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MEMORANDUM

TO: Joanne Chamberlain and Fatih Gordu

FROM: INTERA

DATE: December 31, 2018

RE: REVIEW OF WEKIVA RIVER HYDROLOGY AND HYDRAULIC MODELING

Introduction

Minimum flows and levels (MFLs) are mandated to be established for priority water bodies (Section 373.042, Florida Statues). The Wekiva River system contains 4 water bodies that are on the St. Johns River Water Management District's (the District's) priority list: Wekiva River at SR 46, Little Wekiva River, Wekiwa Springs and Rock Springs.

In support of MFL development, the District developed HSPF and HEC-RAS models of the Wekiva River system. These models were reviewed by INTERA with an emphasis on available data, model conceptualization, and model calibration. Overall, the models generally follow standard engineering practice and utilize the best available data.

This technical memorandum summarizes INTERA's review of the Wekiva River HEC-RAS and HSPF models including the following documentation:

- *Wekiva River Hydrology and Hydraulic Modeling for Minimum Flow and Level Evaluations (Seong and Wester, 2018)*

Review Questions

The review questions below were provided by the District. To assess each question, model input files and model documentation were reviewed by INTERA. INTERA responses to the review questions are provided below.

(1) Assess adequacy and appropriateness of the data used in model development, calibration, and long-term simulations.

Data used for model development include rainfall, daily flow, basin boundaries, channel cross sections, land use, potential evapotranspiration (PET), and point source discharges. The data were reviewed to determine if the best available data was utilized for the model development, and calibration. The following datasets were reviewed for adequacy and appropriateness:

- Rainfall,
- Daily flow,

- Basin boundaries,
- Stream cross sections,
- Land use,
- Potential evapotranspiration, and
- Point source discharges
- Spring flow data

Rainfall

The HSPF .uci files referenced 4 rainfall data sets from DSN 802 (Deland), DSN 3202 (Lisbon), DSN 3902 (Orlando) and DSN 4102 (Sanford). Each timeseries was exported from the RainModel_2017.wdm file and summed by year, as shown below, and compared to Figure 6 of Seong and Wester (2018). The annual totals matched, however Figure 6 of Seong and Wester (2018) should be modified to add the Sanford station to the legend. Examination of the individual hourly timeseries found that the time series between stations matched at times, which was due to gap filling techniques. Additional detail is needed in the document regarding the gap filling techniques used and the performance of the gap-filling techniques. If error statistics are available for gap-filling, they should be presented in the report. If error statistics are not available, they should be calculated by applying the gap-filling technique to a period of the record with observed rainfall and calculating the difference between the observed rainfall and the rainfall simulated with the gap-filling. Overall, the rainfall totals were consistent between gauges and were within reasonable and expected ranges for Florida hydrology.

