CHAPTER 3: WATERSHED HYDROLOGY
APPENDIX 3.C: USJR POSTPROCESSING OF SIMULATED FLOWS AND STAGES

The simulated average daily reach flows at the Cocoa (Reach 37 in the HSPF model) and Christmas (Reach 41) gauges were adjusted at low flows, providing a better match to the observed data at these gauge stations. Observed and simulated data were taken from the calibration period of the model, 01 January 1995 to 31 December 2006. The flow at which the observed and simulated flow-duration curves began to exhibit increasing differences was chosen as a break point. Only flows below this point were used in the adjustment process. These flows were 1320 cfs and 1380 cfs for Cocoa and Christmas, respectively. For each set of flows below the break point, a plot of observed versus simulated data was developed. A curve was fit to each plot using MS EXCEL 2007.

Cocoa (Reach 37), $R^2 = 0.9995$:

$$\text{Obs}=1.0943\times10^{-12}x^5 - 3.8721\times10^{-9}x^4 + 5.0991\times10^{-6}x^3 - 2.8986\times10^{-3}x^2 + 1.5852x - 83.927 \quad (1)$$

Christmas (Reach 41), $R^2 = 0.9992$:

$$\text{Obs}=2.9557\times10^{-12}x^5 - 1.0091\times10^{-8}x^4 + 1.2199\times10^{-5}x^3 - 6.0488\times10^{-2}x^2 + 2.0095x - 130.86 \quad (2)$$

where

x = the corresponding simulated model flow

APPLICATION OF POSTPROCESSING EQUATIONS TO UNGAUGED REACHES

Postprocessing was applied to main stem reaches of the USJRB downstream of the Lake Washington weir. These included reaches 33, 34, 35, 36, 37, 40, 41, 42, and 43. For Reaches 33 to 36, the difference between the raw value and the adjustment using the Reach 37 equation was multiplied by a flow-specific ratio and subtracted from the raw value. That ratio was then calculated by dividing the raw value of the reach by the flow duration equivalent for Reach 37. For Reach 36, given the small difference in average flow for the period of record (876 versus 879.8 cfs), the equation for Reach 37 was used directly for adjustment. For Reach 40, a ratio of 0.485:0.515 was applied between the equations for Reaches 37 and 41, respectively, for all flows below 1320 cfs. For flows between 1380 and 1320 cfs, that same ratio was applied using the raw flow value of Reach 40 and the equation for Reach 41. For Reaches 42 and 43, the equation developed for Reach 41 was used directly to adjust the flows.

Additionally, five locations (environmental transects) were added that were not present in the model. Three of these, Tosohatchee 528, Great Outdoors, and Tosohatchee North, were between the outlets of Reaches 40 and 41. The other two, Lake Cone and H-1, were between the outlets of Reaches 41 and 42. For these points, flows were interpolated from adjusted flows of the nearest reaches. The interpolation ratios were developed by the river distance between the added site and closest reach flow points. The ratios of Reaches 40 and 41 flows for Tosohatchee 528 were 0.9:0.1, for Great Outdoors they were 0.53:0.47, and for Tosohatchee North were 0.22:0.78. The ratios for reaches 41 and 42 flows for Lake Cone were 0.6:0.4, and 0.12:0.88 for the H-1 site.

After adjusted time series had been calculated for all the reaches, flow duration curves were developed for use in a HEC-RAS model. This process was repeated for every scenario being studied so that results between scenarios remained relative.

The HEC-RAS model used to develop rating curves at the environmental transects was developed from the minimum flows and levels (MFLs) model of the USJRB from State Road (SR) 46 to Fellsmere Grade. This model has primarily been used and calibrated for MFLs from SR 46 to SR 520. However, for the WSIS the model was used from SR 46 to the Lake Washington weir and had many more flow changes through these reaches than the original model. This caused elevations to be 0.2 to 0.5 ft higher than the original model and up to 1 ft higher than the observed data. This was considered a poor calibration for this data set, so a recalibration of the model was performed calibrating similar duration-flow events to similar duration-stage events. More detailed flow changes needed for the WSIS were included in the recalibration of the HEC-RAS model.

