

**Comments from Members of the Chartered SAB on the SAB Draft Report:
SAB Review of Lake Erie Nutrient Load Reduction Models and Targets (2/27/2017)**

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March 30, 2017

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Comments from Lead Reviewers

Comments from Dr. Sylvie Brouder

Q1) Charge questions adequately addressed?

Overall assessment is that the Report gives good and fairly comprehensive coverage to the general essence of all six charge questions. It highlights a representative array of issues and challenges that are either limitations of the written documents themselves or the general scientific uncertainties that are likely to be encountered in efforts to deliver upon the loading targets and/or an effective adaptive management process for delivery on objectives.

Specific suggestions regarding the charge questions are as follows:

Charge Question 1 on the adequacy of the evaluation of models used to develop load-response curves...

- The main critique of the modeling work is that an ensemble modeling approach was proposed but, in the end, not pursued. Although perhaps unnecessary, it might be beneficial to make a clear statement on what specific activities should have been pursued and to what purpose had an ensemble modelling approach actually been pursued/completed. Based on what was apparently done with the models, the recommendation to pursue only one model seems reasonable, efficient, etc. However, my understanding of the purpose of robust ensemble modeling is to identify strengths of different (all-ready proven?) models, intentionally designed for disparate purposes with distinct differences in the approach to process representation; the ensemble modeling goal is to contribute to elucidation of critical system components under the working hypothesis that all models are wrong, some are useful, AND the utility of various models may be specific to parameters, key phenomenon, space-time scales, etc. Thus, outputs from multiple models would be considered for the insight their differences highlight and not just used to average into a mean result. It seems quite possible that we would make a different recommendation had ensemble modelling been completed to a reasonable degree. Is this a point requiring a bit more emphasis? I recommend being a bit more specific regarding both comments on consequences of not completing the ensemble modelling as well as on the rationale for recommending selection of the WLEEM model – specifically detail the characteristics of this model that make it the superior choice.
- In both the Executive Summary and the full responses to the charge questions, statements are made about the SAB finding that not all models were of equal “reliability” (pg. 1, L45; pg. 8, L15-17). How did the SAB determine “reliability”; what were the criteria to identify a model as relatively more or less reliable?
- In the paragraph on ongoing analyses of a chosen model(s) to predict responses to changing conditions (pg. 9, L4), the text may be strengthened with a clear statement on what the models could and couldn’t do in their present form.
- I support using much stronger language in both the Executive Summary and full response on the need to link land use/landscape models with the models predicting lake response to loads. It is certain that the loads (quantities and forms of P as well as co-nutrients) are changing / have already changed as both a function of land management and prevailing

precip and temperature regimes. This linkage is a key component of an effective “adaptive management process” (discussed more below in response to charge question 6). With respect to improvement of in-lake load response models, it seems irresponsible to treat the landscape processes, managements and thus generation of loads as static and known given that we know they are neither. Without coupling, there is a distinct probability that load responses could be examined in an incorrect inference space.

- In the recommendation regarding funding model development work (pg. 10; L. 18-19), I suggest trying to position this statement as a critical knowledge gap that hinders progress on dependent questions rather than just saying this “should be funded” – after all, “shouldn’t” research be funded on multiple aspects of the problem (e.g. controls on toxin production, ...)?
- Should the intermediate term recommendation for developing a more sophisticated approach to combining results from multiple models be changed to a near term recommendation. It seems imperative that if multiple models are to be retained/applied/improved that there be a clear experimental strategy for their combined use.

Charge Question 2 on whether load targets reflect the best available evidence...

- The comment in the full response that the relationship between P loading and hypoxia IS NOT a direct relationship (in contrast to the relationship between P loading and algal production) because of synergist factors and processes is important to understanding the “uncertainties” (pg.13, L 31 onward) and the Executive Summary could be strengthened by adding a sentence to this effect (pg. 2, L41). Right now the Executive Summary text emphasizes just a lack of understanding about hypoxia but not the complexity of the processes that need understanding.
- I don’t believe a definition of “legacy P” is provided. The term is used but in such a way as that the meaning is not clear (e.g. pg. 14, L1); as presented in the text it could be interpreted as a model residual. A clear definition of the term could be added as a footnote or even defined in the text with a highlighting of how this pool represents challenges to future predictions of spatio-temporal loads of different P species including biologically reactive P. Legacy P is also a problem in the context of land use/landscape models and their ability to predict loading of tributaries. The concept of legacy could also be introduced into the Executive Summary in the laundry list of missing components (pg. 3, L. 8). (Note, in the Executive Summary, I find the mention of “forward residual of P” to be vague and hard to interpret for importance (pg. 3, L. 1).) (Note, legacy P is mentioned as Intermediate Term Key Recommendation under the response to the Charge Question on the need for an N strategy (pg. 23, L. 40) but I do not believe it was defined in the text preceding that section either.)
- In the list of missing model components, the last bullet (pg. 14, L. 42 -43) seems to implicate the need for coupling with landscape models – should this be stated explicitly? (Note, missing “)” at the end of the bullet). At the end of the section on P loading targets, the need for coupling to landscape modeling is termed “essential” (pg. 16, L.35-36) yet no mention is made of this in the key recommendations specific to understanding the extent and changing nature of P loads from tributaries (pg. 16-17). Is this an important omission?

Charge Question 3 on developing load targets specific to controlling Cladophora growth in the Easter Basin...

- The Executive Summary characterizes Cladophora growth as a developing problem that “warrants immediate action” (pg. 3, L. 21) – I suggest one or two key immediate actions be explicitly spelled out here for the sake of clarity.

Charge Question 4 on whether consideration of N control is warranted...

