Wekiva Basin HSPF and HEC-RAS model preliminary review comments

George McMahon, Ph.D., PE, D.WRE, PH, Arcadis

Yi Zhang, Ph.D., PH, Arcadis

October 19, 2018

HSPF model:

1. The calibration period for the HSPF model was 2003 – 2012, but the model was not validated – as is normally the case – using a different (non-overlapping) period of analysis. The model simulation period was 2001 – 2016, 60 percent of which comprised the calibration period. Consequently, the model's accuracy over a longer period of record and a full range of hydrologic conditions period has not been verified.

2. The model should be verified for hydrologic conditions ranging from severe drought to high floods that have historically been experienced over a long (i.e. statistically-significant) period of record, i.e. several decades.

3. Statistical analysis of long-term mean aerial precipitation (MAP) data over the Wekiva Basin would be useful to identify where the simulation and calibration periods (2001-2016 and 2003-2012, respectively) rank in terms of long term climate cycles and hydrologic extremes. Figure 1 below shows wetter summers (June – September) on average during the 2001-2016 model simulation period (red line) than throughout the 1914-2016 precipitation record (blue line). Overall, average annual precipitation during the simulation period is also slightly higher (about 1.5%) than over the full period of record.

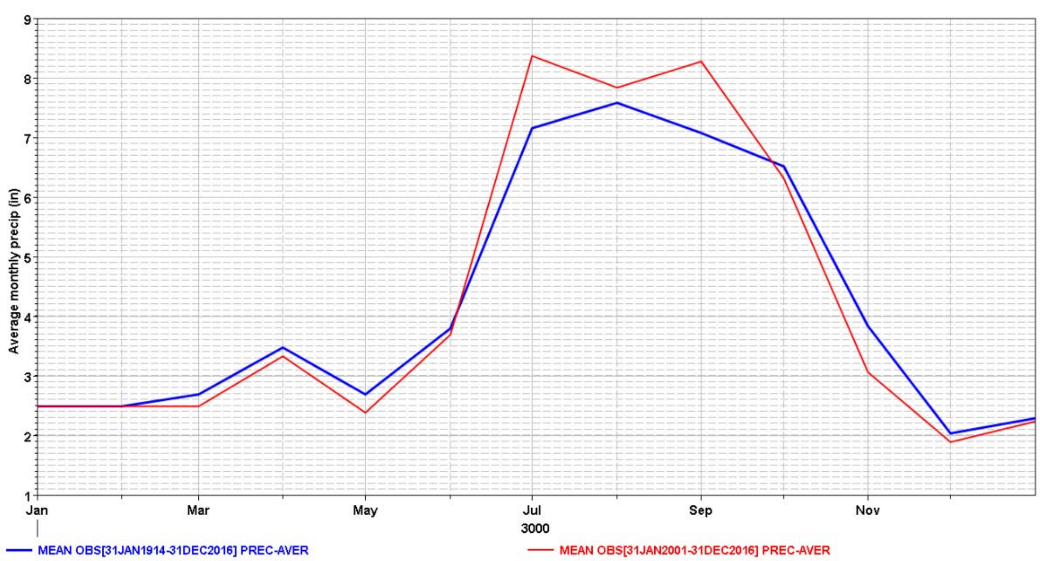

Figure 1: Mean monthly precipitation for the 1914-2016 period of record (blue line) and the 2001-2016 HSPF model simulation period (red line)

4. Sixteen years is not a long period of analysis for derivation of unbiased streamflow statistics (frequency and duration) representative of historical hydrology, and consequently MFLs derived based on these statistics may not be realistic. As previously described, daily precipitation records at the rainfall gages applied in the model date back to 1914, potently allowing (depending on other observed or synthesizable data that potentially could be developed) for simulation of more than 100 years of daily flows and stages as the basis for MFLs.

5. Municipal water withdrawals from surface or groundwater were not mentioned in the Draft Report nor found in model input. Moreover, it is not clear whether the HSPF model accommodates any consumptive water uses other than irrigation. Under low flow conditions, well withdrawals by municipalities including OUC, Orange County, Seminole County, and Winter Springs can be significant, which could affect model calibration and accuracy of simulation results. Failure to account for large well withdrawals could lead to over-simulation of flows and levels and unrealistically high MFLs, which could become increasingly difficult to achieve with growing water demands and non-stationary climate.

