Manuscript: **Modeling of Hydrodynamics and Sediment Transport in St. Clair River**

Author(s): **Xiaofeng Liu and Gary Parker**

Name of Reviewer: **Brian Barkdoll**

1. Are the objectives of the work clearly stated? 1

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

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

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

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

6. Are all of the figures and tables useful, clear, and necessary? 2

7. What is the quality of the overall work? 2

Recommendation (please circle your response)

C - acceptable if adequately revised

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

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

40

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?
Thorough analysis including 1D, 2D, and 3D with water surface profiles and sediment transport guided by field data.

B. What is the most critical aspect of the study/analysis? Why?
The change in water depth due to dredging is the main question to be answered.

C. Which aspect of the analysis/modeling is weakest? Why? How can it be improved?
Models chosen must be verified by listing assumptions and discussing applicability to the St. Clair River. Other models for 3 flow and sediment transport should be compared.

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?
Numerous grammatical errors need corrected.

See comments below to authors.

Please indicate any confidential comments to the Co-Chair(s) of the Independent Peer Review Group in the space below. Comments for transmission to the author(s) should be on a separate sheet attached.

Signature: _Brian Barkdoll__________________ Date: 4/27/09_____________

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.

This report describes the modeling of the St. Clair River.

In general, the study is well done. The following general comments are offered for consideration:

1. Section 2.2.1 needs justification for the use of these equations. Are they applicable for river bends, or just for straight river sections? What were the conditions for which they were developed? Please justify.
2. Justify the use of "the value of *nk* is fixed as 2". Why this seemingly arbitrary value?
3. Please show the locations of Thalwegs 1 through 4 referred to in Table 1.
4. Explain how you came up with the Hydraulic Condition Sets for Table 3. Was it based on certain return period flows or what? Now it seems arbitrary.
5. Please explain results of Figure 2. It seems like the predicted match the observed for Hydraulic Condition Set 1 only. Is this acceptable or not? Please discuss.

6. Table 5 and Fig. 3 do not seem to agree with each other in the sense that Table 5 mentions grid spacing of up to 800 m, but Fig. 3 seems to show a much denser grid. Please clarify.
7. In Table 5 it is unclear what "mesh size" means. Is that an 800m by 800m grid, for example?
8. Try other turbulence closure models, such as k-τ and k-ω. Compare and contrast results from the various turbulence closure models.
9. Give the source of values in Table 6.
10. Demonstrate that "The level drop is about 9 to 10 cm for all the cases. This number is also consistent with the results from other studies". Cite the other studies and give specific values.
11. Explain why the sudden discontinuities in Fig. 13.
12. Give the calculation procedure for the following statement: "The calculation results are shown in Table 9. For 0.5%, 1%, and 5% changes of the St. Clair River conveyance, it takes 110, 55, and 11 years to lower the lake level by 0.8 m."
13. In the discussion regarding draining time of Lake Michigan-Huron due to conveyance increases, is that assuming no new inflow to the Lake from precipitation and tributaries? If so, that should be stated. The lake would not really drop that fast if it was being replenished.
14. In the statement "In this study, since HydroSed2D is used to calculate the shear stresses on the river bed, normal flow assumption is not necessary." What is meant by "normal flow"? Do you mean uniform flow?
15. In Fig. 28, "Long Profile" is confusing. Do you mean "Longitudinal Bed Profile"?
16. The phrase "in the upstream" and similarly for downstream, would be clearer if it read "in the upstream section."
17. Typo in Section 5.2 "Figure 1Figure 30 shows the four different bed material coverage for transect TN07-03."
18. Justify the use of the Engelund-Hansen sand transport method. Why not others? Does the range of data used in its analysis match those of the St. Clair River? Compare with other models.
19. Either complete or remove the section entitled "*5.3 Glacial Till Erosion Test and Analysis* (To be finished by Jose Mier)"
20. Figure caption for Fig. 31 is repeated in the middle of a paragraph by mistake.
21. Give your basis for the critical wave height in the statement "Base(d) on the 0.5 ft wave height as the critical value for sediment movement, ".
22. Describe efforts of mesh size studies for 3D and 1D models in addition to the 2D model.
23. Justify use of Parker gravel transport method including assumptions and applicability for the St. Clair River.

Specific comments:

Legends in graphs are too small many times.

There are many grammar corrections to be made. Some follow here, but there are many others. A careful editing is needed.

