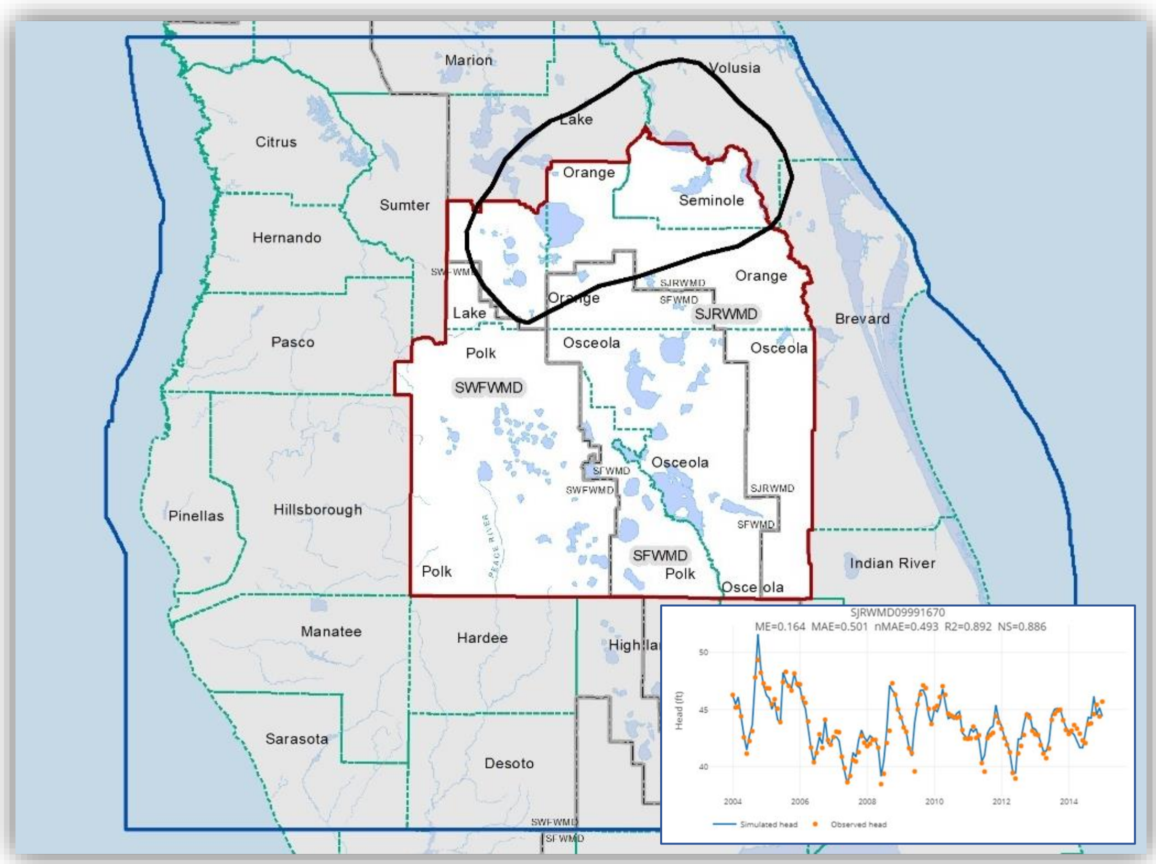
East-Central Florida Transient Expanded (ECFTX) V2.0 Model Report



March 2022

East-Central Florida Transient Expanded (ECFTX) V2.0 Model Report

by

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ACRONYMS AND ABBREVIATIONS

APhpz	Avon Park high permeability zone
APPZ	Avon Park permeable zone
APT	aquifer performance test
cfs	cubic feet per second
CFWI	Central Florida Water Initiative
CUP	consumptive use permit
DRN	Drain package
DRT	Drain Return package
DWRM	Districtwide Regulatory Model
dy^{-1}	ft per day per ft
ECFT	East-Central Florida Transient model
ECFTX	East-Central Florida Transient Expanded Model
EFH	equivalent freshwater head
ET	evapotranspiration
FAS	Floridan aquifer system
ft/d	feet per day
ft^2/d	Feet squared per day
GHB	General Head Boundary package
gpd	gallons per day
HAT	Hydrologic Analysis Team
IAS	intermediate aquifer system
ICU	intermediate confining unit
K	hydraulic conductivity
Kh	horizontal hydraulic conductivity
Kv	vertical hydraulic conductivity
LFA	Lower Floridan aquifer
LFA-upper	First subdivision of the LFA – upper permeable zone
LF-basal	Lower Floridan aquifer – basal permeable zone
MAE	mean absolute error
MCU	middle confining unit
MCU_I	first component of the MCU
MCU_II	second component of the MCU
ME	mean error
mg/l	Milligrams per liter
MGD	million gallons per day
MODFLOW-2005	USGS Modular Groundwater Flow Model 2005

MSR	mean-square residual
NAVD88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
NS	Nash-Sutcliffe coefficient
OCAPlpz	Ocala-Avon Park low-permeability zone
OMR	overall mean residual
PZ	Permeable zone
R^2	coefficient of determination
RMS	root mean square
RMSR	root-mean-square-residual
RWSP	Regional Water Supply Plan
SAS	Surficial aquifer system
SFWMD	South Florida Water Management District
SJRWMD	St. Johns River Water Management District
SWFWMD	Southwest Florida Water Management District
UFA	Upper Floridan aquifer
UFA-upper	Uppermost permeable zone of FAS
UPW	Upstream weighting
USGS	United States Geological Survey
USGS-ECFT model	USGS version of the ECFT model
Districts	water management districts
WUP	water use permit

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CHAPTER 1 – INTRODUCTION

1.1 Background

The East Central Florida Transient Expanded (ECFTX) model was developed in 2020 to support central Florida regional water supply planning and used as a primary tool to estimate groundwater availability and assess water supply and management strategies in the Central Florida Water Initiative (CFWI) planning region (CFWI, 2020). The ECFTX model domain covers about a 23,800-square-mile area of central Florida, including the entire CFWI area and extends from central Volusia County (to the north) to the Charlotte-Desoto County line (to the south) and from the Atlantic Ocean (to the east) to the Gulf of Mexico (to the west) (Figure 1.1). The model has 603 rows and 740 columns with a uniform grid spacing of 1,250 feet (CFWI HAT, 2020).

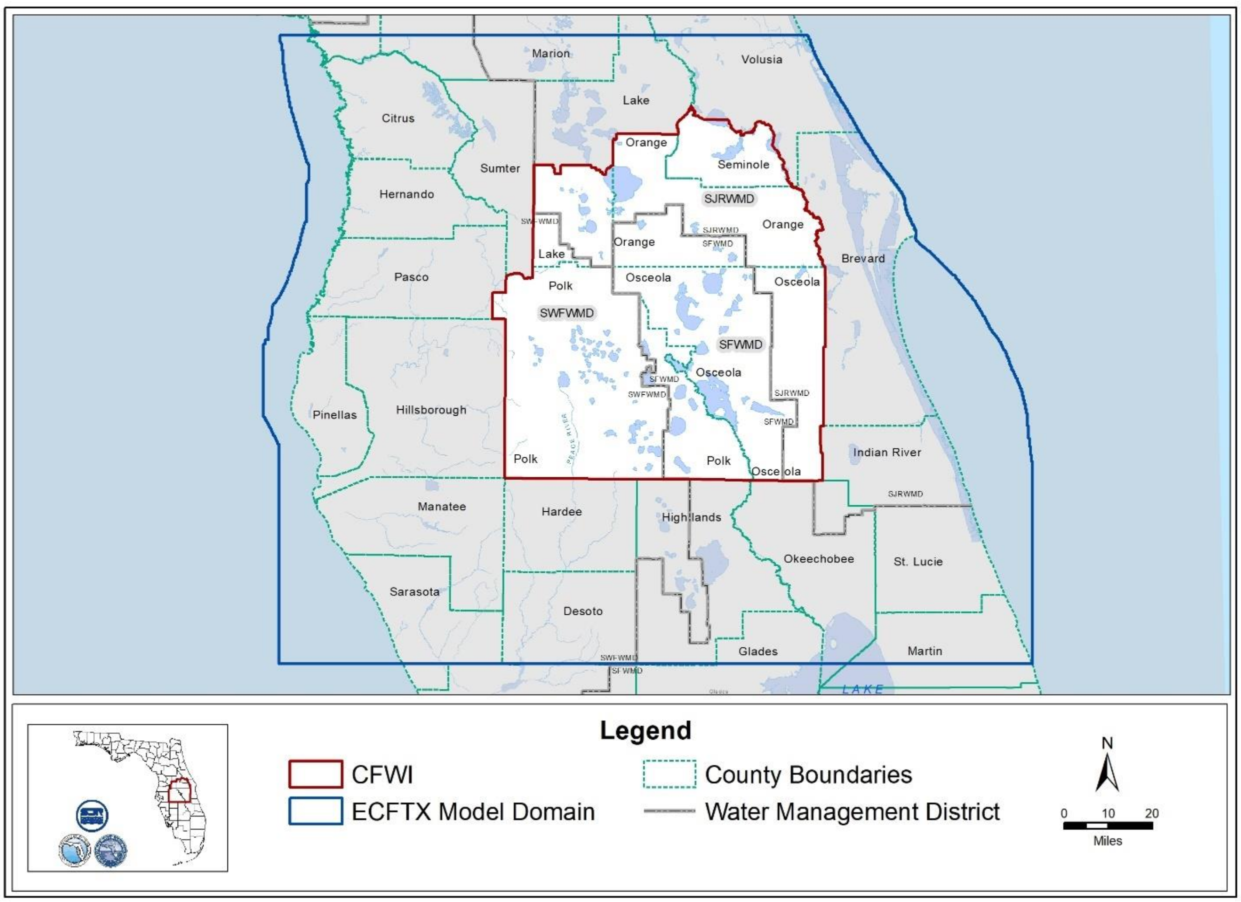


Figure 1.1. ECFTX Model Domain

The ECFTX model is a fully three-dimensional groundwater flow model using the MODFLOW NWT (Niswonger, et al., 2011) computer code. All elevation data for the model are in a vertical datum of NAVD 88. 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 were inactivated, and general head boundaries were set along the edge of the active areas (CFWI HAT, 2020). The model consists of 11 hydrostratigraphic layers — layer 1 is the Surficial aquifer (SA), layer 2 is the Intermediate Aquifer System/Confining Unit (IAS/ICU), layers 3–5 are the Upper Floridan aquifer (UFA), layers 6–8 are Middle Confining Unit (MCU I and II), and layers 9–11 are the Lower Floridan aquifer (LFA) (Figure 1.2).

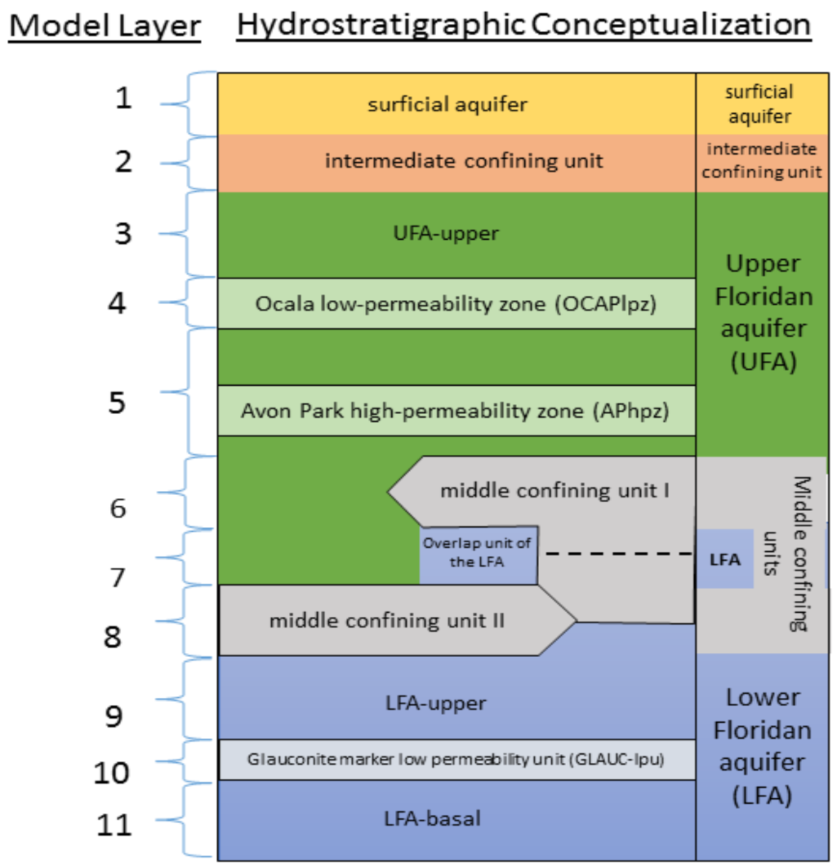


Figure 1.2. ECFTX Model layers (CFWI HAT, 2020).

The ECFTX is a transient model simulating monthly groundwater flows and levels from 2004 through 2014 with an average 2003 steady-state condition serving as the initial conditions. It was calibrated to match observed flows and levels in 2003 (annual averages) and 2004 through 2012 (monthly averages). The years 2013–2014 were used as the verification period.

1.2 Objectives

The main purpose of the ECFTX model was to support water supply planning decisions. To make the model a more suitable tool for regulatory decisions and improve the model performance in the areas where critical minimum flows and levels (MFL) water bodies are located, a groundwater modeling team from three districts (SJRWMD, SWFWMD and SFWMD) reviewed the model and identified an area within the CFWI portion of the domain where the original calibration could be improved. This area primarily included the Wekiva River springs groundwater contributing basin and Seminole County, shown in Figure 1.3 as circled areas.

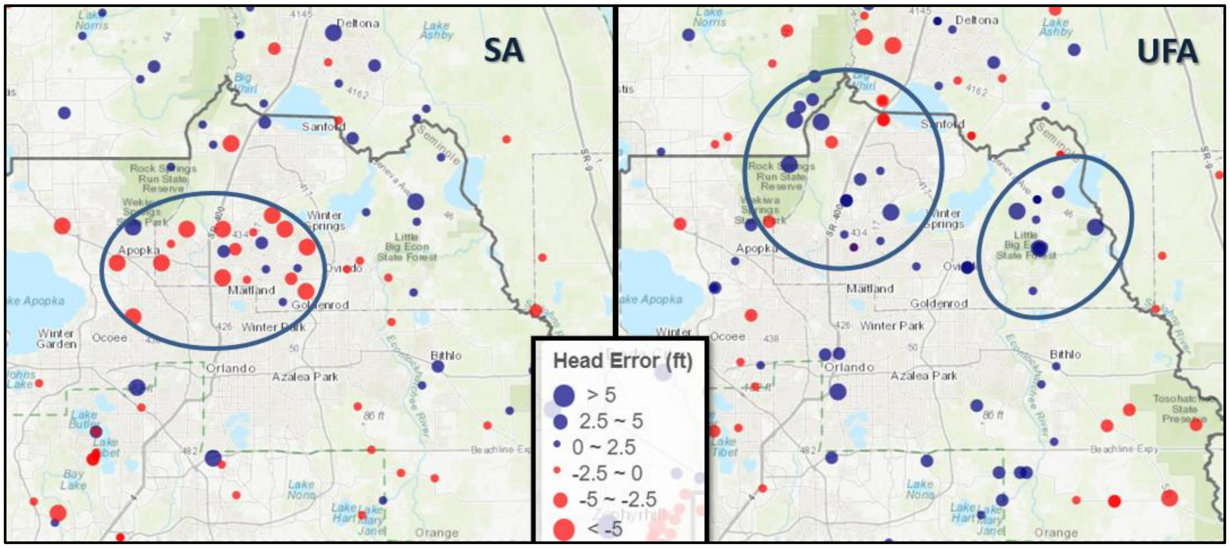


Figure 1.3 Areas of concern

As a result of more thorough review of the local-scale data in these areas, the team also identified opportunities for refinements to the following:

- Spring pool elevations
- Wekiva River stages
- Groundwater level targets near Wekiwa Springs
- Layering of pumping wells

To facilitate the recalibration effort, a local groundwater basin (focus area) was delineated using the Wekiva River groundwater contributing basin and the USGS May/July 2010 UFA potentiometric surface (Figure 1.4). The recalibration effort was conducted only in the focus area with a goal to improve the model's ability to better match observed water levels and spring flows. In addition, the horizonal hydraulic conductivity (Kh) for the IAS/ICU (layer 2) in the Southern Water Use Caution Area (SWUCA) of SWFWMD outside the focus area was modified to improve accuracy of the model conceptualization, model convergence, and run time (Appendix A).

This report describes the model updates, recalibration approach and results, and a sensitivity analysis to better understand the influence of recharge on model calibration. The original and recalibrated models are referred as ECFTX v1.0 and ECFTX v2.0, respectively, in this document.

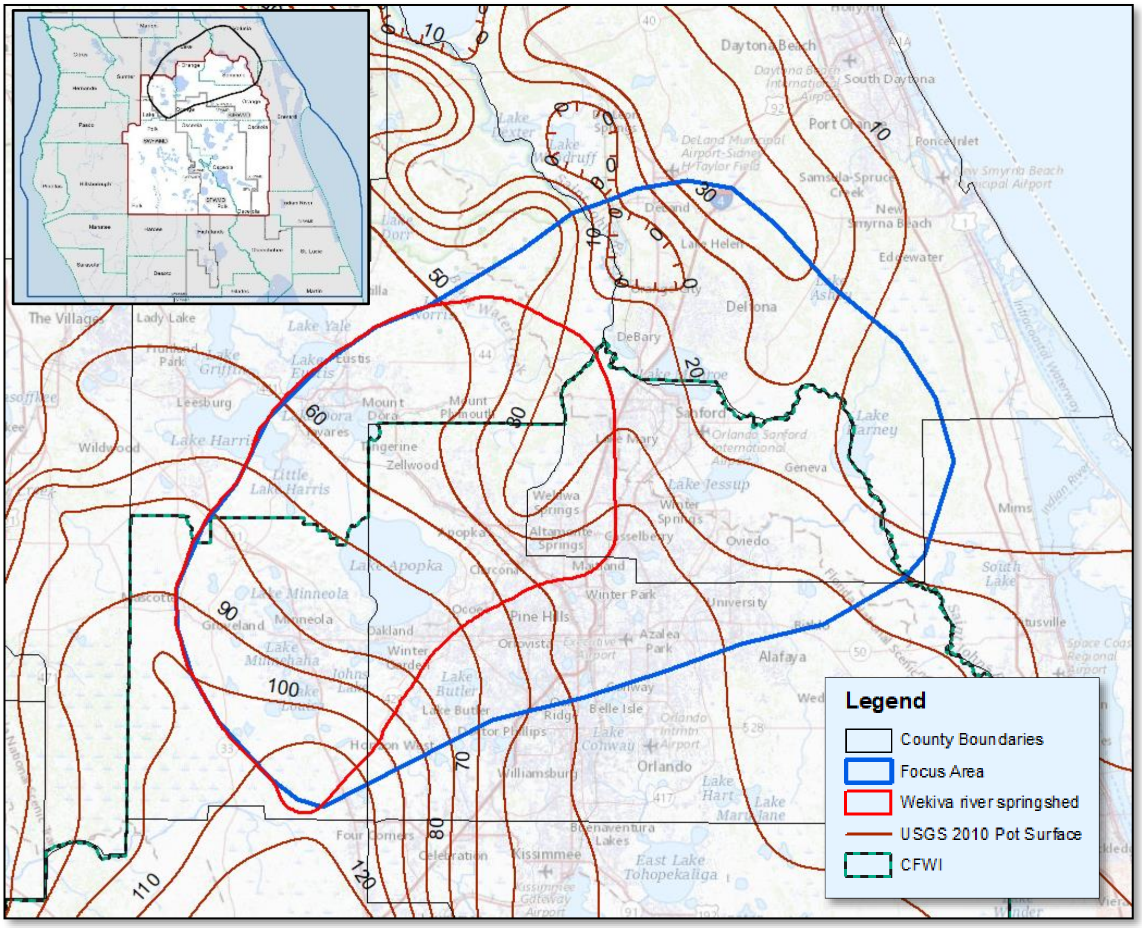


Figure 1.4 Focus Area

CHAPTER 2 – MODEL UPDATES

ECFTX model updates, generally limited to the focus area as shown in Figure 1.4, included modifications to spring pool elevations, river stages, and groundwater level targets. Minor adjustments were also made to recharge, maximum saturated evapotranspiration (MSET), and groundwater withdrawals. Changes to the model outside of the focus area included updates to layer 2 horizontal hydraulic conductivity (Kh) in the region where the Intermediate aquifer system (IAS) is present.

2.1 Spring pool elevations

A review of the springs in the model indicated the pool elevations assigned to several springs within or near the focus area needed to be modified due to an older vertical elevation datum, feet NGVD29, previously used. Therefore, pool elevations were updated to reflect the appropriate vertical datum, feet NAVD88, for the model simulation period of 2003 to 2014. Figure 2.1 shows the locations of the 12 springs where the pool elevations were revised in the model and Table 2.1 includes the change in updated 2003 to 2014 average pool elevation at each spring. Of the springs with revised pool elevations, Alexander Spring was the only spring categorized as a magnitude 1 spring (with a discharge at or greater than 100 cfs). The remaining revised springs were of magnitudes 2 or 3 and were mostly within the Wekiva River springshed, apart from Gemini Springs and Green Spring, which were outside of the springshed but within the focus area (Figure 2.1).

Table 2.1. The revised springs

Name	ID	Magnitude	ECFTX V1.0	ECFTX V2.0
			2003 to 2014 Average Pool Elevation (Feet, NAVD88)	2003 to 2014 Average Pool Elevation (Feet, NAVD88)
Sanlando Springs	1736	2	26.20	25.59
Palm Springs	1456	3	22.47	21.43
Starbuck Spring	1916	2	21.02	19.97
Miami Spring	4109	3	15.21	14.20
Wekiwa Spring	2353	2	13.29	12.17
Holiday Spring	841	3	65.03	67.03
Bugg Spring	256	2	60.51	61.67
Rock Springs	1624	2	26.26	25.16
Green Spring	730	3	11.34	10.40
Gemini Springs #2	4163	2	2.61	1.68
Gemini Springs #1	4161	2	2.61	1.23
Alexander Spring	16	1	2.95	9.41

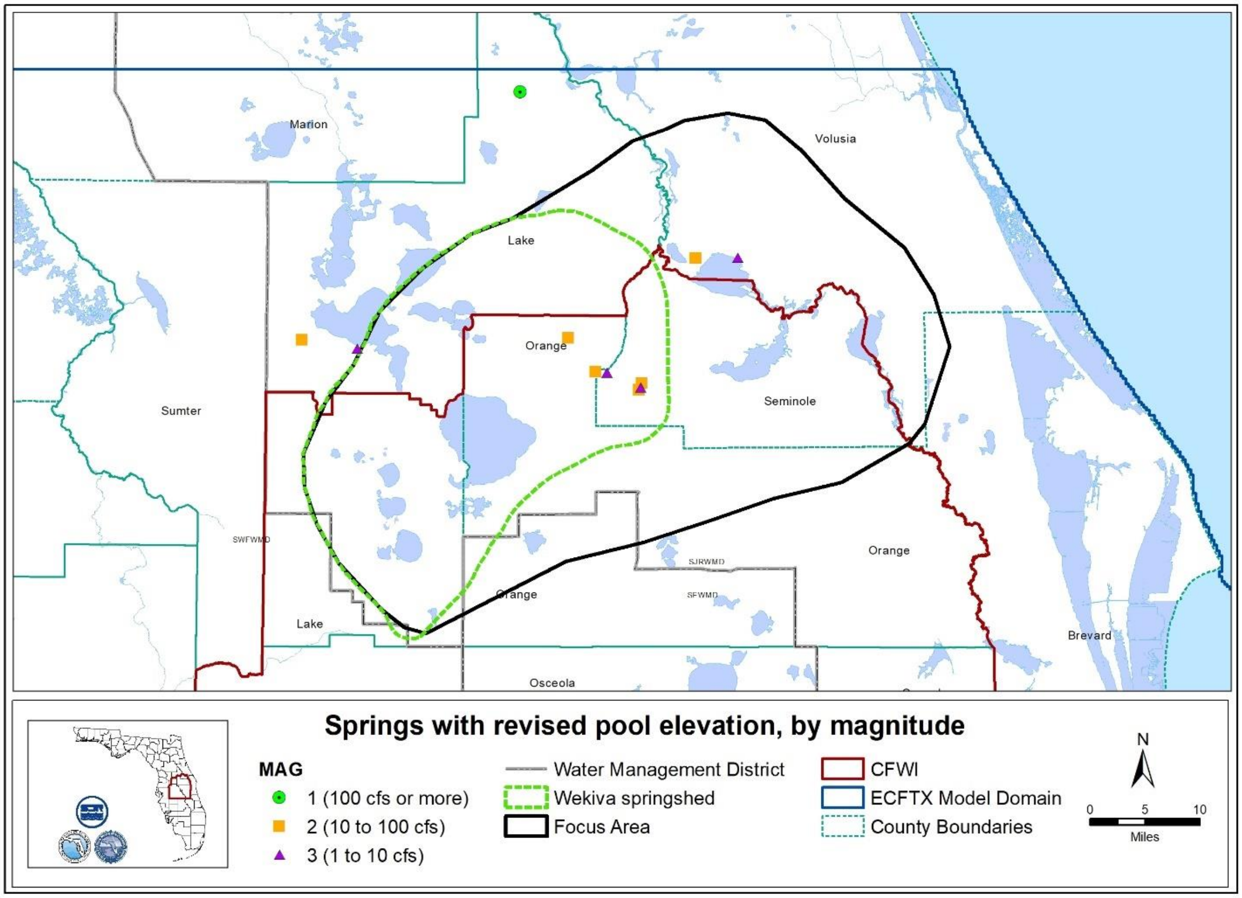


Figure 2.1. Spring locations with revised pool elevations

2.2 Wekiva River stages

A comparison of modeled Wekiva River stages with the observed data, where available, indicated the modeled stages needed to be modified at several locations in the river, likely due to data error or the use of an old vertical elevation datum. The simulated stages from the Wekiva River HEC-RAS model (SJRWMD, 2019) were used to update river stages at cell locations representing the Wekiva River in the model for the period of 2003 through 2014. Linear interpolation was used to estimate the stages in between locations where HEC-RAS model data were available. At river boundary cells where the stages were adjusted, the river bottom elevations were also adjusted to maintain the depth assigned to each cell in ECFTX V1.0. Figure 2.2 shows the river boundary cells representing the portion of the Wekiva River where stage was adjusted.

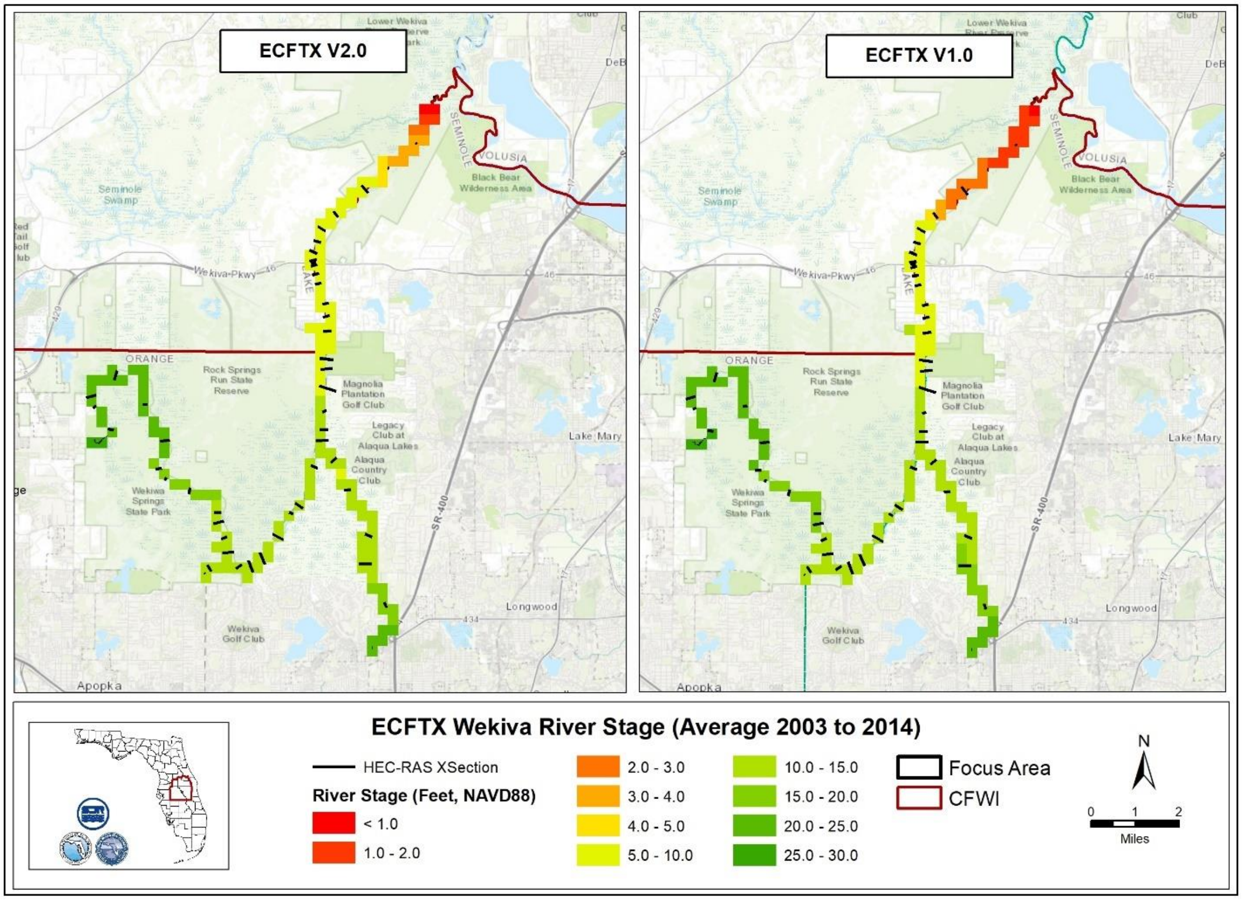


Figure 2.2. Wekiva River cell locations where the river stage and bottom elevation were updated in the model. The 2003 to 2014 revised stage in ECFTX V2.0 is shown on the left while the stage in ECFTX V1.0 is shown on the right for comparison.

2.3 Groundwater level targets

Groundwater level targets in the focus area were reviewed for location accuracy and observation values. Monitoring wells OR0547 and OR0548 are near Wekiwa Springs (Figure 2.3). OR0548 is open to the shallow part of the UFA (model layer 3) and OR0547 is open to MCU_1 (model layer 6). The vertical head difference between these wells exceeds 20 feet. Our review of the head observation (HOB) package indicated OR0548 was not utilized in the ECFTX v1.0 model calibration and OR0547 well was assigned to the wrong model layer, layer 5. The HOB package was modified by assigning OR0547 well to layer 6 and OR0548 well to layer 3. Additionally, the model grid cell assigned to surficial aquifer monitoring well OR0894 near Prevatt Lake (Figure 2.3) was shifted 1 grid cell east (row 118 and column 382) to avoid the OR0894 grid cell intersecting with a river boundary cell in the model (row 118 and column 381). This prevented the simulated groundwater levels at the OR0894 grid cell from being strongly influenced by the specified stage in the river cell.

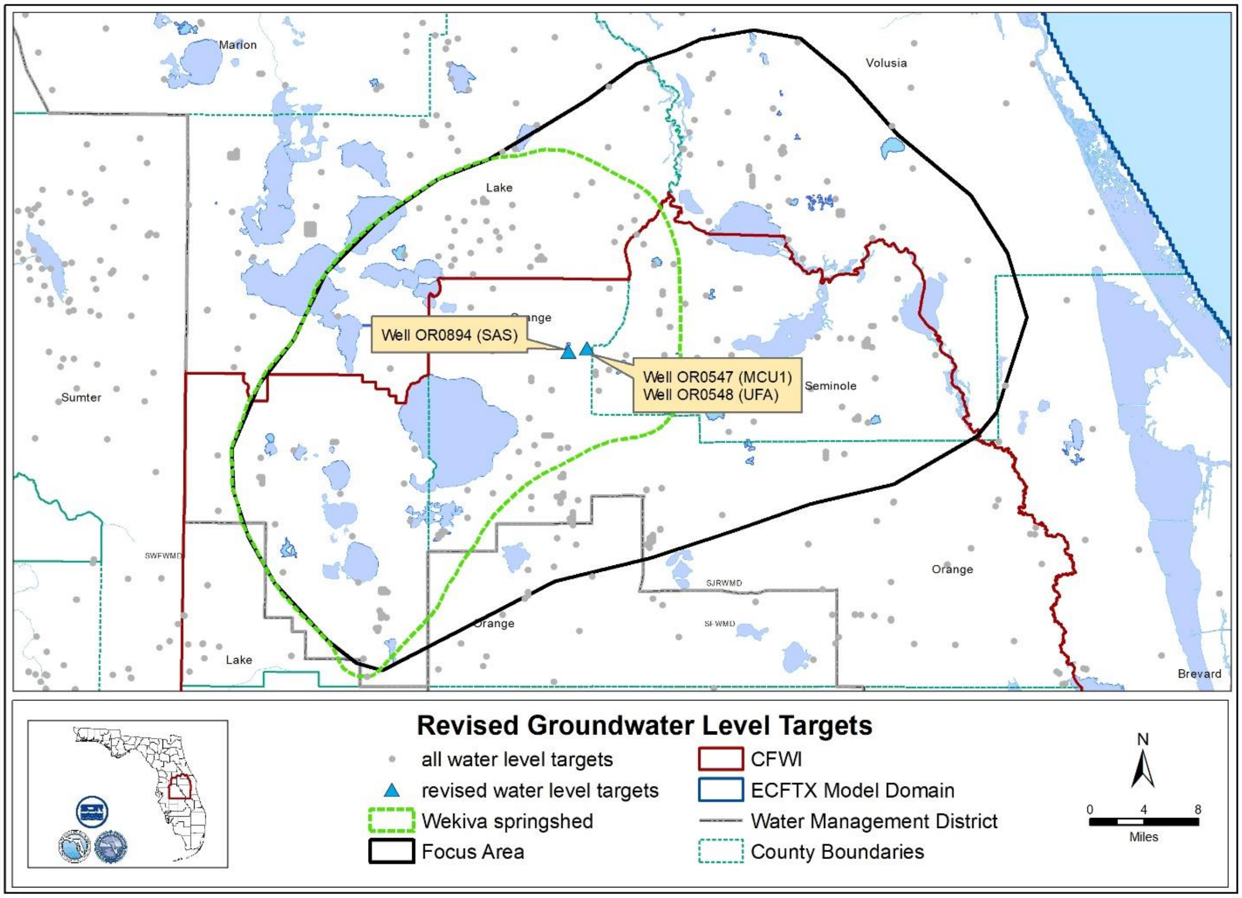


Figure 2.3. Locations of revised groundwater level calibration targets in the model.

2.4 Groundwater withdrawals

A review of groundwater withdrawals in the ECFTX model revealed several consumptive use permits (CUPs) in SJRWMD required updated layer assignments due to inaccurate well construction information used to assign the model layer in the MODFLOW well package. Thus, the model layers in the well package were adjusted based on the updated well construction data for the following CUPs: City of Casselberry (CUP 8284), City of Altamonte Springs (CUP 8372) and the City of Eustis (CUP 84879). Review of well construction information at well SJ_8284_15422 indicated that this well was constructed deeper than originally modelled and was open to layers 5 through 9. Therefore, fluxes previously assigned to layers 3 and 4 at this well in ECFTX v1.0 were redistributed to layers 5-9. Review of well construction information at wells SJ_8284_15427, SJ_8284_15428, SJ_8372_15672, SJ_8372_19978 and SJ_8372_19979 indicated that fluxes previously assigned to layers 3-5 in ECFTX v1.0 needed to be redistributed to layers 7–9. Review of well construction information at SJ_84879_34862 indicated that this well is open to the basal UFA (layer 5) and not the LFA as modeled in ECFTX v1.0; therefore, the model layer was adjusted.

2.5 Recharge and Maximum Saturated ET rates

Recharge and maximum saturated ET rates were set to zero at the grid cells representing the Wekiva River in layer 1 of the model, shown in Figure 2.4, because the specified river stages in the model already accounted for the influences of actual recharge and ET on water levels. The Wekiva River Basin was the primary focus for recalibration; therefore, this change was only applied at the grid cells representing the Wekiva River. Recharge and ET in the model domain outside of the Wekiva River remained at rates assigned to ECFTX V1.0 (CFWI HAT, 2020). It should also be noted that this adjustment was made for more accurately calculating baseflows within the Wekiva River Basin and had little or no effect on model results since river stages were specified in the model.

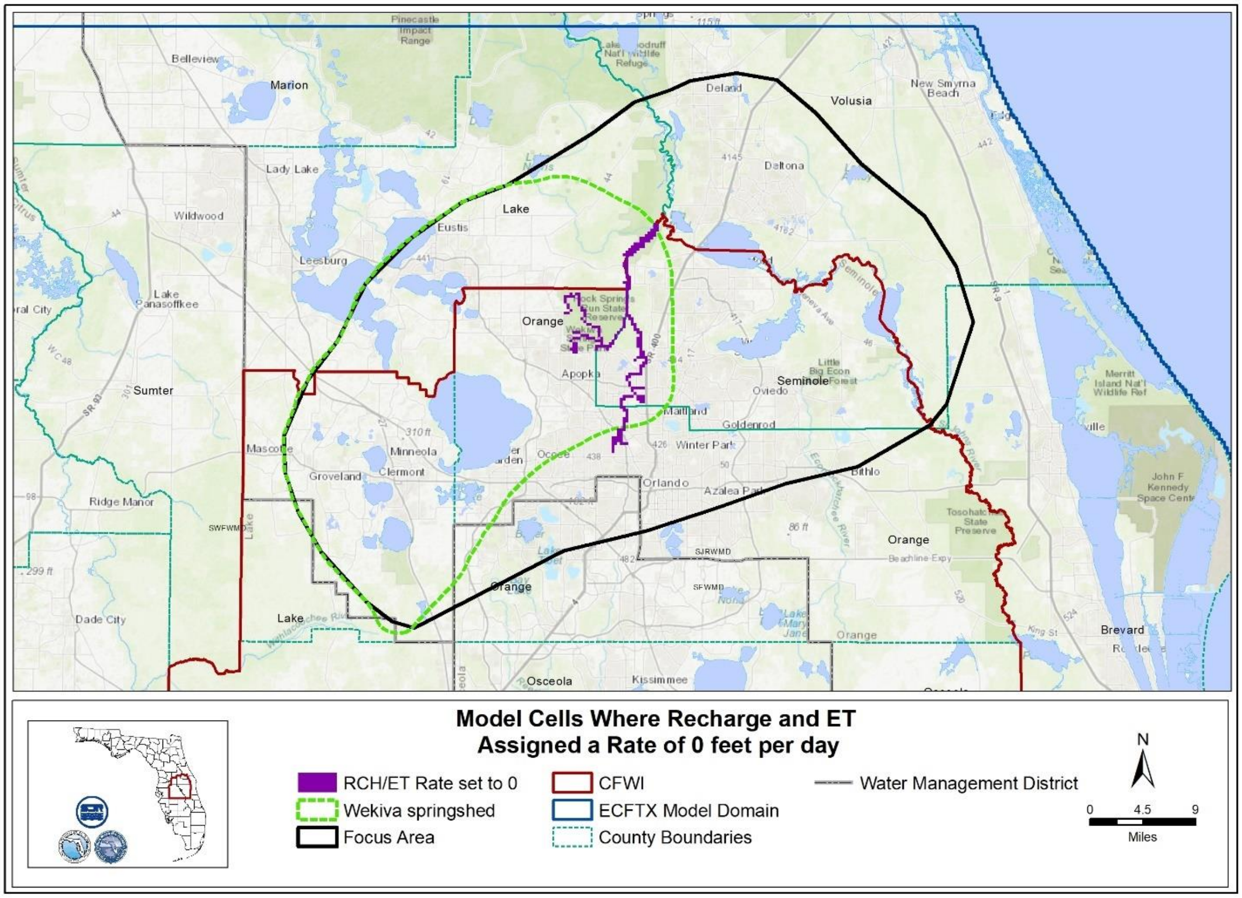


Figure 2.4. Locations where the recharge and ET rate in the model were assigned a value of 0 feet per day for all stress periods.

2.6 Outside Focus Area updates

The Hawthorn aquifer system (HAS) (also more generally referred to as the intermediate aquifer system) exists within an approximate 5,000-square-mile area of DeSoto, Sarasota, Hardee, Manatee, and parts of Charlotte, Hillsborough, Highlands counties, and in the southwest portion of Polk County within the CFWI region. Two main water-producing aquifers exist within the HAS: the Upper Arcadia aquifer and Lower Arcadia aquifer. The ECFTX v1.0 treated the HAS as a confining unit and did not simulate the individual aquifers within the HAS. As a result, assignment of low hydraulic conductivity values to the areas where the HAS existed has resulted in convergence issues in the model due to the presence of pumping wells in these aquifers. Although the convergence issue has not affected the results significantly (see Appendix A), it has considerably increased model run time. Therefore, as part of this update, the horizonal hydraulic conductivity (Kh) for layer 2 was increased so that the model becomes more conceptually accurate by simulating horizontal flow within the intermediate aquifer system and consequently improving model convergence and run time. Vertical hydraulic conductivity values were unchanged in layer 2 and overall vertical leakage from the surficial aquifer to the UFA through layer 2 largely remained the same as ECFTX v.1.0. Appendix A presents details of this update.

CHAPTER 3 – MODEL RECALIBRATION

3.1 Calibration Approach

After the model was updated, model parameters were recalibrated to improve the model performance within the focus area. No changes were made to the parameters outside the focus area as part of recalibration. Because the focus area was identified as a local groundwater basin with limited flow exchange across the lateral boundary, the modifications to the model parameters within the focus area were assumed to minimally affect the groundwater levels and flows outside the focus area. Model testing after recalibration generally confirmed this understanding.

As recommended by peer reviewers of ECFTX 1.0 (Andersen, et al. 2020), the automated parameter estimation tool (PEST) by Dougherty (2014) was used for recalibration. The following parameters were adjusted using PEST:

- Hydraulic conductivities of all layers
- Spring conductances
- River conductances along Wekiva River

Initial parameter values were obtained from the ECFTX v1.0 model. The upper and lower bounds of the pilot points, utilized for adjustment of hydraulic conductivities, were set so that the UFA and LFA transmissivities and ICU and MCU leakance values were maintained within the values consistent with the known hydrogeology of the area. All observations utilized for PEST calibration were located within the focus area. The following observations were employed for PEST calibration:

- Groundwater levels for all layers
- Groundwater level differences between UFA and SA and between LFA and UFA
- Spring flows
- Baseflows within Wekiva River Basin

The model was recalibrated using a four-step approach as follows:

1. PEST optimization was first conducted on a steady-state model representing the average 2003-2014 condition.
2. Once a steady-state calibration was satisfactory, a transient model was run with the updated parameters.
3. Storage coefficients were adjusted as needed.
4. Steps 1 through 3 were repeated until a satisfactory transient calibration was achieved.

The calibration criteria set for ECFTX v1.0 were used to evaluate model performance. The recalibration was performed to ensure that the modeled groundwater levels and spring flows matched observed ones closely within the focus area and the modeled baseflows were within the range of estimated baseflows at critical gages in Wekiva River basin. The remaining simulated baseflows within the focus area were reviewed qualitatively to ensure that the ECFTX v2.0 performed in a similar manner as ECFTX v1.0. Simulated groundwater level contours were compared with potentiometric surface maps to further assess the model's ability to adequately match the configuration of the UFA flow field and groundwater flow direction. Aquifer performance test (APT) and literature data were utilized qualitatively to evaluate the reasonableness of the aquifer parameters.

In addition to PEST calibration, the GHB conductances were manually adjusted along the eastern boundary to ensure the fluxes across that boundary were similar to the ECFTX v1.0 fluxes. No recharge adjustment was made. However, a recharge sensitivity analysis, described in detail later in this report, was performed to better understand the effect of recharge on model parameterization. Upon review and testing, storage coefficients were left unchanged from the original ECFTX v1.0 values. After the recalibration was finalized, model-wide calibration statistics were also reviewed to ensure there was no degradation in model performance outside the focus area.

3.2 Transient Calibration Model Results

Monthly average aquifer water levels, springflow and baseflow estimates, developed for the calibration of ECFTX V1.0, were utilized in this recalibration effort as calibration targets to assess model calibration metrics. These included average monthly water levels from observation wells from the SA (layer 1), UFA (layers 3–5), and the LFA (layers 9–11). Additional information regarding the observation data utilized to calibrate the model can be found in Chapter 5 of the ECFTX V1.0 documentation (CFWI HAT, 2020). In addition, vertical head differences (VHDs) between the SA and the UFA and between the UFA and the LFA were introduced as new quantitative targets.

The ECFTX v1.0 calibration criteria were also used in this recalibration effort and included: 1) a mean error for SA, UFA, and LFA aquifer heads from all wells of less than one foot, 2) a root mean squared error of less than 5 feet from all wells within each aquifer, and a mean absolute error within 5% of the total head elevation range for each aquifer. Total modeled spring flows had to be within 10% of the estimated/measured flows. Mean simulated discharge at each magnitude 1 and 2 spring with observed records also individually had to be within 10% of the observed flows. Specific to the CFWI area, 50% of the mean absolute simulated head residuals for all wells in the SA, UFA, and LFA had to be within 2.5 feet of observed and 80% of the mean absolute simulated head residuals for all wells in the SA, UFA, and LFA were required to be within 5 feet of observed values (CFWI HAT, 2020).

Model statistics for observation wells are presented in this section for three geographic areas: 1) ECFTX model domain, 2) CFWI area and 3) focus area, shown in Figures 1.1 and 1.4. For assessing improvement in model prediction performance, model statistics for all calibration target groups were compared to ECFTX v1.0.

3.2.1 Groundwater levels

Transient model calibration statistics were computed for the target wells in the SA, UFA and LFA within the focus area (Table 3.1), CFWI area (Table 3.2) and ECFTX model domain (Table 3.3). The spatial distributions of mean error, expressed as the simulated minus observed water level, for the target wells for the SA, UFA, and LFA in the focus area are shown in Figures 3.1 through

3.3. The calibration period mean simulated versus observed water levels for the SA, UFA, and LFA targets in the focus area are compared between version 1.0 and 2.0 of the models in Figures 3.4 through 3.6. Figures 3.8 through 3.13 show individual simulated versus observed water level hydrographs at selected wells within the focus area (Figure 3.7). Figure 3.14 shows the location of 50 vertical head difference targets located in the focus area that were used to calibrate the model. The calibration period mean simulated versus observed vertical head differences in the recalibration focus area are compared between version 1.0 and 2.0 of the models in Figure 3.15. The 2003 to 2014 average flooded depth in layer 1 is compared in Figure 3.16. Appendix B includes graphs of simulated versus observed water levels for the calibration period at each target well grouped by major aquifer within the focus area.

Table 3.1. Transient model calibration period statistics of the target monitoring wells in the focus area.

	Focus Area – V1.0			**Focus Area – V2.0**		
	SA	**UFA**	**LFA**	**SA**	**UFA**	**LFA**
Residual Mean	-0.72	0.42	1.96	-0.10	-0.25	-0.02
Error Standard Dev	5.04	4.44	1.51	2.19	1.85	0.42
5% Observation Range	6.86	5.73	2.5	6.86	5.73	2.50
Absolute Residual Mean	3.68	3.39	2.11	1.90	1.60	0.82
Error sum of squares	1789	1670	65	331	293	2
RMS Error	5.05	4.43	2.43	2.17	1.86	0.4
Minimum Residual	-13.12	-9.63	-0.12	-7.71	-8.00	-1.1
Maximum Residual	18.47	22.07	4.54	9.37	5.11	0.47
# Observations	70	85	11	70	85	11
% MAE < 2.5 ft	57%	48%	64%	87%	89%	100%
% MAE < 5.0 ft	74%	82%	100%	94%	96%	100%
$R^2 > 0.4$	81%	94%	100%	84%	94%	100%

All values in feet except as noted. Calibration period is 2004 to 2012. Mean error is expressed as simulated minus observed.

Table 3.2. Transient model calibration period statistics of the target monitoring wells in the CFWI area.

	CFWI Area – V1.0			CFWI Area – V2.0		
	SA	UFA	LFA	SA	UFA	LFA
Residual Mean	-0.64	0.34	1.23	-0.42	-0.06	-0.16
Error Standard Dev	3.47	3.75	2.68	2.86	3.18	2.46
5% Observation Range	8.6	6.2	2.62	8.60	6.20	2.62
Absolute Residual Mean	2.61	3.24	2.48	2.23	2.64	1.80
Error sum of squares	3442	2729	202	2299	1956	140
RMS Error	3.53	3.75	2.9	2.88	3.18	2.42
Minimum Residual	-16.51	-11.93	-5.46	-16.52	-11.98	-7.16
Maximum Residual	13.29	10.11	5.73	13.28	10.03	4.82
# Observations	277	194	24	277	194	24
% MAE < 2.5 ft	71%	52%	58%	77%	67%	83%
% MAE < 5.0 ft	87%	85%	88%	92%	89%	92%
R^2 > 0.4	78%	96%	92%	79%	96%	92%

All values in feet except as noted. Calibration period is 2004 to 2012. Mean error is expressed as simulated minus observed.

Table 3.3. Transient model calibration period statistics of the target monitoring wells in the ECFTX model domain.

	ECFTX Model Domain – V1.0			ECFTX Model Domain – V2.0		
	SA	UFA	LFA	SA	UFA	LFA
Residual Mean	-0.46	0.46	0.46	-0.43	0.39	-0.65
Error Standard Dev	4.24	4.7	3.33	4.09	4.58	2.96
5% Observation Range	8.97	7.59	2.79	8.97	7.59	2.79
Absolute Residual Mean	2.83	3.78	2.65	2.72	3.62	2.11
Error sum of squares	18156	20666	329	16878	19599	266
RMS Error	4.27	4.72	3.31	4.11	4.60	2.98
Minimum Residual	-31.65	-22.1	-10.19	-31.69	-22.10	-10.15
Maximum Residual	21.15	19.14	5.73	21.15	19.14	4.82
# Observations	997	928	30	997	928	30
% MAE < 2.5 ft	68%	48%	60%	70%	53%	80%
% MAE < 5.0 ft	88%	76%	87%	89%	77%	90%
R^2 > 0.4	78%	93%	93%	78%	93%	93%

All values in feet except as noted. Calibration period is 2004 to 2012. Mean error is expressed as simulated minus observed.

3.2.2 Spring flow

Simulation period model statistics for 17 magnitude 1 and 2 springs are included in Table 3.4. The observed and simulated flux in Table 3.4 is computed as the average for the 2003 to 2014 simulation period. The spatial distribution of the mean error for the 17 simulated springs is shown in Figure 3.17 and a regression plot of simulated versus observed mean spring flow is shown in Figure 3.18. Simulated versus observed monthly flow hydrographs for Wekiwa and Rock springs are shown in Figure 3.19. For the calibration period from 2004 to 2012, mean simulated springflow in the model from all 158 springs was 2,104 cfs, while observed (estimated and measured) was 2,159 cfs, resulting in a mean error of 2.5%. Appendix C contains graphs of simulated versus observed springflow where it was continuously measured.

Table 3.4. Model simulation period statistics of the magnitude 1 and 2 target springs simulated in the ECFTX model.

Spring Name	**Observed Flux (cfs)**	**ECFTX V1.0**		**ECFTX V2.0**	
		Simulated flux (cfs)	% error	Simulated flux (cfs)	% error
Lithia Spring Major	34.7	33.2	-4.4%	33.1	-4.5%
Buckhorn Main Spring	12.2	12.1	-0.9%	12.1	-1.0%
Sulphur Spring	34.7	35.4	2.0%	35.4	2.0%
Crystal Main Spring	45.5	46.4	2.0%	46.3	1.9%
Weeki Wachee Spring	160.4	167.3	4.4%	167.3	4.4%
Chassahowitzka Spring	59.6	59.3	-0.6%	59.3	-0.6%
Homosassa Spring	83.5	84.5	1.1%	84.5	1.2%
Gum Spring	63.8	64.8	1.5%	64.8	1.5%
Rainbow Spring*	71.3*	73.3	2.0%	73.3	2.0%
Apopka Spring	24.9	24.8	-0.1%	24.9	0.0%
Sanlando Springs	18.8	19.9	5.4%	18.9	0.1%
Starbuck Spring	12.1	12.6	3.9%	12.0	-0.5%
Wekiwa Spring	61.0	64.6	5.8%	61.3	0.4%
Bugg Spring	10.6	9.7	-8.2%	10.0	-5.2%
Rock Springs	54.9	51.6	-6.1%	54.7	-0.5%
Volusia Blue Spring	143.6	132.4	-7.9%	144.3	0.5%
Alexander Spring	100.1	98.9	-1.2%	99.8	-0.3%

*Observed flow reduced by 88% since only 12% of rainbow springshed included in active domain.

3.2.3 Baseflow

Calibration criterion for simulated baseflows was within an order of magnitude due to the variability of estimation methods for this more uncertain flow statistic. Information about the baseflow estimation methods used for the ECFTX model can be found in Chapter 4 of the ECFTX V1.0 report (CFWI HAT, 2020). A total of 18 USGS gages where baseflows were estimated are included in Table 3.5, alongside the minimum and maximum estimated baseflows. Gauge 02238000, Haynes Creek at Lisbon, was removed from the list because its flows have been regulated with multiple control structures. Wekiva River at Sanford gauge 02235000 was added to the list because it was one of the gauges used to set minimum flows and levels at Wekiva River. For the calibration period, from 2004 to 2012, mean simulated baseflow in the model from all 18 USGS gauges was 5,557 cfs, while the range of estimated flows varied between 2,391 and

9,998 cfs. A total of 15 out of 18 USGS gauges were within the range of estimated baseflows by baseflow separation methods (Figure 3.20).

Table 3.5. Simulated mean baseflow from 2004 to 2012 compared to estimated ranges using the USF method and USGS Groundwater Toolbox methods at 18 stations.

Gage	Station	Min (cfs)	Max (cfs)	Simulated (cfs)	
				V1.0	V2.0
02232400	St. Johns River nr Cocoa FL	221	928	293	293
02232500	St. Johns River nr Christmas FL	282	1085	384	383
02234000	St. Johns River above Lake Harney nr Geneva FL	441	1473	856	860
02236000	St. Johns River Near DeLand FL	389	3186	1768	1946
02235000	Wekiva River nr Sanford	184	254	278	247
02294650	Peace River at Bartow	21	125	77	78
02294898	Peace River at Fort Meade	19	144	129	129
02295637	Peace River at Zolfo Springs	80	350	331	334
02296750	Peace River at Arcadia	118	596	533	537
02298830	Myakka River nr Sarasota	14	150	50	50
02300500	Little Manatee River nr Wimauma	23	88	70	70
02301500	Alafia River at Lithia	53	189	110	111
02303000	Hillsborough River nr Zephyrhills	65	145	102	102
02310000	Anclote River nr Elfers	4	38	11	11
02312000	Withlacoochee River at Trilby	28	153	165	164
02312500	Withlacoochee River at Croom	56	211	190	195
02312762	Withlacoochee River nr Inverness	156	378	36	46
02313000	Withlacoochee River nr Holder	237	505	-8	1

3.2.4 Water budget

The simulated water budget including boundary condition inflows (Table 3.6) and outflows (Table 3.7) from the ECFTX v2.0 model by layer were prepared for the calibration period. The total flux (IN-OUT) balances to within less than 0.05 inches/year. Net fluxes for each major component of the water budget during the calibration period included recharge of 8.7 in/yr, GHB lateral flux of 0.9 in/yr into the model with constant head, well, river, springs, and drains having net outflow components of 2.3, 2.0, 0.8, 1.3, and 3.5 inches per year, respectively. A total net storage change of +0.4 in/yr occurred over the 2004–2012 period based on the model results. Net fluxes for each major component in ECFTX v1.0 included recharge of 8.7 in/yr, GHB lateral flux of 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 inches per year, respectively. A total net storage change of +0.4 in/yr occurred over the 2004–2012 period based on the model results, which is unchanged from v2.0.

Table 3.3.6. Annual average boundary condition influx in the ECFTX transient model during the calibration period (2004-2012). Note units are in inches per year.

Layer	Constant Head in/yr	GHB in/yr	Well in/yr	River in/yr	Recharge in/yr	ET in/yr	Spring in/yr	Drain return in/yr	Drain in/yr	Storage in/yr
1	0.22	0.04	0.08	3.23	21.83	-	-	-	-	0.38

Layer	Constant Head in/yr	GHB in/yr	Well in/yr	River in/yr	Recharge in/yr	ET in/yr	Spring in/yr	Drain return in/yr	Drain in/yr	Storage in/yr
2	-	0.26	-	-	-	-	-	-	-	0.01
3	-	0.48	-	-	-	-	-	0.07	-	-
4	-	0.23	-	-	-	-	-	-	-	-
5	-	0.57	-	-	-	-	-	-	-	-
6	-	0.10	-	-	-	-	-	-	-	-
7	-	0.08	-	-	-	-	-	-	-	-
8	-	0.06	-	-	-	-	-	-	-	-
9	-	0.21	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-
11	-	0.16	-	-	-	-	-	-	-	-
Total	0.22	2.19	0.08	3.23	21.83	0.00	-	0.07	-	0.39

Table 3.3.7. Annual average boundary condition outflux in the ECFTX transient model during the calibration period (2004-2012). Note: units are in inches per year.

Layer	Constant Head in/yr	GHB in/yr	Well in/yr	River in/yr	Recharge in/yr	ET in/yr	Spring in/yr	Drain return in/yr	Drain in/yr	Storage in/yr
1	-2.56	-0.02	-0.17	-4.03	-	-13.13	-	-	-3.61	-
2	-	-0.03	-0.02	-	-	-	-	-	-	-
3	-	-0.45	-0.64	-	-	-	-1.29	-	-	-
4	-	-0.11	-0.30	-	-	-	-	-	-	-
5	-	-0.06	-0.59	-	-	-	-0.01	-	-	-
6	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-
9	-	-0.12	-0.31	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-
11	-	-0.51	-	-	-	-	-	-	-	-
Total	-2.56	-1.30	-2.03	-4.03	-	-13.13	-1.30	-	-3.61	-

3.2.5 Aquifer and Confining Unit Properties

Hydraulic properties within the ECFTX model include hydraulic conductivity (both vertical and horizontal) and specific storage properties. During the calibration process, the initial estimates of hydraulic conductivity were adjusted within reasonable limits to improve the agreement between simulated and observed conditions while maintaining parameterization consistent with the conceptual model of the system. After testing different values of storage properties, the V1.0 model assigned values were left unchanged. The horizontal hydraulic conductivity distribution in model layer 1 is shown in Figure 3.21 and hydraulic conductivity maps for all model layers are included in Appendix D. Transmissivity, the product of the aquifer K and the saturated thickness expressed in feet squared per day (ft^2/d), was computed for the UFA (layer 3 through 5) and the LFA (layer 9 through 11). UFA transmissivity is compared with APT results (Figure 3.22) and the September 2010 UFA potentiometric surface map (Figure 3.23). The potentiometric surface maps provide evidence of higher or lower transmissivity based on whether the gradient is flat or steep and was used as a qualitative guide to calibration. LFA transmissivity is compared with APT results in Figure 3.24. The leakance coefficient, computed as the vertical hydraulic conductivity divided by the confining unit thickness and expressed in units of ft/d/ft (d^{-1}) was computed for layers 2, 6, 8 and layer 10 (Appendix D).

3.3 Recharge Sensitivity Analysis

Recharge was not adjusted during the recalibration of the model because it was originally estimated using a water-balance model and generally seemed to work well for ECFTX v1.0. The results presented above show that the model was able to be successfully recalibrated by adjusting aquifer parameters without modifying the recharge in the model. However, recharge, being a large water budget component, is one of the largest sources of uncertainty in the model due to lack of measured data. Therefore, a full PEST recalibration was also performed with a recharge rate reduction of 20% within the focus area to test the sensitivity of the model performance to recharge.

3.3.2 Methods

As described in Chapter 3.1 Calibration Approach, an initial steady-state model was developed for automated calibration representing the average (2003 to 2014) ECFTX V1.0 model. Within the initial model, recharge rates were not adjusted from ECFTX v1.0, apart from not assigning a value (0 feet per day) to grid cells representing the Wekiva River (Figure 2.4). As a sensitivity test, another model was developed in which the initial model recharge rates were reduced by 20% within the focus area. Except for recharge rates, both models were identical and were assigned the same initial parameter values and bounds in PEST. For each model, PEST was independently run. The same calibration approach described in section 3.1 was implemented.

3.3.3 Groundwater levels

Transient model calibration statistics were computed for the target monitoring wells in the SA, UFA, and LFA within the focus area (Table 3.8). The spatial distribution of mean error, expressed as the simulated minus observed water level, and observed versus simulated water levels for the target wells in the SA, UFA, and LFA in the recalibration focus area are compared in Appendix E.

Table 3.8. Transient model calibration period statistics of the target monitoring wells in the recalibration focus area with and without the recharge rate adjustment.

	Focus Area No recharge adjustment			Focus Area Recharge reduced by 20%		
	SA	**UFA**	**LFA**	**SA**	**UFA**	**LFA**
Residual Mean	-0.10	-0.25	-0.02	-0.41	-0.3	-0.18
Error Standard Dev	2.19	1.85	0.42	2.36	1.82	1.01
5% Observation Range	6.86	5.73	2.50	6.86	5.73	2.5
Absolute Residual Mean	1.90	1.60	0.82	1.93	1.52	0.91
Error sum of squares	331	293	2	398	287	11
RMS Error	2.17	1.86	0.4	2.38	1.84	0.98
Minimum Residual	-7.71	-8.00	-1.1	-9.7	-7.37	-2.92
Maximum Residual	9.37	5.11	0.47	8.21	4.67	1.03
# Observations	70	85	11	70	85	11
% MAE < 2.5 ft	87%	89%	100%	83%	88%	91%
% MAE < 5.0 ft	94%	96%	100%	94%	98%	100%
$R^2 > 0.4$	84%	94%	100%	87%	96%	100%

All values in feet except as noted. Calibration period is 2004 to 2012. Mean error is expressed as simulated minus observed.

3.3.4 Spring flow

Simulation period model statistics for 17 magnitude 1 and 2 springs are included in Table 3.9. The observed and simulated flux in Table 3.9 is computed as the average for the 2003 to 2014 simulation period. A regression plot of simulated versus observed mean spring flow for the magnitude 1 and 2 springs is included in Appendix E.

Table 3.9. Transient model calibration statistics of the magnitude 1 and 2 target springs simulated in the ECFTX model.

Spring Name	**Observed Flux (cfs)**	**Focus Area No recharge adjustment**		**Focus Area Recharge reduced by 20%**	
		Simulated flux (cfs)	% error	Simulated flux (cfs)	% error
Lithia Spring Major	34.7	33.1	-4.5%	33.2	-4.4%
Buckhorn Main Spring	12.2	12.1	-1.0%	12.1	-1.0%
Sulphur Spring	33.7	35.4	2.0%	35.4	2.0%
Crystal Main Spring	45.5	46.3	1.9%	46.3	1.9%
Weeki Wachee Spring	160.4	167.3	4.4%	167.3	4.4%
Chassahowitzka Main Spring	59.6	59.3	-0.6%	59.3	-0.6%
Homosassa No. 1 Spring	83.5	84.5	1.2%	84.5	1.2%
Gum Spring Group	63.8	64.8	1.5%	64.8	1.5%
Rainbow Spring*	71.3*	73.3	2.0%	73.3	2.0%

Spring Name	Observed Flux (cfs)	Focus Area No recharge adjustment		Focus Area Recharge reduced by 20%	
		Simulated flux (cfs)	% error	Simulated flux (cfs)	% error
Apopka Spring	24.9	24.9	0.0%	24.7	-0.8%
Sanlando Springs	18.8	18.9	0.1%	18.5	-1.7%
Starbuck Spring	12.1	12.0	-0.5%	11.9	-1.9%
Wekiwa Spring	61.0	61.3	0.4%	61.1	0.1%
Bugg Spring	10.6	10.0	-5.2%	9.9	-7.0%
Rock Springs	54.9	54.7	-0.5%	53.1	-3.4%
Volusia Blue Spring	143.6	144.3	0.5%	144.4	0.6%
Alexander Spring	100.1	99.8	-0.3%	99.8	-0.3%

*Observed flow reduced by 88% since only 12% of springshed area represented in active domain

3.3.5 Baseflow

A total of 18 USGS gauges where baseflow was estimated are included in Table 3.10, alongside the minimum and maximum estimated baseflow. For both runs, with and without the recharge adjustment, a total of 15 out of 18 USGS gauges where baseflow was estimated were within the range of flows estimated baseflow.

Table 3.10. Simulated mean baseflow from 2004 to 2012 compared to estimated ranges using the USF method and USGS Groundwater Toolbox methods at 18 stations.

Gage	Station	Min (cfs)	Max (cfs)	Simulated (cfs)	
				No recharge adjustment	Recharge reduced by 20%
02232400	St. Johns River nr Cocoa FL	221	928	293	293
02232500	St. Johns River nr Christmas FL	282	1085	383	383
02234000	St. Johns River above Lake Harney nr Geneva FL	441	1473	860	784
02236000	St. Johns River Near DeLand FL	389	3186	1946	1730
02235000	Wekiva River nr Sanford	184	254	247	223
02294650	Peace River at Bartow	21	125	78	77
02294898	Peace River at Fort Meade	19	144	129	129
02295637	Peace River at Zolfo Springs	80	350	334	331
02296750	Peace River at Arcadia	118	596	537	532
02298830	Myakka River nr Sarasota	14	150	50	50
02300500	Little Manatee River nr Wimauma	23	88	70	70
02301500	Alafia River at Lithia	53	189	111	110
02303000	Hillsborough River nr Zephyrhills	65	145	102	102
02310000	Anclote River nr Elfers	4	38	11	11
02312000	Withlacoochee River at Trilby	28	153	164	164
02312500	Withlacoochee River at Croom	56	211	195	194

Gage	Station	Min (cfs)	Max (cfs)	Simulated (cfs)	
				No recharge adjustment	Recharge reduced by 20%
02312762	Withlacoochee River nr Inverness	156	378	46	42
02313000	Withlacoochee River nr Holder	237	505	1	-2

3.3.6 Aquifer and Confining Unit Properties

Horizontal hydraulic conductivity maps for all layers, leakance coefficient maps for layers 2, 6, 8, and 10, and UFA and LFA transmissivity maps for the recharge sensitivity simulations are included in Appendix E.

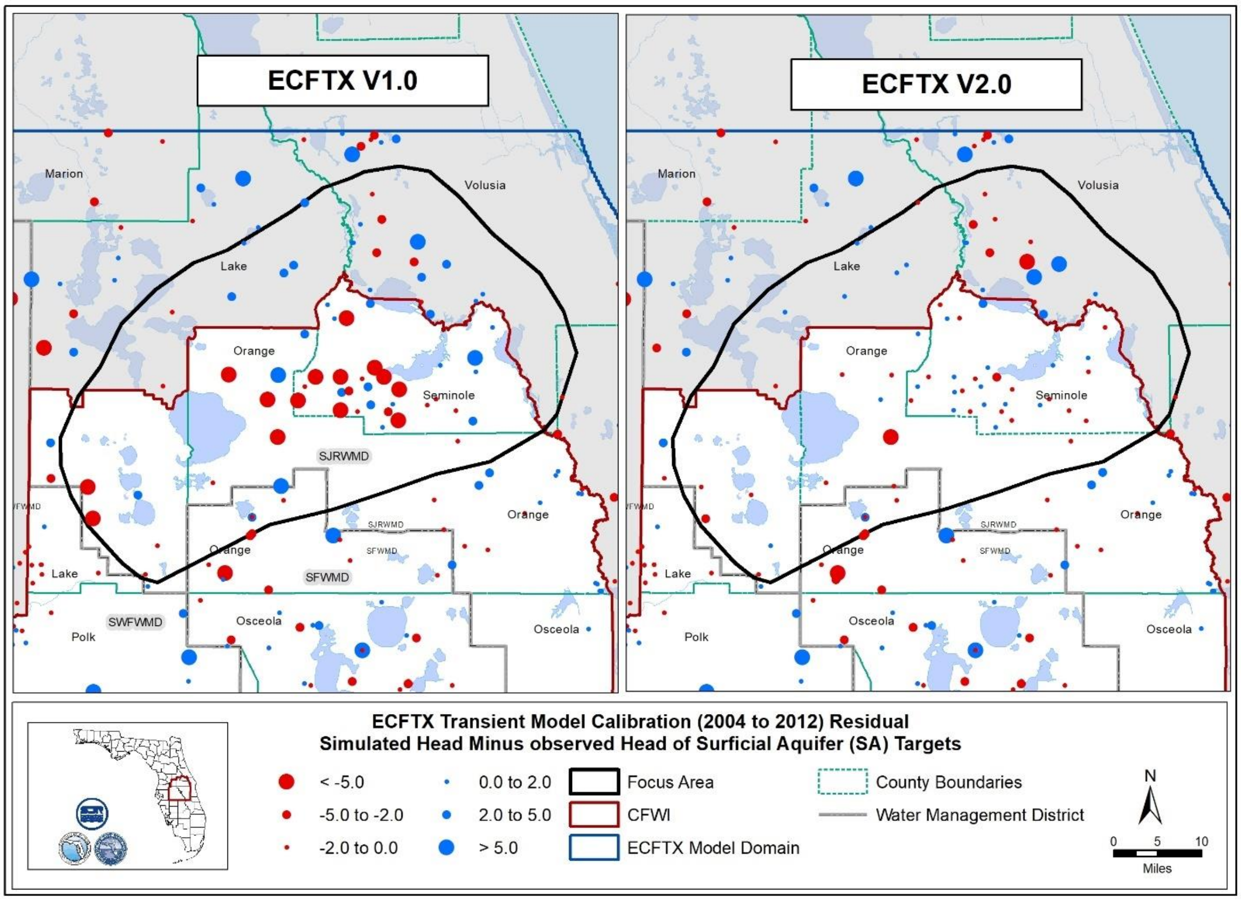


Figure 3.1. Spatial distribution of mean error for the SA targets within the focus area in the ECFTX transient model calibration.