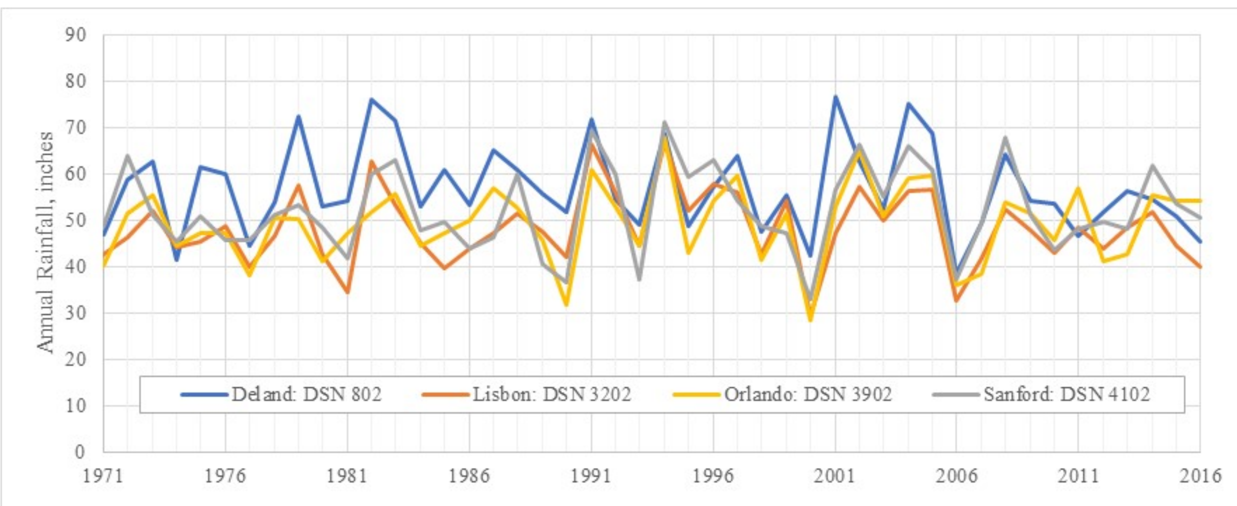


Figure 1. Rainfall WDM Annual Totals

Daily Flow

Daily flow and stage data were available at eight locations within the area-of-interest. The documentation contains a detailed inventory of the available locations and their source. Flow measurements are based on rating curves which may change over time. This represents standard engineering practices and is the best available data for flow measurement to be used for model calibration.

Basin Boundaries

Watershed boundaries for the HSPF models were determined by the District using elevation and terrain models. Watersheds were grouped into 3 major sub-watersheds: Black Water Creek, Wekiva River, and Little Wekiva River. Although the basin boundaries presented in Figure 2 of Seong and Wester (2018) appear reasonable, additional details on the terrain modeling and a citation for a report could be given, if available. If ground verification of the sub-watershed boundaries was performed, details should also be added to the document. Additional details regarding the closed sub-watersheds (sub-watersheds 39-44) should also be given, including whether the sub-basins are closed 100% of the time or are these basins conditionally isolated.

Stream Cross Sections

Stream cross sections for the HEC-RAS model were obtained from various sources. Additional surveying was performed for the current modeling effort. When multiple surveys were available at the same cross section, the District performed a comparison of the surveys. The results found that the surveyed bottom elevations, stream width and bank and general cross section shape were similar. The data presented in Table 9 of Seong and Wester (2018) represents the best available data for river transects.

Land Use Data

The District's land use/land cover from 2009 was used for HSPF model development. For consistency, FLUCCS codes were grouped into the 13 land use classes used for the Water Supply Impact Study (Cera et al. 2012). Land use data from 2014 became available after the model was calibrated, making the 2009 data the best available data at the time of model development and calibration. Wetlands were divided into riparian wetlands and non-riparian wetlands based on whether they were located adjacent to streams or lakes. Conceptualization using this approach allows for a more realistic representation of surface water drainage and storage.

Potential Evapotranspiration (PET) Data

PET data was calculated using the Hargreaves method with correction factors as noted in Seong and Wester (2018) for each of the 4 NOAA data stations within the model domain (Deland, Lisbon, Orlando, and Sanford). The extent to which gaps were filled in each of the records should be discussed in the documentation. Table 3 of the documentation contains summary information for PET from 1970 through 2016. To verify the PET data, the DSNs for HPET were exported from RainModel_2017.wdm file and summed by year and compared to Table 3 of Seong and Wester (2018). Results of the export matched the minimum annual PET, maximum annual PET and average annual PET that were shown in the table. In the external sources block of the model ucis, it was noted that scaling factors were applied to each PET time series, as shown in the table below. The scaling factors are applied by HSPF when the time series is used, making the PET equal to the time series in the RainModel_2017.wdm times the scaling factor. The values presented in the documentation do not include the scaling factors. Documentation should be added to describe the scaling factors and the statistics presented in the documentation should reflect the final PET time series for each station. When scaled, the annual values are slightly low, but not out of the range of what is reasonable for Florida PET rates.

Statistic	Deland: DSN 806	Lisbon: DSN3206	Orlando: DSN 3906	Sanford: DSN 4106
Average Annual Raw PET	59.35	57.65	59.12	59.21
Maximum Annual Raw PET	63.79	64.06	62.42	63.37
Minimum Annual Raw PET	54.28	53.33	56.55	55.70
EXT SOURCES factor	**0.8726**	**0.9114**	**0.9109**	**0.8888**
Average Annual Factored PET	51.79	52.54	53.85	52.63
Maximum Annual Factored PET	55.66	58.38	56.86	56.32
Minimum Annual Factored PET	47.37	48.60	51.51	49.51

Point Source Discharges

Major point source discharges from 2 wastewater treatment plants (WWTPs) are described in the model documentation. These were included as external sources in the HSPF models. Minor point sources were not discussed in the documentation and were not included in the models. Although minor point sources will likely have a minimal effect on the overall model calibration, the extent to which minor point sources are present should be discussed in the documentation.

Spring flow Data

Spring flow data is discussed in Appendix A of the model documentation. A detailed inventory of spring flow data is provided. Additional details regarding the “Step 3” springs should be added to Table 4 of Appendix A, including flows and dates used for scaling. Overall, the gap-filling methodology used for all 3 categories of springs follow standard engineering practices.

a) Was "best information available" utilized to develop and calibrate the models?

