Peer Review Report of:

East-Central Florida Transient Expanded (ECFTX) Model

Prepared for:

Central Florida Water Initiative (CFWI)

Hydrologic Analysis Team (HAT)

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List of Acronyms

APhpz	Avon Park high-permeability zone
cfs	cubic feet per second
CFWI	Central Florida Water Initiative
DRT	Drain with Return Flow package of MODFLOW
ECF	East Central Florida groundwater model
ECFT	East Central Florida Transient groundwater model
ECFTX	East Central Florida Transient Expanded groundwater model
ET	Evapotranspiration
FTP	File Transfer Protocol
GHB	General Head Boundary
GLAUClpu	low permeability glauconitic marker unit, second subdivision of the LFA
HAT	Hydrologic Analysis Team
HAT-ECFT	ECFT model developed by the HAT
IAS/ICU	Intermediate Aquifer System/Confining Unit
Kh	horizontal hydraulic conductivity
Kv	vertical hydraulic conductivity
LFA	Lower Floridan Aquifer
LF-basal	Lower Floridan Aquifer – basal permeable zone
LFA-upper	upper permeable zone of the LFA
MCU_I	first component of the Middle Confining Unit
MCU_II	second component of the Middle Confining Unit
MODFLOW-NWT	Modular groundwater flow model using the Newton-Raphson solver
NEXRAD	Next Generation Radar
OCAPlpz	Ocala-Avon Park low permeability zone
Panel	scientific peer review panel
PEST	Parameter Estimation model

SA	Surficial Aquifer
SFWMD	South Florida Water Management District
SJRWMD	St Johns River Water Management District
SWFWMD	Southwest Florida Water Management District
UFA-upper	Upper Floridan aquifer – upper permeable zone
USGS	United States Geological Survey
USGS-ECFT	ECFT model developed by the USGS
WMD	Water Management District
3D	three dimensional

Introduction

The Central Florida Water Initiative (CFWI) Planning Area is located within central Florida and consists of Orange, Osceola, Polk, and Seminole counties and southern Lake County, covering approximately 5,300 square miles. Due to the extent and complexities of the planning area, the CFWI requires a collaborative effort by three water management districts (WMDs), other public agencies, and stakeholders. One group of the CFWI is the Hydrologic Analysis Team (HAT). The objectives of the HAT are to provide the necessary modeling tools and data analysis and to work collaboratively with other CFWI teams to:

1. Estimate the potential availability of groundwater.
2. Produce model output that can be used by the other technical teams to evaluate the effects of groundwater withdrawals on natural systems.
3. Assess future water-supply and management strategies.
4. Develop processes to assess the long-term effectiveness of management strategies.
5. Support collaborative water-supply planning.
6. Support future regulatory actions.

One such modeling tool is the East Central Florida Transient Expanded (ECFTX) model, which was developed from 2016 to 2020, and is the subject of this peer review. The ECFTX model is a modified and expanded version of the East Central Florida (ECF) model, which was originally developed by the SJRWMD as a steady-state model (McGurk and Presley, 2002). In 2006, SFWMD converted that model into a transient model, and it was then referred to as the East Central Florida Transient (ECFT) model. The ECFT model underwent an independent peer review (2007) consisting of review of the model as well as documentation of suggested improvements. The United States Geological Survey (USGS) was contracted to implement these and other improvements as described by Sepúlveda et al. (2012). The ECF, ECFT, and the USGS version of the ECFT Model (USGS-ECFT) models were developed prior to formal initiation of the CFWI effort and did not include the entire CFWI Planning Area. The HAT reviewed the model construction, distribution of input parameters, and model performance and determined that several items needed to be updated for use of the USGS-ECFT model in the CFWI process. These items were updated, the model recalibrated, and then became referred to as the HAT-ECFT model. The HAT recognized the need for further improvements to the HAT-ECFT model, including the needed to expand the model domain outward away from the CFWI Planning Area to minimize boundary condition effects on the simulation. The expanded version of the ECFT model is referred to as the ECFTX model.

The ECFTX model domain covers about a 23,800 square mile area of central Florida that stretches from the Atlantic Ocean to the Gulf of Mexico and from southern Marion - central Volusia counties in the north to Lake Okeechobee in the south. The study area spans approximately 143 miles on its eastern and western sides, approximately 175 miles on its northern and southern sides, and covers the entire CFWI Planning Area. It includes the major metropolitan areas of Tampa-St Petersburg, Orlando, Lakeland, Melbourne, Sarasota, and Vero Beach.

The ECFTX model is a fully three-dimensional (3D) groundwater flow model and uses MODFLOW NWT (Niswonger et al., 2011) as the simulation code. All elevation data for the model are assigned a vertical datum of NAVD 88. Active and inactive areas of the model layers are delineated. In general, for those areas of the model where chloride concentrations exceed 5,000 mg/l (or 10,000 mg/l total dissolved solids), the layers are populated with appropriate aquifer parameters but are inactivated and general head boundaries are set along the edge of the active areas. The model has 603 rows and 704 columns with a uniform grid spacing of 1,250 feet. The selection of the grid size was based on the planned use of the model, data availability, and computational considerations. Vertically, the model includes eleven hydrostratigraphic layers. In descending order, they are: (1) the Surficial Aquifer (SA); (2) the Intermediate Aquifer System/Confining Unit (IAS/ICU); (3) the Upper Floridan aquifer – upper permeable zone (UFA-upper); (4) the Ocala-Avon Park low permeability zone (OCAPlpz); (5) the Avon Park high-permeability zone (APhpz); (6) MCU_I, the first component of the Middle Confining Unit; (7) the overlap unit of the Lower Floridan Aquifer (the third component, where MCU_I and MCU_II overlap without touching); (8) MCU_II, the second component of the MCU; (9) the upper permeable zone (the first subdivision of the LFA called the LFA-upper); (10) the low permeability glauconitic marker unit (second subdivision of the LFA called GLAUClpu); and (11) the Lower Floridan aquifer – basal permeable zone (LF-basal).

Parameterization from previous modeling efforts/prior knowledge of the system was introduced into the prototype model. This model included many modifications to the original ECFT model, including the expanded domain, revised boundary conditions, updated pumping, detailed inclusion of lakes and rivers, and a revised representation of the recharge/evapotranspiration process. The model was initially calibrated to an average 2003 steady-state condition. The steady-state simulation served as the initial conditions for a long-term monthly transient simulation from 2004 through 2014. In the greater ECFTX model domain, there were 703, 779, and 18 monitor wells within the SA, UFA, and LFA, respectively, to match or compare simulated water levels with observed water levels in 2003. In addition, there were 17 springs with measurements during 2003 within the entire model area that served as springflow targets during the steady-state calibration. There were also 18 USGS streamflow gages within the entire model domain where simulated baseflow was compared to the range of estimated baseflow. In addition to the targets mentioned previously, additional criteria such as long-term depth to water-table measurements from 807 SA observation wells, vertical head difference from 214 SA and UFA nested wells, and vertical head difference between 29 UFA and LFA nested wells were reviewed during the calibration process to guide adjustments for leakance (vertical hydraulic conductivity/thickness) using the water table depth and head difference data.

Calibration primarily consisted of manually adjusting hydraulic conductivity, specific storage, and drain/river cell conductances to improve matches between simulated and observed heads. For springs, calibration involved modifying conductance values within reasonable limits to meet their calibration targets. Parameters were constrained within reasonable ranges based on previous modeling efforts and prior knowledge of the hydrogeologic system. An automated calibration process, or parameter estimation, using a computer program called PEST (Dougherty, 2014a and b) was originally proposed and conducted in the early part of the model calibration. However, it's use was abandoned in favor of the manual calibration when a number of issues arose, including excessive simulation times, dry cells,

and relatively poor calibration results. Head calibration targets were achieved for the CFWI Planning Area and the ECFTX model domain, with normalized root mean square errors of 2.4%, 3.1%, and 5.9% for the SA, UFA, and LFA, respectively. Springflow calibration targets were achieved for the CFWI Planning Area and the ECFTX domain. For the calibration period from 2004-2012, mean simulated springflow in the model from all 158 springs was 2,082 cfs, while observed (estimated and measured) springflow was 2,158 cfs, resulting in a mean error of -3.5%.

Peer Review Process

The purpose of the peer review was to provide independent review of the ECFTX model, focusing on assessing the following:

- Model objectives, conceptualization, and design
- Assumptions and limitations of input data
- Model calibration and sensitivity
- Model documentation (explanation of model, data sources and assumptions)
- Suitability of model for its intended applications.

Given the scope of model improvements, the HAT determined it was best to convene an independent scientific peer review panel (Panel) during each major phase of the construction and calibration of the updated ECFTX Model. Three independent groundwater modeling experts with experience in Florida were assembled to conduct this review. Traditionally, peer reviews have been implemented once the model is calibrated and the documentation developed. The HAT thought an improved approach was to convene the Panel earlier in the model development process. In this way, the Panel could provide early input to better minimize the chance that a major model revision would be needed at the conclusion of the project. Towards that end, the Panel was engaged at the conceptual model development phase and throughout calibration and model documentation. The Panel was formed, and the first meeting held in September 2016. Throughout the peer review process, periodic publicly noticed teleconference calls were conducted to update the Panel on the HAT's progress and solicit input. All communication with the Panel was conducted via a SWFWMD electronic web board, available to the public. Publicly noticed meeting dates were posted prior to the meetings, and all documents and correspondence between staff and the Panel were conducted via the web board. Meeting summaries for each meeting were similarly posted on the web board.

Fifteen teleconferences and two in-person meetings were held over the course of the peer review. The dates and topics of these meetings are summarized in Table 1. The teleconferences were generally 2 hours in length and occurred at key junctures in the modeling process or when the HAT had questions for which they sought input from the Panel. Major topics discussed included the conceptual model of the system, resolving dry cells, baseflow estimation, boundary condition selection, rainfall-adjusted NEXRAD estimation, calibration approaches (e.g., automated vs. manual), calibration targets, statistical

measures of calibration success, and modification of general head boundary fluxes. Two in-person meetings were conducted at the SFWMD St. Cloud Field Station. The first meeting occurred following conceptual model development. The second meeting occurred after the Panel had reviewed the draft modeling report and provided comments. The purpose of this meeting was for staff to respond to comments and gain clarification of issues prior to finalizing the model document. Minutes from the meetings are provided in the Appendix.

Table 1. Summary of teleconferences and meetings during the peer review process.

Meeting #	Date	General Topic	Specific Topics	Notes	Duration (hrs)
1	9/2/2016	Background and Introduction	Sunshine laws, web-board, process and schedule, overview of CFWI, previous groundwater modeling.		2:00
2	9/29/2016	Background and Conceptual Model	Rationale behind simplifying different elements for inclusion in the ECFTX model: Lakes and stream flow runoff, LFA, lateral flow boundaries, recharge process, calibration criteria.		2:00
3	10/13/2016	Conceptual Model	Discussed Panel question on conceptual model, identified the topics to be presented at the face-to-face meeting, planning for face-to-face meeting.		1:00
4	10/18/2016	Address questions and comments by the Panel on the ECFTX Conceptual Model Document	Overview and purpose of model. Recharge process, lakes and rivers, other return flows, water withdrawals, drainage features, calibration process, hydrostratigraphy, model boundaries, equivalent freshwater heads, springs.	Face-to-face meeting in St. Cloud, FL	6:30
5	11/29/2016	Conceptual Model Followup	How to finalize the Panel's review of the Conceptual Model Document.		1:00
6	12/6/2016	Conceptual Model Followup	Discuss first draft of "Updates to Overall Modeling Approach, ECFTX".		2:00
7	12/13/2016	Conceptual Model Followup	Discuss the second draft of the technical memorandum (TM) entitled, "Updates to Overall Modeling Approach, ECFTX Groundwater Model.		1:00
8	3/2/2017	Model Status	Update Panel on progress regarding calibration of the ECFTX model. Discussion of steady-state calibration, general head boundaries, dry cells, layer 1 transient model, isolated lakes, equivalent freshwater heads.		2:00
9	4/26/2017	Model Status	Update the Panel as to the District's progress regarding calibration of the ECFTX model. Discussion of isolated lakes, structural issues (cell-to-cell discontinuity), ECFTX calibration plan (PEST), equivalent freshwater heads, layer 1 transient model, and path forward.		2:30
10	7/12/2017	Model Status Update	Update the Panel as to the District's progress regarding calibration of the steady state 1- layer model and layer 1 transient ECFTX model. Discussion of ECFTX calibration plan (PEST), isolated lakes, equivalent freshwater heads, issues of concern, and Panel recommendations.		2:00
11	7/21/2017	Model Status Update	Targets analysis, seepage lakes, kx and kz maps, transient calibration plan, base flow separation, layer 1 transient calibration.		2:00
12	1/25/2018	Calibration Status	Update Panel on the calibration of the 11-layer ECFTX model. Dry cell and flooding issues during PEST calibration, NEXRAD data adjustments, lateral boundary conditions, steady state model, and path forward.		2:35
13	5/21/2018	Review of Final Steady-State Calibration	Present to the Panel the District's final steady-state calibration for the 11-layer steady-state ECFTX model.		3:00
14	10/4/2018	Transient Model Calibration Status	NEXRAD adjusted data and effect on model results, DRT package, calibration targets, District-specific calibration efforts, storage coefficients, and timestep expansion factor.		2:20
15	12/12/2018	ECFTX calibration Update	Model changes since last meeting, calibration criteria and statistics, lakes, spikes in water levels, baseflows, comments from Panel, path forward.		3:05
16	8/15/2019	ECFTX calibration Update	Districts' update to the transient calibration results for the ECFTX Model. Anomalous GHB fluxes and fix, predictive scenarios, transient response, schedule for draft report.		3:15
17	12/11/2019	Staff Response to Panel Review of Draft ECFTX modeling Report	Responses and presentations to discuss Panel's reviews of the draft modeling report. Comment resolution.	Face-to-face meeting in St. Cloud, FL	3:40

Findings of the Panel

The findings of the Panel regarding the draft modeling report (subject to clarifications and corrections that were agreed upon during the December 11, 2019 meeting) are described below. It should be noted that the Panel provided comments and recommendations throughout the course of their involvement as reviewers. These comments and recommendations are not shown here because they were generally heeded as a part of the model development and are therefore not relevant to the final product. These comments and recommendations are included in the meeting minutes and draft report review comments in the Appendix.

Elements of a Modeling Report

A well-constructed modeling report should present (1) the objectives of the study, (2) a description of the work that was done, (3) logical arguments to convince the reader that the methods and analyses used in the study are valid, and (4) results and conclusions (Reilly and Harbaugh, 2004). Coverage of the following topics is recommended (based on Reilly and Harbaugh, 2004 and Anderson et al., 2015):

1. The purpose of the study and the role that the simulation plays in addressing that purpose;
2. A description of the hydrologic system under investigation;
3. A discussion of the mathematical methods used and their appropriateness to the problem being solved;
4. A description of the hydrogeologic character of the boundary conditions;
5. A description of how the system is discretized;
6. A description of the aquifer properties that are modeled;
7. A description of the stresses modeled such as pumpage, evapotranspiration from ground water, recharge from infiltration, river stage changes, leakage from other aquifers, and source concentrations in transport models;
8. Initial conditions and discretization of time for transient models;
9. A description of the calibration criteria, procedure, and results; and
10. A discussion of the limitations of the model's representation of the actual system and the impact those limitations have on the results and conclusions presented in the report.

