SJRWMD and SWFWMD Responses to Technical Peer Review Comments Regarding the Preliminary Models and Model Report for the Central Springs Groundwater Flow Model (CSM) version 1.0

January 31, 2024

Introduction

Independent technical peer review was conducted for the preliminary models and model report of the Central Springs Groundwater Flow Model (CSM) version 1.0 by Dr. Louis Motz, PhD, PE, and Mr. Patrick Tara, PE. This resolution document provides responses to the final submitted technical peer review comments (Appendix A).

Technical Peer Review Comments and Responses

Comment*: Use the Model Summaries in Groundwater Vistas to indicate the numbers of each of the boundary cells in the Model Boundary Conditions in Chapter 3.*

> **Response:** The total number of wells and constant head boundary, general head boundary, no-flow boundary, river, and drain cells in the CSM was added to the text in Chapter 3 of the final CSM report. In addition, the number of grid cells (total and active) was added to text in Chapter 2.

Comment: *The calibration results shown in Figures 5-17, 5-19, 5-21, 5-23, 5-27, and 5-28 should also be presented in histogram plots that indicate the mean residuals, root mean square error, and number of values (n) used in the analyses.*

> **Response:** Groundwater head, vertical head difference, and springflow residual histograms for the steady-state model were added to Chapter 5 of the final CSM report and groundwater head residual histograms for the transient model were added to Chapter 6.

Comment: *Eliminate Apparent Model Errors in Groundwater Vistas concerning zero conductances, stages below bottom layer, and nearly 1,000 river stages < 0.*

> **Response:** RIV, DRN, and GHB cells with zero conductance were modified to reasonable values. Cell locations where the CHD head value was less than bottom elevation were converted to active cells. There were no remaining error messages in Groundwater Vistas except "Starting heads in layer x are below the bottom of the layer", which is expected. Staff did not feel it was necessary to include this response in the CSM report, however, it is memorialized in this resolution document. The measured water level (NAVD88) in some locations of St. Johns River and lagoon areas were less than 0 at some stress periods, this is why the river stage < 0 in those cells.

Comment: *There are relatively large numbers of flooded and dry cells in Figures 6-13 and 6-14. Revised Figures 6-13 and 6-14 in the draft final report indicate a significant reduction in flooded cells but no significant change in dry cells (only the color for dry cells has been changed from red to brown). In the draft final report (p. 142), it is indicated that the conductances for rivers, lakes, and wetlands were adjusted seasonally in the transient model. This requires further explanation, i.e., what is the basis for seasonally* *adjusting conductances. Conductances are a physical property of the porous media the water is flowing through. Instead of adjusting boundary condition conductances, maybe other variables such as river and lake stages should be adjusted to achieve the reduction in the numbers of flooded cells.*

Response: To address concerns regarding the seasonal adjustment of conductance values, the following text was added to Chapter 6 of the final CSM report: "The conductance of rivers, lakes, and wetlands was adjusted seasonally in the transient model based on the seasonality of the recharge. The seasonally adjusted conductance accounts for the geometric variations of rivers, lakes, and wetlands during the wet and dry season. For each RIV/DRN cell, monthly recharge ratios were computed by dividing the recharge in that month by the average recharge value across the entire simulation period. Subsequently, the conductance of the river and wetland cells was adjusted based on the respective recharge ratio in each cell." River and lake stage varied in the transient model based on the available measured data.

To address concerns regarding dry cells, the following text was added to Chapter 6 of the final CSM report: "Areas in which layer 1 is dry generally correspond to regions where the SAS and/or ICU are thin or completely absent. The large areas of dry cells in the western part of the model domain were expected as the UFA in this area is unconfined and the water table can be greater than one hundred ft below land surface. Model-simulated mean depths-to-water table were compared to observed well data (Figure 6-18). The transient simulation compared favorably to the observed data, indicating a deep water table along the Brooksville Ridge and ridges in the Orlando area."

Comment: *Water balances in new Tables 5-8 and 5-9 in the draft final report satisfactorily indicate that fluxes associated with CHD and GHB have been reduced and that recharge and ET are relatively larger in the water budget. However, questions remain about whether the River/Lake boundary conditions should be in Layer 1 (surficial aquifer) and whether springs should be in Layer 4 (Ocala Limestone/upper Avon Park Formation). At a minimum, discussion for these decisions should be provided in the final report.*

Response: In response to concerns regarding the river and lake boundary conditions, the following text was added to Chapter 3 of the revised report: "All river cells were assigned to layer 1 of the model. The decision was made based on the comparison of RBOT with the layer 1 bottom elevation. It was noted that a direct hydraulic connection existed between several rivers (e.g., Withlacoochee River and Hillsborough River) and the UFA within the model domain. The exchange between aquifer and river cells was jointly simulated through the conductance of river cells and vertical leakance of the groundwater cells." "All lake cells were assigned to layer 1 within the model based on the analysis of lake bathymetry and the bottom elevation of model cells. It was noted that many lakes in the central Florida area had a direct connection to the UFA and the flow exchange between lake and aquifer was simulated in the model through the river package and vertical interlayer flow."

