statistical approach used by the EPA for developing the draft EEMs for broiler confinement houses and swine and dairy lagoons/basins. In addition, please comment on using this approach for developing draft EEMs for egg-layers, swine and dairy confinement houses.

I find that the approach used by EPA for developing the draft EEMs for emissions to be inadequate. The approach used to develop draft EEMS for the broiler confinement houses (and this would hold true for egg-layers, swine and dairy confinement houses) do not include the variables that would have the greatest impact on or relationships with emissions. The statistical models were developed using variables such as animal numbers, animal weight, temperature, pressure and humidity and several interaction terms. What are missing are the variables that would actually drive the emissions, for example nitrogen and moisture content of the litter would have a large impact on the emissions of $NH_{3,}$ while bird activity (which could be related to the lighting schedule) would have a large impact on particulate emissions. I would expect that developing EEMs using the current method would produce a method for estimating EEMs that are only applicable to the houses used to develop the equations and would not be applicable to houses across the US, which was the goal of the project. This is even more of a problem with development of methodologies to estimate emissions from lagoons as there is so much variation from one lagoon to another. It is imperative that EEMs are developed based on the characteristics of the source of the emissions not on animal numbers and ambient weather conditions.

One other concern that I have related to the development of EEMs using these techniques is that there is no recognition of realistic biological thresholds. There should be upper and lower limits set on the EEM methodologies that would prevent the potential to calculate an EEM that is not biologically possible. For example, you would never have NH_3 emissions that exceeded the total nitrogen content of the source. I think that there has to be some thresholds set to ensure that due to the methodology itself you cannot calculate an emission rate that is not feasible.

Question 2: Please comment on the agency's decision to combine the swine and dairy dataset to ensure that all seasonal meteorological conditions are represented. In addition, the agency also seeks the SAB's comments on whether the agency should combine lagoon and basin data.

While I understand that due to the limited dataset EPA decided to combine all of the lagoon emissions data, I do not feel that this is a good approach. But my concern is not just with the combination of swine and dairy lagoon data; it extends to the combination of dairy and dairy lagoon data as well. I do not feel it is possible to have one EEM methodology that describes all lagoons irrespective of the manure management system. Even within dairy lagoons there can be differences in emissions of an order of magnitude to do the manure management system and what is ending up in the lagoon. It is not possible to model something that is this complex without either separating the lagoons by manure handling system or basing the EEMs on the lagoon characteristics (i.e. nitrogen content, solids, pH, etc.). Again, developing an EEM based on variables that do not adequately describe the source of the emissions will lead to EEM methodologies that are not applicable beyond the dataset they were developed with. I strongly suggest that EPA consider better utilizing the data that was collected that describes the physical and chemical properties of the lagoons and base the emissions estimates off of these variables instead of the surrogates that were chosen. Even with this, there will still be problems with developing EEMs that are widely applicable, especially when you begin to develop the H_2S EEMS as you will also need to consider the biology of the lagoons as well.

Question 3: Please comment on the agency's decision to use static predictor variables as surrogates for data on lagoon/basin conditions. Given the uncertainties in that approach, does the SAB recommend that EPA consider specific alternative approaches for statistically analyzing the data that would allow for the site-specific lagoon liquid characteristics to be used as predictor variables?

As mentioned above, the use of static predictor variables is not adequate to develop lagoon EEMs that can be widely applied throughout the US. The EEMs methodology needs to be based on the characteristics and biology of the source that is producing the emissions.

Question 4: Does the SAB recommend that EPA consider alternative approaches for developing the draft NH_3 EEM that balances the competing needs for a large dataset (to reflect seasonal meteorological conditions) versus incorporating additional site-specific factors that directly affect lagoon emissions. If so, what specific alternative approaches would be appropriate to consider?

As mentioned previously, I strongly urge EPA to go back and utilize the data that is available from the study (physical and chemical characteristics of the lagoons) and develop EEMs from this dataset. Although I understand that this dataset will be smaller, it may produce more meaningful results. It is also possible to extrapolate some of the information to missing time periods, for example the lagoon characteristic may not change significantly over short periods of time and therefore you may be able to more widely apply some of the available data. I also suggest that EPA consider utilizing the bLS data as there seems to be more valid data utilizing this measurement technique than the RPM technique. I would also consider "gap filling" missing data to provide more available data for the analysis. Perhaps the dataset could be greatly expanded by following these suggestions, which will provide a much more robust dataset to utilize for the EEM development.

Question 5: Please comment on the EPA's approach for handling negative or zero emission measurements.

Based on the information provided at the meeting, it seems logical to include some or all of the negative and zero emission estimates. However, it needs to be carefully documented why these negative values occurred and only include negative numbers that were due to calibration adjustments and not due to instrument errors or anomalies in emission calculations. In regards to the lagoon emissions, as these were calculated using either the RPM or bLS models, greater care should be taken to ensure that negative values were not generated due to anomalies in the model or wind statistics used in the model as these may bias the dataset. A statistical technique to identify outliers should be utilized with the lagoon emissions dataset to ensure that there are not any large negative emission values generated that would skew the dataset.

Question 6: In the interest of maximizing the number of available data values for development of the draft H_2S EEMs from swine and dairy lagoons/basins, does SAB recommend any alternative approaches for handling negative and zero data other than the approach used by the agency.

Please refer to the comments under Question 5.

Question 7: Please comment on the approach EPA used to develop the draft broiler VOC EEM.

As there was only VOC data available from the two sites in KY, I find it unreasonable to attempt to develop EEMs based on such a limited dataset. I believe that the speciation data that was collected that describes the composition of the VOCs is of value and should be reported as it will be valuable for future VOC studies. However, to develop an EEM methodology from data from only two farms in the same region would be unreasonable as there would be no indication as to how much VOC emissions might vary by region or management practices. In addition, I don't believe that just reporting total VOCs is particularly useful, it is more important to identify the VOCs that are highly reactive and could have negative impacts on air quality and quantify these.

Comments on Draft EEM documents

Development of Emissions Estimating Methodologies for Broiler Operations

There is mention in the document regarding collection of litter samples, feed samples etc. but no information related to when these samples were collected, how they were collected, how often they were collected etc. In addition it is unclear whether EPA has this information or will have access to the information.

Page 4-9 regarding the 75% completeness goals. It is unclear why the goals of 75% of the hourly average data values were deemed critical for determining an hour average. Was this 75%

of the raw data or was this 75% of the two 30 min averages? Perhaps this is too stringent of a criterion. If there was good quality data collected during a particular hour interval I would think it would be wise to include this data as there are already many gaps in the data used for the development of these EEMs. On the other hand the goal of having 75% of the hourly averages in order to have a valid monitoring day may not be stringent enough. That means that you could be missing as many as 6 hours worth of data in a day and it is important to know when that data is missing and whether that missing data would bias the daily average. For example, if data were consistently missing at a time period when the emissions might be high or low, then the overall average may be biased in one direction or the other. It is important to note whether the missing hourly values were random or whether they occurred in some discernible pattern.

In addition, has EPA considered using any methods to "gap fill" missing data. In some cases emissions follow very distinct patterns and it is possible to fill in missing data using interpolation or other algorithms which would increase the number of "valid days" available for analysis.

Table 4-3. There is a value of H_2S emissions of 6.87 lb/d-house for CA1B, H12. Please double check this value as the maximum daily emission from that house was reported as 0.40 lb/d-house. It should be impossible to have an average value greater than your maximum value.