The East-Central Florida Transient Expanded (ECFTX) Model February 2020 Final Report generally follows the guidelines and recommendations of Reilly and Harbaugh (2004) and Anderson et al. (2015) listed above. The background leading to the study, the objectives of the present study, previous studies and models, a description of the peer review process, and acknowledgments are in Chapter 1 of the ECFTX model report. The topography and physiography, land use, hydrography (rivers, lakes, swamps and wetlands), climate (rainfall and evapotranspiration), and soil groups and infiltration characteristics are described in Chapter 2. The geologic framework, the hydrogeologic framework consisting of the surficial

aquifer, the intermediate aquifer system/intermediate confining unit, and the Floridan aquifer system, and water use and previous water-budget studies are described in Chapter 3. The conceptualization of the groundwater system and model calibration are presented in Chapters 4 and 5. A sensitivity analysis, summary and conclusions, model limitations, recommendations for future data collection, and future model refinements are in Chapter 6. Lists of references and 14 appendices that are available on an FTP site are included also. The ECFTX draft model report includes 139 figures and 22 tables that support the narrative of the report[1]. A list of acronyms and abbreviations used in the report facilitates review and study of the draft report.

Conceptual Model

A conceptual model is a qualitative description of the hydrogeologic system, including boundaries to the natural system, hydrostratigraphy, hydraulic parameterization, inflows and outflows, and temporal changes over the period of interest. The qualitative conceptual model forms the basis for the quantitative numerical model. The Panel provided extensive review of the conceptual model: six meetings (including an all-day face-to face meeting) over the course of a three-month period were held specifically to discuss the conceptual model. In addition, the Panel reviewed and provided comments on a written report on the conceptual model.

Elements of the conceptual model that were considered in detail included: 1) process for estimating recharge; 2) simulation of lakes, simulation of rivers and determination of base flow; 3) water withdrawals; 4) model boundaries; 5) drainage features; 6) use of equivalent freshwater head; 7) hydrostratigraphy; 8) simulation of springs; and 9) simulation of wetlands.

The Panel finds that the conceptual model in the ECFTX is satisfactorily described and documented. In addition, the conceptual model is reasonable based on our knowledge of the hydrostratigraphic system and prior models that include parts of the ECFTX model domain.

Steady-State Calibration

Guidelines for calibrating a groundwater flow model generally consist of establishing calibration targets for heads and flows such as springflows and baseflows and associated acceptable residuals and residual statistics, identifying calibration parameters and boundary conditions whose values are adjusted during the calibration process, and varying values of the calibration parameters and boundary conditions until the model simulation reproduces measured heads and groundwater flows to the desired degree of accuracy (based on ASTM 2018, Reilly and Harbaugh 2004, and Anderson et al. 2015).

The purpose of the steady-state calibration was primarily to provide initial conditions for the transient calibration. It provided ~~s~~ a set of conditions (hydraulic parameters, boundary conditions, and computed water levels) that were in equilibrium with one another at the start of the transient calibration period. The steady-state calibration was ~~is~~ important in order to avoid the necessity of the model having to adjust to pre-specified conditions that were likely not physically consistent with one another during the

[1] The ECFTX final report was expanded to include 15 appendices, 155 figures, and 32 tables. The additional materials are responsive to Panel requests and comments.

transient calibration period, thereby resulting in inaccurate results during the early parts of the transient period.

The steady-state calibration process for the ECFTX model described in Section 5.1 generally follows the guidelines suggested by ASTM (2018), Reilly and Harbaugh (2004), and Anderson et al. (2015). In the steady-state calibration, average annual aquifer water levels, springflows, and baseflow estimates were calculated for calendar year 2003, and average annual heads from observation wells for the SA (layer 1), UFA (layers 3-5) and LFA (layers 9-11) were assigned as target wells for the steady-state calibration. The steady-state calibration consisted of manually adjusting hydraulic conductivity fields to improve matches between simulated and observed heads using starting parameters from existing regional models. In the CFWI area, 197, 161, and 15 monitor wells in the SA, UFA, and LFA, respectively, were used as target wells for the steady-state calibration. In addition, there were eight springs and five USGS streamflow gages in the CFWI area that served as calibration targets. In the greater ECFTX model domain, 703, 779, and 18 monitor wells in the SA, UFA, and LFA, respectively, were used as target wells for the steady-state calibration. In addition, there were 17 springs and 18 USGS streamflow gages in the ECFTX area that were used as calibration targets. In the CFWI area, 53 percent of the mean absolute simulated head residuals for all wells in the SA, UFA, and LFA were within 2.5 feet of observed values for the steady-state period (Table 12). In the ECFTX model domain, 50 percent of the mean absolute simulated head residuals for all wells in the SA, UFA, and LFA were within 5 feet of observed values for the steady-state period (Table 12). The steady-state simulated UFA heads compared well with the observed regional configuration of the UFA water levels under average 2003 conditions with the Polk City potentiometric high, East Pasco potentiometric high, and steep hydraulic gradient areas represented well (Figure 92). The 2003 steady-state simulation was subsequently utilized as the initial condition for the monthly transient simulation from 2004 to 2012.

Transient Calibration

The transient calibration for 2004 to 2012 is described in Section 5.2. Monthly average aquifer water levels, springflows, and baseflows were obtained from recorded observations or estimated values during 2004 through 2012 to calibrate the transient model. Calibration targets for water levels, springflows, baseflows, and structure flows are listed in Figure 91. For the entire ECFTX domain, these criteria require a mean error of less than one foot for all wells in the SA, UFA, and LFA, a root mean squared error of less than 5 feet from all wells within each aquifer, and a mean absolute error within 5 percent of the total head elevation range for each aquifer. For the CFWI area, 50 percent of the wells were required to have a mean absolute error of less than 2.5 feet, and 80 percent of the wells were required to have a mean absolute error of less than 5 feet. Total modeled springflow had to be within 10% of the estimated/measured mean springflow and simulated mean springflow for each 1st and 2nd magnitude spring with continuous observations had to be within 10% of mean average observed flow over the calibration period. The calibration criterion for baseflows specified a mean error for the baseflows to be within an order of magnitude for the sum of all simulated baseflows. The calibration criteria for structure flows specified a deviation of volume (DV) less than 15 percent, a Nash-Sutcliffe efficiency (NS) greater than 0.5, and coefficient of determination (R^2) greater than 0.5. The statistical calibration

criteria selected for the ECFTX Model are similar to other regional models in the area and are considered to be reasonable by the Panel.

The calibration procedure consisted of manually adjusting hydraulic conductivity, specific storage, and drain and river cell conductances to match simulated and observed heads. Spring conductances were adjusted for the springs to meet their calibration targets. Starting conditions and initial parameters were from the steady-state 2003 calibrated model.

In the CFWI area, 277, 194, and 24 monitor wells in the SA, UFA, and LFA, respectively, were used as target wells in the transient calibration. In addition, there were eight springs and five USGS steam flow gages in the CFWI area that served as calibration targets in the transient calibration. In the greater ECFTX model domain, 997, 928, and 30 monitor wells in the SA, UFA, and LFA, respectively, were used as target wells in the transient calibration. In addition, there were 17 springs and 18 USGS steam flow gages in the ECFTX area that were used as calibration targets in the transient calibration. In addition, qualitative criteria such as long-term depth to the water table and vertical head differences between SA and UFA and UFA and LFA nested wells were reviewed during the calibration process.

Head calibration targets were achieved for the CFWI and ECFTX model domain (Table 13). The spatial distribution of error for all aquifers within the CFWI area is smaller than the domain outside the CFWI area (Figures 93 through 95). Simulated versus observed potentiometric surfaces for May 2010 and September 2012 (Figures 96 and 97) indicate that the Polk City potentiometric high, the East Pasco potentiometric high, the high along the Lake Wales Ridge, and the configuration of the UFA flow field are well-represented by the transient model. Histograms and regression plots of simulated versus observed water levels for each aquifer are shown in Figures 98 through 109 for the CFWI area and ECFTX model domain. Figures 110 through 115 show individual simulated versus observed water-level responses at selected wells across the CFWI area within the SA, UFA, and LFA (Figure 116). A full suite of model hydrographs is in Appendix G.

Springflow calibration targets were achieved for the CFWI area and the ECFTX domain. For the calibration period from 2004-2012, mean simulated springflow in the model from all 158 springs was 2,082 cfs, while observed (estimated and measured) springflow was 2,158 cfs, resulting in a mean error of -3.5%. Calibration target statistics were also achieved for each of the 17 1st and 2nd magnitude springs that had continuous measurements during the calibration period (Table 14). Each 1st and 2nd magnitude springs with measurements had to have a mean error less than 10 percent to meet calibration criteria. The spatial distribution of error for the 17 simulated springs is shown in Figure 117. A regression plot of simulated versus observed mean springflow is shown in Figure 118. Simulated versus observed monthly springflow hydrographs for Wekiwa and Gum Springs are shown in Figure 119. Simulated versus observed springflow hydrographs for all 17 springs with continuous measurements are shown in Appendix H.

The baseflow calibration targets were achieved for the ECFTX domain. For the calibration period from 2004-2012, mean simulated baseflow in the model from all 18 USGS gages was 5,170 cfs, while observed/estimated baseflow varied from 2,226 to 9,160 cfs. The calibration criterion for estimated baseflow was to have the model simulate baseflow within an order of magnitude due to the variability

of estimation methods for this more uncertain flow statistic. A total of 15 out of 18 USGS gages where baseflow was estimated were within the range of flows estimated by the methods described in Chapter 4 (Figure 120).

The Panel believes that the pre-specified calibration criteria have been met for the transient ECFTX model and the model is considered to be calibrated subject to those criteria.

Model Verification

A model verification step is part of good modeling practice. It essentially involves running the model for a different time period with a different set of stresses (pumping, recharge, and ET) than were used to calibrate the model. The objective of model verification is to determine if the calibrated model can satisfactorily simulate a time period (and stresses) different than those for which it was adjusted to match. The verification step provides limited assurance that the model can be used in a predictive mode.

The two-year monthly transient period from 2013-2014 was selected as the model verification period, and simulated heads, springflows, and baseflows calculated for this period were determined to meet the calibration criteria specified for the 2004-2012 transient calibration period with only minor exceptions. Within the CFWI domain, simulated heads at 220, 161, and 25 monitor wells within the SA, UFA, and LFA, respectively, were compared to observed water levels from 2013-2014 at these wells. In addition, there were 8 springs with measurements from 2013-2014 within the CFWI area that served as targets to evaluate model performance. There were also 15 USGS streamflow gages within the CFWI area where simulated baseflow was compared to the range of estimated baseflow calculated from multiple methods. In the greater ECFTX model domain, simulated heads at 796, 709, and 31 monitor wells within the SA, UFA, and LFA, respectively, were compared to observed water levels from 2013-2014. In addition, there were 17 springs with measurements during the verification period within the entire model area. There were also 18 USGS streamflow gages within the entire model domain where simulated baseflow was compared to the range of estimated baseflow.

Head calibration targets were achieved for the CFWI area during the verification period and were comparable to the calibrated model. For the ECFTX model domain, all head targets were within the defined calibration criteria except that the mean error for the SA was -1.01 ft, which very slightly exceeded the less than one-foot criteria assigned to the domain as a whole for each aquifer (Table 15). Simulated versus observed potentiometric surfaces for May and September 2014 are shown in Figures 129 and 130. Similar to the calibration period flow field, the Polk City potentiometric high, the East Pasco potentiometric high, the high along the Lake Wales Ridge, and the configuration of the UFA flow field are well-represented by the transient model.

For the verification period from 2013-2014, mean simulated springflow in the model from all 158 springs was 2,121 cfs, while observed (estimated and measured) was 2,165 cfs, resulting in a mean error of +2%. The simulated springflow comparison with observed (estimated and measured) springflow for the verification period was similar for the CFWI area during the calibration period but not for two springs within the larger ECFTX model domain. Verification period statistics were comparable to the calibration

period for the 17 springs with measurements except for the Rainbow No. 1 and Lithia Major Spring which slightly exceeded the calibration period metric at 11% and 14%, respectively (Table 16). The baseflow match for the verification period was similar to the calibration period for the ECFTX domain. For the verification period from 2013-2014, mean simulated baseflow in the model from all 18 USGS gages was 4774 cfs, while the observed (estimated and measured) springflow varied between 3352 and 9814 cfs. A total of 10 out of 18 USGS gages where baseflow was estimated were within the range of flows estimated by the methods described in Chapter 4 for the verification period. The simulated heads, springflows, and baseflows calculated for the 2013-2014 model verification period meet the calibration criteria specified for the 2004-2012 transient calibration period with only minor exceptions. It is common for minor exceptions to meeting the calibration targets to be present during verification. This is because the calibrated parameters, by definition, are not adjusted during the verification period and therefore, the comparison of modeled results to target values provides an indication of model performance during the predictive phase when the model parameters are also held at their calibrated values. The minor exceptions noted are typical for regional models.

Water Budget

In Section 5.4 of the draft report, a simulated water budget from the ECFTX model by layer is described for the period 2003-2014 (Table 17). Net fluxes for each major component of the water budget are shown in inches per year by model layer. The total flux (IN minus OUT) balances to within less than 0.05 inches/year. Net recharge averages a little over 9 inches/year. GHB lateral fluxes were an average of 0.9 inches/year into the model. Constant head, well, river, springs, and drains were outflow components of 2.4, 2.2, 0.9, 1.3, and 3.6 inches per year (Figure 131). A total net storage change of 0.2 inches/year occurred over the 2003-2014 period based on the model results. A more detailed water budget is contained in Appendix L.[2]

The Panel believes the model computed water budget of the ECFTX is consistent with expectations that are based on knowledge of the hydrogeologic system and the results of other models in the area. The water balance difference between inflow and outflow (IN-OUT) is acceptable for numerical accuracy.

