

Review of: West Consultants, July 2016, *Lake Clarke and Lake Aldred Sediment Transport Modeling*, Draft Report (In Progress) for Exelon Energy Corp. Report received via email on 1 August 2016.

Review by: Peter Wilcock, Ph.D. 12 October 2016

Review Comments

West Consultants, Inc. has developed a HEC-RAS 5.0 model of sediment transport and associated morphodynamic change for Lake Clarke and Lake Aldred. The motivation underlying the modeling is to provide information on sediment flux through the reservoirs and into Conowingo Pond.

The model was calibrated for the period 2008-2013 (which includes Tropical Storm Lee). The model was then run for the period 2008-2015 to add a two-year verification period. The last two years contained no large flows. Although the absence of high flows in 2013-2015 could be argued to provide a different flow regime useful for verification, a larger issue is that the rate of sediment transport is much larger at higher flows and no verification of model performance at high flows was possible. In the end, calibration was done for the full 2008-2015 period because “an iterative calibration process was required to further balance differences between the two periods and achieve modeled volume changes within the target ranges for both reservoirs.” The end result is a calibrated, but not verified model. A calibrated model is useful for the purposes defined in the *Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment*. In particular, the RAS model provides a physical basis for estimating sediment loadings to Conowingo Pond as a function of observed loadings at upstream gaging stations.

Calibration of the model was achieved primarily against observed changes in reservoir bed elevation. This approach was necessitated by the absence of sediment transport data at the downstream end of the model reach. The available bed elevation was limited, primarily because of the smaller number of bed observations at the earliest time period (2008). In the end, only cross sections that closely matched in space in 2008, 2013, and 2015 were used to develop the model topography. Calibration against change in bed elevation is, in fact, the most challenging and revealing basis for calibrating a morphodynamic model because successful matching of changes in bed elevation requires that all components of the model – flow, transport rate, and scour/deposition – must function well. If any part of the model is off, progressive changes in bed elevation over time will make a credible match to observations unlikely.

The selection of model parameters and functions appears reasonable and consistent. As presented, the modeled results match observed changes in bed volume remarkably well (Figures 3-9 and 3-10). However, these plots show cumulative sediment volume change summed over each reservoir as a whole, combining the scour and deposition of all individual reaches. When the cumulative sediment volume changes are examined for individual modeled reaches, the agreement is less good. The modeled change in bed volume falls outside of the estimated range of observed bed volume change in nine of 18 cases (nine modeled reaches for two time periods; Tables 3-1 and 3-2). That is, although the estimated sediment volume change in half of the modeled reaches falls outside of the observed range, positive (deposition) and negative (scour) errors tend to offset such that the overall sediment storage in each reservoir matches very well.

Application of the model as a predictive tool requires an understanding of whether the close balance between positive and negative error observed over the modeled period of 2008-2015 is likely to occur under different conditions. A reliable forecast of sediment storage and release for each reservoir as a whole is sufficient for using the RAS estimates to drive forecasts of input to Conowingo Pond. But how can one be sure that the positive and negative errors at the reach scale will continue to cancel under

forecast conditions? The patterns and mechanisms of the discrepancy between modeled and observed sediment volume change is worth more careful examination in order to evaluate the forecast ability of the RAS model.

The model calibration is based on sediment volume change defined over bed areas between cross sections at which elevation change could be measured. A related but different model test would be to show the predicted vs observed bed elevations for the actual model sections. This is the actual information available to match to the model. To be precise, the model uses bathymetry developed from a “set of common cross-sections … based on those with good spatial agreement between the USGS survey and model datasets and the Gomez and Sullivan bathymetry data.” It would be useful to develop plots for each of these cross-sections, with each plot showing both observed and predicted bathymetry for all three time periods (2008, 2013, 2015).

Response to Review Questions

1. Is the modeling approach reasonable and credible to satisfy the goals defined in the *Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment?*

The calibrated model is useful for the purposes defined in the *Proposal for Lower Susquehanna River Reservoir System Model Enhancements in Support of the 2017 Chesapeake Bay TMDL Midpoint Assessment*. In particular, the RAS model provides a physical basis for estimating sediment loadings to Conowingo Pond as a function of observed loadings at upstream gaging stations.

2. Does the Lake Clarke/Lake Aldred HEC-RAS Model (HEC-RAS Model) provide added value to the information available to the EPA Chesapeake Bay Program and the State of Maryland? Does it inform and advance the current science and understanding of the Lower Susquehanna River Reservoir System?

The HEC-RAS model is the best effort yet to capture the response of Lake Clarke/Lake Aldred to water and sediment supply. The spatially integrated patterns of sediment scour and deposition have an excellent match to observations. This is an important advance in understanding the sediment storage behavior of the Lower Susquehanna River Reservoir System.

3. Given the data which were available to the modelers, evaluate the model results, input parameters, and modeling assumptions made to determine if the models perform reasonably.

The documented assumptions, parameter values, and function selection are within reasonable bounds. The model appears to function in a credible fashion.

4. Are the modeling outputs developed under this study appropriate to help inform or guide the suite of Chesapeake Bay Program models (i.e. the Watershed Model and Water Quality and Sediment Transport Model)?

The model provides reasonable predictions of the change in bed sediment storage. This is the appropriate information needed link upstream water and sediment input to the sediment delivered to Conowingo Pond.

5. While keeping the goals of the study in mind, could the models and outputs be improved? If possible, please identify specific areas of potential improvement (e.g., model input datasets/parameters, modeling assumptions, process description, other modeling systems or programs, etc.).

(1) Further exploration of model results would be useful for developing confidence in the ability of the model to forecast future conditions. Although the model shows an excellent agreement between predicted and observed bed volume change integrated over each reservoir, predicted and observed bed volume change does not match for half of the modeled reaches. A better understanding of the discrepancy between predicted and observed at the scale of local model reaches would be useful for evaluating model performance under future conditions.

(2) The HEC-RAS model predictions have uncertainty. A basis is needed for propagating that uncertainty into the model for the Conowingo Pond. How will that be done?

(3) A better explanation is needed for some of the calibration adjustments discussed in the text:

Overall, the model initially under predicted deposition for the system as a whole, though results varied by sub-area. To increase deposition, ***the sediment loading at Marietta was increased by 20-30% at various flows***. This resulted in loading values still well within the range of scatter in the observed loading, and matched the HEC-6 input values (Hainly, et al., 1995) very closely for several flows.

prw: Although within the range of scatter, not all changes to the sediment loading may be plausible. A plot of the Marietta sediment loading actually used would be useful for review.

Finally, ***hybrid bed gradations were created for many cross-sections, with the percent clay and cohesive parameters adjusted to promote or resist scour***. The changes were relatively small: increases or decreases in clay composition of less than 4% of the total sample, and cohesive parameters limited to the range measured in the SEDFLUME analysis of Conowingo sediments

prw: small changes in clay composition or cohesive parameters can have a large effect on transport or scour. The nature of the “hybrid” bed gradations and the adjustments in percent clay and cohesive parameters is needed.

End of Review



Peter Wilcock
12 October 2016