Dr. Lucinda Johnson

Lake Erie Phosphorus Reduction Strategy Panel
Comments from Lucinda Johnson

Johnson, General comments:

- The rationale for setting 2008 as the benchmark year for setting targets is buried deeply within the document and took some careful reading of the Phosphorus Targets report to uncover. Since this is a critical piece of information, this should be presented earlier in the document.
- Climate driven processes are critical to future measurements of flow, loading, water temperature, and conditions that are optimal for development of HABs. Many of these models could be run under future scenarios that include higher air and water temperatures along with greater spring precipitation levels.

Approach for Developing Lake Erie Phosphorus Load Reduction Targets

Nine different Lake Erie models were used to predict the response of selected eutrophication response indicators to different phosphorus load scenarios (see Table 1 in the Annex 4 Ensemble Modeling Report). The eutrophication response indicators evaluated were (1) overall phytoplankton biomass represented by chlorophyll a, (2) cyanobacteria blooms in the Western Basin, (3) hypoxia in the hypolimnion of the Central Basin, and (4) *Cladophora* in the nearshore areas of the Eastern Basin. Technical evaluation criteria were used to assess the capabilities of each model (see Section 2.3 and Appendix B of the Annex 4 Ensemble Modeling Report) and load-response curves were generated for each eutrophication response indicator (see Section 3 and Appendix B of the Annex 4 Ensemble Modeling Report).

CQ 1: Please comment on whether the evaluation of the models was adequate to inform how model results should be interpreted, given differences in model complexity and scale. Please identify any additional analyses that may be needed to improve future development and interpretation of the load-response curves for the eutrophication response indicators.

- Model evaluation was adequate, especially for common variable resulting from different models. The use of common metrics for model evaluation was very helpful. Models have been well-vetted through peer reviewed publications; the diversity of modeling approaches have produced relatively coherent results. Should future funding become available for this work it would be helpful to parameterize models using the same input data, which will allow for a more accurate model comparison.

- It would also be helpful to document the model biases in a manner that would allow end users and decision makers to understand the appropriate uses for each model (maybe a matrix?). In particular, it seems that some of the models are especially sensitive to initial conditions; this seems like critical information that would be useful for interpreting the model output for the purpose of setting limits and reduction targets.

- See below for additional suggestions on analyses, relative to climate change impacts on P loading and hypoxic zone extent.

The document, R*ecommended Phosphorus Loading Targets for Lake Erie* describes the process followed by the Annex 4 Objectives and Targets Task Team to develop phosphorus loading targets for Lake Erie. The document indicates that, to achieve a Western Basin cyanobacteria bloom biomass threshold no greater than that observed in 2004 or 2012, 90% of the time, a spring Maumee River load of 860 metric tons of total phosphorus and 186 metric tons of dissolved reactive phosphorus is recommended. In addition, a 40% reduction in the spring load of total phosphorus and dissolved reactive phosphorus from other Western Basin tributaries and the Thames River is recommended. To meet a threshold of 2.0 mg/L or higher of hypolimnetic dissolved oxygen, an annual total phosphorus load of 6,000 metric tons to the Western and Central Basins is recommended. The Task Team did not recommend new phosphorus concentration objectives for the open waters or the nearshore be identified at this time.

CQ 2: Please comment on whether the recommended targets reflect the best available information on the drivers of cyanobacteria growth and seasonal hypoxia in Lake Erie and are appropriate to meet the nutrient Lake Ecosystem Objectives defined in the GLWQA (as reflected in Table 1 on page 7 of the document titled *Recommended Phosphorus Loading Targets for Lake Erie*).

- The best available science about drivers of cyanobacteria growth and seasonal hypoxia was used to set phosphorus targets.
- There is some discrepancy between the thresholds for DO between the Annex 4 report and the Phosphorus Reduction Strategy report. The rationale for the 2 mg/L DO target was made clear and makes sense from a policy perspective. However, the 4 mg/L DO target is an important ecological endpoint that should not be disregarded because it does not currently appear to be attainable.
- "Because discharge varies considerably from year to year, and because the discharge of the Maumee River was so large in 2008 that it has only been exceeded about 10% of the time in the last 20+ years, the Task Team expects that achieving a FWMC of 0.23 mg/L for TP and 0.05 mg/L for DRP will result in phosphorus loads below the targets (860 and 186 metric tons) 90% of the time (9 years out of 10), **if precipitation patterns do not change.**" This is an unrealistic expectation, since there is good evidence that precipitation patterns already showing signs of change, with strong evidence of increases in spring precipitation. Given the expectation that precipitation will continue to increase, these targets may not be protective enough. As proposed above, scenarios that include higher spring precipitation levels should be explored to assess the potential impacts of slight and/or moderate precipitation increases on the proposed targets. Precipitation timing is also predicted to shift towards earlier spring peak flows, with a great incidence of rain-on-snow events. These scenarios should be included in the model projections. Projections of the aerial extent of the hypoxic zones under warming climatic conditions should also be conducted. Earlier warming and earlier onset of stratification is likely to increase the duration and size of the hypoxic zone.