Page 4-10, Other Relevant Data. I argue strongly against the idea that only data that were collected with methods consistent with the NAEMS procedures are acceptable for use in development of the EEMs. Even though methods to measure emissions may vary, there is no strong evidence to suggest that one method may be better than another for determining emissions from broiler houses (i.e. chamber vs. whole house monitoring) as it is the litter that is generating the emissions. I think it might strengthen the results of the EEM development to compare or include data collected via other methodologies to see how they compare to the data collected in the NAEMS study. As there is a very limited data set available for development and validation of the EEMs it would be prudent to utilize all available data. Even studies that are looking at mitigation strategies would have control treatments (no mitigation strategy was applied) that could be used as a reference. I strongly suggest that EPA go back and reconsider some of the information collected under the CFI.

Table 5-13. How were the average NH_3 (g/d-bird) calculated, they seem to be wrong. For example, in CA1B H10 you had 11,072.25 g NH_3 day and 21,000 birds which would give you a value of 0.53 g/d-bird instead of 1.37 which was reported in the table. Also the range of NH_3 emissions listed do not seem correct for CA1B H10 and H12, 42 and 40 g/d-bird are too high.

Development of Emissions Estimating Methodologies for Lagoons and Basins at Swine and Dairy Animal Feeding Operations

In the appendices of this document there is reference to several pre-study validation studies and I think it is essential that the results from these validation studies are included somewhere so that it is possible to evaluate the data quality that may have been generated using these techniques that were tested.

Section 2 needs to be improved to better describe both the dairy and swine industries, in particular the waste handling techniques.

Page 3-5, I have the same concerns as stated above regarding the 75% completeness goals. This is particularly a concern for the lagoon data as the models that are used to generate the emissions estimates do not work very well under certain climatic conditions which tend to occur at the same time of the day and could cause gaps in the data when emissions were high or low, therefore biasing the overall dataset. Again EPA could consider using a "gap filling" technique to fill in missing data. Emissions from lagoons tend to have strong daily trends that can be modeled and therefore it is possible to fill in times when you have missing values using some simple regression techniques.

Page 4-4. Since only OK4A site had met the completeness criteria and has the most useable data, will this skew the analysis as most of the data will be from one site?

Table 4-1. According to this table there are 285 valid data days utilizing the bLS technique and only 69 valid days of data using the RPM technique, why is EPA not using the bLS data instead as they have more data points? One thing that would need to be considered if EPA decided to use the bLS data is that the bLS QA procedures may need to be adjusted. In the appendix under the Open Source NAEMS page 15, Table 23.18 the criteria for data flag 8 should be set at $|L| < 10$ m or at least ($|L| < 5$ m) in order to get better quality data. Also, I think it is important to use some sort of method to identify and remove outliers as there are frequent occurrences of outliers for certain wind conditions that may not be filtered out with the QA process. Then you could determine whether or not there is more useable data using the RPM or bLS technique. You may also be able to increase the amount of useable data by running the models on 15 min averages instead of 30 as less data may be filtered out with the QA procedures.

Section 4.1.3.2 Intermittent data. It seems that there has been intermittent data collected that would be much more valuable for estimating emissions than the variables that were chosen (for example the N, NH_3, Sulfur, pH and solids data). I would strongly suggest that EPA consider utilizing the data that they have available that includes these measurements in order to develop an EEM methodology that would be more widely applicable than using the variables that were chosen for the analysis. Even though the total number of data points available might be less, the quality of the analysis would be much better. Also, it may be possible to extrapolate these data in some cases to fill in missing times. For example, the nitrogen content of the lagoon would not be something that would change drastically from day to day provided there were not any management practices occurring that would dilute or concentrate the lagoon liquid, or any change in total N input (such as feed or bedding). This could increase the number of points that are available for analysis.

Table 4-5. How is it possible to have more valid daily emissions values using the bLS technique yet have more valid hourly emissions values using the RPM technique? Wouldn't more valid daily emissions values mean that there were more valid hourly emissions values?

Section 5.1 It is stated that as the RPM dataset is larger that EPA chose to use the RPM emissions data, yet according to the tables there is more available data from the bLS model than the RPM model, can you please explain this? It is also stated in this section that “The EPA did not use the bLS emissions measurements because these data were collected under the NAEMS to conduct a validation study of the bLS model performance relative to the RPM model.” This is in no way a validation study for the bLS model. In order to conduct a validation study you would have to know the true emission values from the source, as the true emissions are not know from any of the open source areas, you do not know which model performed better and which model produced an emission rate closest to the true rate. Therefore, you cannot draw any conclusions as to which model more closely estimated the true emissions from the source. Based on the few published validation studies available, the bLS model has performed very well for open source areas. In one study it was shown that the bLS model more accurately predicted emissions from open sources than the RPM model (Ro et al., 2011; Ro et al., 2012). Therefore, I suggest that all language related to “bLS validation study” be removed from the document and that EPA reconsider the decision to only utilize the RPM data.

As you performed all of the statistical analysis on the NH_3 emissions per day, is it possible that you are masking trends in the data because you are not evaluating the data on a similar basis such as kg/ha or kg/metabolic weight?

Section 5.3.4 Solar radiation via the diurnal cycle. Here EPA states that the highest NH_3 emission rates were found at night. In all of the work that we have done, emissions always tended to be highest during the daytime as both temperature and wind speed increase throughout the day which typically increases NH_3 emissions. I think that the timestamps on the data need to be double checked. It is possible that at night when you have lower wind speeds that you could have higher NH_3 concentrations which, depending on how the model calculates the emission rate, could lead to higher emission values at night vs. day, but we have not seen this in any of our dairy lagoon data. If you read all of the NAEMS final reports, in instances where you do have a distinct diurnal trend in the data, the trend was for higher emissions during the day.

Figure 5-17 and 5-18 also show that the peak temperature values occurred over night and the peak humidity values occurred in the middle of the day, I find this very hard to believe.

Table 5-10. It is reported that the OK3A site has an odor control technology, what was that technology? Would this influence the lagoon emissions?

Preliminary Comments from Dr. Ronaldo Mahirang

<u>Response to Charge Questions</u>

Question 1: *Please comment on the statistical approach used by the EPA for developing the draft EEMs for broiler confinement houses and swine and dairy lagoons/basins. In addition, please comment on using this approach for developing draft EEMs for egg layers, swine and dairy confinement houses.*

Response:

For the grow-out period for broiler facilities, process-based models would be more appropriate for estimating emission rates, especially on a daily basis, for emission constituents in which the fate and transport are known (e.g., ammonia). The multiple regression approach (i.e., statistical approach) is a plausible approach for those emission constituents, provided that the set of predictor variables is able to accurately depict the phenomena that govern the emission processes and/or factors affecting the emission processes. For constituents that do not lend themselves well to process-based modeling (e.g., particulate matter), the statistical approach would be acceptable, if the predictor variables are able to accurately represent the emissions mechanisms. It should be noted that multiple regression models would be reliable only over the ranges of the experimental data on which the models are based; extrapolation beyond the ranges of experimental data to predict emission rates would introduce considerable errors in the emission rate estimates. In addition, extensive performance evaluation and verification of the prediction models should be conducted.

For swine and dairy lagoons/basins, similar to broiler facilities, process-based mechanistic models would be more appropriate for estimating daily and annual emission rates. Statistical models could also work if the set of predictor variables is able to accurately represent the physical and chemical phenomena that govern and/or affect the emission processes. Extensive performance evaluation and verification of the predication models should also be conducted.

Question 2: *Please comment on the agency's decision to combine the swine and dairy dataset to ensure that all seasonal meteorological conditions are represented. In addition, the agency also seeks the SAB's comments on whether the agency should combine lagoon and basin data.*

Response: Combining the swine and dairy dataset to ensure that all seasonal meteorological conditions are represented in the statistical model is not appropriate, particularly with the proposed statistical approach (i.e., multiple regression approach with static predictor variables). Combining the dataset could work if the prediction model is able to accurately represent the physical and chemical phenomena that govern the emission mechanisms for the constituent of interest.