In response to concerns regarding the spring boundary conditions, the following text was added to Chapter 3 of the revised report: "All spring cells were assigned to layer 4 based on the assumption that the springs in the region were hydraulically connected to the high permeability zone of the UFA."

Comment: *The District's presentation displays spatial plots of the simulated fluxes slides 45 to 58 depict the simulated fluxes for various model components for the steady-state simulation. These plots could be helpful for the transient simulation. As previously mentioned, these results should be presented in the final report.*

Response: Steady-state and transient model boundary condition flux and flux between model layers are provided as figures in Appendix B and Appendix C.

Comment: *What are spatially averaged values for rainfall, actual ET, potential ET, and HSPF spatially-averaged annual recharge rates, maximum saturated ET, and extinction depth?*

Response: A figure showing 2005 to 2018 average annual potential ET as well as figures showing 2005 to 2018 average annual HSPF-derived recharge and maximum saturated ET were added to Chapter 3 of the revised report. Spatially averaged values of rainfall, actual ET, potential ET, HSPF-derived recharge, HSPF-derived maximum saturated ET, and ET extinction depth were added to the text in Chapter 3.

Comment: *In Figure 5-13 it is difficult to interpret the comparison between the APT and calibrated transmissivity results. This can be resolved by plotting the values for UFA transmissivity from the PEST calibration (x coordinates) versus the results from the aquifer performance tests in the corresponding cells (y coordinates). Please refer to NFSEG (Durden et al. 2019) Figure 4-85 for an example.*

Response: A scatter plot of modeled UFA transmissivity versus normalized UFA transmissivity values from aquifer performance tests was added to Chapter 5 of the revised report.

Comment: *The segmental baseflows needs more introduction in the text. The report currently directs the reader to Appendix H with a single sentence. More detail is necessary to educate the reader as to what they are seeing. This added detail will differentiate Appendix G from Appendix H.*

Response: Introductory text was added to Chapter 6 and Appendix J explaining segmental (pickup) baseflow.

Comment: *Some of the "Observed" peaks seem very high for baseflow. The peak "Estimated Maximum" baseflow mimics the total streamflow hydrograph. There is a large degree of variability between the Max and Min Baseflow. The target does not constrain the parameter estimation. This combined with a binary penalty function, must lie within the max and the minimum, causes issues within PEST. PEST works best with functions with derivatives instead of binary functions (Using PEST EIS can help dramatically).*

Response: Additional text was added to Chapter 4 and Chapter 6 of the final CSM report to address uncertainty associated with baseflow estimates and the decision to utilize baseflow as qualitative targets during model calibration. Baseflow can't be adequately measured in the field, therefore a range of baseflow estimation methods were utilized in the CSM calibration effort to estimate total baseflow at each stream gaging station. These methods generally produce a wide range of estimates that increase uncertainty in the true baseflow value. There are also several issues that can affect the quality of derived baseflow estimates, including periods of missing data, difficulty in estimating daily values because of rating curve uncertainty, complexity of hydrogeologic conditions near a stream gaging station, or by regulation of surface flows. Estimation of baseflow target values can also be difficult and less accurate when extremely high flows occur during a period of interest. Variations in flows during extremely high conditions can be more difficult to estimate because the inundated cross section of the river is much greater under these conditions, so small levels of uncertainty in the river stage can be associated with larger levels of flow uncertainty. In addition, under highly unsteady conditions, river flows often become more difficult to estimate with stage discharge ratings because the water surface slope (and energy gradient) varies with the passage of the flood wave. Even in the absence of extreme conditions or conditions that pose challenges for estimating flow records, baseflow estimation is commonly subject to high levels of uncertainty. ASTM document, D5981/D5981M-18, (ASTM 2018) notes that "… baseflow estimates are generally accurate only to within an order of magnitude." The uncertainty associated with baseflow estimates provides justification for the decision to utilize cumulative baseflow estimates as qualitative targets in the CSM calibration effort. PEST was not used for baseflow calibration.

Reference: [ASTM] American Society for Testing and Materials. 2018. *Standard guide for calibrating a groundwater flow model application*. ASTM International, West Conshohocken, PA.

