

Science Advisory Board (SAB) Draft (10/13/16) to Assist Meeting Deliberations – Do not Cite or Quote.

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Dr. Lucinda Johnson’s Suggested Ranking of the Lake Erie Recommendations

10/13/16

Charge Question 1. (recommendations on page 9 of the report)

Key Recommendations

Commented [Office1]: These are both committee comments and recommendations. I have tried to edit them to turn the statements into recommendations.

- **RANK HIGH:** ~~The SAB finds that the models~~Because the models used in the analysis are not of equal reliability, the SAB panel recommends that ~~the assessment of load-responses could be improved by more heavily weighting response curves generated by the models deemed most reliable.~~

- **RANK HIGH:** Given the limitations of the models and the practical limits of funding, ~~and the limitations of a number of the models used in the analysis,~~ the suite of models considered should be reduced and p-Priority ~~should be~~ given to the process-based models that have the capability to account for the response of key processes. Consideration should be given to further developing one model using the insights and demonstrated capabilities provided by the other models; making the Western Lake Erie Ecosystem Model (WLEEM) could be the consensus model for this purpose., with a goal of extending this model to all of Lake Erie, to changes driven by load reductions, climate changes and internal storage and recycling of nutrients.

~~It might prove efficient to choose a single model and to further develop that model using the insights and demonstrated capabilities provided by the other models and the results of ongoing process research and monitoring. Consideration should be given to making the Western Lake Erie Ecosystem Model (WLEEM) the consensus model for this purpose, with a goal of extending this model to all of Lake Erie.~~

- **RANK LOW:** Analyses of the ability of the chosen model(s) to predict responses to changing conditions should be conducted on an ongoing basis.

- **RANK HIGH:** Research and model development work should be funded to improve model accuracy and reliability within the overall nutrient loadings management and decision-making framework.

Commented [Office2]: This is a general recommendation that could stand alone.

- **RANK HIGH:** Additional in-Lake synoptic sampling of key variables such as vertically averaged cyanobacteria abundance, water column and surface sediment nutrients (e.g., N, P), TSS and

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dreissenid mussel biomass should be conducted on an ongoing basis to support model evaluations and refinements.

- **RANK HIGH:** Measurements of flow, TSS and nutrient concentrations in all the significant tributaries to Lake Erie should be made at sufficient frequency each year to determine accurate estimates of loading, particularly during the March to July period.
- **RANK LOW:** ~~It would be useful to develop a model of nutrient and TSS loading that includes inputs from smaller tributaries. This would most likely be a hierarchical or Bayesian hierarchical model that accounts for multiple factors and it might require additional monitoring for adequate estimation of model parameters and subsequent estimates of nutrient loadings from the smaller tributaries.~~
- **RANK HIGH:** ~~It seems worthwhile to improve the estimates of loading by linking land use models with loading models. Correspondingly, there might be an opportunity to collaborate with farmers in the Lake Erie watershed who are practicing precision agriculture to better estimate optimal fertilizer application rates as a way to reduce nutrient loading.~~
- **RANK LOW:** ~~To the extent that~~ multiple models are retained for use in the analysis, ~~consideration should be given to combine~~ 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.

Charge Question 2. (recommendations on page 15 of the report)

Key **Recommendations**

- A conservative estimate of a 40% reduction in TP load **<<DFO NOTE: Should this indicate that the load reduction is to the Western and Central Basin?>>**, ~~at a minimum~~, projects a response which improves water quality and reduces HABs. However, continued research and monitoring is needed to reduce uncertainty.
- **RANK HIGH:** Lake and tributary monitoring is critical for continued development of the models and for adaptive management. ~~Lags in indicator response and inter-annual trends can only be elucidated accurately with an adequate monitoring program in place. In particular, monitoring of the 11 priority tributaries identified by the Annex 4 Objectives and Targets Task Team is essential and should~~

Commented [Office3]: again, this contains summaries and recommendations

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~~include measurement of: flow, nitrogen species (good *in situ* NO₃ sensors are available for high temporal resolution sampling), phosphorus (all forms) and organic carbon (dissolved organic carbon, DOC, and particulate forms). Event based sampling (to capture the effects of the rising and falling limb) within these systems is also critical for calculating loads. Precipitation and tributary flow also are critical variables that should be monitored.~~