Question 3: *Please comment on the agency's decision to use static predictor variables as surrogates for data on lagoon/basin conditions. Given the uncertainties in that approach, does the SAB recommend that EPA considers specific alternative approaches for statistically analyzing the data that would allow for the site-specific lagoon liquid characteristics to be used as predictor variables.*

Response: Using static predictor variables as surrogates for data on lagoon/basin conditions would likely result in considerable errors, particularly if the static predictor variables are not able to accurately represent the phenomena that govern and/or affect the emission processes.

Question 4: *Does the SAB recommend that EPA consider alternative approaches for developing the draft NH_3 EEM that balance the competing needs for a large dataset (to reflect seasonal meteorological conditions) versus incorporating additional site-specific factors that directly affect lagoon emissions? If so, what specific alternative approaches would be appropriate to consider?*

Response: A subset of the dataset has measurements on lagoon/basin liquid properties and could be analyzed to establish the effects of these properties on calculated emission rates. Such analysis can provide a framework for statistically-based prediction models.

Question 5: *Please comment on the EPA's approach for handing negative or zero emission measurements.*

Question 6: *In the interest of maximizing the number of available data values for development of the draft H_2S EEMs for swine and dairy lagoons/basins, does SAB recommend any alternative approaches for handing negative and zero data other than the approach used by the agency?*

Response (Questions 5 & 6): The EPA's approach to use valid zero emission rate values is appropriate. Negative emission rate values should also be used, on a case-by-case basis, to minimize systematic bias on the data set. Negative emission rate values should be included if they are brought about by slightly negative concentration values (e.g., because of noise, calibration, extremely low actual concentration) and/or measured background concentrations slightly greater than measured concentrations at the exhaust.

Question 7: *Please comment on the approach EPA used to develop the draft broiler VOC EEM.*

Response: Available VOC data are not sufficient to support the development of the VOC EEM, particularly for estimating daily VOC emission rates, at this point in time. However, there are valuable components of the VOC data (e.g., speciation, ranges of emission rates) that could provide useful information.

Development of EEMs for Broiler Operations

1) General comments/notes

   a) Throughout the report, the term "emissions" is used to denote either an emission constituent (e.g., particulate matter, ammonia, hydrogen sulfide, etc.), measured concentrations of the constituent, and calculated emission rates. To minimize confusion, the terminologies should be as consistent and specific as possible.

2) Section 4.0 – Data available for EEM development

   a) P 4-2. As indicated, "it was determined that the negative values were a result of instrumentation drift, and are considered to be valid values. To avoid possible complications with EEM development,… the negative values were withheld from the data sets used for EEM development. The amount of measured negative values is low (less than 1.7%)." – These negative values are likely due to very low concentrations and low emission rates. While the number of negative values might be small compared to the total number of measurements, the number might be considerable if only the number of measured "low" values is considered instead.

   b) P 4-9. What is the basis for the 75% data completeness criterion?

   c) P 4-10 Table 4-3. Some values appear to be incorrect – e.g., for CA1B H12 (average daily emission rates for H_2S and NMHC are the same; maximum daily emissions for PM_{10}, TSP, and $PM_{2.5}$ are the same) and for CA1B H10 (for maximum daily emissions for PM_{10}, TSP, and $PM_{2.5}$ are the same).

3) Section 5.0 – NAEMS Data Preparation

   a) P 5-15, Table 5-13 – It's not clear how the average daily emissions on a per-bird basis was obtained for ammonia. The values seemed to be higher than what they should be if the values are compared with those in Table 5-12.

   b) Include uncertainty estimates of the calculated emission rates.

4) Section 6.0 – Measured Emissions from Broiler Operations

   a) The section presents the daily emissions values (g/day) to identify general and seasonal trends or cycles in pollutant emissions over the monitoring period.

      i) The plots do not include the negative values – "valid" negative emission rates should be included.

ii) Consider expressing emission rates on a per unit area basis or some other appropriate units.
iii) The plots provide useful information on where the missing values are and variability of the values.

b) Figures 6-3 to 6-7 (for ammonia)

i) The curves (colors) are difficult to distinguish. How about using symbols instead for measured data?

ii) Including the 95% confidence intervals for the mean ammonia emissions for all plots will be helpful in comparison

iii) Also, in comparing the emission rates for the season compared to the overall mean, showing the mean values for the season will help. Any statistical/quantitative comparisons will also be useful (instead of just the qualitative comparisons).

iv) The legends need to be cleaned up because they include items that are not in the plot and/or the legends are not consistent:
(1) SP/SU in Figure 6-3
(2) CAH1BH10 F1 and CAH1BH12 F1 in Figure 6-5
(3) Use of Tyson instead of KY in some plots (e.g., Figure 6-4, 6-5)

c) Figures 6-10 to 6-14 (for H2S) – see comments above

d) Figures 6-17 to 6-21 (PM10) – see comments above

e) Figures 6-24 to 6-27 (PM2.5) – see comments above

f) Figures 6-30 to 6-33 (TSP) – see comments above

g) Figures 6-35 to 6-38 (VOCs)

i) See comments above.

ii) Use NMHCs

h) If possible, compare the values with published data. Include uncertainty estimates of the calculated emission rates.

5) Section 7.0 – Development of EEMs for Grow-out Periods

   a) How the EEMs will account for various differences in types of manure management practices, building types (e.g., tunnel ventilated vs. cross-ventilated vs. naturally ventilated), ventilation rates, etc. should be addressed.

   b) How the EEMs will be used should be explained? For example, for determining daily emission rates, will the point estimates be used or the confidence limits? Note that for daily emissions, the 95% confidence interval is quite large. The uncertainty in the predictions should be addressed, particularly if the EEM is to be applied to individual houses.

   c) On instrumentation drift, likely they happened at low or very low concentrations. If that's indeed the case, why not treat the concentrations at the minimum detection limit or half of the detection limit?

   d) Ventilation rate was not included in the regression analysis and yet, ventilation rate was cited as the primary reason for some of the high emission rates in some instances (e.g., H_2S, PM). More important, predictor variables should be based on factors that govern emission mechanisms.

   e) Include ranges of the experimental data for the predictor variables used. Note that the statistical models will result in considerable errors if they are used beyond the ranges of experimental data.

   f) Any residual analysis/plots (e.g., residuals vs. predicted emission rates) to determine adequacy of the statistical models?

   g) Extensive performance evaluation and/or verification of the models should be conducted.

   h) How would the proposed EEM consider control/abatement measures? Would the abatement be limited to reducing the number of broilers raised?

<u>Development of EEMs for Lagoons and Basins</u>

1) Terminologies/Executive Summary

   a) Lagoon vs basin – need to use appropriate terms.

   b) Emissions vs. concentrations vs emission rates – need to use terms appropriately

c) As stated, "the EEMs can used to provide daily and annual estimates of NH_3 emissions from dairy and swine lagoons." Will this be in the form of point estimates or confidence limits? Also, how will effects of abatement measures be considered in the estimates?

2) Section 1.0 – Introduction

a) The process-based approach recommended by the NRC report is not being addressed by the proposed EEMs. Approaches or plans to consider the process-based approach should be specified in the report.

b) P 1-6. As stated, "due to the very limited amount of data received for the nitrogen concentration, solids content, and pH of the lagoon liquid, these data were not included in the EEMs." Why not do an analysis of the emission rate data using the lagoon water characteristics? There's a fairly good number of data points with lagoon water characteristics.

3) Section 3.0 – Data Available for EEM Development

a) P 3-2. What is meant by valid values? If there's instrumentation drift, would that not constitute invalid measurement? Also, are the negative values being referred to concentrations or emission fluxes or both? Are the negative values (<2%) random or at the tail end of the distribution? If they are at the tail end of the distribution, would that not impact the tail end of that distribution?

b) Any information on outlier analysis?