1. Modify "The roughness is important since it is the parameter which defines the drag force experience by the flow." To read "The roughness is important since it is the parameter which defines the drag force experienced by the flow."
2. Modify "The roughness of the first two bends area is determined by sediment sizes based on the analysis of the under water images." To "The roughness of the first two bend areas is determined by sediment sizes based on the analysis of the underwater images."
3. Modify "The zones for roughness: (a) the whole river (b) the upstream part In each zone, the Manning's n is adjusted to match the simulated water surface elevations with the measurements." To "The zones for roughness are (a) the whole river and (b) the upstream part. In each zone, Manning's *n* is adjusted to match the simulated water surface elevations with the measurements."
4. The calibration section seems disjointed with no connected phrases telling why each equation is mentioned or how they are used in the calibration process.
5. Modify "Table 1. Roughness calculation based on sediment size distribution from images analysis" to read "Table 1. Roughness calculations based on sediment size distribution from image analysis"
6. Modify "For a large, as well as complicated, lake-river system of the Lake Huron-St. Clair River-Lake St. Clair, a decent mesh with high quality is important for the creditability of the simulation results. The mesh need to be as fine as possible to capture most of the geometry and bathymetry details." To read "For the large, as well as complicated, lake-river system of the Lake Huron-St. Clair River-Lake St. Clair, a decent mesh with high quality is important for the creditability of the simulation results. The mesh needs to be as fine as possible to capture most of the geometry and bathymetry details."
7. Modify "The reason has two folds. First, there are a lot changes around the bends (such as the big scour hole, the tongue features, and historical ship wreckages). to "The reason is twofold. First, there are numerous changes around the bends (such as the big scour hole, the tongue features, and historical ship wreckages)."
8. Modify "As shown in the shear stress analysis, the contraction from the Lake Huron to the St. Clair River makes the bottom shear stresses is highest in this area." To "As shown in the shear stress analysis, the contraction from Lake Huron to the St. Clair River makes contains the highest bottom shear stresses."
9. Modify "This might lead to the explanation of the tongue features of the sand bars and their effects in terms of conveyance. Mesh is also refined in the area of the delta in Lake St. Clair. Refined mesh is needed to well represent the narrow navigation channel which controls the water surface elevation throughout the St. Clair River." to "This might explain the tongue features of the sand bars and their effects in terms of conveyance. The mesh is also refined in the area of the delta in Lake St. Clair. A refined mesh is needed to well represent the narrow navigation channel which controls the water surface elevation throughout the St. Clair River."

10. Modify “However, the fine mesh has more double the cell number than the intermediate mesh which makes the computational time much longer. The coarse mesh (mesh ID A) seems not representing the domain and bathymetry well and it gave a result with high level of error.” to “However, the fine mesh has more than double the cell numbers of the intermediate mesh which makes the computational time much longer. The coarse mesh (mesh ID A) seems to not representing the domain and bathymetry well and it gave a result with a high level of error.”

Manuscript: Modeling of Hydrodynamics and Sediment Transport in St. Clair River

Author(s): X. Liu and G.Parker

Name of Reviewer: Colin Rennie

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.)
- *Please see detailed comments to the authors below.*

A. What is the best/most unique part of the analysis?
- *Analysis of sediment transport in the reach.*
- *Verification of the 2D model using a 3D model.*

B. What is the most critical aspect of the study/analysis? Why?
- *Obtaining a good mesh that represents the river bathymetry is the most critical component of 2D modelling. This is because 2D models directly estimate losses due to acceleration and deceleration of the flow. Unfortunately, the report provides no information on how survey data were converted to a model mesh.*

C. Which aspect of the analysis/modeling is weakest? Why? How can it be improved?
- *The sand transport across a section appears to be calculated incorrectly (see comment 6c below).*

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?
- *Please see detailed comments below.*

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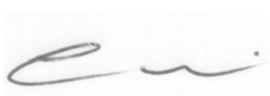
Signature: _  Date: July 31 2009

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.

Report Summary

This manuscript presents a two-dimensional numerical model study of conveyance in the St. Clair River using the in-house code HydroSed2D. The model roughness was calibrated by comparison with water levels, and model sensitivity to mesh density was tested. The model was used to estimate the change in river conveyance between 1971 and 2008, and to estimate bed shear stress throughout the model domain of the entire St. Clair River. Usefully, the model results for bed shear stress were verified by comparison to three-dimensional model results for the most important region near the river inlet.

For all flows considered, the change in conveyance was found to be such that 10 cm less Lake Huron elevation was required in 2008 than 1971 to convey the same discharge. This is comparable to the measured change in conveyance, in which about 20 cm less head was required in 2001 than in 1962 to force the same discharge in the St Clair River (Bruxer and Thompson report Figure 6-5). It appears that the 2D numerical model provides reasonable results.