Sensitivity Analysis

A sensitivity analysis is described in Chapter 6 in which model parameters were systematically varied to determine which parameters have the most influence on the simulated heads at the groundwater monitoring wells, the simulated flows at the 1st and 2nd magnitude springs, and the structure flow discharge locations. The model input parameters used in the sensitivity analysis and the different multipliers that were applied to the calibration parameters are listed in Table 19. The tested parameters are: vertical hydraulic conductivity (Kv) in model layers 1 through 11; horizontal hydraulic conductivity (Kh) in model layers 1 through 11; specific storage (Ss) in model layers 1 through 11; specific yield (Sy) in

[2] The final report provides water budget information that is slightly different than the draft report. For the calibration period, recharge is 8.7 in/yr, GHB lateral influx is 0.7 in/yr into the model with constant head, well, river, springs, and drains having net outflow components of 2.3, 2.0, 0.9, 1.3 and 3.4 in/yr, respectively. Net storage change is +0.4 in/yr for this period.

model layers 1 through 3; conductance values for drains, rivers, and general head boundary (GHB) cells; groundwater recharge; saturated zone evapotranspiration rates (ET); and the ET extinction depth. For each parameter, model runs were made using the four multipliers identified for each parameter in Table 19. Additional model runs replacing time-varying heads in the GHB cells with a constant-head boundary in addition to a no-flow boundary (GHB conductance equal to 0) in model layers 1 through 11 were also simulated. A total of 192 model runs were conducted to complete the sensitivity analysis. The simulation period for the sensitivity analysis was January 1, 2004 to December 31, 2012, which is the same as the calibration period for the ECFTX transient model and is used to compare spring and structure flows. Both the calibration and verification (January 1, 2013 to December 31, 2014) periods were used to evaluate the model's sensitivity to simulated heads due to several Lower Floridan Aquifer monitor wells with observation data that are relatively new and not available during the calibration period. The results of the sensitivity analysis are shown in Tables 20-22, Figures 134-139, and Appendix M.

It is discussed in Section 6.2.7 that the results of the sensitivity analysis indicate that the ECFTX model is most sensitive to changes in the hydraulic conductivity of the ICU and UFA including both producing zones separately; the drain conductance term; and the recharge rates. The results from the global model sensitivity changes indicate that changing any parameter model wide does not result in an improvement in the overall model calibration and modifying the most sensitive of parameters generally results in a net degradation of the calibration statistics. This would tend to suggest the model appears to be reasonably calibrated.

Analysis of the figures in Appendix M indicates that reducing or increasing some of the calibration parameters would result in improvements in water-level, springflow, and baseflow statistics in some cases but would result in deterioration of other statistics.

Final Report

Additional updates were made by the HAT to the draft report reviewed by the Panel. These updates included numerous edits and clarification of text, new section 4.13 that addresses QA/QC of the model datasets, paragraph of new text on the use of PEST initially to calibrate the model in section 5.1.1, new Section 5.4 on the model fit during high and low periods, new head duration graphs of all monitor wells used as calibration targets in Appendix L, adding outflow components and developing the budgets separately for the calibration and verification periods in Section 5.5 (Water Budget), separate baseflow tables comparing estimated baseflow to simulated for the calibration and verification periods, adding average flux to the UFA during the calibration period as a new figure, and adding the recommendation to use PEST and an uncertainty analysis for the next major recalibration effort of the model in Section 6.5 future model refinements.

Summary

Table 2 provides answers to questions posed by the HAT that were intended to summarize the scope of the peer review.

Table 2. Answers to questions posed to the Panel by the HAT.

1. Documentation provided by WMDs		
Question	**Response**	**Notes**
A. Does the documentation provide a clear and appropriate description of the ECFTX?	Yes	
B. Are the objectives of the documentation clear?	Yes	
C. Are the objectives met?	Yes	
D. Is the documentation readable? Are the figures clear?	Yes	
E. Are additional levels of detail required to serve the intended objectives?	No	
F. After reading the documentation, are the purpose, scope, strengths/weaknesses, and limitations of the ECFTX understandable?	Yes	
G. Does the scope or format of the documentation need to be modified or expanded?	No	The model documentation contains 15 appendices that provide much detail on the model.
2. Model Implementation		
Question	**Response**	**Notes**
A. Based on the documentation and presentations provided, are the modeling techniques and methodologies proposed for the ECFTX model appropriate for the temporal and spatial scale of the model?	Yes	
B. Is the conceptual model appropriate?	Yes	
C. Physical and Hydrologic Processes:	Yes	
Question	**Response**	**Notes**
a. Will the ECFTX model include all the important physical and hydrological processes necessary to address sub-regional-scale water resource issues in Central Florida?	Yes	
b. Are the physical features and hydrologic processes represented adequately? Examples of physical features and hydrologic processes include:	Yes	
c. Groundwater Flow	Yes	
d. Climatic Variability	Yes	

Question	Response	Notes
e. Boundary Conditions	Yes	At some point in the future, it may be useful to have a dynamic seaward boundary where the saltwater interface position responds to changes in water levels.
f. Applied Stresses	Yes	
g. Topography	Yes	
3. Model Calibration		
Question	**Response**	**Notes**
A. Does the model appear to be adequately calibrated relative to other commonly employed calibration methods?	Yes	Similar model statistics for goodness of fit compared to other models in the area
B. Are there any other alternative calibration criteria or methods that could be used?	Yes	Recommend that future versions consider use of PEST
C. Is additional sensitivity analysis needed for the intended purpose of the model?	Maybe	Recommend that future versions use PEST to develop a more concise presentation of model sensitivity.
D. Are the verification methods appropriate?	Yes	2-yr post calibration verification period.
E. Does there appear to be any model bias throughout range of model predictions?	No	Staff plotted head duration curves to test for transient model bias, Nash-Sutcliffe statistic, wet and dry year calibration head statistics, and times series of mean error graphs (Section 5.4).
4. Overall appropriateness of model		
Question	**Response**	**Notes**
A. What are the model strengths?		Detailed representation of all features, boundaries are located far from area of interest and are natural boundaries, and model is well calibrated to transient conditions.
B. What are the weaknesses of the model?		Reliance on past models for initial parameter values / distributions may prevent a comprehensive exploration of alternative conceptual models
C. Are there any deficiencies in the model?	No	
D. Is the model suitable and defensible for the intended applications?	Yes	

Recommendations

The Panel made numerous recommendations during the course of the peer review. As many of these were heeded, they are not mentioned here. The following are recommendations that pertain to the future of the ECFTX model.

It is recommended that the current model be maintained on a relatively continuous basis. Model maintenance includes having a formal means for users of the model to report bugs or anomalous behavior to a designated “model custodian” such that any errors can be readily addressed.

The model should continue to be updated as new data become available and the hydrologic system is affected by new and potentially different stresses (droughts, extreme precipitation from tropical storms,

new wellfields, land-use changes, etc.). The new data and stresses should be used initially in a post-audit to test the current model performance and the new information later incorporated as a part of a longer-term calibration.

It is difficult to draw meaningful conclusions from the sensitivity analysis reported in the model documentation because of the large number (192) of model runs and figures and tables that were produced in performing the sensitivity analysis. This difficulty illustrates the disadvantage of using a manual trial-and-error technique to perform a sensitivity analysis for a large complex model such as the ECFTX model. Processes used to formulate unit response functions in an automated parameter estimation technique such as PEST lend themselves to an efficient means of testing and reporting model sensitivity. The use of PEST for this purpose, even if not for model calibration, should be considered.

It is recommended that any future development of the model should consider an automated procedure using a code such as PEST for the steady-state calibration as well as the transient calibration.

The Panel believes that the methodology used for the peer review of the ECFTX model was effective in that it allowed the Panel to contribute to major decisions regarding conceptual model formulation, model construction, calibration, and verification. This methodology prevented potential disagreement from the Panel at the end of model development on a decision made by the modeling team early in the modeling process.

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Appendix

Minutes from Peer Review Panel Teleconferences and Meetings

MEETING SUMMARY

Meeting Date: September 2, 2016

Subject: ECFTX Peer Review: Meeting 1 - Introduction and Background

Attendees:

Panel Members: Pete Andersen, Lou Motz, Mark Stewart

Districts: Pete Kwiatkowski, Uditha Bandara, Jeff Giddings, Tim Desmarais, Wei Jin, and Mark Barcelo

Utility Representatives: Keith Browning, Al Aikens, Brian Megic, David MacIntyre

Other: Ilia Balcom (Duke Energy)

1. Welcome and purpose of meeting — HAT
    - All meeting participants were identified
    - Purpose of the meeting is to provide the Peer Review panel with background information on the CFWI and ECFTX model, and discuss the overall peer review process
2. Overview of Sunshine Law requirements — SWFWMD
    - Goal is to conduct peer review in an open and transparent manner
    - Communication among panel members about the ECFTX model must only occur in a publically notified meeting or via the Web Board
3. Web Board — SWFWMD
    - A Web Board has been established for the review effort
    - Instructions for gaining access to the Web Board were discussed
    - Organization of the Web Board was identified as an item to address to make sure searches for posted items can be done reasonably well
4. Discussion of overall process and schedule — Peer Review Panel
    - The Panel asked what the specific charge to them was. The panel is responsible for reviewing the ECFTX model to determine if good modeling practices were followed and the model can be used for the stated purposes. Following are questions for the panel that were discussed during the presentation for item 6.
        i. Did HAT use standard/good modeling practices?
        ii. Did HAT consider appropriate hydrologic processes?
        iii. Is there an appropriate balance between model detail and computational efficiency for a regional model?
        iv. Are there areas for improvement?

v. Can the model be applied for its intended purposes? What are limitations of the model?

- The model will be judged based on its value and not on comparison to previous models
- The overall SOW includes four major review items:
  i. Background and introduction (September 2016)
  ii. Conceptual Model (mid-September 2016 through October 2016)
  iii. Interim (about 50 to 75 percent complete) calibration results (March 2017 time frame)
  iv. Final model and documentation (August 2017)
- The level of detail to be included in the Conceptual Model document was discussed. The document will include a good level of detail on model construction, assumptions used, boundary conditions, etc.
  i. The panel supports including a good amount of detail in the document
  ii. They stressed the importance of documenting processes used and decisions made as the model is being calibrated
- The anticipated review schedule was discussed. The short-term goal of HAT is to provide the conceptual model document to the panel in the mid-September timeframe.

5. Overview of the CFWI HAT
   - A brief overview of the CFWI was provided
   - The area includes southern Lake and all of Polk, Orange, Osceola, and Seminole counties and is shared by three different water management districts
   - Goals include a single shared groundwater model to determine groundwater availability, one coordinated strategy for MFLs prevention and recovery, and one regional water supply plan
6. Previous groundwater modeling work to support the CFWI RWSP HAT
   - An overview of the ECFTX model was provided. ECFT refers to the East Central Florida Transient model and ECFTX refers to the Expanded ECFT model.
   - The ECFT model is an outgrowth of modeling work done over the past 20 years by the both the SJRWMD and SFWMD and, was developed by the USGS and modified by the CFWI HAT to support the 2015 CFWI RWSP.
   - Modifications to the USGS ECFT model by the HAT were the result of a cooperative effort by staff from the three districts and technical representatives of utilities and others in the CFWI.
   - Key objectives of the ECFTX model are to expand the ECFT model area to include the entire CFWI area, increase computational efficiency, resolve water use discrepancies, reach consensus on hydrostratigraphy and model layering, and incorporate recent data.
   - An overview of the principal changes to the model was presented.

i. Water use updates – consistency with RWSP
ii. Expanded model boundaries – incorporate entire CFWI area and ability to simulate lakes on Lake Wales Ridge in Highlands County
iii. ET/Recharge process – change to SCS/AFSIRS Water Budget approach
iv. Lakes and Rivers – use River Package and perform sensitivity analysis on selected lakes using Lake Package
v. Hydrostratigraphic framework
vi. Other
    1. Land use – incorporate period changes
    2. Man-made drainage
    3. Reclaimed water and RIBs
    4. Springs
    5. Return flow

- Model calibration and documentation is anticipated to be complete by August 2017.
- Peer Review will occur from September 2016 to December 2017

7. Public comment
    - David MacIntyre clarified the reasons for HAT moving away from the Green-Ampt ET/recharge pre-processor used for the ECFT model
8. Things To do
    - Provide the Conceptual Model Document to the Panel by mid-September 2016
    - A face-to-face meeting will be scheduled for mid-October 2016. Panelists will provide potential open dates for a full day face-to-face meeting.
    - Prior to the face-to-face meeting, the Panel will provide the HAT with a list of questions, issues and concerns regarding the conceptual model document. This will allow the HAT to prepare responses/explanations and facilitate a more productive meeting.

The meeting was adjourned at noon.

MEETING SUMMARY

Meeting Date: September 29, 2016

Subject: ECFTX Peer Review: Meeting 2 - Background and Conceptual Model

Attendees:

Panel Members: Pete Andersen, Lou Motz, Mark Stewart

Districts staff: Pete Kwiatkowski, Uditha Bandara, Jeff Giddings, Tim Desmarais, Wei Jin, and Mark Barcelo

Utility Representatives: Keith Browning, Brian Megic

The meeting began at 2:05 p.m.

1. Welcome and purpose of meeting
    - All meeting participants were identified
    - Purpose of the meeting is to plan upcoming meetings and provide the Peer Review panel with the opportunity to discuss how to conduct review of the Conceptual Model document.
2. Web Board
    - The Web Board was unavailable for posting documents over the past week. As required under the Sunshine Law, the SWFMWD posted the required noticing that the Web Board will be used for the Peer Review process.
    - Beginning Friday, October 1, 2016 panelists will be allowed to post documents.
3. Upcoming meetings
    - ~~October 11, 2016~~ October 13, 2016 - teleconference from 2pm to 4pm to discuss plans for face to face meeting
    - October 18, 2016 - face to face meeting to discuss the Conceptual Model Document.
        i. Meeting will be in the Orlando area. Confirmation of meeting location will be provided in the upcoming week.
        ii. Panelists will post questions/comments to the Web Board by ~~October 7, 2016~~October 10, 2016.
4. General discussion
    - Panel is familiar with the complexities associated with the USGS ECFT model but would like to understand the rationale behind simplifying different elements for inclusion in the ECFTX model
        i. Lakes and stream flow runoff

1. Little benefit was obtained by using these more detailed packages in the ECFT regional model.
2. Panel recognizes there is detail needed on a local scale that doesn't necessarily benefit the regional scale model.

ii. LFA

1. Suggestion was made that during the calibration process the lower layers could be shut off to determine effects on the overall model. The feedback would determine the need to keep those layers in the model. Staff stated the rationale for increased LFA discretization is to allow heads to be simulated below the LFA production zone to better ensure this resource is not overstressed.
2. Because such little information on the LFA is known, consider excluding these layers from PEST.

- Lateral boundaries and the influence of seawater conditions
  i. Proper location of model boundaries can be used to support use of a solute transport model such as SEAWAT in the future
  ii. Panel would like to understand our plans for dealing with water of different densities
- Recharge process
  i. Recharge is calculated on a daily basis and accumulated to monthly values for input to the model
- Calibration criteria
  i. Statistical calibration criteria are good for a steady-state model but are not adequate to capture the transient nature of model
  ii. Need to be able to describe how well the model performs during wet and dry periods
  iii. PA will post a paper he developed with a co-worker that describes ways to characterize the transient nature of models
  iv. WMDs want flexibility in the calibration evaluation process

5. Public comment
   - Keith Browning suggested a discussion on how the WMDs plan to use the model
     i. Model uses include support for the RWSP and Solutions development phases of the effort.
     ii. Model will also be modified for use in resource regulation
6. Things To do
   - WMDs will schedule upcoming meetings
     i. Teleconference - ~~October 11, 2016~~ October 13, 2016 from 2pm to 4pm

    ii. Face to face with teleconference/Web Ex access – October 18, 2016 from 10am to 4pm (advertised time is 9:30am to 5pm in case we have all participants available)
- Panel will post their questions to the Web Board by ~~October 7th~~ October 10th.
    i. Questions will be identified according to: major issue, minor issue, or editorial, and major strengths and weaknesses will be identified
    ii. PA will post a paper regarding criteria for evaluating transient calibrations.
- Topics for face to face meeting
    i. How will model be used and will simplifications to reduce run times affect the ability to use the model as planned?
    ii. Boundary locations, treatment of boundary heads, and conversion of water levels at monitor wells to equivalent freshwater heads
    iii. Description of calibration process – manual vs PEST processes.
    iv. Calibration criteria – steady state versus transient
    v. Recharge – description of process to calculate recharge
    vi. Prepare cross-section views of model layering and hydrostratigraphy prior to face-to-face meeting.