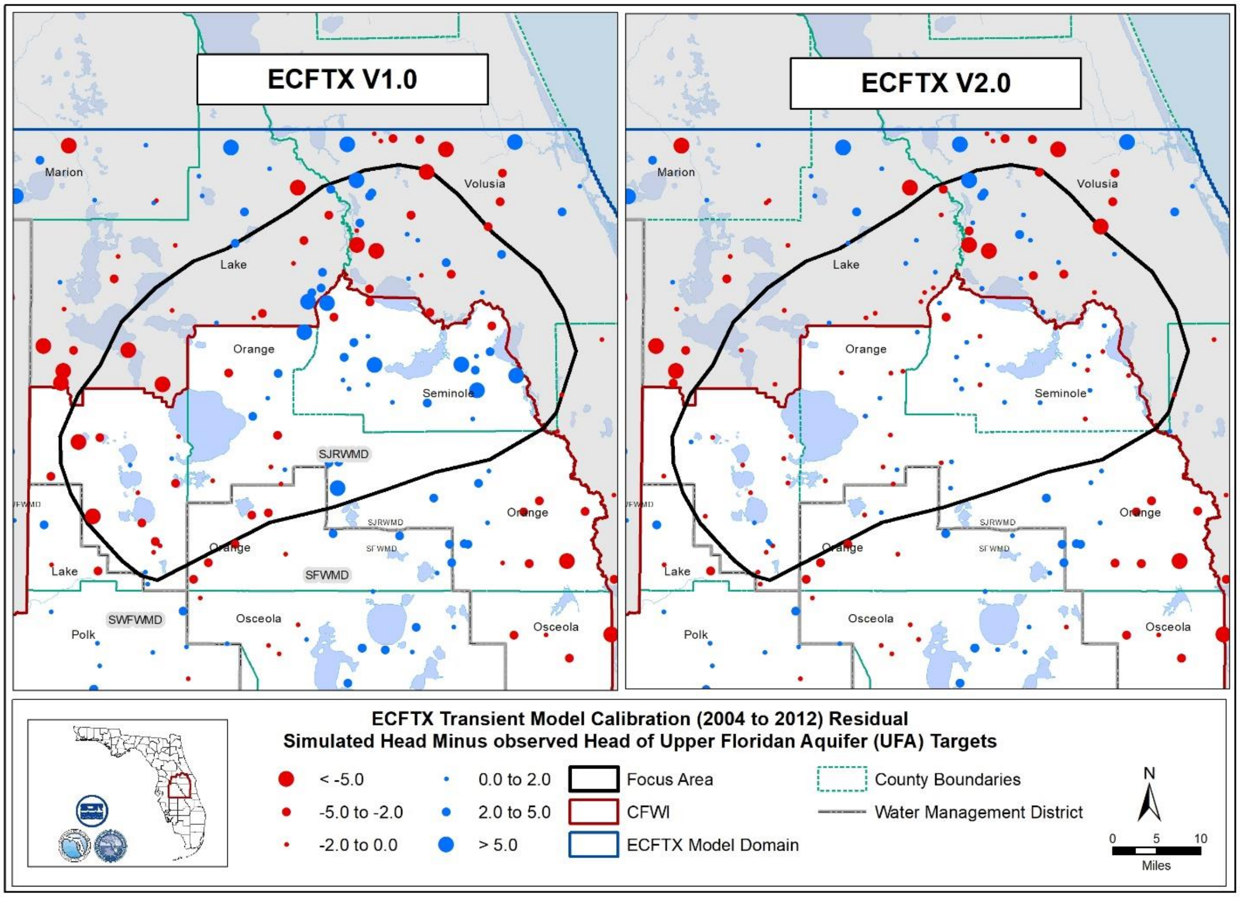


Figure 3.2. Spatial distribution of mean error for the UFA targets within the focus area in the ECFTX transient model calibration.

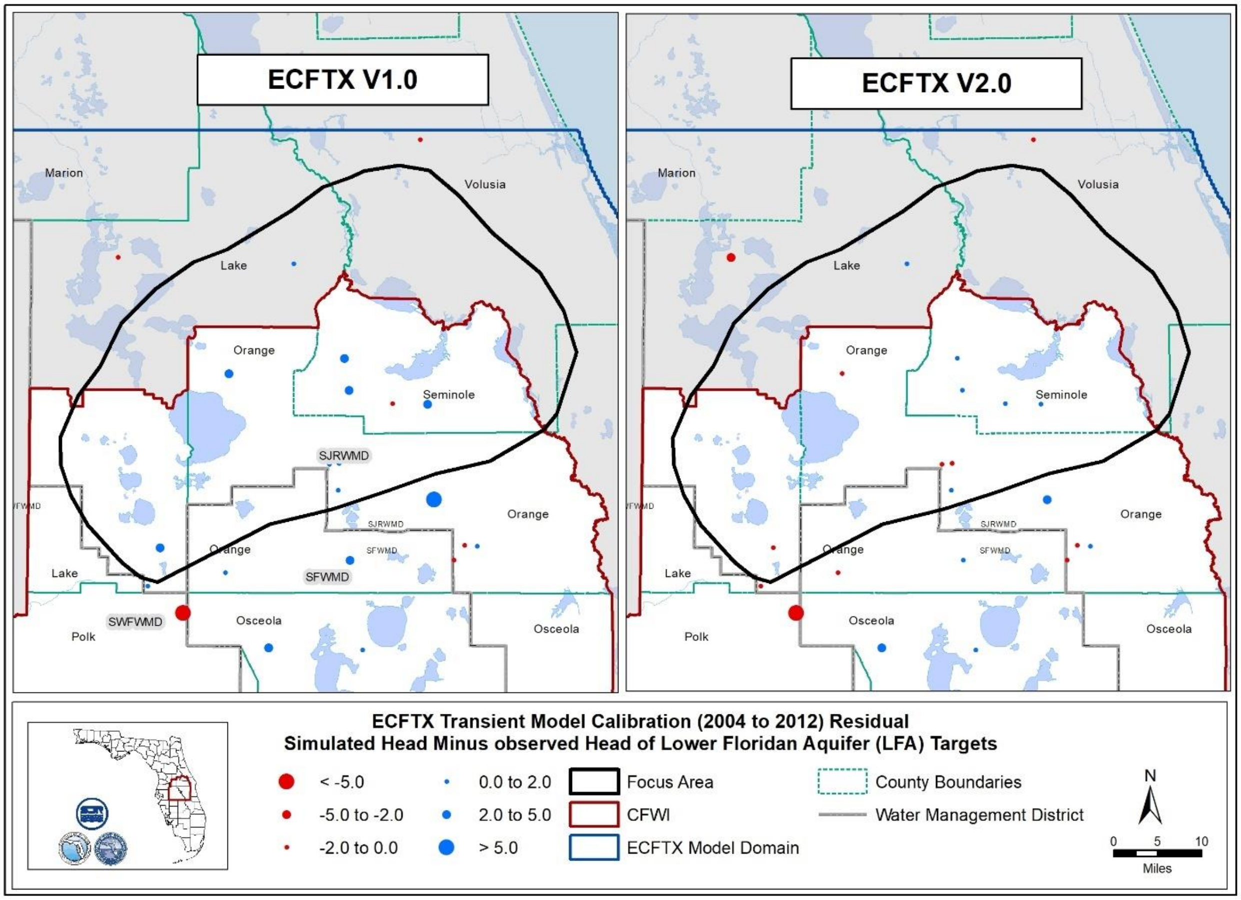


Figure 3.3. Spatial distribution of mean error for the LFA targets within the focus area in the ECFTX transient model calibration.

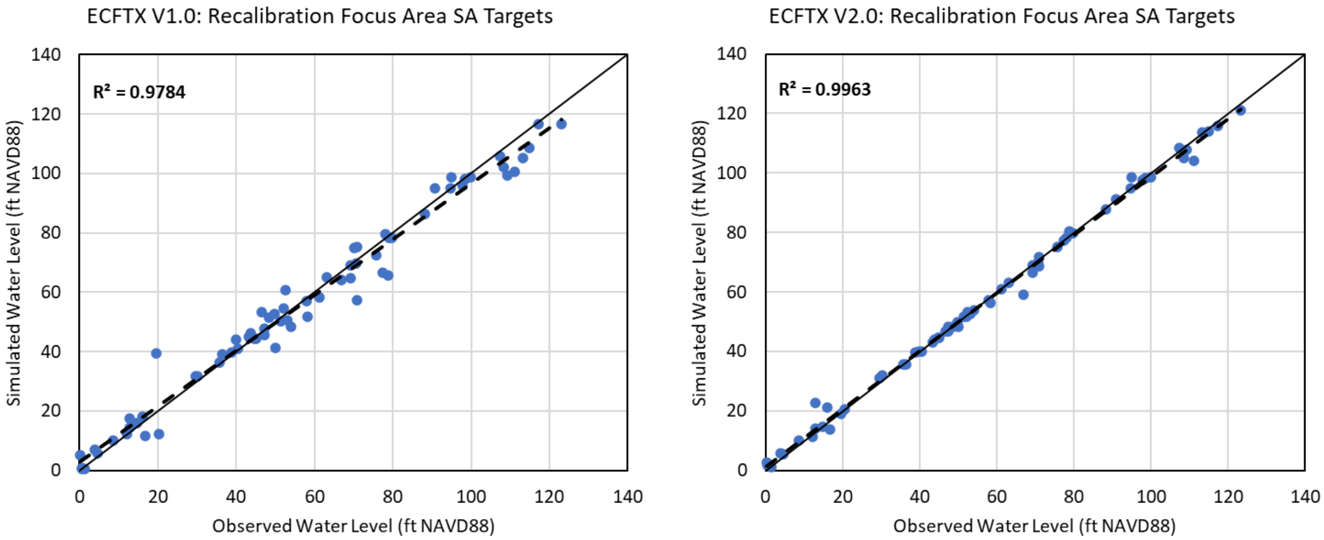


Figure 3.4. Mean simulated versus observed water levels for the SA within the focus area in the ECFTX transient model for V1.0 (left) and V2.0 (right). (Note: Solid line is 1:1 relation between simulated and observed water levels; dashed line is linear regression of simulated versus observed water levels from target wells)

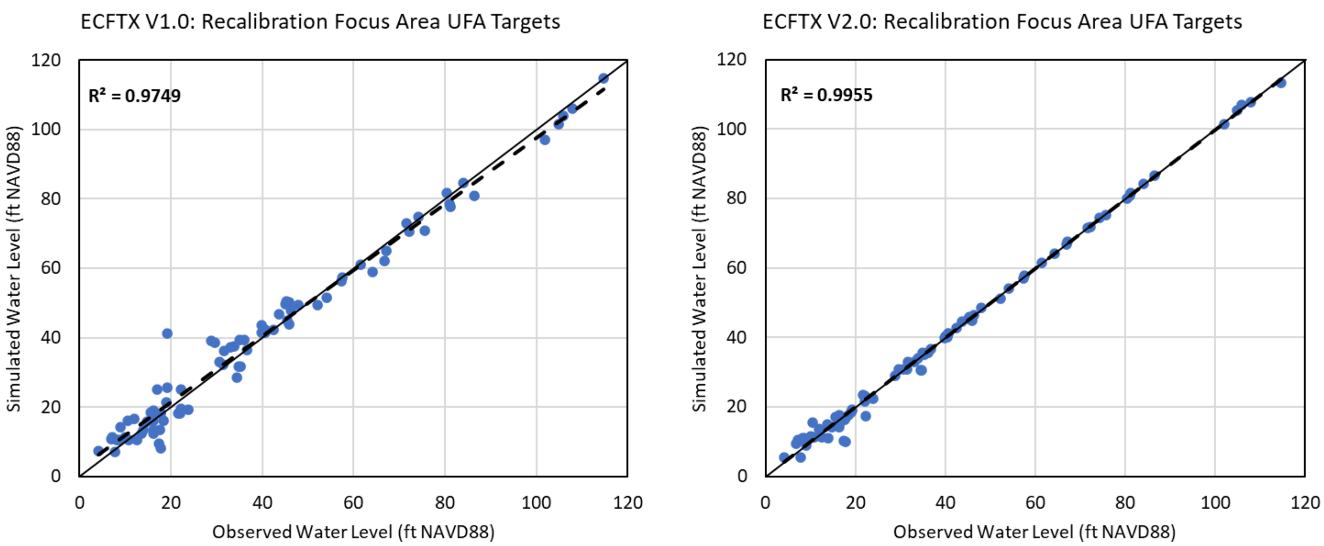


Figure 3.5. Mean simulated versus observed water levels for the UFA within the focus area in the ECFTX transient model for V1.0 (left) and V2.0 (right). (Note: Solid line is 1:1 relation between simulated and observed water levels; dashed line is linear regression of simulated versus observed water levels from target wells)

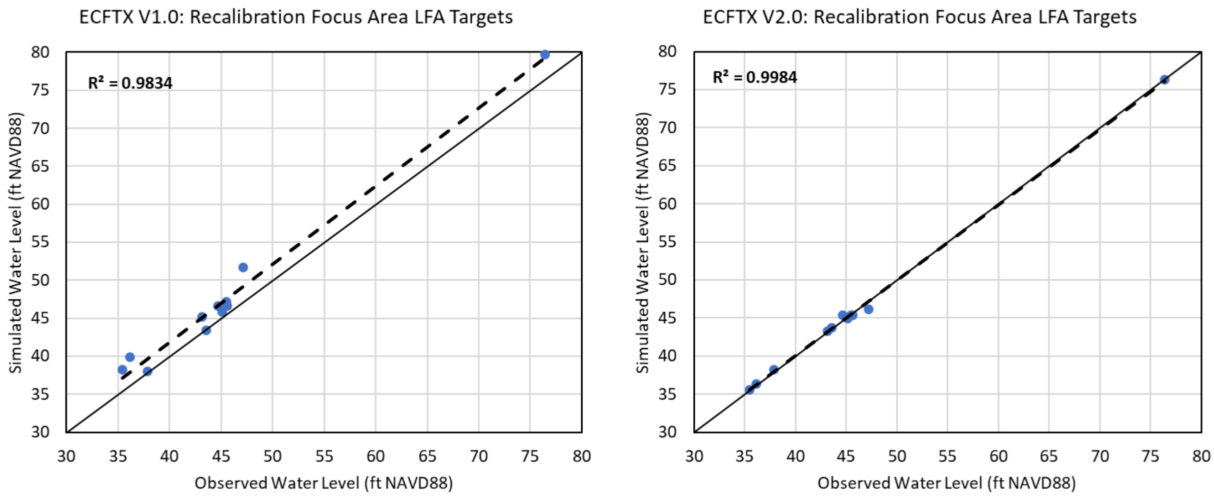


Figure 3.6. Mean simulated versus observed water levels for the LFA within the focus area in the ECFTX transient model for V1.0 (left) and V2.0 (right). (Note: Solid line is 1:1 relation between simulated and observed water levels; dashed line is linear regression of simulated versus observed water levels from target wells)

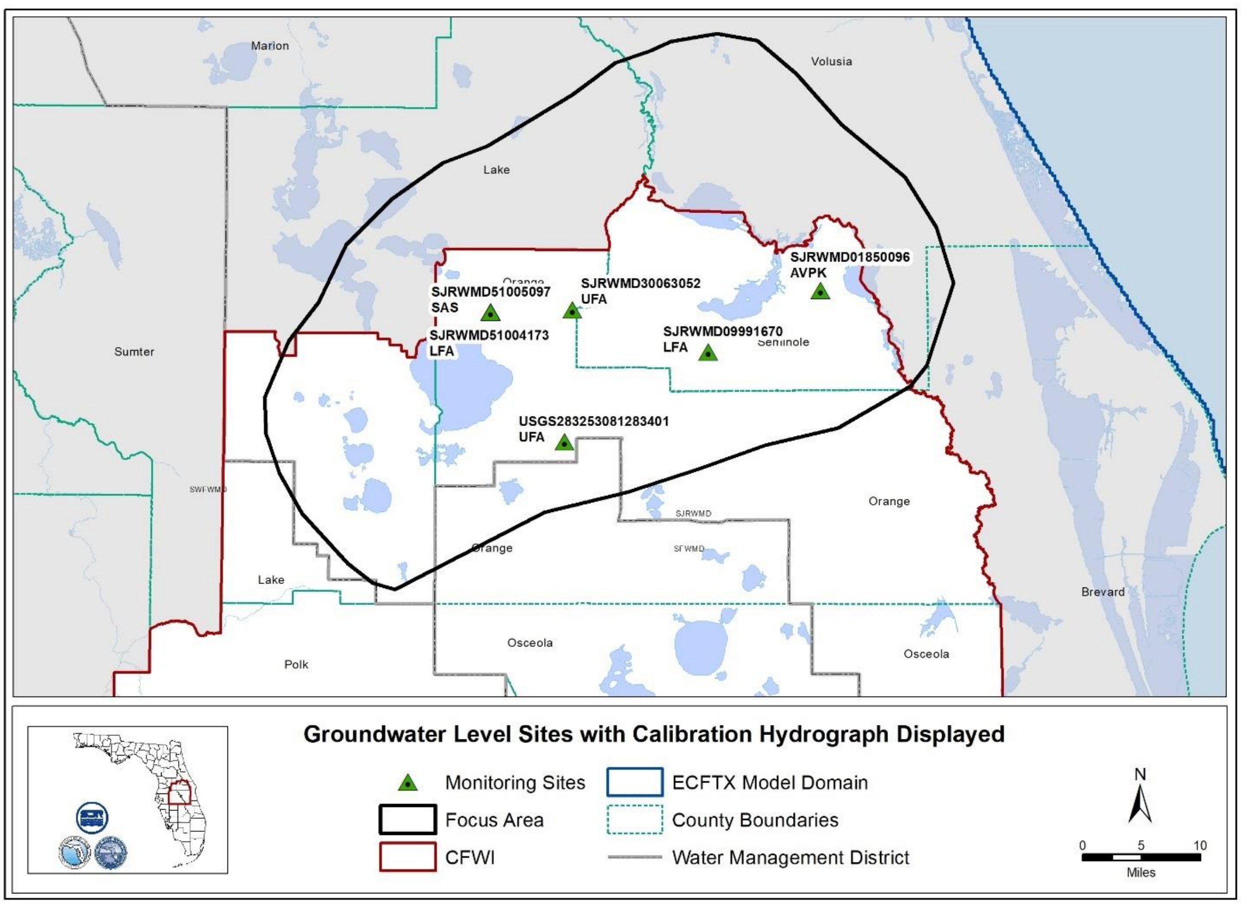


Figure 3.7. Location of hydrographs of selected simulated versus observed water levels for the SA, UFA, and LFA within the focus area.

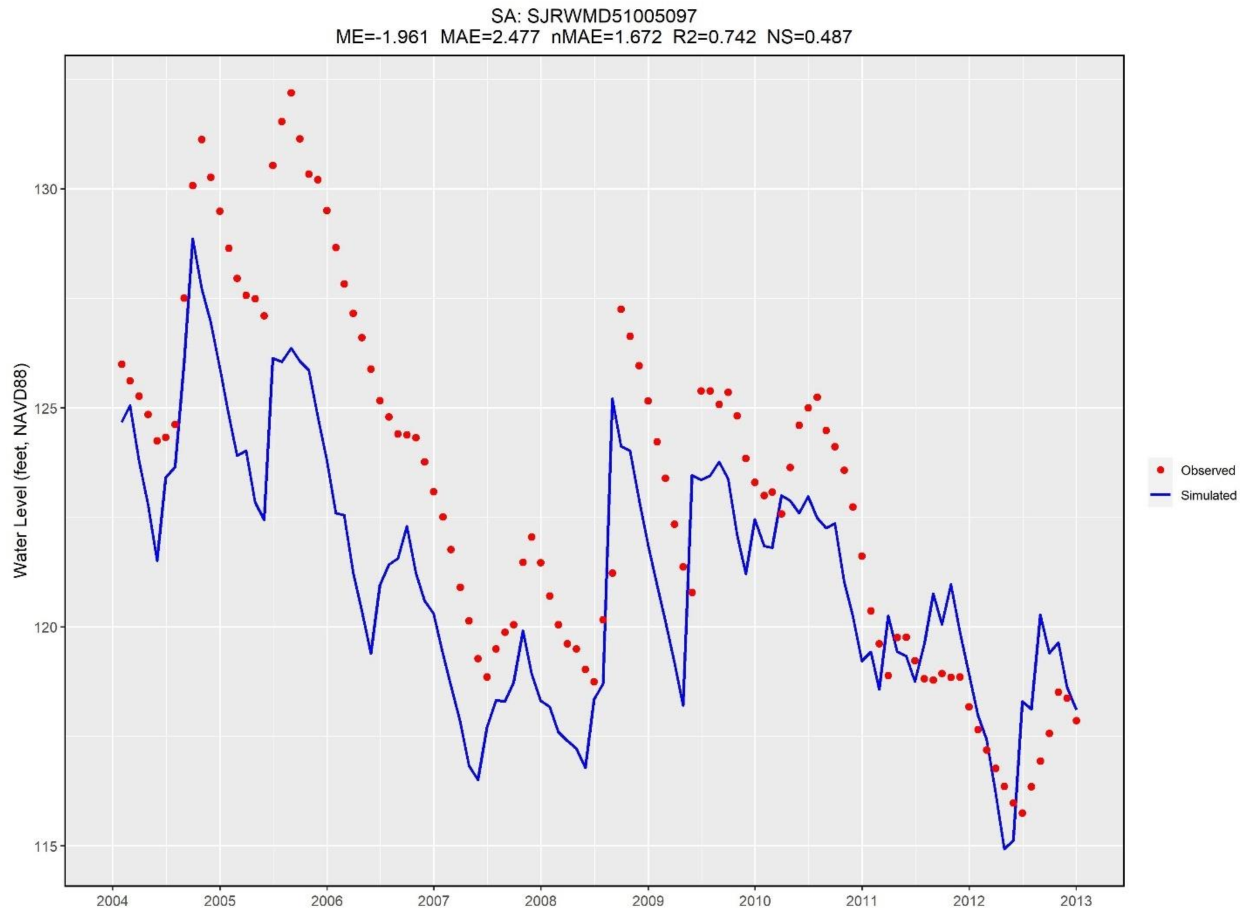


Figure 3.8. Simulated versus observed water levels for the SA monitor well OR0107 at Plymouth Tower.

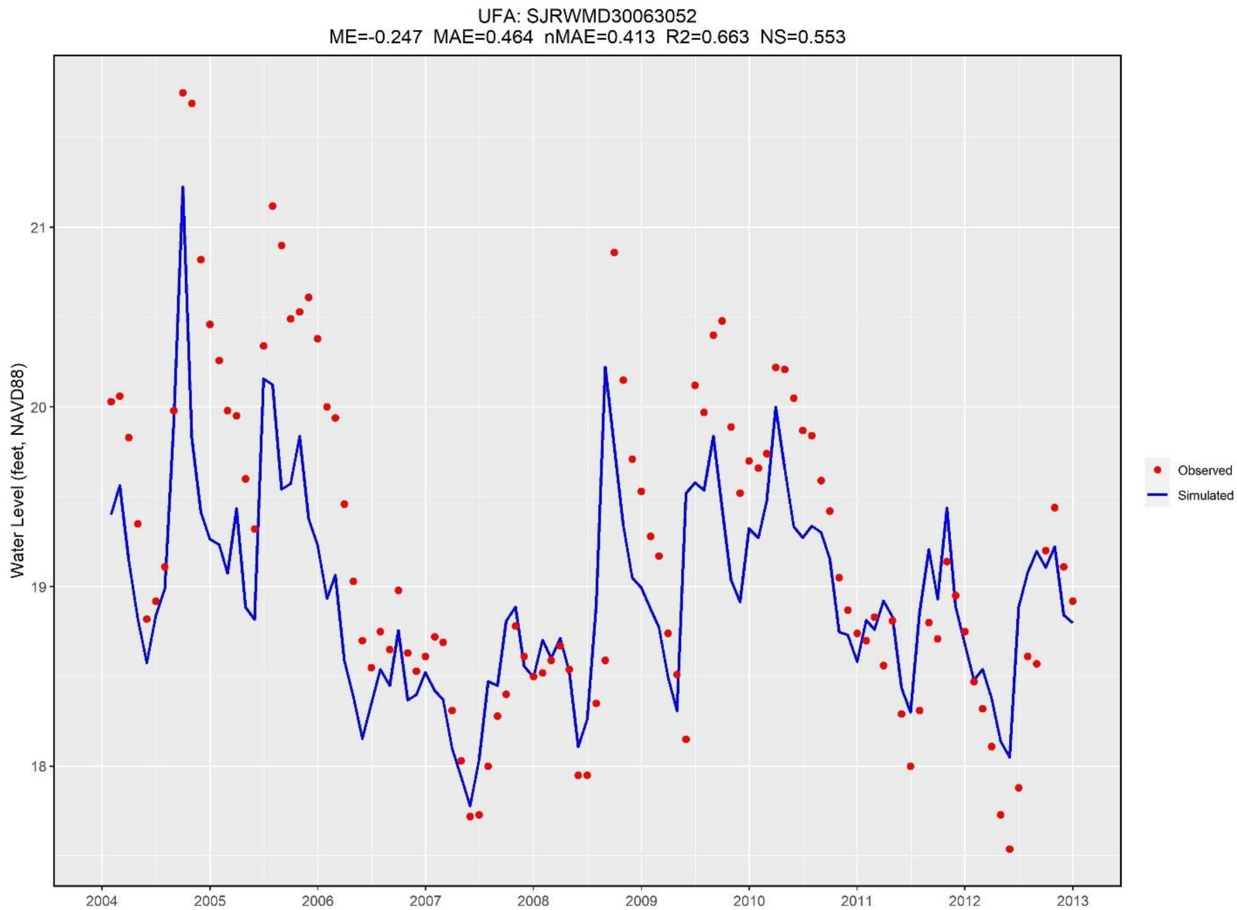


Figure 3.9. Simulated versus observed water levels for the UFA well OR0548 at Wekiwa Springs State Park.

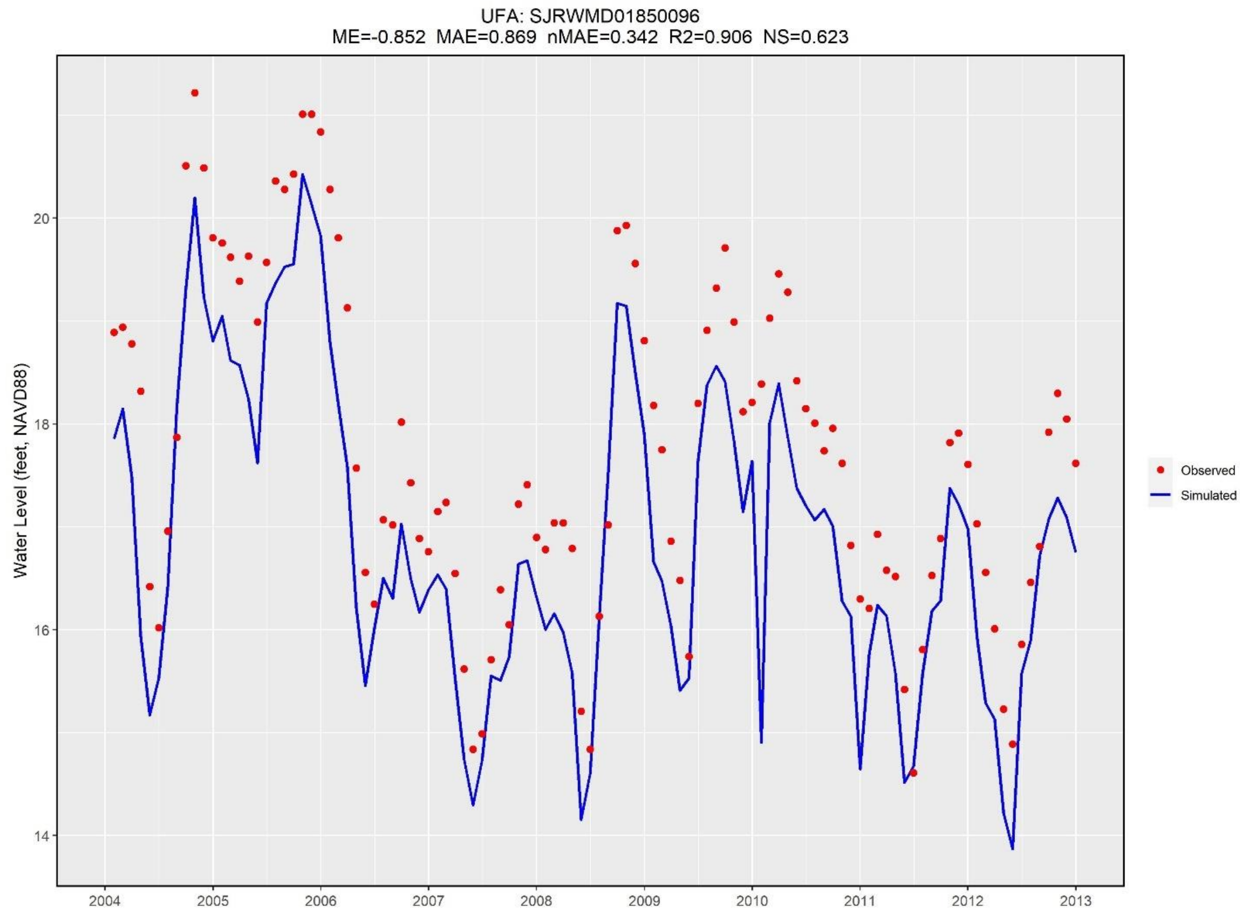


Figure 3.10. Simulated versus observed water levels for the UFA well S-1224 at Geneva Fire Station.

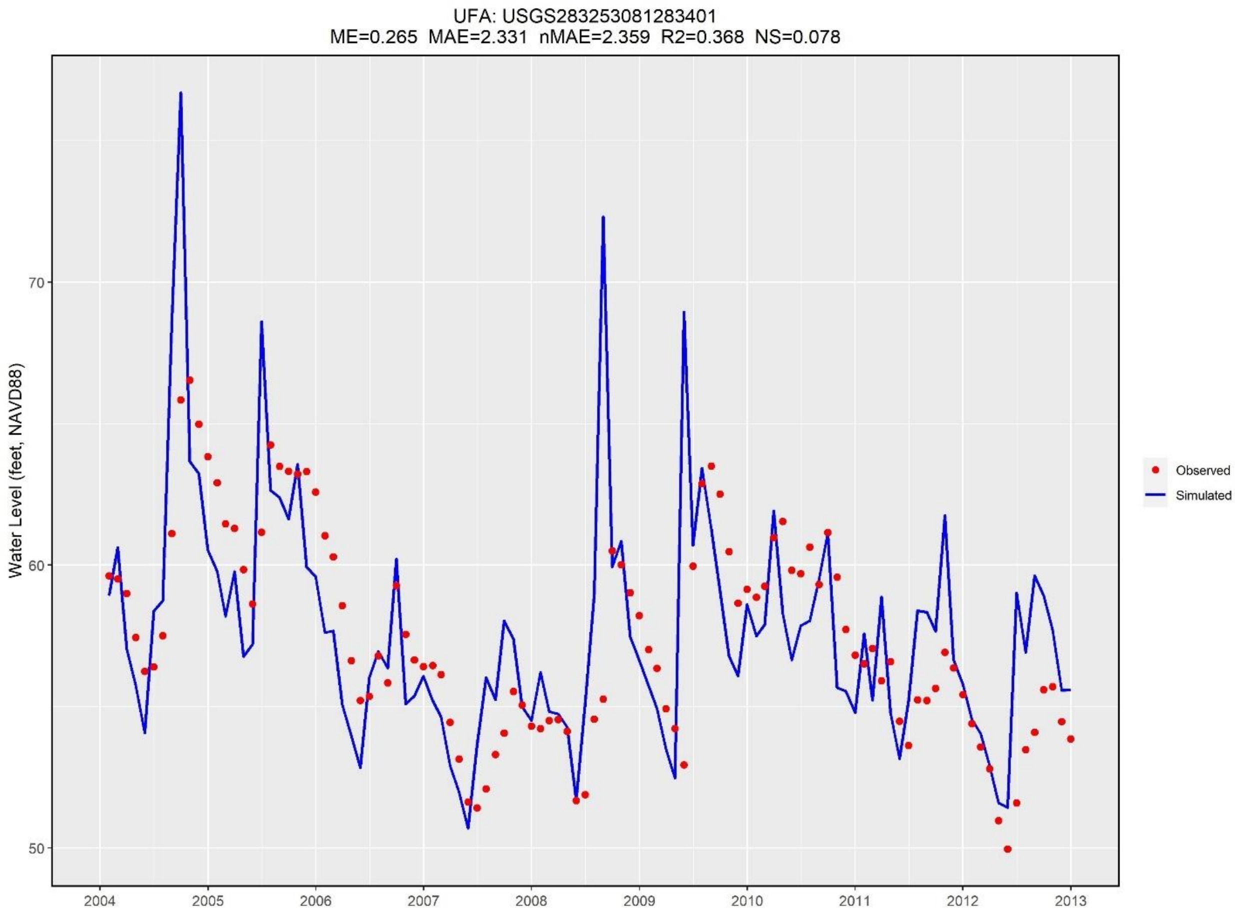


Figure 3.11. Simulated versus observed water levels for the UFA well OR-47 at Orlo Vista, FL.

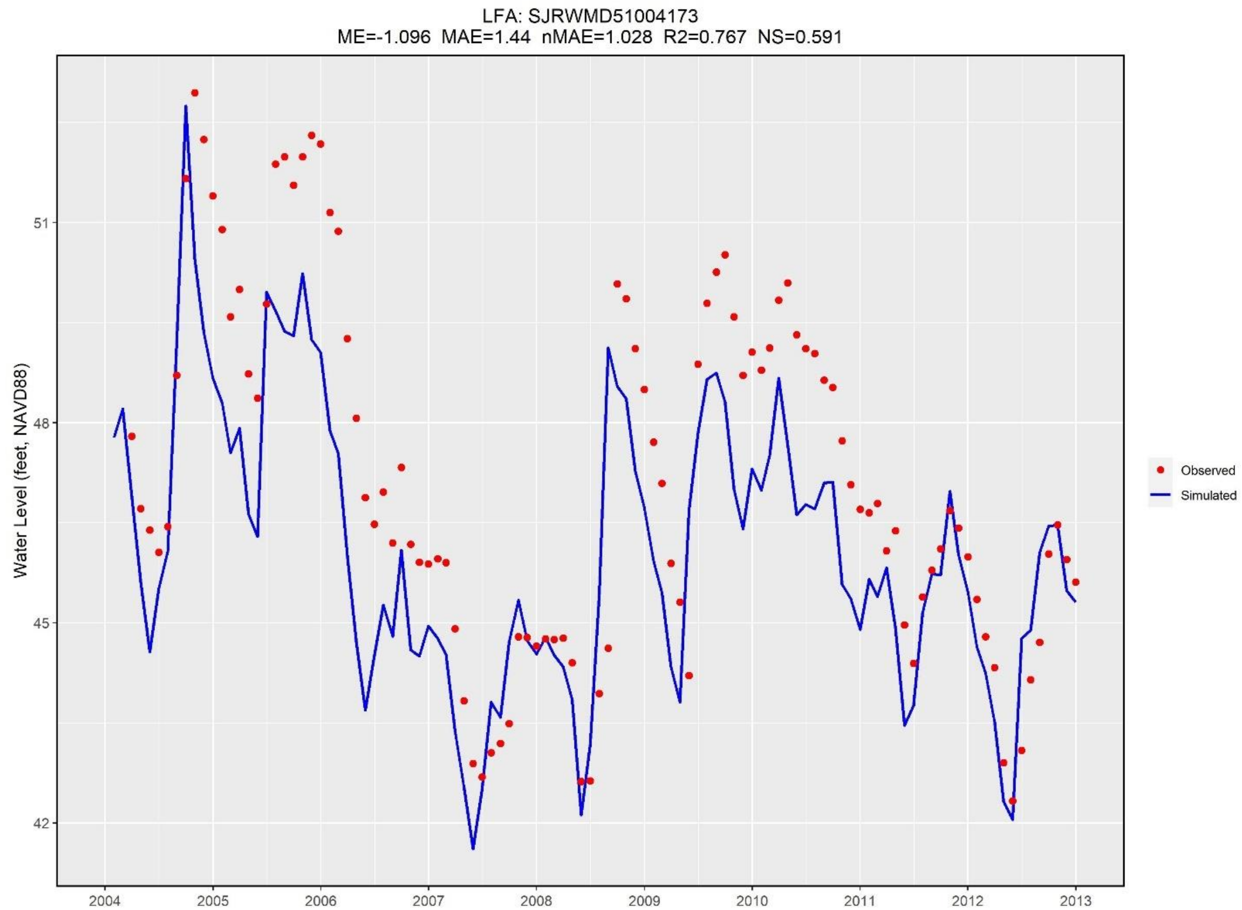


Figure 3.12. Simulated versus observed water levels for the LFA well OF0794 at Plymouth Tower.

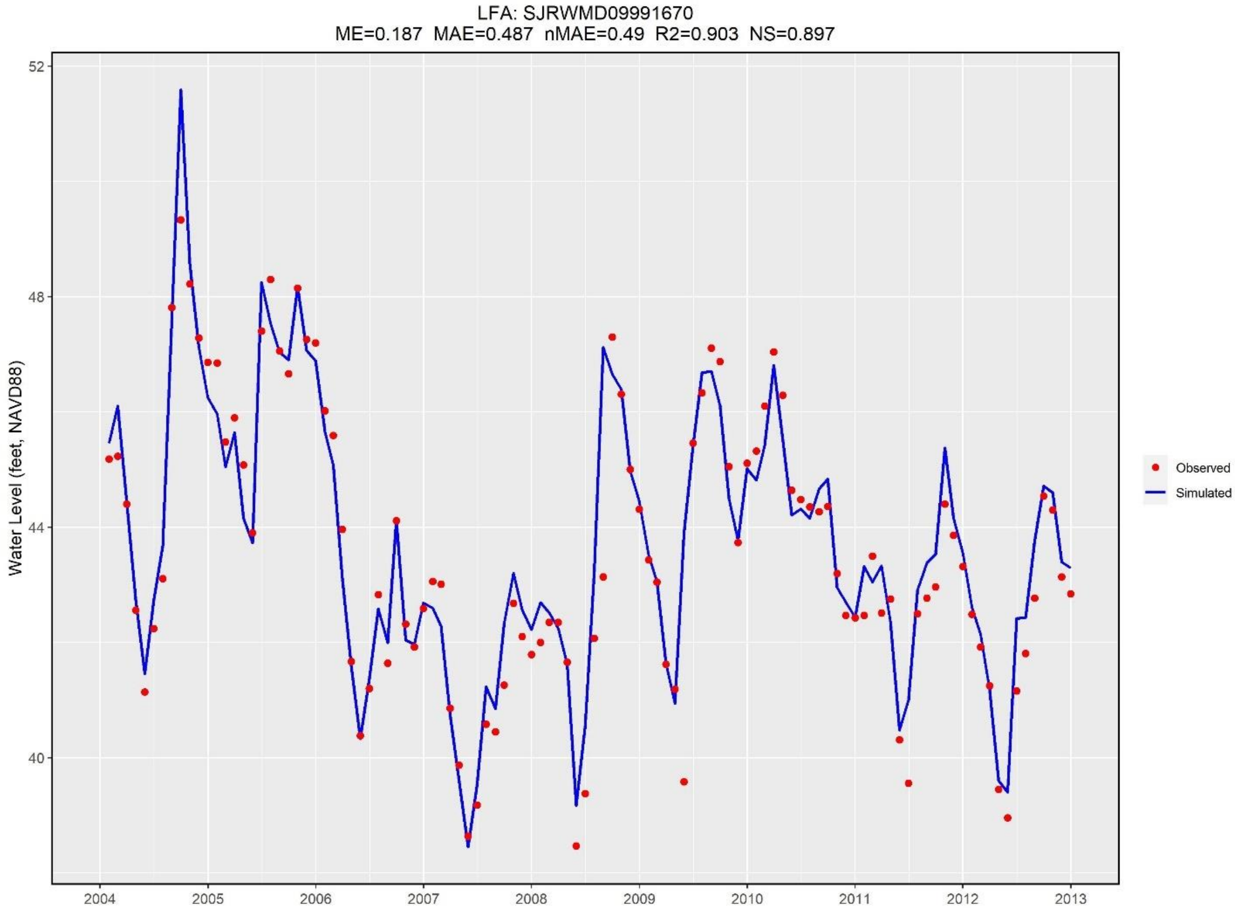


Figure 3.13. Simulated versus observed water levels for the LFA well S-1329 at Winter Springs at Casselberry.

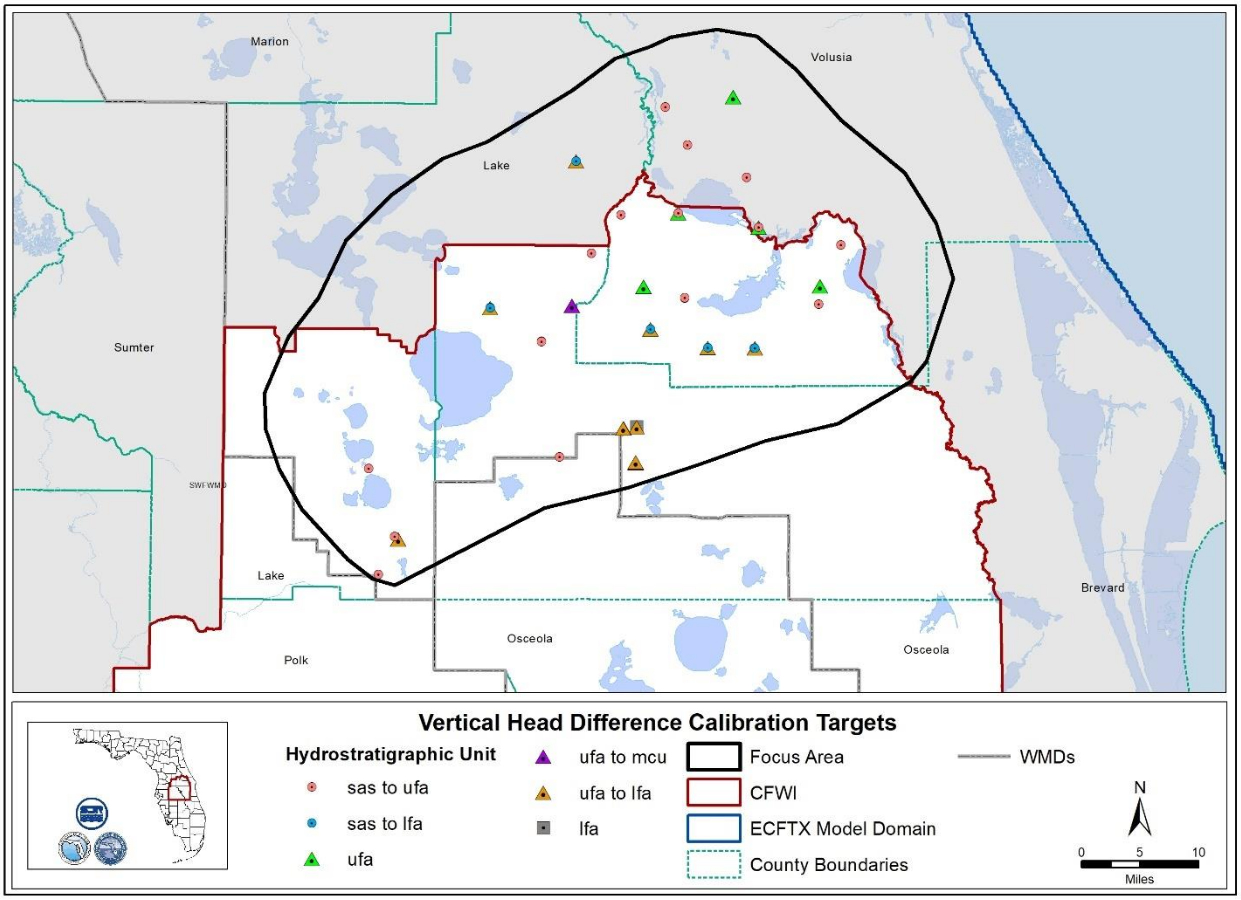
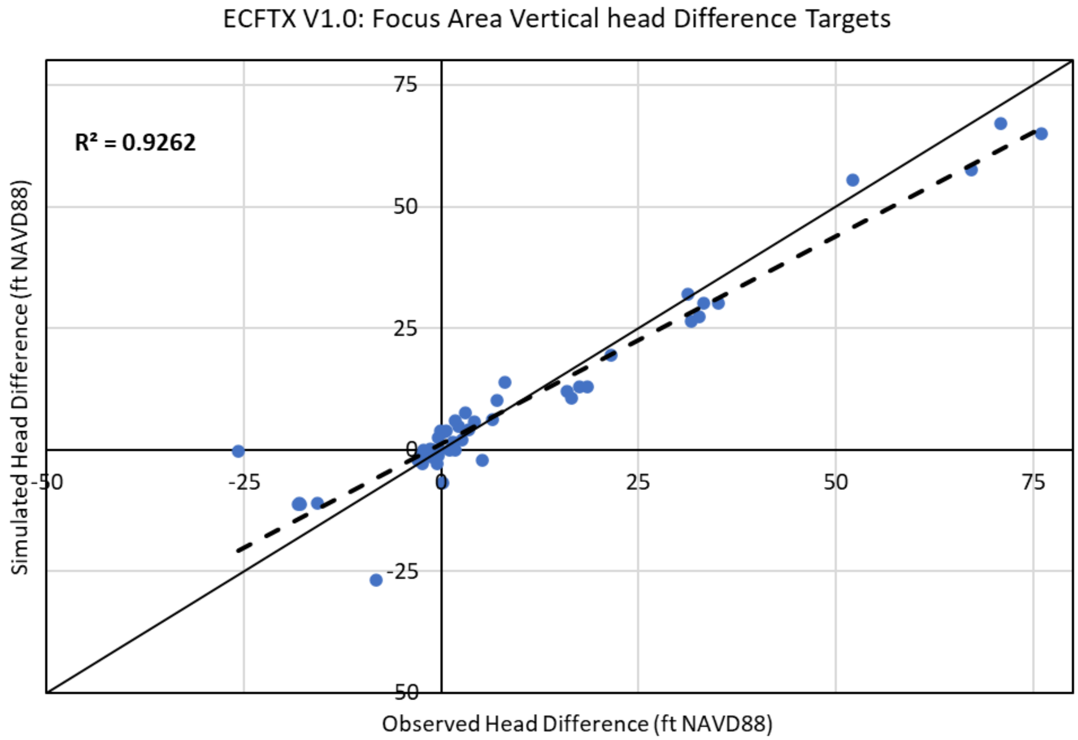


Figure 3.14. Location of vertical head difference targets in the focus area.



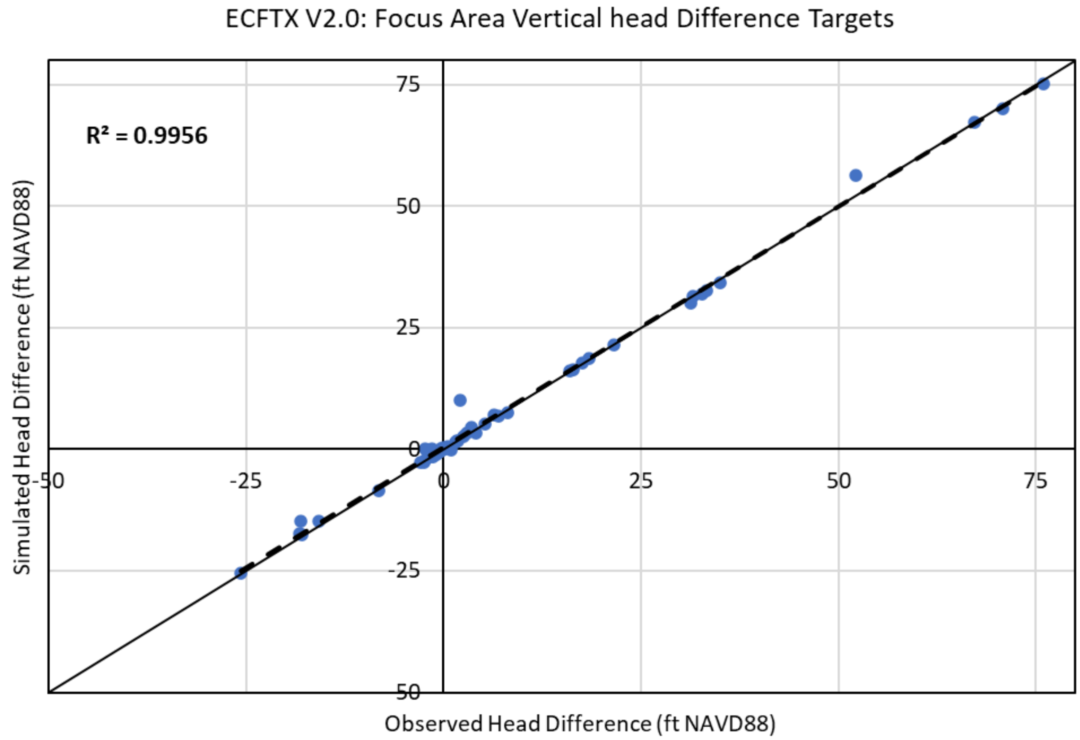


Figure 3.15. Mean simulated versus observed vertical head differences at targets within the focus area in the ECFTX transient model for V1.0 (top) and V2.0 (bottom). (Note: Solid line is 1:1 relation between simulated and observed head differences; dashed line is linear regression of simulated versus observed head differences).

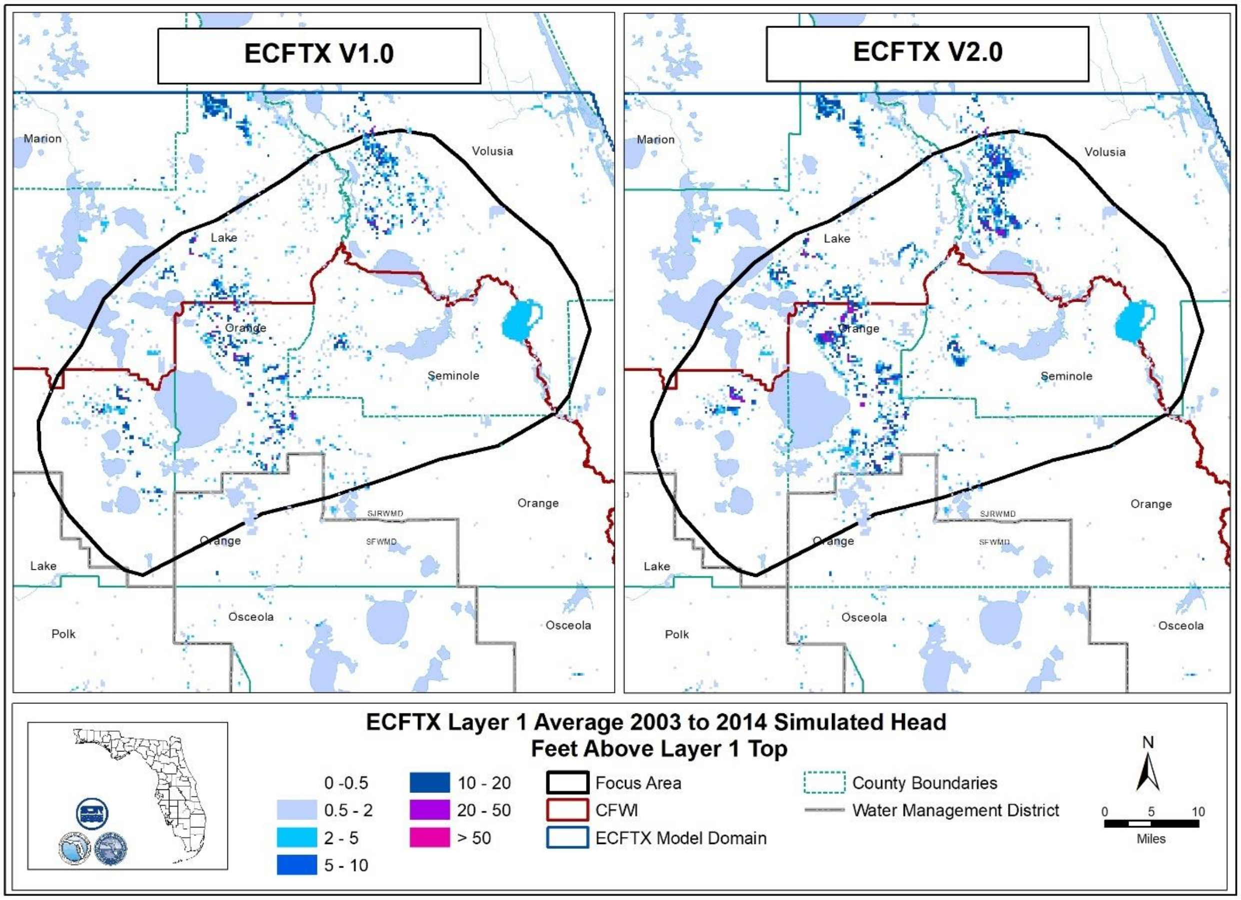


Figure 3.16. Simulated average 2003 to 2014 layer 1 flooded depth for ECFTX v1.0 (left) and ECFTX v2.0 (right).

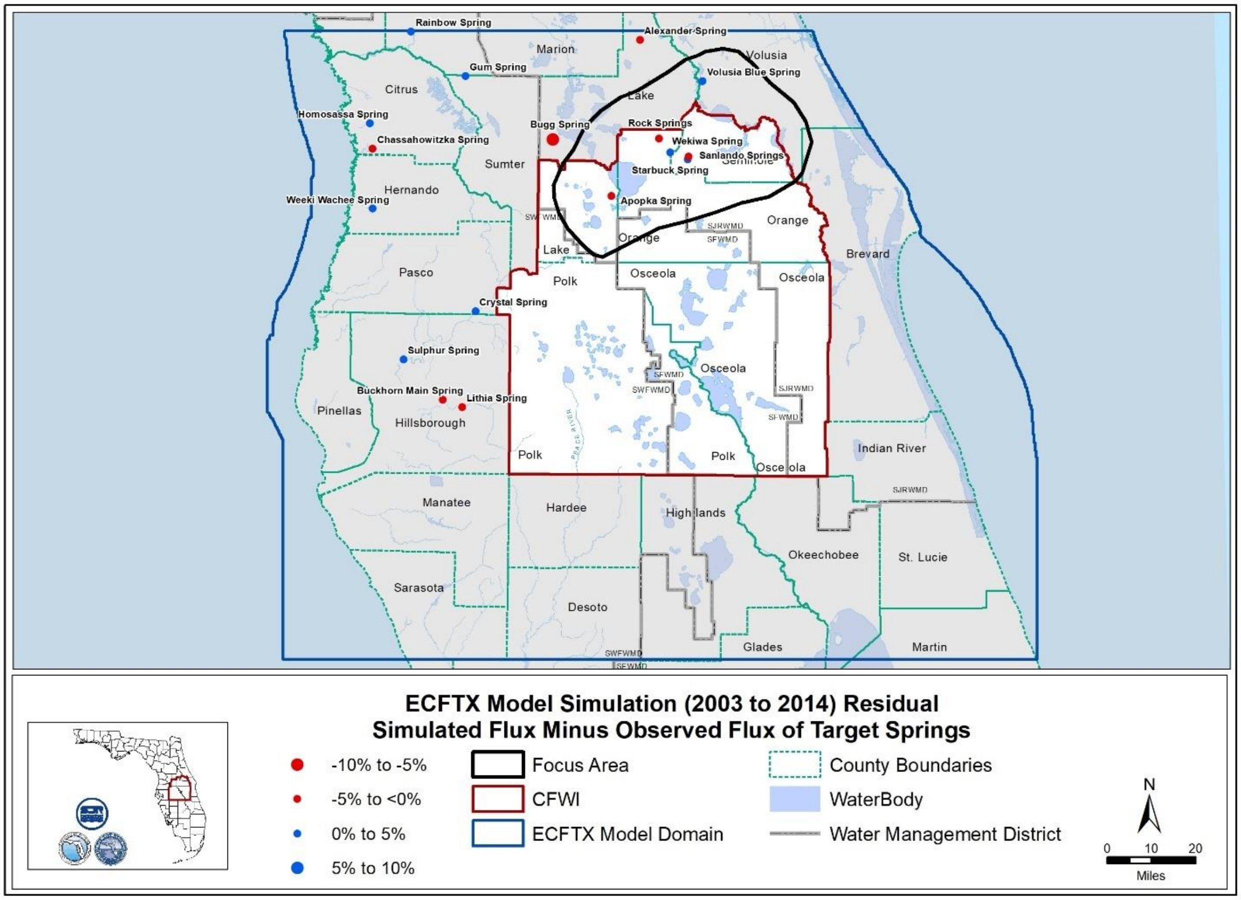
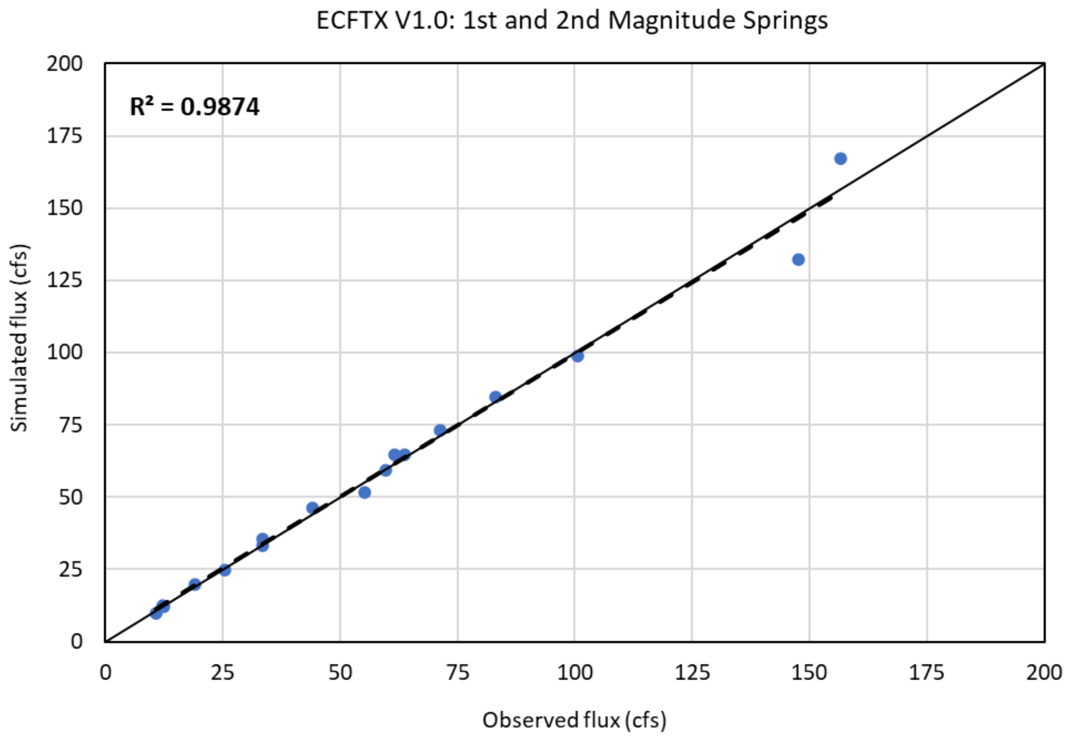


Figure 3.17. Spatial distribution of mean error for 17 magnitude 1 and 2 springs within the ECFTX model during calibration period. Blue indicates simulated flows higher than observed, red indicates simulated flows lower than observed.



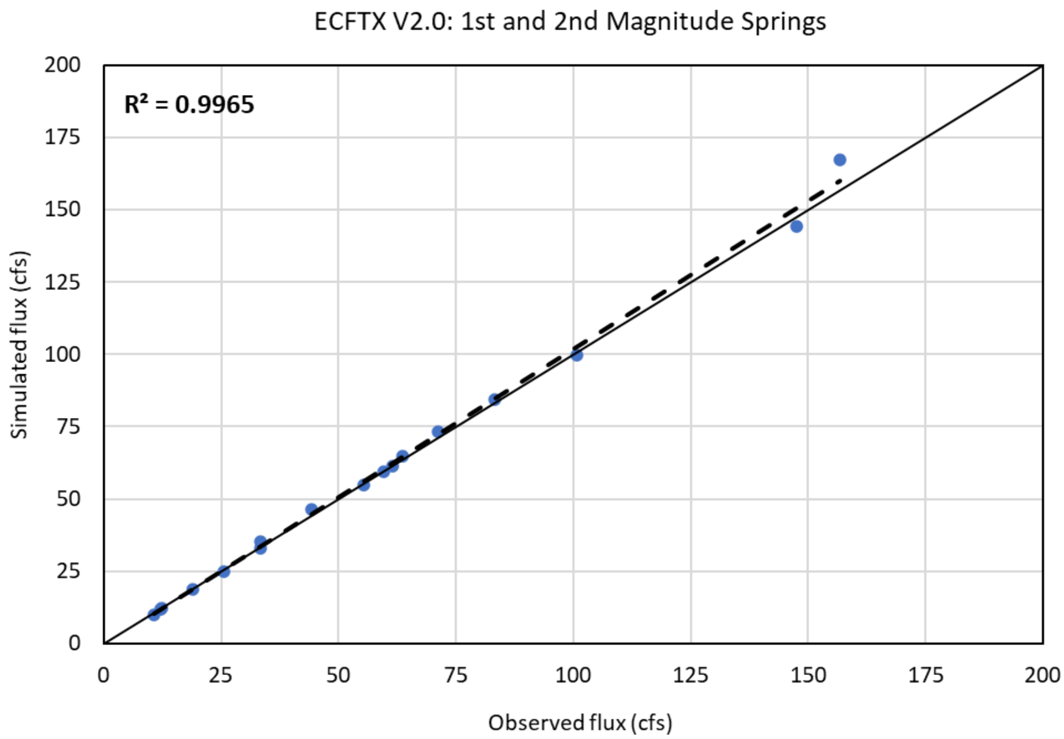
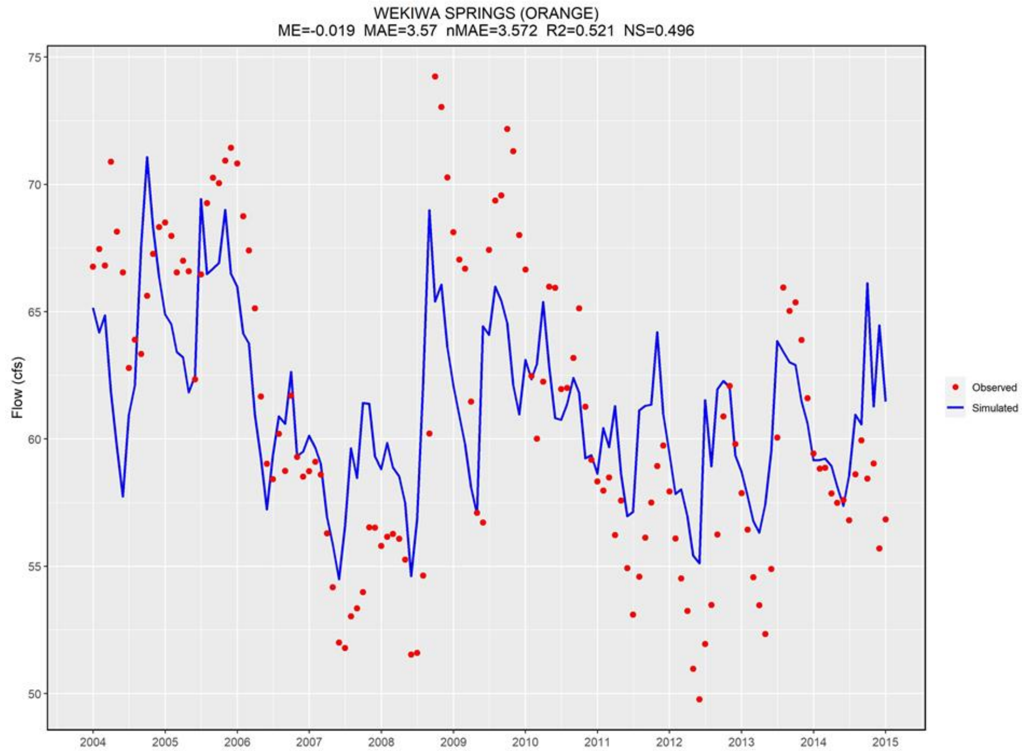


Figure 3.18. Mean simulated versus observed flow for magnitude 1 and 2 springs within the ECFTX model domain. Note: solid line is 1:1 relation between simulated and observed flow; dashed line is linear regression of simulated versus observed flow from 17 springs.



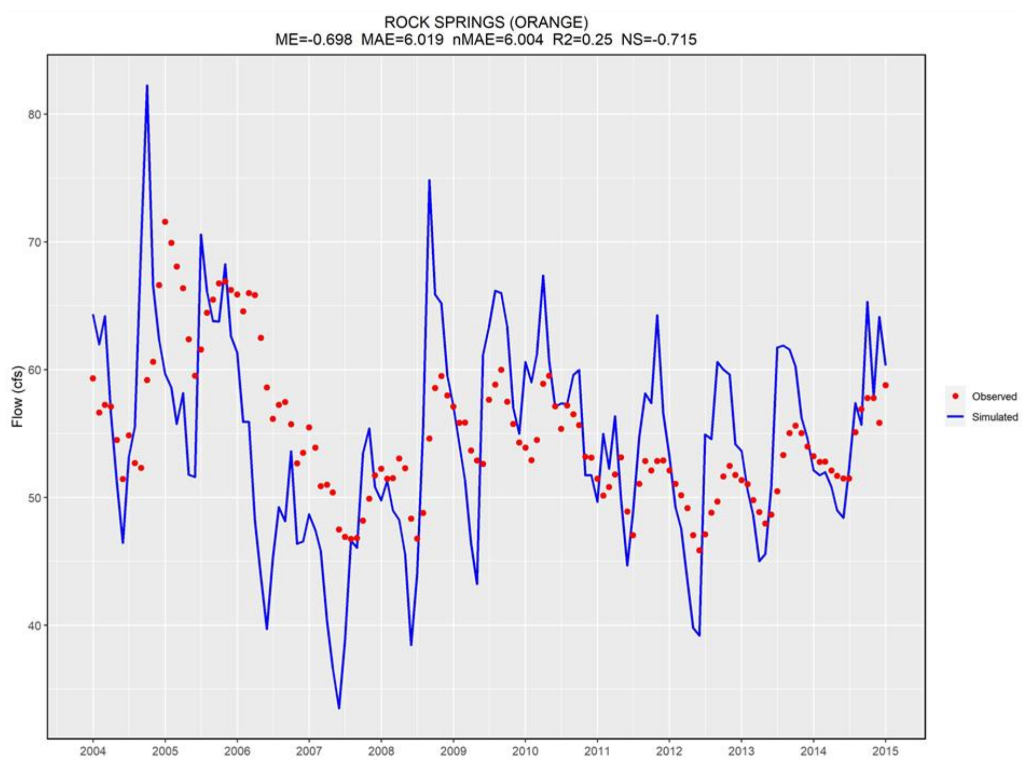


Figure 3.19. Simulated versus observed flows at Wekiwa (top) and Rock springs (bottom) within the ECFTX model.

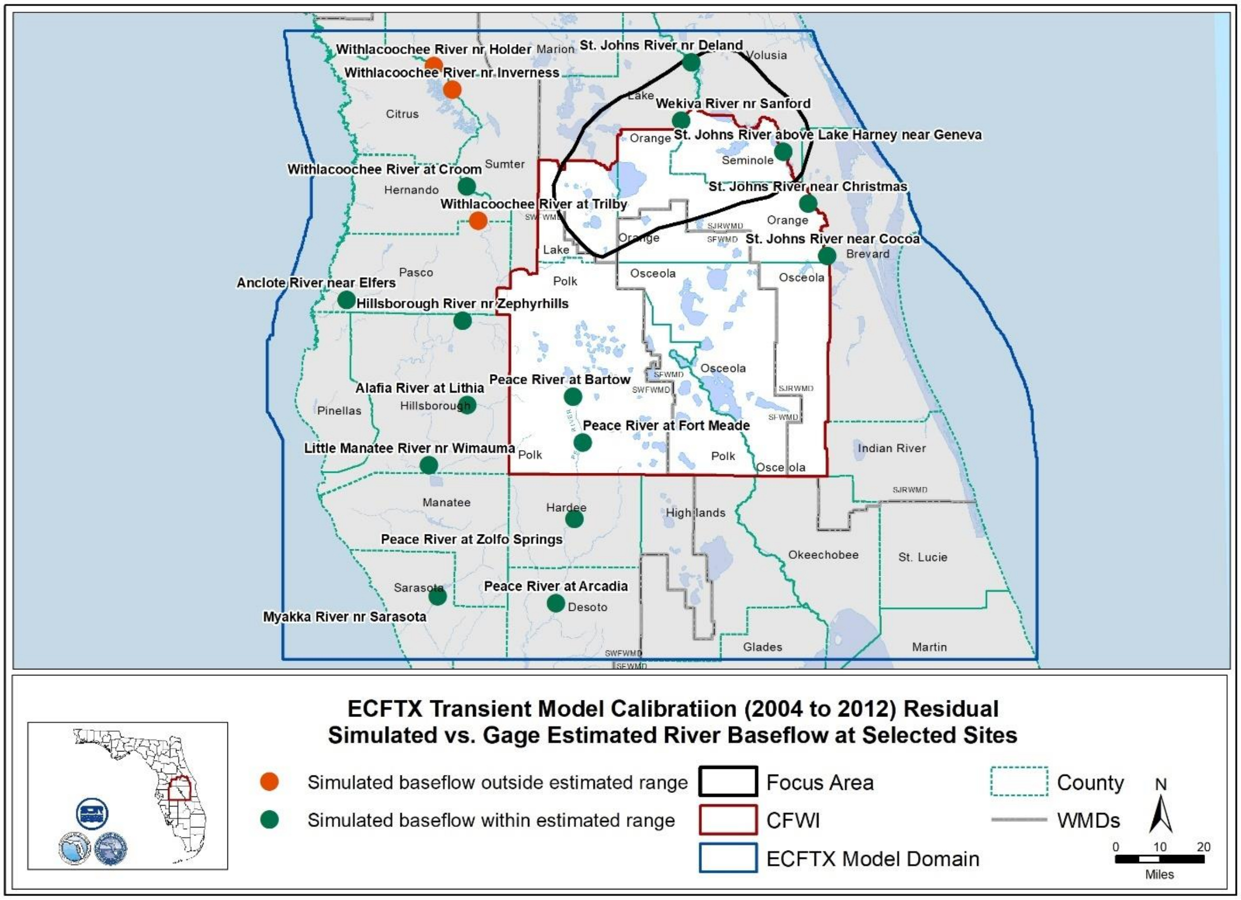


Figure 3.20. Spatial distribution of the USGS streamflow gages that were within or outside the baseflow estimation ranges within the ECFTX domain for the calibration period.

