Manuscript: Options for Restoring Lake Michigan-Huron Water Levels: An Exploratory Analysis

Author(s): IUGLS Study Team

Name of Reviewer: Eric D. Loucks, PE

1. Are the objectives of the work clearly stated? 1 2 3 4 5

2. Are the methods employed valid, appropriate and sufficient to address the questions, hypotheses or the problem? 1 2 3 4 5

3. Are the observations, conclusions and recommendations supported by the material presented in the manuscript (e.g., data, model and analyses)? 1 2 3 4 5

4. Are the assumptions used valid and are the mathematics presented correct? 1 2 3 4 5

5. Is the manuscript well organized, material precise and to the point, and clearly written using correct grammar and syntax? 1 2 3 4 5

6. Are all of the figures and tables useful, clear, and necessary? 1 2 3 4 5

7. What is the quality of the overall work? 1 2 3 4 5

Recommendation (please circle your response)

A - acceptable
B - acceptable with suggestions for revision
C - acceptable if adequately revised
D - unacceptable

If you have selected **C**, do you wish to receive the revised manuscript for further review? yes no

Rating (Circle the rating you would like to give this manuscript. Unacceptable work should be given a score of 40 or less.)

100 90 80 70 60 50 40 30 20 10 0

Comments (limit responses to one paragraph for each question; reference pages, charts, and data. Please distinguish if responses are of major or minor concerns.)

A. What is the best/most unique part of the analysis?

Generally does a good job of quantifying the impacts of the scenarios in specific quantified terms

B. What is the most critical aspect of the study/analysis? Why?
The environmental analysis is key and quite well done.

C. Which aspect of the analysis/modeling is weakest? Why? How can it be improved?

From the italicized statement on page 6 that both structural and non structural measures were to be considered. No non-structural measures are presented and the structural measures are weak. The structural concepts date from the 30's and early 70's and none achieves the 40 or 50 cm targets. Far too much detail is presented on the nature and dimensions of these structures which neither meet the objectives and lack environmental viability. Some ideas that could have been considered include terminating the Chicago Diversion, diverting water from a north-flowing watershed into Lake M-H, increasing Lake SUP outflow or direct mitigation for parties harmed by M-H lowering. Would like to see what a measure that achieves 50 cm would look like.

Non-structural measures were not considered in this work, but will be covered in the Adaptive Management sections of the final report of the International Upper Great Lakes Study. This restoration report focused specifically on measures that could be implemented in the St. Clair River to raise water levels of Lake Michigan-Huron, and the impacts these structures would have throughout the basin. The reasoning behind including the details of the various structures reviewed in the report is that it allows the reader to see what assumptions and limited design details were used in developing the cost estimates, so as not to mislead the reader into thinking that the estimates can be thought of as anything more than exploratory in nature.

The reviewer suggests four additional ideas for consideration, three involving structural measures, the other a non-structural alternative. Since the lowering of Lake Michigan-Huron water levels over the past century or so has been attributed primarily to changes in the St. Clair River as a result of dredging, the focus of the report was on restoration measures that could be implemented at this location. Furthermore, as this was to be an exploratory-level analysis, the Study focused on using existing studies and information when available. The reviewer is also referred to section 2.2.6 of the report for further details on the limited number of options described in this report. However, the additional suggestions provided by the reviewer are also discussed briefly here.

The first of these suggestions is a termination of the Chicago Diversion. According to the IJC (1985) report "Great Lakes Diversions and Consumptive Uses", if it is assumed that