The meeting was adjourned at 4pm.

MEETING SUMMARY

Meeting Date: October 13, 2016

Subject: ECFTX Peer Review: Meeting 3 – Preparation for Face to Face Meeting

Attendees:

Panel Members: Pete Andersen, Lou Motz, Mark Stewart

Districts staff: Pete Kwiatkowski, Uditha Bandara, Tim Desmarais, Wei Jin, and Mark Barcelo

Utility Representatives: Keith Browning, David MacIntyre, Oscar Vera

The meeting began at 2:05 p.m.

1. Welcome and purpose of meeting
    - All meeting participants were identified
    - Purpose of the meeting is to plan for the face to face meeting on October 18th.
2. Upcoming meetings
    - October 18, 2016 - face to face meeting to discuss the Conceptual Model Document.
        i. Meeting will be at the SFWMD's St. Cloud field office.
3. General discussion
    - Districts presented a spread sheet that summarized and grouped the questions and comments on the Conceptual Model that were posted by the Panelists.
    - Discussion generally focused on identifying the topics to be presented at the face to face meeting
        i. Need to understand the purpose of model
        ii. Need to better understand the rainfall vs recharge estimation process
        iii. With respect to calibration, we need to understand the proposed uses of the model and the desired accuracy
        iv. Calibration process
            1. What will be calibrated through use of PEST – hydraulic parameters such as K, S, and L
            2. Recharge component and boundaries are generally adjusted outside of PEST
            3. Process is a "learning" process, Team will adjust to information gained during process
        v. Wetlands are not explicitly simulated in model
        vi. Long run times are anticipated to occur during PEST calibration.

1. USGS tried a transient calibration but it took too much time and they resorted to a series of steady-state calibrations.
2. USGS used the last two years of their 12-year simulation period for a transient calibration. Staff noted that the ECFTX Model may be more readily calibrated via PEST because computationally intensive packages such as Stream Routing, Lakes, UZF, etc. are not proposed.

- A proposed meeting agenda is as follows:
    i. Overview and purpose of ECFTX model
    ii. Primary discussion topics
        1. Calibration process
        2. Process to estimate recharge
        3. Simulation of lakes and rivers
        4. Water withdrawals
    iii. Remaining discussion topics
        1. Model boundaries
        2. Other return flows
        3. Drainage features
        4. Use of equivalent freshwater heads
        5. Hydrostratigraphy
        6. Springs
        7. Other

4. Public comment
    - Keith Browning suggested the first discussion item should be an overview of how the districts plan to use the model
5. Things to do
    - WMDs will finalize the agenda with input from Panel and post it to the Web Board

The meeting was adjourned at 3 pm.

MEETING SUMMARY

Meeting Date: October 18, 2016

Subject: ECFTX Peer Review: Meeting 4 – Face to Face (Conceptual Model)

Attendees:

Panel Members: Pete Andersen, Lou Motz, Mark Stewart

Districts staff: Tim Desmarais, Wei Jin, Doug Hearn, Kevin Vought, and Mark Barcelo

Utility Representatives: Keith Browning, David MacIntyre, Al Aikens, Brian Megic, Debbie Bradshaw

Attending by phone: Pete Kwiatkowski, Uditha Bandara, Jeff Giddings, Teresa Remudo-Fries, and Wayne Son

General Public: David Gore

The meeting began at 9:30 a.m.

1. Welcome and purpose of meeting
    - All meeting participants were identified
    - Purpose of the meeting is to address questions and comments by the Panel on the ECFTX Conceptual Model Document
    - Time for public comment is reserved for the end of the meeting
2. Overview and purpose of model
    - The model will be used to evaluate groundwater availability and assess management strategies
    - Types of information to be obtained from the model includes surficial aquifer and UFA drawdowns and changes in river base flows and spring flows.
        i. Previous efforts obtained SA drawdown representative of a large area versus individual cells
        ii. An estimate of total SA drawdown is needed to support MFL work in the SWFWMD.
        iii. SA drawdown at specific locations could be considered an “aspirational goal” for the model
3. Discussion Items – presentations were prepared to describe the different elements of the overall ECFTX modeling process for the Panel.
    - Recharge process
    - Lakes and rivers

i. Recommendation was made to be cautious about excessive flux calculated between the surficial aquifer and lake. This is related to calculating SA heads in cells that are also occupied by a river cell, which has a constant-head source term. Concern is altering the conductance term to the point where the model doesn't accurately simulate the response of water levels to pumping. Recommend considering monthly specified heads as an alternative.
ii. Baseflow calculated using the Perry method can underestimate quantities

- Other return flows
- Water withdrawals
- Drainage features – Included further discussion of baseflow, particularly reviewing observations during extended dry periods, and that baseflow separation other than Perry method be considered.
- Calibration Process
    i. Essentially this will be a two-step process: manually calibrating the surficial aquifer to daily heads and flows as described in the recharge presentation and use of PEST to calibrate the hydraulic parameters for the remaining model
        1. PEST will be difficult to use on the approach discussed for the SA, though some aspects may be included in limited runs.
        2. SA and UFA aren't completely independent of each other due to leakance between the two
    ii. Consider starting with the ECFT model area and expanding from that
    iii. A steady-state model is a good place to start in order to obtain calibration of static parameters (faster than performing a transient calibration)
    iv. Use extinction depths as calibration point
- Hydrostratigraphy – Al Aikens requested we prepare a cross-section along US-27 with the intent of incorporating new wells that SWFWMD is constructing to better depict the "overlap" unit(s).
- Model boundaries
- Equivalent freshwater heads
    i. Consider converting target wells to equivalent freshwater heads where possible, even if TDS is less than 10,000 mg/l
- Springs

4. Public comment
    - D. Gore recognized the Panel's expertise in groundwater modeling and expressed his understanding of the ECFTX model and its importance to assessing groundwater availability in the region
5. Things to do

- It was decided to allow the Panel time to consider the material that was presented before scheduling another meeting.

The meeting was adjourned at 4 pm.

MEETING SUMMARY

Meeting Date: November 29, 2016

Subject: ECFTX Peer Review: Meeting 5 – Follow-up discussion of Conceptual Model

Attendees:

Panel Members: Pete Andersen, Lou Motz, Mark Stewart

Districts staff: Pete Kwiatkowski, Uditha Bandara, Jeff Giddings, Tim Desmarais, Wei Jin, Doug Hearn, and Mark Barcelo

Utility Representatives: Oscar Vera

The meeting began at 2:05 p.m.

1. Welcome and purpose of meeting
    - This meeting is for the purpose of determining how to finalize the Panel's review of the Conceptual Model Document
2. Discussion
    - MB – the panel has reviewed the Conceptual Model Document, provided questions and comments, and met with the Team to discuss the review. We're now at a point where we need to discuss how to finalize the review.
    - PA – Many questions have been addressed. Some things are more clear and better understood than before but, there are questions that need more clarification, at least in terms of what the WMDs final course of action will be. The question was asked whether the Panel needs to provide a "final" report on peer review of the conceptual model or if what has been done is sufficient?
    - PK – we are looking for a document from the Panel that says the Panel reviewed the Conceptual Model Document and staff presentations, and indicates whether or not we are on the right track and have addressed concerns that were noted. This would represent a milestone in the model development process and show there is consensus that the Panel generally concurs with the approach and that we can move forward with calibration.
    - MS – expressed concern about how things are documented and the potential for conflicts with different documents. The Panel reviewed the conceptual model and had comments that differed from the WMDs approach at the time. It was further noted that WMDs will consider these comments as we move forward, such as the choice of using river cells to simulate lakes. He will make an article

available on the Web Board that discusses effects of grid discretization on river conductance values.

- LM – the Panel has done most of the required work. They provided comments and the WMDs made presentations to address the comments. Maybe a memo needs to be prepared that discusses how the issues raised were addressed.
- PA – there are still some questions to resolve. Some things were discussed and on the spot decisions made that were later modified, such as starting with a steady-state vs transient calibration and use of PEST in the calibration.
- PK – WMDs need to summarize the changes in the modeling approach that have been made based on the Panel's review. These changes can be memorialized in a couple of pages. If Panel still has questions, the WMDs will follow up to bring closure to issue. Calibration approach will continue to evolve as more information is developed. The WMDs reserve the right to pursue a different approach from the Panel's comments based on interim calibration results.
- LM – we need to identify the major points and use the next two phone calls to resolve them.
- PA – we need a logical endpoint to the review process.
- PK – WMDs will put together a brief overview of changes to conceptual model and calibration plan and the Panel can identify their remaining questions
- LM – the memo should be made current as in, " . . . here's what we (WMDs) are doing."
- PK – WMDs will complete the memo in 1 week. This will be a discussion item for the December 6th Peer Review meeting. All WMDs (PK, DH and MB) agreed to this approach. The Panel was asked if they have additional questions
    i. PA – several things were discussed during previous meetings but the final decisions weren't always clear. The possibility of eliminating LFA during calibration because of lack of data has not been addressed. Clarification on use of PEST during the calibration. Treatment of rivers and lakes can be further addressed.
    ii. LM – no major problems. Clarification on the calibration plan is needed. He's ok with the freshwater head issue. Lakes as river cells could be problematic but, it is recognized that using the Lake Package can also be problematic due to model layering limitations. Steady- state calibration vs transient calibration. How will PEST and manual calibration be managed.
- MB – we still need something like a letter that wraps the review up. That is, something written is needed that recognizes the review work that was done, recommendations that were made and decisions made regarding changes to the approach. It will be helpful to show that the Panel generally concurs with the approach. The next two review items for the panel are review of interim

calibration results and the final model document. So, they will be kept apprised of changes to the calibration approach that may be made and have the opportunity to comment.

- PK – suggest that the Panel provided a letter that would accompany the WMD's memo and other items that have been prepared for the review. The letter would say the Panel reviewed the information, are satisfied with the responses and generally concur with the WMDs moving forward on approach that is documented.
- PA – sounds appropriate. WMDs will discover things during the process and will adjust as they go along. At end of process we will have a final document, . . . will this include the Conceptual Model?
- PK – intent would be to include content from the conceptual model document in the final report. There are no plans to revise the conceptual model document. PK will provide a first draft of memo to Panel summarizing changes that have been made and post it to the Web Board prior to the next meeting on December 6th.
- WMDs are good with this plan.

3. Public Comment
    - No comments were made
4. Things to do
    - WMDs will provide the Panel with a brief written document that summarizes changes that will be made to the calibration plan and modeling process as a result of the Panel's review.
    - Panel will provide any additional comments they may have and feel are necessary to be addressed before finalizing the review.
    - After the Panel is satisfied that their comments have been addressed, they will provide a letter that summarizes the review process and states their concurrence with the WMD's approach.
    - The next meeting is scheduled for December 6, 2016 from 2 to 4 p.m.

The meeting was adjourned at 3:05 pm.

MEETING SUMMARY

Meeting Date: December 6, 2016

Subject: ECFTX Peer Review: Meeting 6 – Follow-up discussion of Conceptual Model

Attendees:

Panel Members: Pete Andersen, Lou Motz, Mark Stewart

Districts staff: Pete Kwiatkowski, Uditha Bandara, Jeff Giddings, Tim Desmarais, Wei Jin, Qing Chen, Doug Hearn, Jason Patterson, and Mark Barcelo

Utility Representatives: David MacIntyre, Brian Megic

Meeting began at 2 p.m.

1. Welcome and purpose of meeting
    - This meeting is for the purpose of discussing the first draft of "Updates to Overall Modeling Approach, Expanded East Central Florida Transient (ECFTX) Groundwater Model" that was prepared by the HAT.
2. Discussion
    - Panel commented that the technical memorandum (TM) was helpful and they did not disagree with the content. Clarification, however, was needed on a few items.
    - Calibration
        i. Question was asked whether the Layer 1 calibration process was a new approach. The approach was discussed at the face-to-face meeting on October 18th.
        ii. The Panel had several questions regarding how the connectivity to lower layers will be addressed during calibration of the layer 1 transient model. This is more of an issue in the northwestern part of the model where there is good connection between the SA and UFA and is less of an issue in areas where there is good separation between the aquifers. Panel expressed concern about not having communication with lower layers. It was suggested that the HAT incorporate fluxes from the steady-state model into the layer 1 model. Suggestion was made to bring panel back together for a "milestone check" when the Team transitions from the steady-state to the transient calibration to see how these issues are resolved.
        iii. The focus of the layer 1 calibration is on water levels and runoff. There will be some iteration between the transient layer 1 and steady state

models during the calibration process but expect more iteration/updates when working on the full eleven-layer model.

iv. The layer 1 transient model will be calibrated for the period 1995 to 2014
v. The 11-layer transient model calibration is planned for the period 2004 to 2014 which is the period with the best water use data. The endpoint of the overall process will be a fully 3D, 11-layer transient model.
vi. The Panel noted that the 11-year calibration period is good, especially considering run times. The concept of using 1995 to 2003 in a transient run as a "verification period" was mentioned as being useful.
vii. Statistical tests to measure goodness of fit for the transient model are important. HAT will need to run these tests throughout the process. Measures discussed were Nash-Sutcliffe at individual sites and RMSE. Need to assess how well we do for highs and lows, not just the average.
viii. HAT will provide more discussion of methods for evaluating calibration and present at the interim check.

- Statistical tests of transient model performance
    i. RMSE and Nash-Sutcliffe methods were suggested as good tests to determine goodness of fit.
    ii. Goal is to understand the predictive capability of the model
    iii. Checks need to be done throughout the process and not just at the end of the process.
- Rivers and Lakes
    i. HAT will develop criteria for where to use high hydraulic conductivity and storage to simulate isolated lakes.
    ii. Panel will post related articles on Web Board.
- Baseflow
    i. Concern is that the 121-day window used with the Perry (1995) method may not be appropriate. This method is a low pass filter and is simple to use which makes it attractive. The point was made that other methods should be evaluated and considered for use and/or the window used with the Perry method should be verified.
    ii. Panel will post related articles on Web Board.
- Equivalent freshwater heads (EFH)
    i. Initial approach was to follow what the USGS did for the ECFT model which was to limit active portions of the model to areas where water quality was less than 5,000 mg/l chloride without making adjustments to EFH (the HAT is using 10,000 mg/l TDS because TDS is more readily available across the entire model area).

ii. This was modified on the western side of the ECFTX model because of poor water quality that exists onshore and the large groundwater withdrawals that exist in coastal counties.
iii. Panel noted that based on their understanding of the problem and information presented at the face-to-face meeting, converting to EFH can make a difference. It's affected by depth and water quality.
iv. HAT will develop a strategy and present to panel.