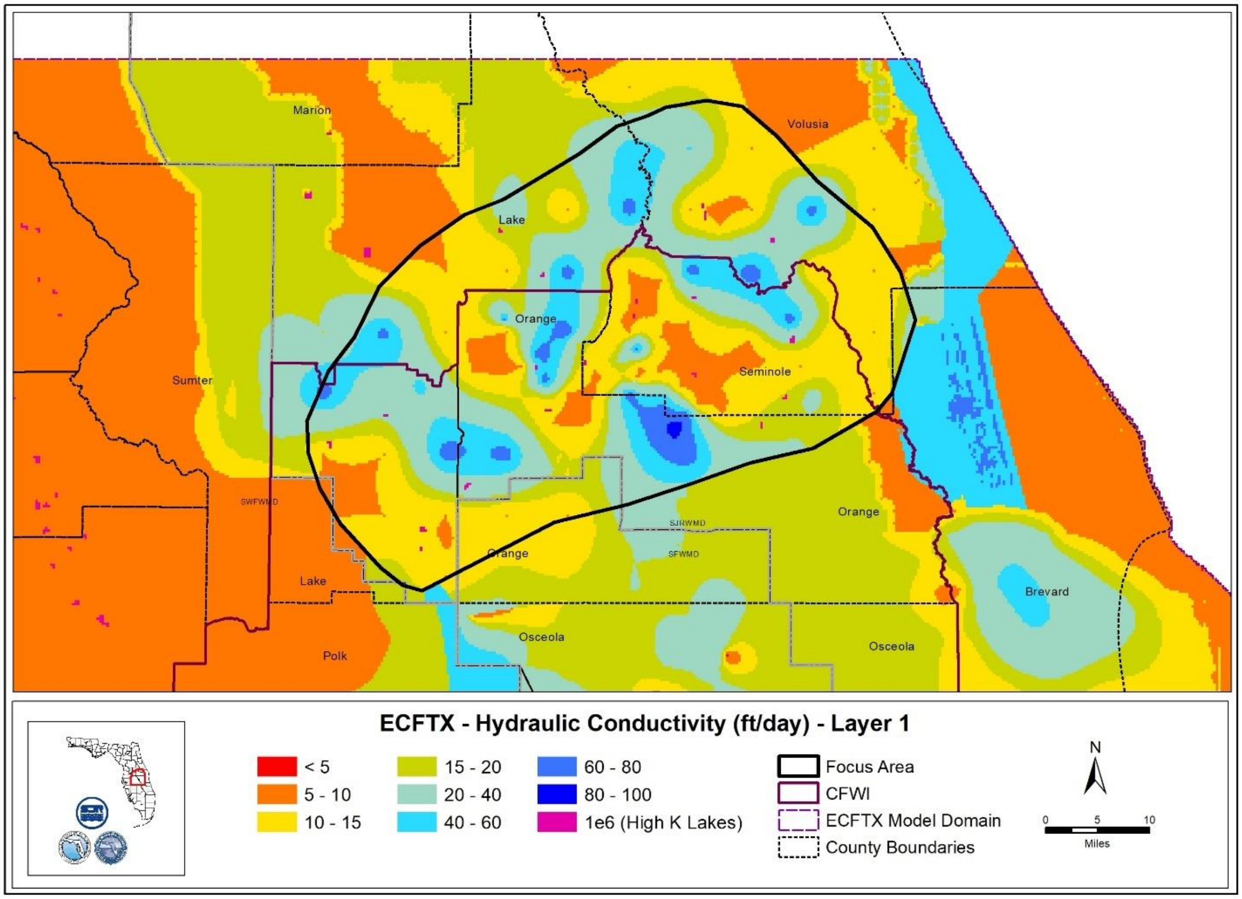


Figure 3.21. Hydraulic conductivity values in layer 1 in the focus area.

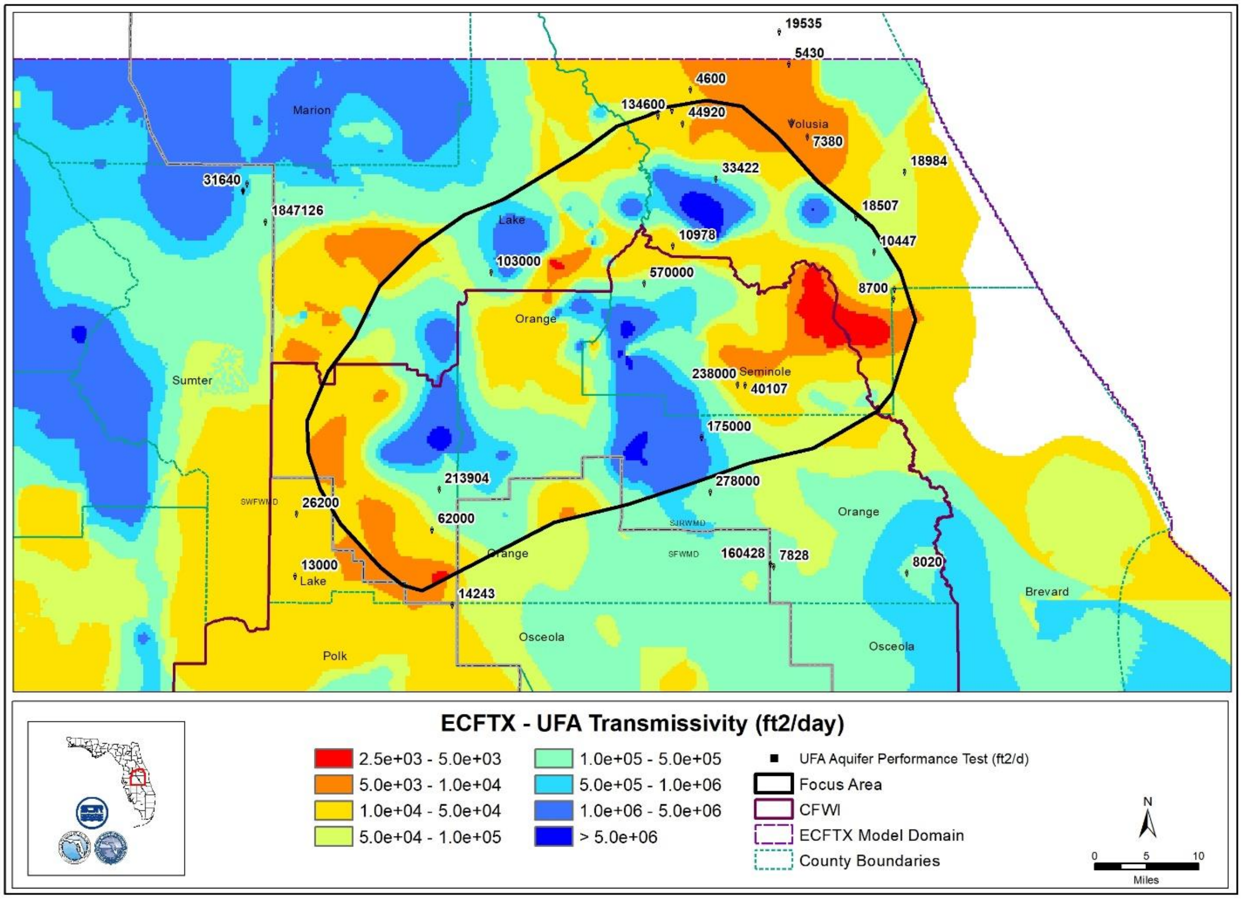


Figure 3.22. Transmissivity values for the UFA (layers 3–5) plotted with historical APT results.

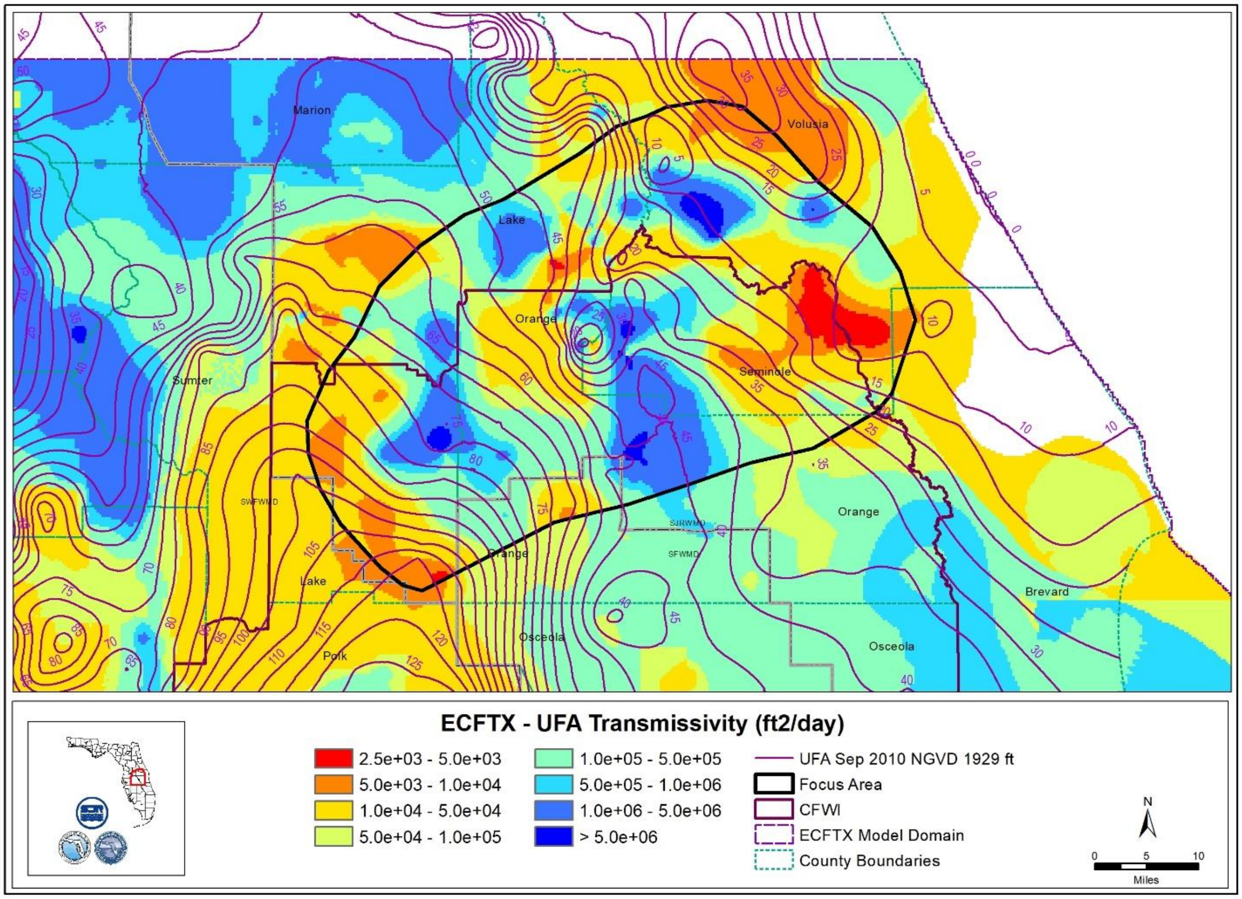


Figure 3.23. Transmissivity values for the UFA (layers 3–5) plotted with the September 2010 UFA potentiometric surface.

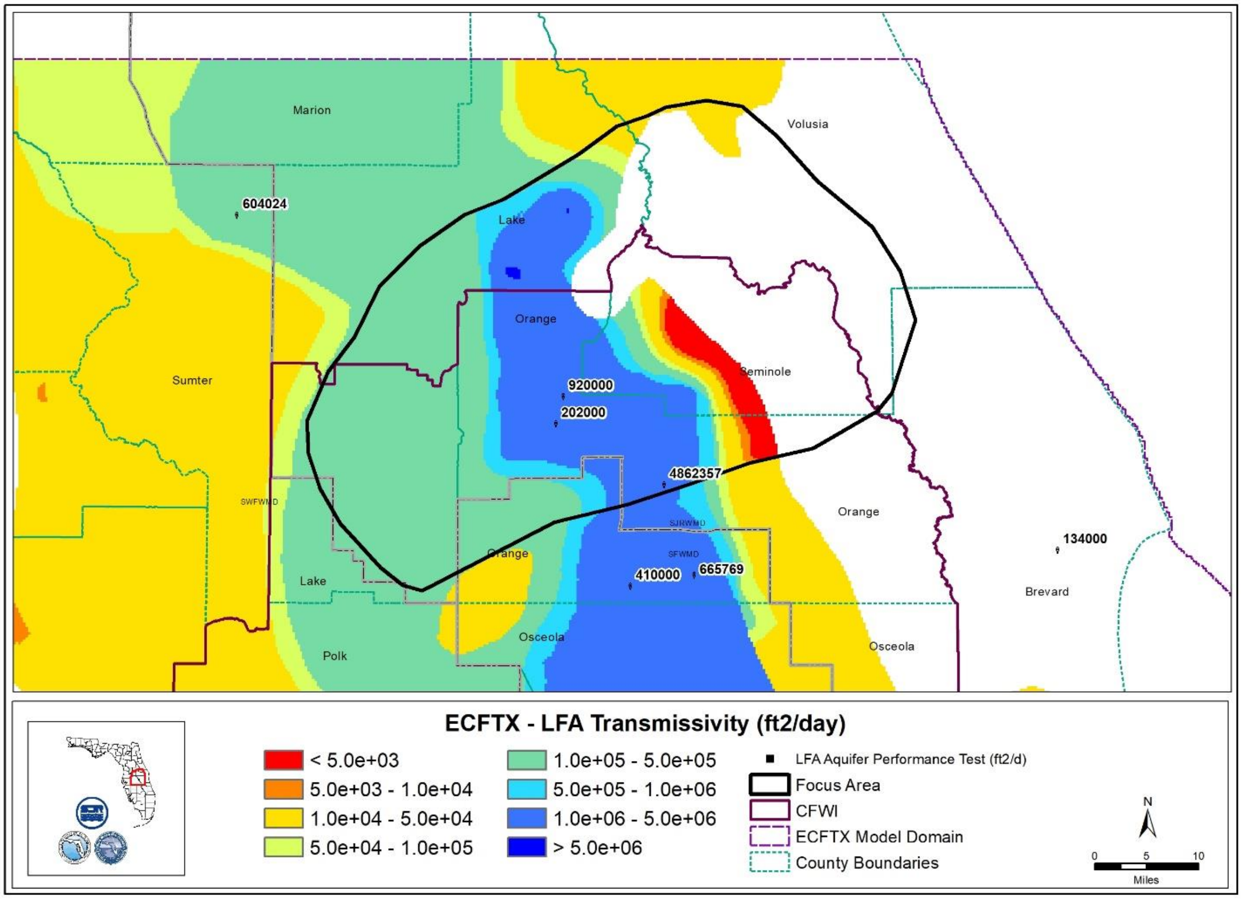


Figure 3.24. Transmissivity values for the LFA (layers 9–11) plotted with historical APT results.

CHAPTER 4 – DISCUSSION

The recalibration of the ECFTX model significantly improved the model performance in the focus area. Average RMS error in the focus area reduced from about 5.1 to 2.2 feet in the SA, from 4.4 feet to 1.9 feet in the UFA and from 2.4 to 0.4 feet in the LFA. In addition, the coefficient of determination (R-squared) values greater than 0.4 were generated by regressing all simulated versus observed water levels in ECFTX v2.0 and compared with those in ECFTX v1.0. These R-squared values were considered a measure of how well the model performed matching shorter-term transient response to dynamic stresses (CFWI HAT, 2020). Compared to ECFTX v1.0, ECFTX v2.0 had higher percentage of R-squared values greater than 0.4 for SA and the same for the UFA and LFA in the focus area. Although overall calibration has been improved significantly, water levels of a few target wells in CFWI were not matched as well as they were in ECFTX v1.0 but the difference was small (increase in MAE < 0.5 ft in the SA and <1.5 ft in the UFA). The maximum increase in MAE (approximately 1.3 ft) was noticed at a monitoring well in northeast Seminole County (SJRWMD ID: 30342858). It appears that the adjustment made to improve several wells near Wekiva River having very high MAEs in ECFTX v1.0 (Figure 3.2) degraded one well slightly.

The simulations of major springs were also improved as the average model error decreased from about 6% to less than 1% in Wekiwa and Rock springs. Moreover, VHDs between UFA and SA and between UFA and LFA were introduced as calibration targets which were not utilized quantitively in the ECFTX v1.0 calibration. The VHDs are one of the primary indicators of the degree of confinement between two aquifers and helped us improve the model's ability to simulate degree of confinement in the region. This is important for accurately predicting the propagation of impacts of groundwater pumping in the UFA and LFA to lakes, rivers, and wetlands. While the calibration improved in the focus area, no significant changes occurred outside it as a result. The improvement in model-wide calibration performance reflects the improvement in focus area calibration performance.

We assessed the reasonableness of the updated simulated hydraulic conductivities by reviewing the transmissivity values of UFA and LFA with APT/literature data, spring locations (karst-dominated geology) and potentiometric surface contour gradients. The leakance values of the ICU and MCU were better represented based on VHDs and literature information.

Figure 4.1 shows the updated UFA transmissivity values with September 2010 potentiometric surface contours, the available APTs, and spring locations. Figure 4.2 shows the updated LFA transmissivity values with the available APTs, and spring locations. Small and large spacings between two contours of potentiometric surface are usually indications of low or high aquifer transmissivities respectively. As shown in Figure 4.1, the recalibrated parameter distribution is generally consistent with the contour spacing as high transmissivity areas usually coincide with the contours with large spacing (flat gradients) whereas low transmissivity areas usually coincide with contours with tight spacing (steep gradients). In addition, very high transmissivity values were assigned to the areas of springs and their vicinities, which is consistent with the fact that aquifers are expected to be highly transmissive in the vicinity of springs due to presence of conduits and large fractures. Although the recalibrated transmissivity values are similar to the APT-derived values in most of the focus area, the transmissivity values in the model are much higher than the APT-derived values in northern Orange County; however, the horizontal hydraulic conductivity values shown in Figures 60 and 61 of the USGS-ECFT model report, corresponding to layers 3 and 5 of the model, seem to be similar to the calibrated hydraulic conductivities in those areas (Sepulveda et al, 2012). Hydraulic conductivity maps of each layer in the model are included in Appendix D. It should also be noted that APT values should be cautiously used for comparing with model parameters. APT values are usually derived from field tests using analytical solutions with limitations. The quality of the field tests and collected data would significantly affect the transmissivity values derived from the APTs. In addition, the APTs (mostly lasting less than 72 hours) usually do not sufficiently stress the aquifer more than a few miles so the derived transmissivity values may not represent large areas. Moreover, some of the APTs are based on only one pumping well (with no monitoring well nearby) and can produce highly questionable transmissivity estimates due to pumping well frictional effect mixing with aquifer water level change due to pumping.

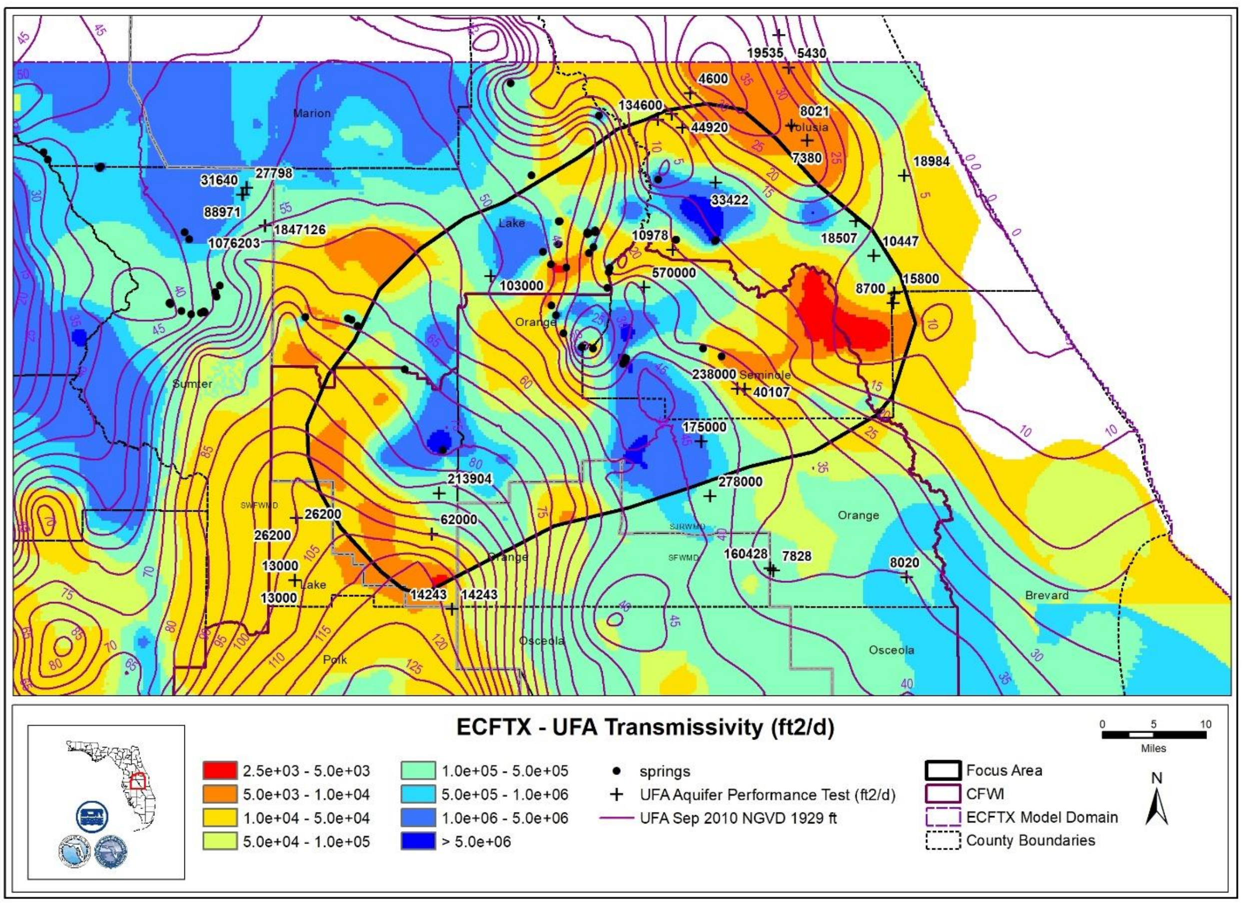


Figure 4.1. UFA Transmissivities with potentiometric surface, spring locations, and APTs.

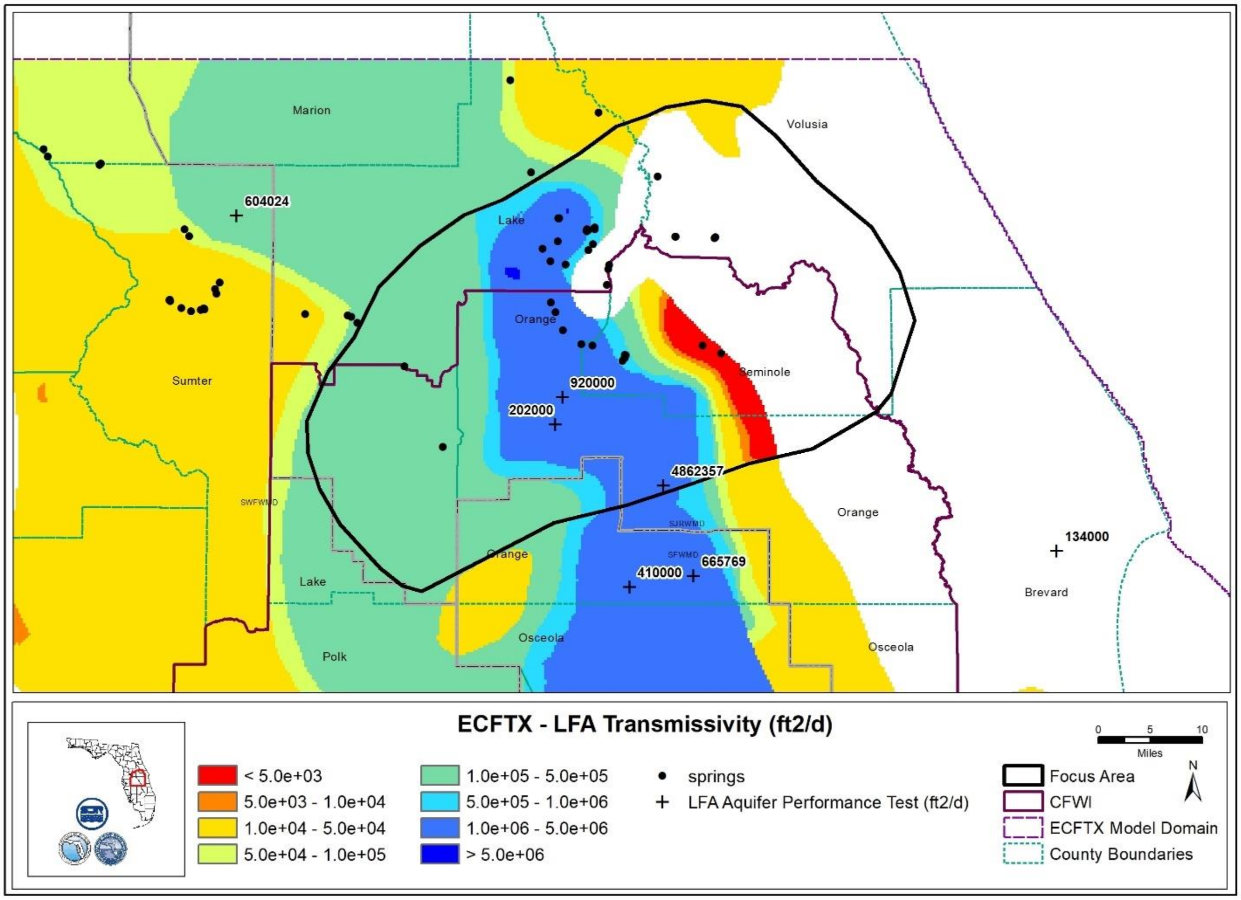


Figure 4.2. LFA Transmissivities with APTs.

Figure 4.3 shows the recalibrated leakance values in the UFA with VHDs between the SA and UFA. As expected, low leakance values are in the areas of large VHDs and high leakance values are in the areas of small VHDs, indicating the reasonableness of the leakance values in the ICU. Similarly Figure 4.4 shows consistency between the VHDs and leakance values in MCU 1.

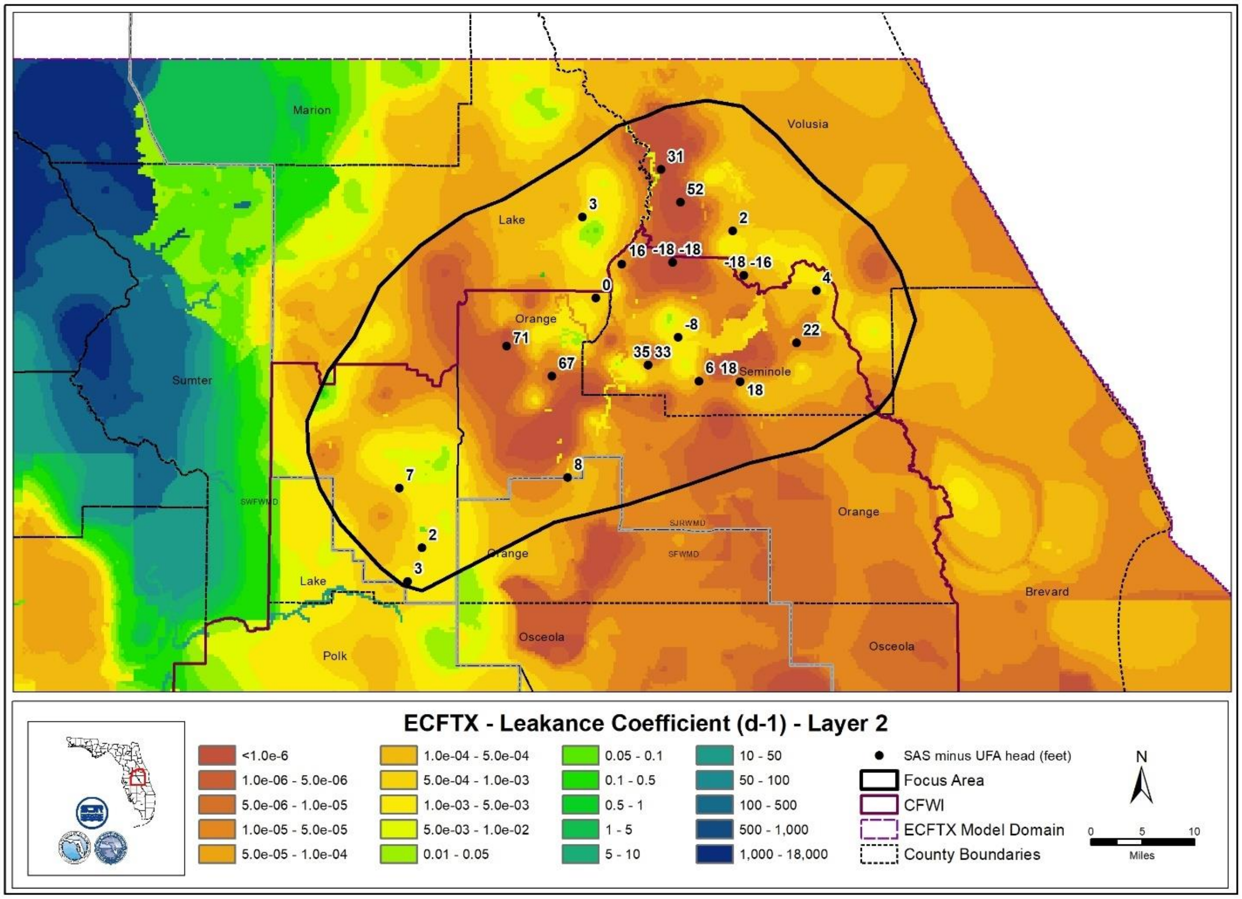


Figure 4.3. ICU Leakances with SA/UFA VHDs.

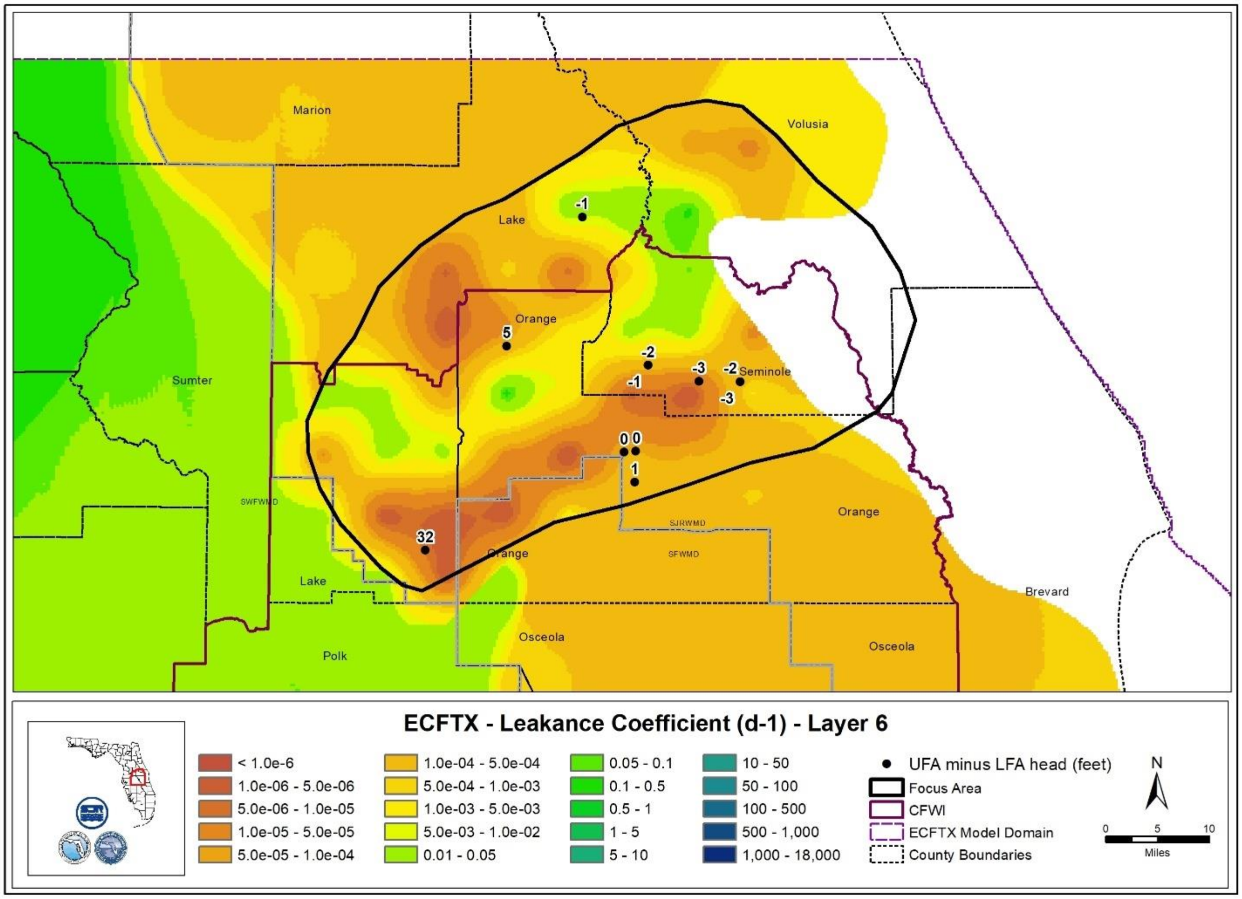


Figure 4.4. MCU_I Leakance distribution with UFA/LFA VHDs.

During the recalibration effort, the recharge used in ECFTX v1.0 was retained. However, because of uncertainties in recharge estimation, a recharge sensitivity calibration simulation was conducted to better understand the effect of recharge on model calibration. A full recalibration was performed using PEST by reducing the recharge by 20%. The purpose was to see if a good calibration (i.e., calibration statistics were similar to the ECFTX v2.0 calibration) could be achieved when the recharge was 20% less and what the parameter distribution would be, compared to the updated parameters. The results indicated that the calibration statistics of ECFTX v2.0 were similar to or better than those of the recalibrated model with 20% recharge adjustment, although a reasonably good calibration was achieved under a reduced recharge condition. However, parameter distribution of the sensitivity run would still be like ECFTX v2.0, providing us more confidence that the final parameters in ECFTX v2.0 were reasonable.

GHB fluxes along the eastern seawater/freshwater interface boundary were a significant concern during calibration of ECFTXv1.0. Large influxes from this boundary would result in an artificial source of freshwater that would tend to artificially mitigate drawdown impacts from wellfield withdrawals. Care was taken during recalibration to adjust GHB conductance to ensure that GHB fluxes in ECFTX v2.0 were similar to those of ECFTXv1.0

CHAPTER 5 – CONCLUSIONS

The ECFTX v2.0 model performance was considerably improved within the focus area including the Wekiva River springs groundwater contributing basin and Seminole County. Aquifer parameters were adjusted within a range consistent with the known hydrogeology in the region. Accordingly, the model-wide calibration performance was also improved as a result of the improvement in the focus area. Overall, this provides greater confidence that ECFTX v2.0 should be considered an appropriate tool for assisting regulatory decisions, minimum flows and minimum levels (MFL) evaluations, and future planning efforts.

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LIST OF APPENDICES

Appendix A – East-Central Florida Transient Expanded (ECFTX) Model Horizontal Hydraulic Conductivity Modifications in Layer 2

TECHNICAL MEMORANDUM

TO: Central Florida Water Initiative (CFWI) Hydrologic Assessment Team (HAT)

FROM: Hua Zang, P.G., Ph.D., Environmental Flows and Levels Section
Jason G. Patterson, P.G., Environmental Flows and Levels Section

DATE: November 10, 2021

SUBJECT: East-Central Florida Transient Expanded (ECFTX) Model Horizontal Hydraulic Conductivity Modifications in Layer 2

The East Central Florida Transient Expanded (ECFTX) groundwater flow model and the subsequent model documentation report were completed by the Central Florida Water Initiative (CFWI) Hydrologic Assessment Team (HAT) in February 2020. During recent discussions, the Districts' members of HAT determined that it was necessary to modify the horizonal hydraulic conductivity (Kh) for layer 2, which represents the intermediate confining unit (ICU) within the ECFTX model. By increasing the layer 2 Kh, the model becomes more conceptually accurate by simulating horizontal flow within the Hawthorn aquifer system (HAS) (also more generally referred to as the intermediate aquifer system) and consequently improving model convergence and run time.

The HAS generally occurs as individual, thin, low permeability water bearing units within the intermediate confining unit, between the surficial aquifer (above) and the Upper Floridan aquifer system (below). The HAS exists within an approximate 5,000 square-mile area of DeSoto, Sarasota, Hardee, Manatee, and parts of Charlotte, Hillsborough, Highlands, and in the southwest portion of Polk County within the CFWI region. There are two main water producing aquifers within the HAS, the Upper Arcadia aquifer and Lower Arcadia aquifer. The lateral continuity and water-bearing potential of the zones within the HAS are highly variable due to a mixture of shell, sand, gravel, dolomite, and thin limestone beds that are interbedded within a clay matrix. This heterogeneous sequence often leads to low permeability of the water bearing zones and complicates mapping the lateral extent of each zone (Basso and Hood, 2005).

Combined groundwater withdrawals from both aquifers were approximately 58 million gallons per day (mgd) in 2006 with roughly 3 mgd occurring within the CFWI region. In 2018, there were groundwater withdrawals of 48 mgd from both aquifers with only about 3.2 mgd occurring within the CFWI region. Due to the unknown extent, water bearing limitations, limited water use, and minimal projected future demands for the HAS within the CFWI region, the HAT determined not to simulate individual aquifers within the HAS as part of the ECFTX model.

Initial Kh values for the intermediate confining unit (layer 2) were derived from vertical hydraulic conductivity (Kv) values calculated from aquifer performance tests (Figure 1). An anisotropy ratio was applied from the Kv value to the Kh (Kh:Kv) of 10:1. After further review, the HAT decided to pursue a more conceptually accurate Kh value to allow horizontal flow through the HAS while maintaining the vertical head differences and fluxes between the surficial aquifer and Upper Floridan aquifer. The revised values of the horizontal hydraulic conductivity were modified from the District Wide Regulatory Model (DWRM3) model developed by Southwest Florida Water Management District (Environmental Simulations, Inc., 2014). The DWRM3 model simulates both aquifers and the confining units above and below the aquifers. Figure 2 shows the modified layer 2 hydraulic conductivity values.

The ECFTX model was re-run with the same transient calibration configuration except for the changes to layer 2 Kh. This modification resulted in very minor changes to the simulated heads of the overlying surficial aquifer and underlying Upper Floridan aquifer. Figures 3 and 4 show simulated head change with the increased layer Kh values in the surficial aquifer and Upper Floridan aquifer, respectively. The change of Layer 2 Kh did not cause significant change to the model calibration statistics of the target monitoring wells as given in Tables 1 and 2. There was a very minor change of -0.1% to simulated spring flow of Lithia Spring and essentially no change on other target springs (Table 3). The summary water budgets in Table 4 and 5 demonstrate that the HAS Kh modification did not cause significant changes to mass balance. A detailed breakdown of general head boundary (GHB) fluxes in Table 6 show that the boundary fluxes were essentially the same except very minor change to the layer 2 (HAS) of southern boundary. Additionally, the modified Layer 2 Kh values improved numerical convergence encountered in layer 2 and shortened model run times.

Table 1. Transient model calibration statistics of the target monitoring wells in the ECFTX Model domain comparing February 2020 calibration versus that with HAS Kh change.

	February 2020 calibration			**HAS Kh change calibration**		
	SA	**UFA**	**LFA**	**SA**	**UFA**	**LFA**
Residual Mean	-0.46	0.46	0.46	-0.47	0.45	0.46
Error Standard Dev	4.24	4.7	3.33	4.26	4.69	3.33
5% of Observation Range	8.97	7.59	2.79	8.97	7.59	2.79
Absolute Residual Mean	2.83	3.78	2.65	2.84	3.78	2.65
Error Sum of Squares	18156	20666	329	18333	20620	329
RMS Error	4.27	4.72	3.31	4.29	4.71	3.31
Minimum Residual	-31.65	-22.1	-10.19	-31.69	-22.1	-10.19
Maximum Residual	21.15	19.14	5.73	21.15	19.14	5.73
Number of Observations	997	928	30	997	928	30
Percentage with MAE < 2.5 ft	68%	48%	60%	68%	48%	60%
Percentage with MAE < 5.0 ft	88%	76%	87%	88%	76%	87%
Percentage with R2 > 0.4	78%	93%	93%	78%	93%	93%

All values in feet except as noted. Calibration period is 2004-2012. Mean error expressed as simulated minus observed

Table 2. Transient model calibration statistics of the target monitoring wells in the CFWI Area comparing February 2020 calibration versus HAS Kh change calibration.

	February 2020 calibration			**HAS Kh change calibration**		
	SA	**UFA**	**LFA**	**SA**	**UFA**	**LFA**
Residual Mean	-0.64	0.34	1.23	-0.65	0.32	1.23
Error Standard Dev	3.47	3.75	2.68	3.48	3.74	2.68
5% of Observation Range	8.6	6.2	2.62	8.6	6.2	2.62
Absolute Residual Mean	2.61	3.24	2.48	2.62	3.24	2.49
Error Sum of Squares	3442	2729	202	3465	2714	202
RMS Error	3.53	3.75	2.9	3.54	3.74	2.9
Minimum Residual	-16.51	-11.93	-5.46	-16.51	-11.93	-5.49
Maximum Residual	13.29	10.11	5.73	13.28	10.08	5.73
Number of Observations	277	194	24	277	194	24
Percentage with MAE < 2.5 ft	71%	52%	58%	71%	52%	58%
Percentage with MAE < 5.0 ft	87%	85%	88%	87%	85%	88%
Percentage with R2 > 0.4	78%	96%	92%	78%	96%	92%

All values in feet except as noted. Calibration period is 2004-2012. Mean error expressed as simulated minus observed

Table 3. Transient model calibration statistics of the target springs simulated in the ECFTX model.

Spring Name	Observed Flux (cfs)	Simulated Flux (cfs)	
		Original	Modified
Lithia Spring Major	34.7	33.2	33.1
Buckhorn Main Spring	12.2	12.1	12.1
Sulphur Spring (Hillsborough)	34.7	35.4	35.4
Crystal Main Spring (Pasco)	45.5	46.4	46.4
Weeki Wachee Spring	160.4	167.3	167.3
Chassahowitzka Spring Main	59.6	59.3	59.3
Homosassa Spring #1	83.5	84.5	84.5
Gum Spring Main	63.8	64.8	64.8
Rainbow Spring #1	71.8	73.3	73.3
Apopka Spring	24.9	24.8	24.8
Sanlando Springs	18.8	19.9	19.9
Starbuck Spring	12.1	12.6	12.6
Wekiwa Spring (Orange)	61.0	64.6	64.6
Bugg Spring (Lake)	10.6	9.7	9.7
Rock Springs (Orange)	54.9	51.6	51.6
Volusia Blue Spring	143.6	132.4	132.4
Alexander Spring	100.1	98.9	98.9

Table 4. Annual average boundary condition influx (in/yr) in the ECFTX transient model (2003-2014)

Layer	Constant Head	GHB	Well	River	Rech	ET	Spring	Drain Return	Drain	Storage
	In/yr									
February 2020 calibration (calib0)										
1	0.22	0.041	0.085	3.0	22.1	-	-	-	-	0.18
2	-	0.25	-	-	-	-	-	-	-	-
3	-	0.47	4E-4	-	-	-	-	0.059	-	-
4	-	0.23	2E-6	-	-	-	-	-	-	-
5	-	0.56	-	-	-	-	-	-	-	-
6	-	0.096	-	-	-	-	-	-	-	-
7	-	0.080	-	-	-	-	-	-	-	-
8	-	0.060	-	-	-	-	-	-	-	-
9	-	0.22	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-
11	-	0.11	-	-	-	-	-	-	-	-
HAS Kh change calibration (calibHAS)										
1	0.22	0.041	0.085	3.0	22.1	-	-	-	-	0.18
2	-	0.25	-	-	-	-	-	-	-	-
3	-	0.47	4E-4	-	-	-	-	0.059	-	-
4	-	0.23	2E-6	-	-	-	-	-	-	-
5	-	0.56	-	-	-	-	-	-	-	-
6	-	0.096	-	-	-	-	-	-	-	-
7	-	0.080	-	-	-	-	-	-	-	-
8	-	0.060	-	-	-	-	-	-	-	-
9	-	0.22	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-
11	-	0.11	-	-	-	-	-	-	-	-

Table 5. Annual average boundary condition outflux (in/yr) in ECFTX transient model (2003-2014)

Layer	Constant Head	GHB	Well	River	Rech	ET	Spring	Drain Return	Drain	Storage
	In/yr									
February 2020 calibration (calib0)										
1	-2.6	-0.022	-0.17	-3.9	-	-13.1	-	-	-3.5	-
2	-	-0.028	-0.021	-	-	-	-	-	-	-
3	-	-0.46	-0.62	-	-	-	-1.3	-	-	-
4	-	-0.11	-0.30	-	-	-	-	-	-	-
5	-	-0.064	-0.58	-	-	-	-7E-3	-	-	-
6	-	-6E-5	-2E-4	-	-	-	-	-	-	-
7	-	-8E-4	-1E-4	-	-	-	-	-	-	-
8	-	-5E-5	-9E-4	-	-	-	-	-	-	-
9	-	-0.18	-0.30	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-
11	-	-0.57	-	-	-	-	-	-	-	-
HAS Kh change calibration (calibHAS)										
1	-2.6	-0.022	-0.17	-3.9	-	-13.1	-	-	-3.5	-
2	-	-0.028	-0.021	-	-	-	-	-	-	-
3	-	-0.46	-0.62	-	-	-	-1.3	-	-	-
4	-	-0.11	-0.30	-	-	-	-	-	-	-
5	-	-0.064	-0.58	-	-	-	-7E-3	-	-	-
6	-	-6E-5	-2E-4	-	-	-	-	-	-	-
7	-	-8E-4	-1E-4	-	-	-	-	-	-	-
8	-	-5E-5	-9E-4	-	-	-	-	-	-	-
9	-	-0.18	-0.30	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-
11	-	-0.57	-	-	-	-	-	-	-	-

Table 6. Annual average general head boundary (GHB) condition flux (mgd) in the ECFTX transient model (2003-2014).

Layer	GHB North		GHB South		GHB East		GHB West		Total	
	influx	outflux	influx	outflux	influx	outflux	influx	outflux	influx	outflux
	mgd									
February 2020 calibration (calib0)										
1	14	-3.0	21	-16	-	-	-	-	35	-19
2	195	-29	0.12	-0.37	0.06	-1E-4	74	-0.19	268	-30
3	439	-221	28	-54	16	-83	3.6	-125	486	-482
4	126	-54	9.8	-21	9.8	-0.63	90	-37	236	-112
5	98	-8.1	292	-1.4	84	-30	87	-24	561	-64
6	1.3	-0.04	70	-7E-3	-	-	14	-	85	-0.05
7	1.4	-0.63	11	-9E-5	37	-0.03	20	-	68	-0.67
8	5E-3	-0.03	2.5	-	34	-6E-4	-	-	36	-0.03
9	50	-5.5	-	-	41	-69	6.2	-6.7	97	-82
10	-	-	-	-	-	-	-	-	-	-
11	2.4	-1.1	-	-	25	-155	5.2	-17	33	-172
HAS Kh change calibration (calibHAS)										
1	14	-3.0	21	-16	-	-	-	-	35	-19
2	195	-29	0.08	-0.43	0.06	-1E-4	74	-0.19	268	-30
3	439	-221	28	-54	16	-83	3.6	-125	486	-482
4	126	-54	9.7	-21	10	-0.63	90	-37	236	-112
5	98	-8.1	292	-1.5	84	-30	87	-24	561	-64
6	1.3	-0.04	70	-7E-3	-	-	14	-	85	-0.05
7	1.4	-0.63	11	-9E-5	37	-0.03	20	-	68	-0.67
8	5E-3	-0.03	2.5	-	34	-6E-4	-	-	36	-0.03
9	50	-5.5	-	-	41	-69	6.2	-6.7	97	-82
10	-	-	-	-	-	-	-	-	-	-
11	2.4	-1.1	-	-	25	-155	5.2	-17	33	-172

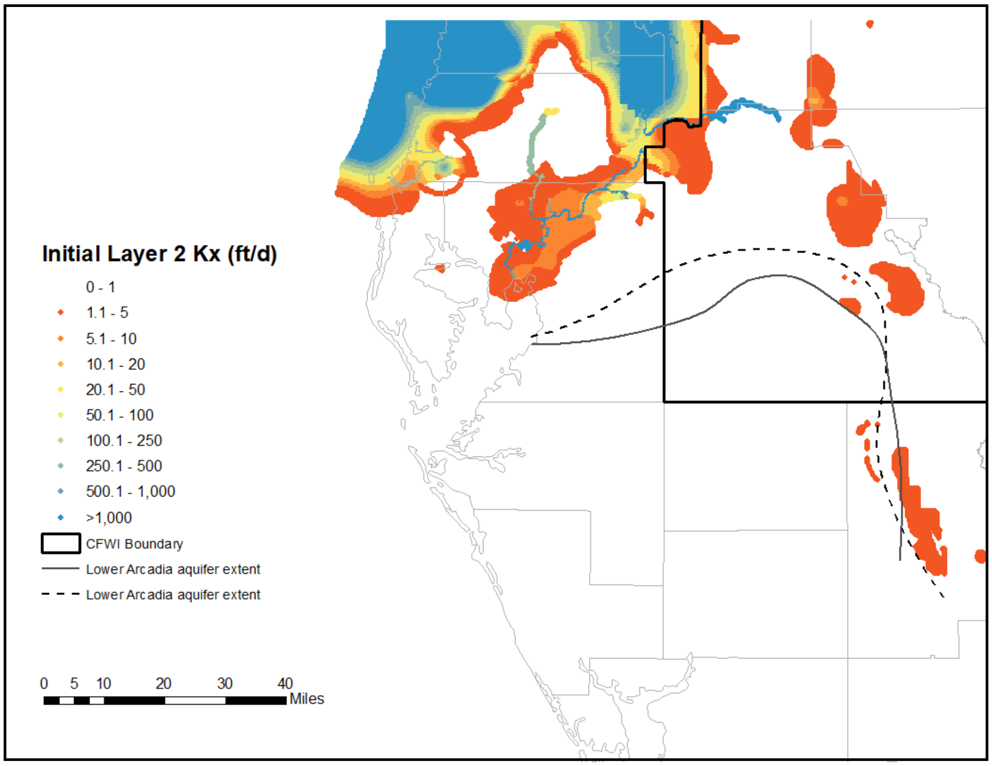

Figure 1. ECFTX Initial Layer 2 Kx Array

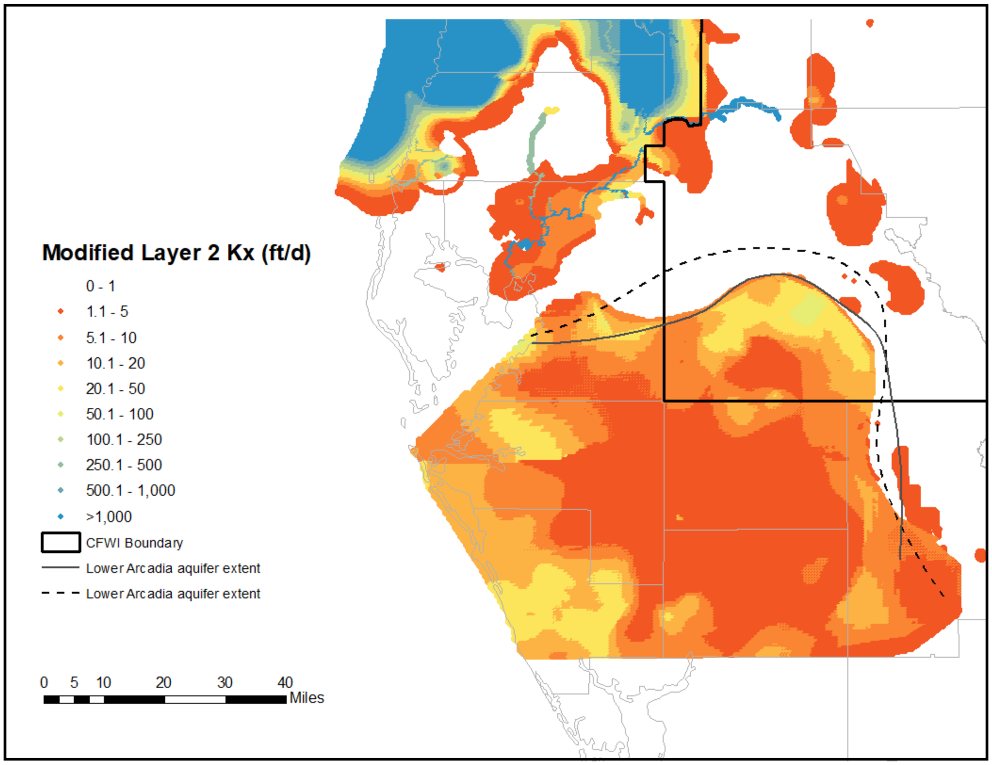

Figure 2. ECFTX Modified Layer 2 Kx Array

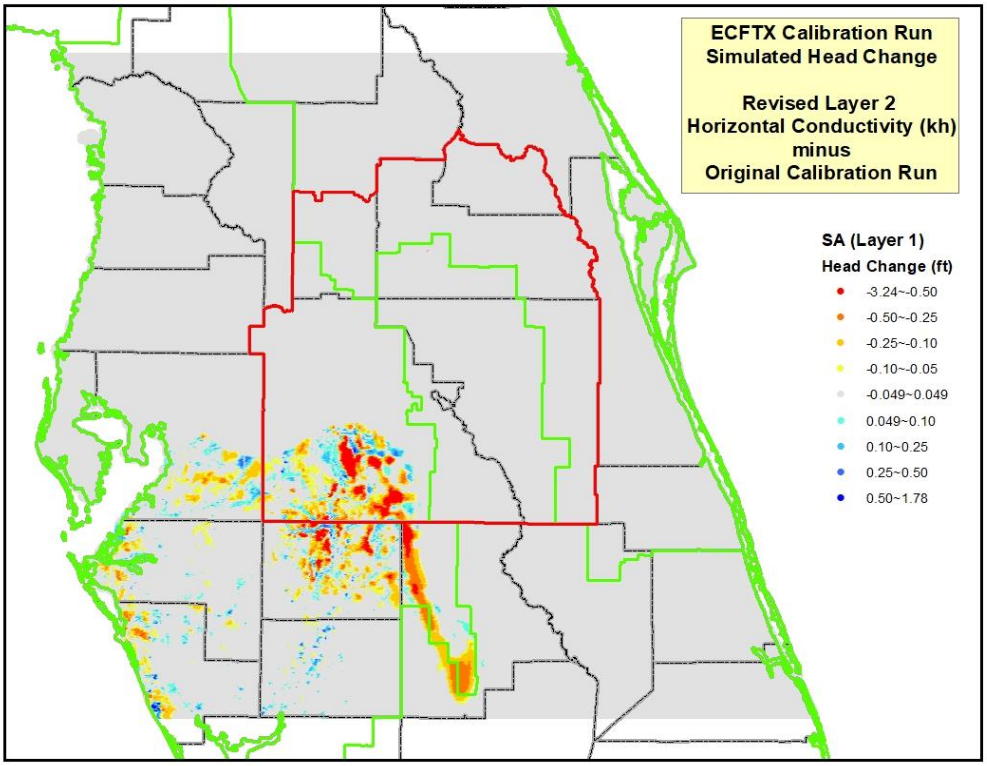

Figure 3. ECFTX Modified Layer 2 Kx Array

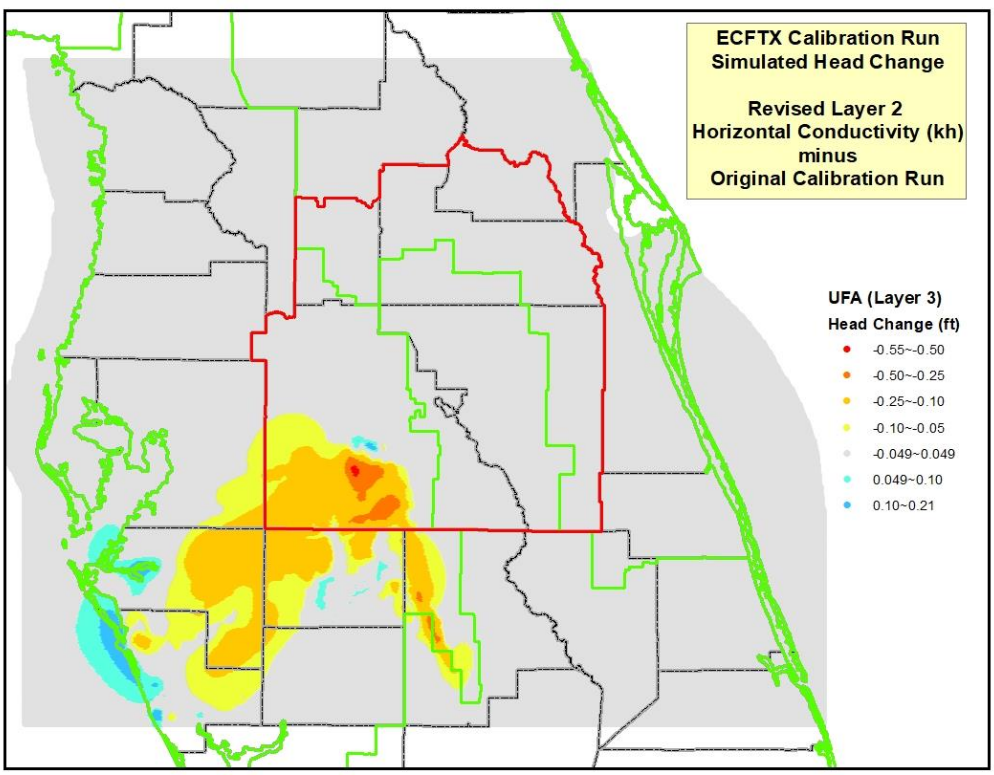

Figure 4. ECFTX Modified Layer 2 K

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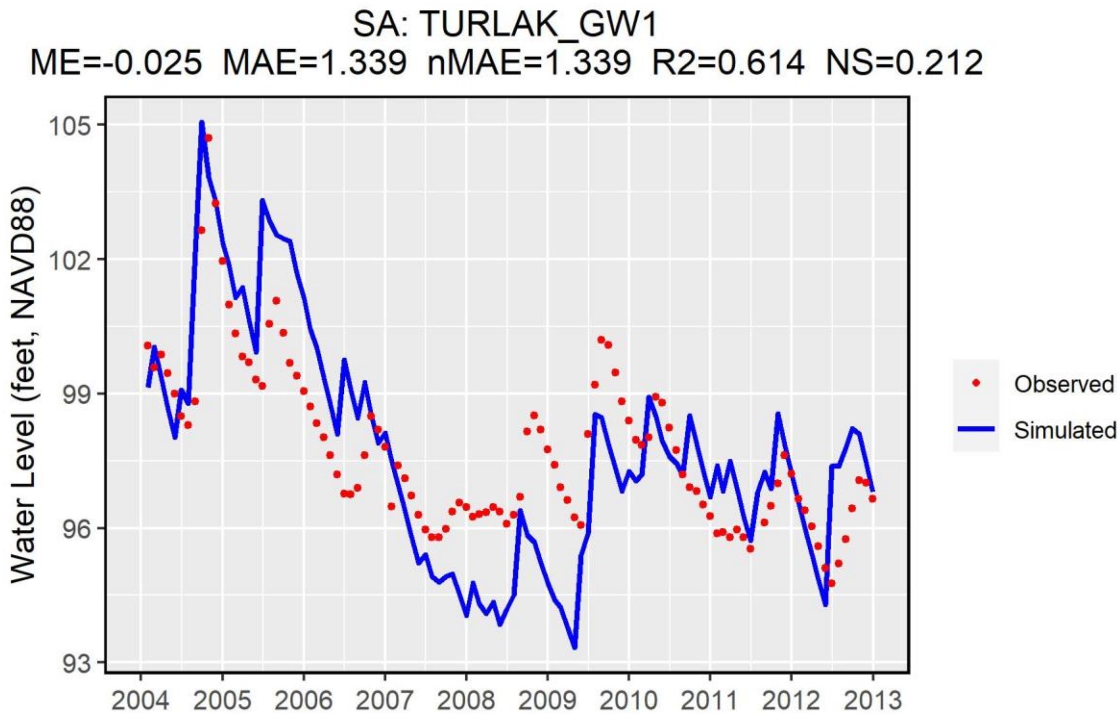
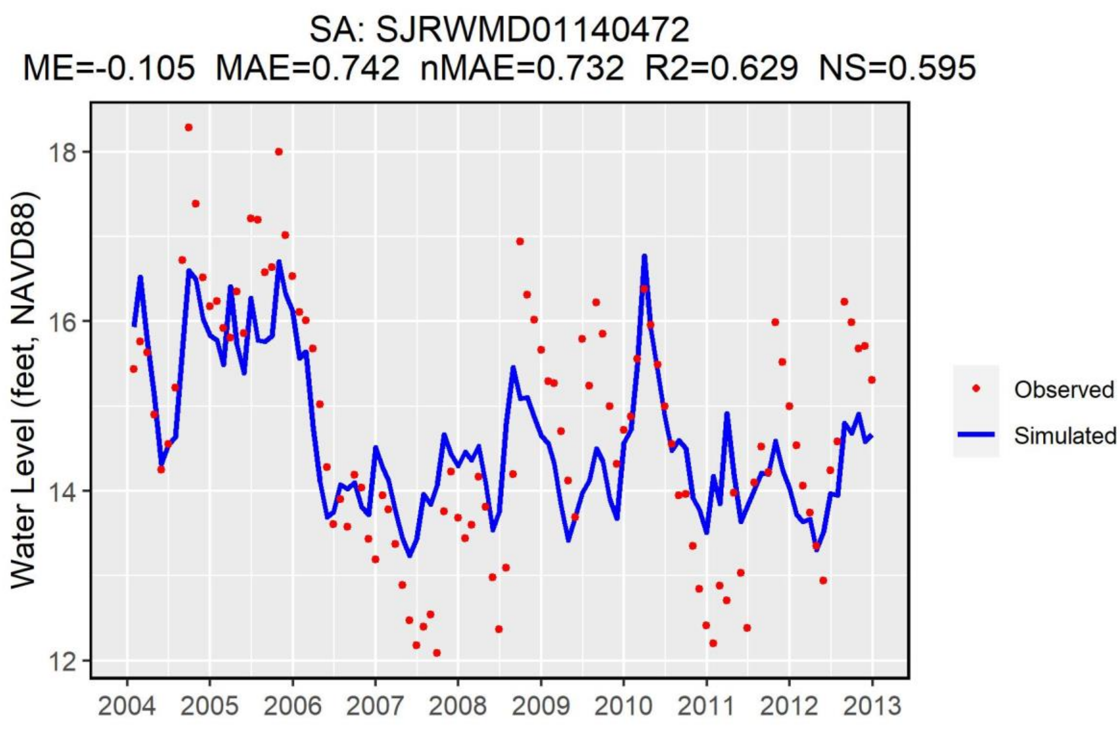
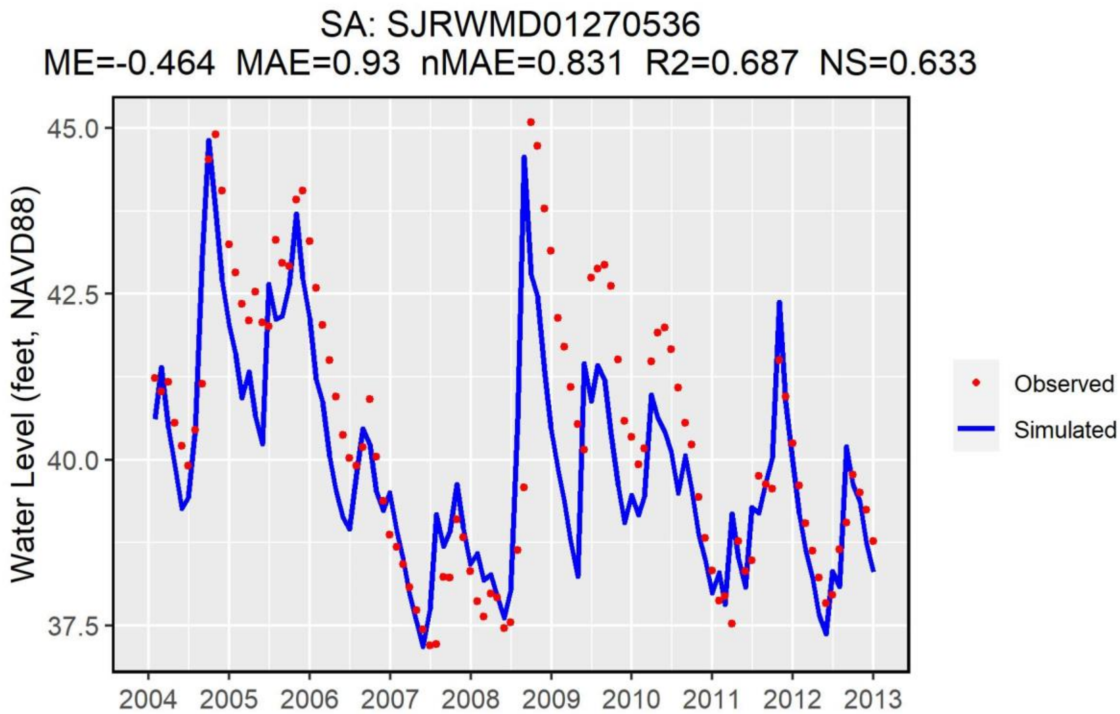
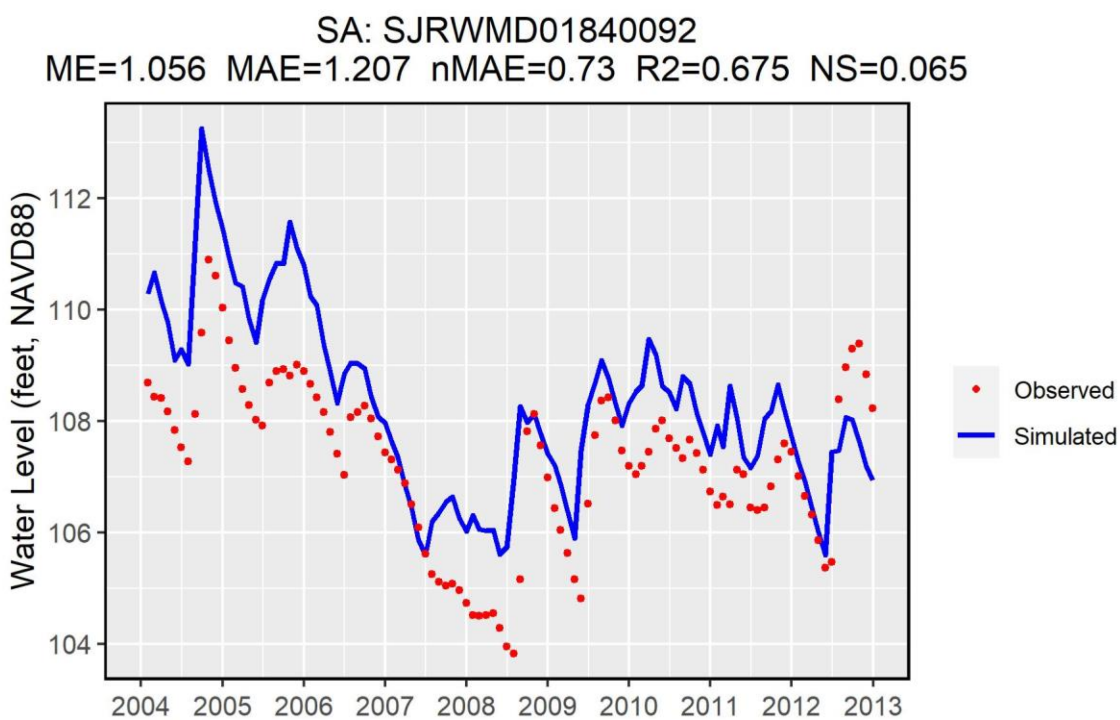
Appendix B – Simulated Versus Observed Water Level Hydrographs at Target Wells in Focus Area