Comment: *One example of the need for segmental baseflow analysis is the Floral City-Inverness and Inverness-Holder. Notice the Floral City-Inverness simulated baseflow peaks at about 500cfs with a median of 160cfs (Appendix H pg. 12). While the Inverness-Holder simulated baseflow only peaks at 190cfs with a media of 90cfs. Therefore, an additional 400cfs are available at peak conditions and at median conditions, nearly an additional 70cfs are available.*

Response: The baseflow in the segment between Floral City and Holder is impacted by the series of controlled structures on the Tsala-Apopka Chain of Lakes. Such controlled flow is not explicitly simulated in the CSM (a groundwater only MODFLOW model). The baseflow simulated in the CSM is a rough estimate of the groundwater exchange with the surface water and does not include other processes contributing the river baseflow. Further analysis of surface water flows is needed to determine the hydrological processes impacting segmental baseflow.

Comment: *There seems to be an issue with the graphics in the draft final report and the ShinyApp hydrographs. The dark blue point in the report graphic to the right (depth to water) is shown identified in the ShinyApp on the left. The dark blue color designates water above land yet the hydrograph does not seem to represent water above land issue. It is possible that the cell average topography is erroneously depicting water above land?*

Response: The depth to water at the dark blue color dot was calculated using average topography of that model cell, where the land surface elevation of the well should be used. This was corrected and the simulated versus observed depth to water figure (Figure 6-18) was updated in Chapter 6 of the revised report.

Comment: *The baseflow hydrographs for Tomoka River near Holly Hill and Econ near Chuluota depict nearly zero baseflow. This condition seems to either represent very low conductance for the boundary conditions (all upstream river cells) or that heads in the river cells are identical to heads in the aquifer.*

Response: The baseflow hydrographs for the Tomoka River near Holly Hill and the Econ near Chuluota indicate a low average baseflow, approximately 0.1 cfs and 8.8 cfs respectively, over the model simulation period. The two gauges are located on tributary streams with relatively small drainage area. While it is true that simulated baseflow at both gages is below the minimum estimated baseflow, this is considered acceptable for a regional groundwater flow model due to the uncertainty associated with baseflow estimation. Additionally, predictive uncertainty analysis will enable the Districts to quantify the uncertainty associated with predictions of baseflow using the model.

Comment: *The Ocklawaha River near Ocala overestimates negative baseflow. The negative baseflow condition persists for more than 50% of the time with an average magnitude of nearly 100cfs. The sign* *convention depicts discharge from the aquifer to the river as positive. Therefore, the negative baseflow condition of nearly 100 cfs for a majority of the simulation shows the aquifer is receiving water.*

Response: The negative simulated baseflow at the Ocklawaha River, depicting discharge from the aquifer to the river, appears to be isolated at the Ocklawaha River near Ocala, FL gage (02339000). Other stream gages on the Ocklawaha River utilized in the calibration effort, including the Ocklawaha River near Conner, FL (02240000) and Ocklawaha River at Eureka, FL (02240500) resulted in simulated baseflows that were within the range of estimated baseflow values over the model simulation period as well as in good temporal agreement between estimated and simulated baseflow over the model simulation period. Additionally, the time series of HSPF-calculated baseflow (AGWO) generally compares favorably to the MODFLOW simulated baseflow in the Ocklawaha Basin as illustrated in Appendix J (HUC 03080102). Staff reviewed the area of the northern Ocklawaha River basin in the vicinity of Lake Weir and agree with the reviewers that this area should be improved in the next version of the model. Additionally, predictive uncertainty analysis will enable the Districts to quantify the uncertainty associated with predictions of baseflow using the model.

Comment: *Comparing the water balance terms to the HSPF simulation results compares well for many of the basins. However, for the Ocklawaha basins there is a significant departure between the simulated MODFLOW ET and the HSPF simulated ET. This departure is significant and represents 5 inches over the basin.*

Response: The CSM is a groundwater only model. The recharge and maximum ET inputs to the model were calculated using independent HSPF models. The dynamic interaction between surface water and groundwater was not explicitly simulated. A substantial effort was made by the modeling team to maintain the mass balance between the HSPF and MODFLOW models. There is a noticeable discrepancy in the simulated groundwater evapotranspiration between HSPF and MODFLOW in a limited number of basins. The Districts are committed to investigating the sources of the discrepancies and improving the representation of groundwater evapotranspiration in a future version of the model.

APPENDIX A – TASK D FINAL PEER REVIEW OF CSM V1.0 FINAL DRAFT REPORT (OCTOBER 2, 2023) DOCUMENTATION AND CALIBRATION[1]

[1]Included in *Final Peer Review of Central Springs Groundwater Flow Model Version 1.0 (CSM v1.0)* submitted to the St. Johns River Water Management District by Dr. Louis H. Motz, Ph.D., P.E., D.WRE., and Patrick Tara, P.E., on November 20, 2023.