4) Section 4.0 – NAEMS Data Preparation

a) P 4-3. As stated, "Meteorological and lagoon liquid data were recorded as 5-min averages, and emissions data were reported as 30-minute averages. These data were aggregated … to obtain daily values." Does this mean the values were added (summed)?

b) Provide information on uncertainty estimates for the bLS and RPM methods.

5) Section 5.0 – Overview of NH_3 EEM

a) Consider expressing emission rate on a per unit area basis or some other appropriate units.

b) How would the proposed EEM account for control/abatement measures for mitigating emissions?

c) P 5-15 – As stated, "Although the pH, ORP, and temperature of the lagoon liquid were expected to affect NH_3 emissions from lagoons, the EPA did not include these data as candidate predictor variables due to the limited number of data values and because data were not provided for sites IA3A and WA5A." Does this mean that those parameters were not measured in IA3A and WA5A? How about analyzing a subset of data with lagoon liquid characteristics?

d) Predictor variables should accurately represent the physical and chemical phenomena that govern the emissions processes.

e) Any residual analysis/plots (residuals vs. predicted emission rates) to determine adequacy of the statistical model?

f) On additional analysis under consideration

   i) Re-examine some suspect data values to determine if they are representative. What are those suspect data values? What criteria will be used to determine if data values are suspect? Need more description on this.

   ii) Consider a weighting scheme whereby some emissions observations are given more weight than others in the EEM development… What would be criteria and basis for applying weighting factors?

Preliminary Comments from Dr. Deanne Meyer

Much discussion occurred during our meeting to address the questions. The following comments are provided in addition to the previous input. It is unclear why EPA chose to not discuss its findings within the realm of existing scientific literature. In both studies, a tremendous effort was made to discount almost all existing reports and publications due to methodological approaches. However, it is clear that in at least one state (California) emissions estimates already exist and have been used by air quality regulatory agencies. It would be important to at least acknowledge how the current data and findings stand with respect to existing scientific literature and regulatory assumptions.

<u>Lagoon & Broiler Reports:</u>

The experimental design of these project and the standard operating procedures may have set them up for reduced utility of data obtained. Certainly, both N concentration and form are important parameters to estimate ammonia emissions. These were not measured or were not measured consistently enough to have sufficient number of data points for use.

<u>The Lagoon Study:</u>

Section 1.

The industry overview misrepresents the US dairy and swine industries. This section needs a major overhaul. The source of the information in this section is unclear. It's not clear how the discussion presented in industry overviews is germane to the subject of emissions.

The discussion on manure management, storage and stabilization needs to be modified. The objective of this study is to measure emissions. The discussion of manure 'treatment' and gas formation is best put in a section that discusses the biological processes associated with decomposition of substrates and formation of the compounds emitted. The design exception difference identified between storage and treatment ponds is inconsistent with fact. One is designed specifically for biological treatment. The other is not.

The text description of the facilities needs to relate to the figures provided for the facilities. Manure was vacuumed from the lactating cow barns and special needs barn every 12 hrs and places in lagoons near the barns. (The barns are not labeled. There is only one 'lagoon' labeled on the map. There are manure pits and it appears they are not all labeled.).

Section 2

Site description suggested improvements: 2.4.1 identifies there was one farm monitored continuously and three remaining farms monitored intermittently. There were only three total farms monitored.

Two out of the three dairy facilities were constructed in 2002. This does not represent the US Dairy industry.

The maps would be more effective if they identified the flow of the water from the source of origin, through the facility, into the monitored structure. Although surface area and depth of structures is provided no information is provided to discuss side slope. The Indiana dairy measurements for the lagoon were done over a structure that contained water and wash down from the milking parlor and holding area. It's not clear if the Washington structure was a separation basin or if it had greater microbial activity. What is a freestall style barn? The WA map should show the sand separator, and the location of the screens and centrifugal/screw presses. Where is the clarified water storage basin? The description of the Wisconsin dairy does not provide sufficient information to determine what went into the monitored lagoons. Manure was flushed, went through a separator. The solids were removed. The effluent went to tanks. Where are the tanks? What is the influent to the lagoons?

Measurements of wind speed at ground level may not be similar to wind speed at lagoon surface level. Lack of information on the depth from the top of the embankment structure to the liquid surface makes it difficult to decipher importance of surface wind speed.

Section 4. It's not at all clear why the criteria for use of a day of data required 75% valid data for completeness. Given the lack of completeness, it may be more important to use more days and sacrifice completeness. It is unclear why sampling dates (4.1.3.2 for intermittent data) did not coincide with the NAEMS measurement events. Explanation is needed.

Section 5. Figure 1. The first step in the detailed figure identifies the need to use existing knowledge about emissions processes to identify key variables. The scientific literature clearly identifies that for animal housing, nutrients excreted are key parameters; for lagoons, pH, temperature, concentration of ammonia are key parameters. Yet, the actual quantification of N or S in base material was not used in these analyses.

Questions posed to the Panel:

Question 1. Please comment on the statistical approach used by EPA for developing the draft EEMs for broiler confinement houses and swine and dairy lagoons/basins is inadequate. In addition, please comment on using this approach for developing draft EEMs for egg-layers, swine and dairy confinement houses.

Much discussion occurred and was captured during the meeting related to statistical methods and will not be repeated herein. The methodology was incomplete. Use of estimated N excretion (broiler study) based on growth curves and breed is biologically superior to use of animal mass and animal number. This may well help explain the reduced emissions measured during the last measurements for each flock.

It is inappropriate to not include the feedstock substrate source as part of the independent variable for chemical (non-PM) constituents. Inclusion of N and S as independent variables (not as surrogates) is important if the compound measured is ammonia or hydrogen sulfide.

Equations developed from these data reflect ONE housing type and should not automatically be applied to other housing types.

Question 2. Please comment on the agency's decision to combine the swine and dairy dataset to ensure that all seasonal meteorological conditions are represented. In addition, the agency also seeks the SAB's comments on whether the agency should combine lagoon and basin data.

The agency should not combine swine and dairy datasets.

The agency should strive for a clear description of the types of lagoons/basins measured and be technically sound in the use of these terms. The report identified "In the NAEMS documentation, the terms "lagoon" and "basin" were used inconsistently to describe the impoundments at the various monitoring sites. Although the EPA acknowledges that there might be differences between a lagoon and a basin (e.g., the degree of microbial activity), the term "lagoon" is used throughout this report to refer to lagoons and basins." The report mentions there may be a difference in contents of these structures based on microbial activity, there may also be differing concentrations of solids in these structures potentially impacting composition of surface area exposed to the atmosphere. One would expect different emissions from a non-crusted versus crusted surface all other constituents equal.

EPA should strive to have technically correct definitions and remove inconsistencies, ambiguities, and opportunities for misunderstanding and misinterpretation from the reports they received. Terminology should be consistent with professional definitions available in Standards from the American Society of Agricultural and Biological Engineers. EPA and the NAEMS scientists should use ASAE Standard: Uniform Terminology for Rural Waste Management. ASABE S292.5. Inconsistently and inappropriately utilizing terminology clouds the ability of anyone to understand what was done and then determine if it was done correctly or if it is appropriate to compare outputs..

The following definitions are from this Standard:

3.39 detention pond: An earthen structure used to temporarily store runoff water, wastewater, or semi-solid slurry, or liquid manure for a period of time. Sometimes called a settling basin.

3.68 lagoon: An earthen facility for the biological treatment of wastewater. It can be aerobic, artificially aerated, anaerobic or facultative depending on the loading rate, design, and type of organisms present.

3.77.1 liquid manure (thin slurry): Manure that by its nature, or after being diluted by water, can be pumped easily. Normally fibrous material such as chopped straw or waste hay is not present.