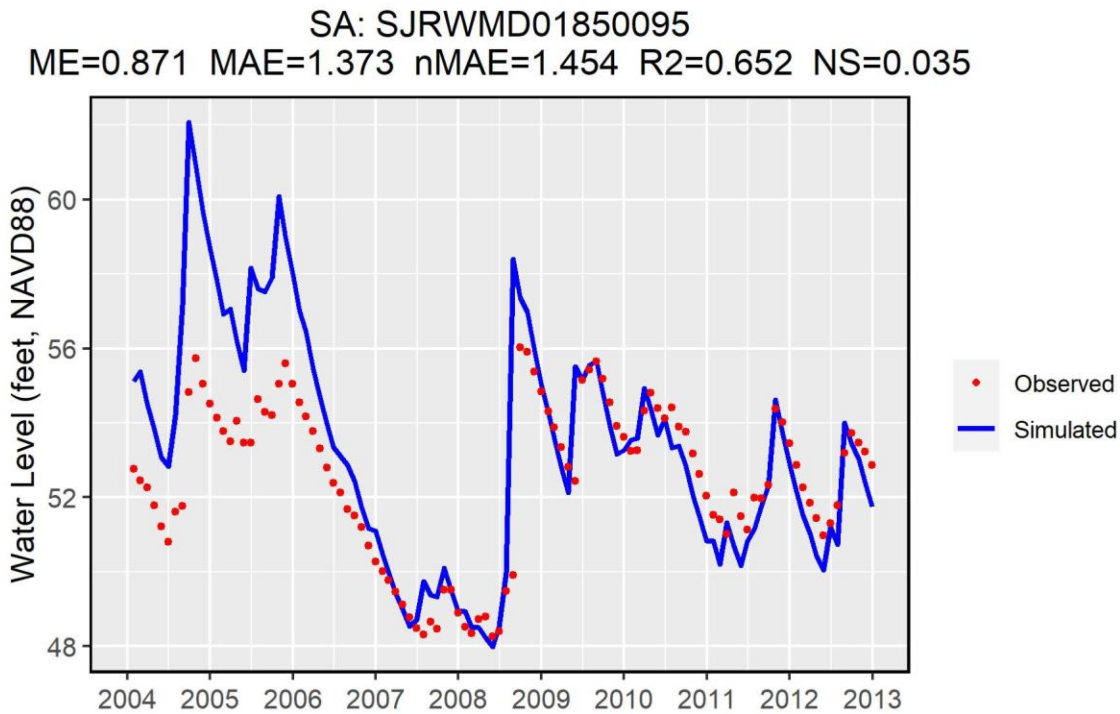
Surficial Aquifer (SA) Target Wells

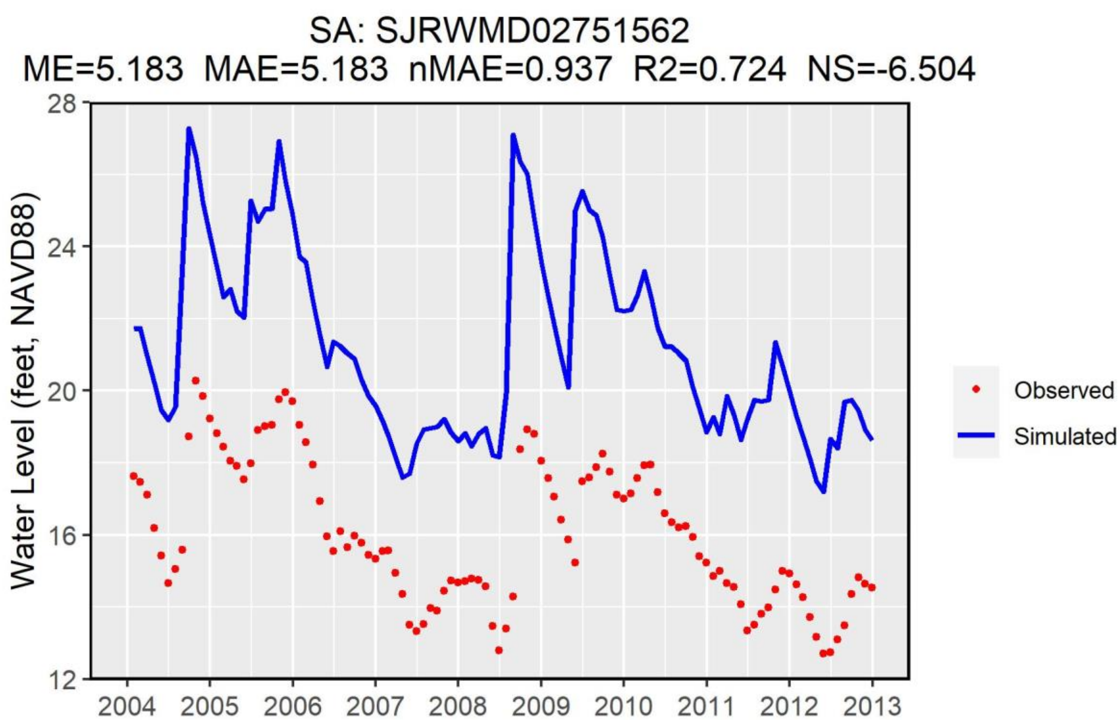


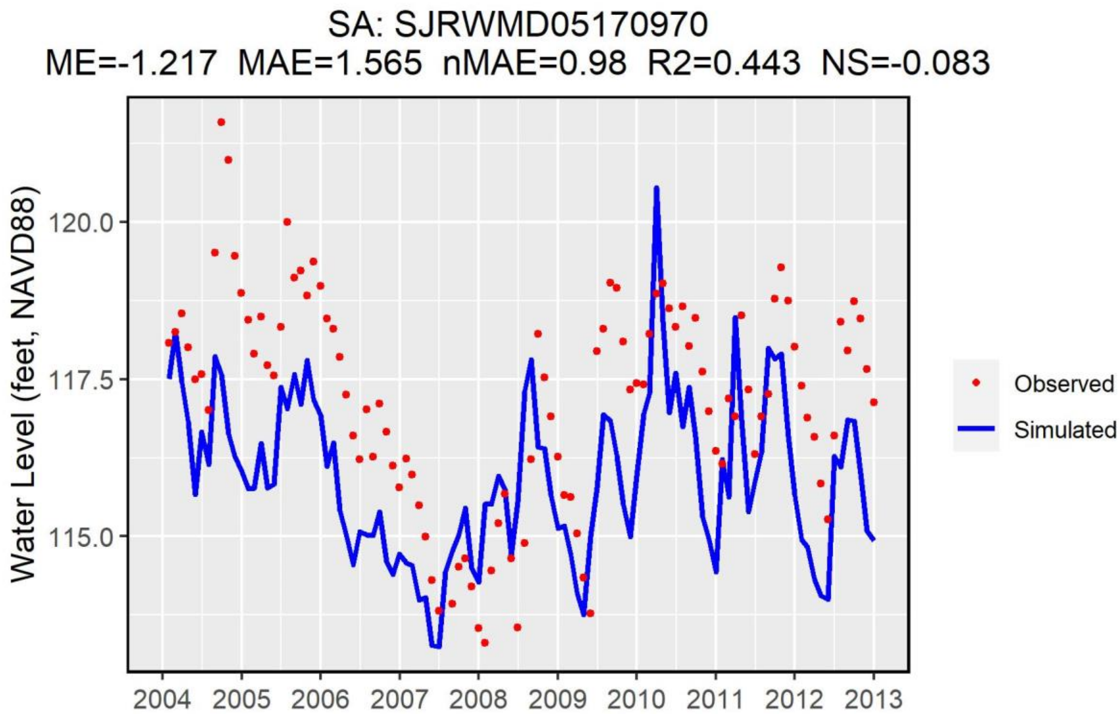


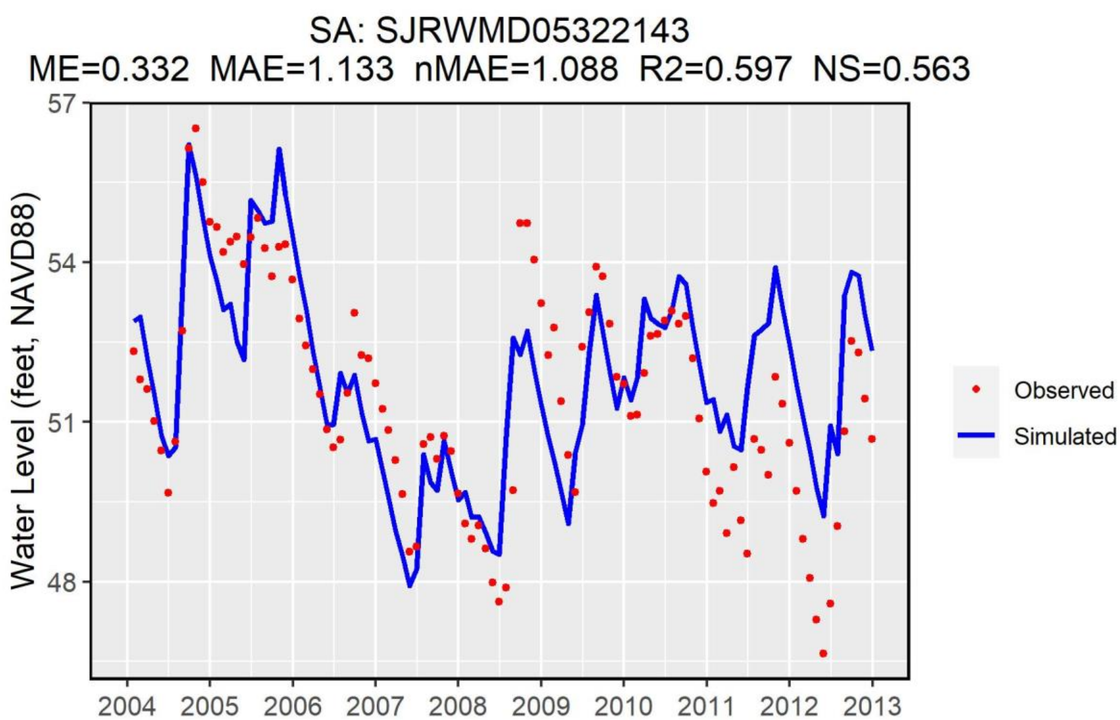

SA: SJRWMD01270536
ME=-0.464 MAE=0.93 nMAE=0.831 R2=0.687 NS=0.633
Water Level (feet, NAVD88)
45.0
42.5
40.0
37.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

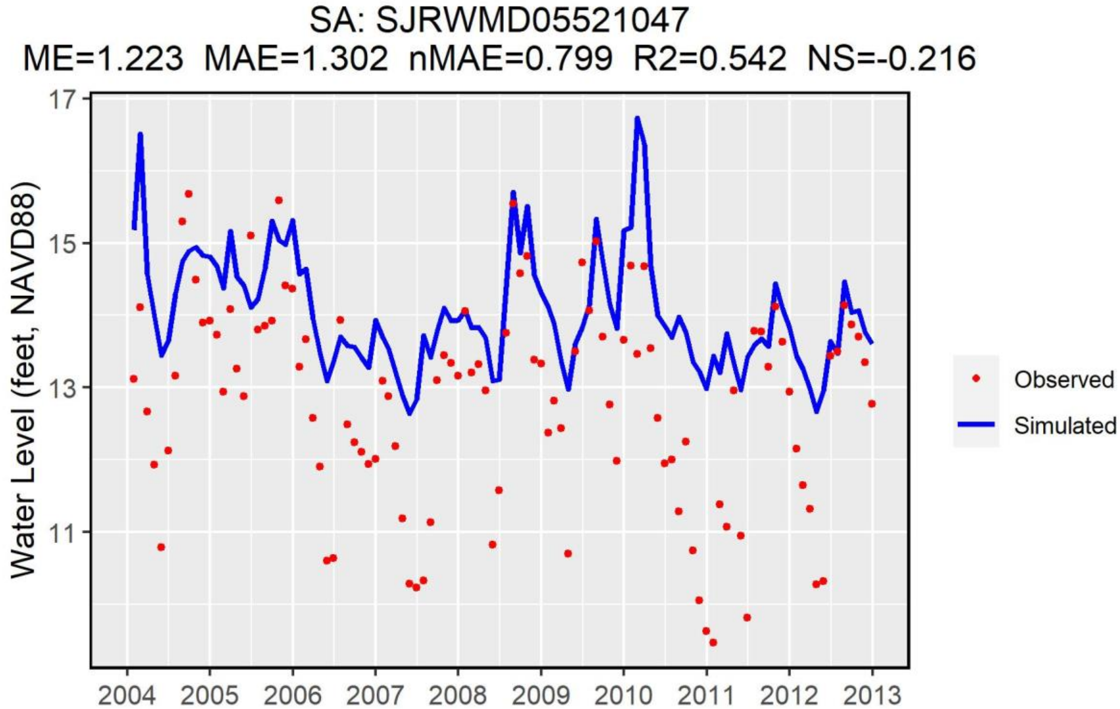

SA: SJRWMD01840092
ME=1.056 MAE=1.207 nMAE=0.73 R2=0.675 NS=0.065
Water Level (feet, NAVD88)
112
110
108
106
104
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

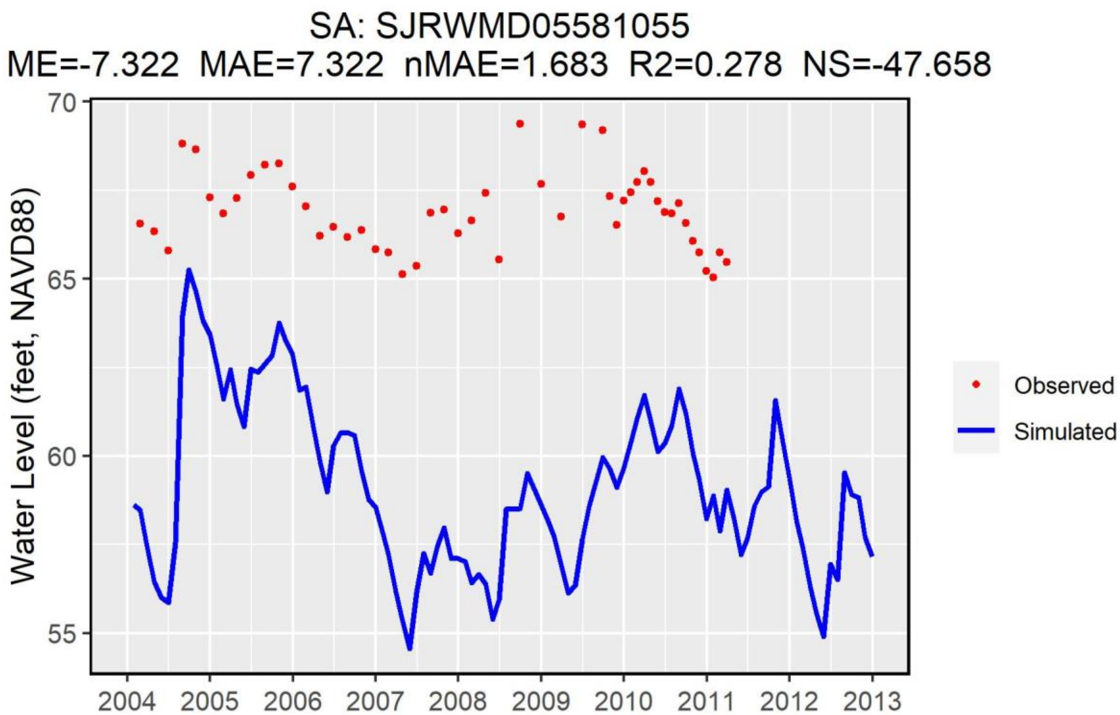

SA: SJRWMD01850095
ME=0.871 MAE=1.373 nMAE=1.454 R2=0.652 NS=0.035
Water Level (feet, NAVD88)
60
56
52
48
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

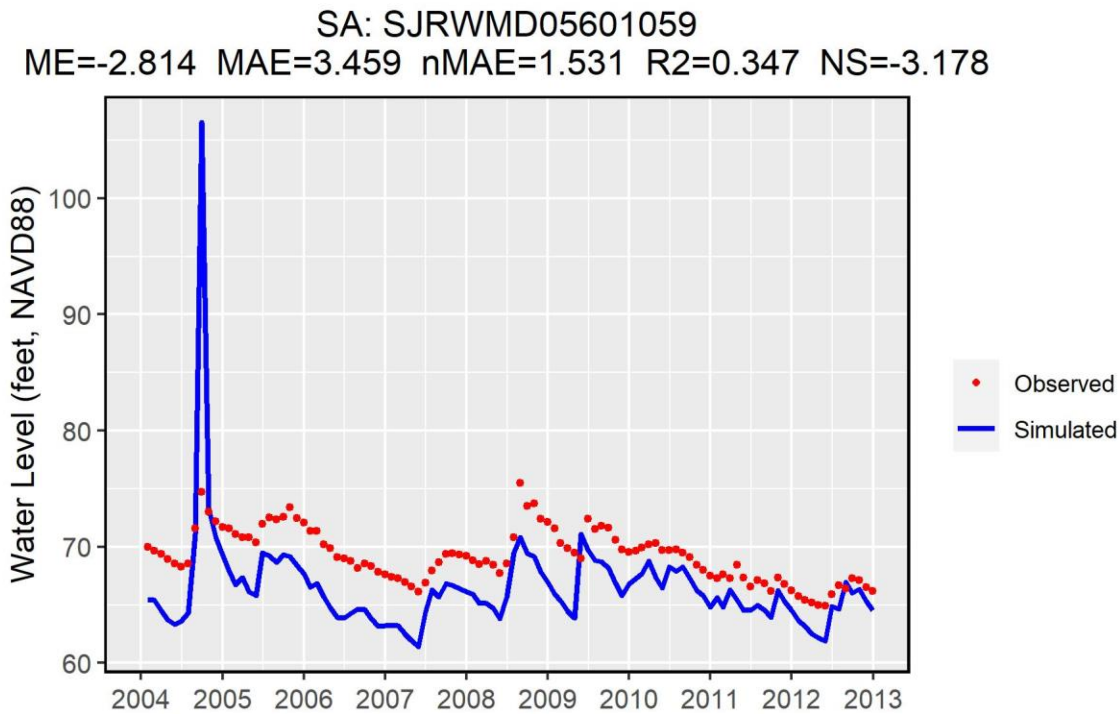

SA: SJRWMD02751562
ME=5.183 MAE=5.183 nMAE=0.937 R2=0.724 NS=-6.504
Water Level (feet, NAVD88)
28
24
20
16
12
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

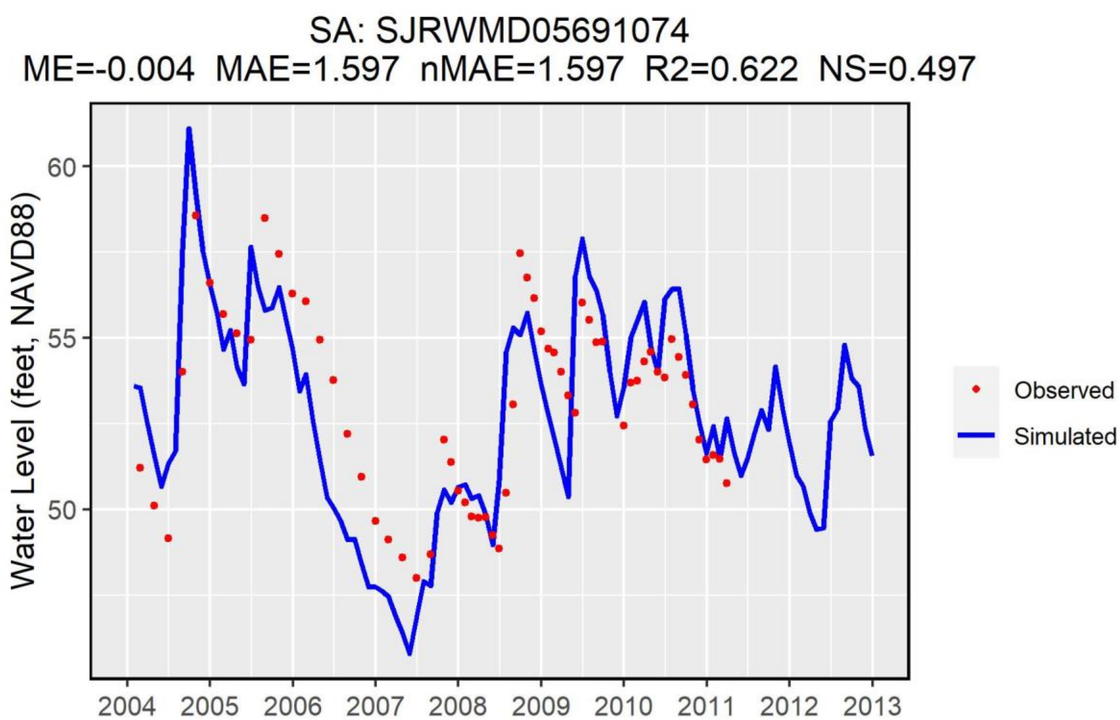

SA: SJRWMD05170970
ME=-1.217 MAE=1.565 nMAE=0.98 R2=0.443 NS=-0.083
Water Level (feet, NAVD88)
120.0
117.5
115.0
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

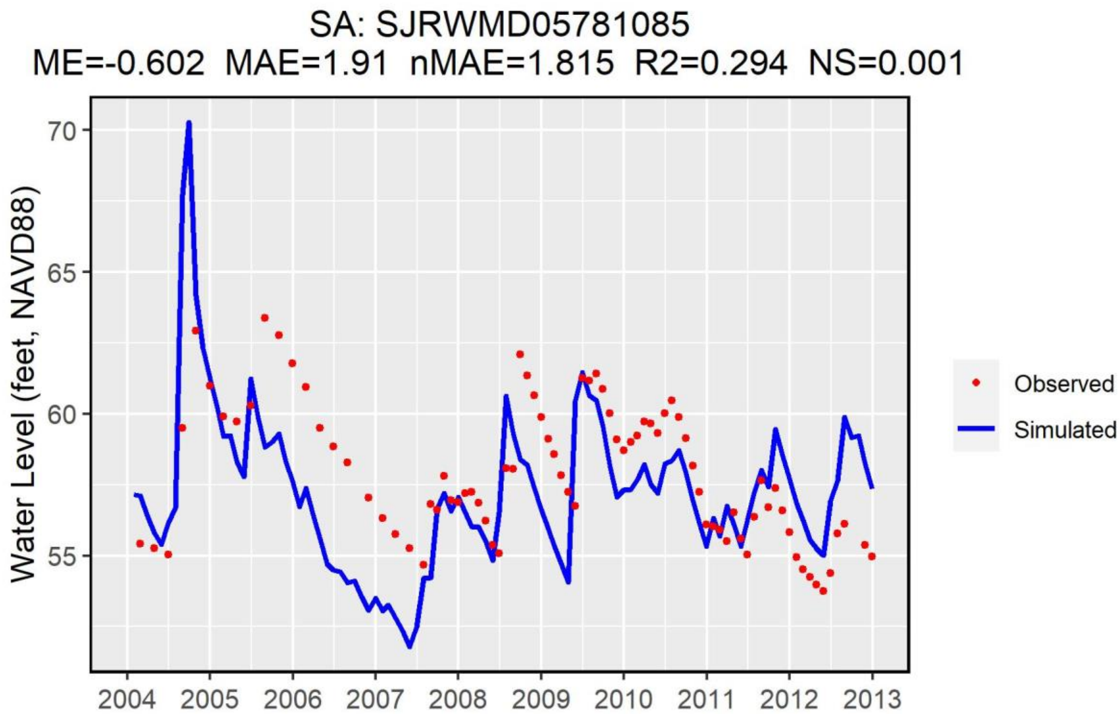

SA: SJRWMD05322143
ME=0.332 MAE=1.133 nMAE=1.088 R2=0.597 NS=0.563
Water Level (feet, NAVD88)
57
54
51
48
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

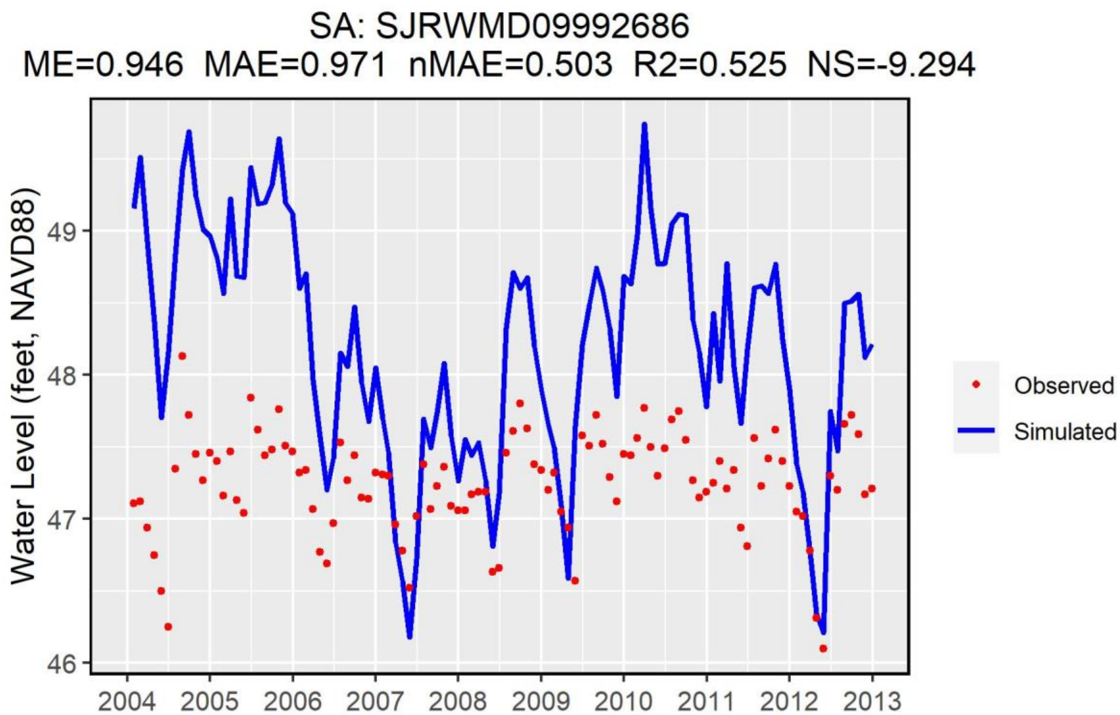

SA: SJRWMD05521047
ME=1.223 MAE=1.302 nMAE=0.799 R2=0.542 NS=-0.216
Water Level (feet, NAVD88)
17
15
13
11
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

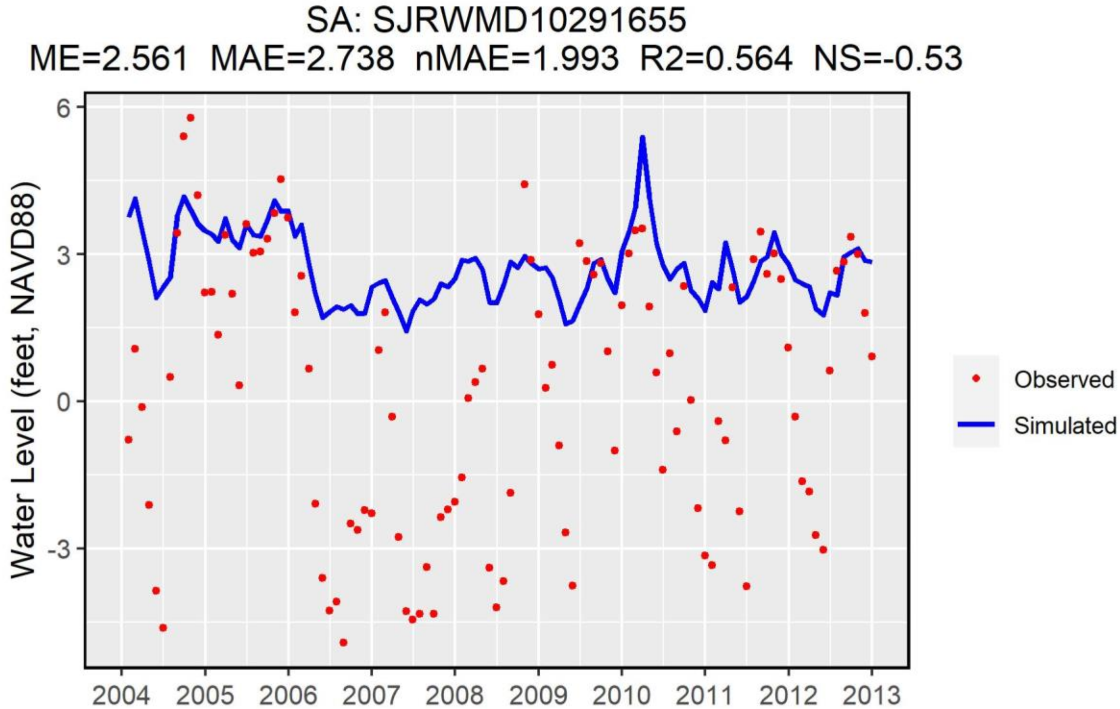

SA: SJRWMD05581055
ME=-7.322 MAE=7.322 nMAE=1.683 R2=0.278 NS=-47.658
Water Level (feet, NAVD88)
70
65
60
55
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

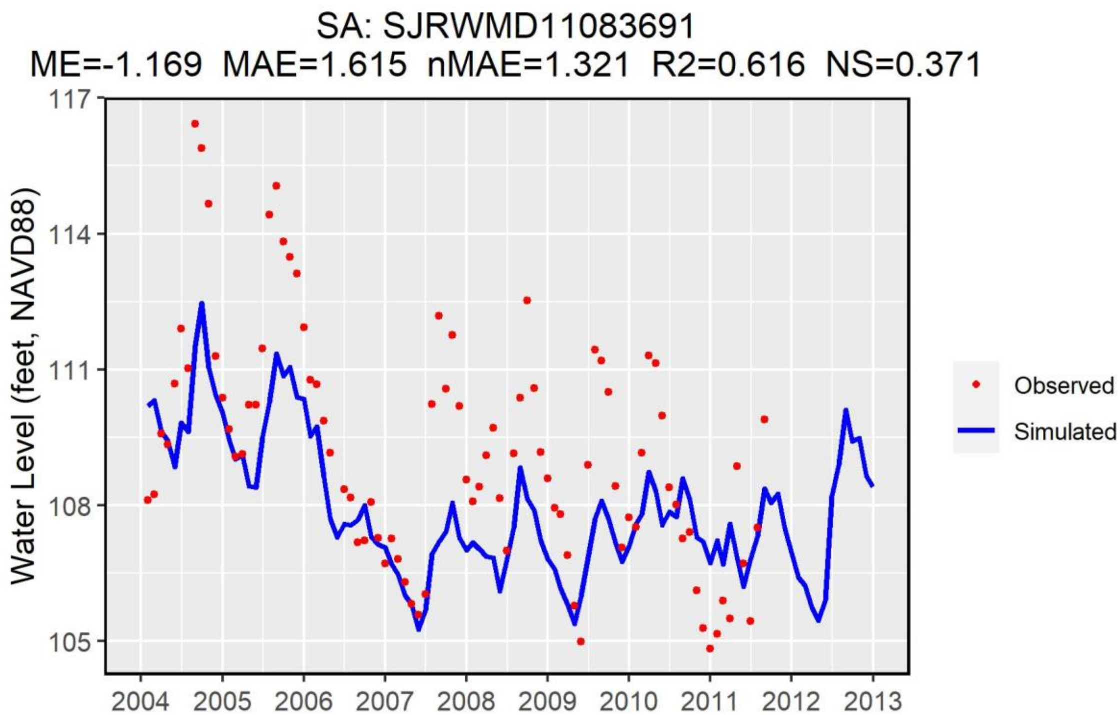

SA: SJRWMD05601059
ME=-2.814 MAE=3.459 nMAE=1.531 R2=0.347 NS=-3.178
Water Level (feet, NAVD88)
100
90
80
70
60
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

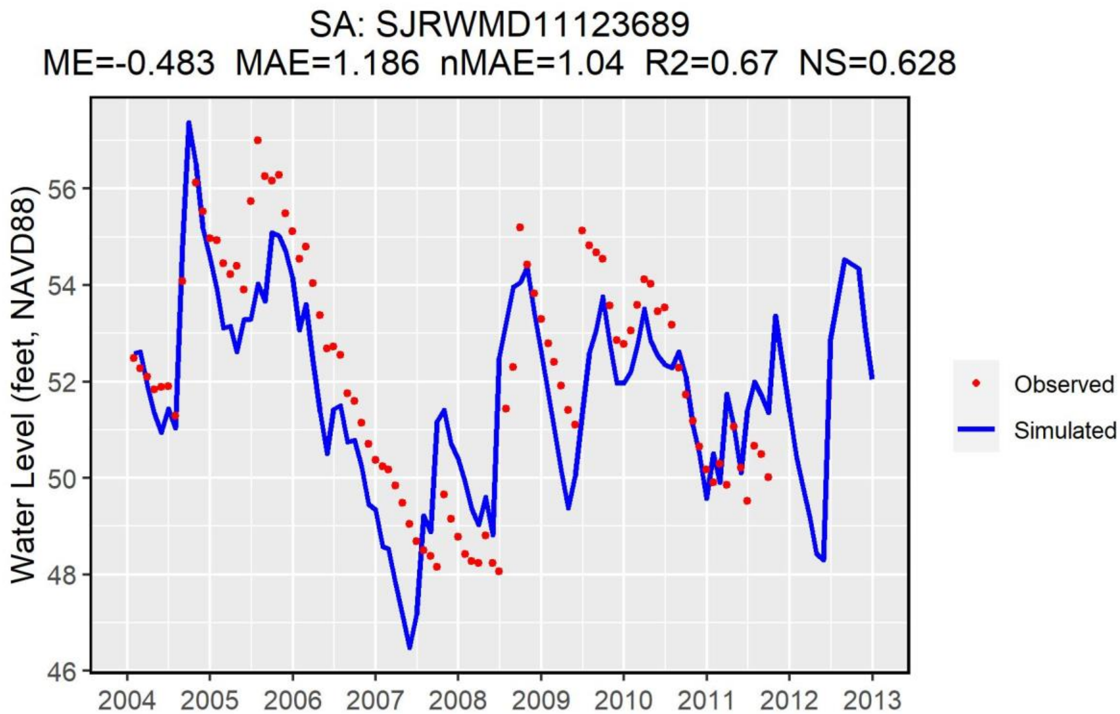

SA: SJRWMD05691074
ME=-0.004 MAE=1.597 nMAE=1.597 R2=0.622 NS=0.497
Water Level (feet, NAVD88)
60
55
50
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

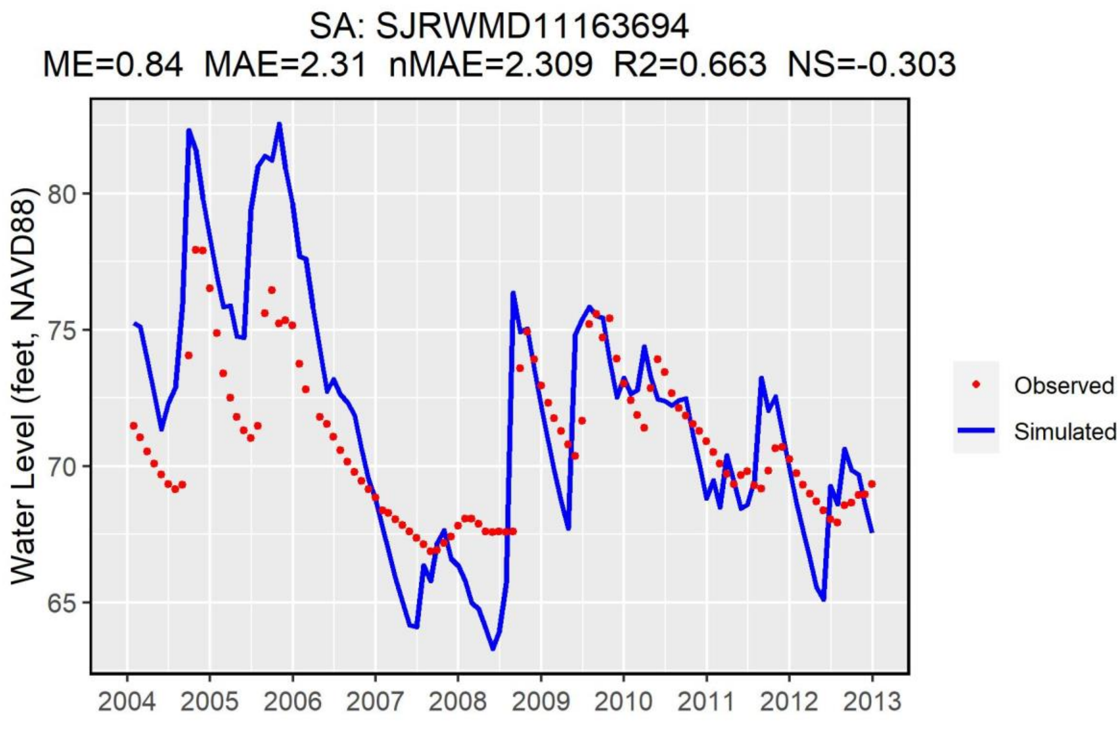

SA: SJRWMD05781085
ME=-0.602 MAE=1.91 nMAE=1.815 R2=0.294 NS=0.001
Water Level (feet, NAVD88)
70
65
60
55
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

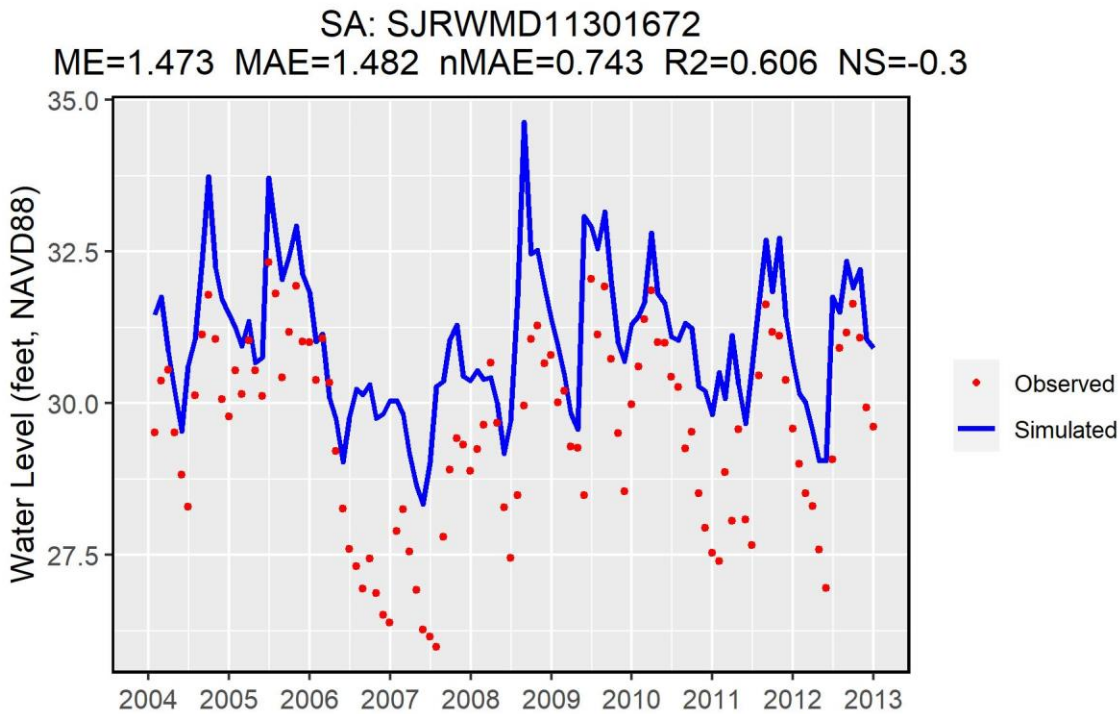

SA: SJRWMD09992686
ME=0.946 MAE=0.971 nMAE=0.503 R2=0.525 NS=-9.294
Water Level (feet, NAVD88)
49
48
47
46
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

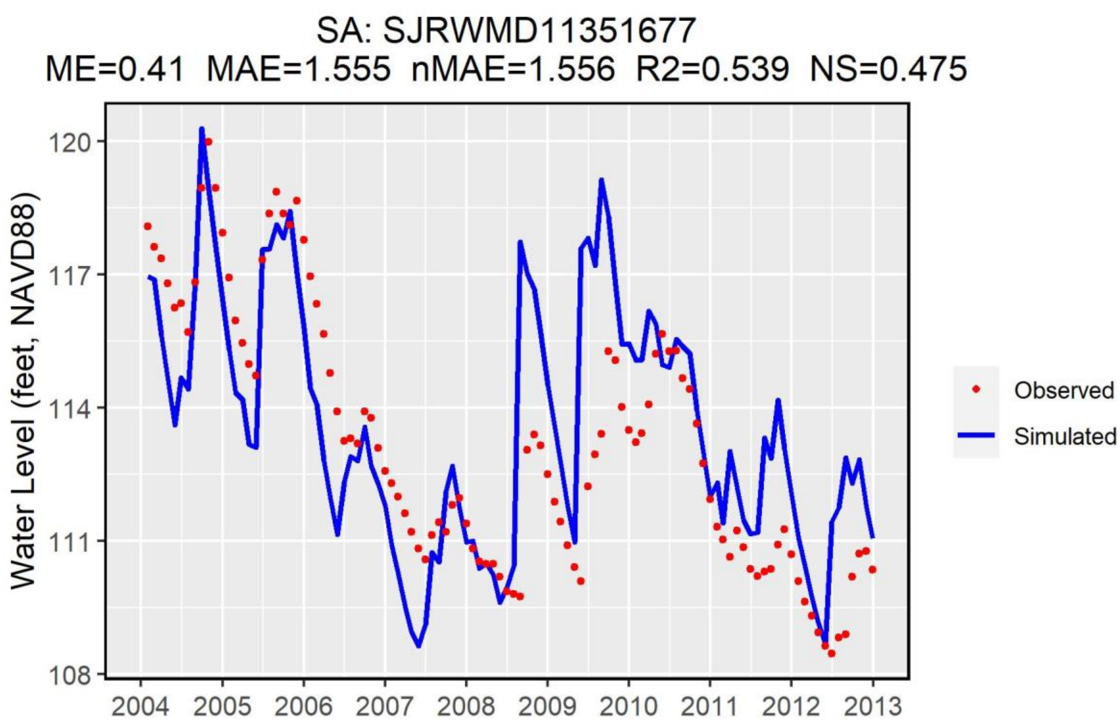

SA: SJRWMD10291655
ME=2.561 MAE=2.738 nMAE=1.993 R2=0.564 NS=-0.53
Water Level (feet, NAVD88)
6
3
0
-3
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

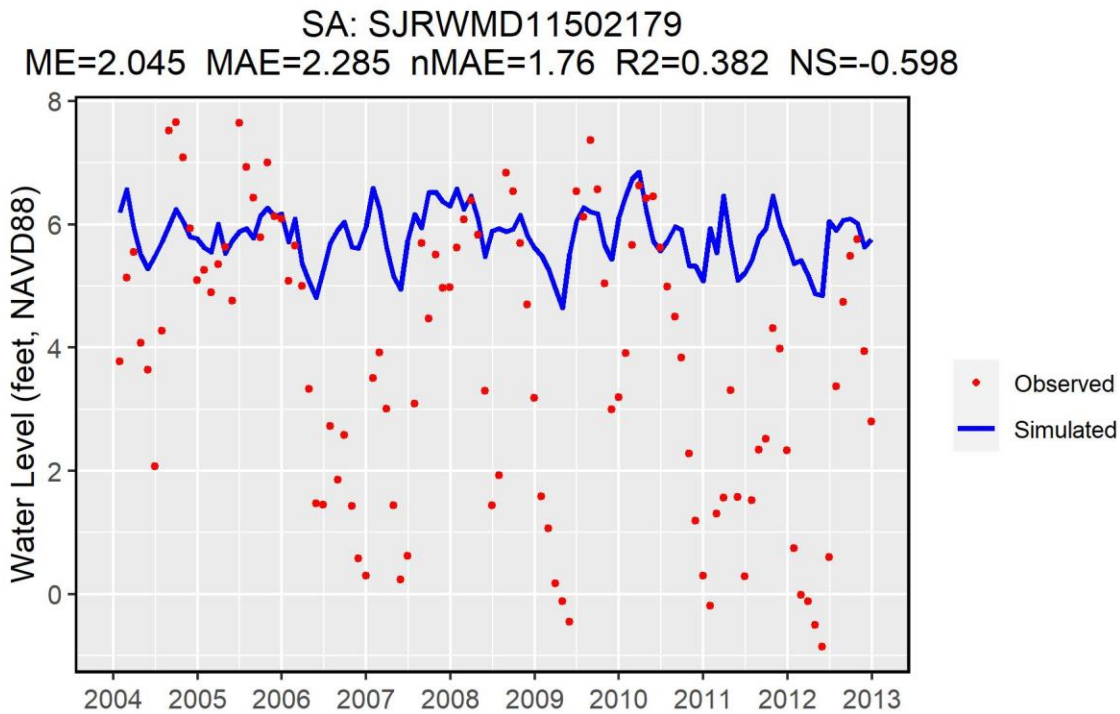

SA: SJRWMD11083691
ME=-1.169 MAE=1.615 nMAE=1.321 R2=0.616 NS=0.371
Water Level (feet, NAVD88)
117
114
111
108
105
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

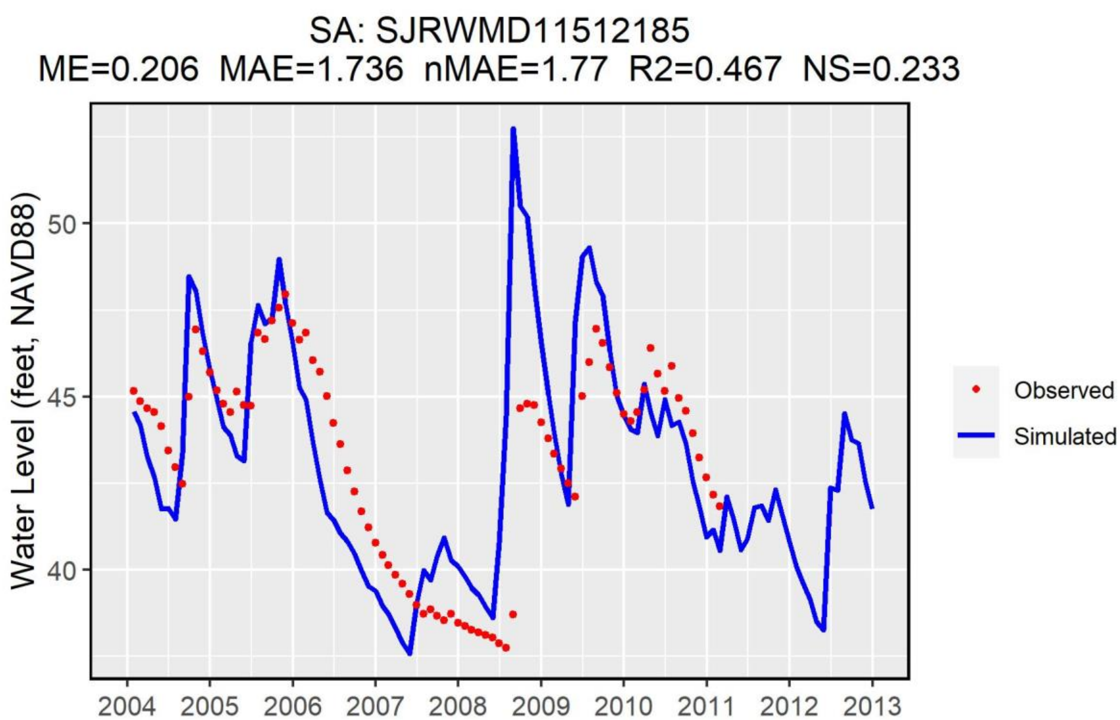

SA: SJRWMD11123689
ME=-0.483 MAE=1.186 nMAE=1.04 R2=0.67 NS=0.628
Water Level (feet, NAVD88)
56
54
52
50
48
46
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

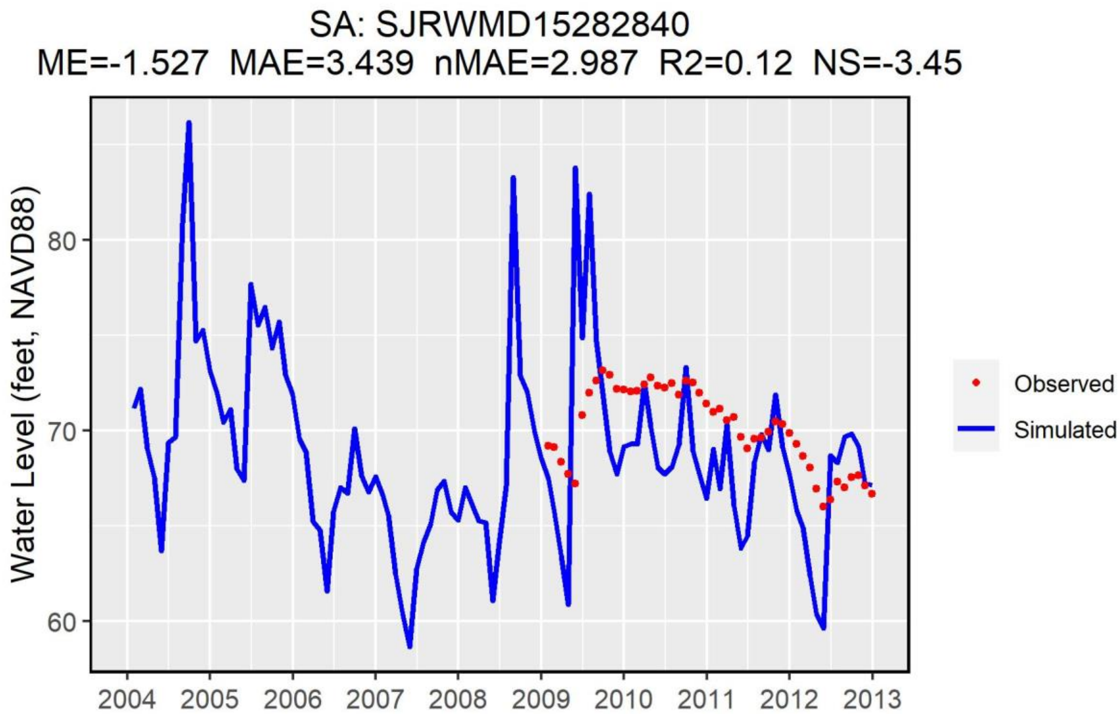

SA: SJRWMD11163694
ME=0.84 MAE=2.31 nMAE=2.309 R2=0.663 NS=-0.303
Water Level (feet, NAVD88)
80
75
70
65
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

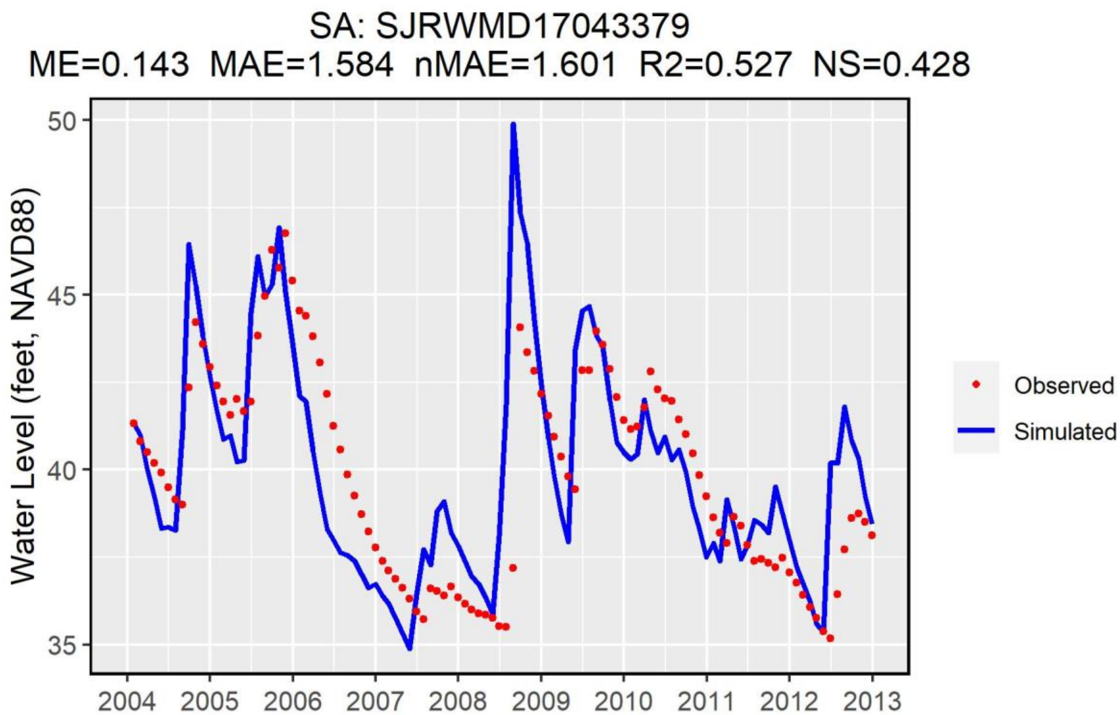

SA: SJRWMD11301672
ME=1.473 MAE=1.482 nMAE=0.743 R2=0.606 NS=-0.3
Water Level (feet, NAVD88)
35.0
32.5
30.0
27.5
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

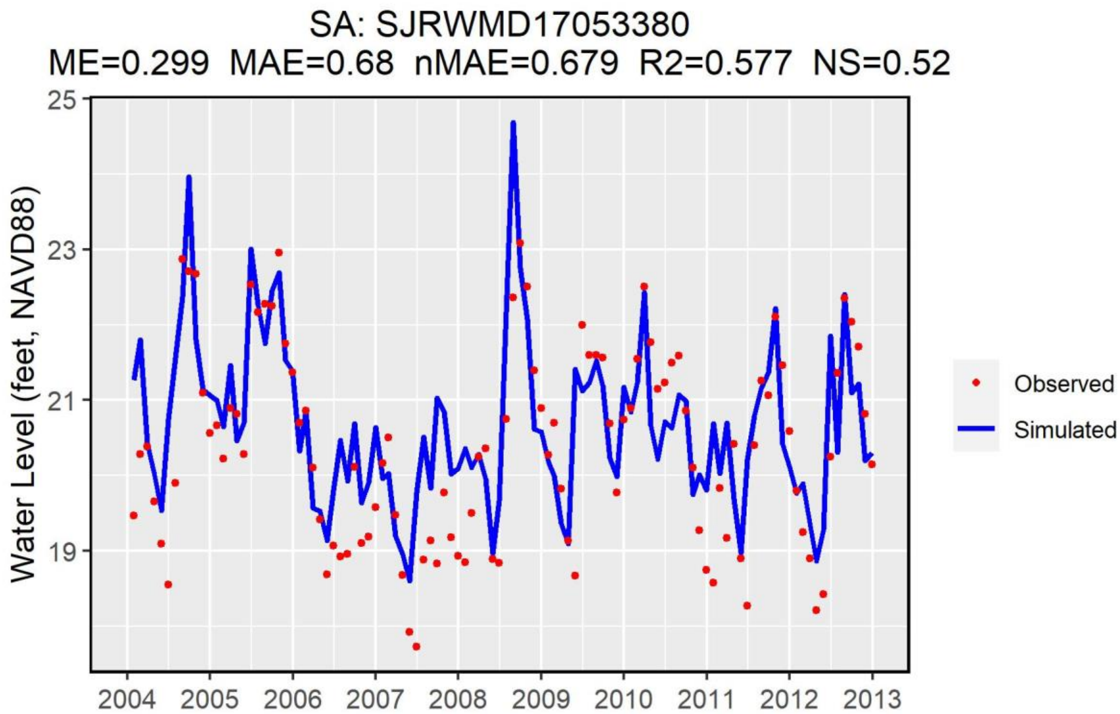

SA: SJRWMD11351677
ME=0.41 MAE=1.555 nMAE=1.556 R2=0.539 NS=0.475
Water Level (feet, NAVD88)
120
117
114
111
108
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

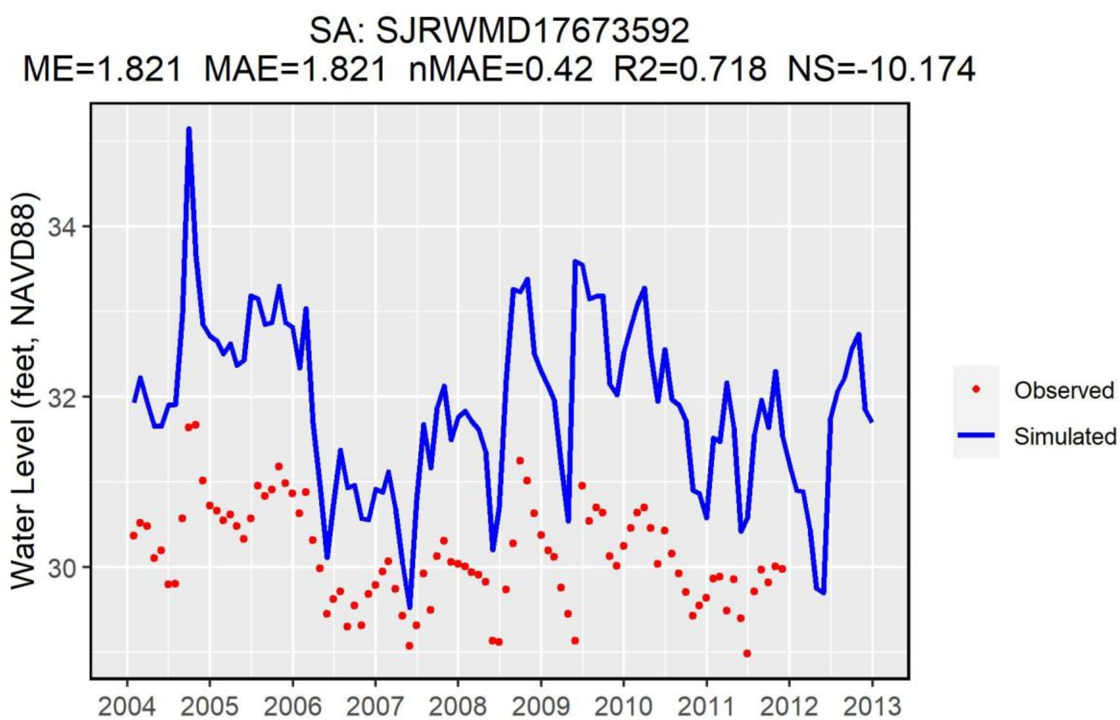

SA: SJRWMD11502179
ME=2.045 MAE=2.285 nMAE=1.76 R2=0.382 NS=-0.598
Water Level (feet, NAVD88)
Observed
Simulated

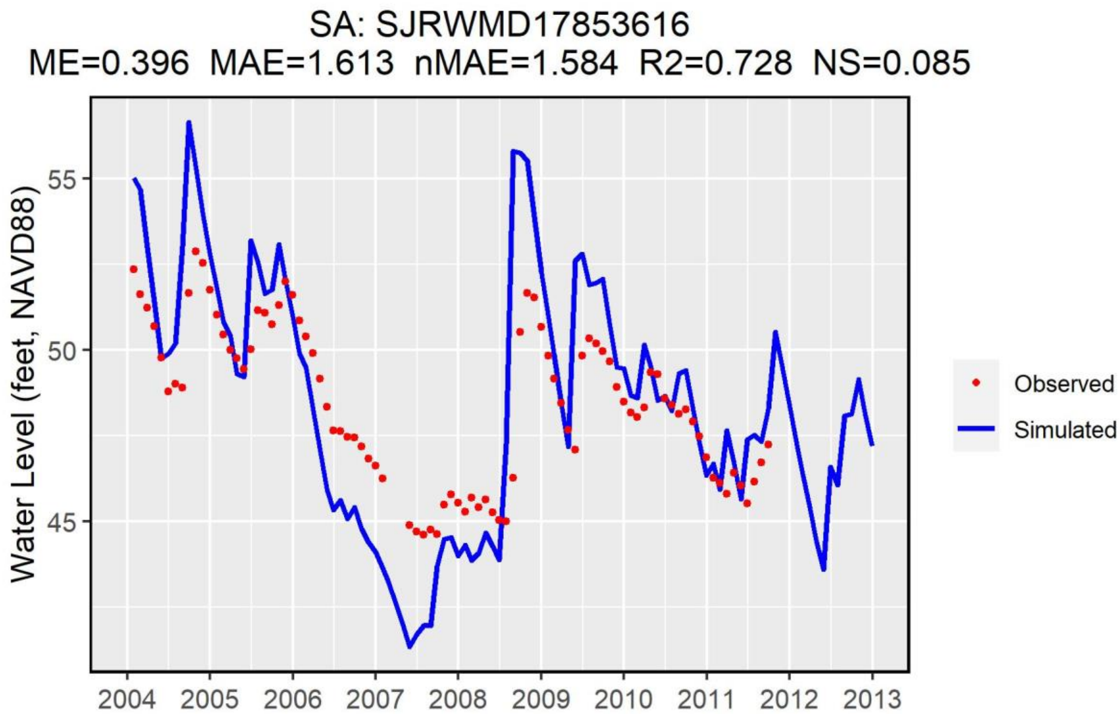

SA: SJRWMD11512185
ME=0.206 MAE=1.736 nMAE=1.77 R2=0.467 NS=0.233
Water Level (feet, NAVD88)
Observed
Simulated

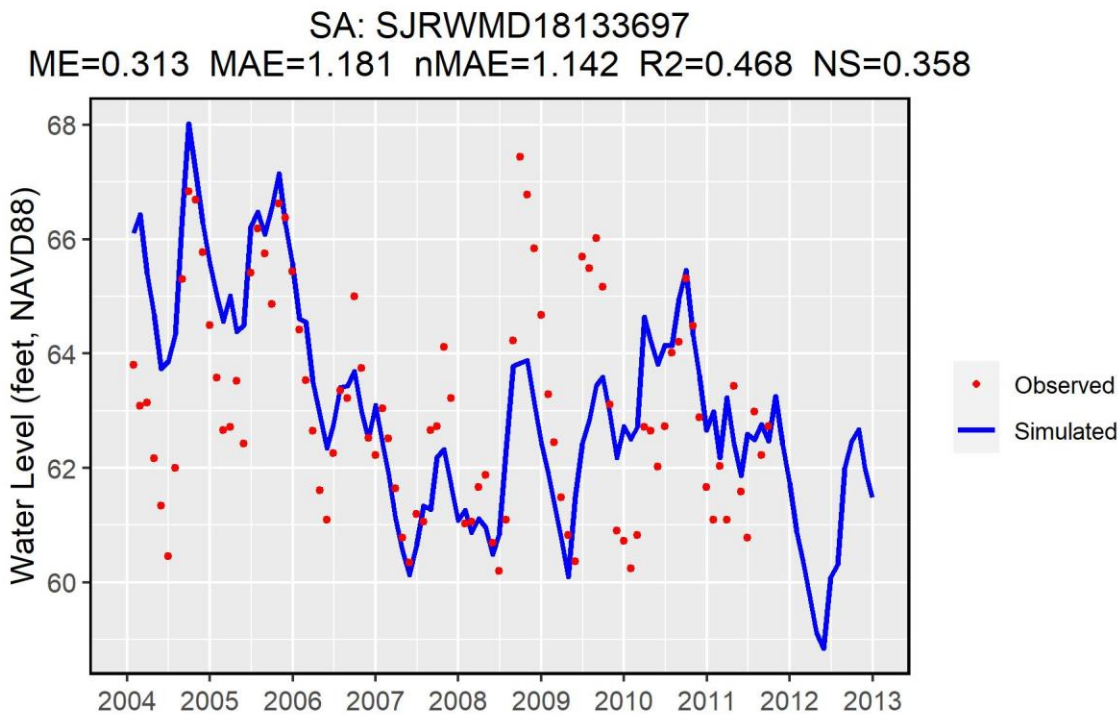

SA: SJRWMD15282840
ME=-1.527 MAE=3.439 nMAE=2.987 R2=0.12 NS=-3.45
Water Level (feet, NAVD88)
60
70
80
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

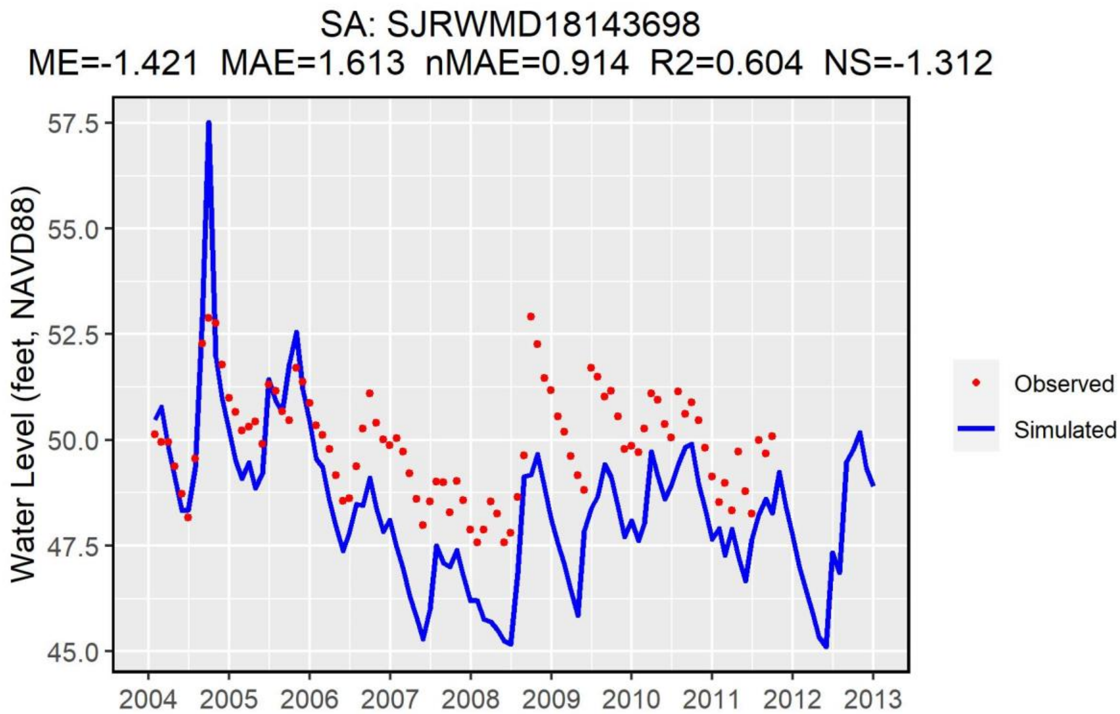

SA: SJRWMD17043379
ME=0.143 MAE=1.584 nMAE=1.601 R2=0.527 NS=0.428
Water Level (feet, NAVD88)
35
40
45
50
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

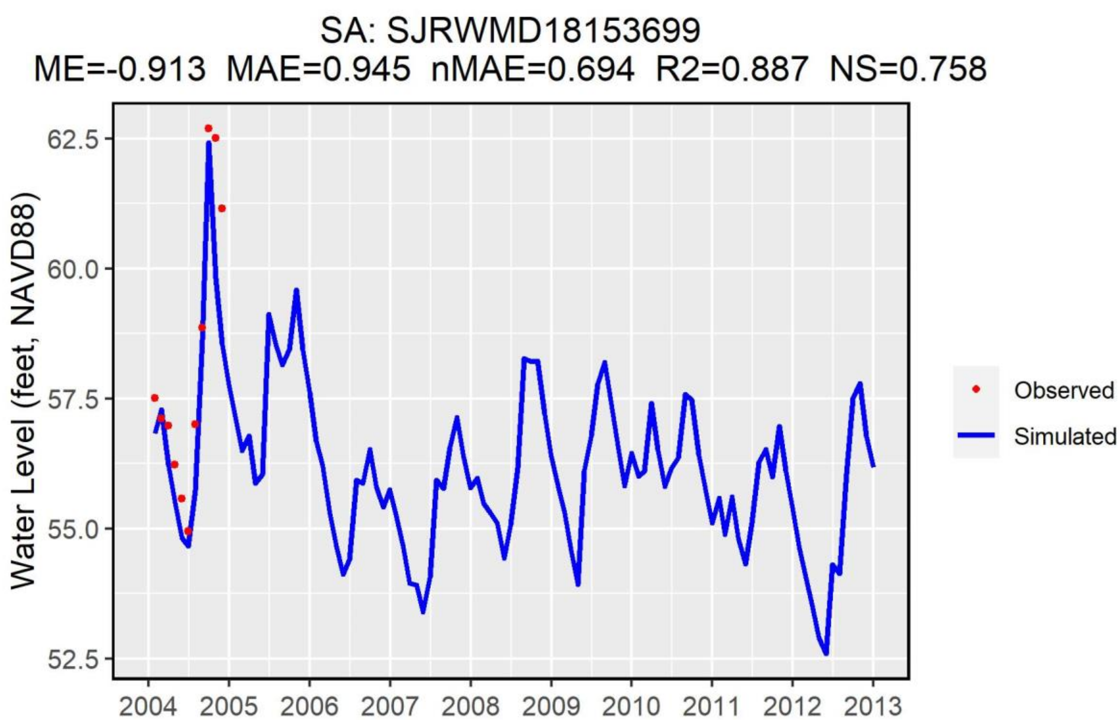

SA: SJRWMD17053380
ME=0.299 MAE=0.68 nMAE=0.679 R2=0.577 NS=0.52
Water Level (feet, NAVD88)
25
23
21
19
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

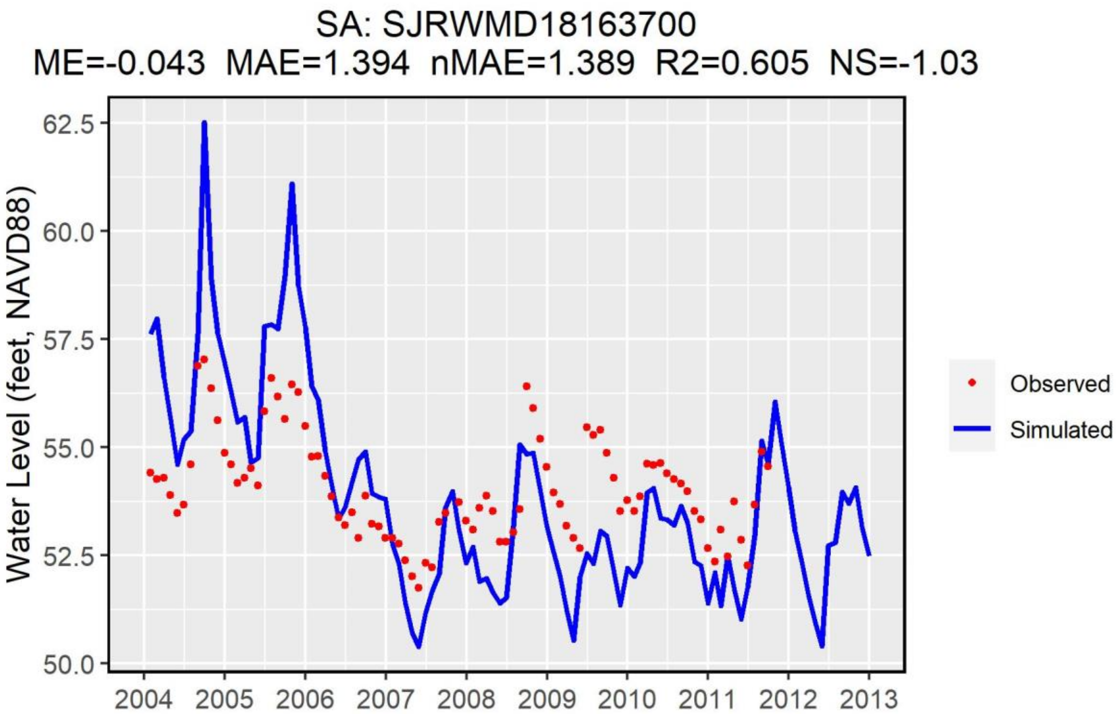

SA: SJRWMD17673592
ME=1.821 MAE=1.821 nMAE=0.42 R2=0.718 NS=-10.174
Water Level (feet, NAVD88)
34
32
30
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