Task D Final Peer Review of CSM v1.0 Final Draft Report (October 2, 2023)
Documentation and Calibration

Review Comment Resolutions From Task C

The peer review comments submitted to SJRWMD/SWFWMD on 6/27/2023 are listed in the table below. Each review comment in the first column is defined by the original slide number from the Task C submittal. The original comment is described in the second column. The third column states whether the comment was addressed, and the fourth column is a response to the resolution.

Peer Review Comment Slide #	Review Comment	Comment Resolved?	Resolution Response
	Overall Comment for the "Central Springs Model Draft Final Document"	Not Completely	The District's slide presentation dated October 2, 2023, which contains 95 slides, responded to review comments. In the District's slide presentation, there are references to specific slides numbers from the review presentation (dated 6/27/23). It is essential that the responses in the District's slide presentation are incorporated into the final report.
3	Will the transient calibration statistical results for the 410 SA monitoring wells, 584 UFA monitoring wells, and 39 LFA monitoring wells in chapter 6 be archived in an appendix?	Yes	The draft final report includes charts in the appendices that adequately document the calibration hydrographs.
4	Use the Model Summaries in Groundwater Vistas to indicate the numbers of each of the boundary cells in the Model	Not Completely	The model summary shown in slide 14 in the District's slide presentation dated October 2, 2023 needs to be included and discussed in the final report.

Peer Review Comment Slide #	Review Comment	Comment Resolved?	Resolution Response
	Boundary Conditions in Chapter 3		
5-7	The calibration results shown in Figures 5-17, 5-19, 5-21, 5-23, 5-27, and 5-28 should also be presented in histogram plots that indicate the mean residuals, root mean square error, and number of values (n) used in the analyses.	Not Completely	This can be achieved by including in the final report the corresponding slides in the District's slide presentation dated October 2, 2023. The slides with histograms for vertical head differences and springflows also should be included in the final report.
8	Eliminate Apparent Model Errors in Groundwater Vistas concerning zero conductances, stages below bottom layer, and nearly 1,000 river stages < 0	Yes	The model conceptualization response in slide 9 in the District's slide presentation dated October 2, 2023 should also be included in the final report.
9-11	There are relatively large numbers of flooded and dry cells in Figures 6-13 and 6-14.	Not Completely	Revised Figures 6-13 and 6-14 in the draft final report indicate a significant reduction in flooded cells but no significant change in dry cells (only the color for dry cells has been changed from red to brown). In the draft final report (p. 142), it is indicated that the conductances for rivers, lakes, and wetlands were adjusted *seasonally* in the transient model. This requires further explanation, i.e., what is the basis for seasonally adjusting conductances. Conductances are a physical property of the porous media the water is flowing through. Instead of adjusting boundary condition conductances, maybe other variables such as river and lake stages should be adjusted

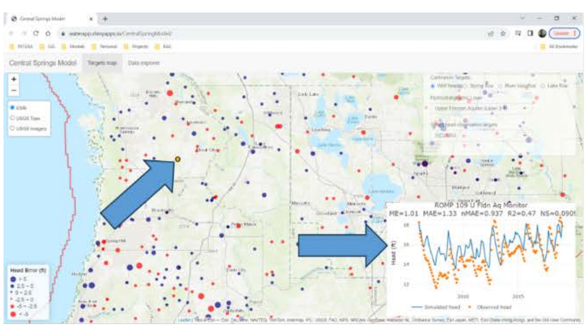
Peer Review Comment Slide #	Review Comment	Comment Resolved?	Resolution Response
			to achieve the reduction in the numbers of flooded cells.
12	"GHB's are regarded as no-flow boundaries" is contradicted by relatively large GHB fluxes in Tables 5-7 and 5-8 in draft interim report.	Yes	Fluxes for GHB's are significantly reduced in Tables 5-8 and 5-9 in the draft final report. Fluxes for CHD's are also reduced in Tables 5-8 and 5-9 in draft final report.
13-14	Are fluxes in CHD and GHB boundaries excessively large in Tables 5-6 and 5-7? Are all fluxes for River/Lake boundaries correctly placed in Layer 1? Should springs discharge from layer 4?	Not Completely	Water balances in new Tables 5-8 and 5-9 in the draft final report satisfactorily indicate that fluxes associated with CHD and GHB have been reduced and that recharge and ET are relatively larger in the water budget. However, questions remain about whether the River/Lake boundary conditions should be in Layer 1 (surficial aquifer) and whether springs should be in Layer 4 (Ocala Limestone/upper Avon Park Formation). At a minimum, discussion for these decisions should be provided in the final report.
15	Is there pumping from layer 7?	Yes	Pumping was moved to layer 6.
16	Plot a map of CBC flow rates for constant head cells (as well as other boundary conditions)	Not Completely	The District's presentation displays spatial plots of the simulated fluxes slides 45 to 58 depict the simulated fluxes for various model components for the steady-state simulation. These plots could be helpful for the transient simulation. As previously mentioned, these results should be presented in the final report.
17-18	What are spatially averaged values for rainfall, actual ET, potential ET, and HSPF spatially-averaged annual	Not Completely	This can be achieved by including in the final report the corresponding slides in the District's slide presentation dated October 2, 2023.