- **RANK HIGH:** Mechanistic models should be extended to include sediment diagenesis and nutrient flux. The depths of the active layer should be refined (e.g., 10 cm is too large - the depth may be 5 cm or less).
- **RANK MEDIUM:** The WLEEM should be deployed for the whole lake in order to better understand how to address the issue of hypoxia.
- **RANK MEDIUM:** Consideration should be given to embedding a *Cladophora* model within the whole lake WLEEM model.
- **RANK HIGH:** Simulations should be run continuously over a period of years as an extended sequence rather than resetting initial conditions every year.
- **RANK MEDIUM:** A better understanding of the influence of winter blooms (under ice phenomena) should be developed and incorporated into the models, particularly for hypoxia in the Central Basin.
- **RANK MEDIUM:** The algal community should be characterized to better understand the relative contribution of N-fixers versus non-fixers. The role of both N-fixation and denitrification in nitrogen cycling and nitrogen budgets in the system should be assessed. ~~This will inform both the question of N limitation and the potential impact of nitrogen reduction strategies (i.e., if N is low, it might stimulate N fixing species).~~
- **RANK MEDIUM:** ~~The effectiveness of BMPs should be characterized with respect to type, spatial distribution, location in the watershed, type of BMP and life cycle effectiveness. This is a large effort, but it is needed if action plans and adaptive management are to be effectively implemented.~~

Commented [Office4]: did we decide to move this to the AM section?
Might get lost there, given the complexity of that section.

Charge Question 3. (recommendations on page 18 of the report)

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Key Recommendations

- **RANK HIGH:** The GLCM ~~was calibrated and confirmed on Lake Huron-Michigan. It model~~ should be calibrated and confirmed in the Eastern Basin of Lake Erie using existing data ~~because there are significant differences between Lake Erie and the lakes on which this model was developed.~~
- ~~Cladophora growth may be linked to SRP content in the overlying water column. The presence of SRP is linked to the swift turnover of TP levels in the open lake (as modeled in the GLCM) but also to local inputs from nearby tributaries, as well as the presence of dreissenid mussels (Higgins 2004). A scientifically sound model must~~ **RANK HIGH:** incorporate site-specific factors in the GLCM model, including local hydrodynamics, tributary inputs, mussel densities, and other important drivers.
- **RANK MEDIUM:** Current and future studies should include investigation of P load inputs from key tributaries (e.g., the Grand River, Ontario) and the relative significance of local inputs and open Lake P on stimulating and supporting *Cladophora* growth.
- **RANK LOW:** The GLCM ~~specifically focuses on Cladophora as the only issue of concern. However, the model would be more useful if it could be applied to the diversity of benthic algae that are important in the Great Lakes, thereby extending the usefulness of the model to other nuisance benthic algae (e.g., Chara, Lyngbya, Spirogyra, etc.) that can cause similar problems.~~ The similarities and differences among these various species need to be considered in order to provide an adequate representation of the problems of nuisance benthic algae in general.
- The nuisance attribute of *Cladophora* is largely the formation of “beach muck” and the attendant problems that arise from it. The formation of “beach muck” is initiated by sloughing of standing crops of the benthic alga. The GLCM provides only a crude estimate of this process, modeling sloughing as a constant coefficient of the calculated standing crop. **RANK MEDIUM:** The process or processes that lead to sloughing (local hydrodynamics, algal senescence, etc.) and eventual decay to “beach muck” need further investigation and likely need to be appended to the GLCM.
- **RANK MEDIUM:** ~~Explore the development of a~~ spatial model ~~was~~ linked to remote sensing information to better understand ~~cyanobacterial HABS. Perhaps a similar approach could be taken with regard to Cladophora to capture information on spatial coverage~~ distribution.

Commented [Office5]: Move this statement into the text above; reframe the rest of the text into a clear and concise recommendation.

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- **RANK HIGH:** The GLCM should be included in a broader whole-lake model to forecast the likelihood of *Cladophora* growth along the shores. Consideration should be given to the possibility that as hazardous algal blooms abate, the likelihood of *Cladophora* growth along the shores may be increased due to improvements in water clarity and colonizable habitat.