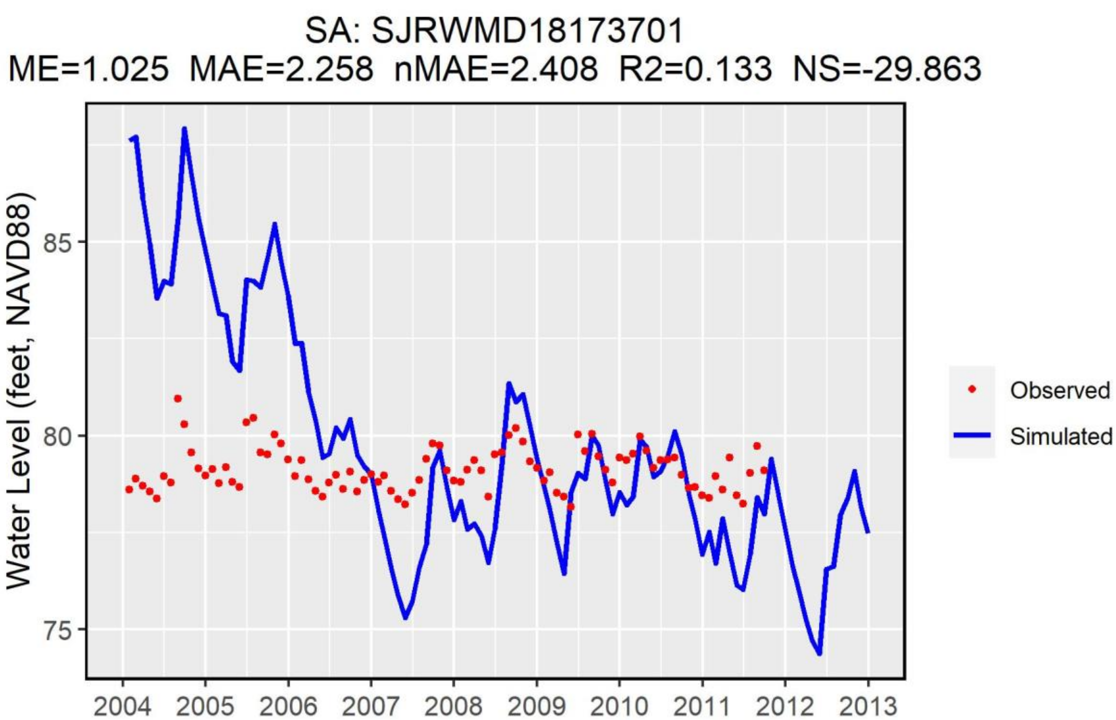

SA: SJRWMD17853616
ME=0.396 MAE=1.613 nMAE=1.584 R2=0.728 NS=0.085
Water Level (feet, NAVD88)
55
50
45
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

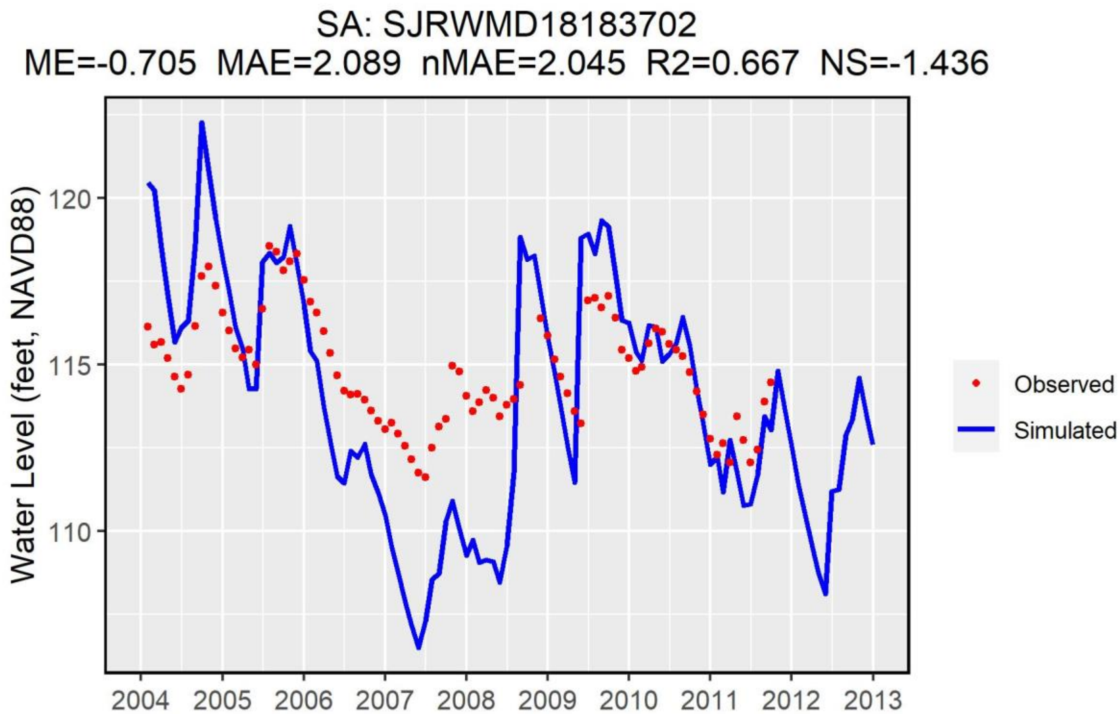

SA: SJRWMD18133697
ME=0.313 MAE=1.181 nMAE=1.142 R2=0.468 NS=0.358
Water Level (feet, NAVD88)
68
66
64
62
60
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

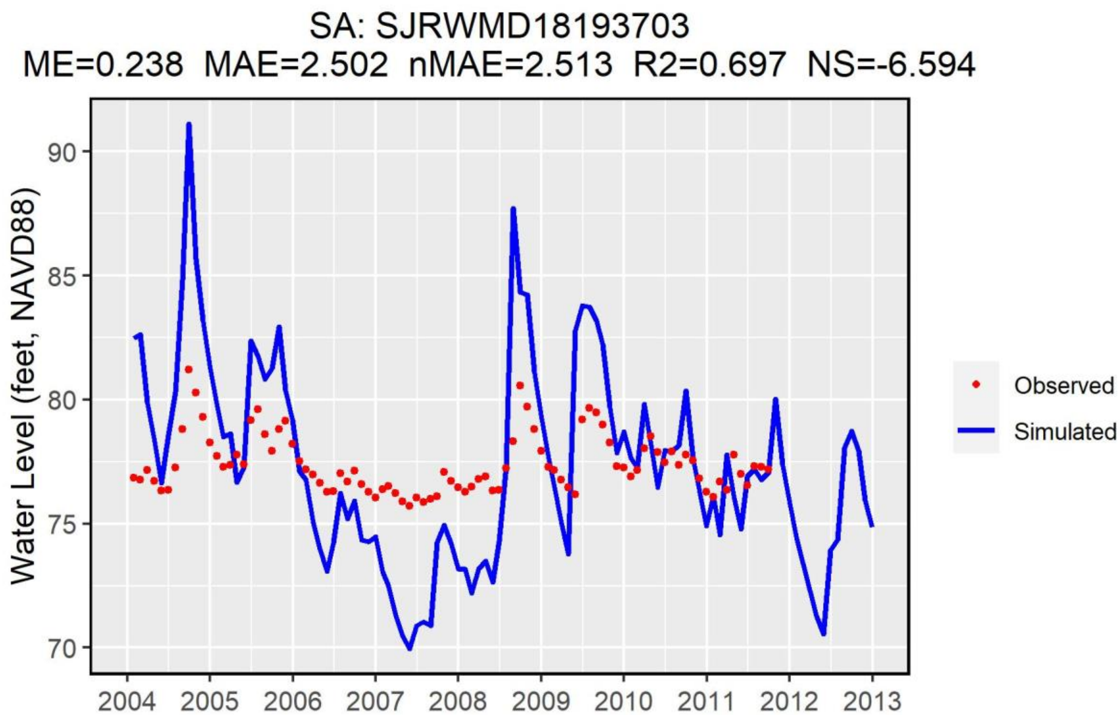

SA: SJRWMD18143698
ME=-1.421 MAE=1.613 nMAE=0.914 R2=0.604 NS=-1.312
Water Level (feet, NAVD88)
57.5
55.0
52.5
50.0
47.5
45.0
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

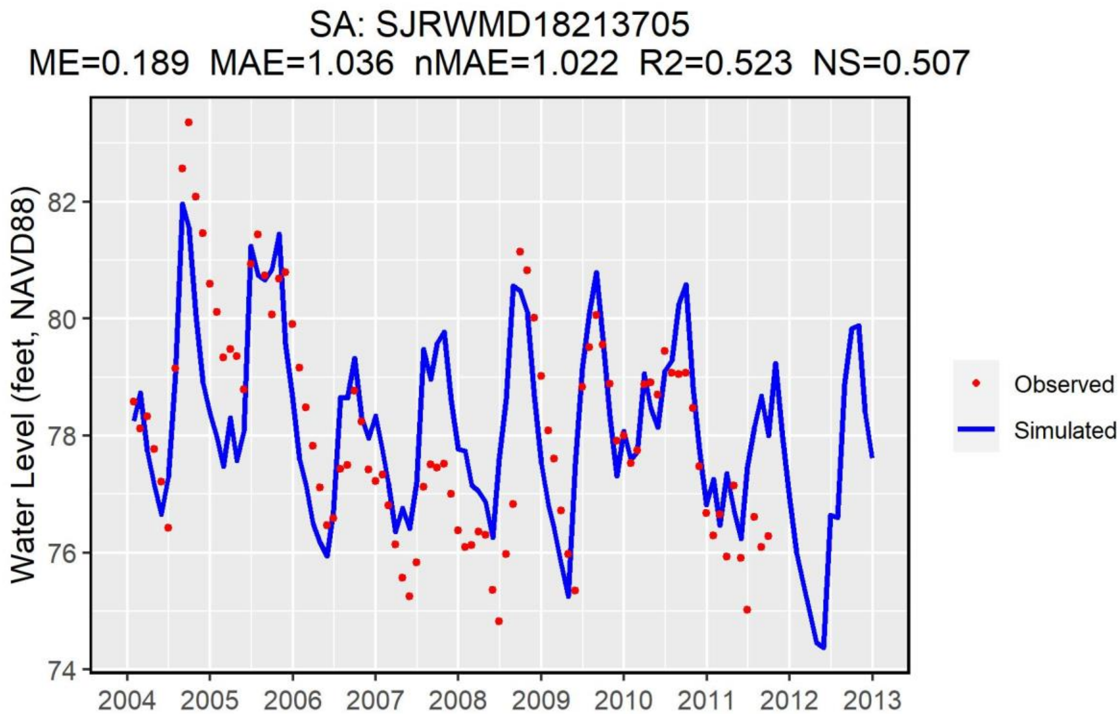

SA: SJRWMD18153699
ME=-0.913 MAE=0.945 nMAE=0.694 R2=0.887 NS=0.758
Water Level (feet, NAVD88)
62.5
60.0
57.5
55.0
52.5
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

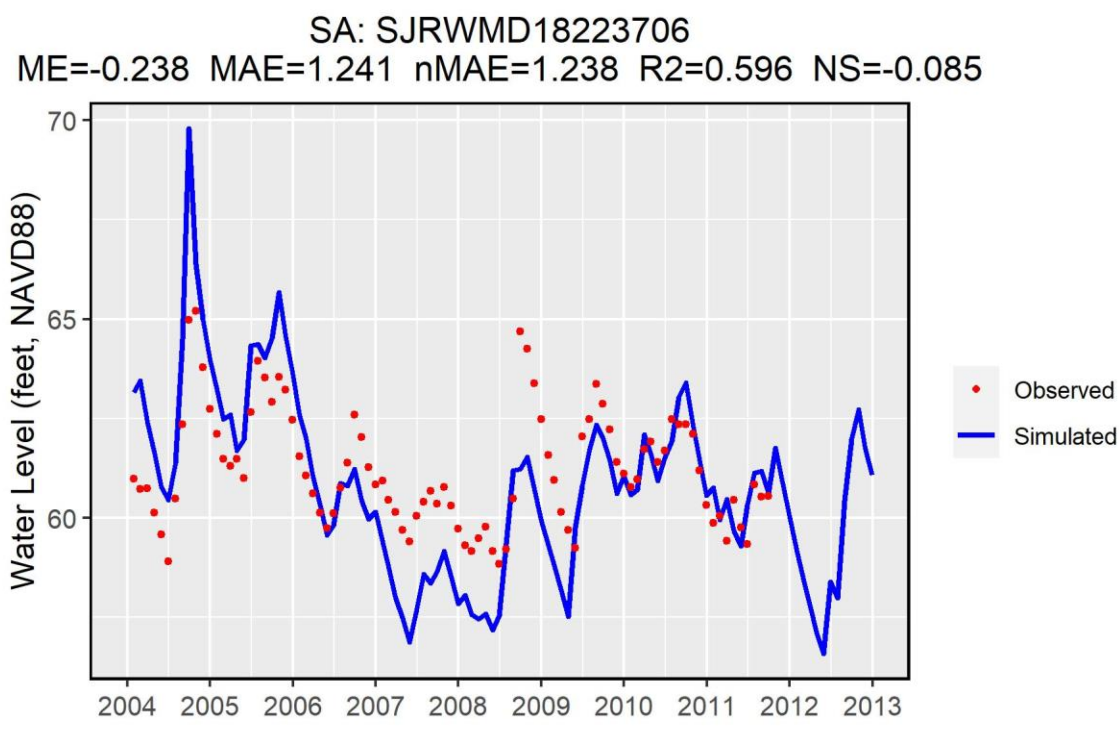

SA: SJRWMD18163700
ME=-0.043 MAE=1.394 nMAE=1.389 R2=0.605 NS=-1.03
Water Level (feet, NAVD88)
62.5
60.0
57.5
55.0
52.5
50.0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

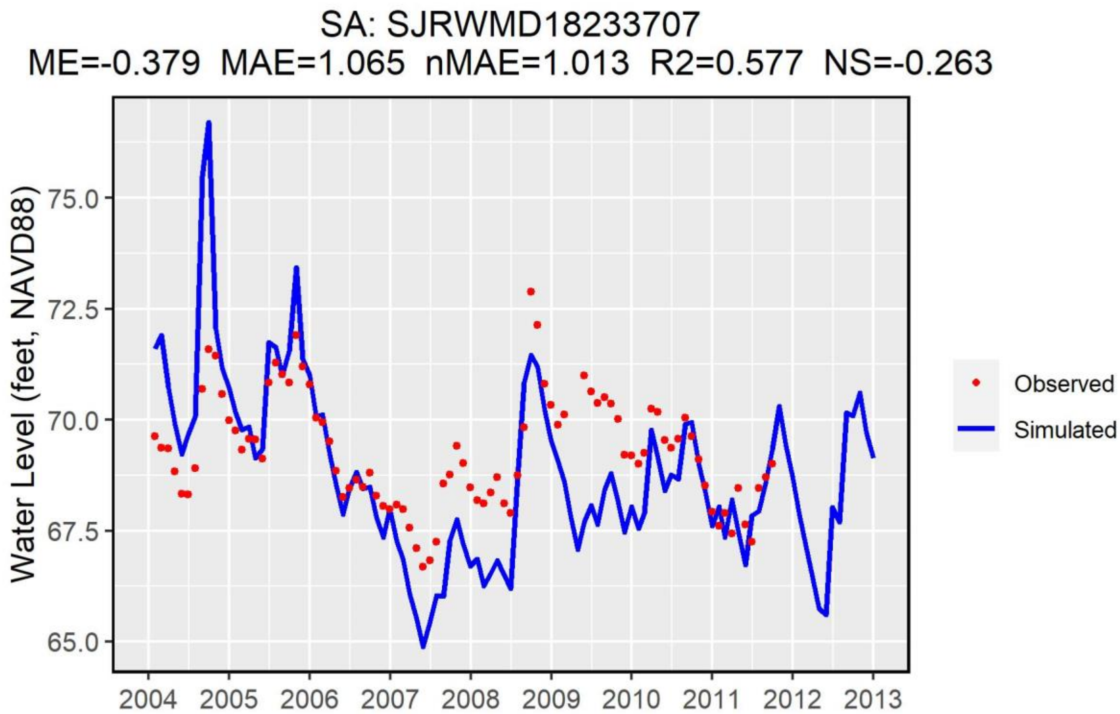

SA: SJRWMD18173701
ME=1.025 MAE=2.258 nMAE=2.408 R2=0.133 NS=-29.863
Water Level (feet, NAVD88)
85
80
75
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

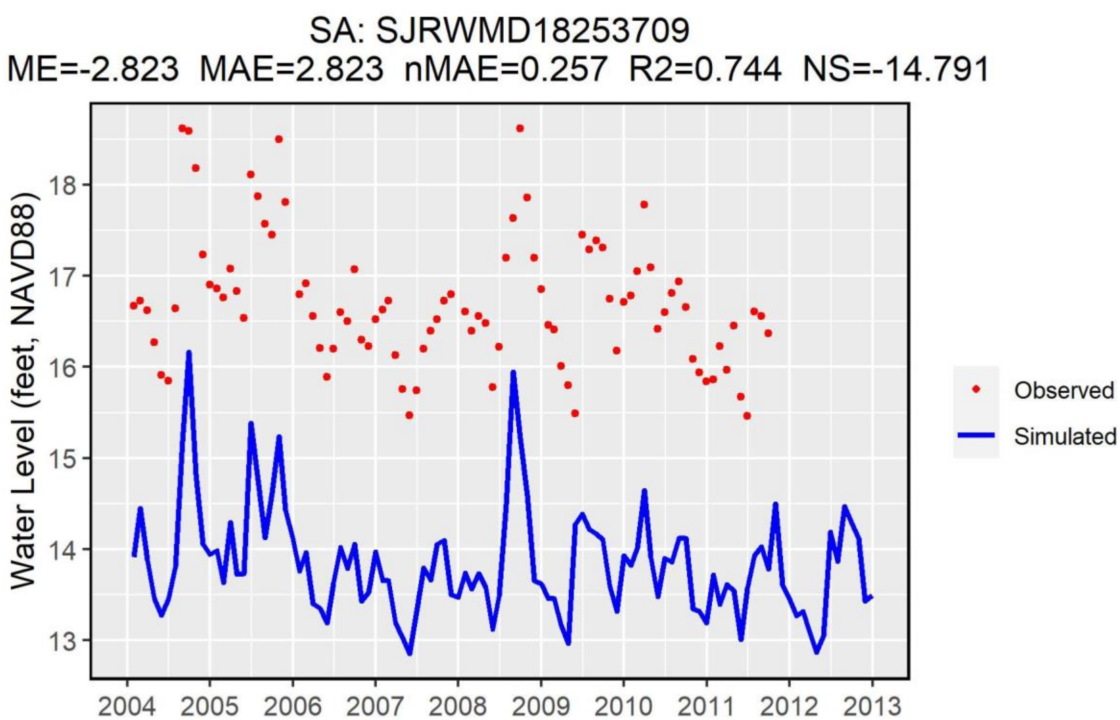

SA: SJRWMD18183702
ME=-0.705 MAE=2.089 nMAE=2.045 R2=0.667 NS=-1.436
Water Level (feet, NAVD88)
120
115
110
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

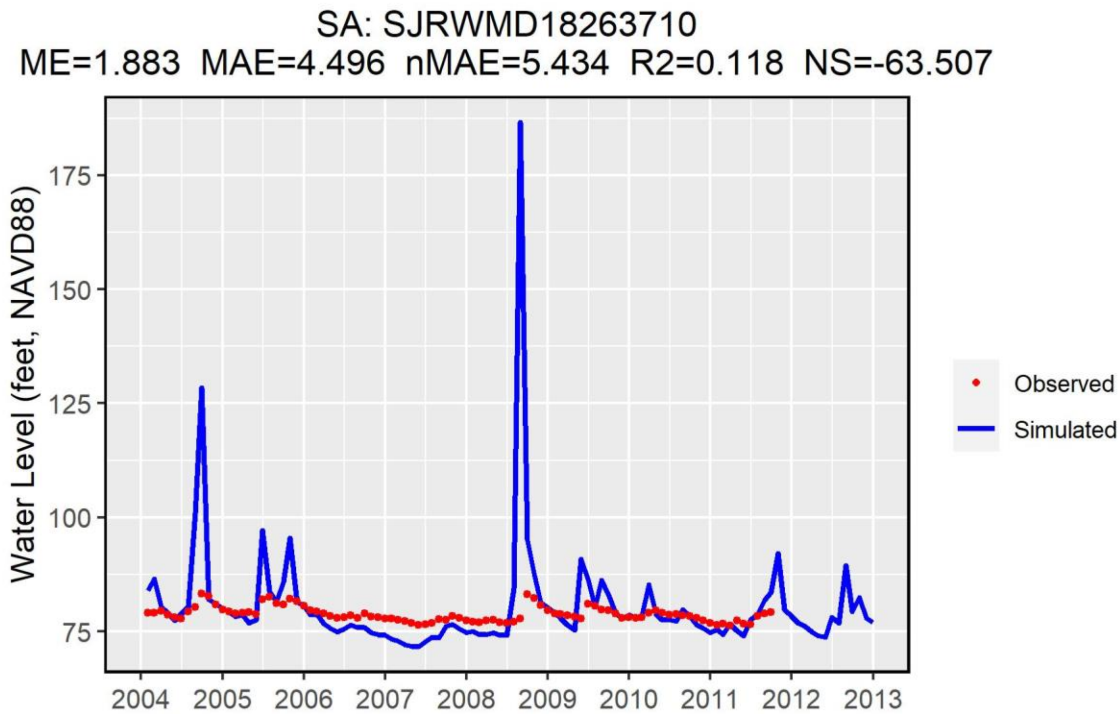

SA: SJRWMD18193703
ME=0.238 MAE=2.502 nMAE=2.513 R2=0.697 NS=-6.594
Water Level (feet, NAVD88)
90
85
80
75
70
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

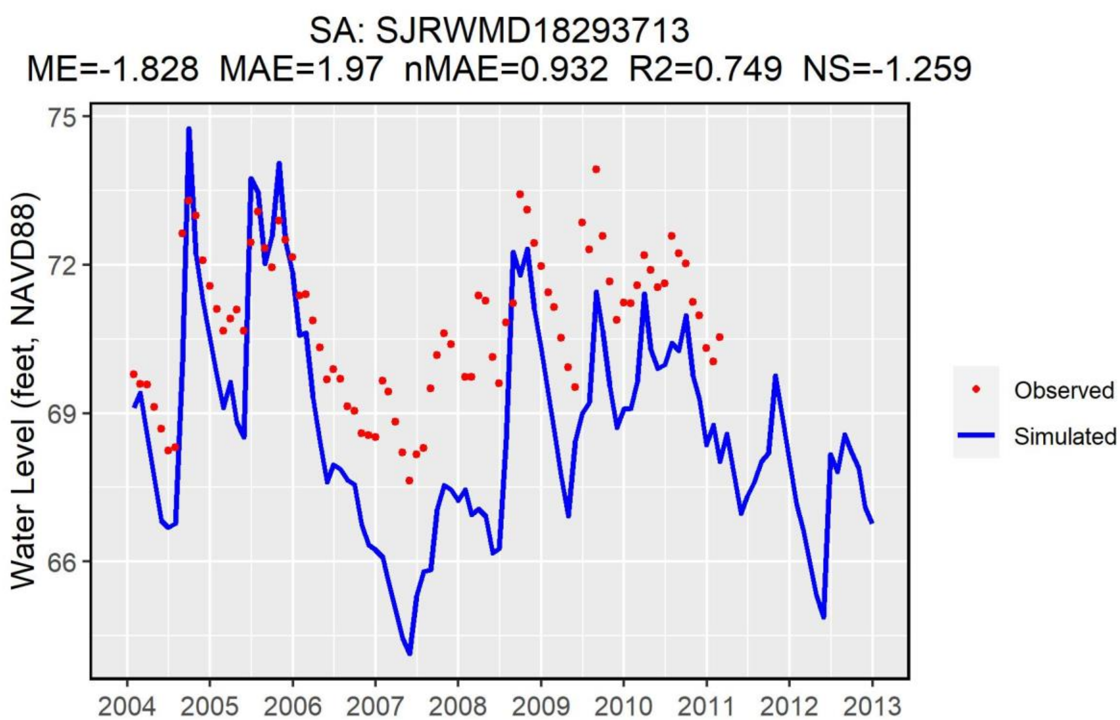

SA: SJRWMD18213705
ME=0.189 MAE=1.036 nMAE=1.022 R2=0.523 NS=0.507
Water Level (feet, NAVD88)
74
76
78
80
82
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

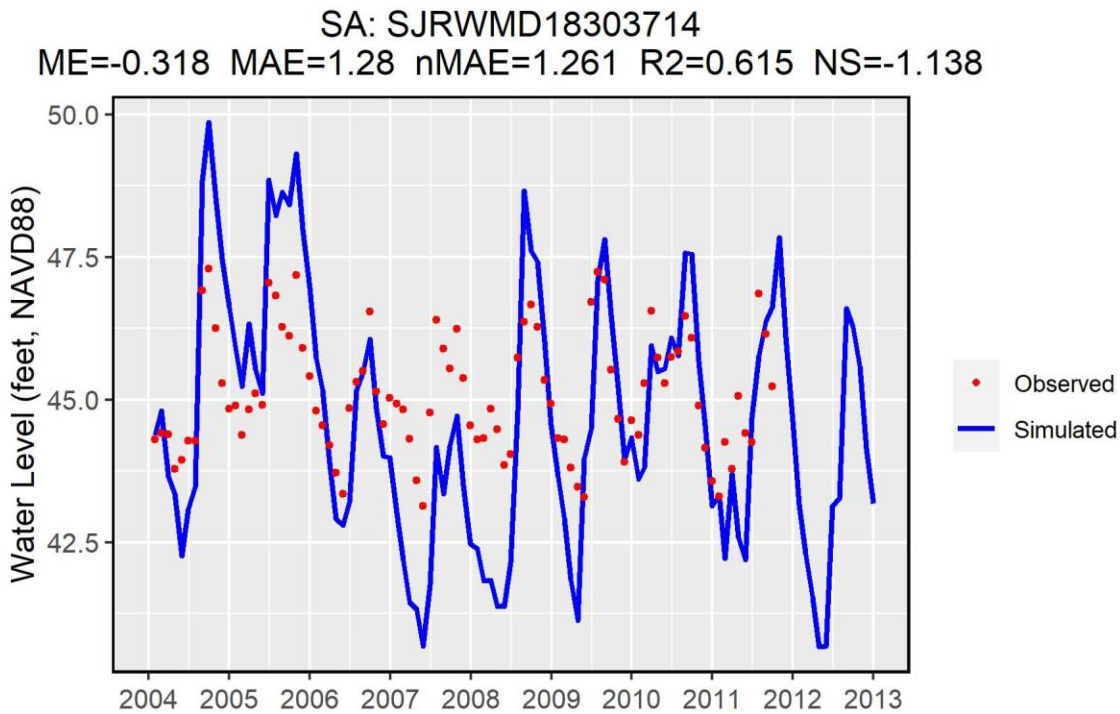

SA: SJRWMD18223706
ME=-0.238 MAE=1.241 nMAE=1.238 R2=0.596 NS=-0.085
Water Level (feet, NAVD88)
60
65
70
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

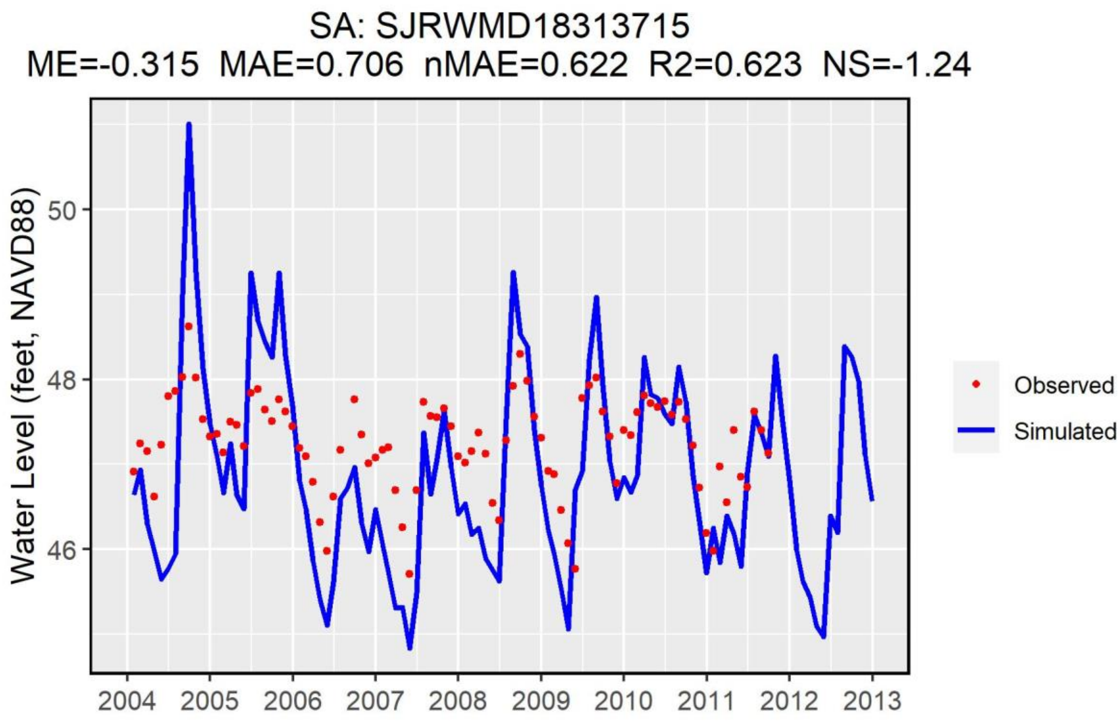

SA: SJRWMD18233707
ME=-0.379 MAE=1.065 nMAE=1.013 R2=0.577 NS=-0.263
Water Level (feet, NAVD88)
75.0
72.5
70.0
67.5
65.0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

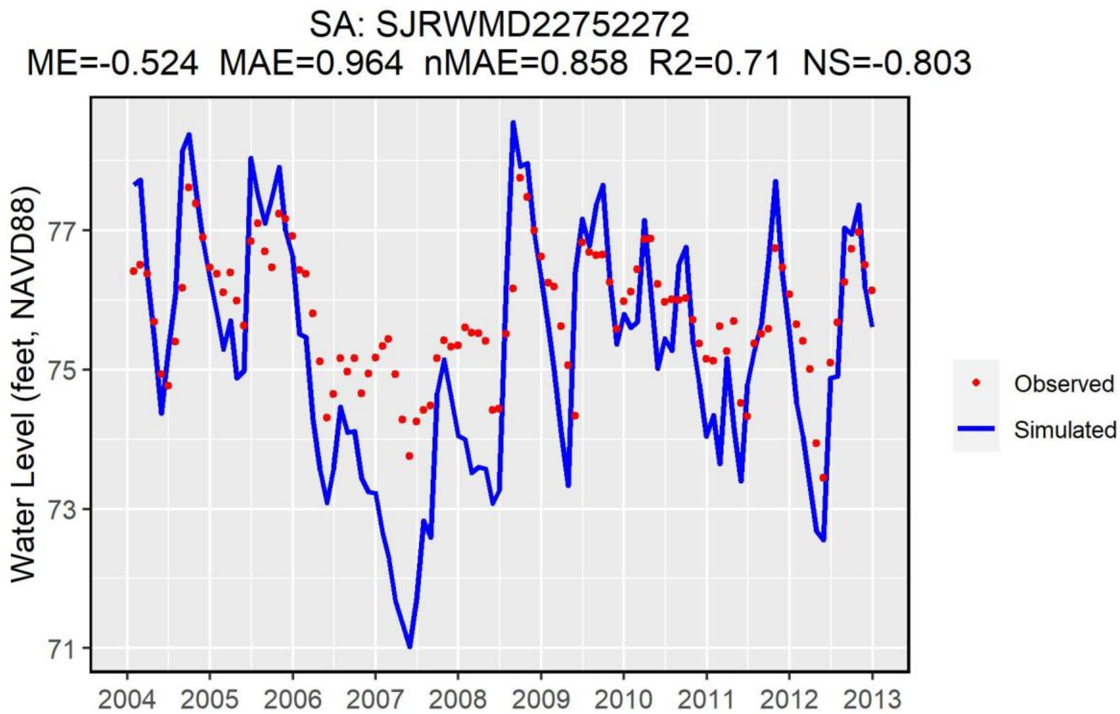

SA: SJRWMD18253709
ME=-2.823 MAE=2.823 nMAE=0.257 R2=0.744 NS=-14.791
Water Level (feet, NAVD88)
18
17
16
15
14
13
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

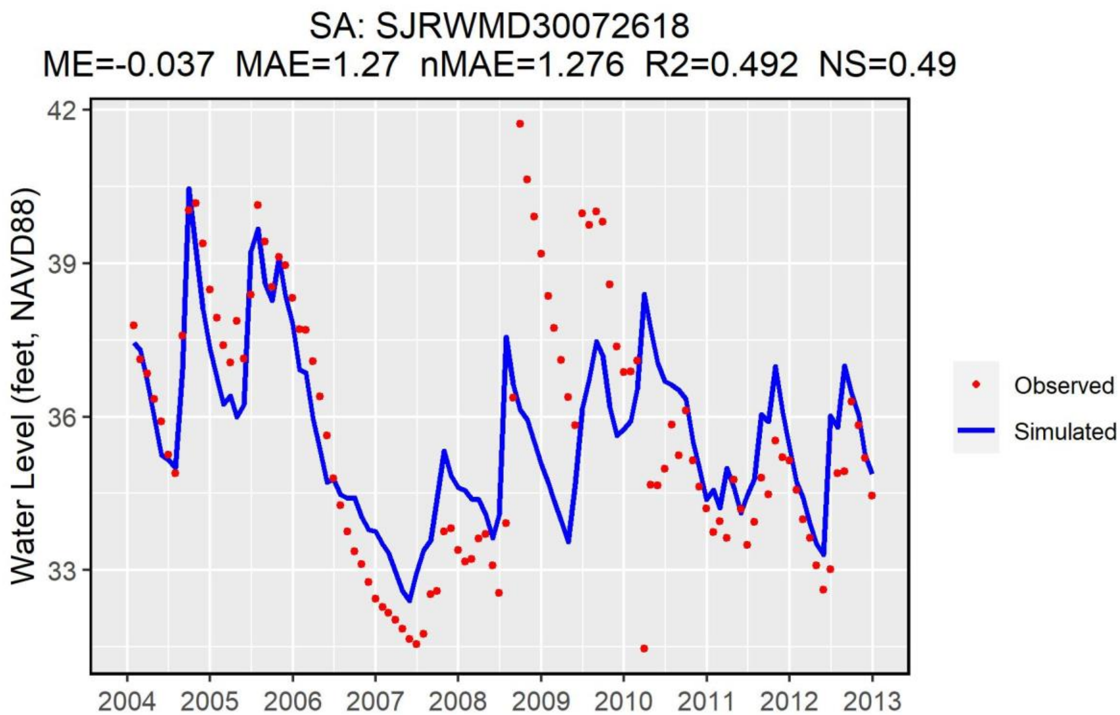

SA: SJRWMD18263710
ME=1.883 MAE=4.496 nMAE=5.434 R2=0.118 NS=-63.507
Water Level (feet, NAVD88)
175
150
125
100
75
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

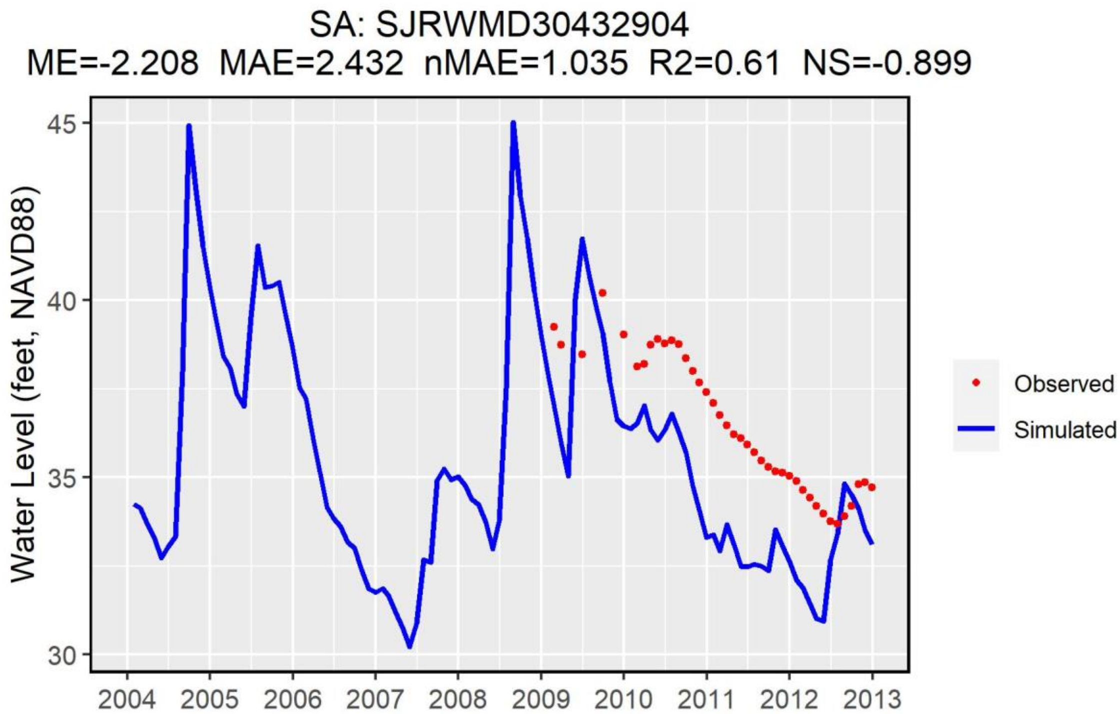

SA: SJRWMD18293713
ME=-1.828 MAE=1.97 nMAE=0.932 R2=0.749 NS=-1.259
Water Level (feet, NAVD88)
75
72
69
66
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

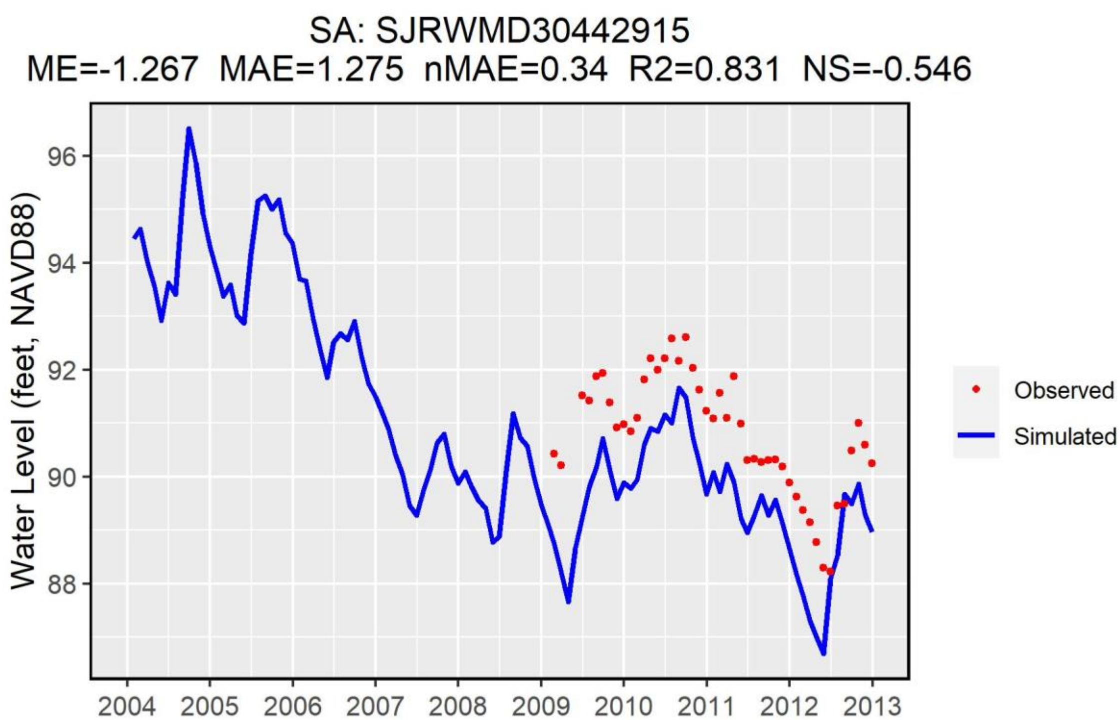

SA: SJRWMD18303714
ME=-0.318 MAE=1.28 nMAE=1.261 R2=0.615 NS=-1.138
Water Level (feet, NAVD88)
50.0
47.5
45.0
42.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

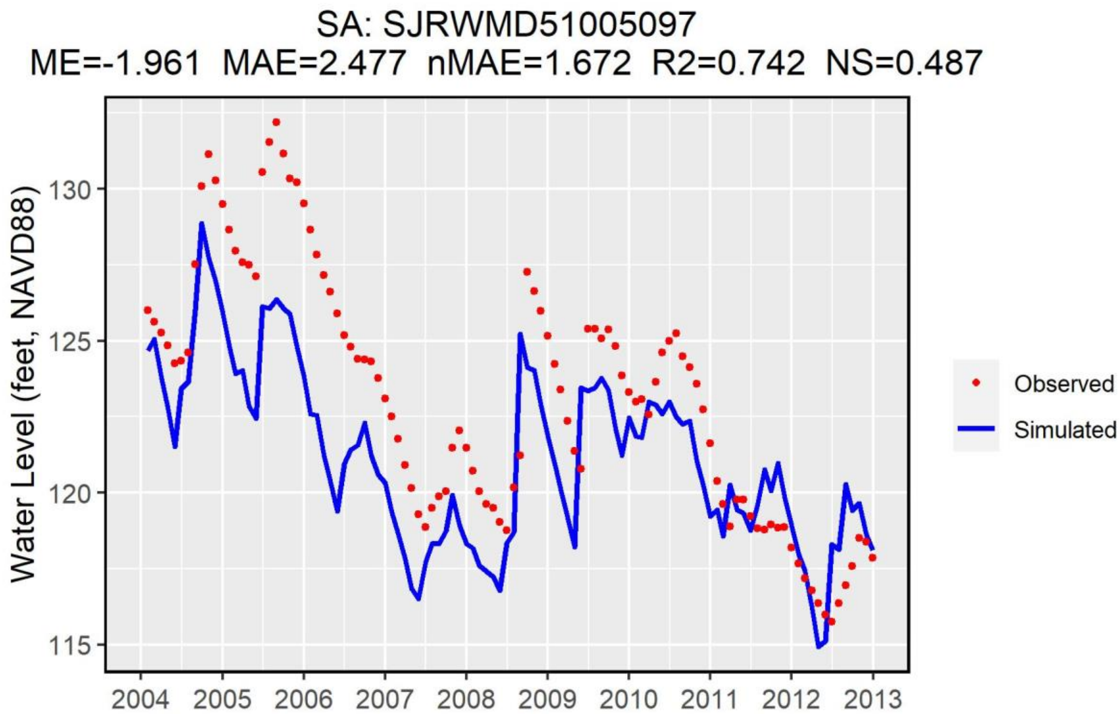

SA: SJRWMD18313715
ME=-0.315 MAE=0.706 nMAE=0.622 R2=0.623 NS=-1.24
Water Level (feet, NAVD88)
50
48
46
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

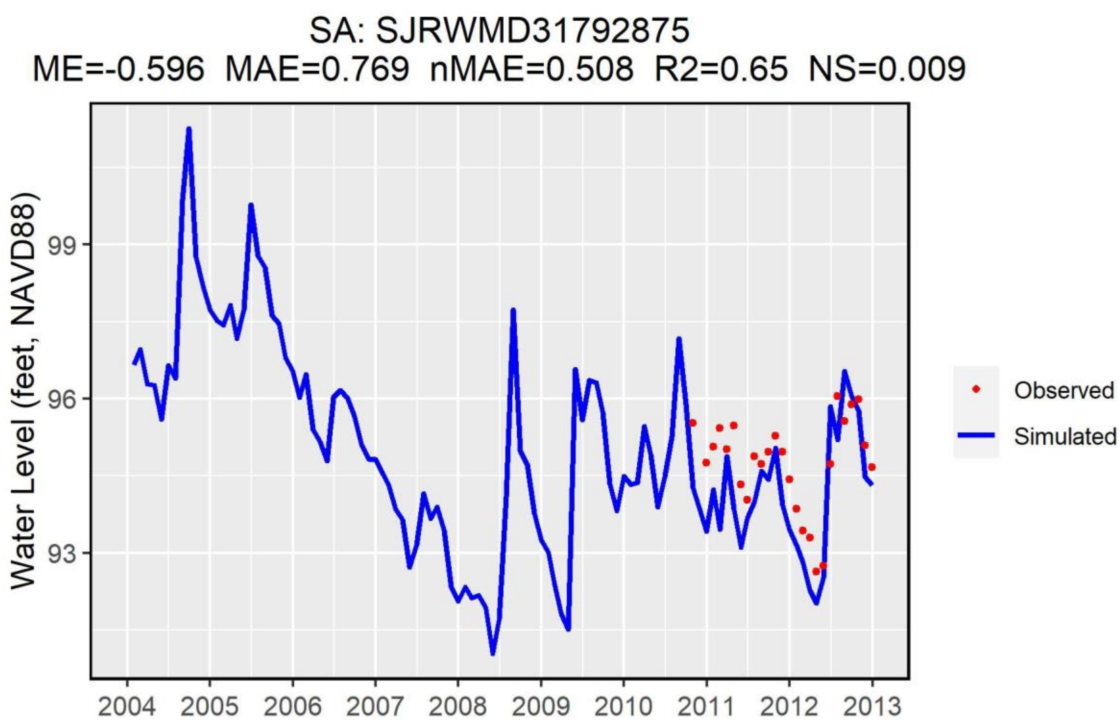

SA: SJRWMD22752272
ME=-0.524 MAE=0.964 nMAE=0.858 R2=0.71 NS=-0.803
Water Level (feet, NAVD88)
71
73
75
77
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

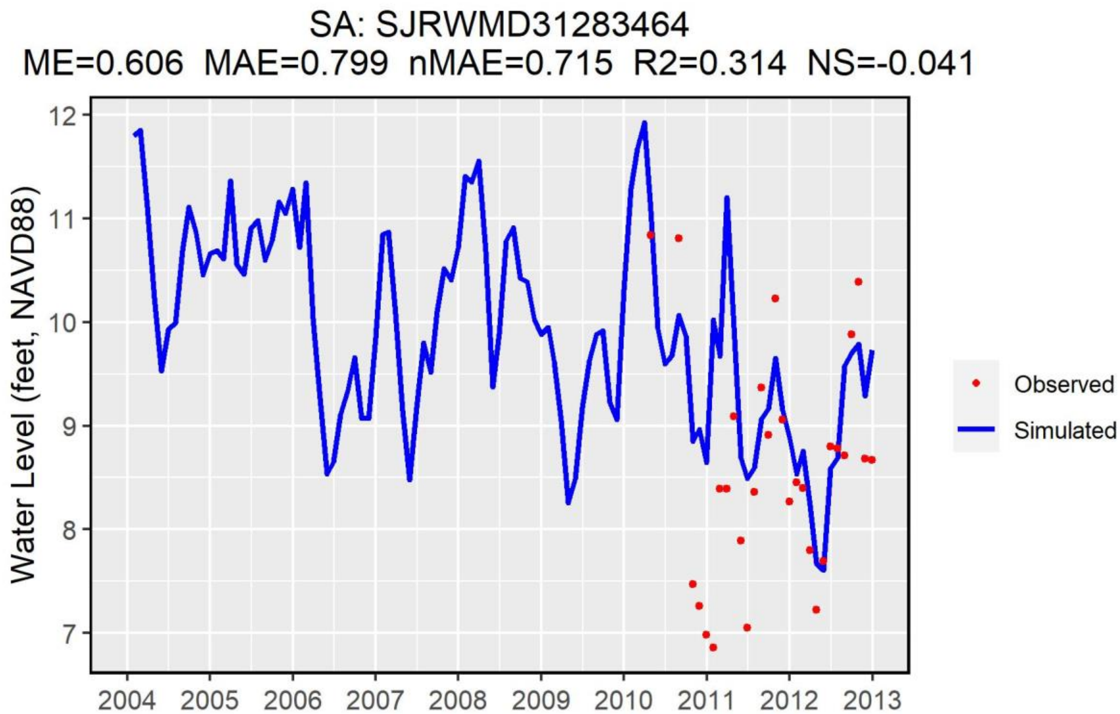

SA: SJRWMD30072618
ME=-0.037 MAE=1.27 nMAE=1.276 R2=0.492 NS=0.49
Water Level (feet, NAVD88)
33
36
39
42
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

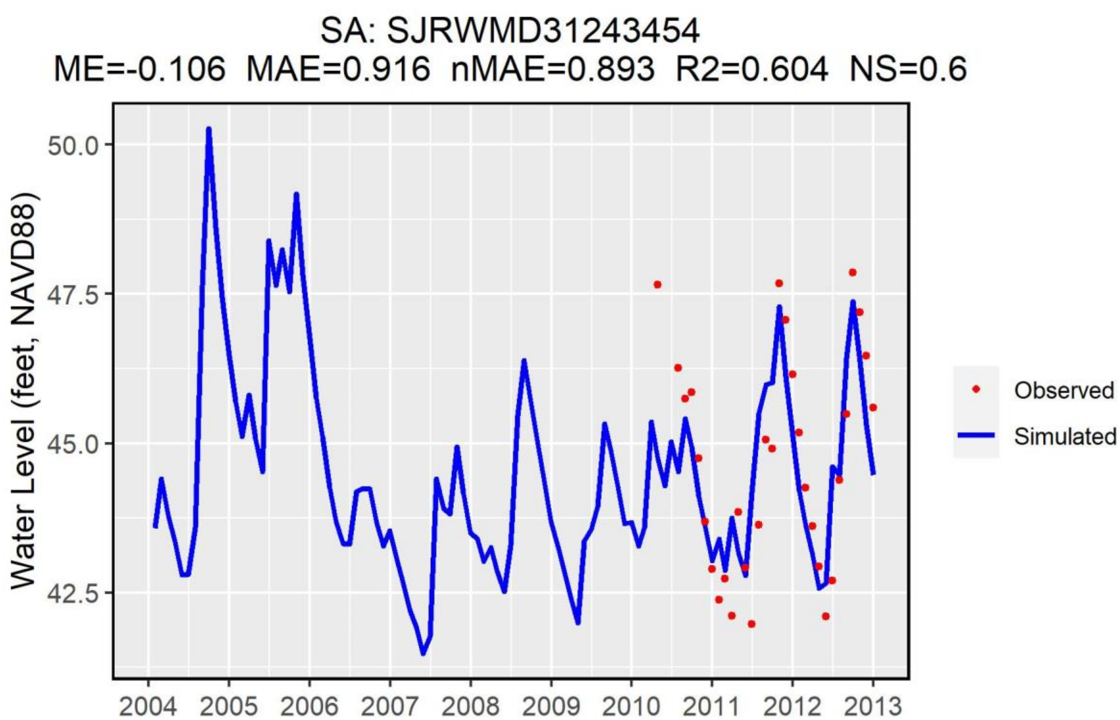

SA: SJRWMD30432904
ME=-2.208 MAE=2.432 nMAE=1.035 R2=0.61 NS=-0.899
Water Level (feet, NAVD88)
45
40
35
30
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

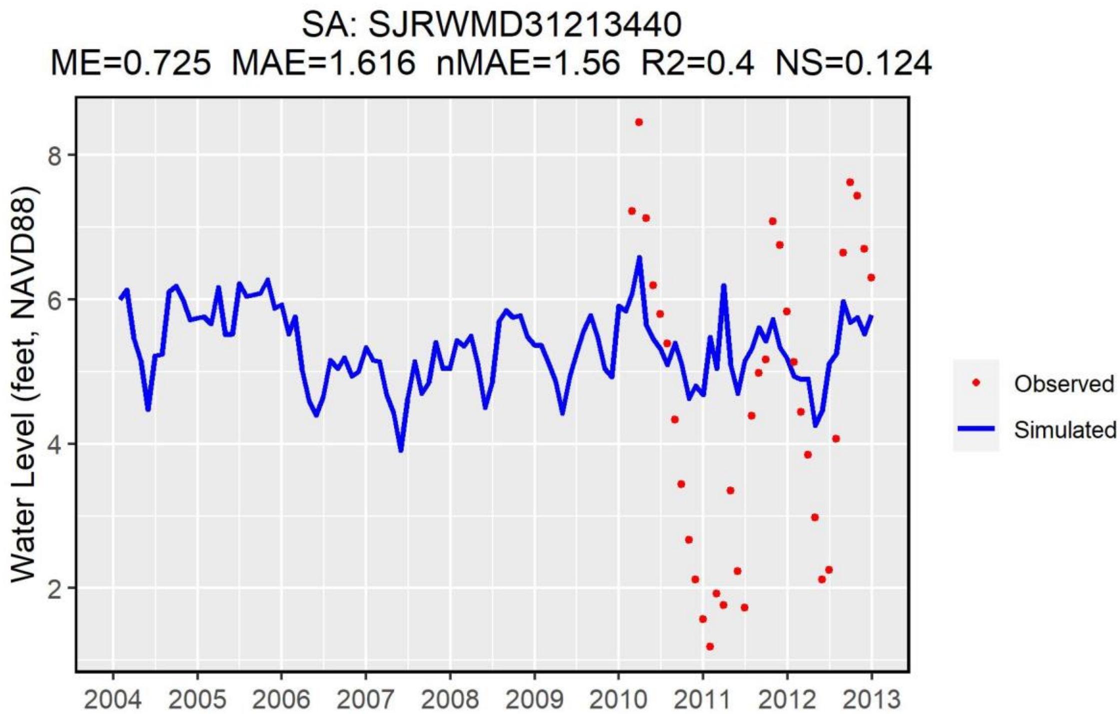

SA: SJRWMD30442915
ME=-1.267 MAE=1.275 nMAE=0.34 R2=0.831 NS=-0.546
Water Level (feet, NAVD88)
96
94
92
90
88
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated


SA: SJRWMD51005097
ME=-1.961 MAE=2.477 nMAE=1.672 R2=0.742 NS=0.487
Water Level (feet, NAVD88)
130
125
120
115
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

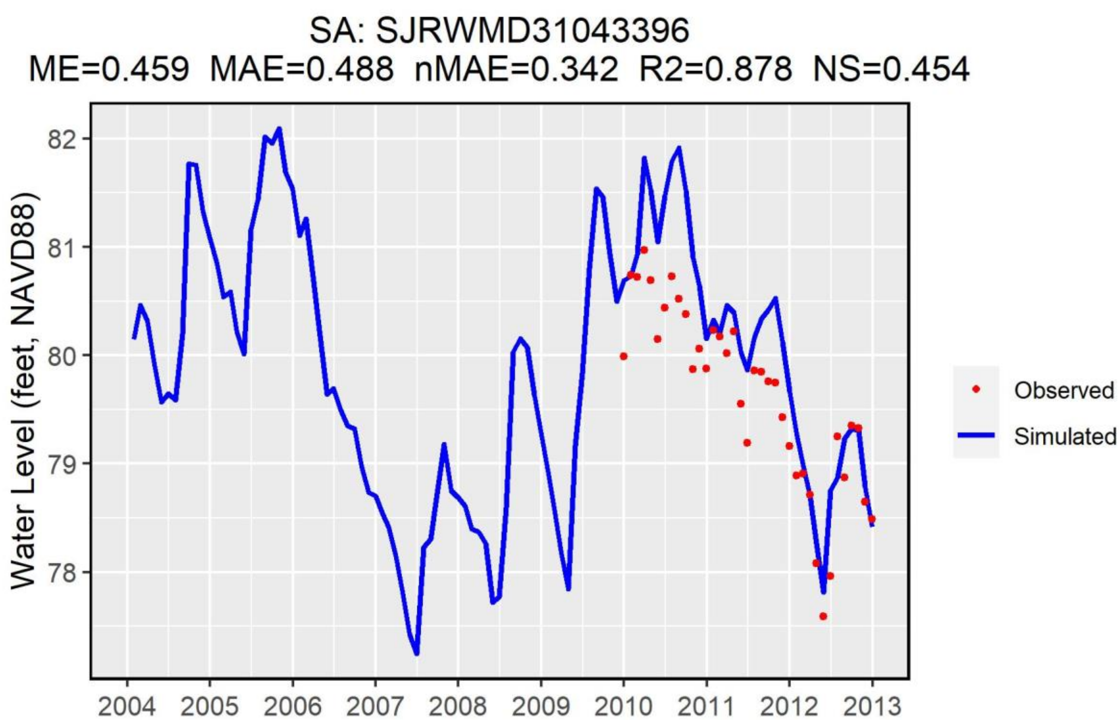

SA: SJRWMD31792875
ME=-0.596 MAE=0.769 nMAE=0.508 R2=0.65 NS=0.009
Water Level (feet, NAVD88)
99
96
93
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated


SA: SJRWMD31283464
ME=0.606 MAE=0.799 nMAE=0.715 R2=0.314 NS=-0.041
Water Level (feet, NAVD88)
12
11
10
9
8
7
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

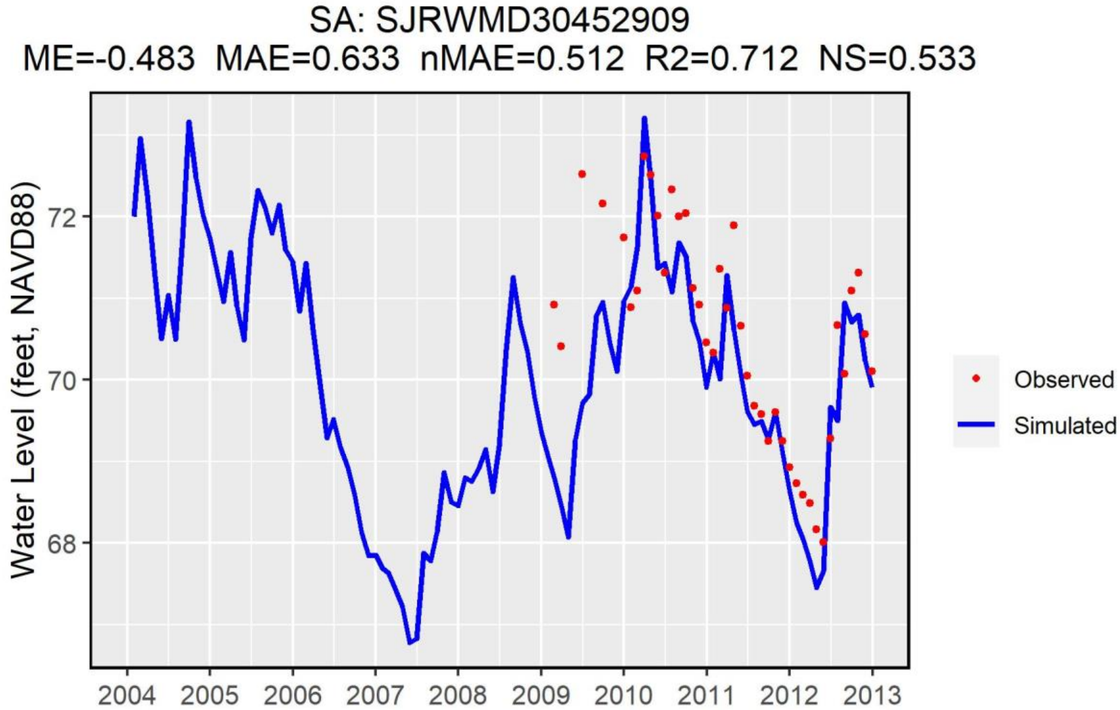

SA: SJRWMD31243454
ME=-0.106 MAE=0.916 nMAE=0.893 R2=0.604 NS=0.6
Water Level (feet, NAVD88)
50.0
47.5
45.0
42.5
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

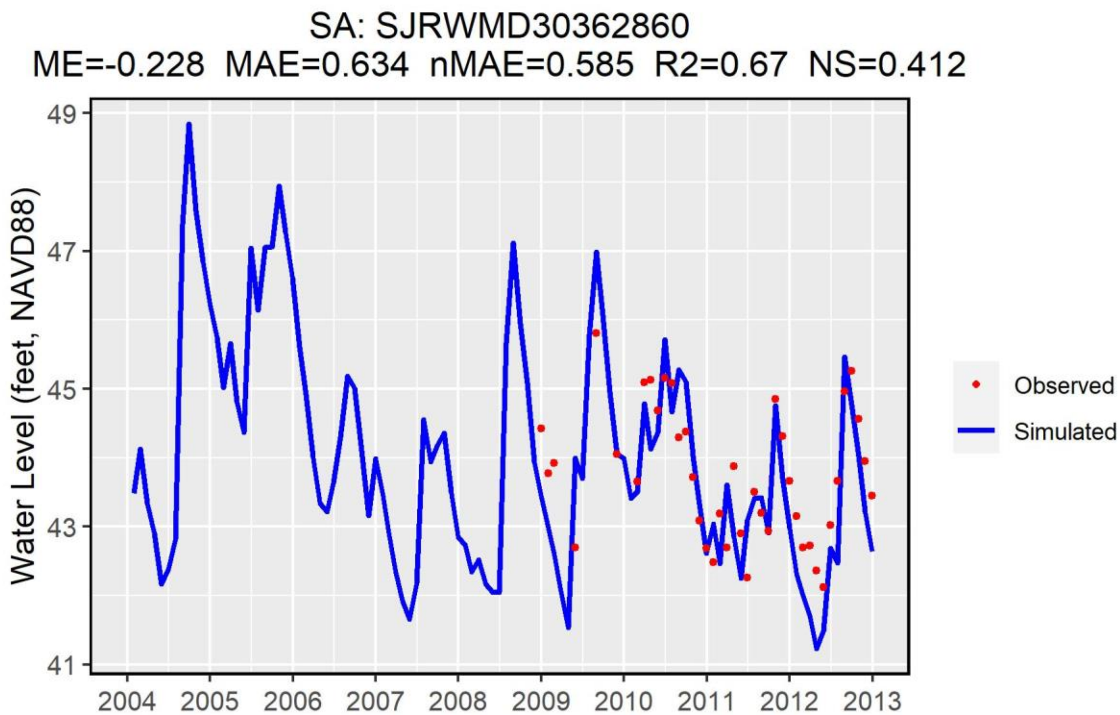


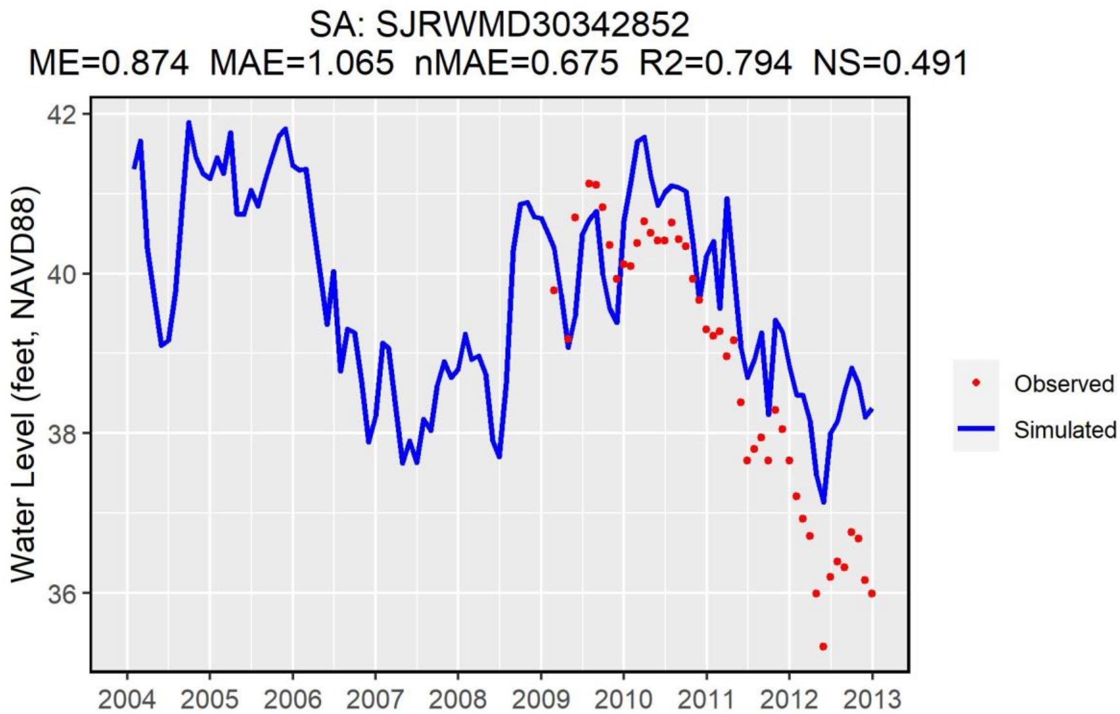
SA: SJRWMD31213440
ME=0.725 MAE=1.616 nMAE=1.56 R2=0.4 NS=0.124
Water Level (feet, NAVD88)
8
6
4
2
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

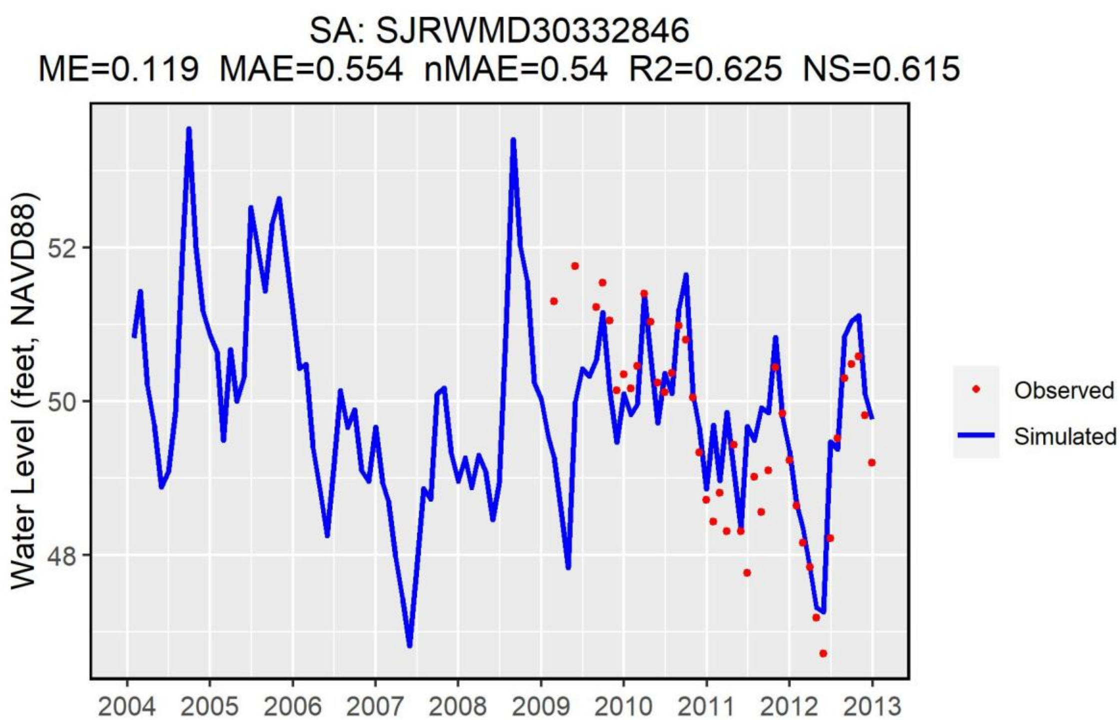


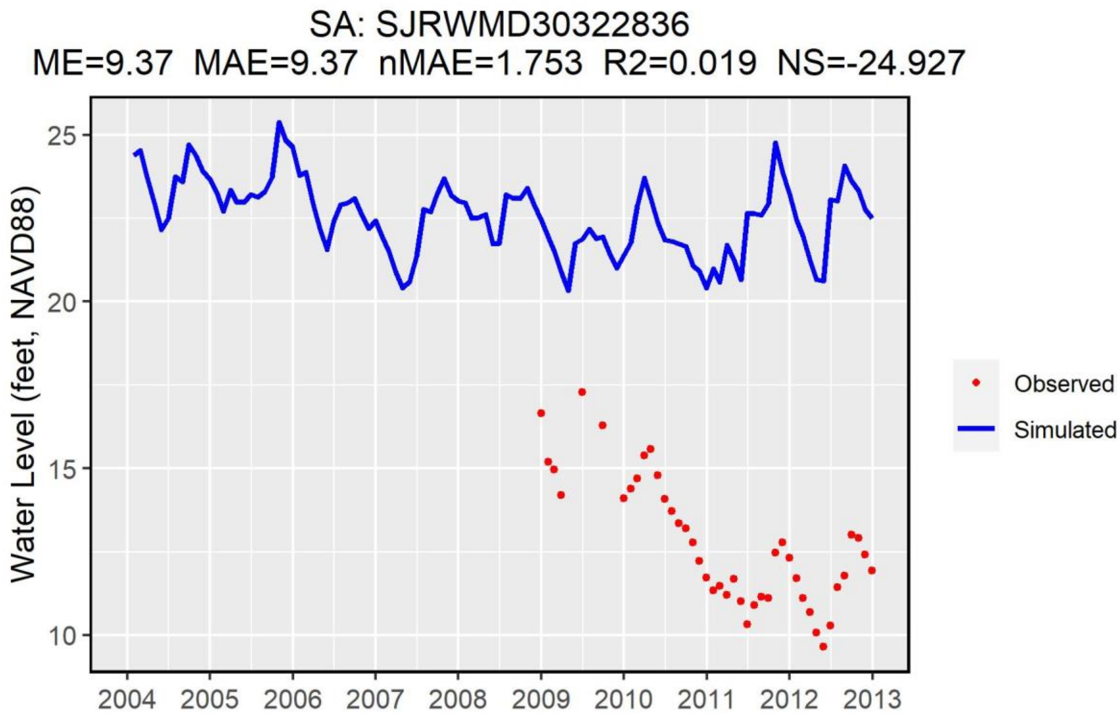
SA: SJRWMD31043396
ME=0.459 MAE=0.488 nMAE=0.342 R2=0.878 NS=0.454
Water Level (feet, NAVD88)
82
81
80
79
78
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