the Chicago diversion diverts 91 m^3/s out of Lake Michigan-Huron, this causes approximately a 6 to 7 cm lowering of the lake's water level, and therefore terminating the diversion would result in only this small of a rise in Lake Michigan-Huron. Furthermore, the socioeconomic and environmental impacts of terminating the Chicago diversion would need to be assessed, but this was beyond the scope of this study (the reviewer is likely aware that a number of studies are currently being pursued by other agencies in this regard in light of recent concerns regarding invasive species entering the Great Lakes from the Mississippi River and other basins). Lastly, terminating the Chicago diversion would have unintended, permanent impacts on the water levels of downstream Great Lakes, whereas downstream impacts of structures in the St. Clair River would be only temporary, as described in the report. Alternatively, one could also terminate the Welland Canal diversion from Lake Erie. Due to backwater impacts, this would cause approximately a 6 cm rise in Lake Michgian-Huron, but similar socioeconomic, environmental and downstream impacts would apply. A note regarding the use of diversions has been added to the caveats section of the final report

The second suggestion was a diversion of a north-flowing river into Lake Michigan-Huron. In effect this would be similar to the existing Long Lac and Ogoki diversions into Lake Superior. The Long Lac/Ogoki diversions provide a good example of the impacts of such a scheme, since the increased flow to Lake Superior also passes downstream and causes a similar rise in Lake Michigan-Huron, as well as downstream lakes. Again, referring to the "Great Lakes Diversions and Consumptive Uses" report (IJC, 1985), the effect of the Long Lac/Ogoki diversion (assumed to be 159 m3/s on average) is approximately 11 to 13 cm for Lake Michigan-Huron (this also agrees well with the impacts of the Chicago diversion described above). Therefore, to provide only slightly more than 10 cm of restoration to Michigan-Huron would require a diversion of the same magnitude as this. Despite this small rise, these are massive projects (for reference purposes, the areas of the Long Lac and Ogoki basins that are diverted are approximately 4377 km^2/1690 mi^2 and 13960 km^2/5390 mi^2, respectively) that were completed for power and industrial purposes during World War II, and the socioeconomic and environmental implications would be immense. As a result, such an alternative is highly unlikely to be considered feasible today, and hence were not considered in the current report.

The remaining two measures proposed by the reviewer include increasing the outflow from Lake Superior, and providing direct mitigation for parties harmed by Michigan-Huron lowering. Lake Superior regulation and adaptive management (including non-structural measures) are being assessed as part of the greater International Upper Great Lakes Study work taking place, and will be presented in the final report prepared by the Study Board and presented to the IJC. But in terms of increasing the outflow from Lake Superior, it should be noted that it would be impossible to have a permanent impact on Michigan-Huron levels under this scenario, since the outflow from Lake Superior would have to be continually increased from its "natural" outflow since the water level of the lake would adjust to the new flow regime (i.e. the level of Superior would continue to fall, with the natural outflow reduced accordingly), and this would therefore eventually drain the lake. Furthermore, even if one wanted to only temporarily increase extreme low

water levels on Michigan-Huron by temporarily increasing the outflow from Lake Superior, due to differences in the surface areas and overall water balance of the two lakes, the increase in water level on Michigan-Huron caused by such an action would be highly disproportionate to the lowering the increased flow would have on Lake Superior. Plan 77R2, described in this report, illustrates the opposite impacts of storing water on Lake Superior when Lake Michigan-Huron is naturally high and also subject to a 10 cm restoration.

D. Are there any other suggestions that are related to how this analysis may be used more effectively or the results explicated in a more understandable manner?

> Could use a clearer statement of objectives. I'm not sure if what I found on Page 6 was really it. I was confused by the Executive summary which mentions analysis of four options but then says the structures evaluated only went up to 25 cm. Once I read the whole report, then I understood.

The Executive Summary has been modified to more accurately reflect the contents of the main body of the report.

> I think too much is made of the adjustment period, which ultimately clouds the results. I think there should be an assessment of the staged and instantaneous transient impacts and then the long term effects should be based on a system in equilibrium. For example, the negative impacts to Niagara Hydropower are only during the transition.