- Status of TM
    i. The Panel concurred with the modeling approach presented by the HAT is good and agreed that the HAT should move forward according to the TM, recognizing that adjustments will likely occur during the process.
    ii. Panel suggested a few changes to the TM before finalizing this phase of the review.

3. Public Comment
    - No comments were made
4. Things to do
    - HAT will develop a process to incorporate fluxes to and from lower layers (layers 2 to 11) of the steady state model as input to the layer 1 model.
    - Suggestion was made to bring panel back together for a "milestone check" when the HAT transitions from the steady-state calibration to the transient calibration to see how these issues are resolved.
    - HAT will provide a more detailed write-up of the statistical methods that will be used to evaluate model output.
    - HAT will develop criteria for where to use high hydraulic conductivity and storage to simulate lakes.
    - HAT will develop a strategy for converting water levels to EFH.

The meeting was adjourned at 4:00 pm.

MEETING SUMMARY

Meeting Date: December 13, 2016

Subject: ECFTX Peer Review: Meeting 7 – Follow-up discussion of Conceptual Model

Attendees:

Panel Members: Pete Andersen, Lou Motz, Mark Stewart

Districts staff: Pete Kwiatkowski, Uditha Bandara, Jeff Giddings, Tim Desmarais, Wei Jin, Doug Hearn, Jason Patterson, and Mark Barcelo

Utility Representatives: David MacIntyre, Brian Megic, Al Aikens

Meeting began at 2 p.m.

1. Welcome and purpose of meeting
    - This meeting is for the purpose of discussing the second draft of the technical memorandum (TM) entitled, "Updates to Overall Modeling Approach, Expanded East Central Florida Transient (ECFTX) Groundwater Model" that was prepared by the HAT.
2. Discussion
    - Panel is in agreement with the changes that were made. Clarification was needed for two parts of the TM:
        i. Reference to the steady-state calibration being " . . . - - with a 20-year calibration period from 1995 to 2014 - - . . ." will be deleted.
        ii. With respect to equivalent freshwater heads, it was decided to change " . . . and possibly incorporated into the final version of the model." to ". . . and incorporated into the final version of the model."
    - HAT will make changes to TM and post to Web Board
    - Panel will write one letter that generally discusses the review process and their general concurrence with the approach that was developed recognizing that it is expected that adjustments will be made during the process.
    - The next meeting of the Panel, as identified in the SOW, will be to review interim calibration results. It is now planned for this meeting to occur before moving forward on full transient calibration.
    - Panel expressed their interest in staying engaged throughout the process. It was decided to have monthly meetings and that the HAT will develop products that can be posted to the Web Board for review by the Panel.
3. Public Comment

- David MacIntyre commented regarding the baseflow calculations and the fact that there may be bias introduced to the SCS curve numbers (CNs) as a result of things such as strormwater facilities, and noted that for wetland areas, such as in the Kissimmee Basin, there can be exceptionally long detention times that sometimes last months. In the Perry method, the 121-day window of time that is used accounts for some of this wetland detention time. Additionally, in the layer 1 model the Muskingum method will be used to route flows in these areas. An additional comment was made regarding the Nash-Sutcliffe method and that it may not be a good indicator of the transient response of the model since you can achieve a good Nash-Sutcliffe result because simulated levels match the general shape though not the amplitude of water level fluctuations.

4. Things to do
    - HAT will make final edits to the TM and post to the Web Board
    - Panel will write one letter that generally discusses the review process and their general concurrence with the approach that was developed recognizing that it is expected that adjustments will be made during the process

The meeting was adjourned at 3:00 pm.

MEETING SUMMARY

Subject: Peer Review Teleconference, Expanded East Central Florida Transient (ECFTX) Groundwater Model

Date: March 2, 2017

Prepared By: Central Florida Water Initiative Hydrologic Analysis Team (HAT)

Attendees:

Panel Members: Pete Andersen, Lou Motz, Mark Stewart

Districts staff: Pete Kwiatkowski, Uditha Bandara, Jeff Giddings, Tim Desmarais, Wei Jin, Doug Hearn, Jason Patterson, Kevin Vought, Tammy Bader

Utility Representatives: Al Aikens, Brian Megic, David Macintyre, Keith Browning

Meeting Purpose

The purpose of this meeting is to update the Panel as to the Districts progress regarding calibration of the ECFTX Model. NOTE: Powerpoint slides for each presentation made at today's teleconference have been posted to SWFWMD's peer review web board.

Steady-State Calibration

Wei Jin presented on the approach and status for calibration via PEST of the steady-state model. Pete Andersen inquired what the presented values of the objective function meant in terms of the mean absolute error of heads, which is more understandable metric of calibration. The team had not yet determined the mean absolute error.

General Head Boundaries, Dry Cells

Tim Desmarais presented on the approach and status of resolving dry cells, updating river cells, and adjusting general head boundaries (GHBs). Mark Stewart noted that since the GHBs were previously estimated values that it was appropriate to make these minor adjustments. Tim Desmarais noted that some of the original estimates were obtained from the USGS Mega Model.

Layer 1 Transient Model

Uditha Bandara presented on the approach and status of the Layer 1 transient model including estimation of evapotranspiration (ET), recharge using the AFSIRS methodology, identification of watersheds for calibration, and some preliminary calibration results. Mark Stewart indicated that estimated baseflow using Geurink's method seem to be producing unrealistic peaks. He further suggested that baseflow should be estimated with a different method as a check in several watersheds given the uncertainty of baseflow estimation. Pete Andersen inquired as to the calculation of ET and recharge for the steady-state model and Uditha Bandara noted that he provided the 2003 annual average ET and recharge for the steady-state model.

Isolated Lakes

Jason Patterson presented on the approach and status of identifying isolated (seepage) lakes to facilitate simulating them via high hydraulic conductivity and high storativity, thereby making them dominated by the water table of the surficial aquifer system. Mark Stewart suggested that we should compare simulated lake levels to observed lake levels to ensure that this approach reasonably simulates the lakes. For those seepage lakes that are not accurately simulated this way, then the lakes are likely more influenced by the Upper Floridan Aquifer (UFA) and leakance should be adjusted accordingly to best simulate these lakes. Lou Motz noted that the USGS and SWFWMD have characterized some lakes in Central Florida as karst lakes, especially those on the Lake Wales Ridge to Highlands County, and again may need adjustment to leakance values to reflect influence of the UFA on these lakes.

Equivalent Freshwater Heads

Kevin Vought presented on the approach and status of calculating equivalent freshwater heads for wells whose water quality is brackish to ensure that the flow field including boundary conditions is accurately simulated. Kevin Vought presented maps for each model layer indicating the change in head as a result of the equivalent freshwater head. Pete Andersen noted that most of the adjustments were minor, and most within the data error bands and calibration targets; however the adjustment was uni-directional and therefore may introduce some bias if simply ignored. Some wells in close proximity to each other along the southern boundary had notable differences in equivalent freshwater heads likely due to the effects of upconing of poor quality water from below. Lou Motz noted that some regional models simply specify these boundaries as no-flow boundaries. Some discussion ensued regarding whether the conceptual model should be that of a saltwater interface (no-flow boundary) or a lateral exit/entrance (specified head or general head boundary). Pete Andersen noted that these conceptual models could be evaluated by varying the conductance of the GHB from high (approximates a specified head) to very low (approximates a no-flow boundary). He recommended that the team perform this type of sensitivity analysis to guide them in selecting the proper boundary condition for layers 9-11.

Public Comment

None

The meeting was adjourned at 4:00 pm.

Agenda

ECFTX Model, Peer Review Update Teleconference

March 2, 2017

2:00 pm to 4:00 pm

Item	Presenter(s)	Presentation	Discussion
Opening Remarks	Andersen/Kwiatkowski		5 m
Steady-State PEST Calibration	Jin	10 m	10 m
GHB and Layer Elevation Changes	Desmarais/Barcelo	10 m	10 m
Layer 1 Transient Calibration	Bandara	10 m	10 m
Isolated Lakes	Patterson	10 m	10 m
Equivalent Freshwater Heads	Vought	10 m	10 m
Public Comment			
Adjourn			

MEETING SUMMARY

Subject: Peer Review Teleconference, Expanded East Central Florida Transient (ECFTX) Groundwater Model

Date: April 26, 2017

Prepared By: Central Florida Water Initiative (CFWI) Hydrologic Analysis Team (HAT)

Attendees:

Panel Members: Pete Andersen, Lou Motz, Mark Stewart (unable to attend)

Districts staff: Pete Kwiatkowski, Uditha Bandara, Jeff Giddings, Joanne Chamberlain, Tim Desmarais, Wei Jin, Doug Hearn, Jason Patterson, Kevin Vought, Tammy Bader, Mark Barcelo

Utility Representatives: Brian Megic, David Macintyre, Keith Browning

Meeting Purpose

The purpose of this meeting is to update the Panel as to the Districts progress regarding calibration of the ECFTX Model. NOTE: PowerPoint slides for each presentation made at today's teleconference have been posted to SWFWMD's peer review web board.

Isolated Lakes

Jason Patterson presented on the approach and status of identifying isolated (seepage) lakes to facilitate simulating them via high hydraulic conductivity and high storativity, thereby making them dominated by the water table of the surficial aquifer system. He reviewed three iterations of the process. The most recent iteration was an effort to adjust the selection of grid cells representing each lake so that the simulated lake surface area was as close as possible to the observed lake area. From the first to the third iteration, the number of lakes simulated was reduced from 145 to 131 and the number of grid cells used has been reduced from 1,112 to 536. Jason also reviewed examples of how the grid cells were selected to represent different lakes and showed examples of lake water budgets using the "uncalibrated" model. The Panel noted from review of the water budgets that the ratio of precipitation to evaporation was highly variable and in some cases the lake evaporation was much less than the lake recharge. Uditha Bandara commented that lake recharge was rainfall and that lake evaporation was "potential

evapotranspiration" obtained from satellite data. It was noted that USGS satellite ET data is provided on a 2 kilometer by 2 kilometer grid and that in many cases, cells representing lakes also include land. The panel responded that the conceptualization of using depth dependent evapotranspiration instead of a fixed lake evaporation was inappropriate for the lakes represented with high storage and hydraulic conductivity. The HAT will revise the representation of lake evaporation and ensure the proper values fro precipitation and evaporation are used. Additionally, the HAT will review how the ET surfaces and extinction depths were determined and make adjustments as needed.

Structural Issues (cell-to-cell discontinuity)

Tim Desmarais presented an overview of the problem related to "cell-to-cell discontinuity." This occurs when the bottom elevation of a model layer assigned to a particular grid cell is above the top elevation of that same layer in an adjacent grid cell. This issue was discovered over the course of investigating dry cells resulting from the initial model runs and is likely the result of kriging used in the development of hydrostratigraphic surfaces. The Panel understood the basic issue, noted that cell-to-cell continuity is not a requirement of MODFLOW and commented that cell-to-cell discontinuity in itself should not cause a problem, but could be an indicator of too coarse a grid or a water table gradient that is difficult to resolve. They asked about the need to adjust elevations for the lower model layers since those cells are not going dry. The adjustment to lower layers is needed to preserve the "minimum thickness" assigned to layer 7, which represents the "overlap aquifer." They further commented that the team needs to be careful about documenting this issue if they decide to implement it. That is, the documentation should be succinct to avoid inconsistencies.

ECFTX Calibration Plan (PEST)

Wei Jin provided an overview of the ECFTX calibration process. The overall process consists of three (3) major steps:

1. PEST calibrations of the 11-layer model. The model will be calibrated to annual-average 2003 steady-state hydrologic conditions and transient hydrologic conditions for the period 2004 to 2014.
2. One-layer transient model of the surficial aquifer (Layer 1 model). The Layer 1 model will be calibrated to hydrologic conditions for the period 1995 to 2014 and used to provide recharge to the water table and hydraulic information to characterize other surficial processes for use in the 11-layer steady-state and transient models.
3. Verification of model calibration. The calibrated transient model will be verified through simulation of the transient period 1995 to 2014.

Wei further explained the general steps that are being followed to calibrate the steady-state model using PEST:

1. Base Case - This involves compiling and running the model to identify conflicts with input data and updating the input data in preparation of the PEST calibration runs.
2. CASE01 – PEST run using regular and irregular pilot points and also using head and head difference targets. Output from this run will be used to update the Layer 1 transient model.
3. CASE02 – use relationships of hydraulic conductivity between layers to reduce the number of PEST parameters; utilize APT values to further constrain PEST; and provide updates to Layer 1 model.

The HAT is currently finalizing modifications of input data and target data for the Base case model run and is a few weeks away from beginning the transient calibration of the 11-layer model.

Equivalent Freshwater Heads

Kevin Vought presented the approach that is proposed to estimate the uncertainty in calculating equivalent freshwater heads (EFH) for the target wells. The approach attempts to account for differences in the location of measured and estimated water quality (TDS) relative to the model grid cell center, where model heads are calculated. Water quality maps for the model area were prepared using measured values, output from SFWMD's density-dependent East Coast Floridan Model (ECFM), and a Floridan aquifer water quality map generated by the SFWMD. These maps were used to estimate water quality at the center of model grid cells corresponding to locations of all target wells. The uncertainty in the EFH calculation for the layers representing the more permeable zones was calculated using the estimated range in water quality at the top and center of each grid cell. The Panel expressed that this approach is well thought out and appears reasonable given the uncertainties in the overall process. They also noted that this approach will be useful for explaining and providing justification for model residuals (e.g., root mean square error [RMSE]), especially in the lower model layers. The Panel also cautioned the HAT about making sure the team is aware of issues associated with the global water budget associated with internal circulation occurring at the model boundaries where EFHs are specified. This issue surprised some folks while reviewing version 5 of the Norther District Model (used by SWFWMD and SJRWMD). The HAT suggested reviewing groundwater flows on shore to establish overall reasonableness of the EFH approach. Additionally, it was noted that there may be an inconsistency between converting the target wells to EFH and the current source heads used for GHBs along the lateral boundaries. The Panel responded that they should be consistent; that is, if the target wells are converted to EFH then the source heads in the GHBs should also be in terms of EFH. The HAT will investigate and address this issue.

Layer 1 Transient Model

Uditha Bandara presented the status of the Layer 1 transient model. He reviewed the model process and explained that recharge and groundwater ET are obtained and will be used for the 11-layer models. There are 77 watersheds that need to be calibrated, 10 of which are done and 62 that are left to be done. Some of the watersheds will need input on flows and heads from underlying aquifers in the 11-layer models before they can be completed. Fifteen watersheds have large data gaps and are being evaluated to determine how they should be handled. He reviewed an example of the calibration results for one watershed with emphasis on baseflow. The estimated baseflow calculated using the Geurink method was much flashier than the baseflow calculated from the Layer 1 model. The Panel previously made comments regarding the baseflow calculated using the "Geurink" method and had suggested the team also calculate baseflow using another method for comparison. Uditha provided a comparison of baseflow calculated using an approach developed by Chapman and Maxwell (1996). Results were found to be similar for both methods and it was decided that he will continue to use the Geurink method. This issue will be explored further with Mark Stewart via the Web Board. Uditha provided an example of a watershed where the flow is dominated by spring flow. In these cases, it will be necessary to obtain input from the 11 layer models to complete calibration of this watershed. A strategy for calibrating ungauged watersheds was also discussed. The strategy is to globally assign and adjust Soil Conservation Service (SCS) curve numbers in these watersheds based on land use type and soil type.