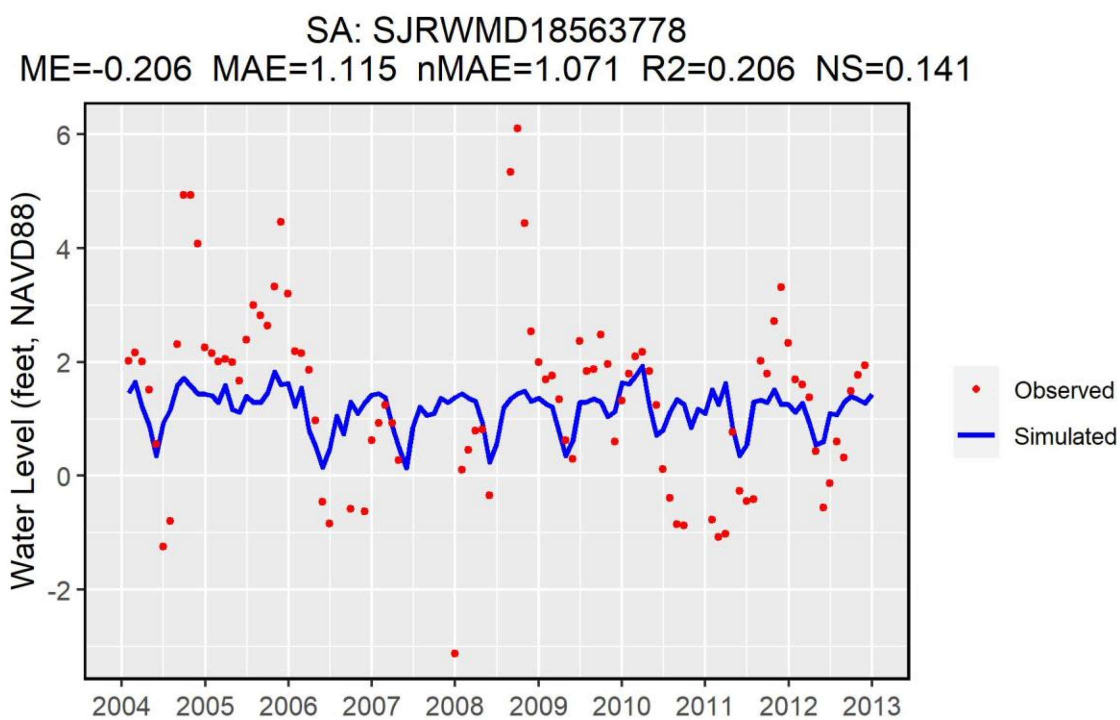

SA: SJRWMD30452909
ME=-0.483 MAE=0.633 nMAE=0.512 R2=0.712 NS=0.533
Water Level (feet, NAVD88)
72
70
68
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

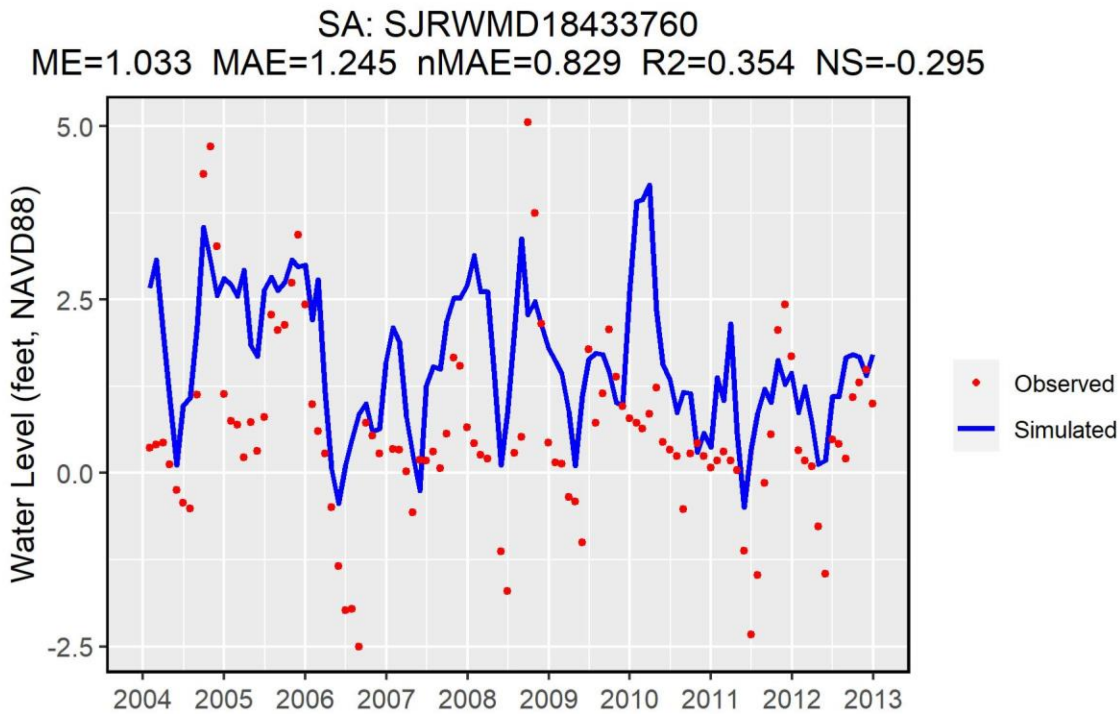

SA: SJRWMD30362860
ME=-0.228 MAE=0.634 nMAE=0.585 R2=0.67 NS=0.412
Water Level (feet, NAVD88)
49
47
45
43
41
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

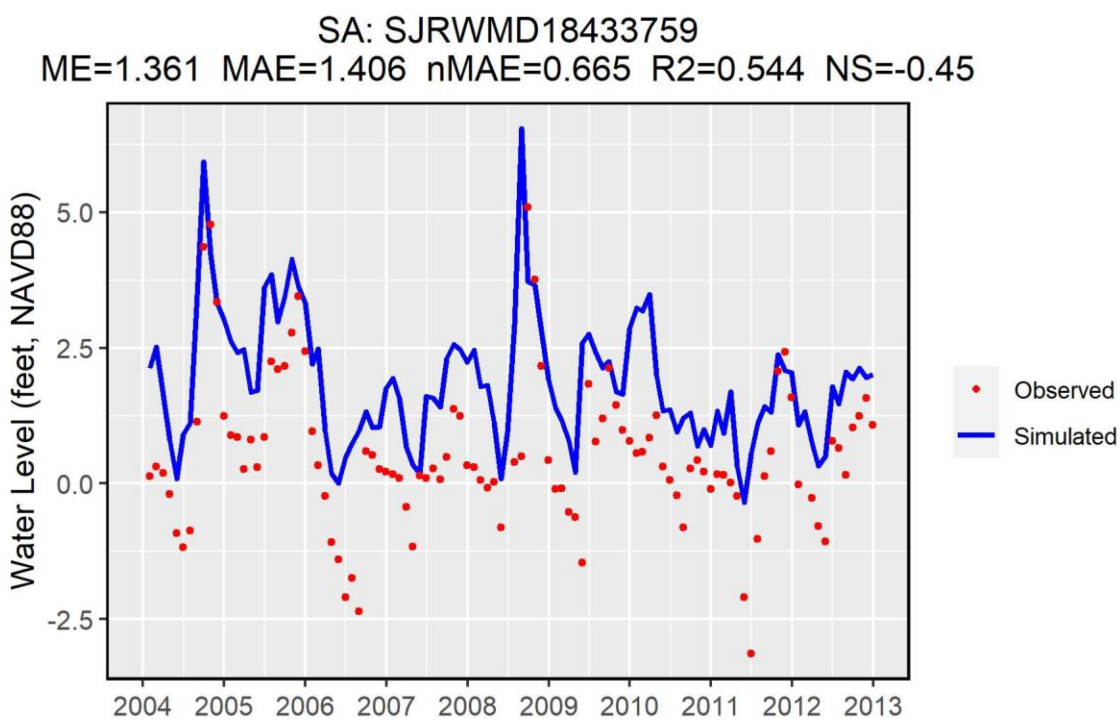

SA: SJRWMD30342852
ME=0.874 MAE=1.065 nMAE=0.675 R2=0.794 NS=0.491
Water Level (feet, NAVD88)
42
40
38
36
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

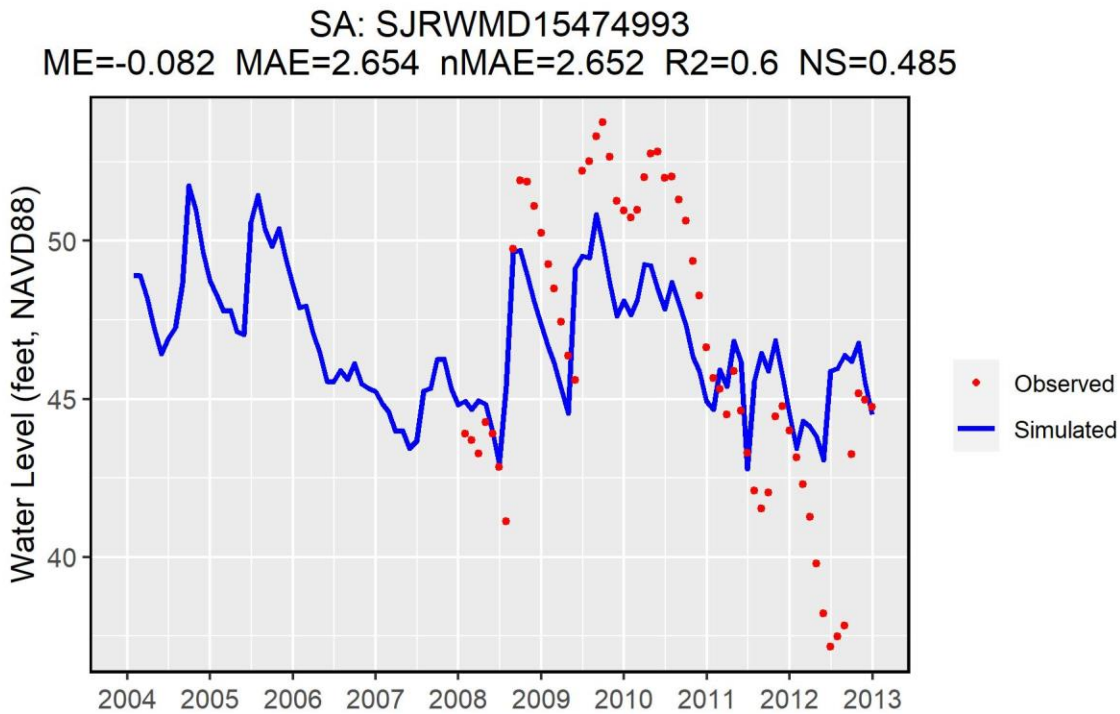

SA: SJRWMD30332846
ME=0.119 MAE=0.554 nMAE=0.54 R2=0.625 NS=0.615
Water Level (feet, NAVD88)
52
50
48
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

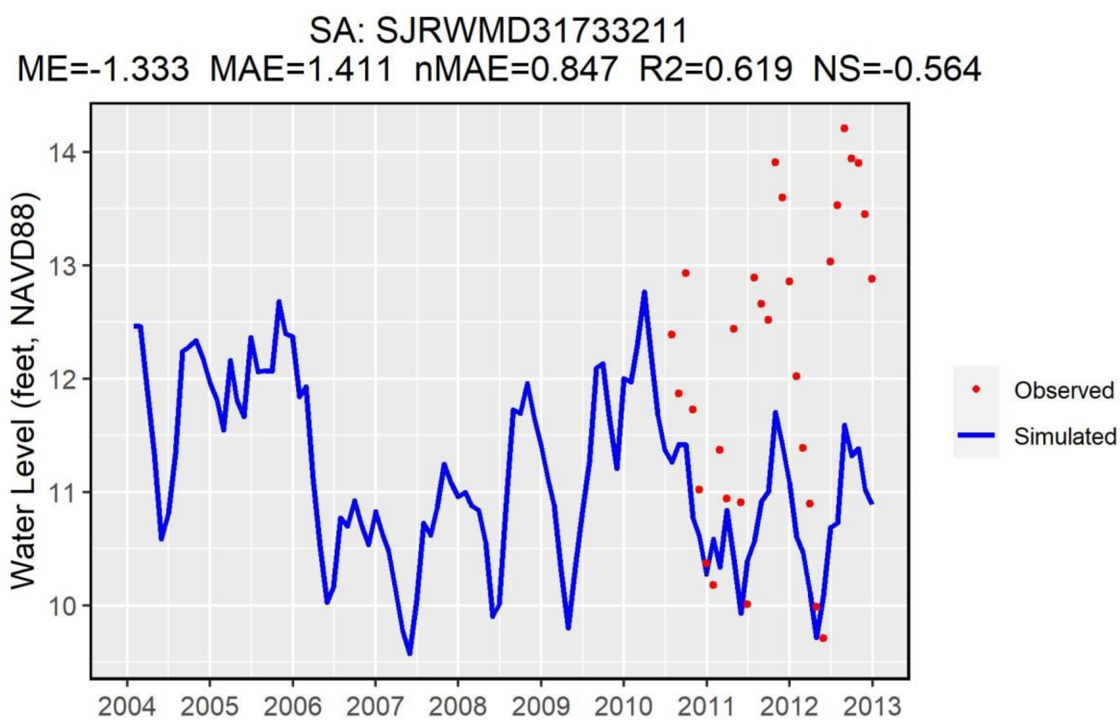

SA: SJRWMD30322836
ME=9.37 MAE=9.37 nMAE=1.753 R2=0.019 NS=-24.927
Water Level (feet, NAVD88)
25
20
15
10
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

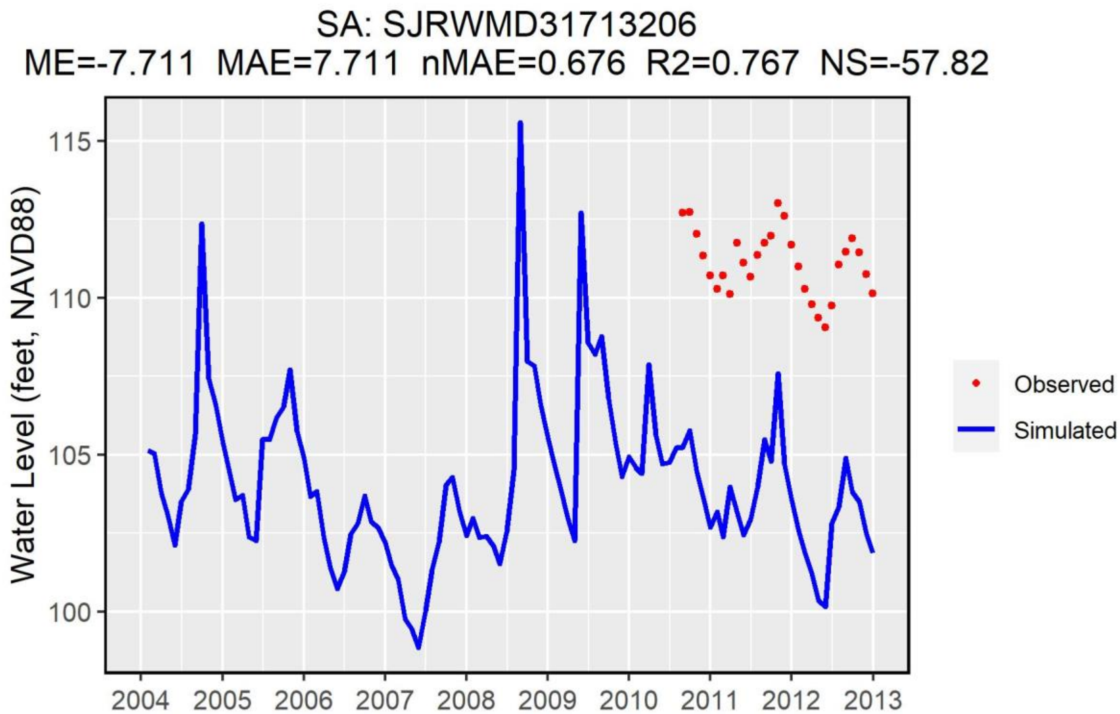

SA: SJRWMD18563778
ME=-0.206 MAE=1.115 nMAE=1.071 R2=0.206 NS=0.141
Water Level (feet, NAVD88)
6
4
2
0
-2
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

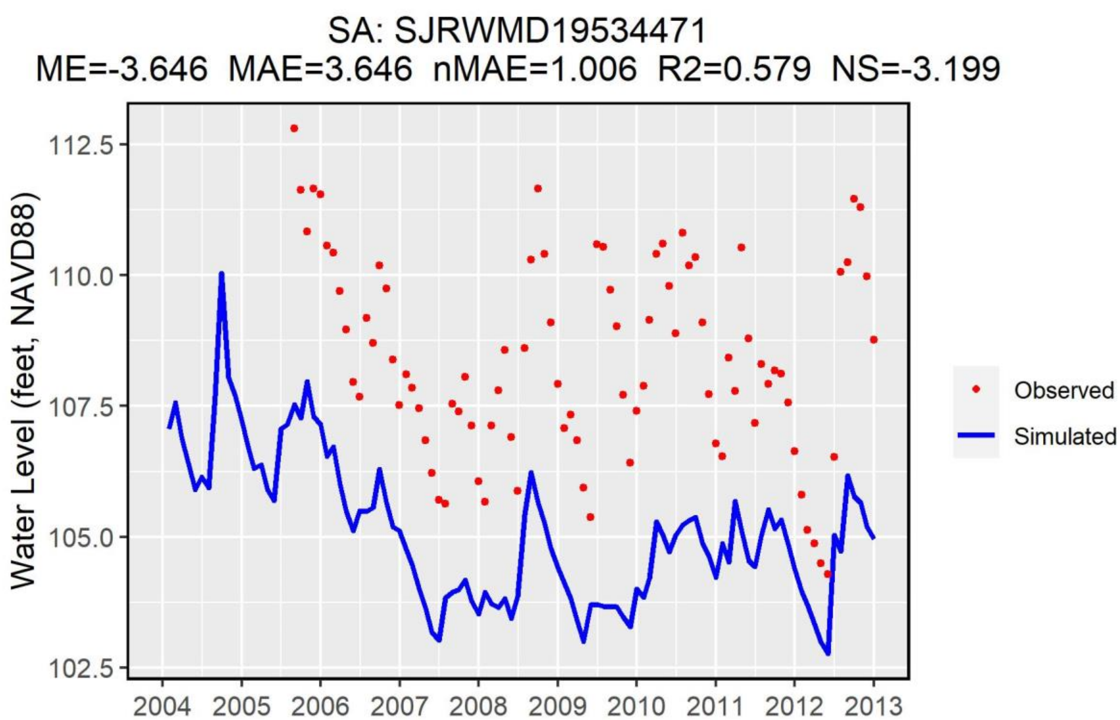

SA: SJRWMD18433760
ME=1.033 MAE=1.245 nMAE=0.829 R2=0.354 NS=-0.295
Water Level (feet, NAVD88)
5.0
2.5
0.0
-2.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

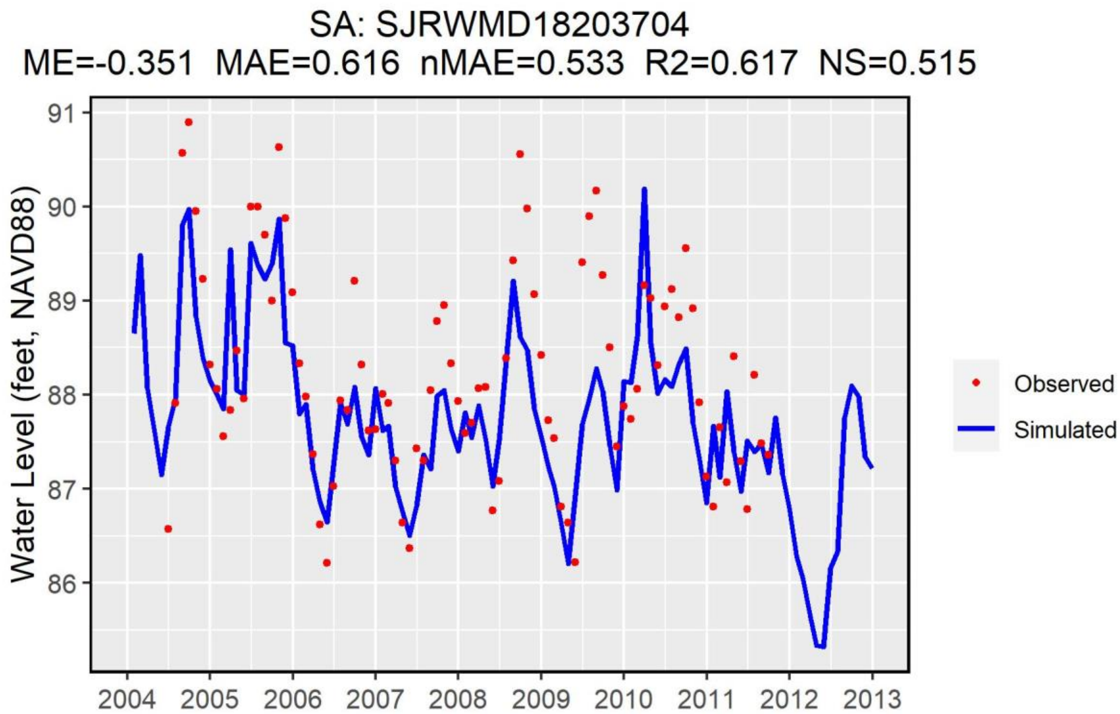

SA: SJRWMD18433759
ME=1.361 MAE=1.406 nMAE=0.665 R2=0.544 NS=-0.45
Water Level (feet, NAVD88)
5.0
2.5
0.0
-2.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

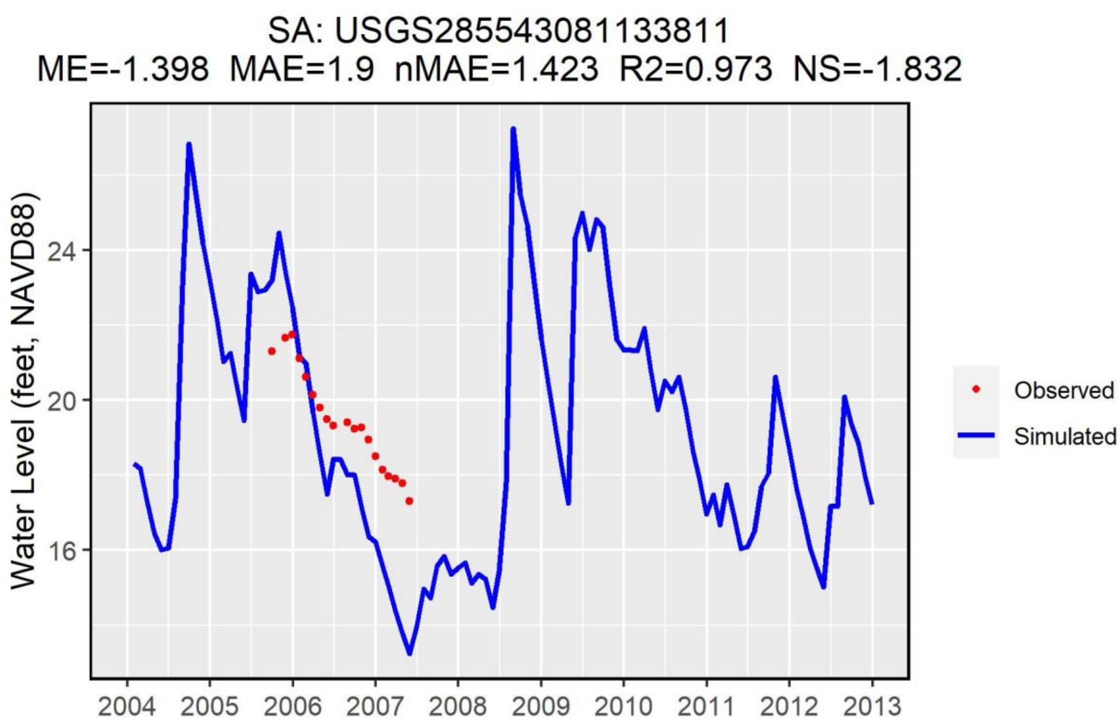

SA: SJRWMD15474993
ME=-0.082 MAE=2.654 nMAE=2.652 R2=0.6 NS=0.485
Water Level (feet, NAVD88)
40
45
50
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

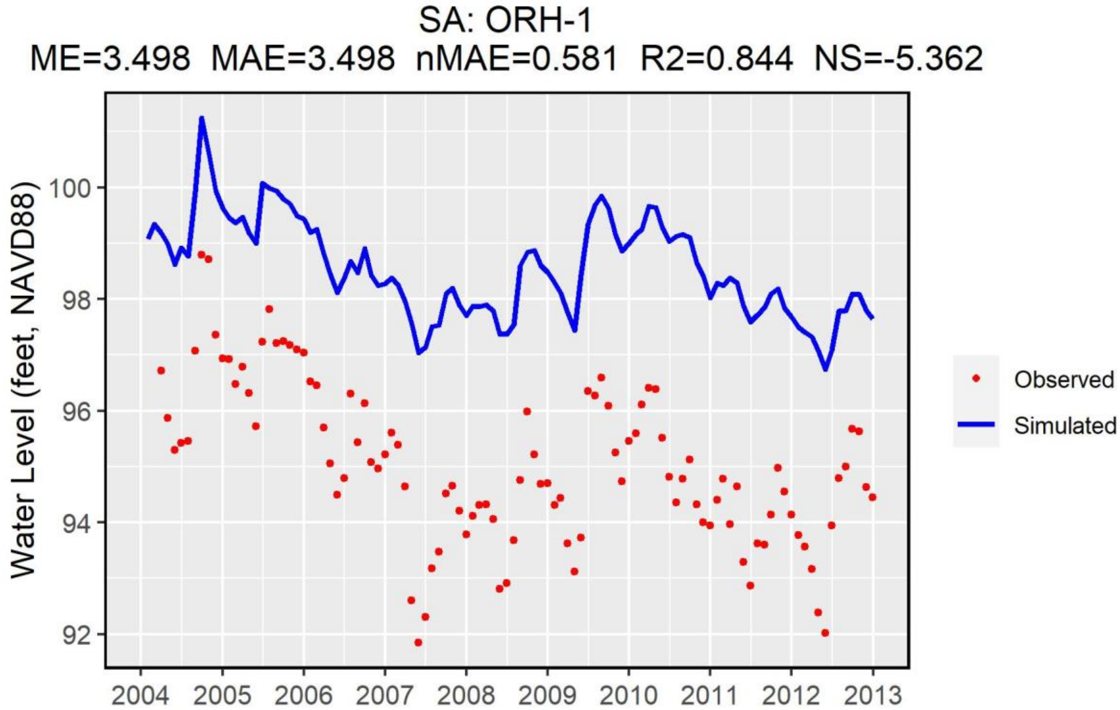

SA: SJRWMD31733211
ME=-1.333 MAE=1.411 nMAE=0.847 R2=0.619 NS=-0.564
Water Level (feet, NAVD88)
10
11
12
13
14
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

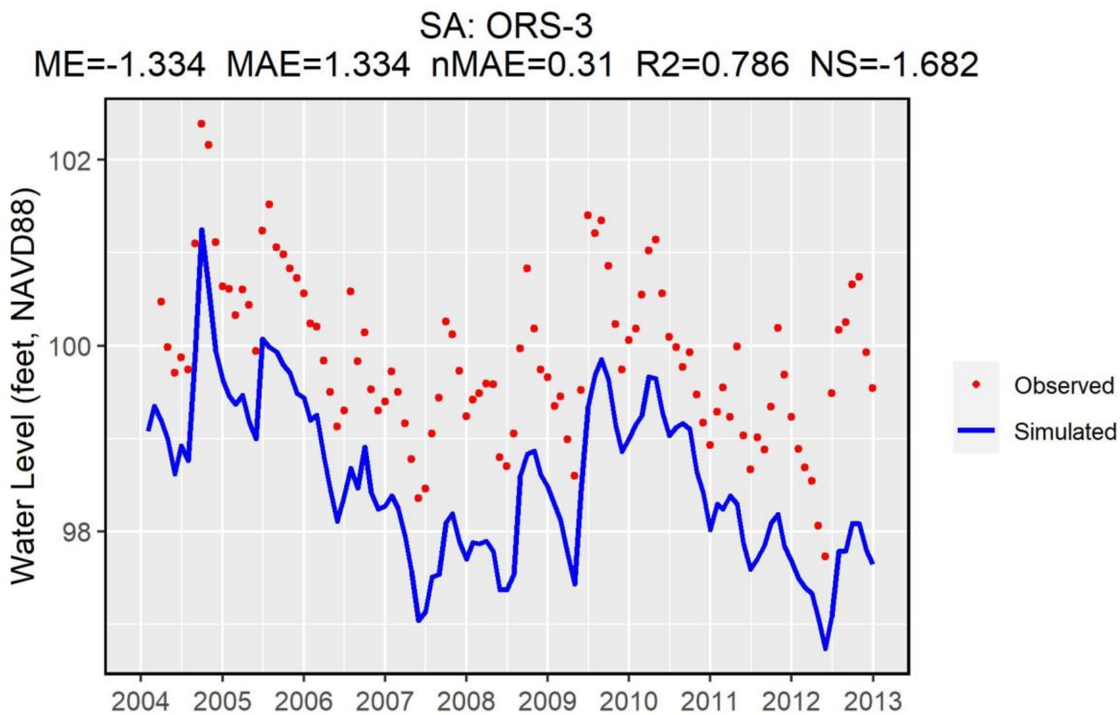

SA: SJRWMD31713206
ME=-7.711 MAE=7.711 nMAE=0.676 R2=0.767 NS=-57.82
Water Level (feet, NAVD88)
115
110
105
100
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

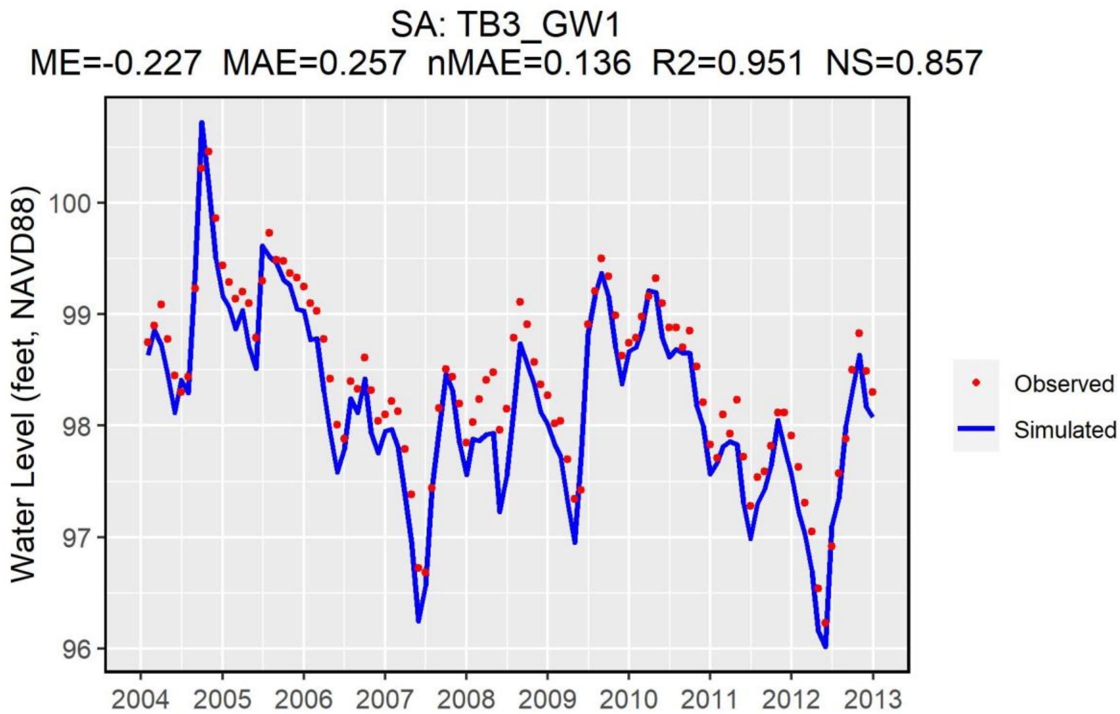

SA: SJRWMD19534471
ME=-3.646 MAE=3.646 nMAE=1.006 R2=0.579 NS=-3.199
Water Level (feet, NAVD88)
112.5
110.0
107.5
105.0
102.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

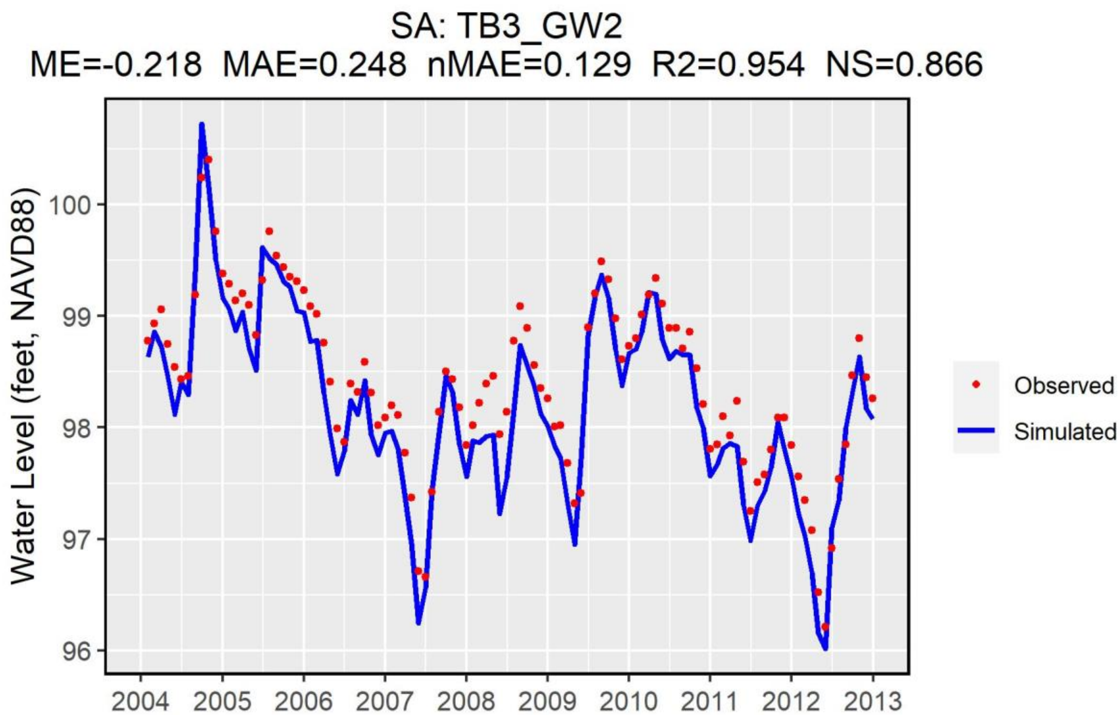

SA: SJRWMD18203704
ME=-0.351 MAE=0.616 nMAE=0.533 R2=0.617 NS=0.515
Water Level (feet, NAVD88)
91
90
89
88
87
86
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

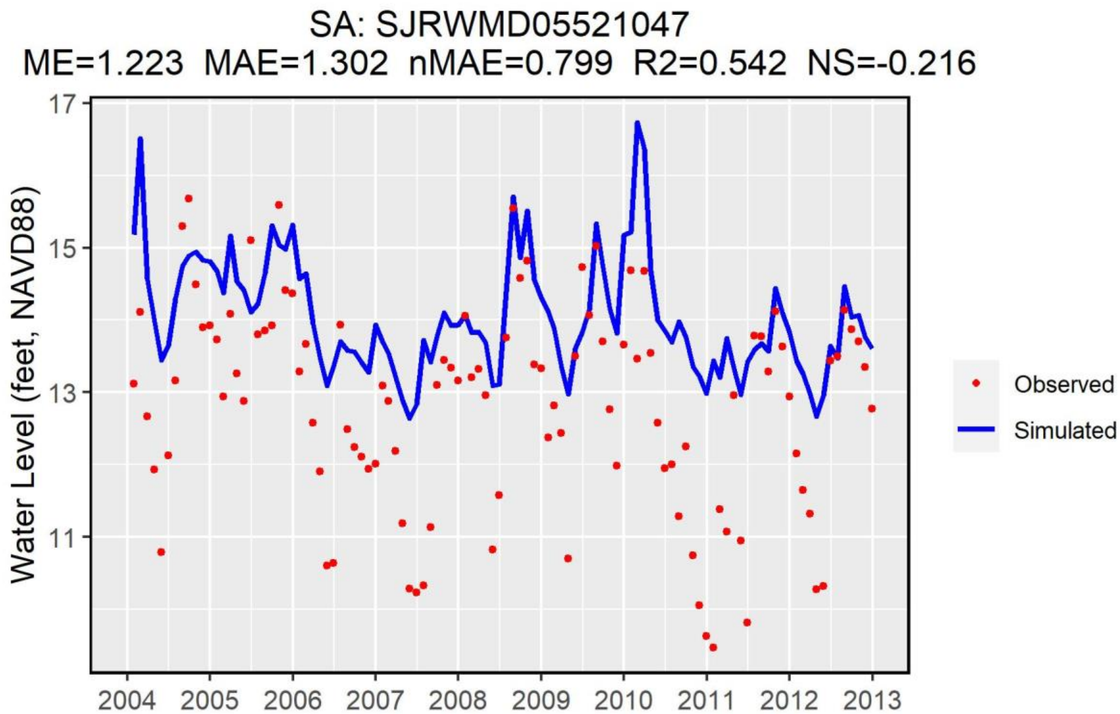

SA: USGS285543081133811
ME=-1.398 MAE=1.9 nMAE=1.423 R2=0.973 NS=-1.832
Water Level (feet, NAVD88)
24
20
16
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

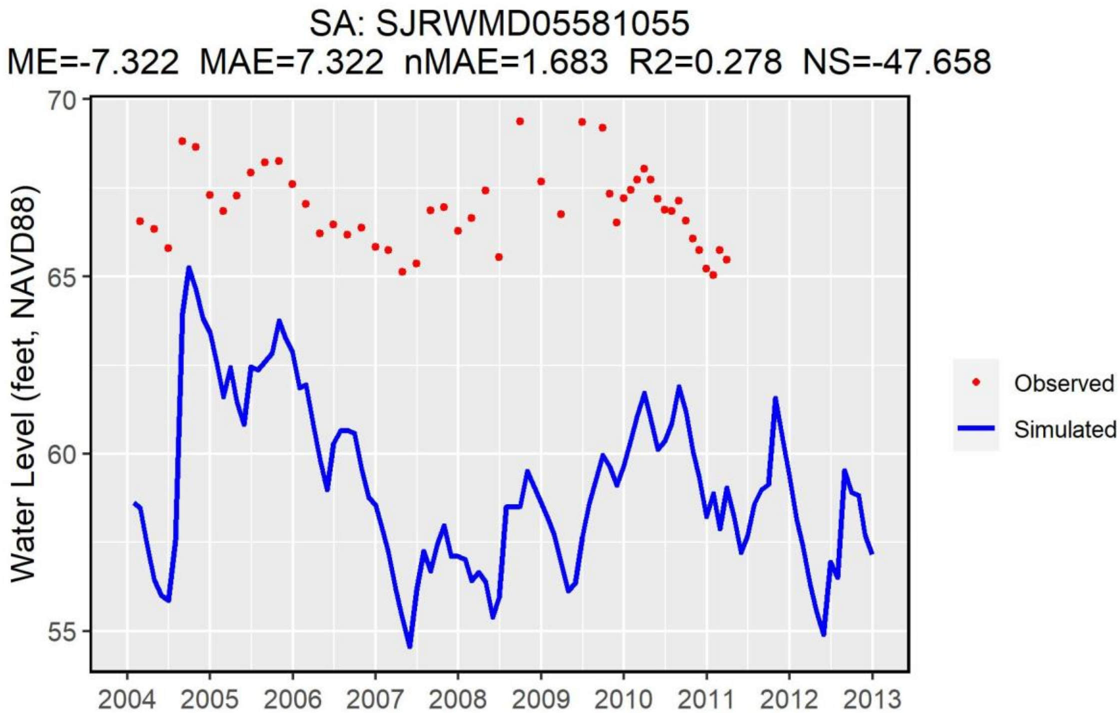

SA: ORH-1
ME=3.498 MAE=3.498 nMAE=0.581 R2=0.844 NS=-5.362
Water Level (feet, NAVD88)
92
94
96
98
100
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated


SA: ORS-3
ME=-1.334 MAE=1.334 nMAE=0.31 R2=0.786 NS=-1.682
Water Level (feet, NAVD88)
98
100
102
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

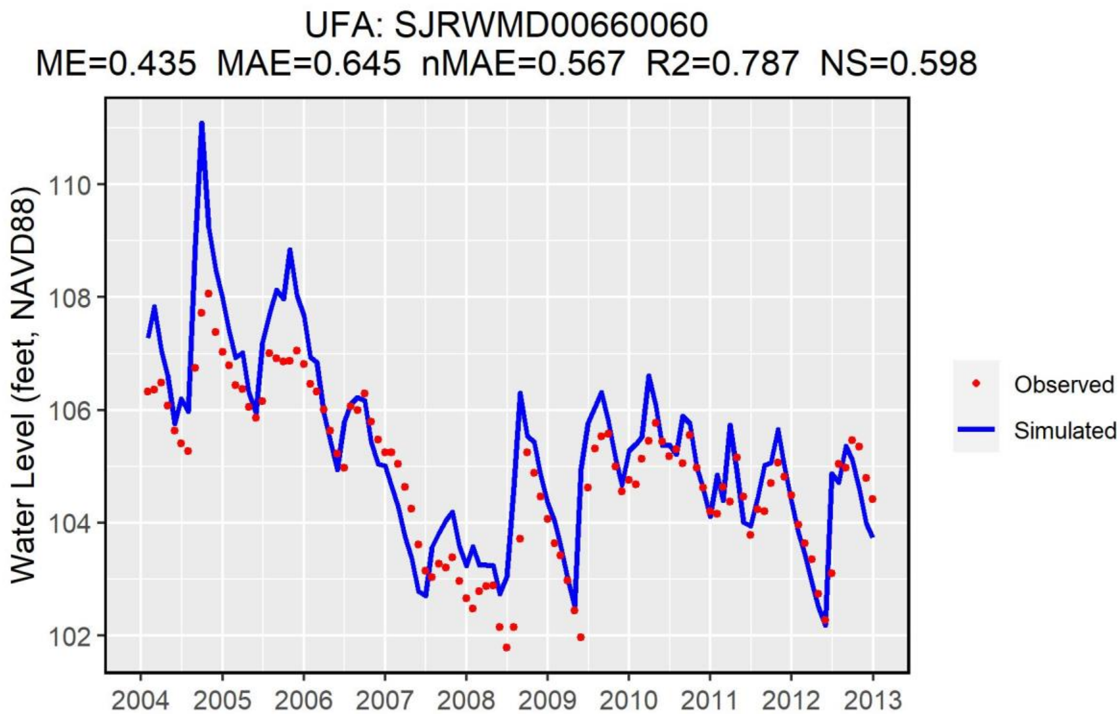

SA: TB3_GW1
ME=-0.227 MAE=0.257 nMAE=0.136 R2=0.951 NS=0.857
Water Level (feet, NAVD88)
100
99
98
97
96
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

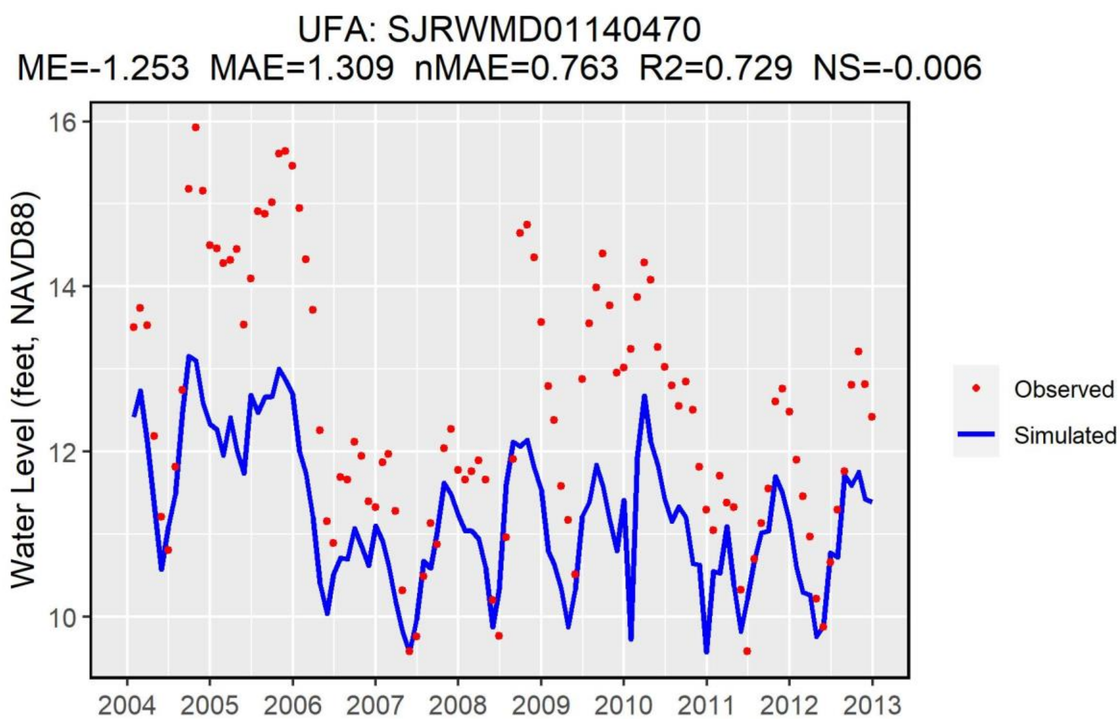

SA: TB3_GW2
ME=-0.218 MAE=0.248 nMAE=0.129 R2=0.954 NS=0.866
Water Level (feet, NAVD88)
100
99
98
97
96
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

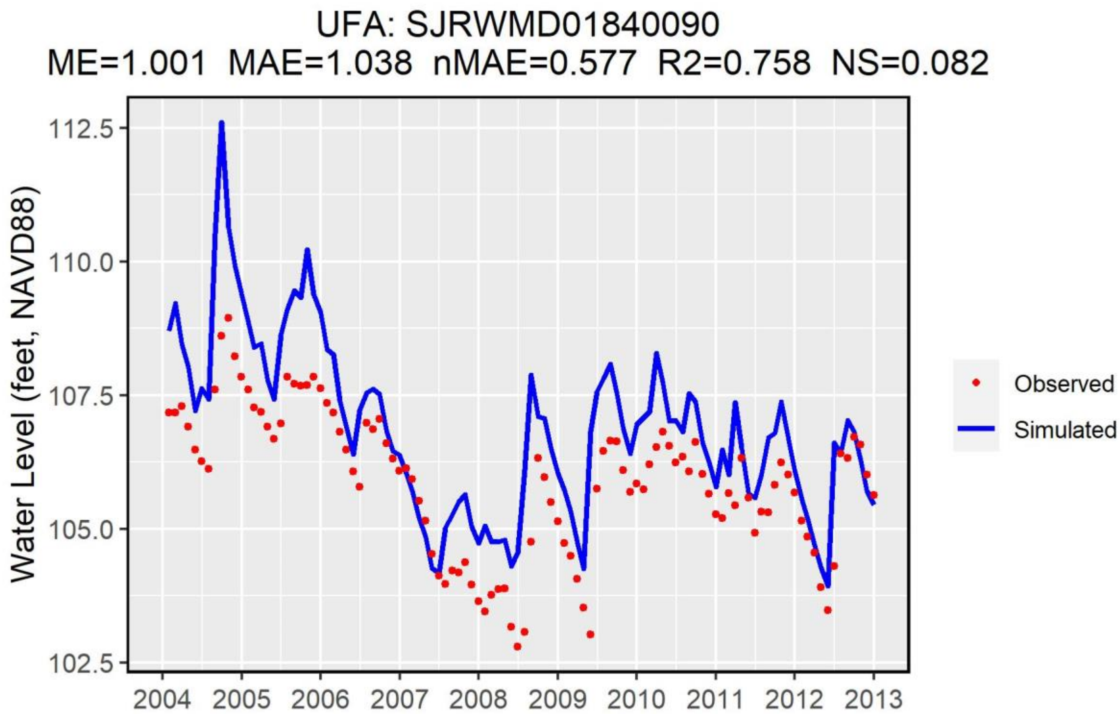

SA: SJRWMD05521047
ME=1.223 MAE=1.302 nMAE=0.799 R2=0.542 NS=-0.216
Water Level (feet, NAVD88)
17
15
13
11
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

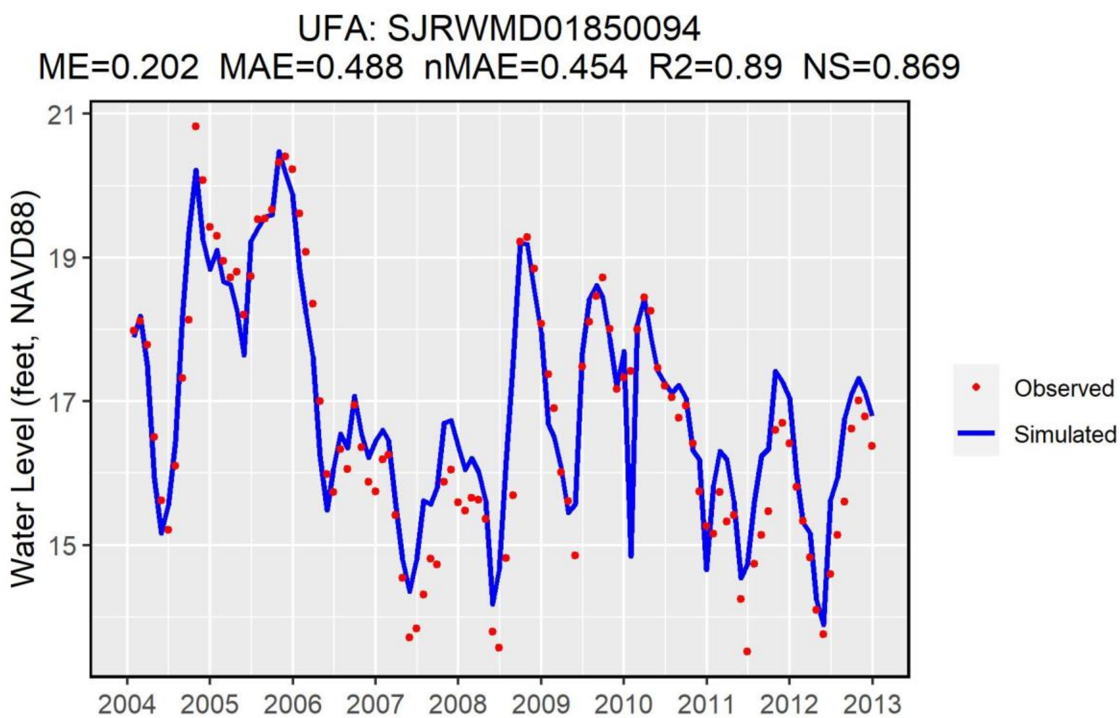

SA: SJRWMD05581055
ME=-7.322 MAE=7.322 nMAE=1.683 R2=0.278 NS=-47.658
Water Level (feet, NAVD88)
70
65
60
55
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

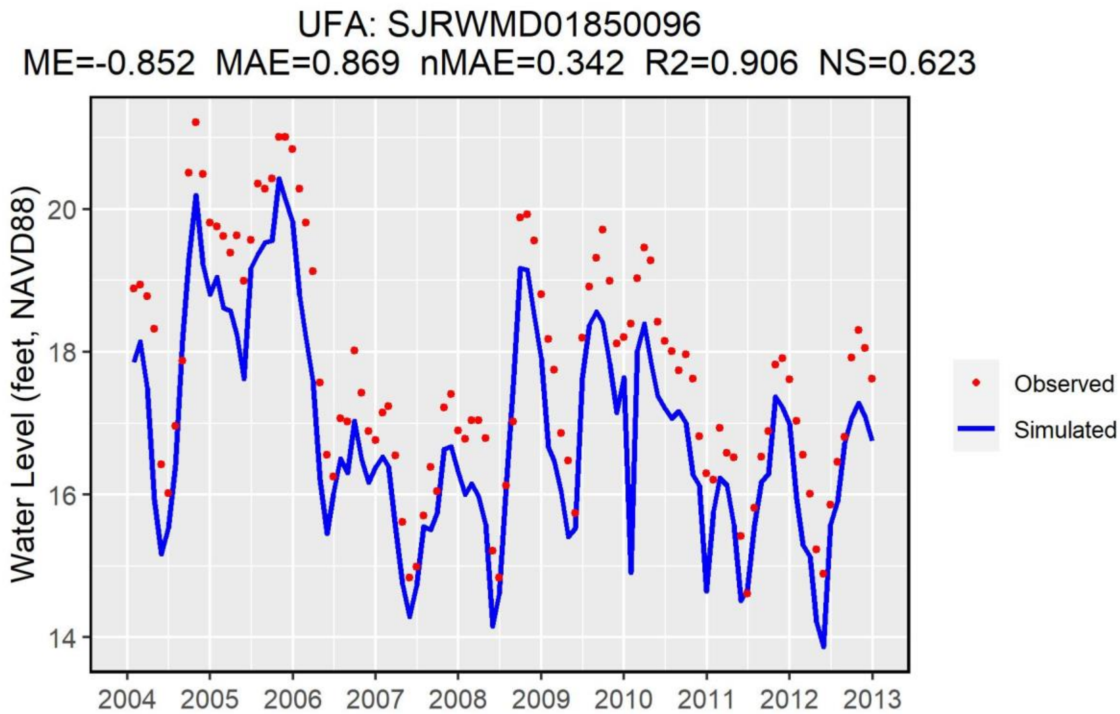
Upper Floridan Aquifer (UFA) Target Wells

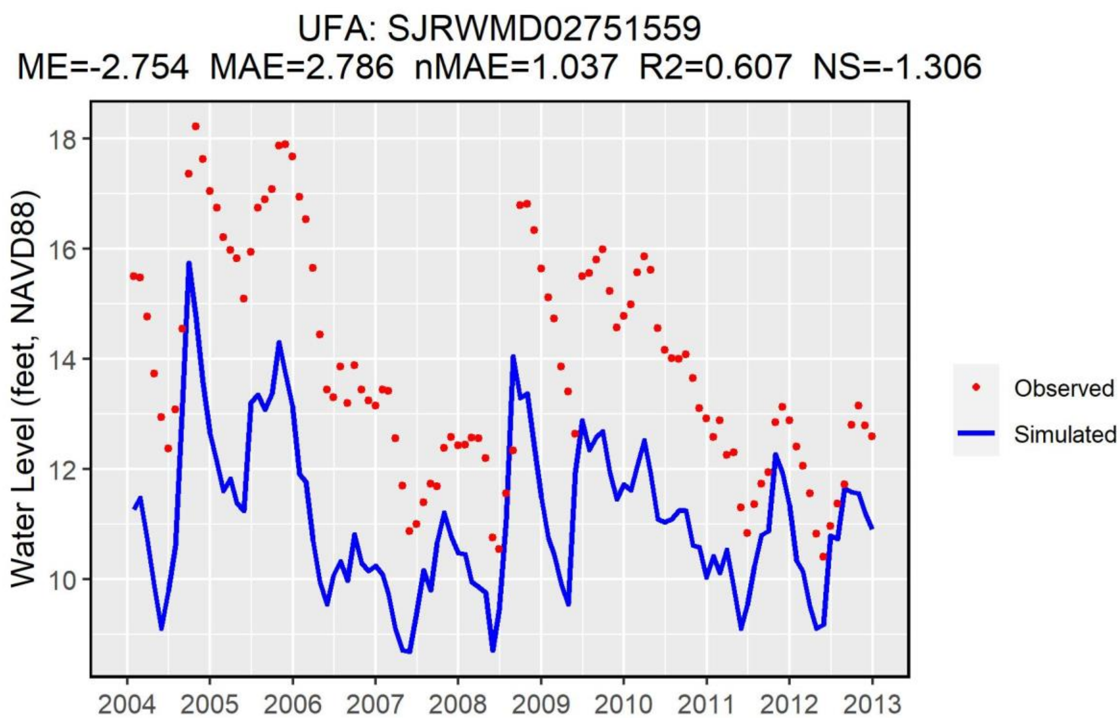


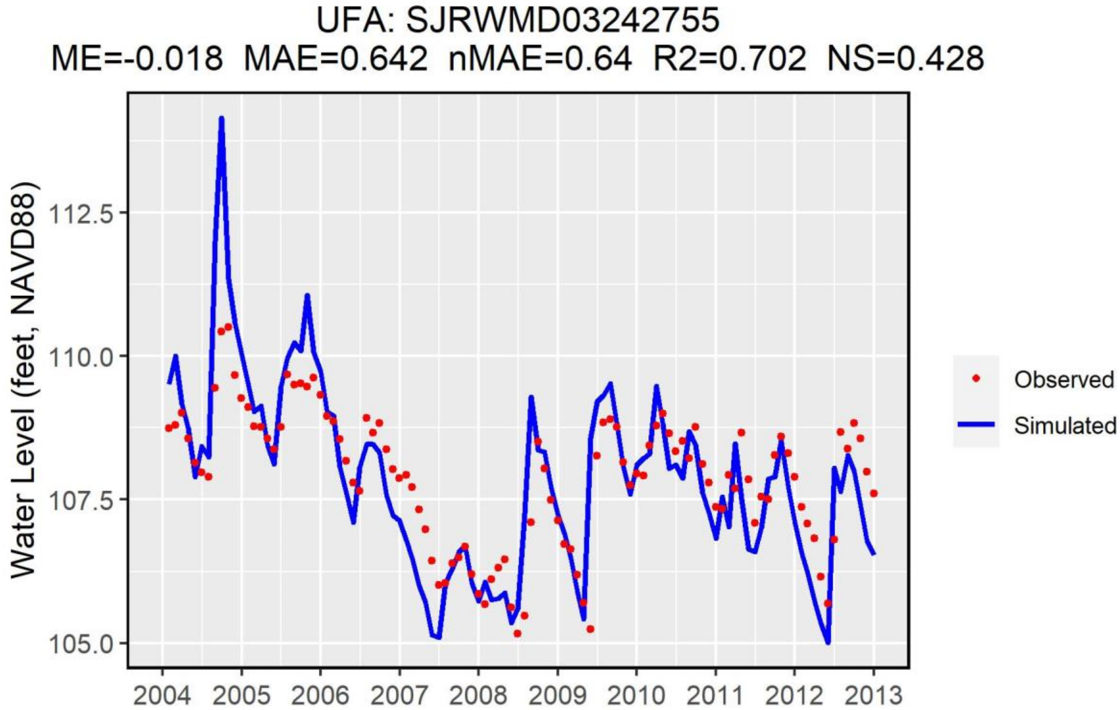


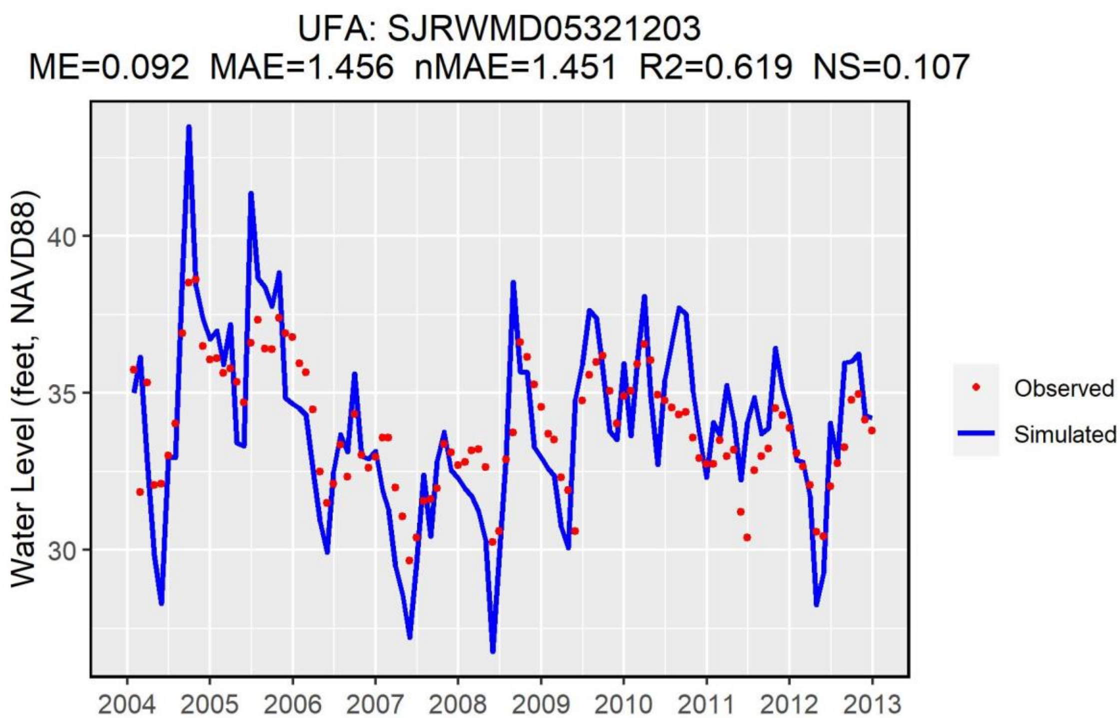

UFA: SJRWMD01840090
ME=1.001 MAE=1.038 nMAE=0.577 R2=0.758 NS=0.082
Water Level (feet, NAVD88)
112.5
110.0
107.5
105.0
102.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

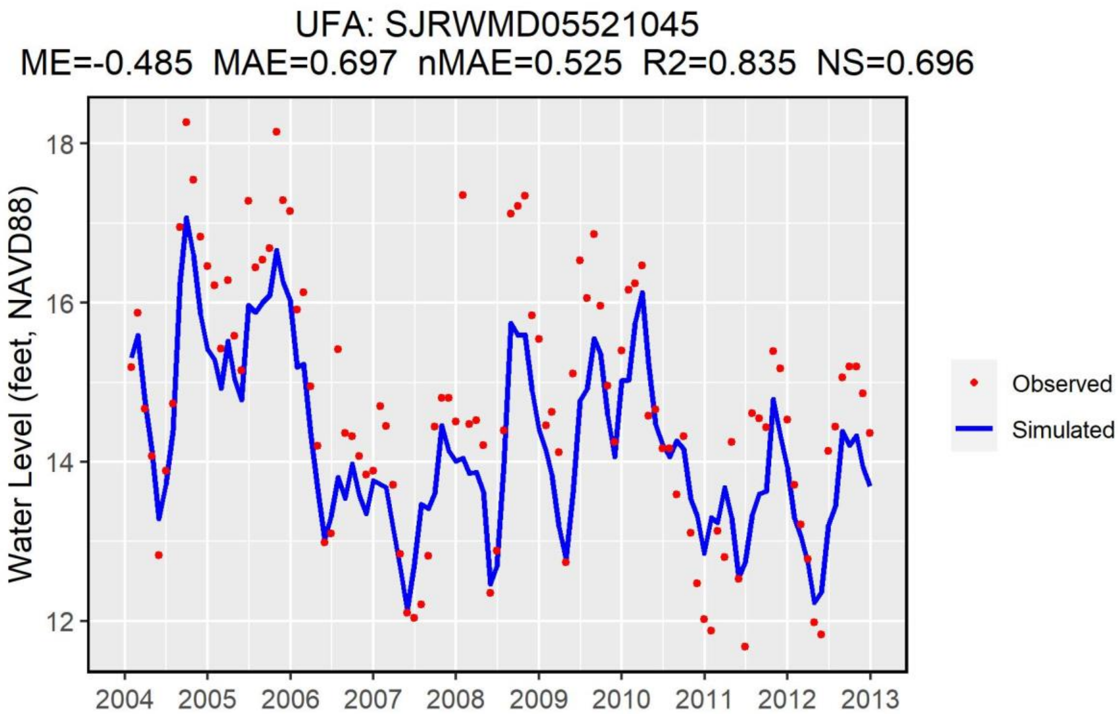

UFA: SJRWMD01850094
ME=0.202 MAE=0.488 nMAE=0.454 R2=0.89 NS=0.869
Water Level (feet, NAVD88)
21
19
17
15
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

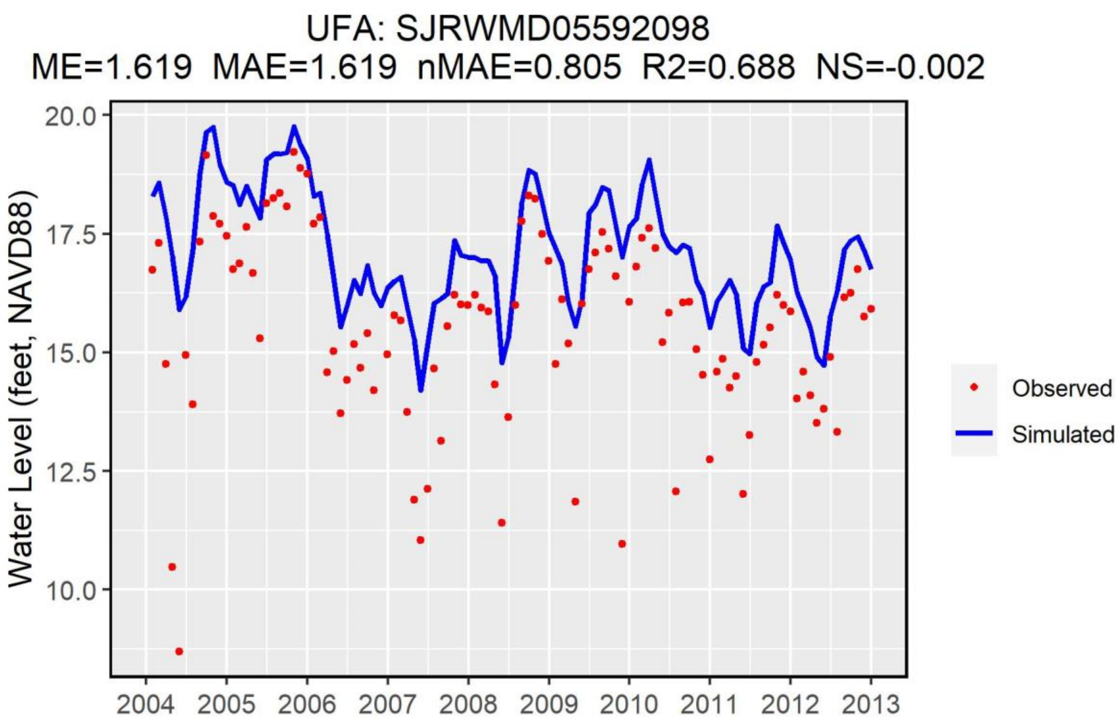

UFA: SJRWMD01850096
ME=-0.852 MAE=0.869 nMAE=0.342 R2=0.906 NS=0.623
Water Level (feet, NAVD88)
Observed
Simulated

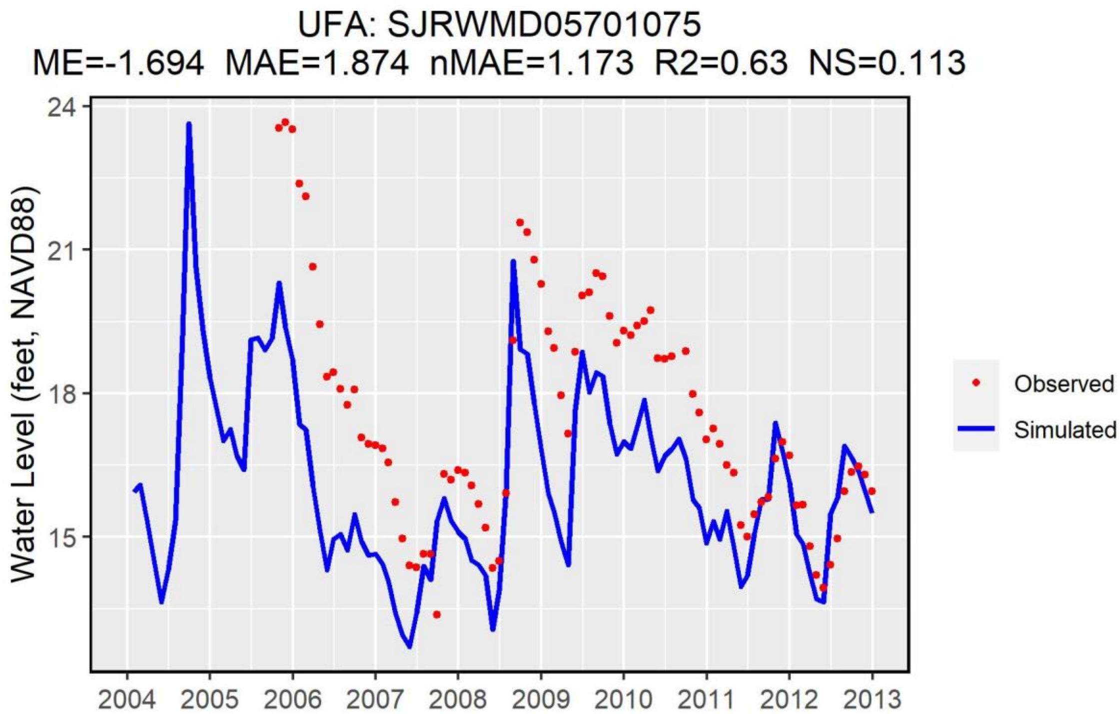

UFA: SJRWMD02751559
ME=-2.754 MAE=2.786 nMAE=1.037 R2=0.607 NS=-1.306
Water Level (feet, NAVD88)
Observed
Simulated