Charge Question 4. (recommendations on page 22 of the report)

Key Recommendations

Commented [Office6]: A couple of these contained distinct recommendations- I separated them into distinct recommendations

- **RANK HIGH:** Research should be conducted to determine the total N loadings entering Lake Erie over time and space, including all the major species of nitrogen, ~~oxidized, reduced, organic and particulate, including flow-weighted mean concentrations (FWMC).~~ An N budget should be developed for Lake Erie, especially the Western Basin, ~~similar to that for Lake Michigan (Han and Allan 2012).~~ Dissolved organic or non-reactive P (DNP) in Lake Erie and tributaries should also be further investigated.
- **RANK MEDIUM:** Research should be conducted to determine: 1) how much of the external N loading can be removed by internal removal process ~~like denitrification, dissimilatory nitrate reduction to ammonium (DNRA), anammox, ammonia volatilization and burial;~~ 2) the consequences of legacy N and P in the sediments and the differences in internal cycling; and 3) the downstream consequences of not following a dual nutrient strategy.
- **RANK MEDIUM:** Research should be conducted to further understand: 1) the importance of concentrations and ratios of nitrogen to other nutrients (P, but also Si) in directing or controlling ecosystem functions, ~~such as nutrient cycling, primary production, species composition and toxin production;~~ and 2) the balance in the ratio of N to P that would be best for ecosystem functioning. ~~Much is already understood about these topics.~~
- **RANK HIGH:** Research should be conducted to show the reliability of current models for assessing the role of nitrogen in Lake Erie eutrophication and whether the models can be improved (or new models developed) to more completely incorporate N including internal N and P pools and ratios.
- **RANK HIGH:** Research should be conducted to understand the expected response of the four eutrophication response indicators to N reduction in the improved models.

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- **RANK MEDIUM:** BMPs should be developed or applied to achieve additional N reduction in Lake Erie if needed.

~~Given the difficulty and expense of controlling and reducing N loadings, it is important to optimize ecologically and economically the N sources to be reduced.~~

- **RANK LOW:** Lessons learned from case studies of nutrient reduction in the Baltic Sea and other areas should be applied to Lake Erie, ~~including. This could include~~ scientific, technical, policy and governance strategies.
- **RANK HIGH:** ~~An obvious lesson would be to~~A standardize monitoring protocol should be implemented among the different groups involved.

Commented [Office7]: This was split off from the previous recommend.

Charge Question 5. (recommendations on page 25 of the report)

Key Recommendations

- **RANK MEDIUM:** The SAB recommends reviewing all available tributary monitoring data ~~(e.g., discharge, flow, concentrations, loads)~~ and multiple assessment approaches ~~(including FWMC and flow-adjusted concentrations)~~ to evaluate efforts to control sources of nutrient loadings.
- **RANK HIGH:** Uncertainty in the values derived using the flow-weighted or flow-adjusted assessment approaches should be explicitly quantified and presented, and detailed information on the implementation of phosphorus reduction strategies should be collected to help explain patterns observed in the future.

- **RANK LOW:** Detailed information on the implementation of phosphorus reduction strategies in each major watershed should be collected into the future.

Commented [Office8]: This should be part of the AD plan

~~Without this information, it will not be possible to adequately identify the primary reasons for the observed changes (or lack thereof) in phosphorus loads delivered to Lake Erie.~~

- **RANK MEDIUM:** ~~If the focus of the Annex 4 Objectives and Targets Task Team expands to consider the control of nutrients other than phosphorus, t~~he same assessment approaches should be

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applied to tributary monitoring data for ~~these nutrients~~ nitrogen as well as phosphorus, to evaluate efforts to control sources of nutrient loadings.

Charge Question 6. (recommendations on page 30 of the report)

Key Recommendations

- **RANK MEDIUM:** A standing adaptive management committee should be appointed to develop a program that investigates alternative hypotheses and long-term forecasts in order to inform future management decisions.
- **RANK HIGH:** A coordinated, binational long-term monitoring program should be developed with stable funding identified.
- **RANK HIGH:** Recommended models should be used as part of the adaptive management process. ~~Models can be used as part of the adaptive management process~~ to identify and evaluate alternative hypotheses. ~~They can also be used to~~ identify data gaps, and ~~to run~~ develop future scenarios
- **RANK HIGH:** Alternative hypotheses for Lake Erie eutrophication should be developed and tested.
- **RANK HIGH:** Future scenarios should be evaluated to understand the effects of climate variability and other factors that may change in the future.
- **RANK HIGH:** The effectiveness of BMPs should be characterized with respect to type, spatial location in the watershed, and life cycle effectiveness.
- **RANK HIGH:** The proposed work should be structured to provide answers to key questions (e.g., are load reduction targets being met, are ERIs responding, are ERIs being predicted accurately) on an ongoing basis.

Commented [Office9]: did we decide to mode this to the AM section?
Might get lost there, given the complexity of that section.