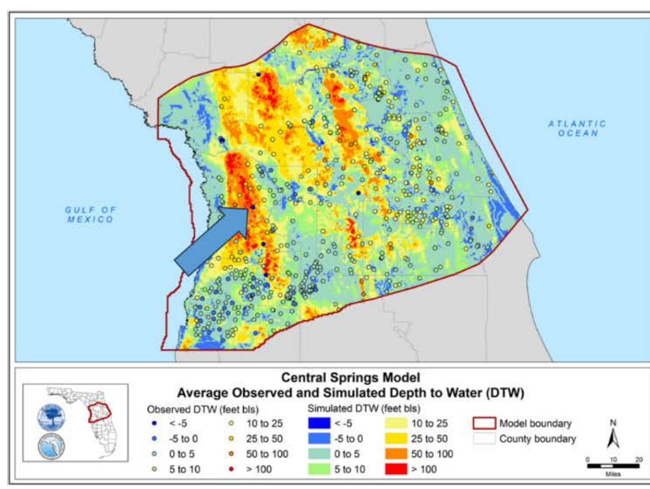
Peer Review Comment Slide #	Review Comment	Comment Resolved?	Resolution Response
	recharge rates, maximum saturated ET, and extinction depth?		
19	In Figure 5-13 it is difficult to interpret the comparison between the APT and calibrated transmissivity results.	No	This can be resolved by plotting the values for UFA transmissivity from the PEST calibration (x coordinates) versus the results from the aquifer performance tests in the corresponding cells (y coordinates). Please refer to NFSEG (Durden et al. 2019) Figure 4-85 for an example.
20-26	Segmental baseflow comparison	No	The segmental baseflows needs more introduction in the text. The report currently directs the reader to Appendix H with a single sentence. More detail is necessary to educate the reader as to what they are seeing. This added detail will differentiate Appendix G from Appendix H. "Selected hydrographs of baseflow discharge at four major rivers (St. Johns, Ocklawaha, Withlacoochee, and Hillsborough) are shown on Figure 6-32 through Figure 6-35, with additional data included as Appendix H." Some of the "Observed" peaks seem very high for baseflow. The peak "Estimated Maximum" baseflow mimics the total streamflow hydrograph. There is a large degree of variability between the Max and Min Baseflow. The target does not constrain the parameter estimation. This combined with a binary penalty function, must lie within the max and the minimum, causes issues within PEST. PEST works best with functions with derivatives instead of binary functions (Using PEST EIS can help dramatically).

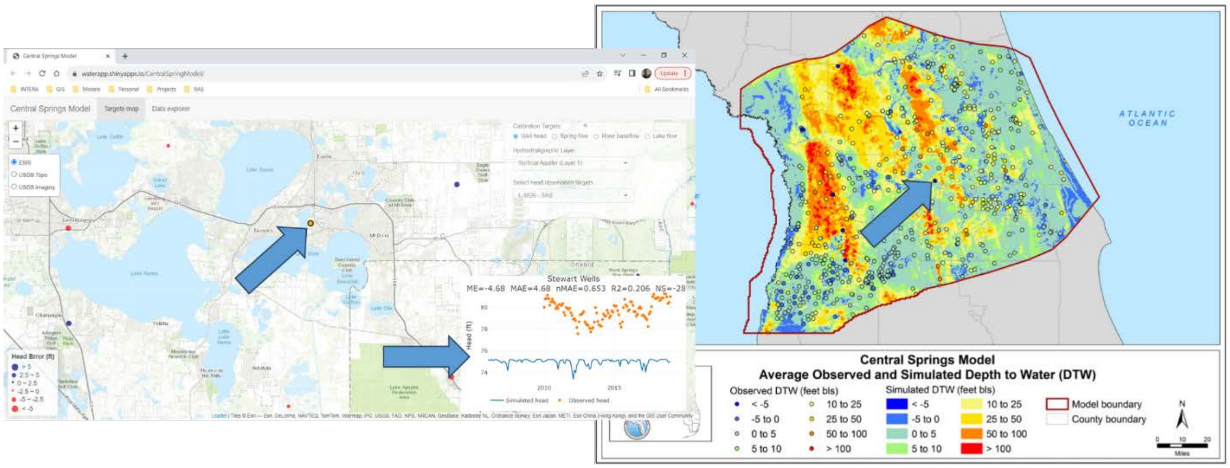
Peer Review Comment Slide #	Review Comment	Comment Resolved?	Resolution Response
			One example of the need for segmental baseflow analysis is the Floral City-Inverness and Inverness-Holder. Notice the Floral City-Inverness simulated baseflow peaks at about 500cfs with a median of 160cfs (Appendix H pg. 12). While the Inverness-Holder simulated baseflow only peaks at 190cfs with a media of 90cfs. Therefore, an additional 400cfs are available at peak conditions and at median conditions, nearly an additional 70cfs are available. See appendix below for graphs and examples.