- The Executive Summary on Determination of Whether Nitrogen Control is Warranted (pg. 3 -4) seems to lack a recommendation specific to EPA. There is a laundry list of N issues identified as requiring research – are we recommending that EPA take on this large research portfolio in its entirety? Are we recommending that EPA take on the development of BMPs or that EPA explicitly develop a seamless partnership with ARS/Landgrants/NRCS and other organizations undertaking this sort of research? I concur that the “lessons learned” effort is important, should be a key component of the Lake Erie effort, and is within EPA’s purview as part of this effort
- The statement that “3 Lake Erie models incorporate N cycling but none address internal N and P pools, fluxes and ratios” (pg. 21, L. 25 -26) seems at least partially contradictory. Clarify?
- Under the need for a Multiple Nutrient Strategy, statements regarding key findings to date including that we may have already shifted lake ecology, suggest that greater progress will be made if the door is opened not only to a multi-nutrient strategy but to a multi-factor strategy including changing biotic and abiotic factors. Indeed, it would seem that to develop/pursue alternative hypotheses and, perhaps eventually, alternative managements that adequately address feedbacks, synergies, tipping points, the question(s) being asked should expand beyond P to abiotic/biotic context in which P is changing. Note, Si is repeatedly mentioned, and justifiably so, but unless I missed something there is no strong statement (with citations) regarding why this nutrient should be a focus.
- The Intermediate Recommendation that the EPA should determine the reduction in N loading that results from reduction in P loading (pg. 24, L. 1 – 3) seems like a monumental task that is perhaps more in the purview of ARS/Landgrants/NCRC etc. who have research agenda’s focused on the development and demonstration of BMPs. Can this recommendation be right-sized? What is it that is most important for EPA to do in this space versus partnering with other agencies?
- The Long Term key recommendation on capturing lessons learned from case studies (pg 24, L. (- 10) seems like it might be something useful to pursue as a short term strategy in order to better guide science towards the most important investments versus become part of a post hoc analysis of things that could/should have been a focus.

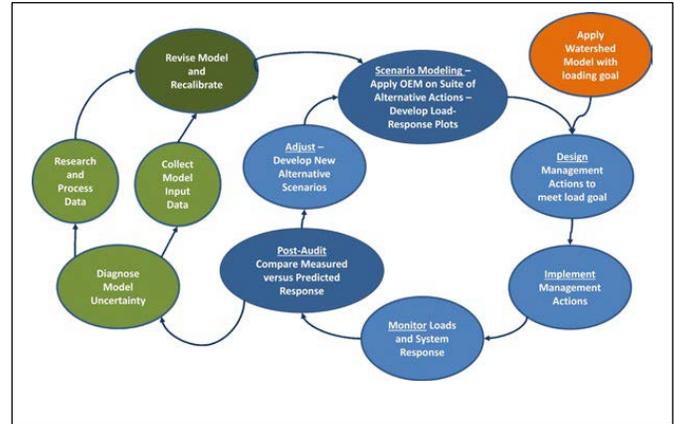
Charge Question 5 on assessing progress in reducing P tributary loading...

- The difference between the FWMC and flow adjusted concentrations is not clear in the Executive Summary (pg. 4, L. 39 – 41). Perhaps a clear definition could be provided in a footnote?
- In the Executive Summary, the second part of the recommendation regarding uncertainty in values derived from FWMC or adjusted conc. seems not to follow from the first part (pg. 4, L. 43 – 45). What is meant by collecting “detailed information on the implementation of P reduction strategies”...? How does this relate directly to the derivation of uncertainty values? Clarify?
- The Intermediate Term Recommendation (pg. 27, L. 20 – 23) seems vague and possibly an expansive task that should be done in collaboration with partners that focus on BMPs

on the land. Are we recommending that EPA undertake a review of all data from studies of BMP efficacy with respect to edge-of-field/land losses of nutrients to surface waters (runoff, erosion and loss via tile drains)?

Charge Question 6 on the adaptive management program...

- I strongly concur with endorsing an adaptive management approach to reducing loading and enhancing lake ecosystem health. Likewise, the Standing Committee is an excellent idea for implementing an effective adaptive management process. What is unclear to me is both what the SAB was asked to comment on and what EPA intends to focus on. In reviewing the Phosphorus Loading Targets Annex 4 (May 11, 2015), I interpret the request to identify key



elements of an adaptive management approach to be derived from Figure 22, pg 45 of that document (copied right). If this is indeed part of the charge question request, then I suggest that we remark directly that this diagram seems not to adequately identify how the lake strategy couples to the development/deployment of alternative land management strategies and the required calibration/verification of landscape models for these new managements. Right now the “orange bubble” seems to lack iterative cycling with the design and deployment of new managements as is captured for the lake models. Are there other elements lacking from this diagram per se?

- Are we assuming that the elements of the program include things that are essential but beyond the specific purview of EPA? If so, I suggest that the Executive Summary spell out that we are assuming that the adaptive management program as proposed by EPA will require a multi-agency/entity collaboration for success (e.g. change the statement on pg. 5, L. 15 to indicate testing alternative hypotheses will be done via collaborations). In the general response text, I suggest that we direct EPA to articulate the partnerships that could be developed to assess the impacts of alternative BMPs on loading (pg. 28 – 29). It seems unlikely that EPA is in the best position and/or will be resourced for land BMPs impacting nutrient losses to H₂O, so while EPA should be encouraged to fully develop Fig. 22, it is perhaps best finalized as in interagency collaborative activity that also articulates partner contributions and focus. At a minimum, this should help prevent redundancy of effort across partners and efficient design and deployment of research agendas across agencies. This could certainly extend to climate change modeling/downscaling and efforts to understand how climate will impact load losses (note: scenarios for future climates are not yet included in Fig. 22 – where does that “element” fit?).
- Under item 6 (pg. 31, L. 12) on structuring the proposed work, it seems like a first bullet might be: “Do current BMPs result in sufficient edge-of-field load reductions to meet target reductions?”

Q2) Technical errors or omissions / issues not adequately addressed?

In addition to the comments noted above, there seems to be a bit of unevenness in terms of the

citation of supporting literature. For Example, in the list of Missing Model components (pg. 14/15), some bulleted statements have citations to support assertions of existing knowledge; would the document be strengthened with the additional citations. E.g. “clear evidence that the system continues to shift” (pg. 15, L. 2) seems to require a citation. Further, is one reference that cyanobacteria are considered a poor quality of food for key zooplankton (pg. 16, L. 9) sufficient scientific evidence to support identifying current primary production as an “ecological dead end?”