Path Forward

The Panel asked about the next scheduled review item, listed as review of the 50 percent completion of the calibration. The HAT explained that it is expected that the review will involve review of the calibrated steady-state model and Layer 1 transient model. The time frame for that review will be discussed by the Team and provided to the Panel over the next week.

Public Comment

None

The meeting was adjourned at 4:28 pm.

MEETING SUMMARY

Subject: Peer Review Teleconference

Expanded East Central Florida Transient (ECFTX) Groundwater Model

Date: July 12, 2017

Prepared By: Central Florida Water Initiative (CFWI) Hydrologic Analysis Team (HAT)

Attendees:

Panel Members: Pete Andersen, Lou Motz, Mark Stewart

Districts staff: Pete Kwiatkowski, Uditha Bandara, Tim Desmarais, Wei Jin, Doug Hearn, Eugene Agyei, Kevin Vought, Mark Barcelo

Utility Representatives: Brian Megic, David Macintyre, Al Aikens, Keith Browning

General Public: Angel Martin, Derieth Sutton, Jared Williams

Meeting Purpose

The purpose of this meeting is to update the Panel as to the Districts' progress regarding calibration of the ECFTX Model (11-layer steady-state and layer 1 transient models). NOTE: PowerPoint slides for each presentation made at today's teleconference have been posted to SWFWMD's peer review web board.

Introduction

Pete Andersen, Panel, Chair, opened the meeting and reminded all attendees that this peer review process is somewhat unique in that the Panel is commenting on interim deliverables in an ongoing process, and today's meeting is consistent with this approach.

ECFTX Calibration Plan (PEST)

Wei Jin provided an overview of the ECFTX calibration process. The overall process consists of three (3) major steps:

1. PEST calibrations of the 11-layer model. The model will initially be calibrated to annual-average 2003 steady-state hydrologic conditions and subsequently to transient hydrologic conditions for the period 2004 to 2014.

2. One-layer transient model of the surficial aquifer (Layer 1 model), to be conducted concurrently with the 11-layer steady-state calibration. The Layer 1 model will be calibrated to hydrologic conditions for the period 1995 to 2014 and used to provide recharge to the water table and hydraulic information to characterize other surficial processes for use in the 11-layer steady-state and transient models.
3. Verification of model calibration. The calibrated transient model will be verified through simulation of the transient period 1995 to 2014.

Wei presented the results from the steady-state PEST calibration, CASE03. He presented layer-by-layer graphics displaying before and after calibration relationships, with the results showing significant statistical improvement. Tim Desmarais presented maps displaying Kh and Kv values on a layer-by-layer basis both before and after PEST calibration. Pete Kwiatkowski stated that although the calibration statistics were acceptable and looked quite good, the model calibration would continue once issues regarding dry cells and very high hydraulic conductivities were resolved.

Isolated Lakes

Mark Barcelo refreshed everyone's memory regarding our approach to simulating isolated (seepage) lakes; that is, simulating them via high hydraulic conductivity (e.g., 1 million feet per day) and high storativity (1), thereby making them dominated by the water table of the surficial aquifer system. He reiterated our strategy of adjusting the selection of grid cells representing each lake so that the simulated lake surface area was as close as possible to the observed lake area. Following Wei's presentation of how isolated lakes were calibrated, Mr. Andersen questioned the approach of having a "ring" of cells around each lake with the same Kh, and the Panel and staff agreed that this topic required further discussion and clarification.

Equivalent Freshwater Heads

In response to previous comments from Dr. Motz regarding staff's approach to equivalent freshwater heads (EFH), Kevin Vought confirmed that the EFHs were calculated for both the source heads in the GHBs and the target wells thereby ensuring a consistent flow field.

Issues of Concern

Tim Desmarais presented an overview of the issues of concern that arose from PEST calibration which include:

- Dry Cells and Flooded Cells
- Use of synthetic targets
- Bounds for aquifer parameters
- Elimination of targets in the intermediate aquifer/confining unit

There are some substantially more dry and flooded cells now than the initial simulation. An attempt to use synthetic targets to minimize the dry and flooded cells was of limited benefit, but there is potential for more benefit through more strategic use of synthetic targets. Tim presented a table displaying the min, max, and average value for aquifer parameters that PEST arrived at on a layer-by-layer basis.

Panel Comments and Recommendations

In general, the Panel recommended that staff conduct some simple data checks to identify the reasonableness of the input data. Pete Andersen recommended that maps of saturated aquifer thickness be developed to help solve the dry cell issues, as well as potentially mapping out cell-by-cell

fluxes with the intent of identifying abnormally high (or low) exchanges. Pete Kwiatkowski suggested that staff present spatial displays of Kh and Kv values to help troubleshoot the issues. The same should be done for recharge as that is likely a contributing factor to the flooded cell issue. Regarding the min, max, and average K values presented, Dr. Stewart suggested that we display the median, not the mean, as this may be skewing the results for some very large data values that PEST has converged upon. Dr. Stewart shared his experience on a previous regional model where PEST was used for calibration. In particular, the issue was solved by establishing a relationship between land surface and the water table surface. He also confirmed that PEST takes pilot points as calibration targets. In response to the very large parameters bounds, he cautioned that over-specifying them would keep the parameters at reasonable values, but that PEST would simply take other parameters out of reasonableness.

Path Forward

Because we did not get through the entire agenda, a subsequent Peer Review teleconference will be held, and the Panel gave preliminary approval for the meeting to be held next Friday, July 21, 2017. In the meantime, staff will follow the Panel's recommendations to conduct some further data investigations as to the potential cause of the flooding and dry cell issues. In addition, Mark Barcelo stated that the presentations that were made would be posted to the web board such that the panel could review in more detail. The panel will review and provide any additional comments at the July 21 meeting.

Public Comment

Mr. Angel Martin concurred with the Panel's suggestions regarding review of reasonableness regarding data input to solve the current model challenges.

Adjourn

The meeting was adjourned at 4:05 pm.

Central Florida Water Initiative

CFWI Water for Tomorrow

MEETING SUMMARY

Subject: Peer Review Teleconference – Meeting 12 (Review of Steady-State Calibration)

Expanded East Central Florida Transient (ECFTX) Groundwater Model

Date: January 25, 2018 (1 PM to 4 PM)

Prepared By: Central Florida Water Initiative (CFWI) Hydrologic Analysis Team (HAT)

Attendees:

Panel Members: Pete Andersen, Lou Motz, Mark Stewart

Districts staff: Pete Kwiatkowski, Uditha Bandara, Tim Desmarais, Wei Jin, Doug Hearn, Jason Patterson, Kevin Vought, Joanne Chamberlain, Ron Basso

Utility Representatives: Brian Megic, David Macintyre, Keith Browning

General Public: Dan Rutland, Royal Consulting (Deseret Ranches)

The purpose of this meeting was to update the Panel as to the Districts' progress regarding calibration of the ECFTX Model (11-layer steady-state model). NOTE: PowerPoint slides for presentations made at the meeting have been posted to SWFWMD's peer review web board.

Pete Kwiatkowski (PK) noted that staff was still having dry and flooded cells during PEST calibration. In the course of resolving this issue, staff has conducted numerous improvements and QA/QC checks that have improved their confidence in the model and its behavior, which was presented today. Ron Basso (RB) summarized all the improvements and issues the modeling team have undertaken since the last peer review meeting. He indicated that several major issues such as recharge, flooded cells, dry cells, GHBs, and ET would be discussed in more detail by

members of the modeling team following his summary. RB also indicated that he'd provide an overview of the current model status with recommendations for future work.

Jason Patterson (JP) and Tim Desmarais (TD) presented on the superposition of rainfall gauge data and NEXRAD rainfall estimates, indicating some large (up to 10 inches) discrepancies for the 2003 steady-state calibration period. TD presented a methodology to spatially correct NEXRAD data that better correlates to rain gauge data. TD noted that 2003 was an early year in the development of NEXRAD, and it has been noted that NEXRAD is much improved since that time. TD noted that staff will be developing this spatial correction for each year of the transient simulation in the near future. Panel Chairman Pete Andersen (PA) inquired as to whether 2003 is considered an "average year" and whether 2003 will be used as the starting point for the transient simulation. The District replied affirmatively for both.

TD noted the presence of flooded model cells. Staff's previous plan was to not "overprescribe" surface water features, and took a conservative approach to including them in the model. TD used National Hydrographic Data (NHD) data to incorporate tertiary surface water features, which might help in alleviating flooded cells in select areas. PA inquired about differentiating between evapotranspiration (ET) vs. incorporating additional drainage features to reduce flooded cells. PK noted this effort was initiated once staff were reasonably comfortable with the ET rates. Panelist Mark Stewart (MS) indicated that the drain package stands in for hydrologic features and should be used with caution, but he noted that it was good staff was checking other aspects of the model. Ron Basso (RB) noted staff has compared recharge and groundwater ET values with those used in other nearby regional models.

Uditha Bandara (UB) presented on the negative net recharge values recently observed in the Green Swamp area, and the efforts to resolve this issue including revisions to curve numbers, groundwater ET, and revised extinction depths. PA noted that reduced extinction depths (some at 2 ft) make the model very sensitive to that outflow. UB noted that this was only applied to approximately 10% of the total wetland acreage in the model domain. UB has a plan to adjust extinction depths to 5 to 6 feet and adjust curve numbers accordingly. UB also presented on comparison between simulated and field measured ET and recharge values at four sites within the model domain, which compared quite well.

Kevin Vought (KV) presented on the correction of lateral GHB values to make boundary flows more reasonable. He focused on Layer 5 (Avon Park Permeable Zone, high T). He changed the relative freshwater heads on the western boundary to achieve the desired boundary flows, with no changes elsewhere. PA noted that the Districts could be criticized for changing the boundary in this one area, but this is not uncommon with offshore boundaries simulated with a single-density model. The important thing is to document it, explaining the rationale and the benefits, and the figure presented is important to include. RB indicated the plan is to do a sensitivity analysis on this boundary in this area. PA asked if this affected deeper layers, but KV indicated it only applied to Layers 3, 4, and 5 (i.e., Upper Floridan Aquifer [UFA]). RB also noted that staff have adjusted the GHBs for Layers 9 and 11 (i.e., Lower Floridan Aquifer [LFA]) by substituting these heads with those assuming a no-flow boundary, which seemed to improve the model.

RB presented an overview of the status of the steady-state model. He noted that heads in the Surficial Aquifer are low in the Northern Tampa Bay (NTB), Green Swamp, and Lake Wales Ridge areas. He also noted that simulated heads in the UFA are too high in southwest Polk County and southern Hernando County, and too low in Indian River County. RB did note that a review of the UFA flow field looked very good with features such as the Polk City potentiometric high, Lake Wales Ridge, and East Pasco High simulated well in the model. PA inquired as to overall mean error of the model, which will be developed once staff resolve the issues discussed today.

RB presented the path forward, including manual calibration in select areas including dry cell clusters, NTB, Lake Wales Ridge, Green Swamp, and other areas. PA noted that PEST is a mathematical calibration technique that must be used with caution because its solutions are not necessarily consistent with model conceptualization. Panelist Lou Motz (LM) indicated he concurred with the approach of doing staff's best on the steady-state calibration, particularly with heads and water budgets, before embarking on the transient calibration.. PA agreed with the overall approach. In response to a question on moving on to the transient calibration, PA indicated a good steady-state calibration doesn't necessarily translate to an easier (or quicker) transient calibration. MS congratulated the team on the results, and the focus on the QA/QC

efforts conducted. RB indicated staff had more work to do to get fluxes correct, and indicated staff plan on computing water budgets for the groundwater basins (about 6) for the report. MS indicated the team was on the right track by checking actual data.

PK indicated that the team will continue to work over the next month or two to finish calibration of the steady-state model. Once finished, he suggested another meeting with the peer reviewers as a follow-up to today's review. The peer reviewers were agreeable to that approach but needed to check their scope-of-work for guidance moving forward.

Public Comment

None.

Adjourn

The meeting was adjourned at 3:35 pm.

Central Florida Water Initiative

CFWI Water for Tomorrow

MEETING SUMMARY

Subject: Peer Review Teleconference – Meeting 13 (Review of Final Steady-State Calibration)

Expanded East Central Florida Transient (ECFTX) Groundwater Model

Date: May 21, 2018 (1 PM to 4 PM)

Prepared By: Central Florida Water Initiative (CFWI) Hydrologic Analysis Team (HAT)

Attendees:

Panel Members: Pete Andersen (Chair), Lou Motz, Mark Stewart

Districts staff: Pete Kwiatkowski, Uditha Bandara, Jeff Giddings, Tim Desmarais, Wei Jin, Doug Hearn, Adam Angel, Jason Patterson, Joanne Chamberlain, Ron Basso, Brian Starford, Lori Burklew, Chris Leahy, Joanna Oseguera, Qing Sun, Lou Donnangelo

FDEP: Pam Flores

Utility Representatives: Oscar Vera, David Macintyre

FDACS Consultant: Steven Memberg

General Public: None

The purpose of this meeting is to present to the Panel the Districts' final steady-state calibration for the ECFTX Model (11-layer steady-state model). NOTE: PowerPoint slides for presentations made at the meeting have been posted to SWFWMD's peer review web board.

Pete Kwiatkowski (PK) welcomed the meeting participants and noted that the steady-state calibration is an important interim milestone and that staff is seeking concurrence from the Panel regarding moving forward with transient calibration. Chairman Pete Andersen (PA) inquired as to the use of automated calibration (PEST) in this version of the calibration, and Ron Basso (RB) indicated that staff used manual calibration only to achieve calibration. Steady-state run times are less than one hour. Uditha Bandara

(UB) made a presentation regarding updated agricultural water use, an AFSIRS code correction, and updated ET-recharge-runoff using AFSIRS. Steven Memberg (SM) requested that permit-level agricultural water use be aggregated and provided to him. UB indicated that further adjustments to 2003 NEXRAD rainfall, which was adjusted spatially based on rain gauges and presented to the Panel in last meeting, were made in three areas including northern Tampa Bay, Lake Wales Ridge, and Seminole Ridge. Panelist Mark Stewart (MS) noted that NEXRAD is an algorithm-derived rainfall estimate so staff should not be apologetic about making further adjustments that better match rainfall gauge data. UB indicated these changes and curve-number adjustments were essential to resolve chronically low water levels in these areas. UB also summarized his efforts to ensure mass balance was maintained. Panelist Lou Motz (LM) inquired as to whether NEXRAD adjustments will be made for the transient simulation and UB indicated we will look at the data and decide. Jason Patterson (JP) noted that preliminary review indicates that post 2005 NEXRAD adjustments may not be needed as the data matched well to observed rainfall gauge data.