***Cladophora* Growth**

Additional phosphorus load reductions may be necessary to reduce nuisance levels of *Cladophora* in the nearshore waters of the Eastern Basin of Lake Erie. The Annex 4 Objectives and Targets Task team did not recommend a specific phosphorus objective or loading target to address *Cladophor*a growth. EPA and Environment and Climate Change Canada convened a workshop in January 2016 to

assess the current state of knowledge of *Cladophora* growth in the Great Lakes and identify potential options for nutrient target development to be considered by the Annex 4 subcommittee. (Please see the background document titled "State of the Knowledge of *Cladophora* in the Great Lakes. Executive summary of Workshop held at NOAA-Great Lakes Environmental Research laboratory, January 26-28, 2016.")

CQ 3: Please comment on whether scientifically-sound phosphorus load reduction recommendations to address *Cladophora* growth in the Eastern Basin of Lake Erie could be developed at this time.

- It does not appear that there are sufficient data available to develop phosphorus reduction targets for this endpoint. In particular I feel there is insufficient knowledge about the sources of phosphorus (i.e., offshore vs inshore) for Lake Erie in particular. Work by Jack Kelly and Peder Yurista suggest that the land-based influence on nutrient dynamics is dominant within the nearshore zone (I'll have to find the information about how they defined this for Lake Erie). The results of the workshop on Cladophora, however, suggest that the dominant sources of phosphorus fueling Cladophora growth may be derived from off-shore. The confounding effects of mussel density is certainly important as well. It seems clear that there is still al lot of work to be done to clarify the ultimate sources, much less to set limits.

Nitrogen Control

While the current strategy focuses on limiting phosphorus loading to the Lake (total and dissolved forms) as the key mechanism for controlling excessive algal growth, it is implied or assumed that nitrogen loading likely will also be reduced through implementation of agricultural best management practices, and the Task Team recommended that tributary nitrogen loads to the Lake be tracked in addition to phosphorus.

CQ 4: What recommendations can the SAB provide for development of an approach to help determine whether consideration of nitrogen control, in addition to phosphorus, is warranted in Lake Erie to prevent harmful algae blooms and manage hypoxia?
In particular, what questions, relationships, or research priorities related to nitrogen loading (different forms and sources) and in-lake cycling must be addressed?

- I don't feel qualified to address this question. I would suggest that particular attention be paid to assessing the structure and function of the lower portions of the food web, in particular, the primary producer communities for evidence of changes that could be linked to nutrient concentration and form.

Evaluation of Nutrient Reduction Targets

The inter-annual loading trends for the Maumee River are greatly influenced by annual variability in flows. The Objectives and Targets Task Team identified a maximum flow below which the target load should be met and recommended the use of flow-weighted mean concentrations (FWMC) as a benchmark for any given tributary target load.

CQ 5: Please comment on the use of FWMC and any other approaches that should be considered to account for inter-annual variability in hydrology in assessing progress in reducing tributary loadings of phosphorus to the Lake.

- FWMC is a reasonable approach for assessing inputs and setting target, given the seemingly dominant delivery of nutrients during high flow events in the spring. My concern about the targets that have been identified, however, lie in the assumption that the system is static and is unlikely to change. As noted above, there is already strong evidence of increasing flows due to precipitation increases. But in addition to changes in climate, there is also a strong trend towards increases in impervious surfaces and decreases in natural vegetation covers (i.e., associated with land cover change and development in coastal zone and up in the watersheds of the Great Lakes region.) These two exacerbating factors are likely to contribute to further increases in peak flow, both in spring and summer. The current targets are set based on current flows and are thus unlikely to result in the projected decreases in the future.

The Task Team recommended development of a comprehensive adaptive management program that would include annual routine monitoring of appropriate load, FWMC, and in-lake nutrient-eutrophication response indicators in conjunction with an intensive monitoring, research, and operational model application program every five years.

CQ 6: Please comment on the value of applying the existing eutrophication models on an ongoing basis to periodically evaluate phosphorus loading targets and eutrophication response indicators. What key elements should be included in the adaptive management approach to successfully implement and evaluate our nutrient reduction goals for Lake Erie?

- A key component of an adaptive management framework includes the data used to develop the models and relationships to begin with, and subsequently rerun models to check assumptions and assess the general trajectory of the system following implementation of management and policy practices. These data streams require programs with consistent funding and appropriate attention to their discoverability, maintenance, and dissemination.

- A key consideration in managing the Lake Erie system in an adaptive manner is to account for the multiple and interacting stressors that influence the delivery of nutrients, sediment, and contaminants to the system from land based sources. To manage those sources effectively, land use and other human activities that influence these delivery processes must be quantified via existing or novel tools to account for their individual and collective impacts. Of critical importance is the integration of future climate scenarios with landscape and hydrology models to predict impacts under both current and future scenarios.