Appendix

There seems to be an issue with the graphics in the draft final report and the ShinyApp hydrographs. The dark blue point in the report graphic to the right (depth to water) is shown identified in the ShinyApp on the left. The dark blue color designates water above land yet the hydrograph does not seem to represent water above land issue. It is possible that the cell average topography is erroneously depicting water above land?



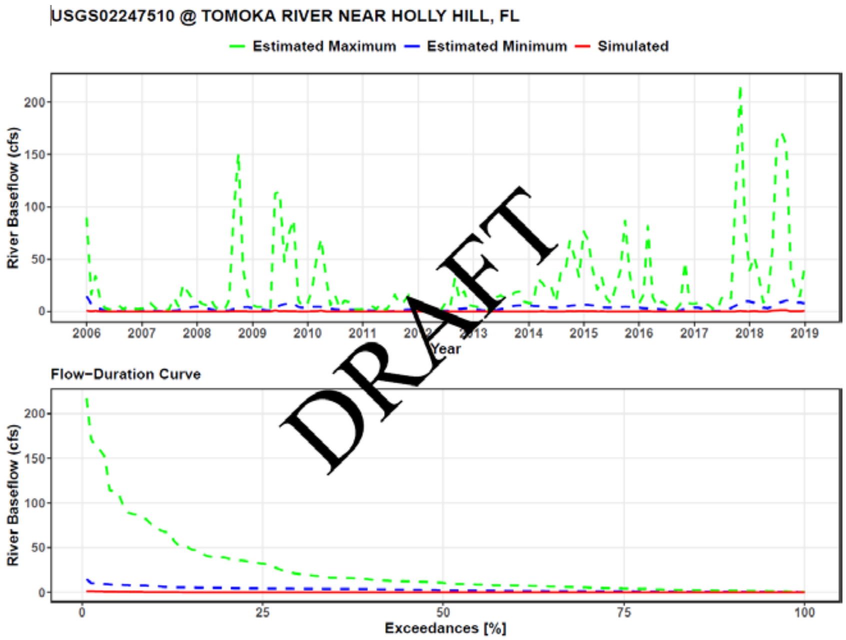


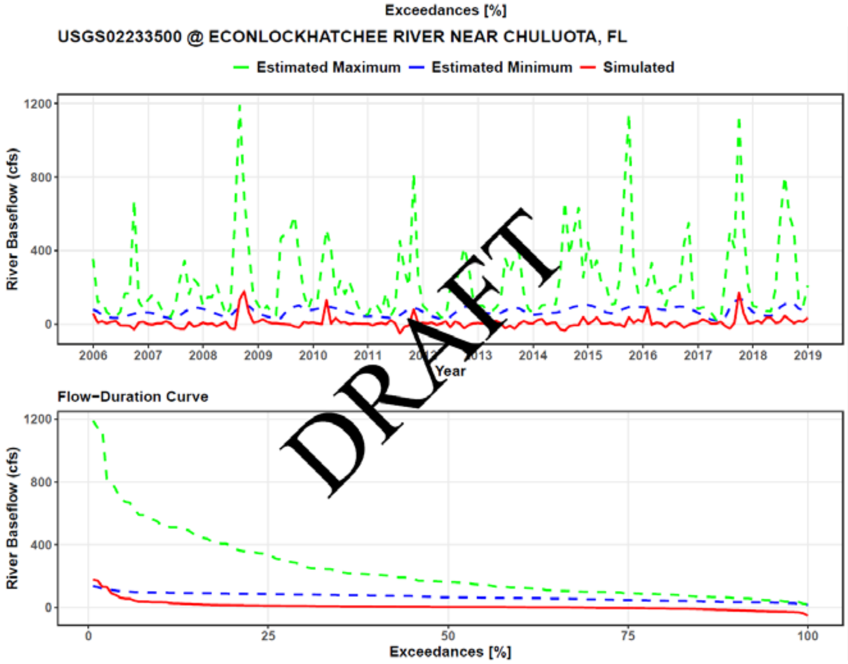


Central Springs Model
Targets map
Data explorer
Head Error (ft)
Stewart Wells
ME=-4.68 MAE=4.68 nMAE=0.653 R2=0.206 NS=-28
Simulated head
Observed head
ATLANTIC OCEAN
Central Springs Model
Average Observed and Simulated Depth to Water (DTW)
Observed DTW (feet bls)
< -5
-5 to 0
0 to 5
5 to 10
10 to 25
25 to 50
50 to 100
> 100
Simulated DTW (feet bls)
< -5
-5 to 0
0 to 5
5 to 10
10 to 25
25 to 50
50 to 100
> 100
Model boundary
County boundary
Miles

6

The baseflow hydrographs below depict nearly zero baseflow. This condition seems to either represent very low conductance for the boundary conditions (all upstream river cells) or that heads in the river cells are identical to heads in the aquifer.