3.77.2 slurry manure: Manure in which the percent total solids approximates that of excreted manure for some species. The total solids content could vary by a few percent depending on whether water is added or a slight drying occurs. It can be handled with conventional, centrifugal manure pumps and equipment.

3.77.3 semi-solid manure: Manure that has had some bedding added or has received sufficient air drying to raise the solids content such that it will stack but has a lower profile than solid manure, and seepage may
collect around the outer edge. It may be pumped with positive displacement pumps or be handled with a front-end loader.

3.77.4 solid manure: Manure that has had sufficient bedding or soil added, or has received sufficient air drying to raise the solids content to where it will stack with little or no seepage. It is best handled with a front-end loader.
Refer to Figure 1 in the standard for species specific ranges for liquid, slurry, semi-solid, and solid manures.

Question 3. Please comment on the agency's decision to use static predictor variables as surrogates for data on lagoon/basin conditions. Given the uncertainties in that approach, does the SAB recommend that EPA consider specific alternative approaches for statistically analyzing the data that would allow for the site specific lagoon liquid characteristics to be used as predictor variables.

Initial site selection for dairy 'lagoons' in this study does not provide representation for measurements of all seasonal meteorological conditions. Moderate winters were not represented. Neither were extended hot conditions in summer. Combining dairy data with swine data is inappropriate. The chemical composition of the waste stream entering the liquid storage structures will vary tremendously between the species. More rapidly fermentable carbohydrates will be present in the swine manure. Different compositions of nitrogen and sulfur are also expected. Combined, these differences in influent concentrations will translate to differences in microbial decomposition activities, rates, and intermediary compounds all influencing potential conversion to methane or non-conversion and potential release of volatile organic compounds to the atmosphere.

Nitrogen quantity and composition and waste stream, pH (among other control points), temperature at the interface between the surface and the atmosphere, and wind speed are known to play key roles in volatilization of N as ammonia. For the dairy systems, 100% of manure was not deposited in the measured structures. Therefore, use of animal number as a surrogate misrepresents the facility. Use of a standard surface area (regardless of depth or collectible animal manure amounts) also misrepresents the facility. Daily loading rate of N and volatile solids, and pH are more appropriate.

Question 4. Does the SAB recommend that EPA consider alternative approaches for developing the draft NH_3 EEM that balances the competing needs for a large dataset to reflect seasonal meteorological conditions) versus incorporating additional site-specific factors that directly affect lagoon emissions.

Having a larger dataset does not help describe emissions if the data in the set do not contain the correct parameters. It merely means there are more data points without potential utility. The two species should not be combined. The chemical composition of the material in the lagoons/basins, and its exposure to the atmosphere are more vital pieces of data to use in predicting emissions.

Question 5. Please comment on the EPA's approach for handling negative or zero emission measurements.

It is very difficult to identify what a negative number represents. This needs to be clearly defined and characterized to be transparent. The report identified that some of the negative values resulted from "drift in instrument readings between calibrations". Regularly scheduled equipment calibrations should have re-zeroed the equipment frequently. Estimated calculated numbers (negative or positive) should not be used if instead of calibrating the equipment the reading of the calibration gases was averaged over a period and subtracted from individual readings.

Question 6. In the interest of maximizing the number of available data values for development of the draft H_2S EEMs for swine and dairy lagoons/basins, does SAB recommend any alternative approaches for handling negative and zero data other than the approach used by the agency.

See comments to previous question.

Question 7. Please comment on the approach EPA used to develop the draft broiler VOC EEM.

EPA does not have sufficient data to develop VOC EEM at this time.

Additional documentation that may be useful to EPA.

Trabue, S., K. Scoggin, H. Li, R. Burns, H. Xin, J. Hatfield. 2010. Speciation of volatile organic compounds from poultry production . Atmospheric Environment 44: 3538-3546.

Summers, Matthew D. 2005. FINAL REPORT: Quantification of Gaseous Emissions from California Broiler Production Houses. Available at: http://www.arb.ca.gov/ag/caf/poulemisrpt.pdf accessed 29 March 2012.

South Coast Air Management District has had emissions estimates for dairy in poultry for years. SCAQMD Poultry and Dairy Emission factors and guidelines for using the online 'calculator' can be found here: www.aqmd.gov/aer/Updates/GuideCalcEmisDairyPoultry.pdf (January 2009).

Preliminary Comments from Dr. Wendy Powers

Question 1: *Please comment on the statistical approach used by the EPA for developing the draft EEMs for broiler confinement houses and swine and dairy lagoons/basins. In addition please comment on the approach for developing draft EEMs for egg-layers, swine and dairy confinement houses*

EPA indicated during the meeting that the purpose of periodic data was to produce a mass balance that could be used to verify the EEM. Based on the data they have received, EPA does not have what they need to conduct a mass balance.

EPA should consider use of metabolic weight ($BW^{0.75}$) rather than a cubic term to describe relationships. Metabolic weight provides a biological basis in that it is a reflection of the biologically active tissue as a proportion of body mass; as animals age the metabolically active tissue is smaller as a percent of total body weight.

Use of hourly averaged data are more appropriate that averaged daily values for developing the EEMs because it allows for diurnal effects to be conveyed.

Question 2: *Please comment on the agency's decision to combine the swine and dairy dataset to ensure that all seasonal meteorological conditions are represented. In addition, the agency also seeks the SAB's comments on whether the agency should combine lagoon and basin data.*

Combining the swine and dairy lagoon/basin datasets does not present a problem if the lagoon/basins are characterized adequately to include the appropriate emissions precursors in the model. Species is less important that storage structure nitrogen and solids content in terms of estimating ammonia emissions. Similarly, hydrogen sulfide emissions are likely more influenced by sulfur content in the manure than by if the manure originated from a pig or a cow. Periodic data that were collected needs to be related to emissions at the general time of collection. Use of these periodic data (nutrient and solids content) in an EEM would alleviate any concerns related to combining lagoons and basins.

EPA should consider including cover or crust formation on the sampled lagoons/basins and see if an estimate of cover can be included in the model.

Question 3: *Please comment on the agency's decision to use static predictor variables as surrogates for data on lagoon/basin conditions. Given the uncertainties in that approach, does the SAB recommend that EPA consider specific alternative approaches for statistically analyzing the data that would allow for the site-specific lagoon liquid characteristics to be used as predictor variables?*

The variables selected are not related to what drives production of emissions from lagoons or basins. The agency needs to identify the important variables and incorporate them into the model even if those variables were collected as part of periodic data. Animal numbers, while supporting the amount of nitrogen entering a storage structure, does not replace the need to consider nitrogen inputs.

EPA include use of the BLS data but needs to also impose an outlier analyses to remove strange values that are due to the model itself.

Question 4: *Does the SAB recommend that EPA consider alternative approaches for developing the draft NH3 EEM that balances the competing needs for a large dataset (to reflect seasonal meteorological conditions) versus incorporating additional site-specific factors that directly affect lagoon emissions? If so, what specific alternative approaches would be appropriate to consider?*

The agency should consider different tiers of complexity that allow for varying degrees of information available to the end user. This might include dietary nitrogen inputs coupled with growth curves and nitrogen needs to support growth as a means of establishing upper boundaries on ammonia emission for a given temperature and management scheme. EPA must conduct performance evaluations of these tiers using NAEMS data and literature data, regardless of what method was used to collect the literature data. Use of data from across a range of methods enhances the robustness of any EEM developed.

Models fitted with periodic data should be compared with models fitted with static data. EPA might find that the models developed using periodic data work well enough to allow use of this approach which will ultimately provide a better EEM to incorporate mitigation options into.