The adjustment period is important, as it has direct implications on the impacts to downstream interests of any structural alternative in the St. Clair River. By staging the construction of structures these impacts are reduced or eliminated. The authors felt it was important to discuss this concept in detail, in order to illustrate downstream impacts of restoration, and how they could be managed should restoration be implemented. Also, while the negative impacts to Niagara hydropower are only during transition, as described in Chapter 4, they are proportionally quite large.

> May be worthwhile to add a discussion on adaptation. Have adaptive strategies to recent low water already begun? If we raise water levels, will coastal riparians adapt to higher water levels thus ameliorating some of the adverse impacts noted in this report?

Adaptation to changes in water level is inevitable. As examples, during relatively low water periods, harbours are dredged for navigation, shore property owners extend the length of or use floating docks, and wetlands can migrate. Likewise, adaptation occurs during periods of high water levels, as property owners build shore protection structures, for example. Unfortunately, however, the adaptations and benefits that result during one water level regime may have negative consequences when water levels return to the opposite regime in subsequent years. Further discussion on adaptation will be provided in the final International Upper Great Lakes Study, which deals with Superior regulation and Adaptive Management.

Signature: ___Eric D. Loucks_____ Date: ___May 2, 2011

Comments for Transmission to Authors

It would be useful to have both general comments and specific comments for major and minor revision. Please use additional sheets should they be required.

Figure 3-1 and others – I presume these will be reformatted. The label "ER" should be removed and consistent number formats applied to all axes. Time series plots in section three number the years on the x-axis from 1 to 109 in varying increments (by 5 here, but 4 in Fig 3-3). The time series plots in section 4 appear use the year from which the underlying NBS was obtained. I prefer the latter. Either approach is confusing to some readers. Changing methods part way through the report is confusing to all readers.

The use of year numbers was intentional since restoration would be occurring at some point in the future, not in the historic record, but the authors agree that this is confusing. The x-axis has been reformatted for the figures in question to show years as opposed to year numbers, with an explanation provided in the text.

Table 3-1 – I don't approve of the use of the term ymSC as if it were a universally understood term. Also it appears two ways here.

As explained in the report, the term ym_{SC} (also shown as ymSC in the report) is representative of the mean channel bottom elevation of the St. Clair River in the stage-fall-discharge equations used to estimate flow. This has been further clarified in the report, and the formatting discrepancy has been corrected to only show the subscript "ym_{SC}" version.

Figure 3-2 – what is the cause of the significant downward trend toward the end of the time series? Is this the 2000-2006 period of low NBS? Is the 50 cm scenario more sensitive to low NBS than the others? By 2100, this low water episode could have high impacts due to adaptation.

The reviewer is correct in his assumption that the downward trend is caused by the period of relatively low net basin supply (NBS) on Lake Michigan-Huron that has occurred over the past decade. The amount of restoration varies slightly with water level, with the rise in water level over the base case (i.e., no restoration) being greatest during periods of high water, and lowest during periods of low water. In absolute terms, the 50 cm restoration scenario is more sensitive to changes in water level than others, but in all cases the difference tends to be small, and as shown in Figure 3-2, is less than a few centimetres, even at the highest level of 50 cm restoration. The result is that if one wanted to raise Lake Michigan-Huron by 50 cm for all water level conditions, the level might need to be raised by somewhat more than that on average. The reviewer is also

correct in his statement that, like any "adaptation" strategy that takes place during an extreme water level condition, the impacts could be high if and when water levels return to the opposite extreme.

Figure 3-3 – perhaps better to show the long-term max/min some other way.

The seasonal (monthly) long-term min and max were presented here to agree with the water level plots, which were also simulated monthly. An explanation has been added to the text.

P. 47 – Second sentence is very long route to a relatively simple point. This is repeated on the following page. Isn't it sufficient to say that the small error in stage is negligible given the huge flow and total head. It sounds like an excuse is being made for a big assumption.