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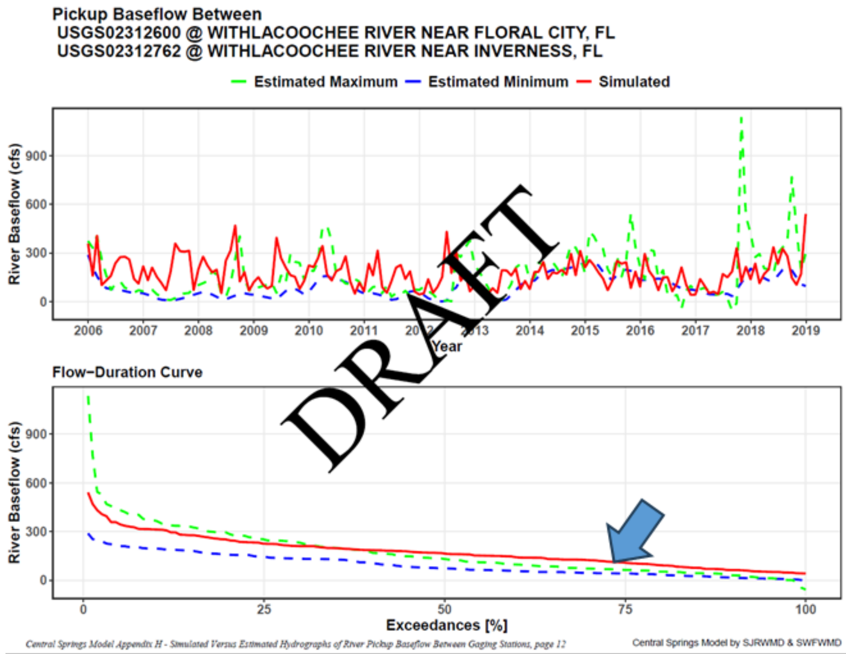
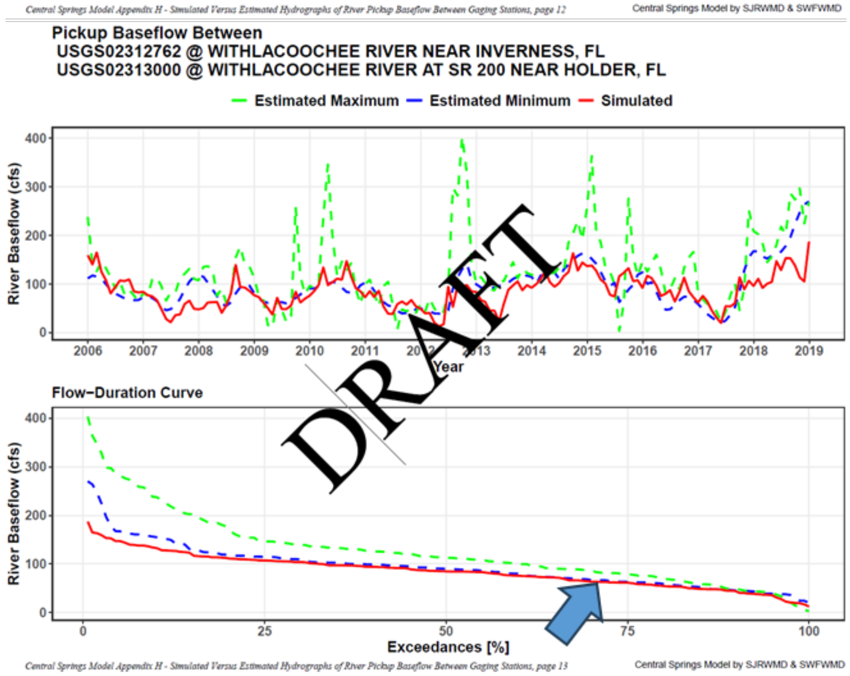
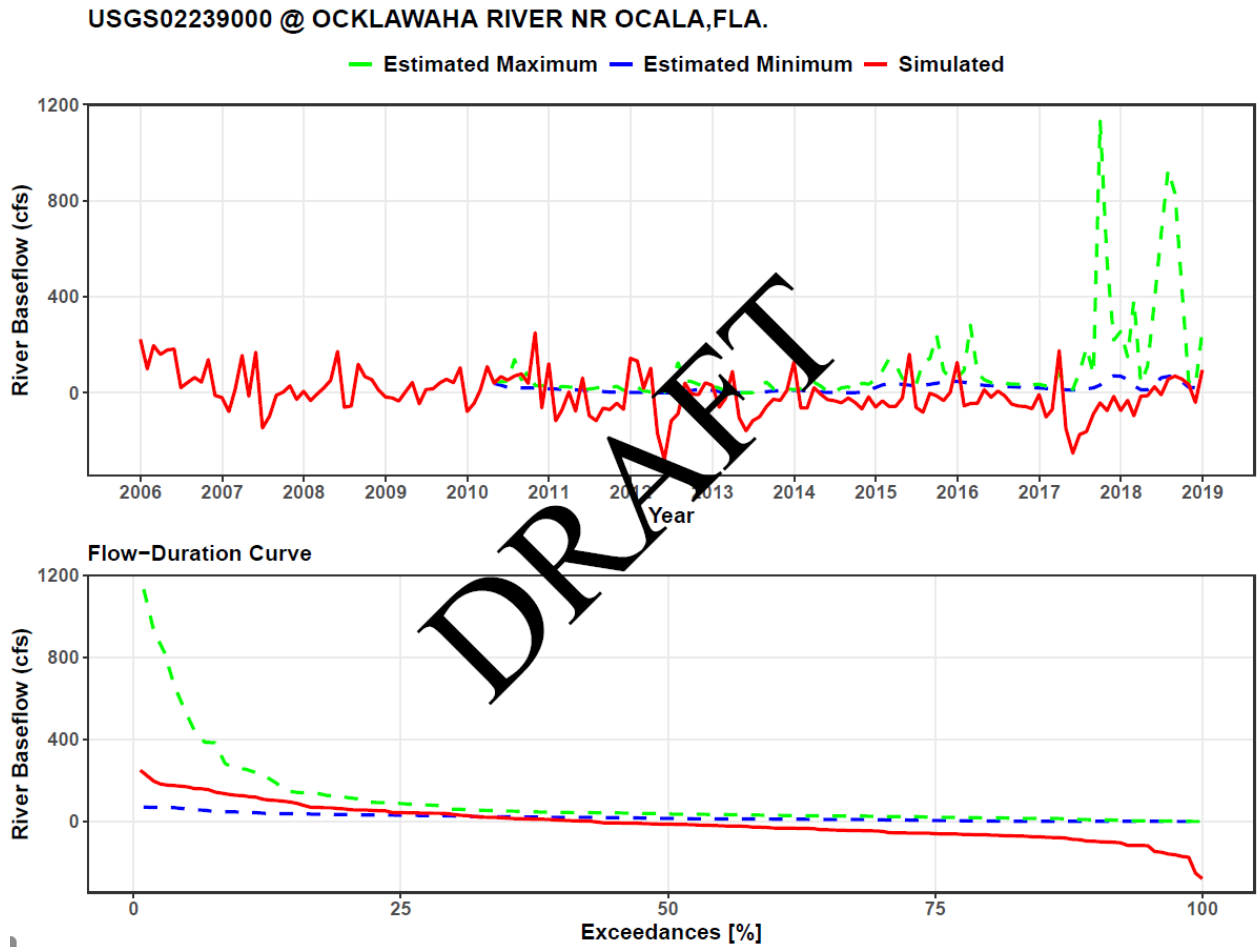
Baseflow is overestimated in the Floral City-Inverness segment then underestimated in the next segment downstream, Inverness-Holder.





The Ocklawaha River near Ocala overestimates negative baseflow. The negative baseflow condition persists for more than 50% of the time with an average magnitude of nearly 100cfs. The sign convention depicts discharge from the aquifer to the river as positive. Therefore, the negative baseflow condition of nearly 100 cfs for a majority of the simulation shows the aquifer is receiving water.



Comparing the water balance terms to the HSPF simulation results compares well for many of the basins. However, for the Ocklawaha basins there is a significant departure between the simulated MODFLOW ET and the HSPF simulated ET. This departure is significant and represents 5 inches over the basin.