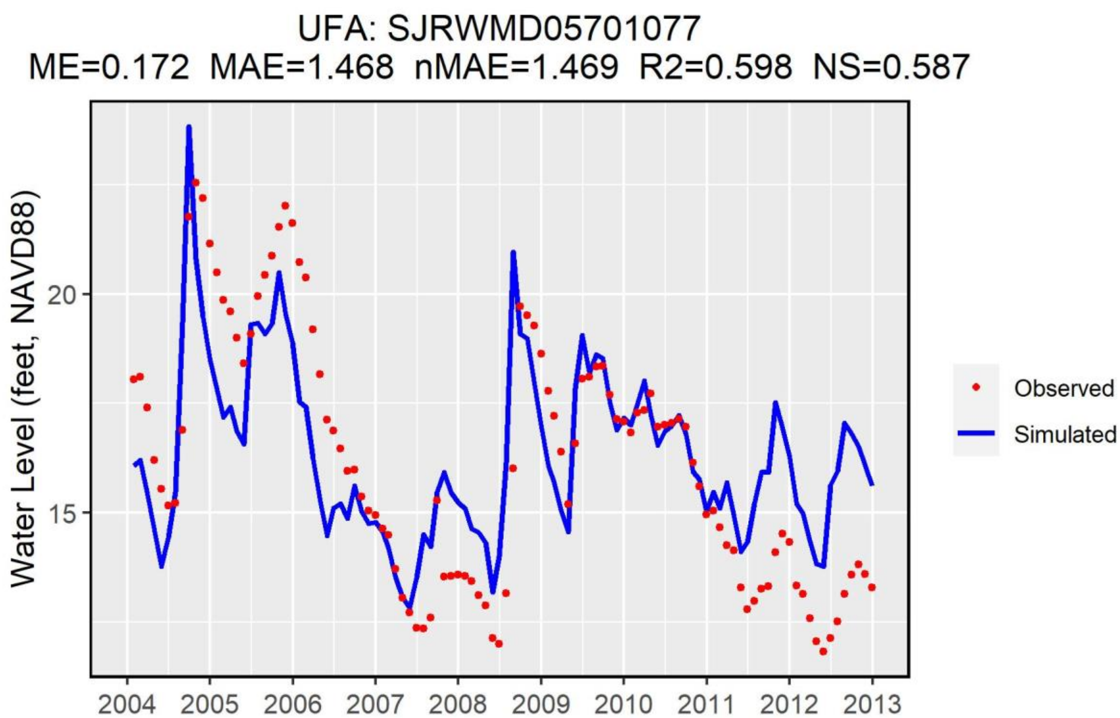

UFA: SJRWMD03242755
ME=-0.018 MAE=0.642 nMAE=0.64 R2=0.702 NS=0.428
Water Level (feet, NAVD88)
112.5
110.0
107.5
105.0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

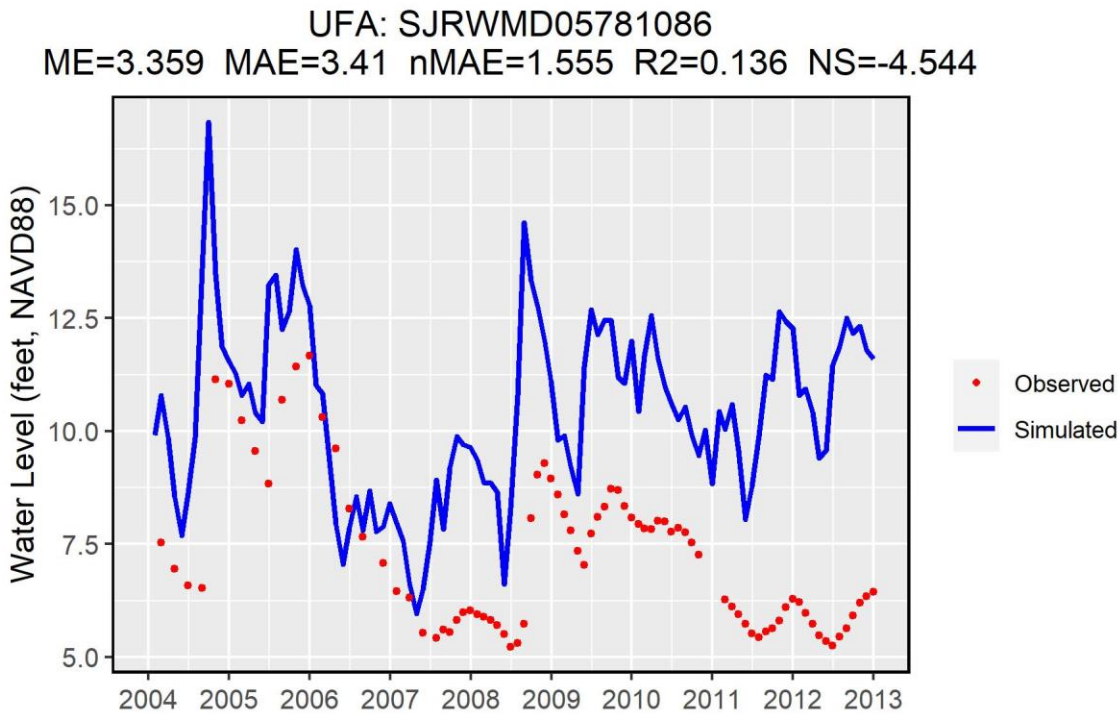

UFA: SJRWMD05321203
ME=0.092 MAE=1.456 nMAE=1.451 R2=0.619 NS=0.107
Water Level (feet, NAVD88)
40
35
30
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

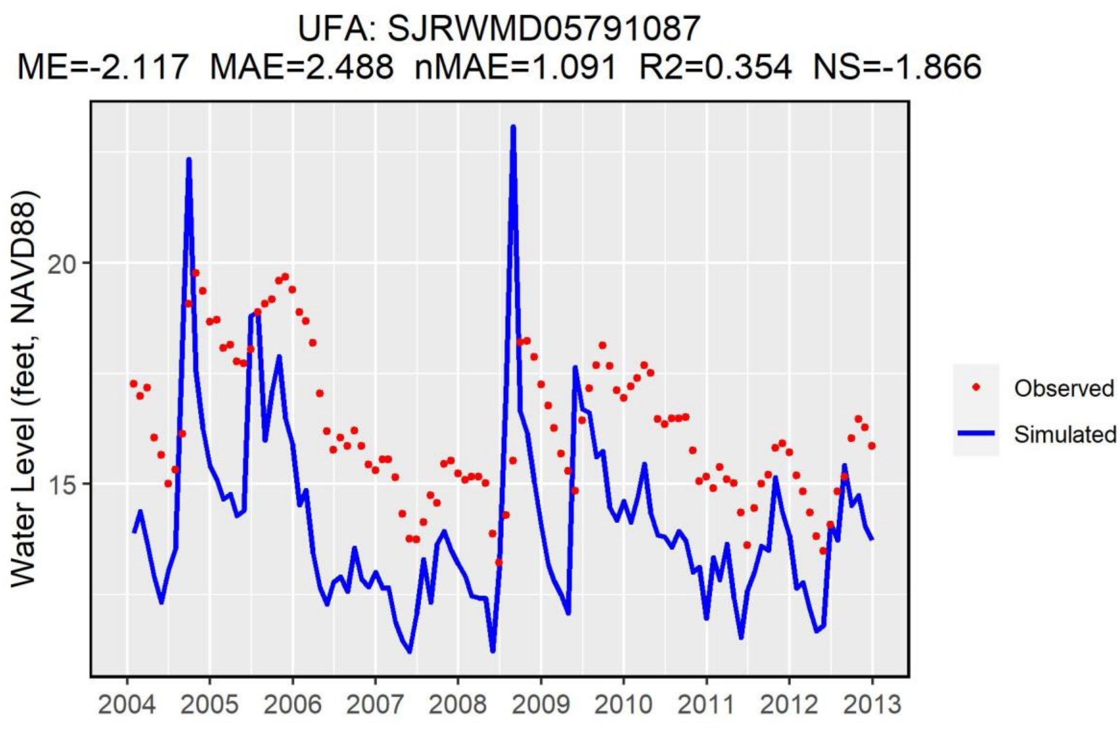

UFA: SJRWMD05521045
ME=-0.485 MAE=0.697 nMAE=0.525 R2=0.835 NS=0.696
Water Level (feet, NAVD88)
Observed
Simulated

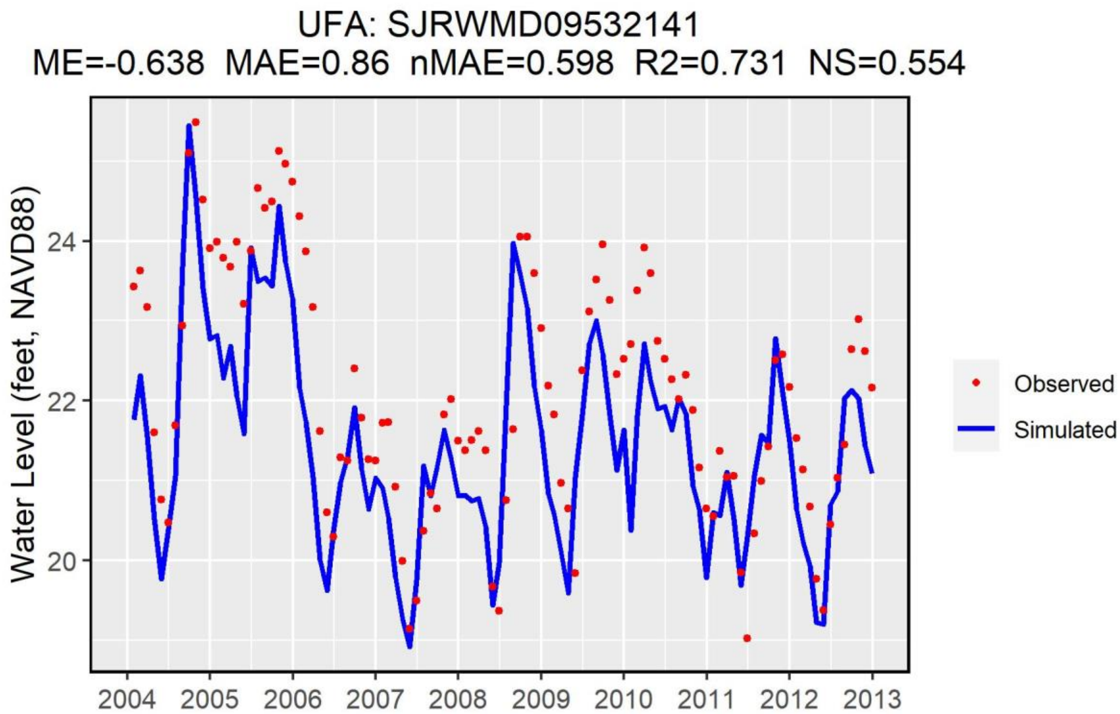

UFA: SJRWMD05592098
ME=1.619 MAE=1.619 nMAE=0.805 R2=0.688 NS=-0.002
Water Level (feet, NAVD88)
Observed
Simulated

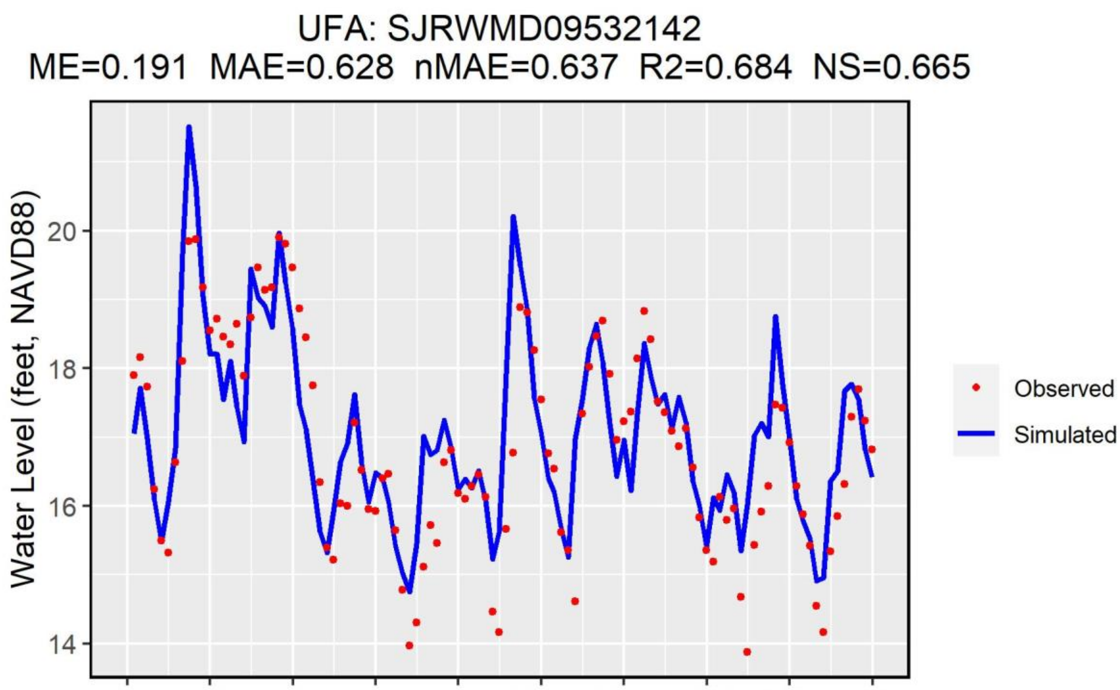

UFA: SJRWMD05701075
ME=-1.694 MAE=1.874 nMAE=1.173 R2=0.63 NS=0.113
Water Level (feet, NAVD88)
24
21
18
15
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

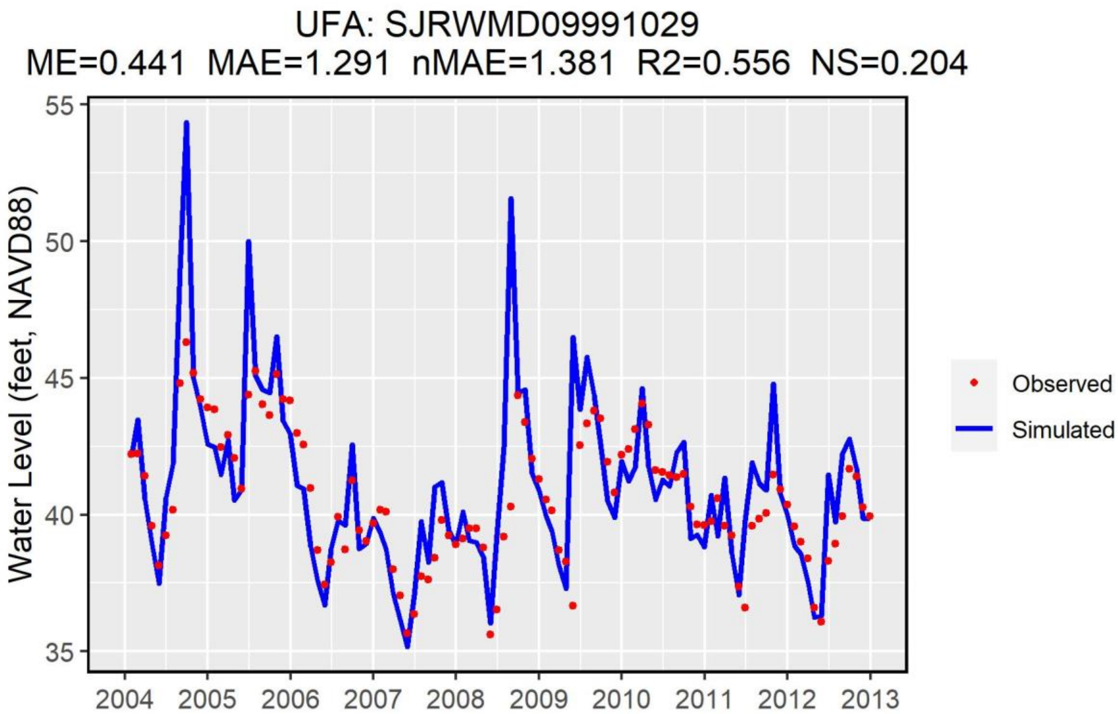

UFA: SJRWMD05701077
ME=0.172 MAE=1.468 nMAE=1.469 R2=0.598 NS=0.587
Water Level (feet, NAVD88)
20
15
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

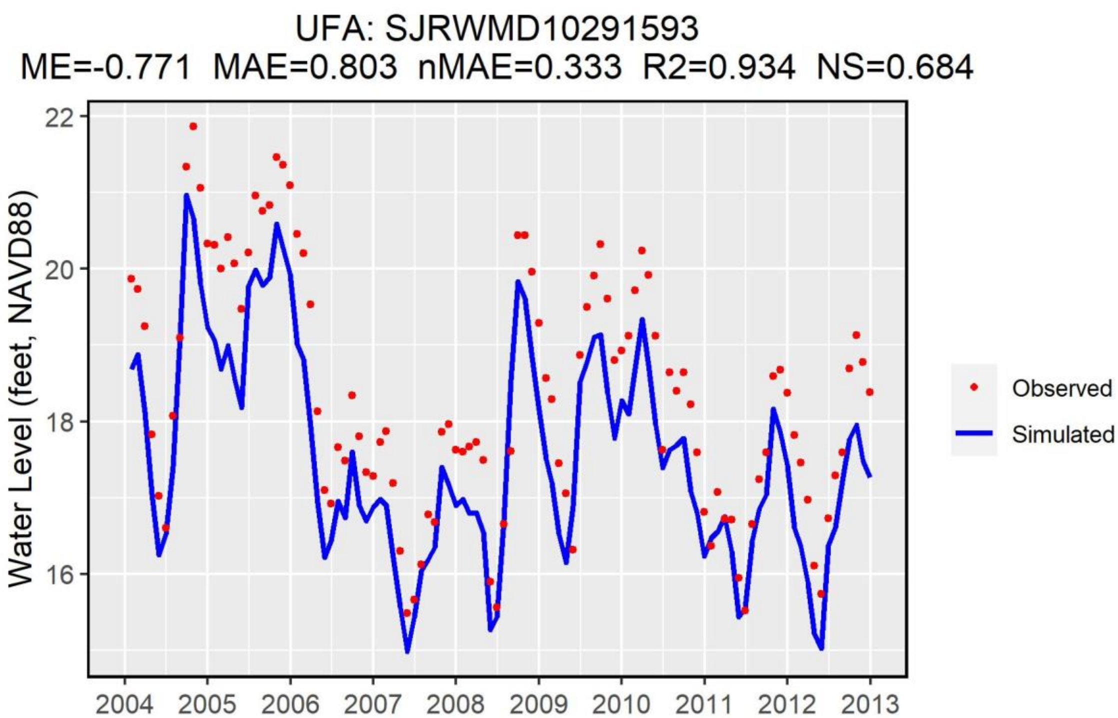

UFA: SJRWMD05781086
ME=3.359 MAE=3.41 nMAE=1.555 R2=0.136 NS=-4.544
Water Level (feet, NAVD88)
15.0
12.5
10.0
7.5
5.0
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

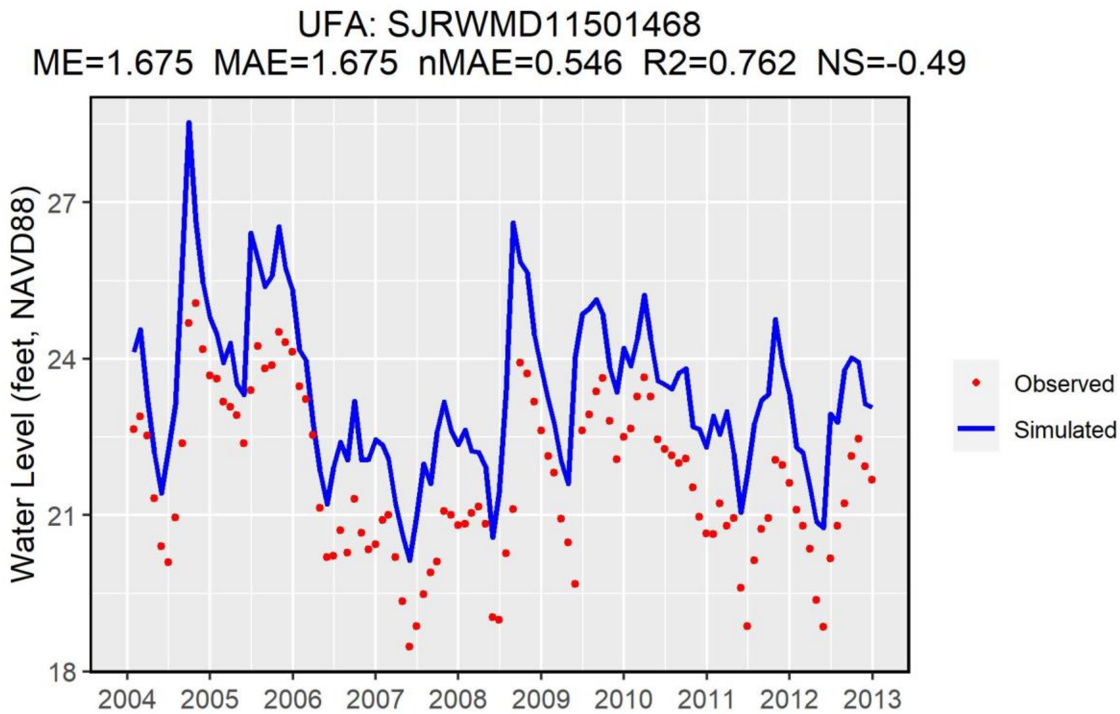

UFA: SJRWMD05791087
ME=-2.117 MAE=2.488 nMAE=1.091 R2=0.354 NS=-1.866
Water Level (feet, NAVD88)
20
15
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

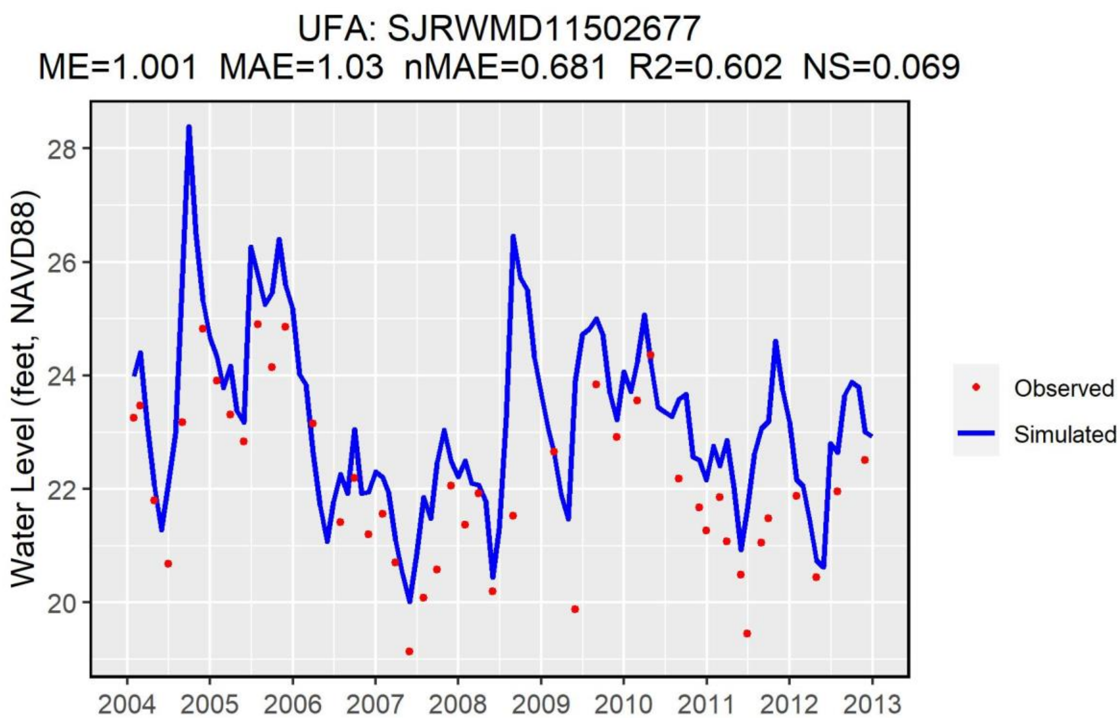

UFA: SJRWMD09532141
ME=-0.638 MAE=0.86 nMAE=0.598 R2=0.731 NS=0.554
Water Level (feet, NAVD88)
24
22
20
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

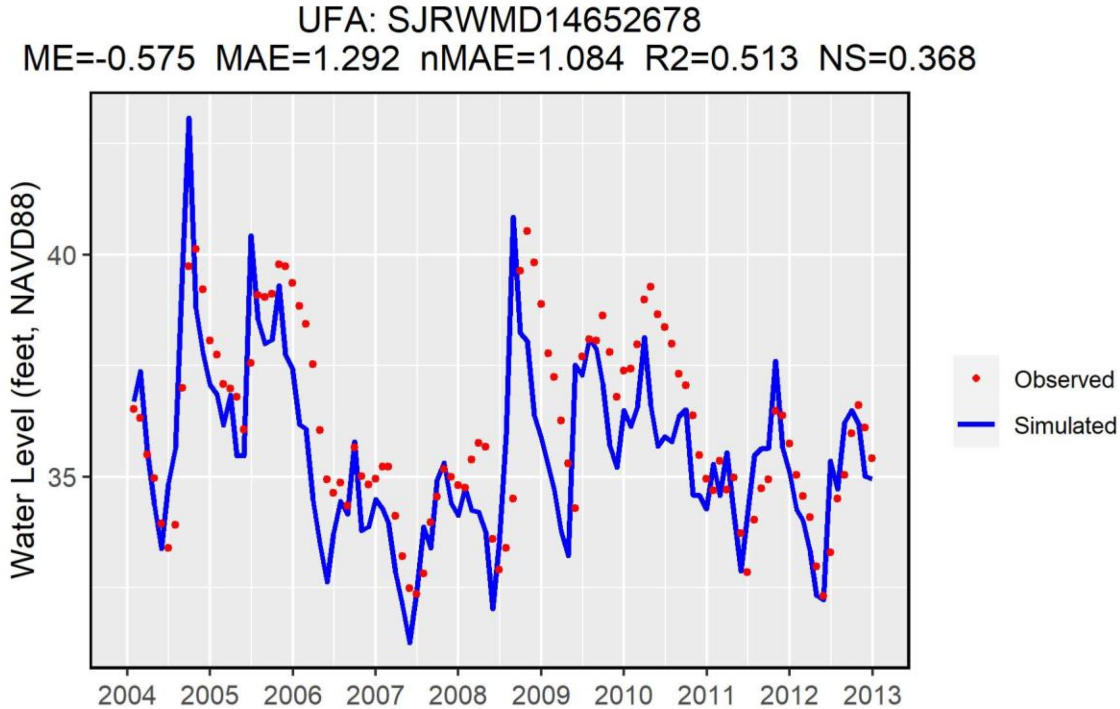

UFA: SJRWMD09532142
ME=0.191 MAE=0.628 nMAE=0.637 R2=0.684 NS=0.665
Water Level (feet, NAVD88)
20
18
16
14
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

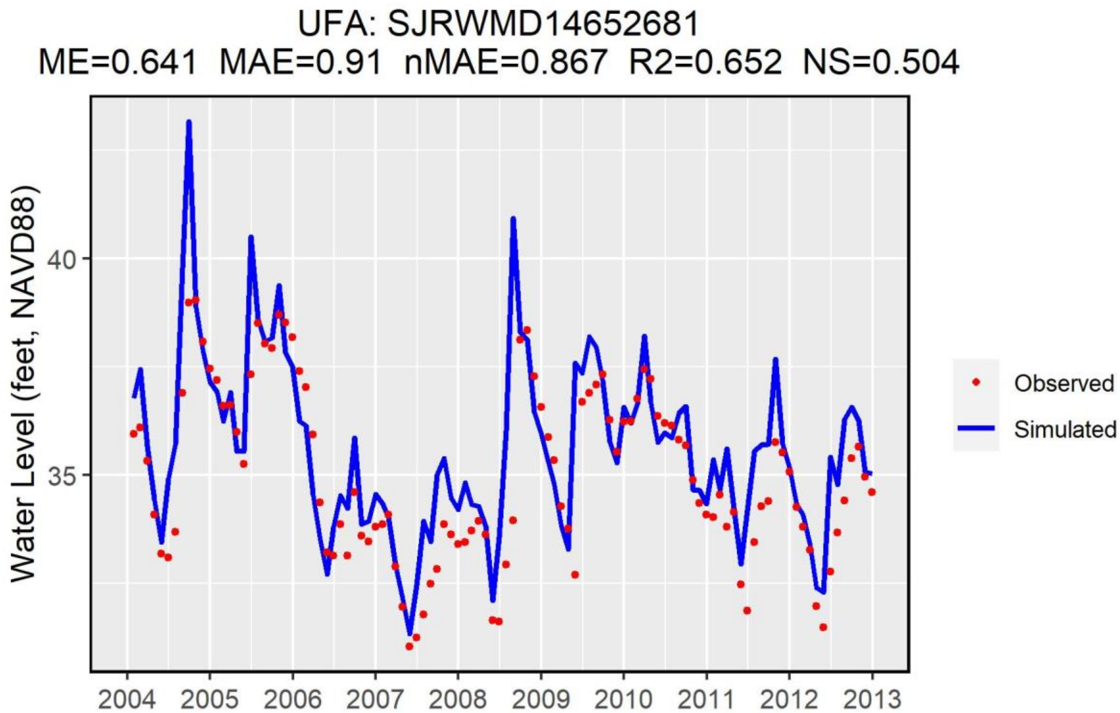

UFA: SJRWMD09991029
ME=0.441 MAE=1.291 nMAE=1.381 R2=0.556 NS=0.204
Water Level (feet, NAVD88)
55
50
45
40
35
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

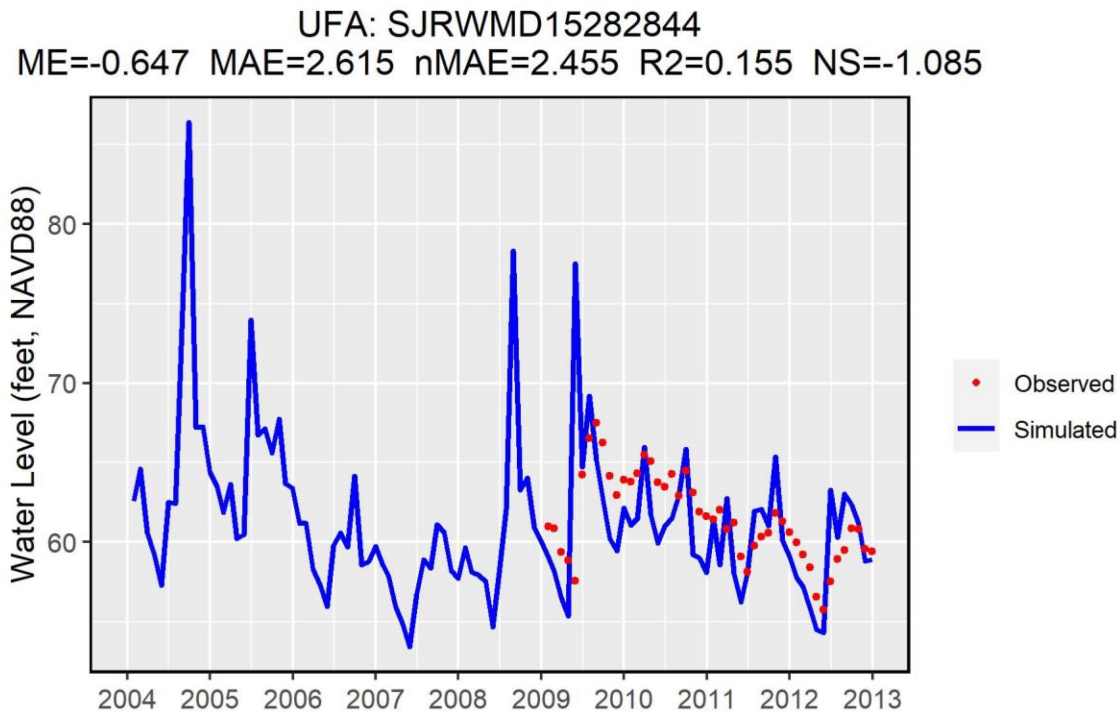

UFA: SJRWMD10291593
ME=-0.771 MAE=0.803 nMAE=0.333 R2=0.934 NS=0.684
Water Level (feet, NAVD88)
22
20
18
16
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

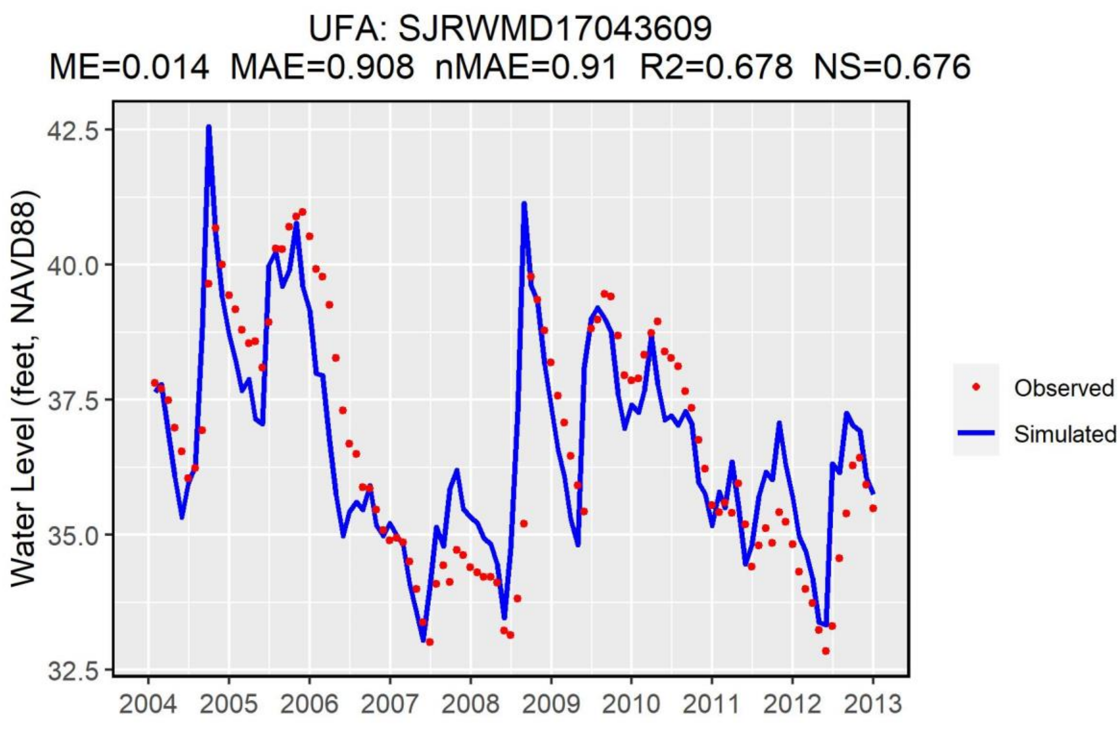

UFA: SJRWMD11501468
ME=1.675 MAE=1.675 nMAE=0.546 R2=0.762 NS=-0.49
Water Level (feet, NAVD88)
Observed
Simulated

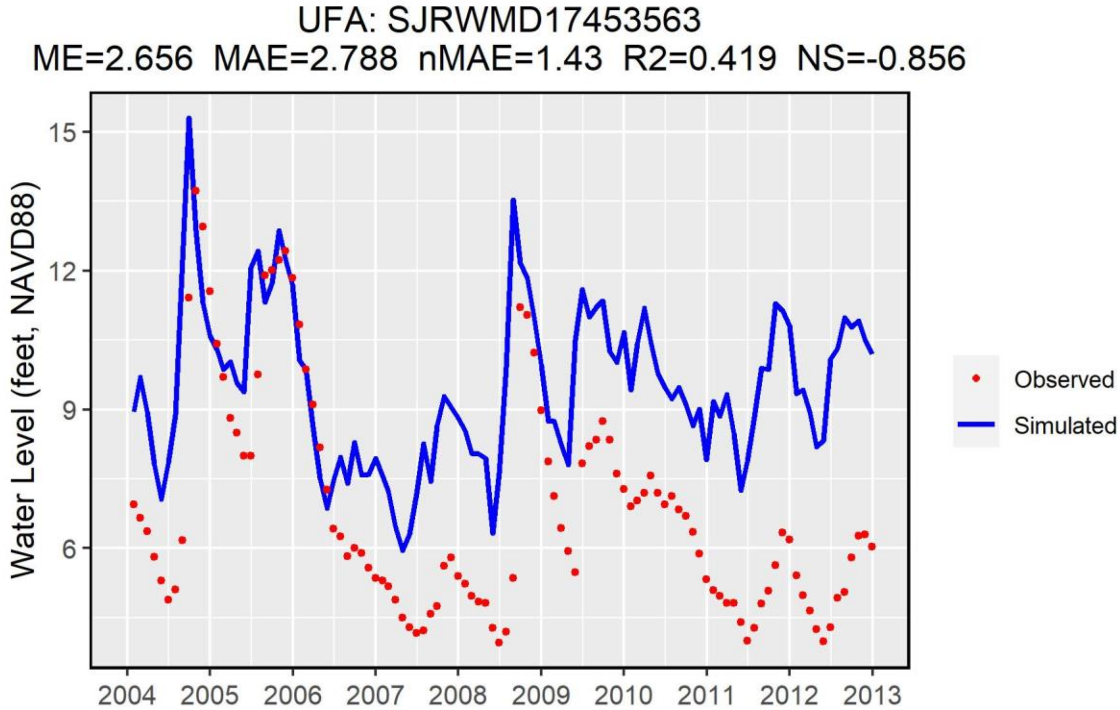

UFA: SJRWMD11502677
ME=1.001 MAE=1.03 nMAE=0.681 R2=0.602 NS=0.069
Water Level (feet, NAVD88)
Observed
Simulated

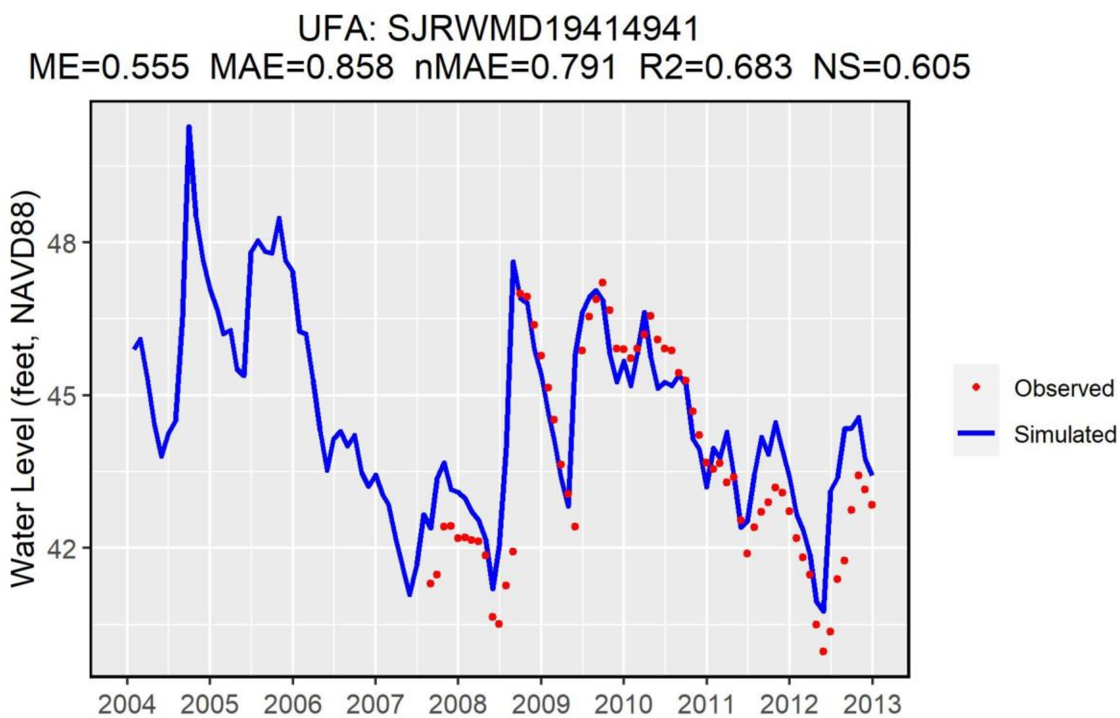

UFA: SJRWMD14652678
ME=-0.575 MAE=1.292 nMAE=1.084 R2=0.513 NS=0.368
Water Level (feet, NAVD88)
40
35
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

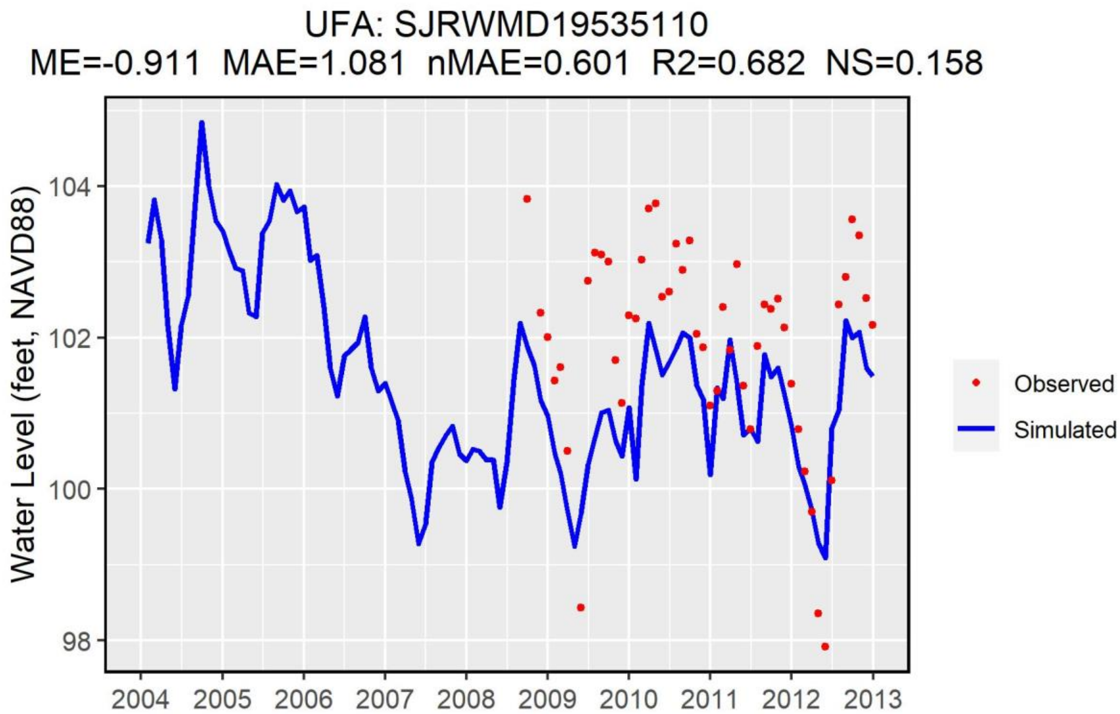

UFA: SJRWMD14652681
ME=0.641 MAE=0.91 nMAE=0.867 R2=0.652 NS=0.504
Water Level (feet, NAVD88)
40
35
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

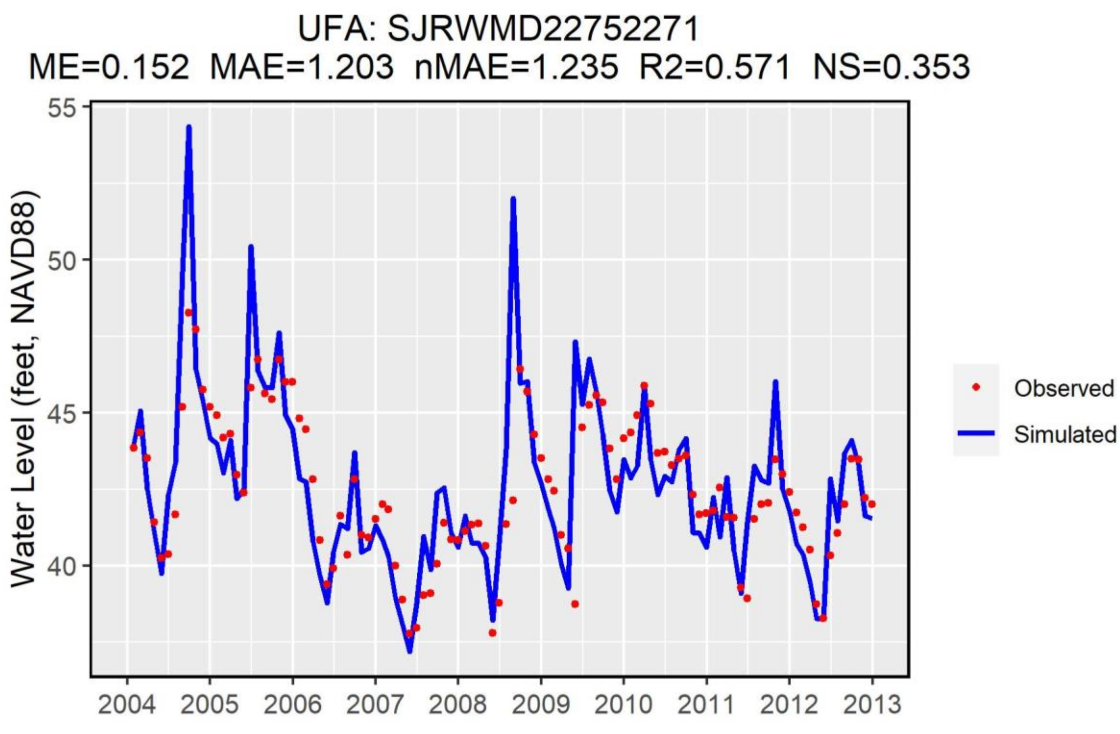

UFA: SJRWMD15282844
ME=-0.647 MAE=2.615 nMAE=2.455 R2=0.155 NS=-1.085
Water Level (feet, NAVD88)
80
70
60
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

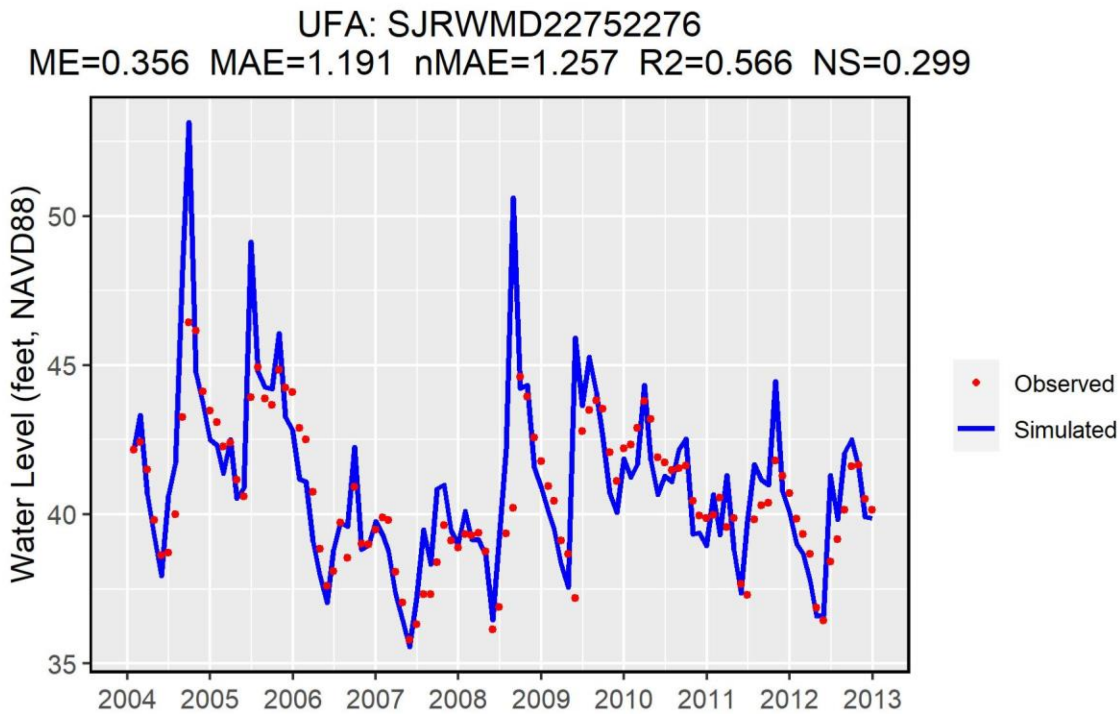

UFA: SJRWMD17043609
ME=0.014 MAE=0.908 nMAE=0.91 R2=0.678 NS=0.676
Water Level (feet, NAVD88)
42.5
40.0
37.5
35.0
32.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

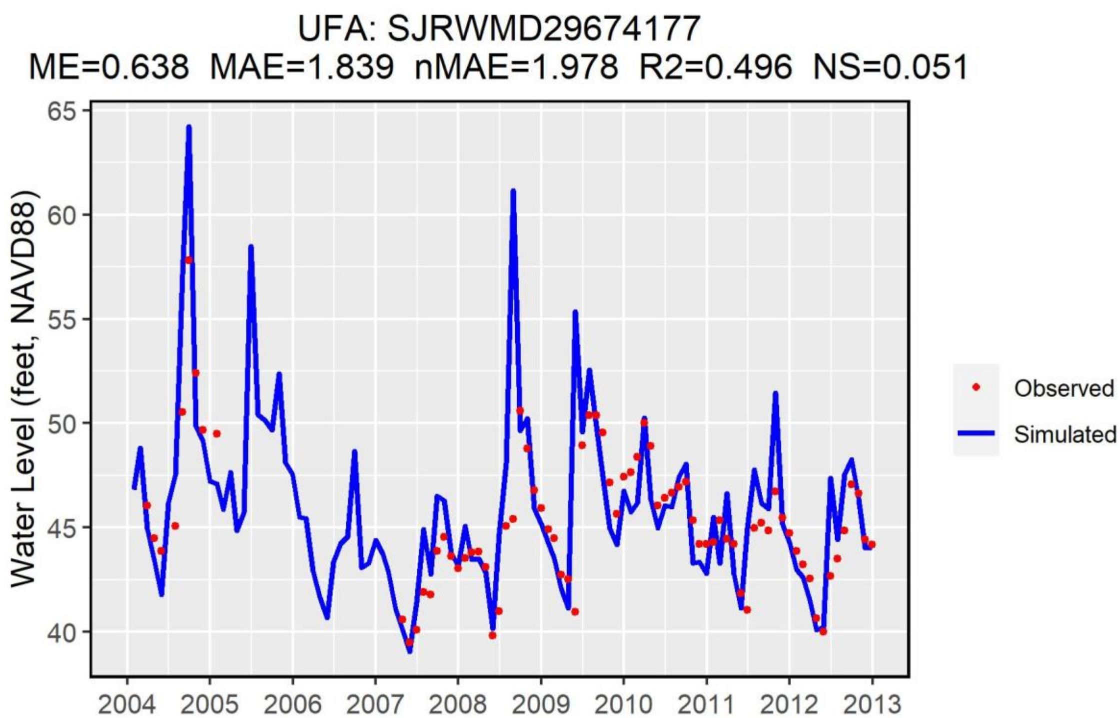

UFA: SJRWMD17453563
ME=2.656 MAE=2.788 nMAE=1.43 R2=0.419 NS=-0.856
Water Level (feet, NAVD88)
15
12
9
6
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

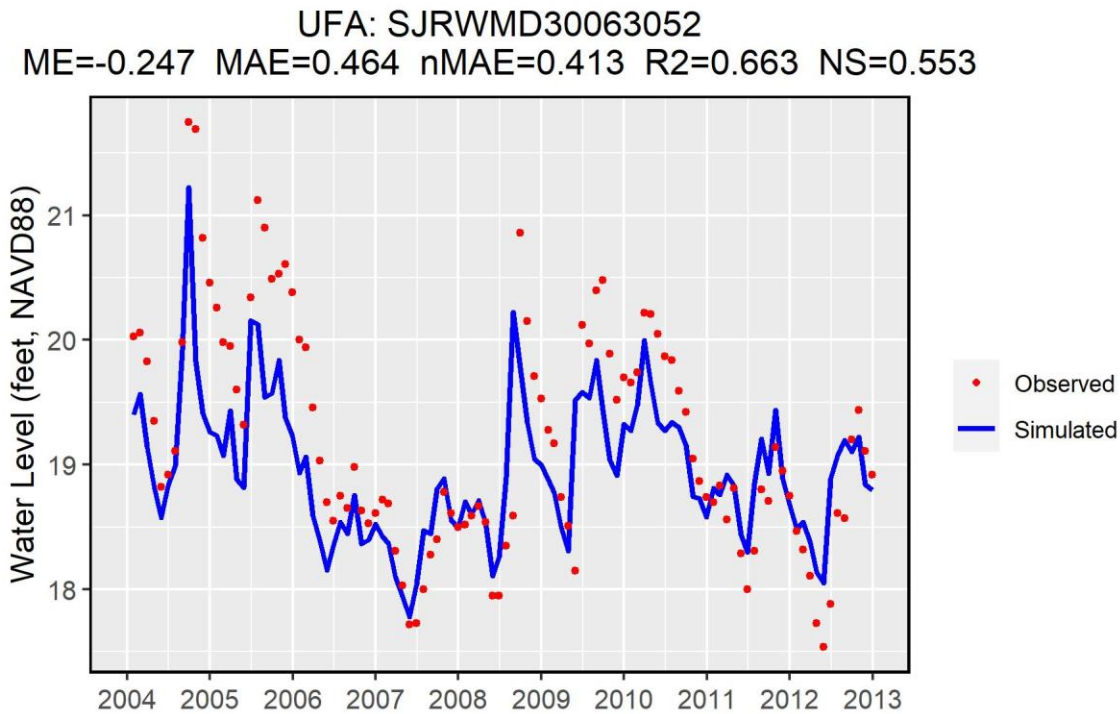

UFA: SJRWMD19414941
ME=0.555 MAE=0.858 nMAE=0.791 R2=0.683 NS=0.605
Water Level (feet, NAVD88)
48
45
42
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

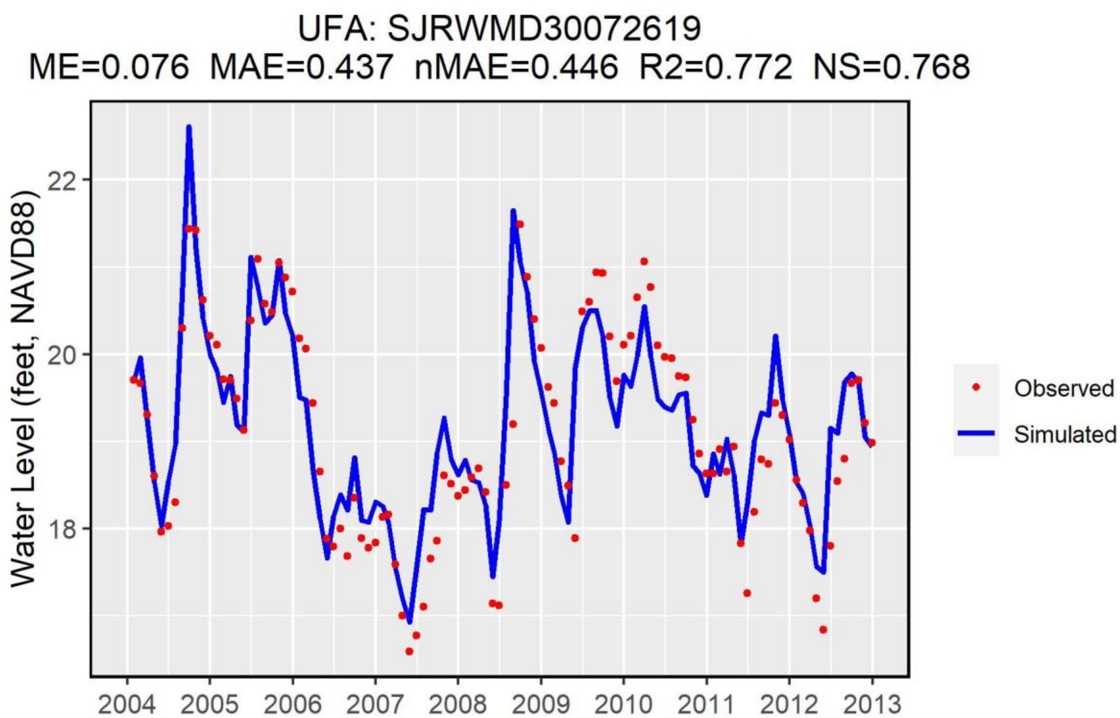

UFA: SJRWMD19535110
ME=-0.911 MAE=1.081 nMAE=0.601 R2=0.682 NS=0.158
Water Level (feet, NAVD88)
104
102
100
98
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

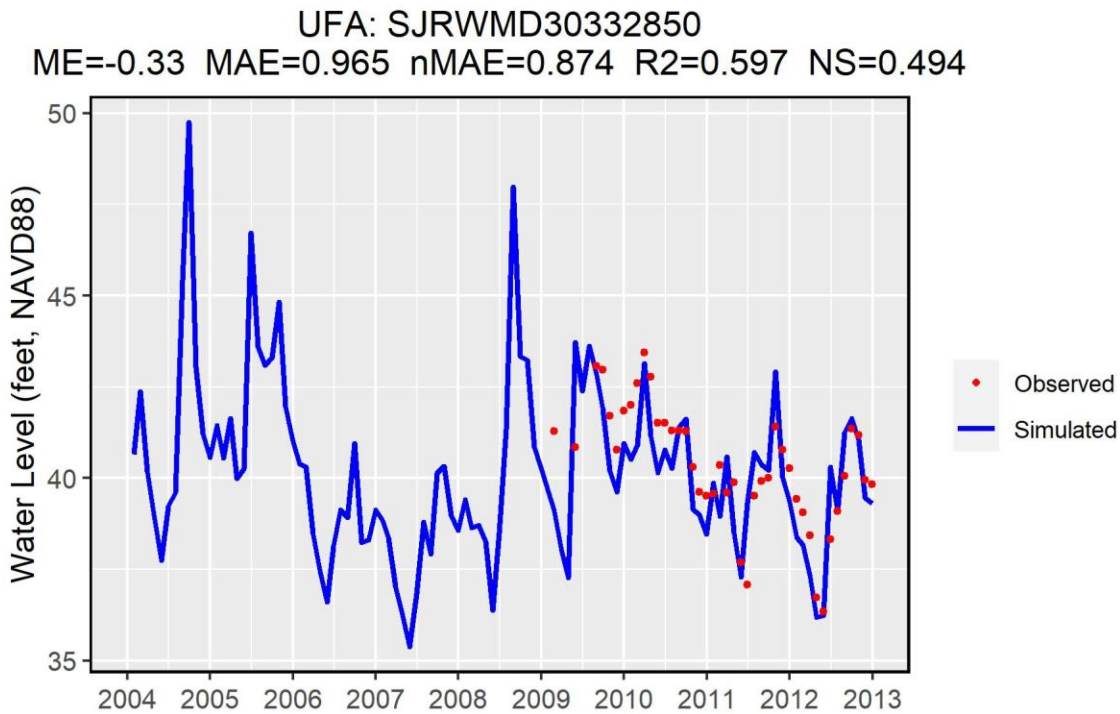

UFA: SJRWMD22752271
ME=0.152 MAE=1.203 nMAE=1.235 R2=0.571 NS=0.353
Water Level (feet, NAVD88)
55
50
45
40
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

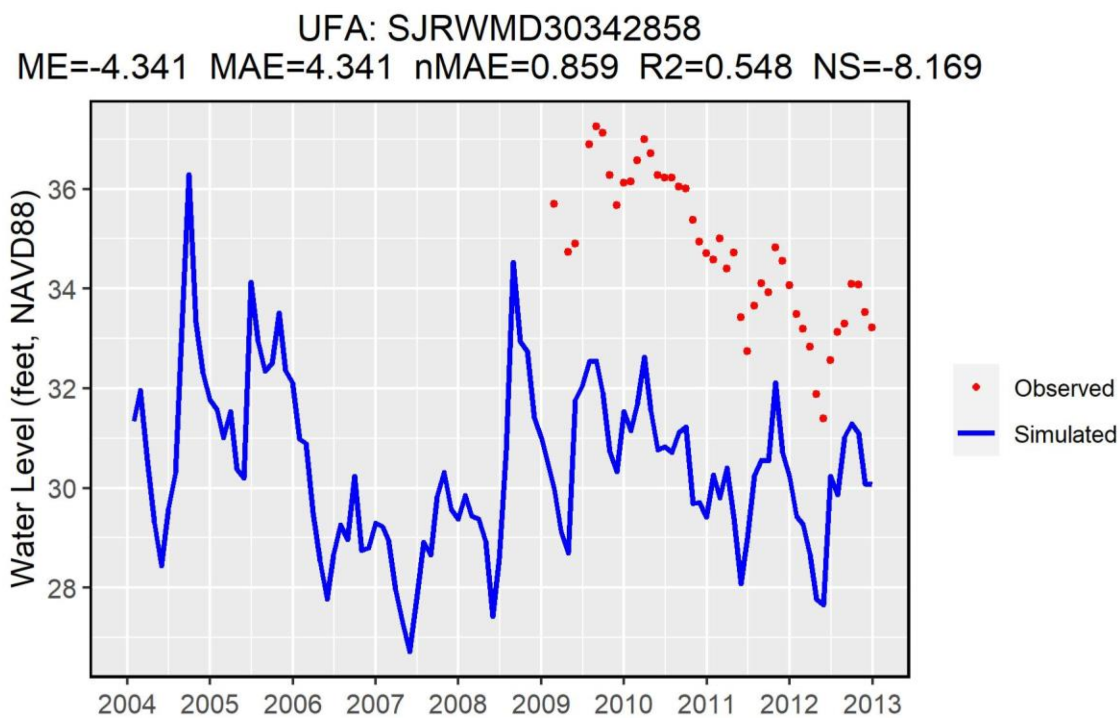

UFA: SJRWMD22752276
ME=0.356 MAE=1.191 nMAE=1.257 R2=0.566 NS=0.299
Water Level (feet, NAVD88)
35
40
45
50
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

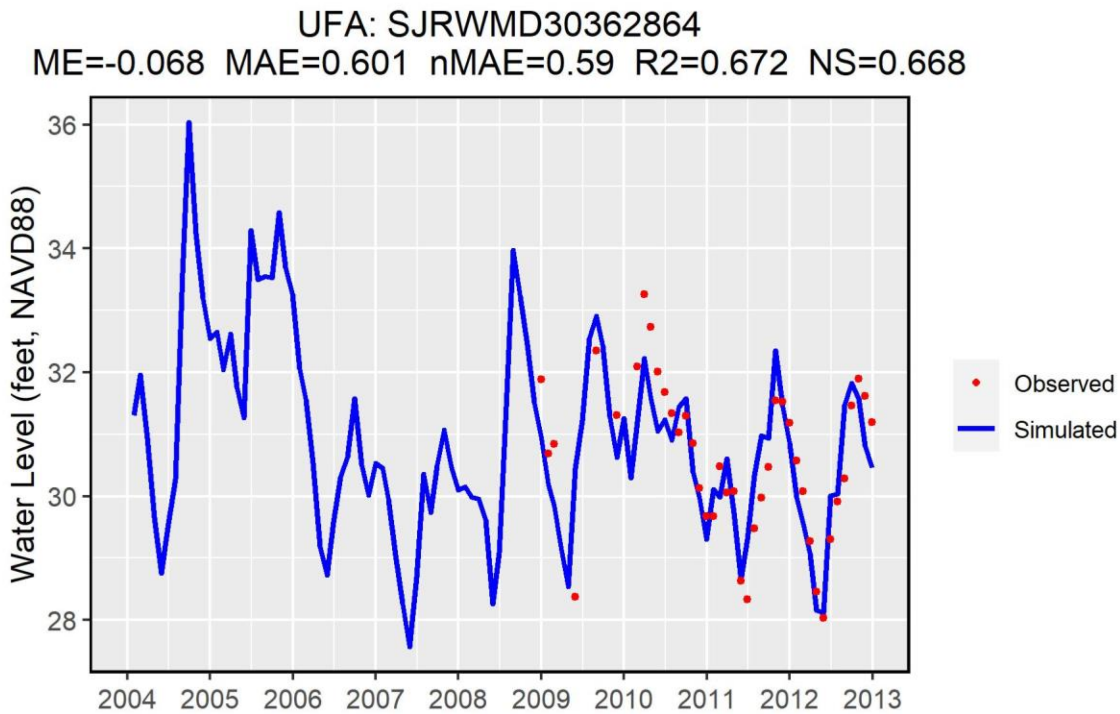

UFA: SJRWMD29674177
ME=0.638 MAE=1.839 nMAE=1.978 R2=0.496 NS=0.051
Water Level (feet, NAVD88)
40
45
50
55
60
65
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

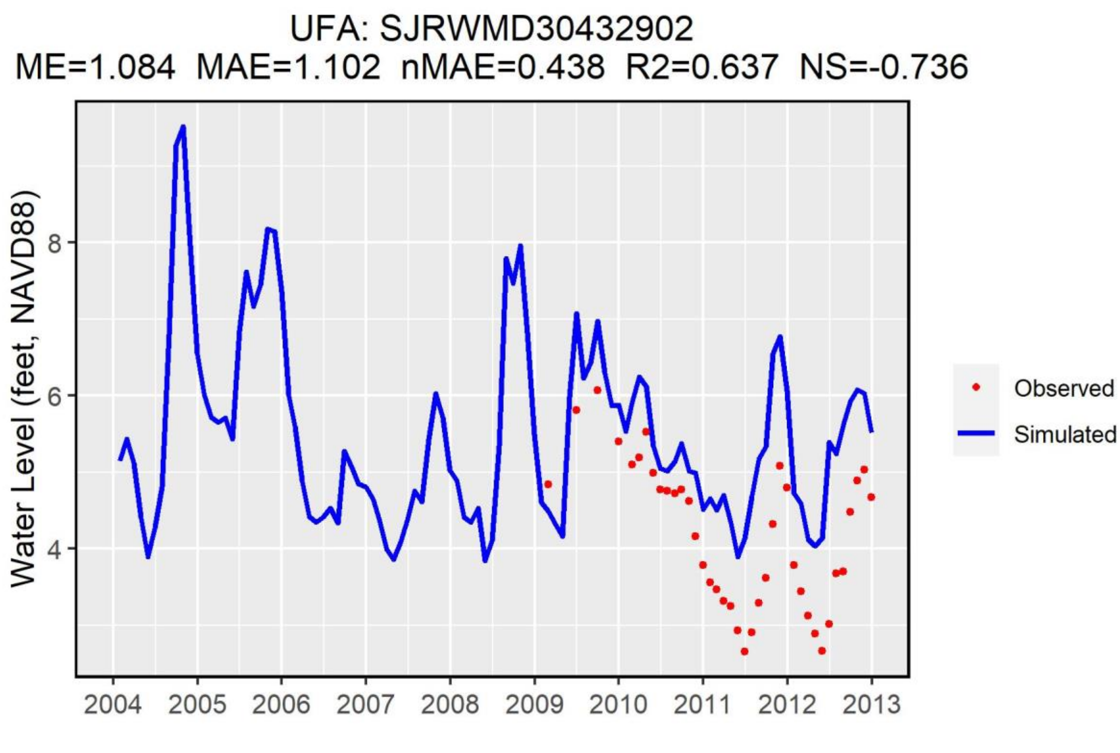

UFA: SJRWMD30063052
ME=-0.247 MAE=0.464 nMAE=0.413 R2=0.663 NS=0.553
Water Level (feet, NAVD88)
21
20
19
18
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

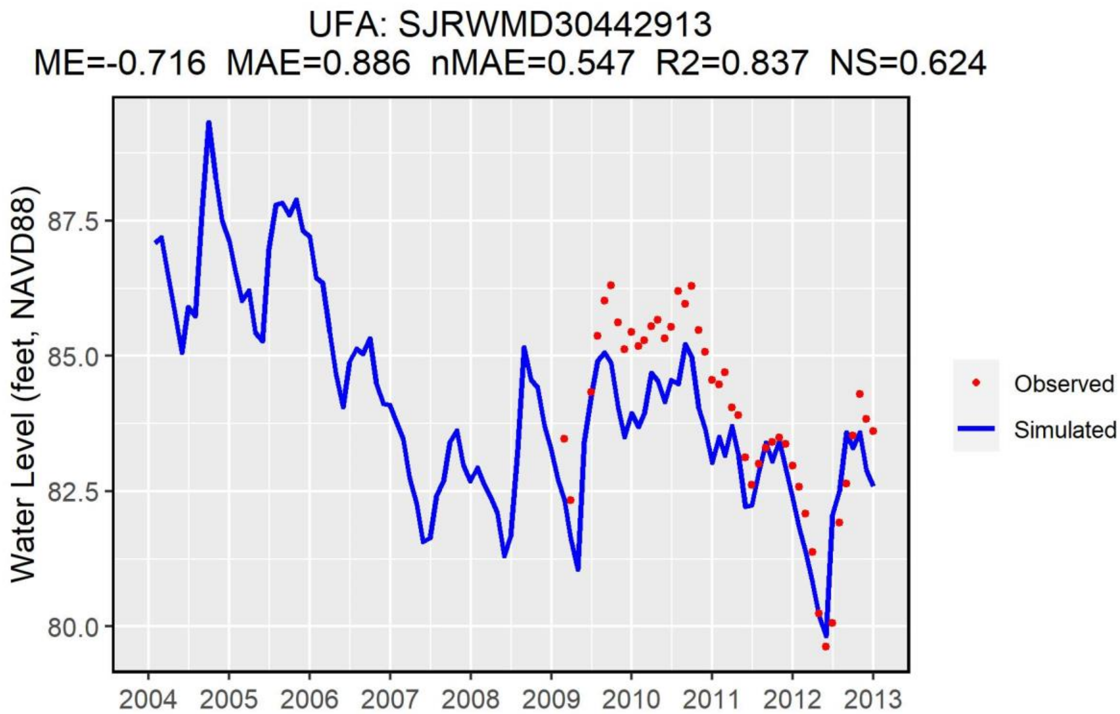

UFA: SJRWMD30072619
ME=0.076 MAE=0.437 nMAE=0.446 R2=0.772 NS=0.768
Water Level (feet, NAVD88)
22
20
18
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