To run the HEC-RAS model starting at SR 46, starting stage and flow values were estimated at SR 46 and at the reaches discussed in the previous section. These starting stage and discharge data were estimated from an observed stage and discharge duration analysis at SR 46.

A stage and duration analysis was also done for the St. Johns River at SR 50 and at SR 520 to develop the flow and discharge data set needed to calibrate the WSIS HEC-RAS model. These actual flows were used for these reaches of the model. However, discharge data needed to be estimated for the additional reaches in the model where flow changes occurred.

The data for SR 50 and SR 520 were plotted against the postprocessed data developed from the HSPF model. A curve was fit to the data, but due to the pattern of low flows, two curves were needed. The data was divided separating the lowest 60% of flows from the highest 40%. For SR 50 this cutoff was 1017 cfs, and for SR 520 it was 756 cfs. Using MS EXCEL 2007, curves were fit to the high and low data for each set of flows.

SR 50 Low, $R^2 = 0.9986$:

$$\text{Obs} = 6.8269 \times 10^{-9}x^4 - 1.1747 \times 10^{-5}x^3 + 5.9207 \times 10^{-3}x^2 + 0.50487x + 13.148 \quad (3)$$

SR 50 High, $R^2 = 0.9965$:

$$\text{Obs} = 4.3534 \times 10^{-11}x^4 - 5.5918 \times 10^{-7}x^3 + 2.3513 \times 10^{-3}x^2 - 2.5951x + 2002.3 \quad (4)$$

SR 520 Low, $R^2 = 0.9968$:

$$\text{Obs} = \mathbf{1.3131 \times 10^{-8} x^4 - 1.7974 \times 10^{-5} x^3 + 7.3684 \times 10^{-3} x^2 + 0.37545 x + 21.520} \quad (5)$$

SR 520 High, $R^2 = 0.9961$:

$$\text{Obs} = \mathbf{4.4657 \times 10^{-11} x^4 - 5.2781 \times 10^{-7} x^3 + 2.0736 \times 10^{-3} x^2 - 1.8646 x + 1361.6} \quad (6)$$

where

x = the corresponding simulated model flow

For flows at Lake Winder and Reach 34, the equations for SR 520 were applied directly to the appropriate flow percentile. For SR 528, Tosohatchee 528, Great Outdoors, and L-7, the low flow equations were used directly by interpolating the equations for SR 50 and SR 520. The high flow equations were used in the same fashion for all but the first and fifth percentile estimates. A direct interpolation of the observed data provided a more reasonable result for those flows. For M-6, H-1, Reaches 42, and 43, the SR 50 equations were used directly in all but the first and fifth percentile estimates. A direct interpolation of the SR 50 data and SR 46 data was used for those estimates.

The calibration of flows for the HEC-RAS model was done primarily by changing the Manning's roughness coefficient for reaches along the river from SR 46 to the Lake Washington weir. In addition, cross sections were interpolated for the reaches upstream and downstream of the H-1 cross section. This interpolation was needed for model stability in these reaches. Primarily the model was calibrated to the observed stage-duration analysis at SR 50, SR 520; an additional stage-duration analysis for stage data at Lake Winder was completed to help calibrate the reach between SR 520 and Lake Winder. In addition, the original flows and levels at points in between the observed data were used as guidelines for these additional cross sections in the model. This was done as a best-fit calibration using a single set of coefficients for high and low flow data instead of calibrating individually for high and low flows.

HEC-RAS was used to develop a rating curve of flows and stages at each of the eight cross sections (H-1, M-6, SR 50, Tosohatchee North, Great Outdoors, Tosohatchee 528, SR 520, and Lake Winder) being analyzed. These rating curves were then used to develop daily stage data at each location from the adjusted discharges at these locations.