PA inquired as to our manual calibration approach. RB indicated that we started out with data sets from merged regional models in the area. Staff leveraged our previous experience on these other regional models and made parameter adjustments based on our knowledge of physiographic regions and associated hydrologic features such as the Green Swamp. JP added that we also used best professional judgement, our understanding of the geology, and made further adjustments based on head and flow targets. PA indicated he will review the model (GW Vistas) files to answer any additional questions he may have.

RB presented on the conceptualization of the aquifers and confining units in the area and the numerical implementation of that conceptualization via aquifer parameter arrays. RB discussed our plan to not use anisotropy as a calibration parameter, and instead fixed these values as 1:1 in aquifer and 10:1 in confining units. JP noted that we focused on horizontal hydraulic conductivity (K_h) for aquifer calibration and vertical hydraulic conductivity (K_v) for confining unit calibration. RB then presented the calibration statistics and noted he was very pleased with the outcome. PA inquired regarding our calibration targets and RB noted that we didn't have any specific targets for the steady-state calibration, and staff intends to refine the targets for the transient calibration. LM suggested that we add (1) plots of simulated vs. observed heads for each aquifer and simulated versus observed spring flows and baseflows and (2) histograms of residuals for groundwater levels, spring flows, and baseflows to improve our calibration justification and staff agreed to do so.

PA inquired regarding spring flow calibration and RB noted that reasonable conductance values were used. He noted that 90 percent of spring flows in the model are from magnitude 1 and 2 springs, which are outside CFWI area, but that model results are good.

Regarding baseflows, RB indicated that staff balanced the need to match estimated baseflow targets while minimizing flooding in Layer 1 in the southern part of SWFWMD. Basically, staff left some baseflow values high to minimize flooding in Layer 1. PA suggested having a more detailed explanation of our baseflow calibration rationale. RB noted the high degree of uncertainty of baseflow estimation as has been discussed at previous peer review meetings. MS suggested that staff explain how the drain totals were arrived at and aggregated within each basin. He again noted the challenges of baseflow estimation. RB noted that the baseflow estimation approach implemented for ECFTX has been reviewed and found to be on the low side of other estimates compared with a range of estimation techniques used with the North Florida Southeast Georgia Model. PA thought that drain values seem high, and RB

noted the highly discretized hydrography. RB agreed to post a map of the drainage network to the webboard for the Panel's information.

PA noted he was reasonably comfortable with the steady-state calibration. He noted that staff was very meticulous when accounting for recharge, pumping, and spring flows. Further documentation of baseflows would be appropriate. MS indicated he had a pretty good idea of staff's approach and what we achieved during steady-state calibration. LM reiterated his previous suggestions regarding developing simulated versus observed plots and histograms of residuals. He further suggested that the "wells" column on the water budget table be divided between pumping wells and drainage wells and staff agreed to do so.

Regarding baseflows, PA offered that staff might want to present a range of estimated baseflows at each gage as targets. PK emphasized staff's earlier comment that the model may not be in steady-state over the entire model domain (e.g., southwest portion where rainfall was higher) and that might limit staff's ability to match baseflows. UB noted that water budgets are handled better during transient calibration. Jeff Giddings (JG) suggested that structure flows (baseflow and runoff) should be used as targets during transient calibration. He also suggested removing baseflow targets from highly managed waterbodies from the baseflow target tables.

Regarding the proposed transient calibration approach, PK noted that staff plans on continuing the manual calibration approach, incorporating transient parameters, and using storage coefficient data from previous models as the starting point. PA inquired if staff intended to leave the steady-state aquifer parameters as fixed, but PK and RB indicated staff is open to altering these parameters within reason during transient calibration. LM suggested we compare the current steady-state calibration and our future transient calibration with that of previous models including ECFT-HAT and ECFT-USGS.

The Peer Review panel indicated they will take about two weeks to continue to review the GWVs file and PowerPoint information before summarizing their review in a one-page memo. PA asked if the Districts planned to develop a report on the SS calibration and PK indicated that today's PowerPoint presentation and supporting information is the proposed basis for the Panel to consider if they concur with staff moving forward with the transient calibration.

Public Comment

David Macintyre (DM) indicated that staff may want to examine how well they are matching total flow at the stream gages. If they are reasonably well at matching total flow, then it's simply the partitioning of what's baseflow versus runoff that is the issue where there is a great deal of uncertainty.

Adjourn

The meeting was adjourned at 4:00 pm.

Central Florida Water Initiative

CFWI Water for Tomorrow

MEETING SUMMARY

Subject: Peer Review Teleconference – Meeting 14 (Review of Initial Transient Calibration)

Expanded East Central Florida Transient (ECFTX) Groundwater Model

Date: October 4, 2018 (2 PM to 4 PM)

Prepared By: Central Florida Water Initiative (CFWI) Hydrologic Analysis Team (HAT)

Attendees:

Panel Members: Pete Andersen (Chair), Lou Motz, Mark Stewart

Districts staff: Pete Kwiatkowski, Uditha Bandara, Jeff Giddings, Anushi Obeysekera, Tim Desmarais, , Doug Hearn, , Jason Patterson, Joanne Chamberlain, Ron Basso, Hua Zhang, Kevin Vought, Brian Starford, Chris Leahy, Joanna Oseguera, Claire Muirhead

FDEP: Pam Flores

Utility Representatives: Brian Megic, David Macintyre, Terry McCue

General Public:

The purpose of this meeting was to present to the Peer Review Panel the Districts' progress on the draft, transient calibration for the ECFTX Model. NOTE: PowerPoint slides for presentations made at the meeting have been posted to SWFWMD's peer review web board.

Pete Kwiatkowski (PK) welcomed the meeting participants. Ron Basso (RB) presented the agenda and began the discussion of team efforts since our last meeting. Initial efforts focused on calibration of the Lower Floridan Aquifer model layers as the last portion of the steady-state calibration. Uditha Bandara (UB) presented information regarding rainfall-adjusted NEXRAD data, which resulted in improved calibration statistics. NEXRAD data was adjusted within the SWFWMD and SFWMD. PK clarified that separate vendors had developed the NEXRAD data for each of the districts and hence it might be expected that different levels of data quality would exist between the districts. Next, UB indicated that updates were made to landscape irrigation, accounting for return flow from domestic self-supply users.

Also, he presented on the use of the drain return (DRT) package and how that coupled with the RCH package were now being used to calculate flows to drainage wells. He indicated this was a superior methodology compared to the previously used, constant flow assumption using the WELL package.

RB summarized the calibration targets for water levels, baseflows, and springflows. Pete Andersen (PA) expressed a desire to come up with a means of evaluating the ability of the model to simulate the dynamic response. Panelists agreed to come up with some suggestions. Later in the meeting, PK indicated our current plan is to use the calibration targets as noted, but to use the simulated vs. observed hydrographs to document the model's ability to capture dynamic response. UB presented on the surface water calibration including baseflows and structure flows.

RB noted that each District was assigned to achieve calibration in their area. Tim Desmarais (TD) presented on the current calibration statistics for the SJRWMD portion of the model domain, Anushi Obeysekera did so for the SFWMD portion, and Hua Zhang presented on calibration status for the SWFWMD portion using their "shiny app" application. PA noted that differences along the boundaries must be resolved, and RB noted our plan to periodically mesh all our calibration efforts together to ensure no boundary effects result.

RB noted that spring flow calibration for Rainbow Springs did not cover the entire springshed. RB also noted that portions of the model had water levels stack upwards of 50 feet associated with extreme rainfall events in September 2004. PA expressed concern and suggested that staff focus their efforts on understanding why this was occurring.

TD described the incremental approach to building the transient model using the transient data sets developed. He also described the balance between model run times and the number of time steps per stress period. For interim calibration runs. Staff have arrived at 6 as the optimum, with current model run times at 31 hours. PA stated that the timestep expansion factor used in the model (1.414) may be too high and suggested a TSMULT of 1.1. LM agreed with that general concept and suggested a TSMULT of 1.2.

RB indicated that the storage coefficients were initially compiled from other regional groundwater models in the area. The Panelists noted that the storage coefficient distribution was sporadic and apparently different on either side of District boundaries, including an area where the magnitude of storage coefficient approaches that of specific yield. Staff agreed to explore this further to ensure final calibrated values are as consistent as practicable and consistent with aquifer test values.

RB noted that our goal was to complete calibration by the end of November. PA inquired about the final report. PK noted that the purpose of convening these progress meetings was so that the Panel could provide input along the way, so that the approach could be understood, and the calibration results would allow the Panel to render their opinion about the model's ability to meet its intent at that time. PK emphasized that the model report would come soon after the Panel's recommendation.

Panelist Mark Stewart (MS) noted that the current calibration status was very good given the short amount of time that transient calibration has been underway. PA agreed that, although more work needs to be done, staff have done a good job so far.

Public Comment

None

Adjourn - The meeting was adjourned at 4:20 pm.

Central Florida Water Initiative

CFWI Water for Tomorrow

MEETING SUMMARY

Subject: Peer Review Teleconference – Meeting 16 (Review of Transient Calibration)

Expanded East Central Florida Transient (ECFTX) Groundwater Model

Date: August 15, 2019 (1 PM to 4 PM)

Prepared By: Central Florida Water Initiative (CFWI) Hydrologic Analysis Team (HAT)

Attendees:

Panel Members: Pete Andersen (Chair), Lou Motz, Mark Stewart

Districts and FDACS staff: Pete Kwiatkowski, Uditha Bandara, Jeff Giddings, Anushi Obeysekera, Clay Coarsey, Fatih Gordu, Wei Jin, Chris Leahy, Tammy Bader, Claire Muirhead, Chris Leahy, Lou Donnangelo, Lori Burklew, Ron Basso, Jason Patterson, Hua Zhang, Saashen Sealy, Brian Starford, Stacey Adams, Angela Chelette, Kathleen Greenwood, Kym Holzwart, James Hollingshead, Rahul Chatterjee

Utility Representatives: Brian Megic, David MacIntyre, Chris Russell

General Public: Prashanth Khambhammath, Angel Martin, Doug Hearn, Ron Stewart, Marc Killingstad, Ed Carter

The purpose of this meeting was to present to the Peer Review Panel the Districts' update to the transient calibration results for the ECFTX Model. NOTE: PowerPoint slides for the presentation made at the meeting have been posted to SWFWMD's peer review web board. In addition, structure flow calibration, calibration statistics, and the "shiny app" means of displaying these statistics spatially is also available at the web board.

Pete Kwiatkowski (PK) welcomed the meeting participants. Ron Basso (RB) presented the agenda and began the discussion of team efforts since our last meeting. RB discussed the scope of work for the Peer Reviewers, and a refresher of the model's essential features. Since our last meeting, he noted that staff made minor adjustments and achieved our calibration

targets. Subsequent to that, a predictive scenario was conducted that revealed an anomaly with respect to layer 8 leakance and transmissivity values of the Lower Floridan Aquifer (LFA) in the southern half of the SWFWMD, which was then corrected. A more recent predictive scenario revealed some anomalous General Head Boundary (GHB) fluxes that staff attempted to address. RB restated the Districts' and peer review panel's choice of simulating boundaries with GHBs and equivalent freshwater heads (EFHs) at the 10,000 mg/L TDS interface in each layer, and that some HAT members thought a no-flow boundary conceptualization was more appropriate. Lou Motz (LM) did not agree with the no-flow boundary approach and suggested that boundaries do move or provide water in response to pumping and the GHB approach simulates this while the no-flow approach does not. Pete Andersen (PA) suggested that potentiometric surfaces should be used to set GHB fluxes but recognized that not a lot of LFA data exists and our understanding of these boundaries is poorly defined. RB indicated that staff improved GHB fluxes by making trial-and-error changes to GHB conductance and aquifer parameters such as reducing Layer 10 vertical hydraulic conductivity. PK noted that adjustments were made to ensure that:

(1) fluxes in aquifers were higher than in confining units on a relative basis
(2) inflows from boundaries known to be brackish/saline were significantly reduced so that they could not be confused as a source of freshwater that could satisfy water demands and
(3) outflow in Layer 11 was more reasonable (i.e., lower).

Once the GHB fluxes were reasonable, staff adjusted aquifer parameters (e.g., Layers 3 and 5 hydraulic conductivity near their eastern boundaries) and achieved statistical calibration. PA noted that the RMS error improved, and staff may have fixed an outlier. Regarding the September 2004 flooded cells map, PK noted that we previously addressed this issue, and it was decided that the changes needed to reduce the number of these flooded cells in this anomalous post-hurricanes month would adversely affect the calibration in the other months so no change was made. PA agreed that the flooding was not an issue if the level of flooding shown was only for the one month that had experienced several hurricanes. It is likely that the amount of precipitation for this month was outside the range of accurate computations using the recharge algorithm.

At PA's request, RB noted that the predictive scenarios like 2040 include running the 2040 water demands along with the 2003 through 2014 climatic conditions. For the comparison of 2014 to 2040 with an increase of 458 mgd in groundwater withdrawn, reduction in outflows is to be expected.

David MacIntyre noted that while he agreed with LM as a general statement on boundary conditions, he noted that no-flow boundaries can be considered appropriate if one can demonstrate that the position of the freshwater-saltwater interface has been relatively stable over the decades under conditions with varying groundwater pumping. He indicated that a previous simulation indicated 40 percent of the 2040 water demand changes compared to 2014

was being satisfied by the flux changes at the GHBs. He acknowledged that it is difficult to determine an appropriate number regarding the flux rate at a particular layer, but the model drawdown results appear sensitive to the assigned values, which is why he has been concerned.

PA asked whether there were any changes in streamflow, and Jeff Giddings indicated none were noted. Mark Stewart (MS) noted our understanding on calibration parameters is known over a broad spectrum, with some parameters well known (e.g., aquifer parameters) while others (e.g., baseflow) are not. He noted that overall the calibration slightly improved statistically and the GHBs are now more in keeping with our general understanding of the flow system. He indicated that overall we've advanced the calibration in the appropriate direction. LM indicated that we've made significant progress. He noted that boundary conditions are often difficult to quantify accurately and agreed with PA that the GHB boundaries should not be significant sources of water in the model. He indicated that overall we're on the right track. The overall water budget for calibration was presented, but we should do so for the predictive scenarios beyond just the changes in GHB flows that had been presented. RB indicated that this budget information would be provided as supplemental material posted to the web board.

PA wanted to ensure that the model effectively simulates the transient response, especially that the model is simulating the minimums and maximums, as major water resource decisions rely on a model's ability to capture them. RB replied that the transient character of the model calibration had not changed significantly from the December 2018 version. He noted a link to the shiny app was sent to the peer review panel to further assess the transient nature of the calibration. WMD staff would look for ways to further demonstrate the robustness of the transient calibration in the draft report.

Panel members summarized that staff have looked at anomalies and have appropriately resolved them. Water budgets are essential, and while the GHB fluxes are important, in this case they are small compared to the other water budget terms. Models are always a work in progress, but staff have satisfactorily resolved concerns, and at this point, the model is ready to be used and the documentation initiated.