Q3) Draft report clear and logical?

Overall, the Letter, Executive Summary and Full Report are clear and easy to read / follow. Comments above under the Charge Questions highlight a couple of points that may require additional clarity. Additionally, the report could be enhanced by pursuing a parallel structure across Charge Questions for highlighting (prioritizing??) research needs. For example, in the Executive Summary section on the importance of N (pg. 4, L. 6 – 20), key research questions are spelled out. Is there value imposing the structure across all other sections. It seems a useful way to highlight the gaps and even suggest a prioritization of effort for what will surely be limited resources when compared to the magnitude of the problem.

Q4) Conclusions drawn / recommendations provided supported by body of draft report?

The recommendations in the Executive Summary and Full Report are numerous. Is it possible that the SAB could somehow help steer EPA to tighter prioritization of research investments and activities? It seems as if there is a risk that too many activity fragments could get undertaken with results that, while contributing pieces to the whole picture, cannot easily be integrated in the near term and therefore are at risk of being perceived to be ineffectual.

Comments from Dr. Kimberly Jones

1. Were the charge questions adequately addressed?

The committee did a very thorough job in addressing the six charge questions. Taken in sum, the responses to the charge questions provides sound advice to EPA on the development of models to inform nutrient-load reduction targets for Lake Erie and on an adaptive management approach to implementing nutrient reduction goals.

Specific comments on each charge question follows:

Charge question 1: Please comment on whether the evaluation of the models was adequate....interpretation of the load-response curves for the eutrophication response indicators.

The committee provided well-supported recommendations with specific advice on adopting a consensus model (Western Lake Erie Ecosystem Model) for possible extension to all of Lake Erie. The key recommendations were organized in reasonable short, intermediate and long term actions. The long term recommendation of developing a model that includes inputs from small tributaries needs more detail. As written, it is so broad and general that it will likely get ignored. It should be either clarified or removed.

Charge question 2: Please comment on whether the recommended targets reflect the best

available information.....for Lake Erie.

The committee recommended that the lake and tributary monitoring (event based sampling) to enable a load calculation based on precipitation and tributary flow, and to investigate organic or non-reactive P in Lake Erie and Tributaries. This recommendation (short-term) is unclear and should include more details on how the monitoring data could reduce uncertainty (in relationship between P loads and eutrophication response indicators?), if that is the point of the recommendation.

The committee includes a disclaimer on 2 recommendations “If feasible, given the computational resources that may be required”. Please clarify this. Does the committee believe that the computational resources are too great for this to really be undertaken based on resources? It’s not clear if they really believe these recommendations are feasible.

Charge question 3: Can scientifically-sound phosphorus.....Lake Erie?

The committee addresses this question by acknowledging the tricky nature of *Cladophora* and stating that there are significant knowledge gaps to be filled. The key recommendations don’t do a lot to provide specific advice for improving the GLCM (Great Lakes *Cladophora* Model). The committee states that the model provides a first order evaluation of *Cladophora* occurrence and initial predictions regarding attainment of the ERI of reduction of *Cladophora* standing crops to acceptable levels with little growth potential. However, knowledge gaps still exist. What is the relative trade-off in further research on this model and use of the basic mass balance model with 2 state variables? In other words, it is not clear to me whether or not the committee believes that scientifically sound P load reduction recommendations can or cannot be developed at this time that will reduce *Cladophora* growth in the Eastern Basin of Lake Erie.

Charge question 4: What recommendations can the SAB provide for development of an approach to help determine whether consideration of nitrogen control.....addressed?

The committee provides a N research roadmap to advise the Agency on the best path for evaluating the importance of N in Lake Erie. The key research issues seem to be included in the list of recommendations.

Charge question 5: Please comment on the use of FWMC....Lake.

The committee provided a relatively comprehensive treatment of FWMC to account for inter-annual variability. Advantages and disadvantages of the approach are explained. The recommendations are good.

Charge question 6: Please comment on the value of applying the existing eutrophicationLake Erie?

The committee’s treatment of this question was very good. It included detailed recommendations for a comprehensive adaptive management strategy.

2. Are there technical errors or omissions/issues not adequately addressed?

I did not find any technical errors. The committee methodically addressed each charge question. Some of the specific recommendations in charge questions 1 – 3 (as described earlier) should be more explicitly written so that the Agency can understand. Some of the recommendations

(particularly some of the long-term ones) are so general that they could be easily ignored. These are mentioned in my comments in question 1.

3. Is the draft report clear and logical?

The report is clear and logical, but the main report, executive summary and letter are organized very differently. The main report states each charge question, explains the approach, addresses the question, and provides key recommendations (short, intermediate and long-term). This type of organization provides direct advice mapped directly to the charge questions. The executive summary paraphrases each charge question then summarizes the response. The letter just lists major comments and recommendations, without a specific link to charge questions (although it seems each bullet corresponds to a charge question). The format of the letter is least useful. Although the six bullets correspond to the charge questions, the organization of the letter should be revisited.

4. Are the conclusions drawn or recommendations supported by the body of the draft report?

For the most part, yes. The conclusions are supported in the body of the report.

Comments from Dr. Robyn Wilson

1) Were the charge questions to the committee adequately addressed?

Yes, the charge questions were adequately addressed overall. I thought the committee was extremely thorough and consistent throughout the report, and that they highlighted several critical weaknesses in the approach to setting reduction targets that should be addressed. Overall, the committee agreed that target reduction levels can be made with the existing models and knowledge, but that clarity is needed as to what achieving the reduction would and would not do (reduce HABs versus improve public health). The committee did an excellent job highlighting next steps that could be taken to better improve the science behind such targets. I particularly appreciated the summary of key recommendations at the end of each section, as I think this brought additional clarity to the review. I also liked how the committee highlighted those that are most feasible and necessary in the short term versus those that could be addressed a bit further in the future. I inserted a few specific comments below under each of the charge questions highlighting my takeaways, and the points I found particularly accurate and useful.