In general, the best information available was used to develop and calibrate the HSPF and HEC-RAS models. Additional information should be added to the documentation to discuss gap-filling measures that were employed for rainfall, PET, and spring flow data. The documentation should be modified to discuss the scale factors that are applied to the PET time series in the model ucis.

b) Are there any deficiencies regarding data availability?

All pertinent data needed to conceptualize and calibrate the HSPF model and HEC-RAS model were available. There were no deficiencies regarding data availability.

c) Was relevant information available that was discarded without appropriate justification? Would use of discarded information significantly affect results?

Based on the data presented in the documentation and knowledge of additional data sources, relevant data was not discarded without appropriate justification. A discussion of minor point source inflows could be added to the documentation, however the effect of this data on model performance is minimal.

(2) Assess the validity, defensibility and appropriateness of the model development and calibration.

a) Determine if the models are appropriate, defensible and valid given the District's MFLs approach.

The modeling strategy used a combination of two models: HSPF to simulate the basin hydrology and HEC-RAS to simulate the river system hydraulics. Both models are well-accepted for use within the engineering community and well-supported by their developers. HSPF and HEC-RAS are regularly applied for MFL development within the District as well as within other Districts in Florida.

b) Evaluate the validity and appropriateness of all assumptions used in the model development and calibration

- **Are the assumptions reasonable and consistent given the "best information available"?**

  Several assumptions were made for the development and calibration of HSPF and HEC-RAS models including:
  - Assumptions regarding HPSF parameters,
  - Assumptions regarding Manning's n values,
  - Assumptions regarding initial storages for impervious land segments (RETSC),
  - Assumptions regarding lower zone storages,
  - Assumptions regarding factors for PET found in the .uci files

Other assumptions include the assumption of various directly connected impervious area (DCIA) percentages for various land segment types. All assumptions made were generally reasonable and valid. Additional documentation is needed on some assumptions, including those noted in the bulleted list above.

- **Is there information available that could have been used to eliminate any of the assumptions? Could the use of this additional information substantially change the model results?**

  Given the available data, the is no additional data that could be used to eliminate any of the modeling assumptions.

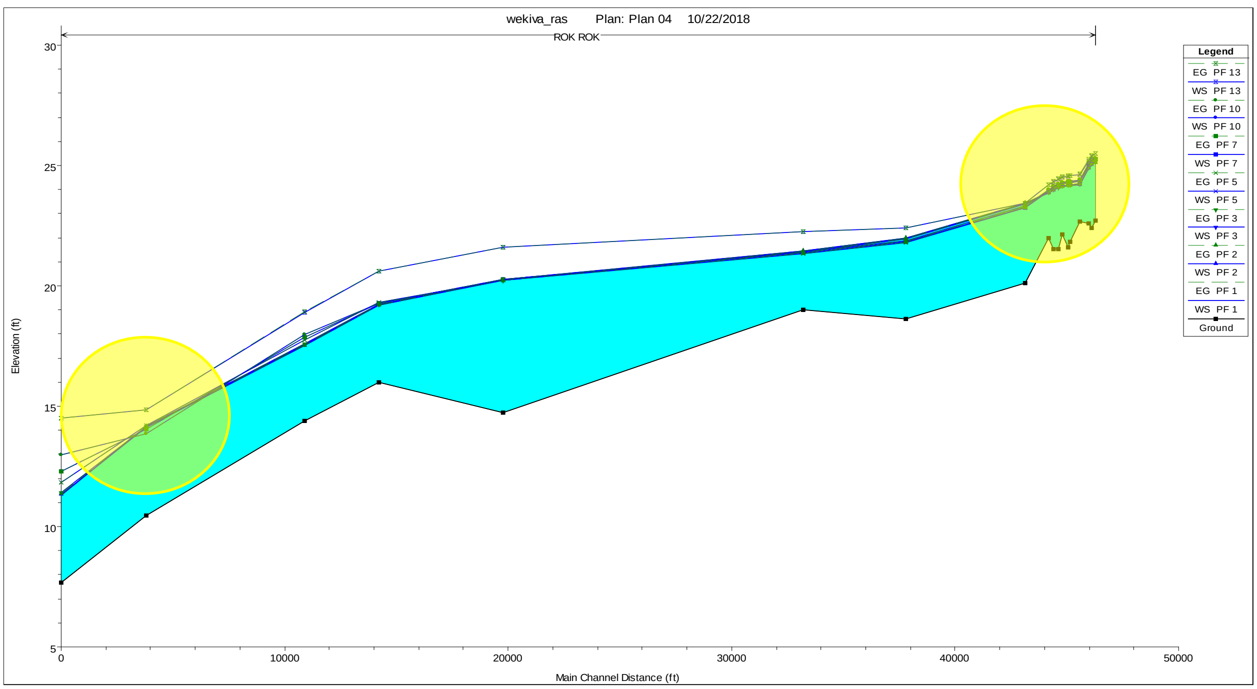
c) Review model input and output data including but not limited to:

- **Model elevations versus collected data to verify the same datum was used consistently**
  Water elevations in Table 14 of the documentation were compared to those as recorded in feet-NAVD88 via either the USGS or District website, as shown below. All elevations presented in Table 14 of the documentation matched the corresponding elevation shown below. The model datum was not explicitly stated in the model documentation. It is recommended to add a sentence in the model construction section of the documentation which states the model datum.

Table 1. Verified Stages

Flow Profile	Location	Verified Stage
PF8 12/4/2014	SJRWMD 340785151 Rock Springs Run ROK2	17.68 ft NAVD88
PF8 12/4/2014	SJRWMD 00330830 Rock Springs at Apopka	24.93 ft NAVD88
PF8 12/4/2014	SJRWMD 09512135 Wekiva River at Old Railroad Bridge at Sanford	9.58 ft NAVD88
PF8 12/4/2014	SJRWMD 00371831 Wekiwa Springs at Altamonte Springs	12.81 ft NAVD88
PF8 12/4/2014	USGS 02234990 Little Wekiva River near Altamonte Springs, FL	23.6 ft NAVD88
PF8 12/4/2014	USGS 02235000 Wekiva River near Sanford, FL	7.49 ft NAVD88
PF6 8/27/2012	SJRWMD 09522138 Wekiva River at Apopka	12.62 ft NAVD88
PF 11 5/22/2009	SJRWMD 09502132 Little Wekiva River at Springs Landing	19.66 ft NAVD88

- **Flow/stage plots to look for model instabilities;**
  Flow and stage plots were examined as appropriate in both models to look for modeling instabilities. No model instabilities were noted in the HSPF model. Slight instabilities were noted in the HEC-RAS model as it relates to the simulated stages. As shown, stages are expected to increase as percentile flows increase. There are instances where the flow profiles for various percentile flows intersect each other. Upon further examination of the flow profiles, it was noted that this is due to inconsistencies in the flow profiles based on the observed data. For example, the flow at ROK4 for PF 12 is 72.5 cubic feet per second (cfs), while the flow at ROK4 for PF11 is 79.5 cfs. The corresponding flows downstream at XS2 are 992.4 cfs and 896.8 cfs. While this is to be expected since it is a steady-state model with flow profiles based on observed data, it may be helpful to smooth the flow profiles so that inconsistencies are not simulated (e.g. a higher stage at a lower flow profile).



- **Output file for model warnings**
  There were no warning or error messages present in the HSPF model. There were several warnings noted in the HEC-RAS simulation related to the potential need for additional cross sections due to the conveyance ratio being outside of the expected range. Additional cross sections could be added if desired, but this should minimally affect the overall model performance. Several errors were noted for cross sections that needed to be extended for the computed water surface, as shown in the example cross section below. These cross sections should be extended so that the water surface is fully contained within the cross-

sectional area. Although this should only minimally affect results, it is good modeling practice.