A greater number of valid days were obtained using the bLS model compared with the RPM model. EPA's justification for using only the bLS model was unacceptable. Is it possible to combine them? For both models you may always be throwing out the same data (low wind speeds, certain stability classes). One could go back and model on a 15-min interval thereby providing more data.

Question 5: Please comment on the EPA's approach for handling negative or zero emission measurements.

Negative emissions values should remain in the data set. More information on treatment of outliers and how the negative emission values originated are needed. For those concentrations that were negative, EPA should consider replacing the negative value with ½ the instrumental MDL, thus eliminating negative emissions values due solely to negative concentrations.

Question 6: In the interest of maximizing the number of available data values for development of the draft H_2S EEMs for swine and dairy lagoons/basins, does SAB recommend any alternative approaches for handling negative and zero data other than the approach used by the agency.

High positive values may be more accurate than negative values because model actually works better under certain conditions. Negative values need to be treated on case-by-case basis but one would never really know why the negative values were generated unless one goes back and looks at every input value for the model.

Question 7: Please comment on the approach EPA used to develop the draft broiler VOC EEM.

I agree that the CA data should be omitted. The value of a VOC EF is questionable unless these are reactive VOCs. I would suggest not using the VOC data at all. The data do not support the development of an EEM for VOCs at this time. However, there are valuable elements to the data that should be disseminated and used as appropriate. Speciation data, coupled with reactivity indication, may be useful for specific situations.

Section-specific comments

Broiler study

Section 1

This section discusses the importance of getting to a process based approach. Maintain an emphasis on process-based modeling in the section.

The ACA, itself, is a very small portion of the AFOs that participated in the ACA and the 2600 is a very small percent of the total industry. So there is a need to talk about how the 2600 that signed up relates to the industry (% of animals represented by the 2600).

Consider establishing some goals that help identify why some things were periodic measures while others were continuous and what one can do with such data.

Talk about how ventilation rate is determined and how that relates to emissions. Give examples.

Put more emphasis on the fact that there are going to be point estimates and confidence intervals provided.

A very generalized description of how NAEMS came about is provided but there were specific charges to NAS. Also include the findings of NAS and the specific goals of NAEMS particularly as it relates to a process based model.

Section 2

Ventilation system characterization for each farm is needed. If ventilation rate is critical then it needs to be spelled out how important that is and the challenges in getting it right.

Section 2.5 – need to clarify that ‘manure storage measures’ were made only when houses were monitored in the absence of birds.

Also acknowledge which data were collected as intended and which were not. Page 1-3 gives a different picture of what the data sets would look like.

Provide a general description of the mechanisms that generate pollutants and therefore what it is we are trying to develop a surrogate for?

Sections 3 & 4

- Sections are clear.
- Great lengths to describe parameters that are not used. If there wasn't enough data then consider upfront and take more time to describe – shorten this section
- Page 4-2 amount of negative values is low suggesting adequate procedures for instrument maintenance and calibration. Low frequency of negative values does convey good maintenance;
- Missing details such as how the change in first 4 months was dealt with
- Several issues with VOCs
- Discussion about periodic grab samples. Why use KY and not CA if both used the same way. So we need more clarity
- Strengths and limitations
    - VOCs n=1
    - 60% of CA NH3 data were compliant – so completeness not met and what caused the other 40% to not be valid
    - Diet formulation not included yet we know it is important. Must be some way to get these data
    - Hottest summer flocks had the oldest litter – highest concentrations plus highest ventilation rates
    - CA1 – not sure when it was built – 1960/2002 so how does this represent the current industry
    - Make sure practices described really represent the industry
    - Table 4-3 H2S data is highly suspect for CA1-B
    - PM2.5 emissions range for CA (table 5-11) is much higher than others and range does not match the same data presented in table 5-12
    - TEOM data has multiple problems and those concerns should be addressed in the document.
    - Type of TSP inlet was inherently a low vol sampler – no such thing as an accurate low vol sampler
    - Growers will routinely record bird weight – not really the case
    - Data received during call – disconcerting how many studies were completely disregarded. Those data should be able to be used to cross validate the developed EEMs. Tables should reflect what data would be applicable to validation
    - Figures are helpful, well organized. Integrate sampler info into the section. What analyzer, what TSP equipment, etc.
    - State in advance what data are not included
    - Change in sampling method 4 months in – is that why 60% completion?
    - EPA should provide a list of independent variables in the model (site? Year?)
    - How did EPA handle data that was not reported? (Wendy – I didn't really understand this)
- Table 3-3. Attempts to provide PM sampler schedule. PM10 is 86% of data collected. Need to provide rationale for disparity between PM10 and PM2.5
- No mention of VOC in the upwind collection for CA, only?

- Table 4-3. Std err or std dev is needed. Avg daily emissions in top of table and range or CI in the lower part would be helpful. H2S numbers the same as NMTHC – footnotes may be incorrect. C footnote needs to clarify that this is not NMTHC for the CA system.
- Units – lb/d/house may be a better term than birds*mass. (Can't distribute more birds over more houses)
- Really need to know how many samples were collected at each time
- Fan calibration procedures and frequency
- Is 75% completeness appropriate for hourly average?
- When taking hourly averages to calculate daily – need to know what 25% was missing. Was the missing data random or was there a pattern?
- 4-10. If they didn't use methods, we aren't going to use the method. Would strengthen the EF is you compared against multiple methods.
- Site selection – 3 sites in 2 states. Would benefit from being cleaned up and more careful about how the sites are described. Ie. Inlet systems are poorly described. Some discrepancies between section and later on
- Ventilation rate should be more carefully described to illustrate the lengths taken to conduct the work (i.e. FANS system and repeated calibrations).

Summary

Consider use of more of the identified data – suggest additional criteria that might be considered or use these data as a performance evaluation of the EEM

Criteria may be identified perhaps after we know why some data were excluded

Done in a commercial facility or one that replicates it, baseline emissions (use the control),

Improve clarity of procedures, facilities

Address omitted data – provide rationale for omission

Address studies that use intermittent datasets and capture data at multiple facilities

Do we have a complete picture of the data? All seasons, all times of day? If almost all winter data were discarded and all summer data were retained, then you need to develop model with data you have and fit it to a real system to avoid bias. We have to move to a process-based model.

Hypothesis about regimes under which the EEM developed under limited number of houses would give inaccurate results. So test the EEM against other data that address these different regimes.

Section 5

Not robust enough in description. 5.1 needs more discussion about calibration procedures and why schedule was different between analyzers. Generation of notes to project personnel – how was equipment fixed and was it in a timely manner. Outliers only marginally addressed. 75% completeness criteria. Are sites and dates monitored comparable? Table 5-2 shows completeness – would it change in negative values were included?

Section 6

Because ‘season’ is not part of the final model it would seem that the term was not a significant model term. Statistical data to support this should be included in this chapter because the section spends a great deal of time displaying data by season yet ‘season’ is not a term in the final model.

Limited data is discussed. EPA needs to consider that the limitation may be to the extent that it is inappropriate to develop useful PM2.5 and TSP EF or EEMs.

The procedure for identifying outlier data points needs to be conveyed.

Plots help identify missing data, negative values should be included. Need to identify if using mean or median should be used with confidence intervals

Symbols for measured data would be the preference rather than use of colors to display data.

Comparison is qualitative in nature – need to include the statistical comparisons, including outliers and variability

Emission are expressed in g/d – express on a mass basis or unit area basis so one can compare between sites

Legends are inconsistent

VOC data are highly variable

Compare values with published data

Emissions on NH3 are highly temp dependent

Use of cycle day rather than date or flock age – structure graph so that you have grow out and clean out sections

Lagoon/basin report

Section 3

Page 3-2: negative values – did these compromise the EEM

Table 3-1: NMTHC concentrations – not received and VOC samples not collected. Not clear if data exist for concentrations or not. Same with NMTHC emissions

75% completeness issue – models work well when we do not have very unstable conditions. So you end up with data for a day that represents the highest, most stable emissions rather than the unstable night data when emissions are lowest. Reporting 30 min data – what were the criteria for constructing the 30 min data?

