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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). The EPA rquested the Science Advisory Board to review two reports that provide modeling results and related information to develop recommendations to reduce phosphorus loads to Lake Erie.

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.

Overall, the group has done very good job in developing scenarios using various models to develop phosphorus loading targets for Lake Erie. Models range in various complexities and scales and modelling results are only good if they are adequately validated with the measured data. Availability of data seems to be limiting the evaluation of models.

Modelling effort is primarily based on external loads of phosphorus to Lake Erie. Models consider three zones in the lake: Western, Central, and Eastern Basins. In the Western Basin cyanobacterial blooms were used as response indicator and hypoxia was evaluated in the Central Basin. *Cladophora* was used as response indicator in the Eastern Basin. Models used whole lake P loads to develop relationships with response indicators in specific lake basin. Since P loads were different for each basin, why not use basin specific P loads to evaluate response indicators. For example, in Figure 6-9 show the relationships based on the Western Basin P load only, not based on whole lake annual P load.

How much of the P loaded to the Western Basin was assimilated within the basin and what portion of this load was actually transported into the Central Basin.

Models did not consider the internal P loads from the benthic fluxes. As we know a significant amount of external P load can be potentially deposited into sediments. Lakes are typically known as sinks for particulate P and source for dissolved reactive P (DRP). Amount of labile pools of P stored in sediments can be potentially released into the water column. The recommended targets for TP and DRP should consider the internal load, as this can increase the lag time for recovery of lake even after external loads are curtailed to certain recommended level.

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*).

Model results suggests that increase in TP loads decreases dissolved oxygen (DO) in the Central Basin creating hypoxia conditions. The target P loading is set at 6,000 mt/year for Western and Central Basins or 40% reduction. What was the rationale for using Western and Central Basins P loads to explain DO levels in the Central Basin. TP loads only provide indirect evidence of hypoxic conditions.

Models should consider watershed management practices and source control should be considered as target nutrient loads are developed.

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.

At present there may not enough scientific information to develop P load reduction targets.

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?

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.

It is important to track N loading along with P loading to reduce any detrimental ecological effects in the lake. Studies have shown that P-only reduction strategies may not always work, because of alternation in N:P ratios phytoplankton. Nitrogen loading can also enhance the hypoxic conditions in the lake. Mutual dependency of macro-elemental cycling should be considered modelling efforts as target nutrient loads are developed.

Models should consider watershed management practices and source control should be considered as target nutrient loads are developed.

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.

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.

I agree with this comment.

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 thorough validation of models should be performed, prior to their use to capture both spatial and temporal variability.

Most of the effort has been only on in-lake processes. Watershed management practices including BMPs, and the effect of legacy nutrients should be considered.