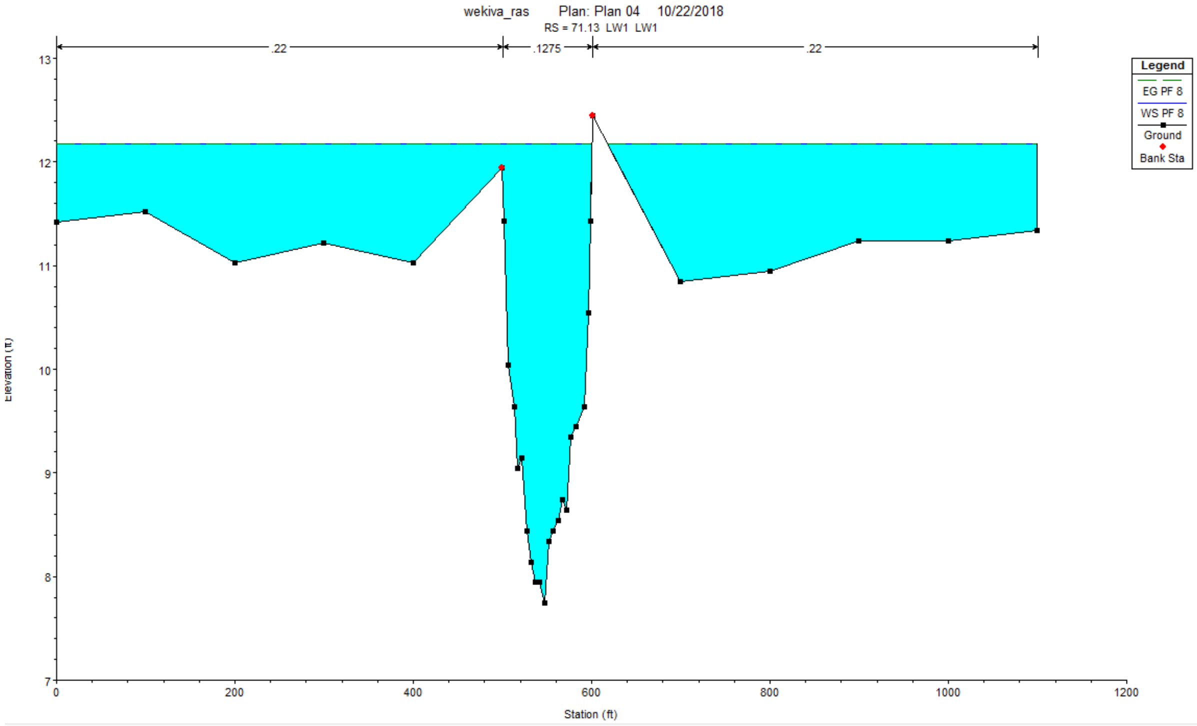


Figure 2. Cross Section Example

- **Continuity error and convergence data;**
  Not continuity issues were noted in the HSPF model. Continuity issues were noted with regarded to the flow profiles in HEC-RAS. Because the flow profiles serve as boundary conditions to the model, they will produce simulated stages that are inconsistent. It is recommended, but not required, that the flow profiles be smoothed to result in consistent stage profiles for MFL development.

- **Water budget to check for reasonableness;**
  A water budget was not explicitly provided in the documentation. An independent water budget was developed during the review process using the HSPF binary output file (*.hbn). Those results are presented in a later section of this document. It is highly recommended that, at a minimum, average basin water budgets be added to the documentation for each of the 3 HSPF models (ideally grouped by land cover). The water budgets should express average annual volume in inches over the basin area.

- **Values assigned to model parameters to check for reasonableness**
  Parameter values were checked for reasonableness in HSPF and HEC-RAS. In HSPF, initial conditions will impact the simulation for a short period of time, ranging from days to months depending on the model and the initial conditions. There are some inconsistencies with respect to the relative moisture levels at the start of the simulation.

Lower zone storage (LZS) is initialized at 6.4-inches for all simulations. Lower zone storage nominal, LZSN, ranges from 0.5 to 7.5 inches, making initial the initial lower zone ratio (LZRAT) vary from almost 13 to just below 1. Additionally, the retention storage capacity, RETSC, is set to 0.1-inches for all impervious land segments. This may be slightly low, which would result in a low impervious ET rate.

Manning's n values were the primary calibrated parameter in the HEC-RAS model. Manning's n was varied with respect to flow to simulate low to high flow regimes for both steady and unsteady simulation. In the steady state simulation, the "Vertical Variation in Manning's n Values" option under cross section data editor was used to vary Manning's n. In the unsteady state simulation, the "flow roughness factors" option was implemented. Manning's n values were generally within the range of what was reasonable and expected.

- **Appropriateness of boundary conditions including spring flows and river stages**

In general, boundary conditions were developed for the HEC-RAS model using standard engineering practices. The use of multiple flow profiles at various percentile flows is common for a steady state model. This improves the calibration because it exposes the model to the entire flow regime as opposed to a single flow profile.

- **Review of the methodologies used to develop boundary conditions including spring flows and incorporate HSPF output into HEC-RAS models.**

Spring flows were handled as an external time series in the HSPF model and also used as a boundary condition for the HEC-RAS model. Almost 30 springs were routed to reaches in the HSPF model. Springs were divided into "Step 1, Step 2, and Step 3" springs depending on the amount of data available at the spring and the necessary gap-filling (the term "Step" is a little misleading and should be renamed to "groups" or "category"). More explanation is needed in the Appendix document for the gap-filling of Step 3 springs. For example, according to Table 4, of Appendix A, Messant Springs was filled with Rock Springs. The filled Messant Springs time series was then used to fill Camp La No Che Springs. It is not clear why Rock Springs was not used to fill Camp La No Che Springs, since it is preferable to fill a spring with an observed time series as opposed to a filled time series. Additionally, for all springs, error statistics can be presented for the gap-filling measures since there are at a minimum several observed data points for each of the springs. The quantification of the error associated with the spring flow estimation is imperative since the spring flows serve as model boundary conditions.