1) *Was the evaluation of the models adequate?* The committee highlighted the need for increased clarity in the relative strengths and weaknesses of each model, and perhaps a need to focus on the most reliable process-based model given the variation in the way the models incorporate process dynamics and assess uncertainty. In my opinion, the future change in load reductions based on upstream actions, the influence of climate change and seasonal variability, and so on are critical and need to be included in any model used to set reduction targets.

2) *Are the P targets based on best information?* The committee agreed that the current

targets are appropriate given the state of the science, but that there are many steps that could be taken to improve the accuracy and usefulness of the targets. The current models could be run as multiple year simulations to better capture aggregated change over time, and in the longer term they could be improved more appropriately capture ecosystem dynamics and changes in the Lake over the last 20 years and expected future changes.

- 3) *Can load reductions address Cladophora?* The committee gave a thorough overview of Cladophora ecology and occurrence and the existing model for the Great Lakes. The committee concluded that the gaps in knowledge are too large to specify the load reductions needed to address Cladophora.
- 4) *Is N control warranted?* The committee highlighted the need to consider N control given how it might interact in this system to increase/decrease impacts, however there are many research gaps that need to be addressed in the short-term. The BMP discussion is a bit limited here; see my additional comments below under “technical errors and omissions”.
- 5) *How do we account for inter-annual variability in assessing progress?* The committee highlighted the need to use multiple methods beyond FWMC to assess the success of efforts aimed at nutrient control. They particularly highlight the need to measure reduction strategies at the watershed scale in addition to known sources of inter-annual variability (spring rains), to better tease out what is driving any observed changes in nutrient loading. This point is critical and could perhaps be highlighted a bit more in the intro and executive summary.
- 6) *How to design an adaptive mgmt. approach?* The committee laid out a very helpful set of action steps that could be taken to ensure that changes in nutrient loading are tracked, and that both the impact of those changes on the lake and the source of those changes upstream, are assessed. I think some additional clarity on possible alternative hypotheses and the role of behavioral and policy science are needed in this section (see my comments below in “technical errors and omissions”).

2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

p. 23, line 5+ - It is perhaps a bit misleading to say that BMPs for P control often target sediments. In the western Lake Erie basin there is a big focus on soluble P, and much discussion about how no-till (a BMP recommended to control sediment P) may be a factor contributing to the increase in DRP (due to the increase of surface application of fertilizer). I would restate this section a bit to be more clear – I agree there is a need to think about the impact of BMPs and P and N, and on different forms of P, but for Lake Erie in particular I think we have moved beyond targeting sediments. It also seems a bit out of touch to just refer to BMPs in the Mississippi River basin as a source of information for the Maumee. There is actually quite a bit of work being done in the Lake Erie basin (see work by Kevin King at USDA ARS, Libby Dayton at OSU, for examples of ongoing field work and Don Scavia at Michigan, Jay Martin at OSU, Rem Confessor at Heidelberg for SWAT modeling studies).

p. 24, line 1 – Similarly, it is a bit naïve to say BMPs should be “developed”. We know what they are, in some cases we know what they are good at (and what they aren’t), but we do need to fine-tune our understanding in some cases (e.g., the impact of multiple BMPs applied on the same field). For example, it is fairly accepted that a combination of filter strips and subsurface placement in western Lake Erie should reduce total P loading into the lake, but there is much greater uncertainty about the net effect of cover crops, another potential tool. Also, much of the current work is focusing more on P, and assuming there are benefits to N reduction in the Mississippi River basin, but not really thinking about the interactions of N and P in freshwater, or the fact that N influences the toxicity of the algae. It is probably more accurate to say BMPs should be identified and applied, as opposed to developed and applied. You could highlight the need for additional edge of field research to assess BMP effectiveness, and highlight what practices, and in what combinations, are best for P versus N reduction. This should include thinking about how these practices perform given variability in field characteristics, farmer motivations, and so on.

p. 24, line 9 – I am not sure why the focus here is on the Baltic Sea given the massive differences geographically, politically, agriculturally, etc. This seems an odd recommendation. Lessons learned from case studies should be applied, but there are case studies in the U.S. and the Midwest in particular that may be more useful. For example, great success has been found in the Chesapeake Bay at paying farmers to adopt cover crops. This is just one example of a policy-based incentive program in a particular location that has been quite effective.

p. 27, line 39+ - I would perhaps be clearer that this adaptive approach hinges on linking the lake models to watershed models of land use. Yes, an important component of adaptive management is the opportunity to evaluate actions intended to reduce loadings, but the Task Team is really just focused on the P loadings and the impact that has on HABs, ecosystem services, etc. One could monitor the relationship between P loadings and lake outcomes over time, but that does not allow you to evaluate actions intended to reduce loading unless you address the upstream dynamics. This is mentioned on line 37 of page 28, but should perhaps be highlighted earlier in this section as well.

p. 29, line 18 “Loading” – I think this section is excellent and there are a lot of gaps here in our understanding, although there are great advances being made in the Lake Erie basin in terms of both modeling the impact of BMPs, and measuring their effectiveness in edge of field studies (I mentioned this previously). What I think is missing here is a recognition of behavioral and policy implications. Even if we knew exactly which BMPs, in which locations, and at what time of the year would “solve” the problems in Lake Erie, this does not ensure that they are adopted. Linking the lake models to watershed models is the next most obvious step, but we need to continue to support the integration of behavioral and policy science into our understanding of how these recommendations would then be implemented (e.g., what is the probability of a particular field having a given practice in place given current incentive structures, outreach programs, etc?). There are ongoing efforts to link behavioral models of farmer decision making to these models of land use and management at a watershed scale, making them even more useful at assessing baseline versus future conditions when it comes to phosphorus loads into the lake. I would also add that the field experiments should look at combinations of BMPs, not just BMPs in isolation given the interactions that can occur (e.g., cover crops are perhaps only

effective for soluble phosphorus when used in a continuous no-till system otherwise they may increase DRP).

p. 31, line 1+ - Similar to my comment above, the potential scenarios listed here could include simulating a variety of policy approaches (different levels of incentives targeted to different BMPs, different forms of outreach targeting farmer efficacy, etc.). This would of course again hinge on linking landscape hydrology models with Lake models.