PK indicated that it would likely take a couple of months to develop the first draft of the model documentation. MS indicated a desire to allow one month for the Panel to review the draft document. RB indicated that it might be advantageous to have a face-to-face meeting to resolve their future comments on the model documentation once received.

Public Comment

Angel Martin suggested that staff look at the SWFWMD's Northern District Model to compare fluxes. RB answered that the Northern District Model was mostly aligned along natural no-flow divides in the system and that it covered a much smaller footprint of the larger 25,000 square mile ECFTX domain. RB answered staff reviews larger regional scale models to generally compare boundary flux magnitude as a test of reasonableness. Angel Martin asked if staff had

looked at making boundaries no-flow, and staff noted that this was investigated as part of the sensitivity analysis.

Adjourn - The meeting was adjourned at 4:15 pm.

Central Florida Water Initiative

CFWI Water for Tomorrow

MEETING SUMMARY

Subject: Peer Review Meeting 17 (Peer Review Comments on DRAFT Model Documentation Report)

Expanded East Central Florida Transient (ECFTX) Groundwater Model

Date: December 11, 2019 (9:30 AM to 1:10 PM)

Prepared By: Central Florida Water Initiative (CFWI) Hydrologic Analysis Team (HAT)

Attendees:

Panel Members: Pete Andersen (Chair), Lou Motz, Mark Stewart

SFWMD: Pete Kwiatkowski, Uditha Bandara, Anushi Obeysekera, Jeff Giddings (remote)

SJRWMD: Clay Coarsey, Wei Jin, Chris Leahy, Lanie Meridth, Paul Bremner, Claire Muirhead (remote), Lori Burklew (remote)

SWFWMD: Ron Basso, Jason Patterson, Hua Zhang

Utility Representatives: Brian Megic, David Macintyre

General Public: Angel Martin

Pete Kwiatkowski (PK) welcomed the meeting participants to SFWMD's St. Cloud Field Station. The purpose of this meeting was to discuss staff's response to the Peer Review Panel's comments regarding the DRAFT Model Documentation Report. Panel Chair Pete Andersen (PA) summarized that staff did a good job developing and documenting the model, and his comments are intended to make it a better work product. Regarding his comment concerning the Agricultural Field-Scale Irrigation Requirements Simulation (AFSIRS) method of estimating agricultural water demands, staff noted that the SWFWMD portion of the model uses metered data, the SJRWMD in general uses AFSIRS estimates tensioned to their benchmark farms, and SFWMD uses the traditional AFSIRS methodology. Jeff Giddings (JG) noted that the benchmark farms were not used in SFWMD because it is specific to a northern Florida climate. JG noted that a previous study estimated that AFSIRS slightly overpredicts metered data. PK noted that there are differences between the methods, but in each case best-available data was used.

Regarding the comment pertaining General Head Boundary (GHB) conductance values and hydraulic conductivity (K) values in adjacent model cells, Anushi Obeysekera (AO) made a brief presentation summarizing staff's approach to adjusting GHB fluxes. Staff ensured that influxes along brackish/saline boundaries were minimized and that they were conceptually consistent between confining and aquifer layers. Mark Stewart (MS) noted that these changes would have resulted in the need to recalibrate the K values in adjacent cells and AO confirmed this was conducted. Regarding specific yield (Sy), staff indicated that the Sy arrays were pulled from existing models that overlapped the ECFTX Model. The Panel expressed some concern with this approach, but Jason Patterson (JP) noted that the values varied with the physiographic region and confirmed that the calibrated values were consistent with aquifer test data. PA expressed some concern regarding the apparently low lakebed conductance values used in the model. JP noted that we calibrated to previously calculated lakebed fluxes and lakebed conductance was used as a calibration parameter to achieve these fluxes. Ron Basso (RB) reminded the Panel members that isolated lakes were simulated with high storage and high K values while others were simulated using the MODFLOW Rivers Package. Regarding pipeline leakage and associated recharge, Uditha Bandara (UB) indicated that his approach of calculating landscape irrigation return flow implicitly includes this recharge component.

There was a lengthy discussion regarding automated calibration (PEST). Brian Megic (BM) noted that the first phase of calibration used PEST but did not achieve the desired calibration. Accordingly, manual calibration was then used to achieve final calibration. RB emphasized that staff relied upon experience with existing regional models and staff's understanding of the hydrogeologic system to guide manual calibration. PA suggested that staff better describe why PEST was not used to achieve final calibration.

PA expressed some concerns regarding the model's ability to reproduce a transient response in wet and dry conditions. In the document, staff emphasizes the model's ability to reproduce averaged conditions. Staff had provided r-squared information but did not adequately describe how this calibration parameter demonstrated the model's ability to reproduce transient conditions. In response, staff agreed to use the Nash-Sutcliffe (NS) method to address this comment. Wei Jin (WJ) noted that the r-squared method was used to quantify the similarity of groundwater head changes between simulation and observation, which provides a quantification of transient model fit given offsets in initial heads. Hua Zhang (HZ) noted that the NS method has limitations when the initial heads in the model do not match the observed heads, which tends to skew the NS results. PA and MS suggested that the offset can be removed and then the NS statistics can be calculated, which staff agreed to do. In addition, HZ indicated that staff will prepare the other statistics that PA suggested in his comment letter.

PA questioned the Layer 5 GHB flux value and noted that it was similar in magnitude to the pumping in that layer RB noted that it is more appropriate to evaluate fluxes not simply on a layer basis but on an aquifer basis along particular boundaries. For example, he noted that there is a known large flux from the Upper Floridan aquifer and Avon Park Permeable Zone (Model Layers 3 and 5) along the northwest portion of the model where springflows occur and the aquifer is highly transmissive. Also, since the northern and southern boundaries are not oriented along flow lines, it should be expected that flow would occur across the northern and southern boundaries. JP noted that test simulations using 25% and 50% reductions in pumpage confirmed that these boundary flues were reasonable and not an artificial source of water to meet water demands.

PA questioned staff's comment about Sy being in an insensitive parameter. He noted that it is important, but perhaps not sensitive. PA and MS suggested that we add a quality assurance section to document the level of detail conducted by staff to develop the model and ensure its quality. PA also suggested that a recommendations section be added, which would describe how the model will be maintained, when and how it will be updated, etc. Model limitations and recommendations that are currently in the Sensitivity Analysis section should be moved to the added recommendations section.

Lou Motz (LM) noted the tremendous amount of technical work conducted to develop the model. LM went over his comments, and staff concurred and agreed to make the applicable changes. Regarding LM's comment concerning mean vs. median values, RB found that there is little difference between these two over the long term. Regarding springflow calibration, RB noted that only 17 springs had sufficient data for calibration purposes, but staff used estimated springflows for others when available.

LM also suggested that staff consider PEST calibration, noting other authors who recognize its benefits in legal and regulatory settings for model applications. RB noted that other regional models that have successfully used PEST have achieved similar levels of quantitative calibration as the current ECFTX Model. He also noted that staff have successfully defended manually calibrated models during administrative hearings; therefore, he did not believe that PEST calibration should be considered mandatory.

LM requested clarification regarding the steady-state and transient models. PK indicated that the steady-state calibration was a milestone in the ultimate development of the transient model and clarified that it is not an independent deliverable. RB clarified that the model consists of a steady-state period (2003), followed by a 2004-2012 transient calibration and a 2013-2014 model verification period. LM suggested that staff better document our calibration criteria, including that used in other regional groundwater models including USGS models. LM, PA, and MS suggested that figures be updated to "stand alone" and should include more descriptive titles, improved legends, etc. LM suggested that statistics be added to the 17 time-series calibration graphs for the springs. LM also recommended that a statistic such as the Nash-Sutcliffe coefficient should be used to evaluate the water-level hydrographs resulting from the transient calibration. Regarding LM's comment concerning water budgets, staff agreed to include net inflows and outflows for each period, and to ensure that figures, tables, and text descriptions are in agreement.

MS indicated that the Panelists comments have been discussed, documented, and addressed as captured in staff's PowerPoint presentations and meeting summaries. He opined that over the more than three years that the Peer Review Panel has existed, it is one of the most well-documented reviews that he is aware of. Accordingly, his comments were predominantly editorial. MS did suggest that staff better explain factual statements by referencing sources of information.

PK thanked the non-water management district HAT members for their comments, and he also thanked Angel Martin for his voluntary review of the document. Staff will incorporate these comments as appropriate to make it a better document. Staff also indicated that they would prepare a written response addressing each of the individual peer review major technical items. That response will be posted to the web board by December 20, 2019.

PK thanked the Panel for their efforts and agreed that staff will make the applicable changes and then finalize the document. PA will prepare a unified, abbreviated, final Peer Review Report that answers the

general peer review questions mentioned in the scope of work, with the meeting summaries as an appendix. A draft of this report will be prepared by January 31, 2020.

Public Comment

Angel Martin suggested that staff add more information regarding model uncertainties, particularly as it relates to model applications concerning minimum flows and minimum levels (MFL) waterbodies.

Adjourn

The meeting was adjourned at 1:10 pm.

Central Florida Water Initiative

CFWI Water for Tomorrow

MEETING SUMMARY

Subject: Peer Review Teleconference – Meeting 15 (Review of Transient Calibration)

Expanded East Central Florida Transient (ECFTX) Groundwater Model

Date: December 12, 2018 (1 PM to 4 PM)

Prepared By: Central Florida Water Initiative (CFWI) Hydrologic Analysis Team (HAT)

Attendees:

Panel Members: Pete Andersen (Chair), Lou Motz, Mark Stewart

Districts staff: Pete Kwiatkowski, Uditha Bandara, Jeff Giddings, Anushi Obeysekera, Wei Jin, Jason Patterson, Joanne Chamberlain, Ron Basso, Hua Zhang, Kevin Vought, Brian Starford, Chris Leahy, Joanna Oseguera, Lori Burklew

Utility Representatives: Brian Megic, David Macintyre, Terry McCue

General Public: Prashanth Khambhammath/ARCADIS, Angel Martin, Berdakh Utemuratov

The purpose of this meeting was to present to the Peer Review Panel the Districts' transient calibration results for the ECFTX Model. NOTE: PowerPoint slides for presentations made at the meeting have been posted to SWFWMD's peer review web board.

Pete Kwiatkowski (PK) welcomed the meeting participants. Ron Basso (RB) presented the agenda and began the discussion of team efforts since our last meeting. Initial efforts focused on resolution of water level spikes in wells and lakes. Uditha Bandara (UB) presented information regarding the methodology to adjust ET-Recharge-Runoff using a time-varying depth-to-water, which results in more water being diverted to runoff and lessens the water level spikes in a hydrologically appropriate manner. Despite these efforts, there were approximately 30 lakes that were converted from high-K lakes to the RIV package with appropriate river bed conductance to ensure fluxes were correct. In addition, some wells still have some water level spikes. Mark Stewart (MS) asked about the underlying mechanism for this phenomenon, which seems to occur in deep water table areas. MS and RB discussed nearby high-K lakes being a potential cause. MS opined that he thought our approach was hydrologically reasonable. RB indicated we developed profiles through the high-K lake areas to ensure that the water table in

adjacent model cells was smooth. In response to a question from Lou Motz (LM), UB indicated that the maximum ET in MODFLOW was specified on a per-cell basis, and the extinction depths varied with land use. UB noted that the ET-RCH-ROFF program was used to provide the ET and RCH input for MODFLOW. This program was also used to calibrate structure flows and baseflows. UB presented on the surface water calibration results including baseflows and structure flows. MS noted that the Geurink (i.e., USF) method is known for underestimating baseflows, and he was pleased to see that we overestimated baseflows when using this method, which is good. MS asked if the low baseflow estimates influenced our selection of aquifer parameters when conducting calibration. RB noted that other criteria, including the presence of flooded cells, tended to prevent over-reliance on baseflow as a calibration parameter. In response to a question from PA, UB confirmed that the baseflows presented were averaged over the simulation period.

RB summarized the calibration results for the ECFTX-wide model domain and the CFWI area. Almost all targets were met, except the 50% criteria being less than 2.5 feet for the UFA (currently 46%). Per a previous comment from PA, a means of evaluating the ability of the model to simulate the dynamic response was developed and successfully implemented: r-squared values of 0.4 for 60 percent of the wells.

RB presented the spatial distribution of aquifer parameters on a per-layer or per-aquifer basis for the calibrated model. He noted that Layer 2 was leakier along the Lake Wales Ridge and the Hillsborough River. MS was pleased to see that we were able to achieve calibration using reasonable specific yield values, noting that previous modeling efforts have not been able to do so. PA noted lots of variability in hydraulic conductivity (K) values. He recalled that we used prior, calibrated models in the area as the starting point, but wanted to know our model calibration process since we were no longer using automated calibration approaches. RB indicated that we looked at residuals and adjusted K values, but kept true to our hydrogeologic conceptualization, while also noting the values used in the steady-state calibration process. Jeff Giddings (JG) noted that we re-kriged K value distributions to ensure smooth parameter transitions.

PA and LM suggested that we present plots of simulated vs. observed residuals on a per aquifer basis (i.e., 45-degree plots) to further display calibration performance. LM also suggested that we plot frequency distributions as well. He wanted to confirm that our calibration wasn't skewed high or low.

PK inquired about the need to meet the 50% criteria noted previously that we missed by a few wells. He noted that we did attempt to meet this criterion, but some of the aquifer parameter adjustments needed to meet this criterion on some of the wells tended to reduce the hydrologic reasonableness of the baseflows, structure flows, or the calibration performance of overlying or underlying target wells so they were not incorporated. PA noted that he had no problem with our calibration, that the 50% criterion is fairly arbitrary, and that targets may not be the best indicator of calibration performance. LM indicated there was no assurance that automated calibration would have improved the results. The Panel suggested that the final documentation discuss the basis for the chosen calibration criteria and relate it back to other regional modeling efforts in the area, ASTM standards, etc. MS noted that the model looks hydrologically reasonable. LM asked what version of MODFLOW was used, and staff noted that we used MODFLOW-NWT. MS suggested adding more information on the legend of our PowerPoint slides to include some of the information shared verbally to make it more informative.

PK noted that staff were pleased with the calibration and intended to move forward using the model to support the overall project and begin conducting predictive simulations. He asked if the Panel – assuming they concurred – could write a brief memo indicating their general concurrence that the model was sufficiently calibrated. MS suggested that the memo be qualified to indicate this concurrence was based on what staff had presented to date, and that final concurrence would come once the final model documentation was developed. PK indicated that it would likely take a couple of months to develop the first draft of the model documentation. PA indicated that he would draft the memo and share it with the other Panel members with the appropriate qualifiers before finalizing it. The Panel indicated that it might be advantageous to have a face-to-face meeting to resolve their future comments on the model documentation once received. In response to a question from PA, PK indicated that the Peer reviewers' scope was focused on model review, its appropriateness for its intended use, and model documentation but did not include review of the proposed predictive simulations.

Staff agreed to provide to the Panel the additional information requested as noted above over the next few days and post it on the web board.

Public Comment

Prashanth Khambhammath/ARCADIS asked about the project schedule. Angel Martin suggested that staff consider looking at other baseflow estimation techniques for the final report.

Adjourn - The meeting was adjourned at 4:05 pm.