The approach used to incorporate the HSPF output is generally valid. Lateral inflows from sub-watersheds that were adjacent to stream reaches were used as HEC-RAS boundary conditions. Adjustment factors combined with HSPF sub-watershed output were used to estimate flows at flow change locations when observed data was not available at a given flow change location. Although this approach is valid, additional details regarding the extent of the use of the HSPF flows and the development of their scaling factors should be added to the documentation.

- **Review of PEST Calibration Approach**

Parameter ESTimation, or PEST, is a very powerful tool to aide in the calibration of numerical model parameters. The HSPF component of the Wekiva River modeling was calibrated with the assistance of PEST. The implementation of PEST to calibrate HSPF follows standard engineering practices. PEST estimates the user-defined list of model parameters based on reducing the user-defined objective function. In the case of the 3 Wekiva Basin models, PEST was utilized to optimize the following parameters:

- LZSN – Lower zone storage nominal
- INFILT – Infiltration capacity
- LSUR – Length of surface runoff
- SLSUR – Slope of overland flow
- KVARY – Non-linear active groundwater parameter
- AGWRC – Daily Recession constant of groundwater
- DEEPFR – Deep fraction
- BASETP – Baseflow ET parameter
- AGWET – Active groundwater ET parameter
- CEPSC – Interception storage capacity
- UZSN – Upper zone storage nominal
- NSUR – Manning's n for overland flow
- INTFW – Interflow inflow parameter
- IRC – Interflow recession parameter
- LZETP – Lower zone ET parameter

The PEST control file received from the District for the Blackwater Creek basin had all the parameters as fixed and only varied INFILT, while the Wekiva basin control file varied LZSN, INFILT, DEEPFR, BASETP, and UZSN. It is hard to determine the parameters that were truly optimized throughout the calibration process. It would be helpful to add detail in the calibration process, to be complete. Including optimization for all three parameters for overland flow (LSUR, NSUR, and SLSUR) is redundant.

The observed data in the PEST control file included the following types of data from one or more stations:

- Daily Hydrographs
- Monthly Hydrographs
- Total Discharge
- Flow duration Data

The weights for the daily, monthly, and total discharge were set to 1.0 while the flow duration data had a weight of 10000. The different weights allow PEST to account for the dramatic change in the range of values and units when aggregated as the objective function. The flow data range from 0 to hundreds of cfs while the flow duration ordinates only range from 0 to 1. The total flow data, however, range in the hundreds of thousands. This will put additional emphasis on the matching of the total flow estimates. Descriptions of the weights and relative contribution to the objective function should be documented.

d) **Development of an independent water budget**
An independent water budget was developed for the Black Water Creek model by exporting components of the .hbn file. The model basin average water balance and the impervious water balance are shown in the tables below. The basin annual average water balance appears within the expected normal range for Florida hydrology. The impervious annual average evaporation may be slightly low, but overall is consistent with Florida hydrology. The low impervious evaporation could be a direct result of the low impervious retention storage capacity (RETSC) in the model.

Water Balance Term	Basin Annual Average, inches
Rainfall	51.4
Basin Discharge	9.8
Recharge	4.2
TAET	38.2
Difference	0.8

Water Balance Term	Impervious Annual Average, inches
Rainfall	51.9
Impervious Runoff	40.5
Impervious Evaporation	11.4
Difference	0.0

Conclusions

In general, the HSPF and HEC-RAS models for the Wekiva River Basin follow standard engineering practice and use the best available data. While some improvements could be made to the documentation to provide additional details on the calibrated model parameters, basin water balance and PEST calibration, overall, the models are calibrated to a wide range of flow regimes and meteorological conditions, making them good tools for MFL development.