3) Is the draft report clear and logical?

Yes, the report is very well written and clear. The logic behind the recommendations and suggestions is well supported by evidence, both that which the committee supplied directly in the report and that which I am familiar with from working in this arena. I have two suggestions for increased clarity in the report.

The first place where I would appreciate more clarity would be in the alternative hypotheses addressing changes in the Lake. The assumption (and a fair one) is that a reduction in P loading will reduce the severity of HABs, improve water quality, etc. I don't think an exhaustive list of alternative hypotheses are needed, but a few examples of what the committee had in mind might be useful. To me the reference to other hypotheses implies that something other than P loading from the tributaries is driving the trends (say legacy P in lake sediment), if that is the case, perhaps that example could be given. If the intention is really to better understand how system dynamics may obscure the impact of P loading on changes in the Lake, then that should be communicated more clearly. For example, if a reduction in P loading does not lead to improved lake conditions, it might be because of dynamic in the Lake that is not accounted for in the models (e.g., warmer surface temperatures). This is a bit different than saying loading is not the problem.

The second place where I would appreciate more clarity would be in the presentation of current modeling gaps. Given the comments made by the committee, I am also unclear if the 40% target accounts for a range of future climate scenarios. This is particularly critical given we know that P loading into the lake is a function of storm-based runoff, and we expect that the frequency and intensity of spring storms may increase under a variety of climate scenarios. The 40% reduction is stated in a very static as opposed to dynamic way – if we are recommending a 40% reduction in current loading, how long do we expect this recommendation to be accurate? Under what conditions? How will we monitor and adapt to account for uncertainty and system complexity over time? If the recommendation is in fact a very static 40% based on current conditions, then perhaps the section on adaptive management addresses this concern sufficiently. But it wouldn't hurt to have a bit more clarity in the executive summary, intro and first two charge questions about what is explicitly accounted for or not in the current models/approach.

4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

The body of the report supports the conclusions drawn by the committee. A major theme of the report is that the current target load reductions are reasonable, but that monitoring and evaluation

is critical moving forward given the weaknesses in some of the models, the uncertainty around the range of response indicators and the potential for future changing conditions. I think this broad conclusion is widely supported by the body of the report and captures both the strengths and weaknesses of the current approach employed by the task team.

Comments from other SAB Members

Comments from Dr. Joseph Arvai

General comments:

I was particularly impressed with the fact that the committee addresses adaptive management. However, the devil will be in the details vis-à-vis how adaptive management is designed and implemented. I would encourage EPA to identify appropriate expertise within and external to the agency to make this aspect of the initiative as meaningful and as successful as possible.

1) Were the charge questions to the committee adequately addressed?

Yes.

2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

No.

3) Is the draft report clear and logical?

Yes.

4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes.

Comments from Dr. Alison Cullen

1) Were the charge questions to the committee adequately addressed?

Yes, the charge questions to the committee were adequately addressed and fully discussed in the report.

2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

I have only one comment about an issue that could perhaps benefit from additional explanation. The report was somewhat brief in the section suggesting an approach in the event of a decision to retain multiple models instead of just the Western Lake Erie Ecosystem Model. The suggestion is: "If multiple models are retained for use in the analysis, model estimates should be combined

using either likelihood-based methods or Bayesian model averaging to produce a combined model-weighted quantitative characterization of the loading curve and associated uncertainty.” More justification for this approach and statement would be helpful. One argument for keeping the model estimates separate is that this would yield a range of estimates for consideration. Also, if the models are of uneven quality (or as a group represent other sources of variability and uncertainty) then combining their outputs would not be a straightforward task, since deciding on the weightings represents a complex step.

3) Is the draft report clear and logical?

Yes, the report is clear and logical. The sections are carefully laid out and the flow enhances understandability. This is a very easy to read report and very concise too. Quite a bit of information is included in a relatively compact document.

4) Are the conclusions drawn, or recommendations provided, supported by the body of the draft report?

Yes, the conclusions and recommendations are supported by the body of the draft report.

Comments from Dr. Otto Doering

I believe that the charge questions were adequately addressed. I did not see technical errors or omissions that were not adequately dealt with in the report. I found the report clear and logical, and the conclusions and recommendations were supported by the body of the draft report.

This is a very well done report.

I strongly support the recognition and concern given in the draft report for such factors as progressive precipitation and discharge increases, increased variability of such factors, and the necessity for recognizing such current and future drivers of nutrient flows in assessments and adaptive management.

Comments from Dr. Michael Dourson

1) Were the charge questions to the committee adequately addressed?

Although this report is outside of my area of expertise, it appears that the committee adequately addressed the charge questions.

2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

Not of which I am aware, although this report is outside of my area of expertise.

3) Is the draft report clear and logical?

Yes, I read the report and was able to follow its recommendations. I particularly like the recommendations given in time sequence: short, intermediate and long term.

4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Although this report is outside of my area of expertise, it appears that the recommendations are consistent with the deliberations described in the text.

Comments from Dr. Susan Felter

1. Were the charge questions to the committee adequately addressed?

Yes

2. Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

Not that I'm aware of, but I note that this is not my area of expertise.

3. Is the draft report clear and logical?

Yes

4. Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Overall the conclusions and recommendations are clear and supported by the report. I have two questions/suggestions:

- The SAB is recommending that EPA formally appoint a standing committee to develop and implement a program to evaluate nutrient reduction goals for Lake Erie. Is the recommendation that EPA should work with Canada to establish a binational committee or is this envisioned as a US effort only?
- The “Key Recommendations” are divided into short, intermediate and long-term. While it can be helpful to provide this distinction, it's not clear how these are defined (is ‘short term’ measured in years and long term measured in decades?) and how they were designated. It is also not clear if the SAB considers there to a *prioritization* of these recommendations. As examples from the Key Reco's in Section 3.1.1 (p. 10) [similar examples can be found in Key Reco's for the other sections as well]:
 - There are 6 reco's under “Short Term” – are these all high priority or are some more essential and others ‘nice to have’? Which ones would have the greatest impact if implemented?