The authors wanted to clearly document the assumptions inherent in the existing hydropower model for Niagara used in this study. The reviewer refers to the model assumption that upstream water levels at the Ontario Power Generation hydropower plants are constant, which we know not to be true. This and a number of other assumptions that were made caused large uncertainty in the model results. It was assumed by the authors, however, that because restoration results were compared to a base case, even though the actual benefits in terms of cost and energy produced were subject to a high degree of uncertainty, the direction of the impact (i.e., positive or negative) of different restoration options could be acceptably described and compared using these metrics. As stated in the report, the Niagara hydropower model is also being reviewed as part of the remainder of the International Upper Lakes Study.

P. 50 – second line impede rather than impeded. This sentence is an awkward double negative.

Corrected.

P. 53 – second sentence of second paragraph. Says three reaches but sounds like two.

Three areas/reaches is the correct number. They are Racine County, Wisconsin; Lake and Cook Counties, Illinois; and the Collingwood-Wasaga Beach area of Ontario. The second of these was accidentally omitted from the report, but this has been corrected.

Figure 4-20 – The boat launch score seems inconsistent with the boat slip data. The data implies that adverse effects kick in when the lake falls below its median level.

The analysis of boat launches and marina boat slips were done independently, but the boat launch score is consistent with the boat slip data. As discussed in the report, boat launches are designed to function properly within a range of relatively normal water levels. During extreme conditions (both high and low levels), boat launches become less effective, and this is shown in Figure 4-20. The boat slip data are similar, in that as

water levels become lower, more slips become unusable; data were not available to describe negative impacts of boat slips at high levels, but they may exist at some locations.

P. 76 – What's the point of saying "statistically small?" The reader will understand if you say small or limited.

The term "statistically small" has been used here to make it clear that, due to limited data, only a small/limited number of utilities were sampled, and as a result, the sample may not accurately represent the full population of municipal and industrial users. The text has been left as is.

P. 78 – option 4 – the words "other more desirable" made me think there must be something undesirable about inflatable flap gates. If not, then just say alternative.

Changed, as suggested.

P 79 – Reference to Figure 3.1 should be 5.1

Corrected.

Figure 6-1 – is unreadable but I assume this is being addressed

Corrected.

Figure 6-3 – Eventually I figured out all the abbreviations except WAYP

This figure has been updated.

P. 131 – "show stopper" is probably an inappropriate colloquialism in the report. Throughout sections 6, 7 and 8 the discussion is heavily slanted toward saying the project is essentially dead due to the impact on the Lake Sturgeon habitat. This almost crosses the line in terms of making a recommendation. I think a reasonable person can see that the cost and environmental consequences are difficult for cash strapped governments to justify.

The wording of this section (along with some other areas of the report at the request of the Study Board and Public Interest Advisory Group) has been softened in some cases, but the authors wish to remain careful not to discount the impacts regulation structures in the St. Clair River would have on the environment and species-at-risk.

P 154 – Section 8.3.1, this is one of many times that the reader is told that the list of structures considered is not exhaustive. In fact, this is an exaggeration as the structures considered were limited to three that were previously proposed and a couple ideas provided in the directive. Perhaps it would be worthwhile to do a quasi-exhaustive enumeration of possibilities and rate their feasibility on a broad scale

As discussed, this was an exploratory-level analysis only, and as such, was limited in scope and the number and type of structural alternatives that could be investigated. Due to limited time and resources available for this Study, even a quasi-exhaustive review of possible options was deemed to be beyond the scope of this work, and rather the authors decided to explore only those restoration alternatives that have been proposed in past studies, since they were presumably deemed to be the preferred options when originally proposed to compensate for past dredging. The current study has provided insight into both the positive and negative impacts of such structures, though these have never been discussed in past studies. Furthermore, a review of previous restoration and regulation studies by Bruxer and Carlson (2010) performed for this Study provides, among other things, additional detail on the use of diversions for restoration and regulation purposes. Lastly, if the governments were to further pursue restoration of Lake Michigan-Huron water levels, a more exhaustive review of not only the possible options for providing it, but also their impacts throughout the basin, would have to be conducted.