Review of Stakeholder Comments

Stakeholder comments were reviewed prior to a public teleconference held on December 13, 2018. This section addresses some of those review comments, as indicated below:

- **Negative stages.** The negative stages found in some of the HSPF reaches result from a stage correction in several rivers including Rivers 39 and 40. The negative stages indicate that the volume in the reach is low, but this does not indicate an error. The negative stages are a result of the negative STCOR (stage correction) in the UCI.
- **Hydrograph alignment and lack of lagging.** The shapes of the hydrographs align with one another because the basin flows are dictated by rainfall. If a single rainfall station is used as a forcing function, this will cause all the hydrographs to align with each other.
- **Fit of springflow statistical models.** Overall, the springs constitute a major source to the river. While some minor springs had poor fits to the observed data, the inflow significance of the smaller springs should be considered in the review of those fits. Stakeholders commented that MODFLOW should be used to model springflows, this would be another modeling alternative to the current

statistical model. While an integrated model would best represent this system, it is likely not cost or time effective and MFLs are to be defined with the best available data. In the absence of having an integrated model, the use of a statistical model or a process model is standard engineering procedure. Using MODFLOW to simulate springflows is just another model (instead of a statistical model, it is a process model). Calibration targets, however, are lacking, and therefore the best available data should be used.

- **Use of dynamic routing.** Stakeholders commented that HSPF can do dynamic routing. In HSPF version 2.4 and 2.5, stream routing is defined by a predefined stage, storage, and discharge rating table. Hydraulic modeling is not possible with HSPF because HSPF does not support dynamic routing. The District linked HEC-RAS to provide for dynamic hydraulic routing in the MFL analysis.

References

Cera, T., Smith, D.S., Cullum, M.G., Adkins, M., Amoha, J., Clapp, D., Freeman, R., Hafner, M., Huang, X., Jia, Y., Jobes, T., and Mao, M. (2012). St. Johns Water Supply Impact Study. Report for the St. Johns River water Management District.

Seong, C., and Wester, A. (2018). Wekiva River Hydrology and Hydraulic Modeling for Minimum Flow and Level Evaluations. Draft Report of the St. Johns River Water Management District.

Editorial Comments

It is recommended that the following editorial comments be addressed in the final documentation:

Title Page – since hydrologic modeling was performed the title should probably be “Wekiva River Hydrologic and Hydraulic Modeling” instead of Wekiva Hydrology; appears multiple times in document

Table of Contents – Appendix A has no page number

List of Figures – inconsistent capitalization, e.g. compare Figure 4 and Figure 5 captions

List of Tables - inconsistent capitalization, e.g. compare Table 6 and Table 7 captions

Introduction – Abbreviation “SR” not spelled out at first appearance

Introduction – Change verb for plural noun agreement (see highlighted words): “MFLs for the Wekiva River at SR 46 were adopted in 1992, and it is currently under reevaluation.”

Introduction – Add the year when this model was developed: “The previous Hydrological Simulation Program – FORTRAN (HSPF) model that was developed…”

Introduction – Should this say evapotranspiration instead of evaporation: “The HSPF model uses the land use, rainfall, evaporation,…”

Introduction – inconsistent capitalization: Wekiva River Watershed vs Wekiva River watershed, this appears throughout document

Introduction – Remove comma and add word “the”, see highlighting: “The existing HEC-RAS, steady state one-dimensional river hydraulics model was updated and extended to include the Little Wekiva

River and Rock Springs Run, as well as the Wekiva River to simulate the water surface profiles of the Wekiva River system."

Section 2.1 – Reword; suggest highlighted words: "The contributions from these closed sub-watersheds to the Wekiva River are assumed to occur through the nearby springs and are not simulated directly in the HSPF model."

Section 2.2 – Reword; suggest highlighted words: "The percent difference between land use area for 2009 and 2014 is listed in Table 1."

Section 2.3 – Use comma, see highlighting: "the watershed data management tool for HSPF (USEPA, 2001),"

Section 2.4 – Inconsistent spelling of gage (it is spelled gauge in section 2.3), gage is most used in document

Section 2.4 – Add suggested highlighted word: "Long-term daily flow and water level data from eight sites"

Section 2.4 – Incorrect figure references, see highlighted corrections: "The dense in-channel vegetation reduces the river flow velocity and raises the in-channel water levels (Figure 8 and 9)"

Section 2.5 – Reword; suggest highlighted word: "The methods used in preparing the spring discharge datasets summarized in Table 5 are described in detail in Appendix A."

Section 2.5 – Add s to word Fall: "A well near Wekiva Falls, constructed in 2007,…"

Section 2.6 – Abbreviation "FDEP" is not spelled out at first appearance

Section 2.7 – Section title should be plural, i.e. Stream Cross Sections

Section 2.7 – Multiple figure references should be plural: "…were surveyed for this project (Figures 14-16 and Table 9)."