- The single Long Term Key Reco states that “A model of nutrient and TSS loading that includes input from small tributaries should be developed”. Is this “Long Term” because it is anticipated that it will take many years to do this, or is it considered a lower priority than the reco’s in “Short Term”? Or both?

Comments from Dr. Robert J. Johnston

1) Were the charge questions to the committee adequately addressed?

Yes, the report has adequately addressed the charge questions.

2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

No, there are no technical errors or omissions that are not adequately addressed by the draft report

3) Is the draft report clear and logical?

Yes

4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes

Comments from Dr. Sue Marty

1. Were the charge questions adequately addressed?

Yes, the charge questions were addressed in a logical order. The letter to the EPA Administrator followed the sequence of the report and captured the main points covered in the report summary.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the draft report?

No, in my view, the report is complete.

3. Is the draft report clear and logical?

Yes, the report is well written.

4. Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes, the conclusions were supported by the report with the recognition that there are many unknown factors remaining. The P load reduction targets appear to be supported by the models, but a greater understanding of model parameters (e.g., load-response curve) can improve the precision of these values. The SAB noted that model weighting would be a useful initial step, but monitoring appears to be needed to fill some data gaps. The SAB recommendation for a better assessment of uncertainty seems reasonable.

Comments from Dr. Kristina D. Mena

1) Were the charge questions to the committee adequately addressed?

Yes

2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

The draft report thoroughly addresses each of the charge questions. However, there are some recommendations presented that may be better interpreted and applied if more information is provided.

- a) Page 10, It is noted that not all of the models evaluated are equally reliable. Given the recommendation to give “greater weight”, would additional information be helpful/necessary to guide EPA on which models are “deemed most reliable”?
- b) Page 10, Connecting land use models is an important recommendation given in the report and, although it is mentioned in the Executive Summary, it is not emphasized. It is also not mentioned in the letter to Administrator Pruitt.
- c) Page 24, Regarding nutrient reduction (including N), could several specific case studies be listed to be reviewed for applicability to Lake Erie? Or, are the references included sufficient?
- d) Page 27, Regarding the development of an adaptive management committee, would the committee benefit from membership by a variety of stakeholders (not just scientists/academicians)? Stakeholders with insight and experience with best management practices and/or realistic management practices would better refine model scenario-building.

3) Is the draft report clear and logical?

Yes

4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes

Comments from Dr. James Opaluch

1. Were the charge questions adequately addressed?

In general, the charge questions were adequately addressed. However, I recommend that the report place greater emphasis on the need for EPA to model the linkages between policy, changes in land use/land management and resultant effects on nutrient loads. An understanding of how policy affects decisions on private land is essential for the successful design of the adaptive management approach advocated by the EPA report. There is now a significant literature on these linkages, and they are key to informing policy makers on the impacts of various policy options.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the draft report?

No, not that I saw.

3. Is the draft report clear and logical?

Page 1 of the Executive summary lists 6 charge questions. Immediately following the heading “Evaluation of models ...”, the executive summary says “The SAB was asked to comment on (1) whether the evaluation of the models was adequate to inform how model results should be interpreted and (2) any additional analyses that may be needed...”. It is confusing how this relates to the six charge questions listed immediately prior to this. These are actually elements charge question (1). The report could make this more clear. For example, the heading could say “Charge Question (1). Evaluation of models...” The first sentence in the section could they say “As part of Charge Question (1) the SAB was asked ...”. If you want to number the items, I recommend you use (a) and (b) or maybe (1a) and (1b).

In the following sentence. Clarify whether the “Modeling Subgroup” refers a subgroup of the SAB panel, or a subgroup of the binational workgroup. Throughout, it would be useful to specifically indicate actions by the binational group report. For example, line 42 refers to “model evaluations”. Are those evaluations contained in the report, or are they the SAB’s evaluations of the models.

Page 2, Line 24. “Charge Question (2). Phosphorus Loading Targets”

4. Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes

Comments from Dr. Thomas Parkerton

1. Were the Charge Questions Adequately Addressed?

The Panel has provided justification for the potential need to consider a dual nutrient strategy (page 21, line 30) and research priorities related N loading (pages 23-24) but could perhaps provide more practical advice to EPA on the development of an approach to determine if consideration of N control is warranted. Given the reality of resource constraints, it seems logical to link the need to address N control to the adaptive management plan, particularly if ecosystem objectives are not being met in response to P reduction. This could help prioritize the extent and pace of the research priorities and BMP efforts that are highlighted in this section. It is important to ensure N loading reduction initiatives can be linked to tangible benefits in achieving ERI ecosystem objectives.

2. Are there Technical Errors or Omissions or Issues Not Adequately Addressed in the Draft Report?

The Panel recommends that remote sensing data be used to characterize the spatio-temporal distribution of *Cladophora* and that this information be linked to model development (page 20, line 21). It might be helpful if the Panel can provide references to further support use of remote sensing and spatial distribution modeling for use in this context.

A list of issues (i.e. loading, cyanobacteria, hypoxia and *Cladophora*) are identified by the SAB that should be considered by the adaptive management committee (pages 29-30).

For cyanobacteria, models that address the transport, bioaccumulation and potential effects of algal toxins might also be included under the research, monitoring and modeling section given

the growing body of literature on this topic (e.g. Hauser-Davis et al. 2015; Preece, et al. 2015). One issue that is not mentioned that I suggest be included in this section is Bioaccumulative Contaminants of Concern which is an important focus of the GLWQI. Cycling of bioaccumulative contaminants (e.g. PCBs, Hg) is influenced by nutrient and energy flows (Verburg et al. 2015; McLoed et al. 2015). Thus, as part of a holistic adaptive management framework it is logical to also consider how changes in nutrients may alter contaminant dynamics in Lake Erie foodwebs. This issue could be addressed by periodically evaluating trends in contaminant monitoring data with ERI metrics as well as developing of process-based coupled eutrophication-food chain bioaccumulation models to investigate the implications of observed or projected nutrient reductions on tissue residue based quality objectives for key contaminants of concern.