Can we use some of the previous data that collected emissions with flux chambers as a means of validating the EEMs developed?

Collectible cow unit – what percent of cow excretions and bedding hit the storage structure to contribute to emissions

Table 3-2: we have 2 lagoons and 1 basin so clarify here. Coverage on the lagoons would be useful info to provide somewhere.

Where we have data, we need to show how these data fit compared to the rest of science

Preliminary Comments from Dr. Al Rotz

Brief Response to Charge Questions

Question 1: *Please comment on the statistical approach used by the EPA for developing the draft EEMs for broiler confinement houses and swine and dairy lagoons/basins. In addition please comment on the approach for developing draft EEMs for egg-layers, swine and dairy confinement houses.*

The statistical approach used by the EPA will not produce robust EEMs that can be broadly applied to operations throughout the U.S. This type of statistical model can only be applied to operations with parameters that fall within the range of the data set from which the EEMs were developed. Extrapolating to other conditions can lead to very inaccurate predictions.

A process modeling approach based upon scientific understanding would be the best approach for developing EEMs. Given that this approach is not going to be used, a more scientifically based empirical model will provide a better approach then is currently used. To develop a more robust and widely applicable EEM, I recommend the following approach for all animal species and facilities:

a. The predicted variable should be the emission expressed per animal unit or per unit of surface area of the facility modeled.
b. The mathematical structure of the EEM should be developed based upon scientific understanding. This would include the use of linear and nonlinear relationships where the bounds are established so that even extreme input parameters will produce reasonable results, i.e. emission predictions will approach zero under the appropriate conditions and meet some reasonable maximum value at the outer extremes.
c. A statistical procedure and the NAEMS data should be used to determine the parameters of the relationship to form the final EEM.
d. Further data and models from other published studies should be used to evaluate the EEM for diverse conditions beyond the original dataset.

Question 2: *Please comment on the agency's decision to combine the swine and dairy dataset to ensure that all seasonal meteorological conditions are represented. In addition, the agency also seeks the SAB's comments on whether the agency should combine lagoon and basin data.*

Using the current statistical modeling procedure, it is not appropriate to combine swine and dairy lagoons to form a common EEM. Using any empirical approach, the ideal would be to develop separate relationships for each species. If adequate data are not available for individual species, the approach outlined in response to Question1 could be used where the prediction is based upon the characteristics of the stored manure including nutrient contents, dry matter content and pH. If this approach were used, lagoons and basins could probably be combined with the same EEM. For many dairy farms, manure is handled as slurry (dry matter content of about 10%). With slurry storage, a surface crust develops that greatly effects the emissions that occur. A different EEM will be required for estimating emissions from this type of storage, or the EEM would have to be appropriately structured to represent this effect. Data for this type of manure storage is not available through the NAEMS.

Question 3: *Please comment on the agency's decision to use static predictor variables as surrogates for data on lagoon/basin conditions. Given the uncertainties in that approach, does the SAB recommend that EPA consider specific alternative approaches for statistically analyzing the data that would allow for site specific lagoon liquid characteristics to be used as predictor variables?*

Unless there is a clear relationship between variables, static predictor variables cannot be used as surrogates in the development of robust EEMs. These surrogates can provide a good fit to the original data, but they cannot be used for other conditions, particularly those beyond the bounds of the dataset from which they were developed.

Manure characteristics within a lagoon or basin do not change that rapidly. Therefore, daily data are not required. If data on manure characteristics are available from NAEMS on a weekly or monthly basis, these data should be used in developing an EEM based upon the characteristics of the stored manure. The approach outlined in response to Question 1 should be used.

Question 4: *Does the SAB recommend that EPA consider alternative approaches for developing the draft NH3 EEM that balances the competing needs for a large dataset (to reflect seasonal meteorological conditions) versus incorporating additional site-specific factors that directly affect lagoon emissions. If so, what specific alternative approaches would be appropriate to consider?*

The modeling approach outlined in response to Question 1 should be used. If NAEMS data on manure characteristics and other site specific conditions are available on a weekly or monthly basis, they should be used for developing the parameters of the scientifically based EEM. A large dataset can be maintained by assuming that parameters such as the manure characteristics remain constant or change linearly between the weekly or monthly intervals when measurements were made.

Question 5: *Please comment on the EPA's approach for handling negative or zero emission measurements.*

The real issue here is how data outliers are handled. All inaccurate data points should be removed when there is a sound basis for determining them as inaccurate. In the case of the broiler data, most of the zero and negative emission values should not be considered as outliers. Due to the measurement calibration procedure used, negative values are just offsetting other positive measurements. For the open path measurement procedures used for lagoons, most negative values are likely outliers and should be removed. With open path measurement, zero values should be included. On a case by case basis, there may also be a sound reason for correcting some negative values to zero. This could only be done by plotting the data to determine outliers. If a visual observation of data trends indicates that certain negative values are due to little or no emission, then I feel that they can be considered to be zero. To eliminate these data will bias the empirical relationship toward greater emissions.

Question 6: *In the interest of maximizing the number of available data values for development of the draft H_2S EEMs for swine and dairy lagoons/basins, does SAB recommend any alternative approaches for handling negative and zero data other than the approach used by the agency.*

As stated in response to Question 5, it does not seem appropriate to include most negative values in determining H_2S EEMs for lagoons. By observation of data trends, some negative values may be considered as zero values. To obtain a larger data set, measurements made using the bLS method should be used alone or along with the data obtained using the RPM method. My personal evaluation of the dairy lagoon data indicates that the data collected by the two different measurement methods are very similar overall. Use of the bLS method alone will provide a larger data set. Perhaps there is a sound reason for not combining the RPM and bLS datasets, but from what I know about the data, I would not have a problem with including both. Using the data from one measurement method to evaluate the EEM created from the other may not work well since you would really be comparing measurement methods.

There is also the issue of a lack of data during the winter months, particularly for the dairy lagoons. The likely cause of this lack of data was that the lagoon was frozen and there was no reason to try to make measurements. Therefore, zero emission data must be added for these periods when emissions were not measurable. To not do so will bias this empirical EEM toward warmer months when higher emissions occurred.

Question 7: *Please comment on the approach EPA used to develop the draft broiler VOC EEM.*

The VOC emission data available for broiler facilities is too limited to support the development of an EEM for national application. Because of the instrumentation problems encountered in measuring VOC emissions in California and the alternate procedure used, the accuracy of these data is uncertain. The limited data obtained (not available on an hourly or daily basis) is not useful for empirical model development. The remaining data for one year from one facility in Kentucky is not adequate for developing a national EEM.

VOC speciation data may be useful for future work. The individual compounds found should be reported for both the Kentucky and California sites. Reactivity of the VOCs included in the measure of non methane hydrocarbons is important and should be available for use with any VOC EEM that is developed and applied to agricultural operations. VOC emissions are a concern only when substantial quantities of moderate to highly reactive compounds are released to the atmosphere.

Preliminary Comments from Dr. Paul Sampson

Response to Charge Questions

Question 1: Statistical approach for draft EEMs. The EPA's statistical approach to developing EEMs is flawed in a number of respects, including (1) models that don't account for aspects of the sampling design structure (notably locations, houses within locations, and flocks within houses in the case of Broilers, (2) other aspects of the mean structure, including use of polynomials for nonlinear relationships, which are dangerous for extrapolation, (3) lack of residual analysis, especially with regard to likely temporal autocorrelation, (4) a validation approach (which is not "cross-validation") that also fails to consider sampling design structure, and (5) an unusual approach to model building (variable selection) that is not well-justified for the primary aim of prediction. These issues should be addressed in a substantially revised statistical approach for Broilers, and Lagoons. They should be carried over into model building for egg-layers, swine and dairy confinement houses.