Section 2.7 – Table should be capitalized: "The identified MFL transects in the study area are asterisked in Table 9."

Section 3.1 – What was the previous modeling period? "The watershed model simulation period was extended from the period of 2003 to ???? to the period of 2003 to 2016."

Section 3.1.1 – Inconsistency sub-watershed vs. subwatershed throughout the document

Section 3.1.1 – Lower case where highlighted: "Among 13 land uses, four urban land uses (Low density residential, medium density residential,…"

Section 3.1.1 – Unusual word "runoffs" used in this section

Section 3.1.1 – Plural needed where highlighted: "Consequently, the baseflow originating from the non-riparian wetland drainage areas is routed to receiving reach segments directly."

Section 3.2 – Add the highlighted word: "Table 10 is a guide for assessing the performance of the hydrologic model."

Section 3. 2 – Change numbers to words as highlighted: “Table 11 presents the statistical measures to quantify the performance of the hydrologic model at the seven discharge stations.” “The model simulation for six of the sites was considered”

Section 4.1.2 – Add the word “the” as highlighted: “The HEC-RAS model provides options for varying Manning’s n by flow or depth.”

Section 4.1.3 – Reword first sentence and remove comma in second sentence: “The geometric data of the bridge at SR46, such as pier and deck were derived from previous HEC-RAS modeling work (SJRWMD, 2016). The bridge geometry located at the end of the Miami Springs Drive, was collected from a field trip in 2018.”

Section 5 – Uses same wording as the introduction; change verb for plural noun agreement (see highlighted words): “MFLs for the Wekiva River at SR 46 were adopted in 1992, and it is currently under reevaluation.”

Section 5- First two paragraphs contain the same sentence (beginning with, “Four water bodies…”)

Literature Cited – Boniol, D., M. Williams, and D. Munch; K. G. Ries and P.J. Friesz; Matalas, N.C., and Jacobs, B.; Terzaghi, K., and R.B. Peck; U.S. Army Corps of Engineers (USACE); and Vogel, R.M. and Stedinger, J.R. are not referenced in the document

Appendix A - Capitalize “island”: “Helen, island, and Sulphur springs…”

Figure 6 – Legend entry for Sanford station is missing but data appears on the graph.

Figure 7 – the Figure number printed on the map says Figure 6, but the caption says Figure 7. If the figure can not be edited, placing a white box over the extraneous Figure 6 label will remove the conflict.

Figure 8 – Discharge misspelled in the legend

Figure 8 – The text mentions Hurricane Irma for 2017 but there is no explanation of the high flows in 2009

Figures 8 and 9 - “El.”can be removed from the secondary y-axis names so the units are ft NAVD88

Figure 10 – y-axis units should be ft NAVD88 (make consistent with figures 8 and 9)

Figure 10 – No reference in text and incomplete discussion about the yearly breakdown shown in the legend

Figure 11 – Caption references a Floridan aquifer well that does not appear in the map or legend

Figure 13 – Remove the word “in” from the caption so that it reads: “Cross section comparison between 1990 and 2013 at ROK2 and ROK3 at Rock Springs Run”. Display Figure 13a and 13b on the same page, or add a caption to Figure 13a.

Figure 18 – Repetitive wording in caption: “(a) Daily observed and simulated flow at Near Debary gage in Black Water Creek at Near Debary gage (SJRWMD 30143084) in Black Water Creek”

Figure A-8 – Legend has Estimated/Observed and Observed, how can the orange line be both?

Figure A-9 – Legend has Estimated/Observed and Observed, how can the orange line be both?

Table 3 - No units are provided

Table 4 – Unclear what 8.2016 is: "8.2016 – present"

Table 4 – Avoid splitting tables over two pages

Table 4 - Three gages have names that do not match the official SJRWMD / USGS station names. The author's aliases are used in Figure 7 and throughout the text also, which may cause confusion unless explained.

Little Wekiva River at SR434 (SR434) is Little Wekiva River near Altamonte Springs (SR 434)

Wekiva River near Apopka (near Apopka) is Wekiva River at Apopka

Wekiva River at SR46 (SR46) is Wekiva River near Sanford, FL (SR46)

Table 5 – Inconsistent formatting using double line borders on some cells but not others

Table 5- Avoid splitting tables over two pages

Table 9 – Repeat caption on second page of the table: "Table 9 River Transect Descriptions (continued)"

Table 12 – Plural needed where highlighted; avoid splitting table over 2 pages: "Selected flow profiles for steady state simulation for Wekiva River"

Table 14 - Add station numbers