3. Is the Draft Report Clear and Logical?

The Panel recommends that research and model development work be funded to improve model accuracy and reliability (page 9, line 5). It seems that the priority should be characterizing predictive performance rather than apriori assuming that improvements are needed. It may also be helpful to clarify what is meant by model accuracy (i.e. calibration performance) versus reliability (i.e. predictive performance)?

The panel states that additional data are needed to produce higher certainty estimates (page 9, line 12). Estimates of what? Model input / output parameters? Note more data may result in more, not less, variance in model variables. Suggest clarifying or rewording this sentence.

The Panel suggests opportunities to collaborate with farmers practicing precision agricultural (page 9, line 28). It is not clear what is meant by precision agriculture.

See earlier comment regarding the third short term recommendation (page 10, line 18).

See earlier comment regarding the fourth short term recommendation (page 10, line 21).

The Panel states that attenuation of hypoxia is more problematic (page 16, line 24). I think what is meant is that the ability to predict the attenuation of hypoxia in response to loading reduction is more problematic.

The EPA should evaluate data needs to reduce uncertainty in the model (page 19, line 43) ... see earlier comments on charge question 1 regarding focus on the need to calibrate, validate and improve process-based GLCM formulation versus reducing model uncertainty as highlighted in the key recommendations that follow.

The Panel indicates that additional research is needed to understand the balance in the ratio of N to P that would be best for ecosystem function (page 23, line 46). How is “best” defined?

Suggest revising text to focus on how N and P are linked to achieving ecosystem quality objectives (e.g. ERIs) as agreed by the relevant stakeholders.

The Panel states that additional factors beyond reducing external P loading might need to be identified and incorporated into the (adaptive) management strategy (page 29; line 3). A good example that could be highlighted here is the potential need for N loading reduction and associated BMPs (see earlier comment).

Editorial suggestions:

page 10, line 40 change loading curve to loading-response curve

page 28, line 1 ...change “the committee should consider alternative management options ...” TO “the committee should consider alternative management options, if warranted ...”

page 28, line 39 suggest changing text from “models be built into alternative hypotheses” TO “models be used to investigate alternative hypotheses”

4. Are the Conclusions Drawn or Recommendation Provided Supported by the Body

of the Draft Report?

The Panel responses indicates the evaluation of models was inadequate because:

- evaluation criteria and goodness of fit metrics were not consistently applied across the models
- performance was only assessed using calibration data (no evaluation of predictive performance)
- inconsistent methods were used to characterize uncertainty
- no effort was made to assess the role of model uncertainty on the likelihood that the stated ecosystem objectives would be achieved for a given target loading reduction

Based on these concerns, I question the conclusion (page 8, line 16) that the assessment of loading-responses would have benefited by giving greater weight to models deemed reliable. Is not the point that the above issues need to be addressed to provide a systematic evaluation of the performance and uncertainty of the models so that results can then reliably inform decision-making?

The Panel suggests that progressing further development of a single, process based model might be the most efficient path forward and suggests consideration be given to the Western Lake Erie Ecosystem Model for this purpose (page 9, line 1). However, the rationale supporting this model over the competing models is not provided. I would recommend that the Panel provides a technical justification to support this recommendation.

The Panel suggests that it seems worthwhile to improve loading estimates by using land use models (Page 9, line 26). However, the need for, and potential improvement afforded by, this recommendation seems premature. Perhaps, the inclusion of such models could be considered as part of adaptive management particularly if predictive model performance does not capture the observed changes in ecosystem objectives OR future observed trends in tributary loading are hypothesized to be due to land use changes in the Lake Erie watershed.

See earlier comment regarding the first short term recommendation (page 10, line 5).

See earlier comment regarding the sixth short term recommendation (page 10, line 31).

The Panel indicates the inclusion of landscape models is an inescapable necessity since actions and practices on land will contribute to P load reductions (page 16, line 37). While I agree that controlling land based sources will contribute to load reductions, I question if land-based models are essential if monitoring data will be collected as recommended on page 27 and used to empirically quantify reliable loads. Given limited resources, I suggest the need to include these models be prioritized in light of other process based model enhancements that are identified as missing components for linking load reductions to ecosystem objectives earlier in this section. This change would be consistent with the fact that incorporation of land-based models is not mentioned in the short or intermediate term priorities listed at the end of this section.

The Panel indicates that an adaptive management committee should be comprised of academic and industry scientists (page 27, line 45). This recommendation may exclude experts from other sectors and thus appears too prescriptive. Suggest revising this sentence.

It is recommended that additional ERIs be considered as part of a binational, long-term monitoring plan (Page 28, line 16). It is important to clarify that inclusion of additional ERI metrics need to be clearly linked to ecosystem objectives. The Panel highlights the potential utility of including a metric for whitefish (*Coregonus clupeiformis*). Can the Panel explain why this species has been specifically highlighted, the type of metric envisioned and the potential management benefit of incorporating such a metric?

Citations:

- Hauser-Davis et al. (2015). Accumulation and toxic effects of microcystin in tilapia (*Oreochromis niloticus*) from an eutrophic Brazilian lagoon. *Ecotox Environ. Safety* 112:135-136.
- McLoed, AM, G Paterson, KG Drouillard et al. (2015). PCB foodweb dynamics quantify nutrient and energy flow in aquatic ecosystems, *Environ. Sci. Technol.* 49:12832-12839.
- Preece, EP, BC Moore, JF Hardy (2015). Transfer of microcystin from freshwater lakes in Puget Sound, WA and toxin accumulation in marine mussels, (*Mytilus trossulus*), *Ecotox. Environ. Safety* 122:98-105.
- Verburg, Piet; Hickey, Christopher W.; Phillips, Ngaire (2015). Mercury biomagnification in three geothermally-influenced lakes differing in chemistry and algae, *Sci. Tot. Environ.* 493:342-354.

Comments from Dr. Tara Sabo-Atwood

1. Were the charge questions to the committee adequately addressed?

Yes. There were 6 charge questions and as a non-expert in this particular area, I felt the panel did address each charge question adequately.

2. Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

No, I did not identify any technical errors or omissions/issues in the report based on my area of expertise.

3. Is the draft report clear and logical?

Yes. The report is clear and logical with the exception of a few minor points:

Page 2 paragraph 2 (“The number of models considered for use should be reduced. Priority should be given to the process-based models that have the capability.....”) refers to the models tested and prioritization of process-based models but there is no reference to how many models were examined and what proportion are actually process-based models

Page 28 line 16 – it is not clear what is meant by biological endpoints of benthic organisms. Is this referring to total numbers of whole organisms or some other biological measure?

4. Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes. In general the conclusions and recommendations are supported by the report and the breakout of short, intermediate and long term suggestions provides clarity.

Comments from Dr. Jeanne VanBriesen

Were the charge questions adequately addressed?

Yes, the charge questions were adequately addressed.

Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the draft report?

I did not detect any technical errors. There are a few points where additional focus or clarification is warranted.

In the executive summary and the report, the SAB notes that models are difficult to evaluate because of insufficient data (LTR p. 1, lines 43-44; Ex Summary p. 1, lines 39-40). This is a common problem, and additional sampling can improve model calibration and also enable improved assessment of model quality. The SAB recommends increased synoptic sampling (ES p. 2 lines 15-16), but this recommendation is included only as a mention of monitoring in several places in the letter to the administrator. Additional data collection is critical to support the recommendation of an adaptive management program, which is to be charged with comparing empirical data and model results. And, as noted (ES p. 3 lines 37-39; Report p. 19 lines 42-44) data collection should be linked with data needs to reduce the uncertainty of model results.

Thus, I recommend including the need for increased data collection as a distinct recommendation in the list that is brought forward to the letter to the administrator.

Report Page 2 Line 17 “at sufficient frequencies” should be further clarified if the SAB is able to provide specifics. If not, a recommendation that EPA determine sufficient frequencies for sampling prior to using sampling data for modeling should be added.

There is some attention to uncertainty, particularly the uncertainty introduced by use of multiple sequential models (i.e., land use to lake) (Report p. 2, lines 20-21), but additional attention is warranted. How should EPA deal with this uncertainty? What is the role for an ensemble approach to modeling as suggested by the EPA but not undertaken by the SAB? What is the role for additional data collection to reduce uncertainty?

Neither the charge questions nor the response address how to deal with variability outside the normal inter-annual hydrologic variations. Non-stationary climate changes are likely to affect Lake hydrology and biogeochemistry. This will challenge attempt to manage nutrient loads and its negative effects. Climate changes effects are mentioned briefly at Report Page 3 line 11 and page 5 line 33 and in more details on page 15 -- where the report says some models consider this effect and others do not. It is not clear that the SAB is recommending using only models that can account for climate change or is merely noting that predictions are unreliable due to expected but not modeled changes associated with climate. This should be made more clear.

The SAB seems to recommend that the WesternLake Erie Ecosystem Model (WLEEM) would be a good consensus model (ES p. 2, lines 12-13), but stops short of an explicit strong recommendation to use with this model. It is not clear why; if this model is far superior to other choices, the SAB should state this.

P. 13 lines 39-40 includes a reference to footnote 3 of the report. This footnote is not on this page so this cross-reference is difficult to follow at this point.

Is the draft report clear and logical?

Yes. The draft report is very well written, logically consistent and clear.

Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes, the conclusions are supported by the body of the report.

Comments from Dr. Charles Werth

1. Were the charge questions adequately addressed?

Yes, the report did an excellent job of directly addressing the charge questions.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt within the draft report?

There are no technical errors or omissions, or issues that were not adequately dealt with, that I could identify.

3. Is the draft report clear and logical?

Generally, the draft report is clear and logical. Below are some suggestions to improve clarity in a few places.

Letter to the Administrator, Page 1, Line 47: The letter might be more transparent if this sentence is modified to read: "The SAB's major comments and recommendations for each of the six charge questions, in order of the questions, are as follows:"

Executive Summary, Page 1, Line 38: The text reads "The Modeling Subgroup applied and evaluated the suite of models independently, rather than as part of an ensemble approach." The phrasing "ensemble approach" is not clear. It can mean quite a few different things, and may not be good to use unless followed by an explanation.

Executive Summary, Page 2, Line 15: The phrase "synoptic sampling" is unclear. It can be interpreted in multiple ways, so perhaps a more descriptive or well known phrase should be used in its place.

Page 14, Line 32: "Vagaries of weather" might more accurately be phrased "stochastic nature of weather"

Page 14, Line 41: A short justification of why "dreissenid mussels" are being singled out here would help.

4. Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Generally, the conclusions drawn and recommendations provided are well supported. One conclusion that might merit further consideration is noted below.

Executive Summary, Page 2, Lines 10-12: The text reads: "Given practical limits of funding and the limitations of some of the models evaluated, consideration should be given to further developing one process-based model using the insights and demonstrated capabilities provided by the other models; the Western Lake Erie Ecosystem Model (WLEEM) could be the consensus model for this purpose." I'm not sure I agree (but perhaps I could be convinced) that all efforts should be focused on developing one model. A case in point occurs 20 lines later (Lines 31-33), where this recommendation is implicitly contradicted when it is argued that good agreement among all or most of the models supports the conclusion that "a 40% reduction in total P load

will improve water quality and reduce the magnitude and extent of harmful algal blooms". Perhaps another approach would be to identify only those models that should no longer be used because they contain fundamental errors. These same issues come up again in the main report on Page 10 (short term recommendations) and Page 11, Line 22.

Comments from Board Liaisons

Comments from Dr. Deborah Swackhamer

1) Were the charge questions to the committee adequately addressed?

Yes, the charge questions were addressed extremely well. The committee had an impressive array of expertise in ecology, modeling, and nutrient dynamics.

2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

No. I am glad to see that SRP or bioavailable P was addressed; it is a big wild card in the nutrient-algal dynamics.

3) Is the draft report clear and logical?

Yes, well written. The summary and cover letter seem consistent with the report.

4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes they are.