The bed shear stress was then used to estimate gravel bed load transport using the Parker (1990) model, and sand transport using the Engelund-Hansen (1976) model. It was found that the river generates insufficient bed shear to transport gravel, and even sand transport is modeled to be limited. This reviewer thinks the finding that gravel transport is nearly zero is reasonable. The river has limited sediment supply, thus the river bed should be in an equilibrium clearwater scour condition. As suggested by the authors, the bed surface should be armoured, and transport of the coarse fraction unlikely.

The report concludes with some general comments about the possible influence of ice cover and ship passage on sediment transport.

In general, this reviewer found most of the methods and results to be sound. However, the detailed comments below provide suggested improvements for a few aspects of the study and the report. Comment 7c is the most serious, in that there appears to be a procedural error in the sand transport calculations.

<u>Technical Content</u>

1) Section 2.1. The authors acknowledge that the model roughness was not recalibrated when running the 1971 model. As noted in the review of the Bruxer and Thompson report, a river will adjust such that it can convey its flow and sediment load. This adjustment can occur via changes in channel gradient, channel section, and/or channel roughness. It is important, therefore, to consider simultaneous changes in bathymetry and roughness. When Bruxer and Thompson evaluated the influence of recalibrating roughness in their Addendum report. Their Table 6-11 shows a small longitudinal trend in roughness change between survey years.

2) Section 2.1.1. The roughness calibration considered only three possible sets of roughness values. Reasonable results were obtained when comparing to observed water levels. Still, further fine tuning is probably possible. Also, presumably, roughness set #1 was selected (no statement is made in the report).

3) Section 2.2 The mesh sensitivity results are not shown.

4) Section 4.2.1. The method to generate the mesh from the survey data is not described. Similarly, errors in the mesh bathymetry are not evaluated. The accuracy of the mesh is the single most important element of 2D or 3D model development. Estimates of mesh accuracy would be useful.

5) Section 4.2.3. The analysis of the influence of conveyance change on Lake Huron water level (Table 9) has assumed no change in Lake St. Clair water level. Has there been a change in Lake St Clair level?

6) There has been no attempt to estimate model errors or the significance of observed changes. While the results appear to be reasonable, an assessment of confidence intervals would be helpful.

7a) Section 5. The sediment transport modelling did not appear to utilize the routines available within HydroSed2D. Instead, sediment transport was calculated at stations distributed across a few sections, using the model output for bed shear stress. Presumably, HydroSed2D would have been able to estimate sediment transport at all model grid cells, which would have provided a full map of sediment transport. This map could be used to surmise or calculate changes in morphology. Why was this not done?

7b) Section 5.1. The coarse fraction (gravel) transport was estimated to be essentially zero using the Parker (1990) model. This result is reasonable given the relatively low bed shear stresses estimated for the reach, and the fact that low transport and a heavily armoured bed are expected for a channel with limited sediment supply. The shear stress is below critical shear stress for gravel, so it is unlikely that any bedload model would predict significant gravel transport. However, bedload computations are highly uncertain, and different models yield drastically different results. It is common practice to employ multiple models in order to overcome some of this model uncertainty. It might be useful to check transport calculations using another model, particularly if bed shear in some locations of the river exceeds local critical shear stress.

7c) Section 5.2. The criticism of the sand transport is more serious. The sand transport was estimated for a given section assuming that the entire section had a sand bed, transport was calculated for each station across the section using the local model estimate for bed shear stress, and the transport across the section was summed. The actual transport for the section was then calculated by multiplying the summed transport by the percentage of the section observed to have a sand bed (Table 14). This last step is faulty because sand is less likely to occur in locations with high shear stress, and the error is exacerbated by the fact that transport is non-linear with shear stress (see the Engelund-Hansen equation). If high bed shear were observed at a gravel bed or bedrock location in the section (a likely scenario) then very high transport would be estimated for the section, whereas actual transport could have been minimal because sand was only present in low shear areas of the channel margins. It is likely, then, that estimated sand transport rates are too high. Why wasn't sand transport estimated across the section only for locations that actually had sand bed? Nevertheless, despite this likely positive bias, total transport rates were estimated to be low.

8) Section 6.2. The influence of ice cover was considered qualitatively. It could have been possible to utilize a numerical model that considers ice cover (such as River2D).

<u>Presentation</u>

9) The manuscript could be better presented. There is no abstract, pages are not numbered, references are not sorted, figures are insufficiently labeled, and the writing could be improved.

10) Figure 3. Which mesh is this? Presumably, it is mesh C.

11) Figure 6. A colour scale is required.

12) Figure 11. Some lines in this figure are masked, which heads changes between years.

13) Figures 11, 12. The distance axis label is distance from where?