6. While point-source discharges were mentioned in the Report, we were unable to confirm whether they were included in the model and the calibration process. Annual average discharge was mentioned, but seasonal variation, which could affect model calibration and simulation results during low flow periods, was not. Figure 1 above, for example, suggests that water demand could be lower during the wetter summers of the 2001-2016 simulation period than could otherwise be expected based on the 103-year historical record.

7. Groundwater – surface water interaction was not discussed in the Report nor were groundwater parameters, other than deep percolation, appear to be considered in the calibration process. Upper and lower zone storage interaction with surface water is significant during low-flow periods and will affect MFL calculation. Only surface water parameters (principally flows and stages) were displayed in the Draft Report.

8. Annual rainfall time series data for the Sanford Gage used in the HSPF model appear to be missing from Figure 6 of the Draft Report.

9. Based on guidelines shown in Table 10, performance measures shown in Table 11 predominantly fall in the 'satisfactory' category, with very few falling in the 'good' or 'very good' categories, and with the 'Near Apopka' location showing unsatisfactory results for daily and monthly flows. The subsequent assertion that the model "performed well" is therefore debatable. More importantly, the authors do not investigate sources of error other than for the Apopka location. Given that Table 11 presents flow statistics, it seems plausible that omission of large municipal water withdrawals, and lack of calibration of ground-surface water interactions could be sources of systemic error or bias. Coupled with the short simulation period relative to the historical precipitation record, there appears to be significant uncertainty in model simulation results and resulting MFLs, sources of which should be estimated. One method for identifying sources of uncertainty would be stepwise regression of monthly model inputs and outputs. Another approach would be to compile and analyze statistics on a seasonal as opposed to simulation period basis.

10. The flow duration curve at SR46 plotted in Figure 23 shows simulated flows to be consistently higher than observed flows up to the 10% exceedance level (high flows). This observation carries through to the unsteady-flow HEC-RAS model simulation results displayed in Figures 42 – 47, suggesting that sources of bias should be examined including those identified above, including omission of large municipal groundwater withdrawals, poor simulation of surface-groundwater interaction, over-simplified channel routing, and/or that HSPF model calibration could be improved.

HEC-RAS models:

1. Channel routing in HSPF appears to be limited solely to storage routing, without consideration of relationships between lag, storage, channel slope and other parameters affecting hydrograph shape as it moves downstream. These variables are, however, incorporated in other widely-used hydrologic models employing lumped and semi-distributed routing techniques, e.g. Muskingum, Muskingum-Cunge, Lag and K, variable Lag and K, etc. While an unsteady-flow HEC-RAS model was developed for Wekiva River hydraulic routing, the Draft Report indicates that it was only applied over a 6-month period in 2009 – a small fraction of the 2008-2016 period displayed in Figure 40 and an even smaller fraction of the full 17-year simulation period. The Report does not indicate whether or how the unsteady-flow HEC-RAS model results may have been applied to HSPF streamflow simulation. The implication is that the steady and unsteady RAS models were developed and calibrated primarily for derivation of river stage-discharge relationships (rating curves), rather than as a means of routing of river flows simulated by HSPF.

2. While cross sections surveyed ROK2 and ROK3 in the 1990s and in 2013 are similar in terms of channel width, invert and bank elevations, differences in floodplain areas appear to be significant. Consequently, more comparison at different locations should be made to determine if the 1990s surveys can still be used with confidence or if new surveys are needed and cross sections generated at different locations than currently. Twenty-year old surveys would normally be considered outdated for accurate unsteady-flow modeling.

3. Flow exceedance curves displayed in Figure 33 of the Draft Report compare simulated and observed flows from 2008 through 2016. However, observed data at SR46 are available from 1986 to the present. The steady-state HEC-RAS model could easily be applied in a quasi-unsteady (repeated backwater profiles) mode to generate a flow-duration curve for a 30-year simulation period from 1986-2016, and a greater range of historical high and low-flow conditions.

4. As previously recommended for the HSPF model, the HEC-RAS model should be validated for high and low flow events outside the 2003-2012 calibration period.

5. At some locations, simulated stages exceed cross section boundaries, necessitating extension of cross sections horizontally and vertically at these locations for accurate simulation results.

6. The Draft Report does not present statistical comparisons of simulated and observed river stages for the steady-state HEC-RAS model, as presented in Table 17 of the Draft Report for flow and stages simulated by the unsteady-flow model. The discussion in Section 4.3.3 of the Draft

Report should be expanded to characterize goodness of fit, identify potential sources of error represented in Table 17, and biases exhibited in Figures 42 – 47, analogous to the discussion recommended above for Table 10 relating to HSPF model simulation results.