On a broader level, no statistical model built from the data from the current studies can be assumed to represent farms across the US. There may be more science and process-models that can guide the construction of statistical models that might be argued to be more reliable for extrapolation, but there will be no statistical basis for extrapolation without considering data from other studies.

Question 2: Combining swine and dairy datasets. The swine and dairy datasets should be separated **IF** EPA can develop a science/process-based approach that elucidates different functional forms of the available predictors for swine and dairy lagoons. Without such an approach AND under assumptions that meteorological effects are consistent between swine and dairy lagoons, the current EPA-proposed statistical approach is valuable, dependent on further diagnostic evaluation of the current model comparing the accuracy of predictions for swine and dairy datasets. Separation of the swine and dairy datasets will still not enable statistical statements to be made about the application of EEMs to other sites.

Question 3. Static predictor variables as surrogates for data on lagoon/basin conditions. The EPA is "stuck between a rock and a hard place". Again, there simply aren't the data (enough different lagoons/basins) to do anything drastically different than to work with the current static predictor variables. Thorough residual analysis should establish how well the current (or any revised) statistical model fits and predicts measured emissions for lagoons and basins. It is possible that the current model provides equally good estimates of emissions for both lagoons and basins, but neither may be considered adequate and, again, extrapolation beyond these farms cannot be defended.

Question 4. NH4 EEM. No comments.

Question 5. Handling negative or zero emission measurements. I cannot condense into a short answer the substantial document on "Charge 5 and 6 – draft summary points …" I'll defer to my statistical colleagues (especially Peter) on this.

Question 6. Alternative approaches for negative and zero data for draft H2S EEMs. No short answer from me.

Question 7. Approach to develop draft broiler VOC EEM. Again, no short answer from me.

Lagoons:

- Suggestion: Boxplots of emissions by the many farm level categorical factors, perhaps separately for different seasons or levels of other factors.

- Diagnostics: the usual residuals vs fitted values, QQ-plots to assess distributional form, etc., but also, break down residuals by farm (hence by animal). However, also generate, separately for each farm, time series of measured and fitted or predicted emissions according to the model.

- Cross-validation rather than simply validation on a reserved dataset of 20% (as suggested in case of Broilers using flocks). Consider cross-validation setting aside blocks of times so that time series of observations and predictions can be generated.

- Extend the current explanation of difference in model predictions for dairy vs swine (Tables 5-17, 5-18) by explaining the explicit computation using model coefficients. More explicitly, for log link or lognormal, explain the translation of model coefficients into modeled % differences in emissions between dairy and swine lagoons.

- In the end you chose a log link, suggesting that a lognormal model might also be reasonable, and fitting a lognormal is simpler computationally (OLS vs GLM) and consistent with the scatterplots of log NH3 vs predictors.

  Note: You need to add a constant to deal with zero emissions for gamma or lognormal. One would obviously need to add a bigger constant to deal with negative emissions.

- It is very surprising that no temporal autocorrelation could be found in 30 min data. Start with an exploratory approach examining residuals from an OLS fit of log NH3. The coverage properties of the predictive intervals are much too high (.99), perhaps due to misspecification of the error structure.

- Note, I believe that there must be something wrong in the computation with an identify link as reported in Table 5-13. Although the form of the link is important, there must be an error to find such a drastic results of tiny predictive intervals with zero coverage of the PIs.

- Table 5-20 reports a model with 80 coefficients!! That has to be overkill! Interactions with "animal" are probably appropriate in order to effectively fit separate models for dairy and swine (something that could be explained or emphasized), but there must be a way to minimize the number of other interactions.

Preliminary Comments from Dr. Eric Smith

Regarding whether it might be useful for EPA to consider using a method such as quantile regression for estimating the percentiles of the distributions rather than the average values: Quantile regression is used some in ecology/environmental applications but I do not think it really solves the problems that are the focus of the farm odor analysis since the EPA approach is not focused on a percentile standard.

Preliminary Comments from Dr. John Smith

Comments on the 7 charge questions

Question 1

The statistical design is flawed. The dairy/swine unit is the experimental unit. In this data set it is confounded by region/climate, manure system type, animal species, animal type within a species, management, etc. This leaves you with little or no degrees of freedom. On top of the design flaws a portion of the data is excluded from the initial analysis to validate the model. This approach further reduces your statistical power. Typically experimental design and power test are run before data collection begins to establish an experimental design. In this case it appears that data was collected prior to developing the correct methodology for data collection. To further complicate the situation, lagoon loading is not taken into account. Lagoon loading can have a dramatic impact on microbial activity. There seems to be little information available concerning what went into the lagoons. There is not any accounting for the animal type, animal density, injection of fresh water, storm water, discarded feed, etc. To complicate the situation analysis of the lagoon liquids is not available or included in the model. It will be very difficult to justify this methodology without a better accounting of lagoon loading.

Due to the flaws in the statistical design, experimental procedures, and limited data, it is inappropriate for the EPA to use this approach for developing draft EEM's for egg layers, swine and dairy confinement housing.

Question 2

The EPA justifies combining the swine and dairy data to ensure that multiple seasonal meteorological conditions are represented. Although this approach represents multiple seasons, little attention is paid to difference in species, production efficiency, diets, feed intake, animal stocking density, injection of fresh water, lagoon loading and many other factors are not accounted for in the EPA's approach. Based on the differences in the species, diets, etc., it is not appropriate to combine the swine and dairy data sets.

These two species are fed very different diets. The dairy producers will feed diets with forages while the swine producers will feed a concentrate diet. Within in dairy and swine you have multiple groups of animals that have different dietary needs. It would be logical to assume that these different groups of animals would also excrete different levels of nutrients.

It is troubling that animal inventories, feed efficiency and production level were not captured throughout the study. As production efficiency increases the amount of nutrients excreted per unit of product decreases. This relationship seems to be ignored. Care needs to be taken in developing regulations that will encourage producers to continue to improve production efficiency.

Question 3

The use of static predictor variables in this situation is driven by the fact that data collection process was poorly managed. Since the data they need is not available the EPA wants to take the easy approach of using static predictor variables. This approach is not fair to animal agriculture. An appropriate statistical model and data collection procedures should be developed that account for all of the appropriate variables including climatic, lagoon loading, facility type, and species. management, etc. and sufficient data should be collected to accurately estimate EEM'S.

Question 4

There is not a new approach the will salvage a flawed data set. The current data set has significant problems and should not be used to develop EEM's. The new approach should be to develop a valid statistical model that accounts for the appropriate variables, than do the power test to determine the sample size needed to accurately develop EEM's. Comprehensive data collection procedures should be developed and implemented to collect a new data set that accurately represents the situation.

Question 5

It appears that the EPA only centered on negative or zero emissions data. It is very possible that there are measurements that error to high side. EPA's approach seems to be centered on only low readings. There are statistical methods to determine data that resides out side of the normal range. The EPA should use a statistical approach to determine which data is above and below the normal range.

Question 6

There are no magic bullets that will allow you to develop draft H_2S EEM's from a flawed data set. The baseline data that has been collected does not account for enough variables. The scientific method needs to be applied to collecting representative base line data so that the swine and dairy draft H_2S EEM's can be developed independently. There is not a statistical method that will correct for poor data collection.

There seems to be little or no willingness to include data collected in previous studies. This troubling considering the lack of planning and incompleteness of this data set. An approach should be taken to incorporate all valid data sets when developing the draft H_2S EEM's.

Question 7

I have no comments on question 7.