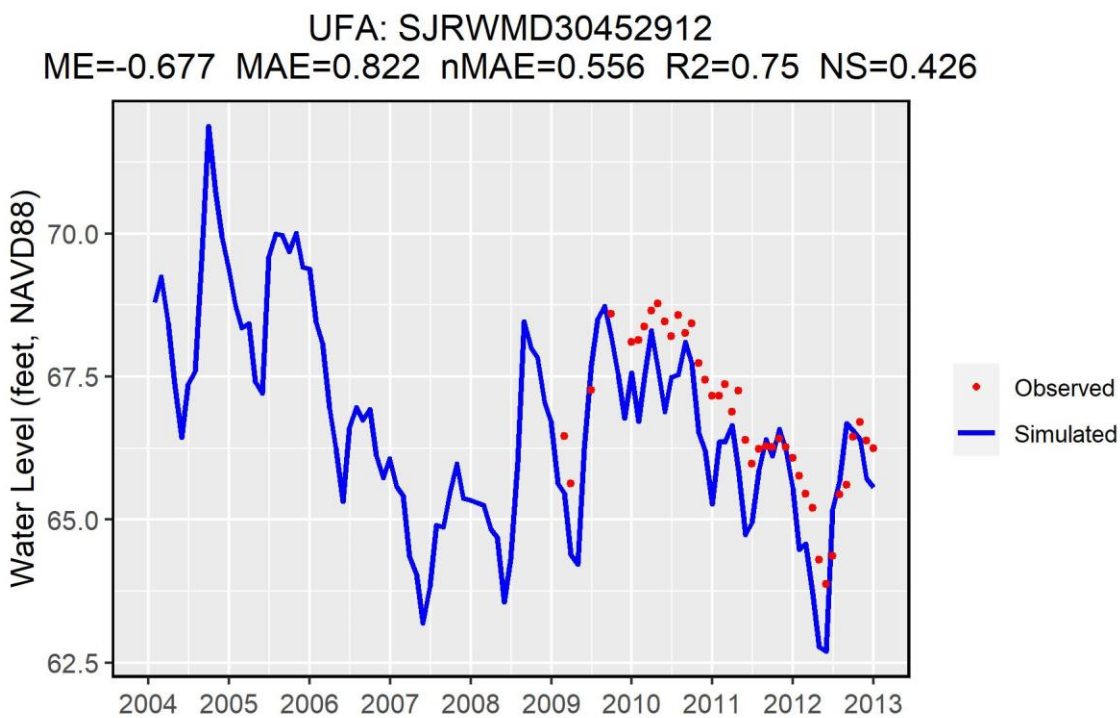

UFA: SJRWMD30332850
ME=-0.33 MAE=0.965 nMAE=0.874 R2=0.597 NS=0.494
Water Level (feet, NAVD88)
50
45
40
35
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

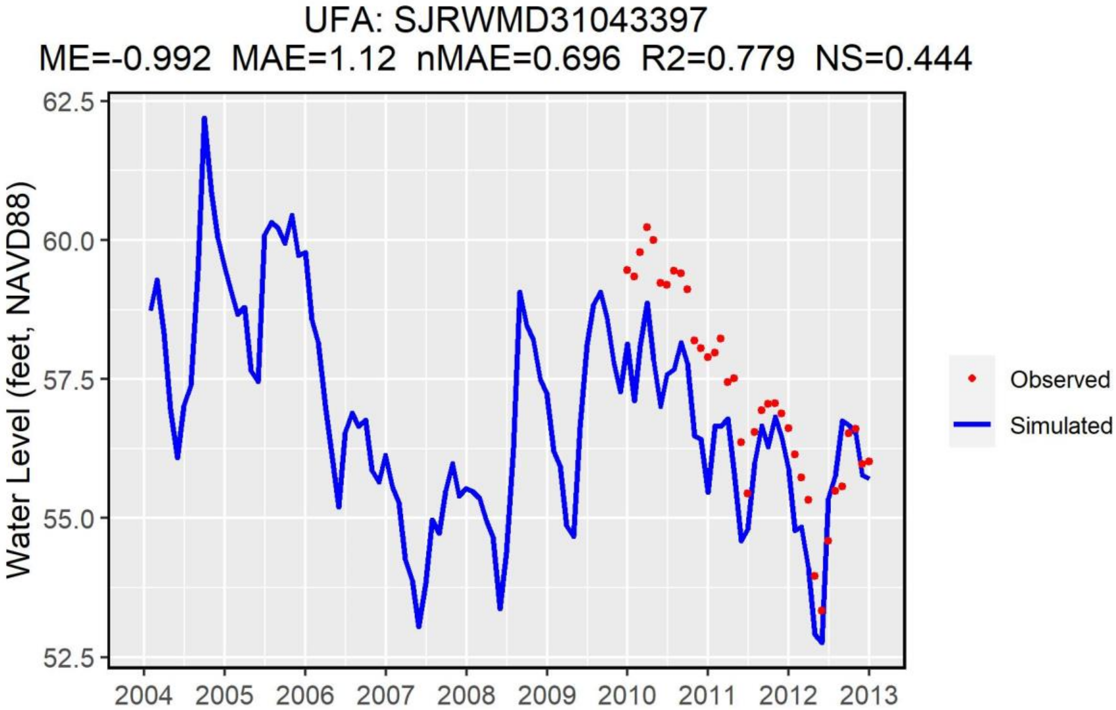

UFA: SJRWMD30342858
ME=-4.341 MAE=4.341 nMAE=0.859 R2=0.548 NS=-8.169
Water Level (feet, NAVD88)
36
34
32
30
28
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

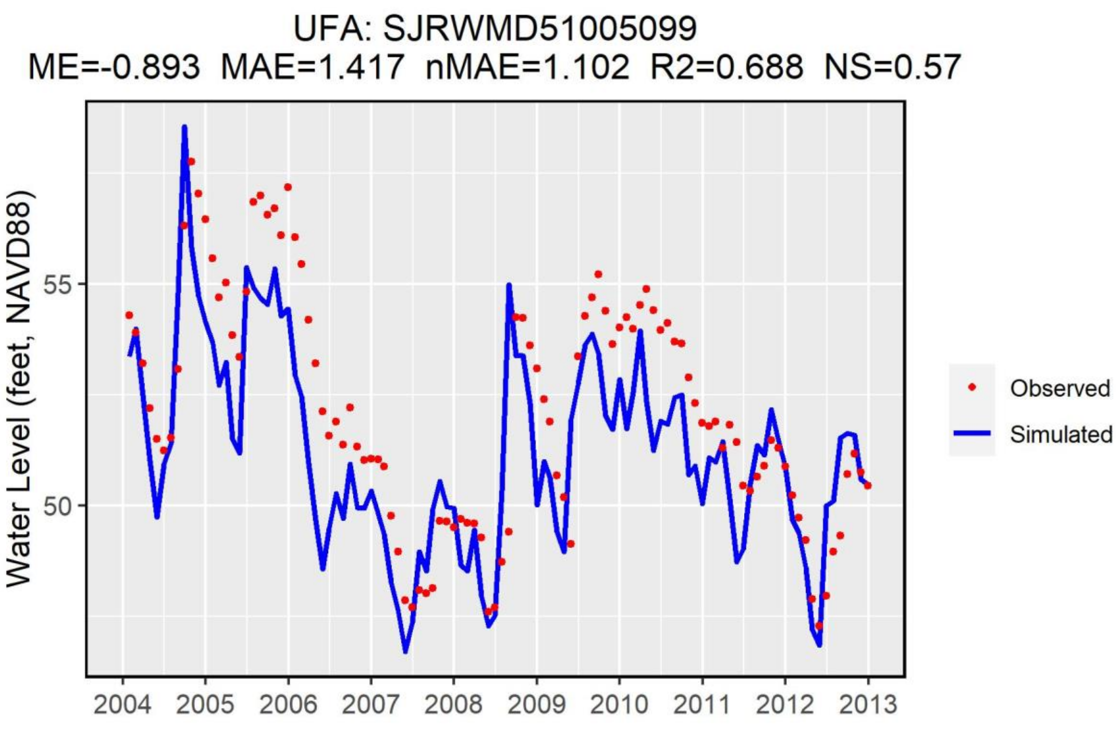

UFA: SJRWMD30362864
ME=-0.068 MAE=0.601 nMAE=0.59 R2=0.672 NS=0.668
Water Level (feet, NAVD88)
36
34
32
30
28
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

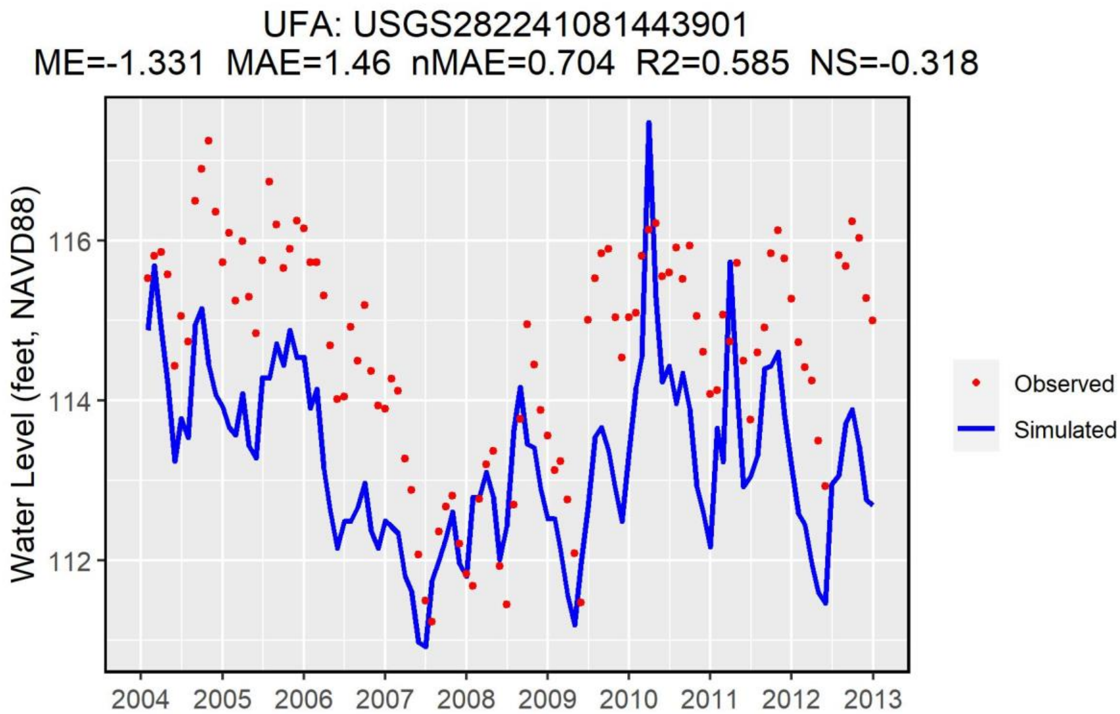

UFA: SJRWMD30432902
ME=1.084 MAE=1.102 nMAE=0.438 R2=0.637 NS=-0.736
Water Level (feet, NAVD88)
8
6
4
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Observed
Simulated

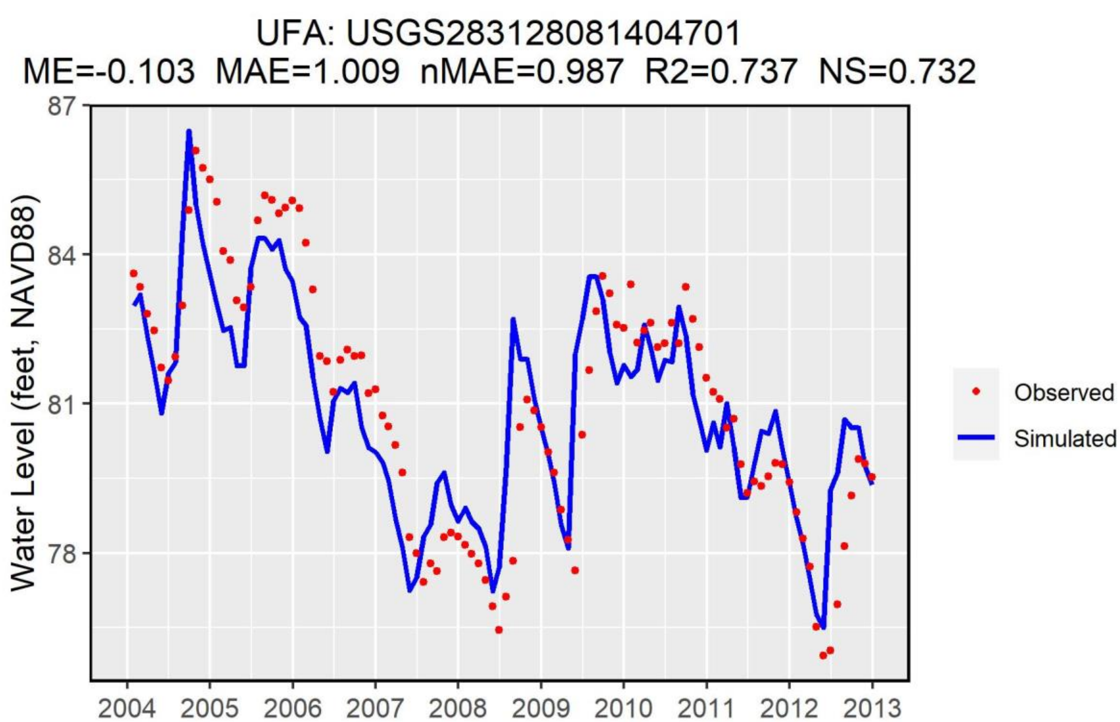

UFA: SJRWMD30442913
ME=-0.716 MAE=0.886 nMAE=0.547 R2=0.837 NS=0.624
Water Level (feet, NAVD88)
87.5
85.0
82.5
80.0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

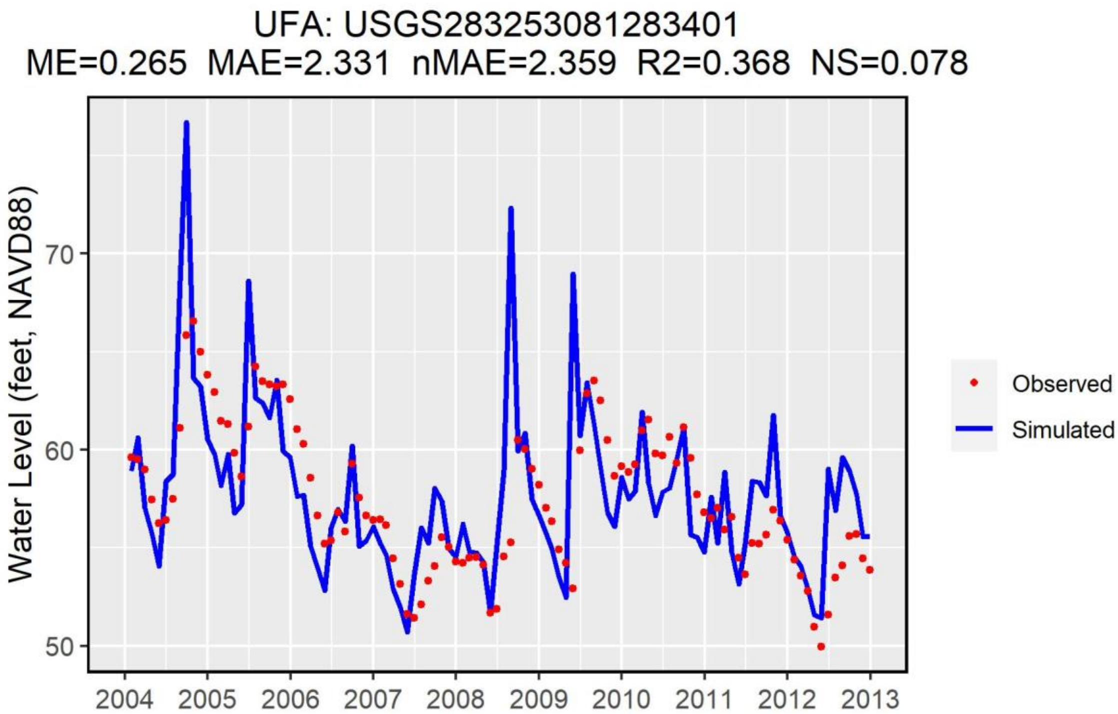

UFA: SJRWMD30452912
ME=-0.677 MAE=0.822 nMAE=0.556 R2=0.75 NS=0.426
Water Level (feet, NAVD88)
70.0
67.5
65.0
62.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

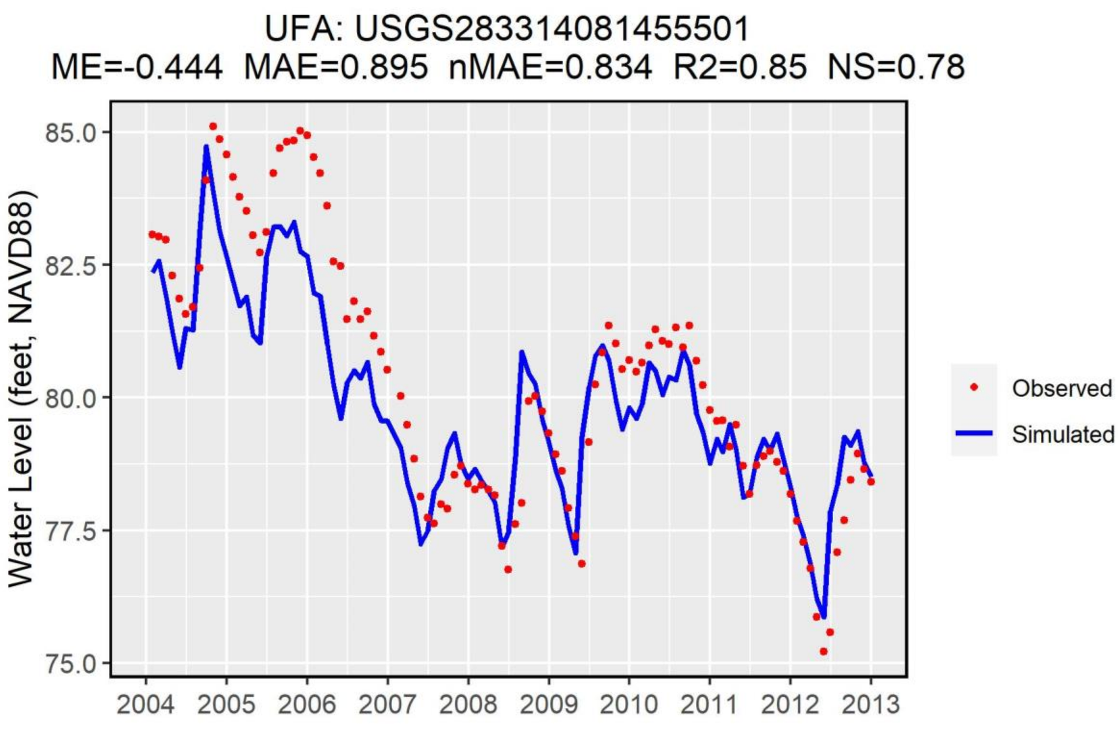

UFA: SJRWMD31043397
ME=-0.992 MAE=1.12 nMAE=0.696 R2=0.779 NS=0.444
Water Level (feet, NAVD88)
62.5
60.0
57.5
55.0
52.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

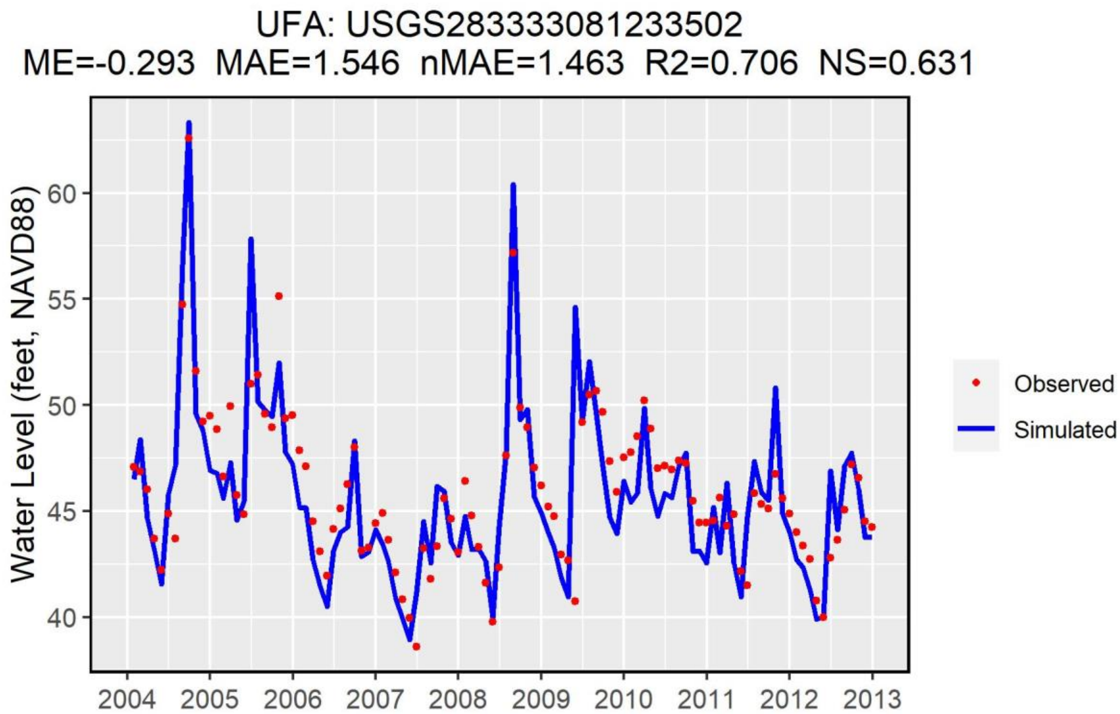

UFA: SJRWMD51005099
ME=-0.893 MAE=1.417 nMAE=1.102 R2=0.688 NS=0.57
Water Level (feet, NAVD88)
55
50
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

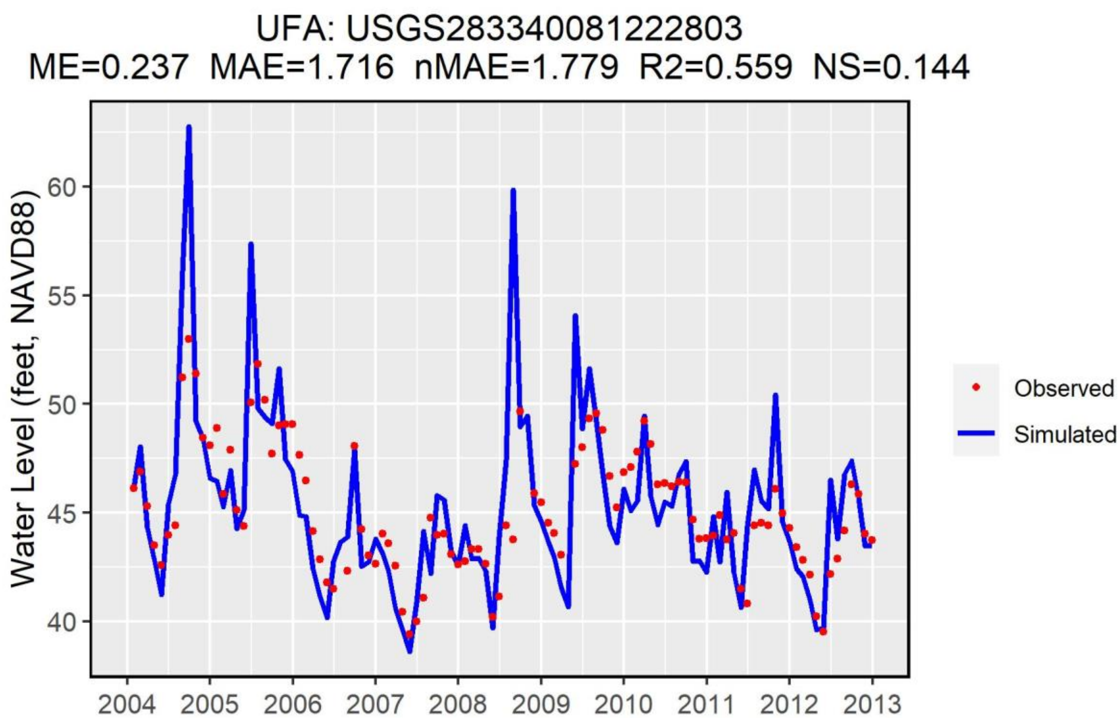

UFA: USGS282241081443901
ME=-1.331 MAE=1.46 nMAE=0.704 R2=0.585 NS=-0.318
Water Level (feet, NAVD88)
116
114
112
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

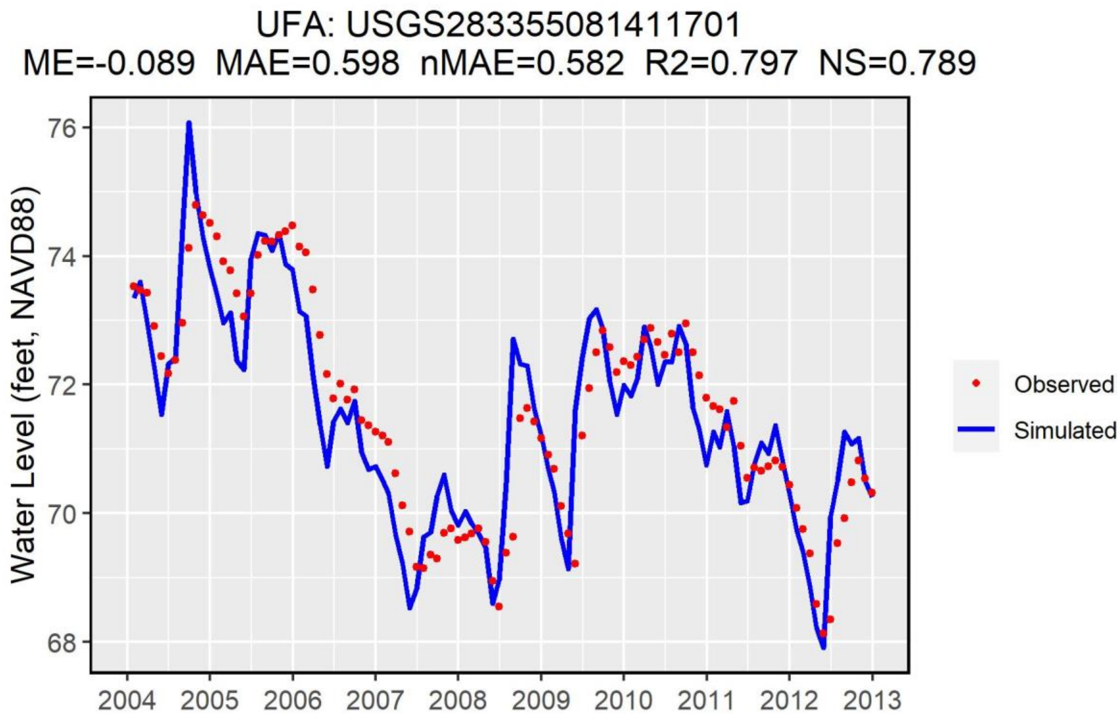

UFA: USGS283128081404701
ME=-0.103 MAE=1.009 nMAE=0.987 R2=0.737 NS=0.732
Water Level (feet, NAVD88)
87
84
81
78
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

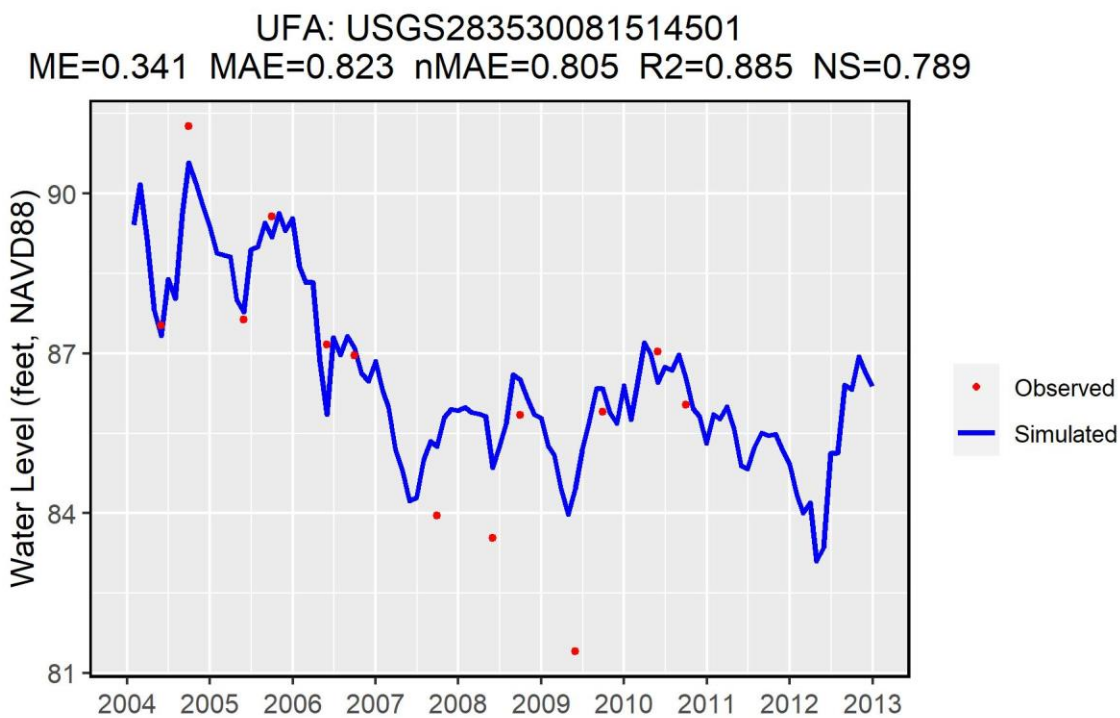

UFA: USGS283253081283401
ME=0.265 MAE=2.331 nMAE=2.359 R2=0.368 NS=0.078
Water Level (feet, NAVD88)
70
60
50
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

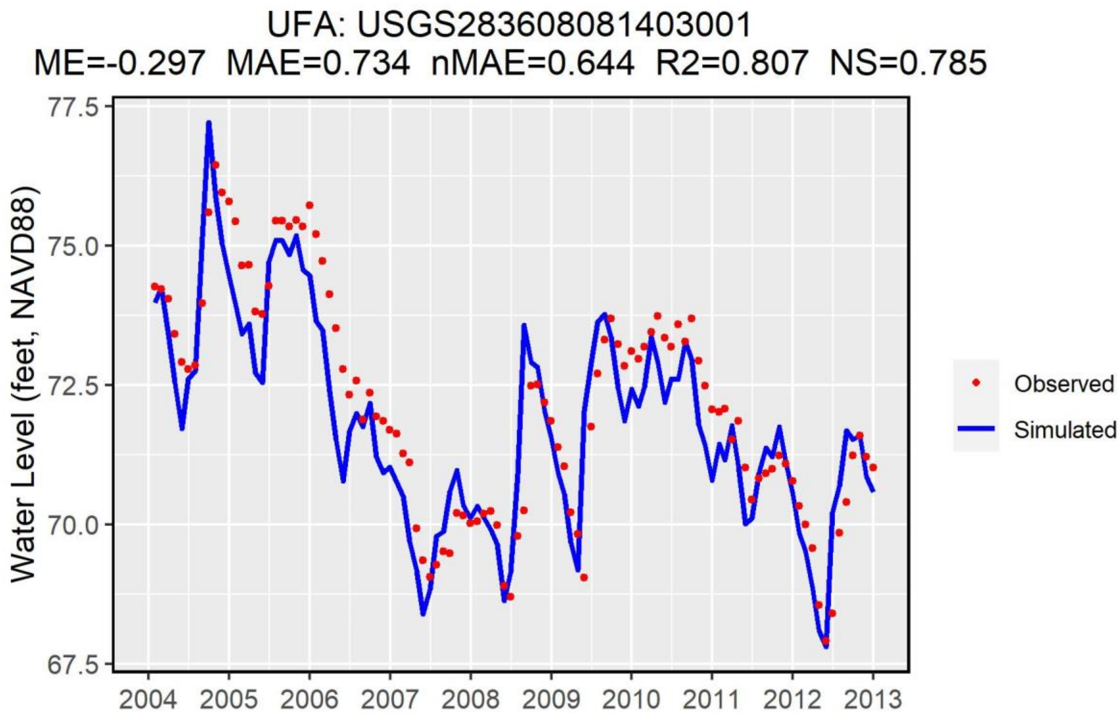

UFA: USGS283314081455501
ME=-0.444 MAE=0.895 nMAE=0.834 R2=0.85 NS=0.78
Water Level (feet, NAVD88)
85.0
82.5
80.0
77.5
75.0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

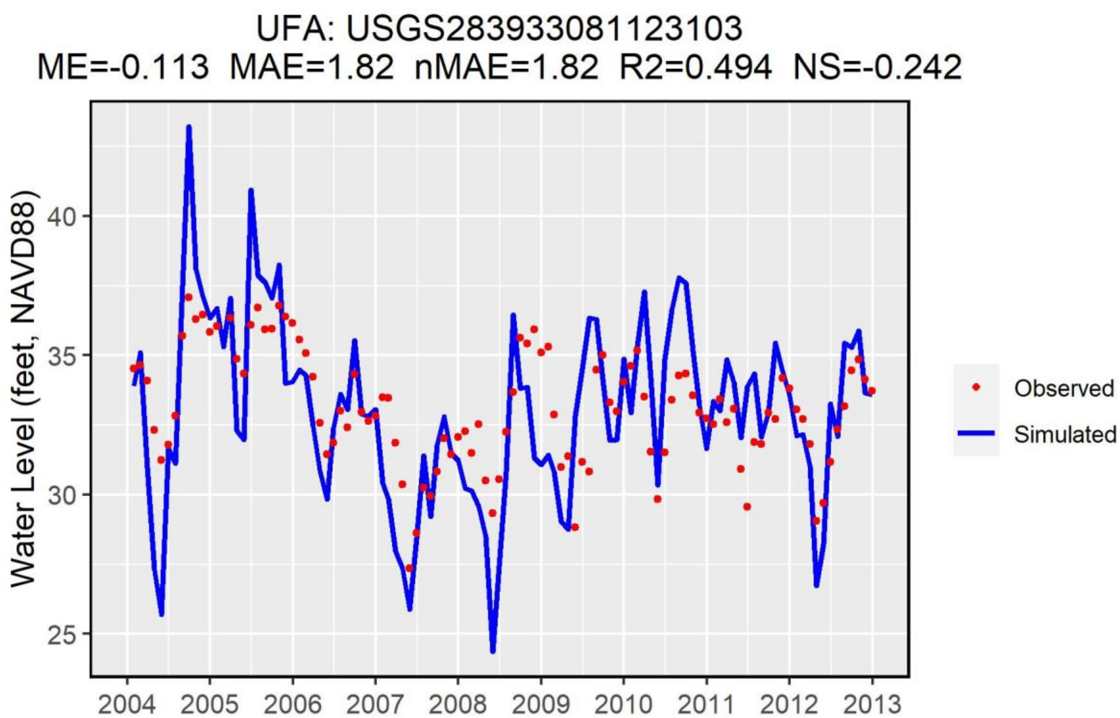

UFA: USGS283333081233502
ME=-0.293 MAE=1.546 nMAE=1.463 R2=0.706 NS=0.631
Water Level (feet, NAVD88)
60
55
50
45
40
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

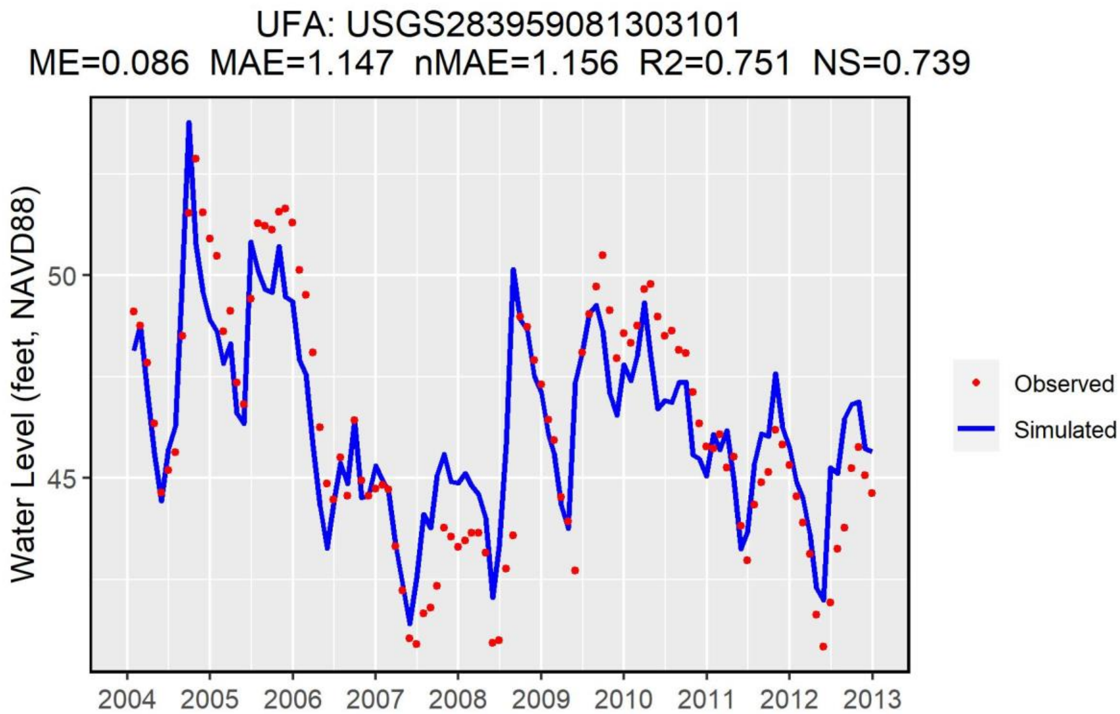

UFA: USGS283340081222803
ME=0.237 MAE=1.716 nMAE=1.779 R2=0.559 NS=0.144
Water Level (feet, NAVD88)
60
55
50
45
40
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

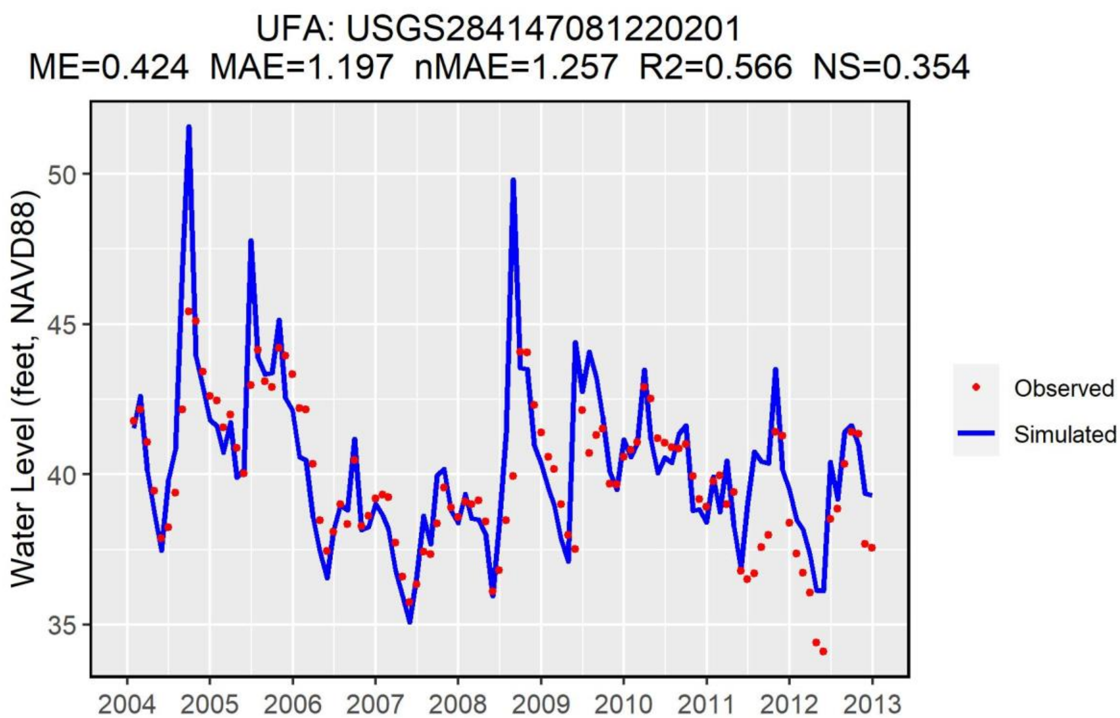

UFA: USGS283355081411701
ME=-0.089 MAE=0.598 nMAE=0.582 R2=0.797 NS=0.789
Water Level (feet, NAVD88)
76
74
72
70
68
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

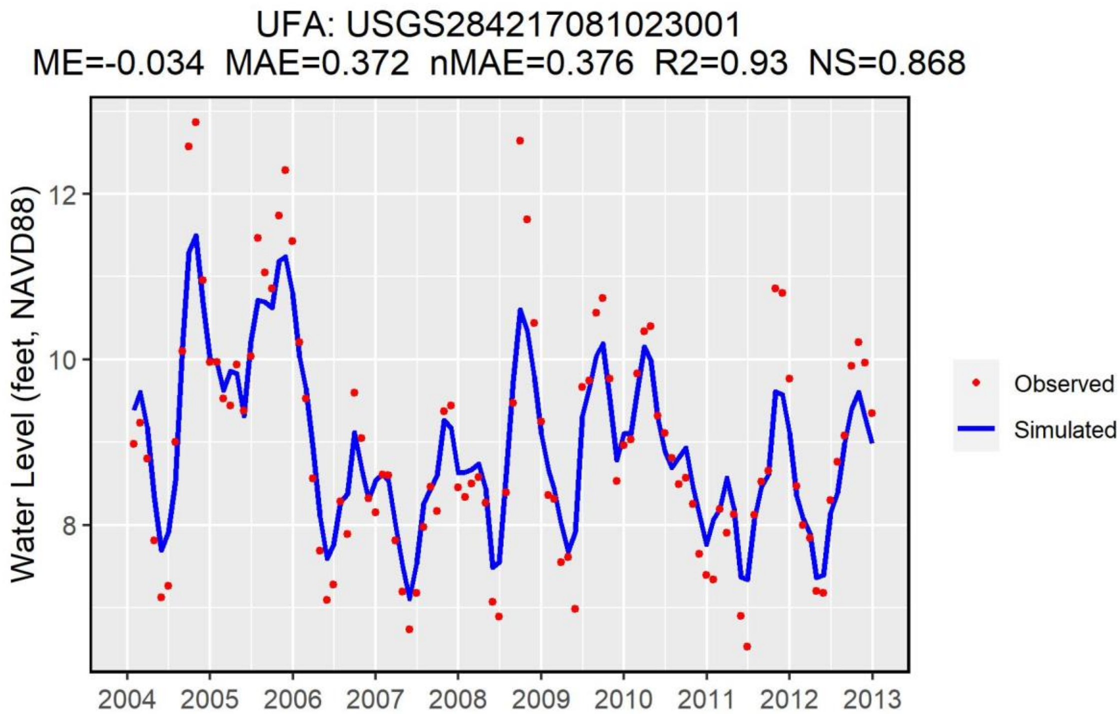

UFA: USGS283530081514501
ME=0.341 MAE=0.823 nMAE=0.805 R2=0.885 NS=0.789
Water Level (feet, NAVD88)
90
87
84
81
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

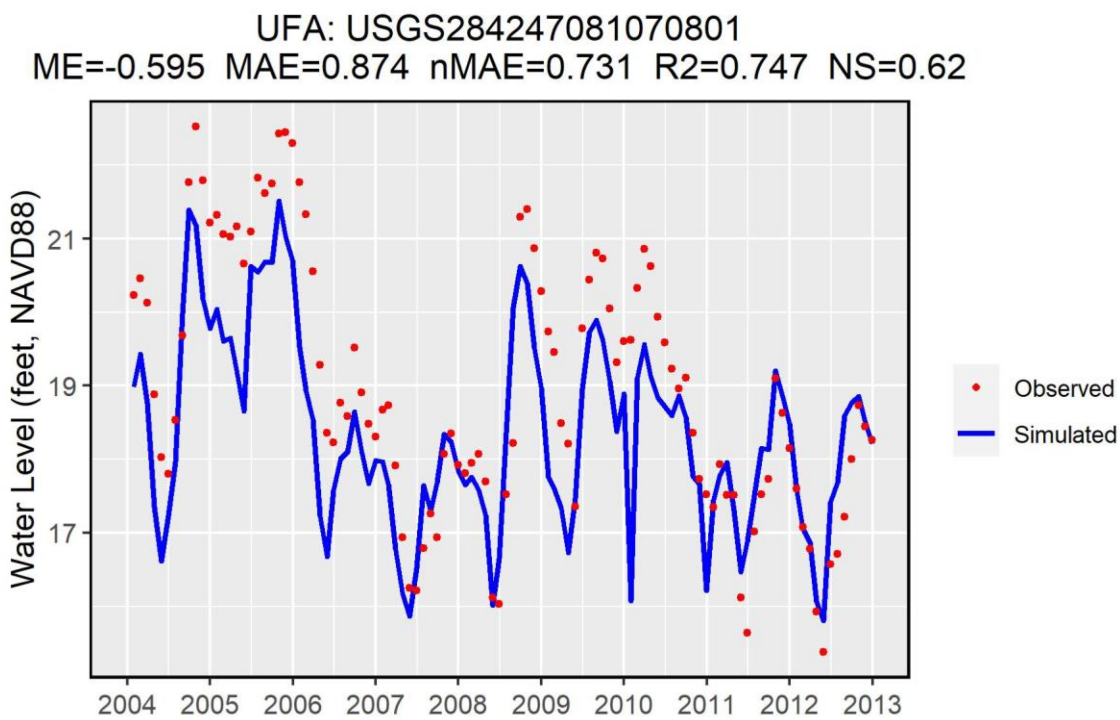

UFA: USGS283608081403001
ME=-0.297 MAE=0.734 nMAE=0.644 R2=0.807 NS=0.785
Water Level (feet, NAVD88)
77.5
75.0
72.5
70.0
67.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

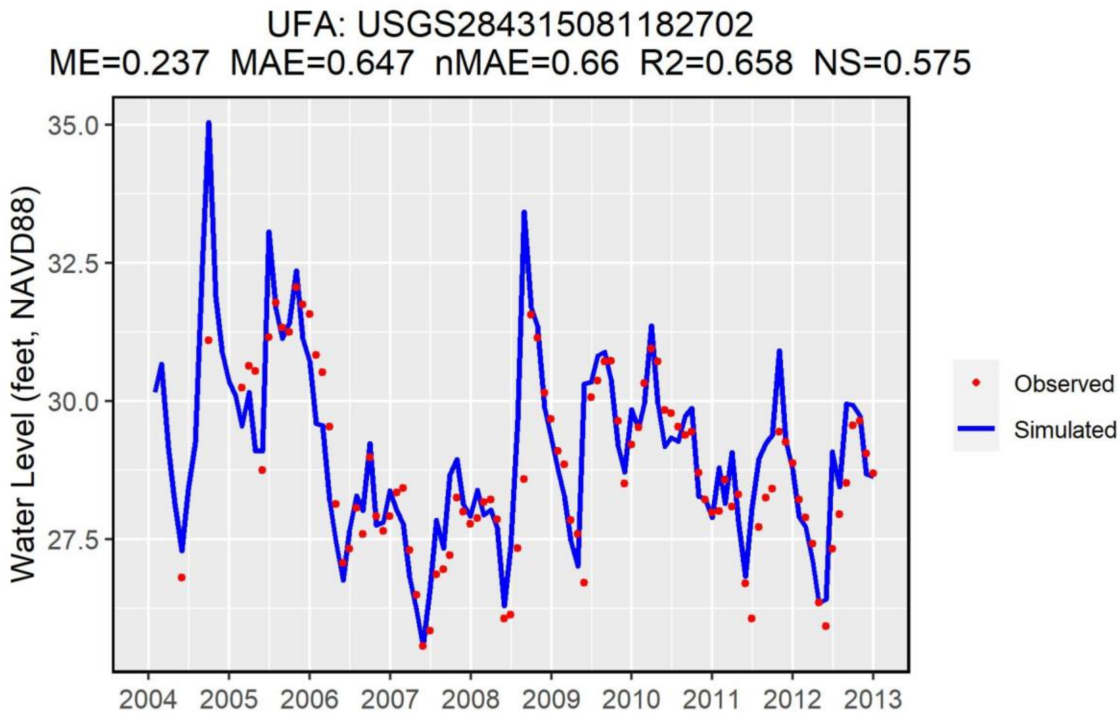

UFA: USGS283933081123103
ME=-0.113 MAE=1.82 nMAE=1.82 R2=0.494 NS=-0.242
Water Level (feet, NAVD88)
40
35
30
25
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

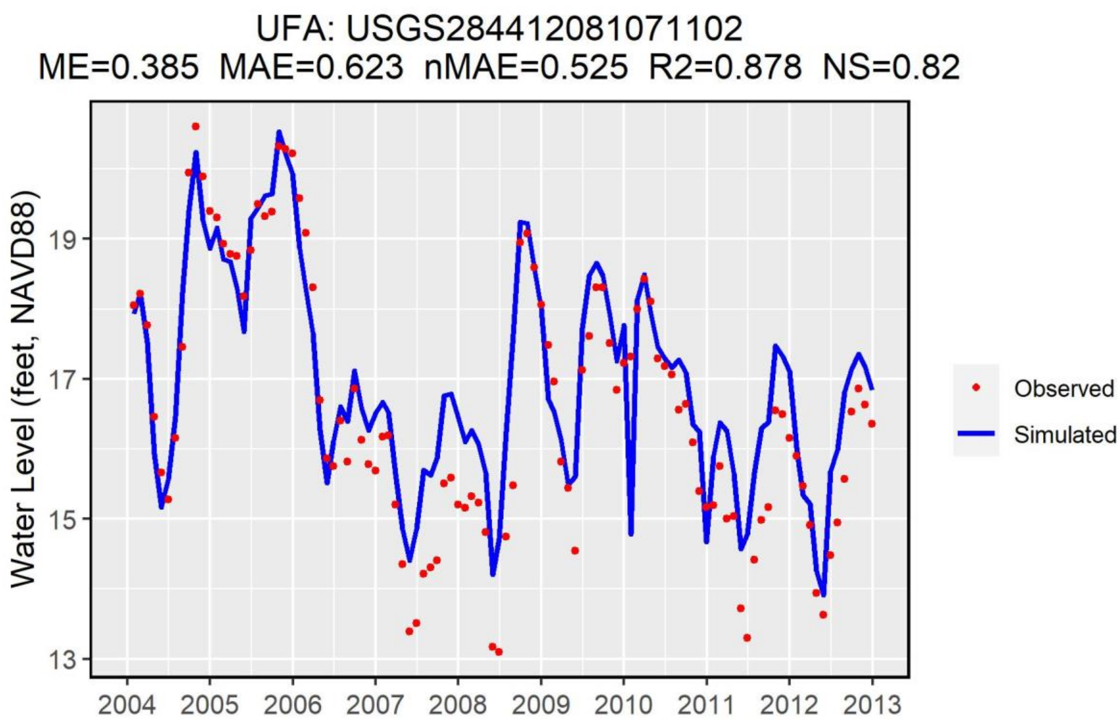

UFA: USGS283959081303101
ME=0.086 MAE=1.147 nMAE=1.156 R2=0.751 NS=0.739
Water Level (feet, NAVD88)
50
45
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

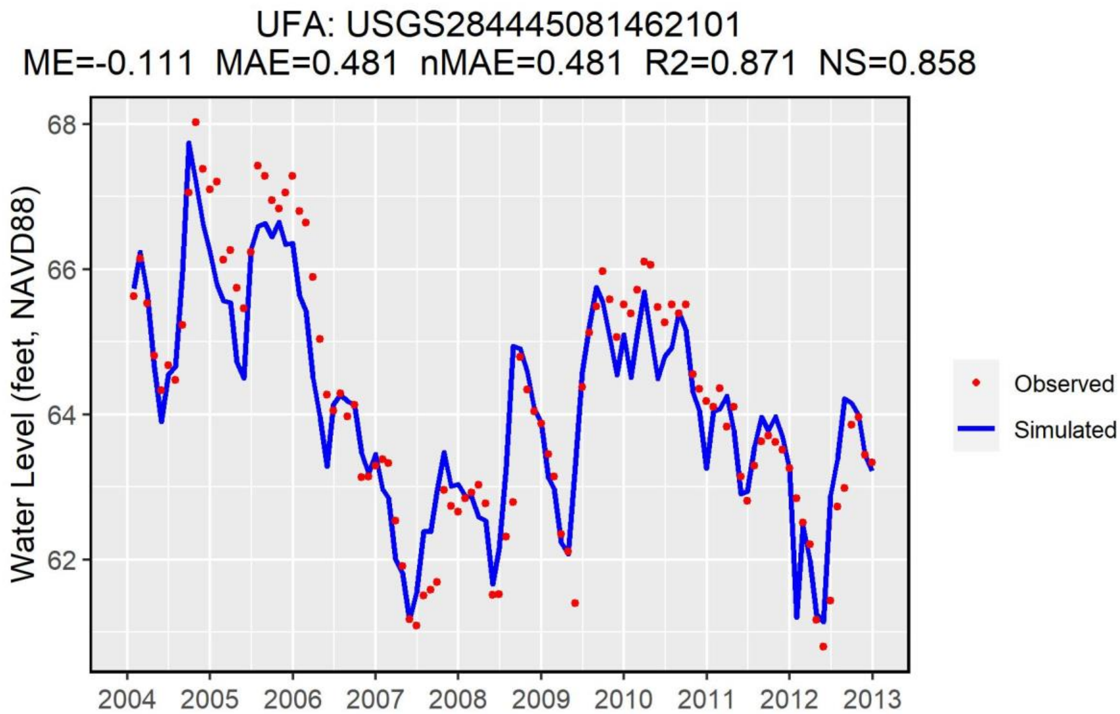

UFA: USGS284147081220201
ME=0.424 MAE=1.197 nMAE=1.257 R2=0.566 NS=0.354
Water Level (feet, NAVD88)
50
45
40
35
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

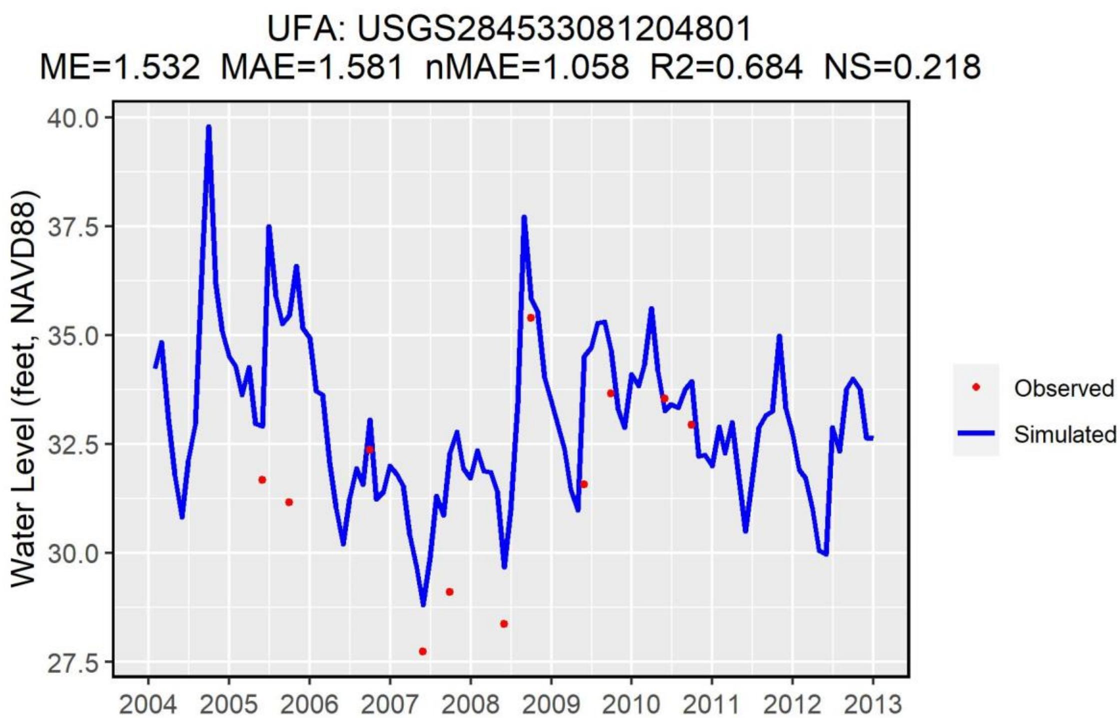

UFA: USGS284217081023001
ME=-0.034 MAE=0.372 nMAE=0.376 R2=0.93 NS=0.868
Water Level (feet, NAVD88)
12
10
8
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

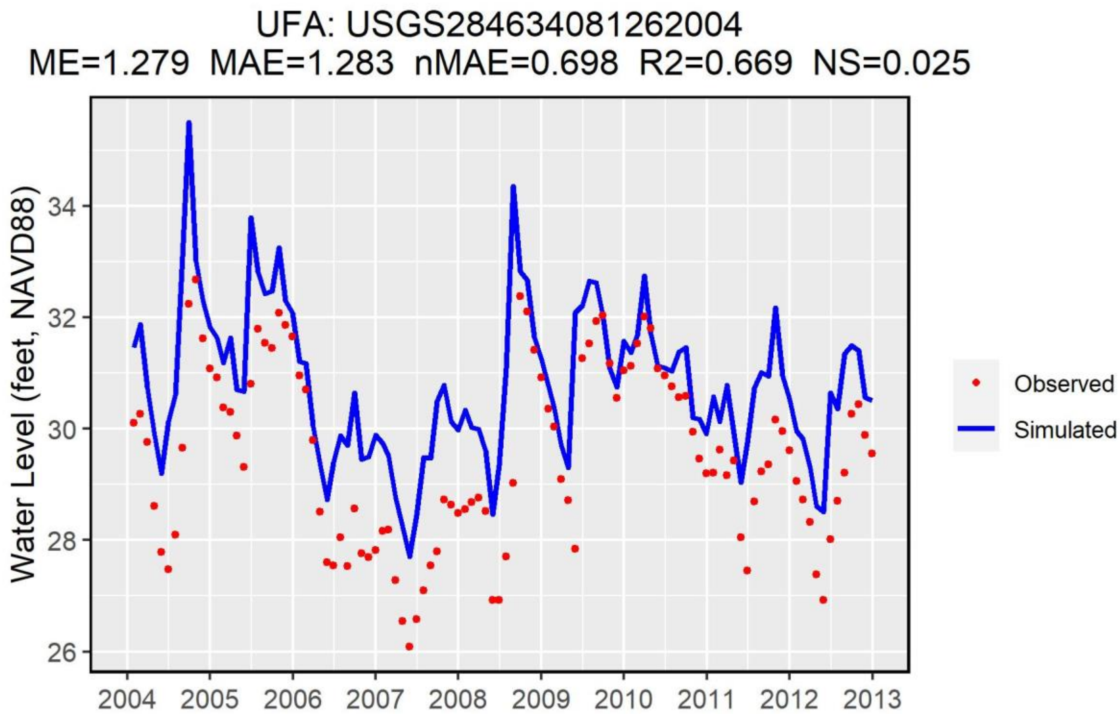

UFA: USGS284247081070801
ME=-0.595 MAE=0.874 nMAE=0.731 R2=0.747 NS=0.62
Water Level (feet, NAVD88)
21
19
17
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

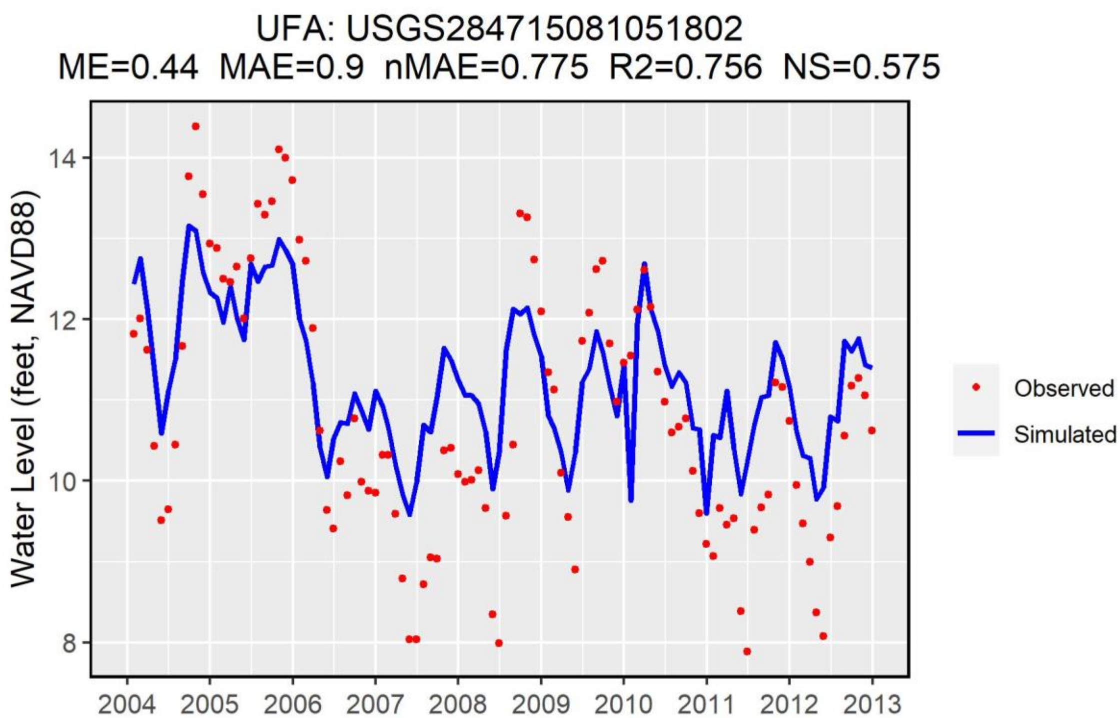

UFA: USGS284315081182702
ME=0.237 MAE=0.647 nMAE=0.66 R2=0.658 NS=0.575
Water Level (feet, NAVD88)
35.0
32.5
30.0
27.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

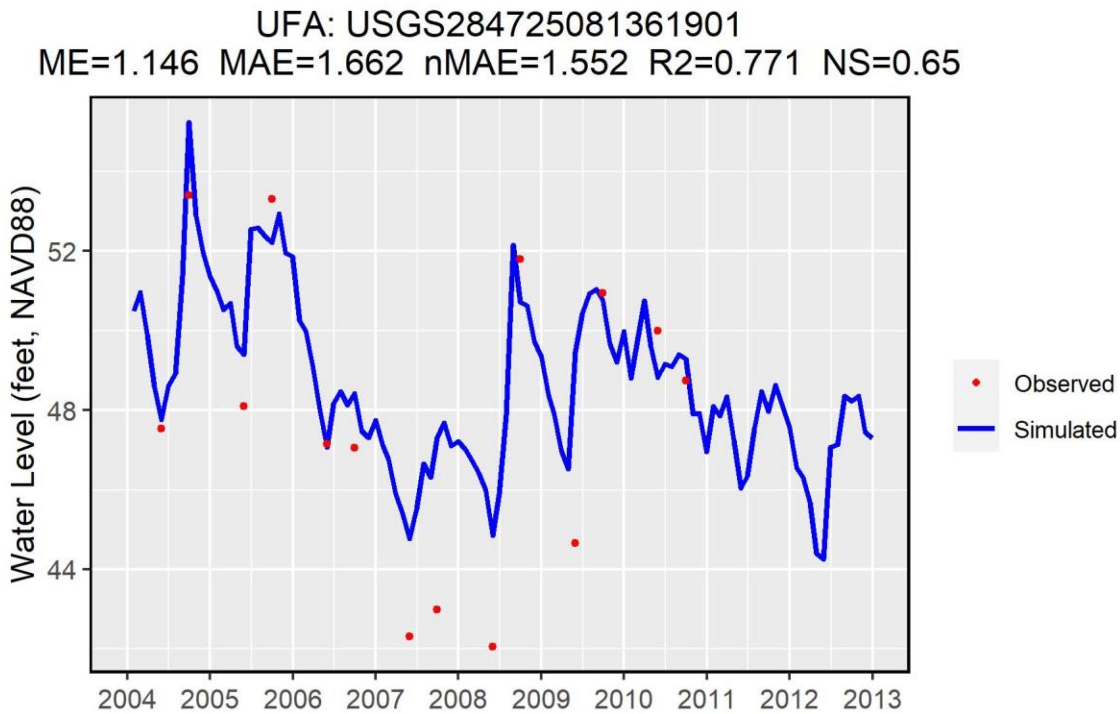

UFA: USGS284412081071102
ME=0.385 MAE=0.623 nMAE=0.525 R2=0.878 NS=0.82
Water Level (feet, NAVD88)
19
17
15
13
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

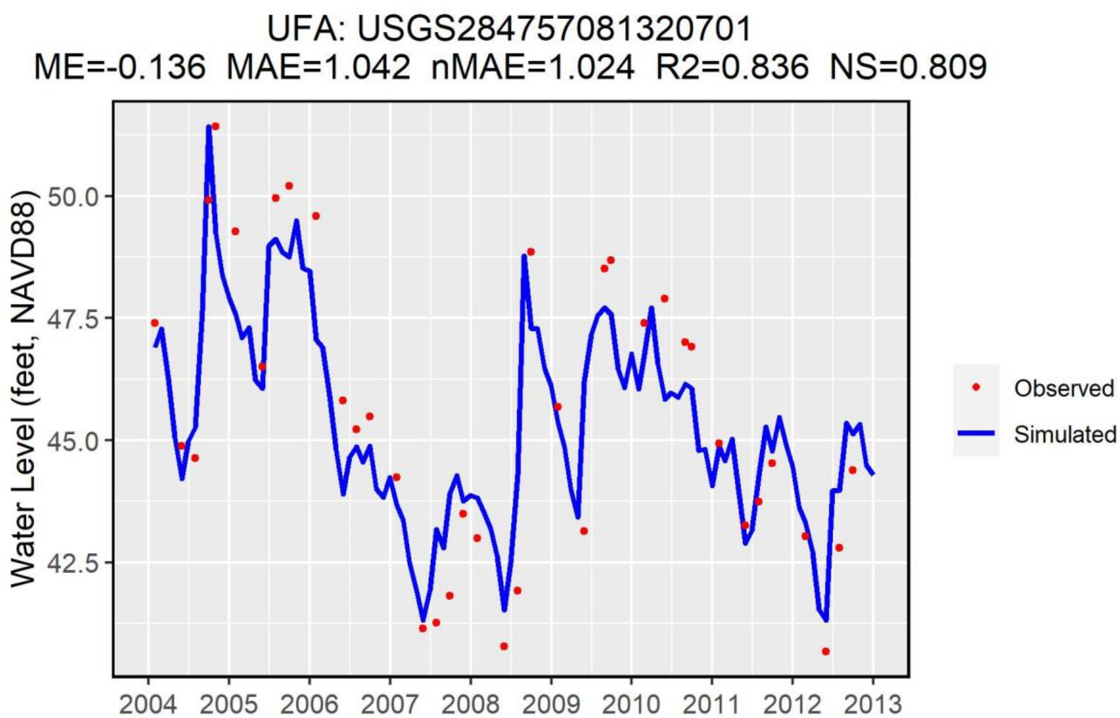

UFA: USGS284445081462101
ME=-0.111 MAE=0.481 nMAE=0.481 R2=0.871 NS=0.858
Water Level (feet, NAVD88)
68
66
64
62
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

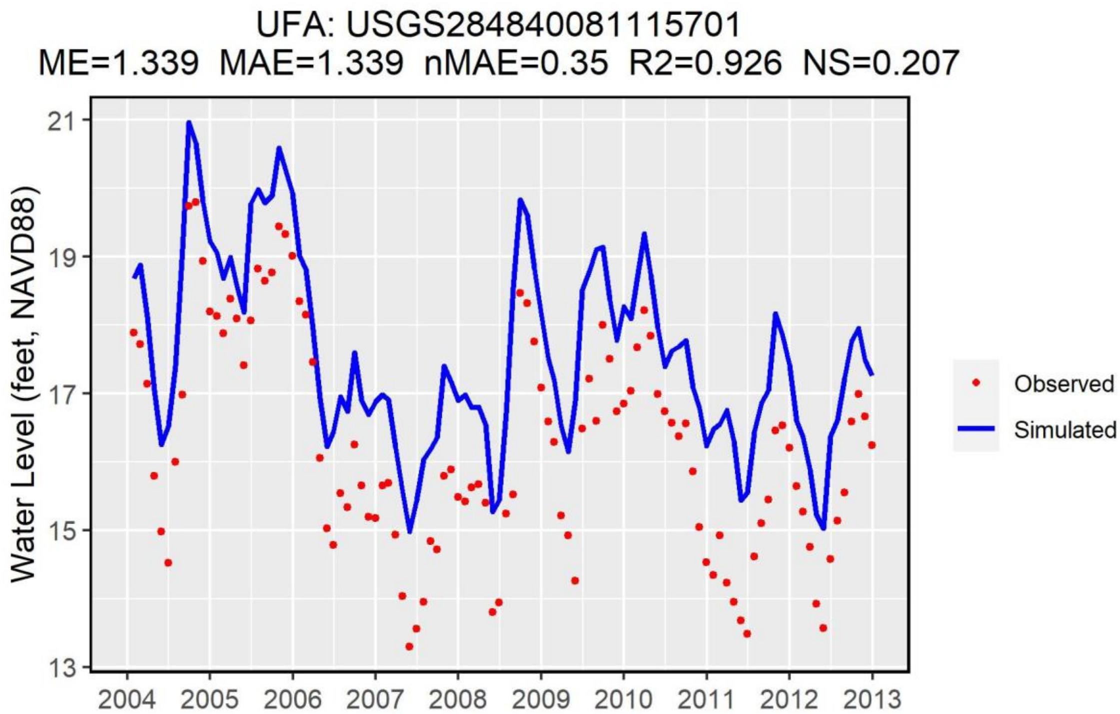

UFA: USGS284533081204801
ME=1.532 MAE=1.581 nMAE=1.058 R2=0.684 NS=0.218
Water Level (feet, NAVD88)
40.0
37.5
35.0
32.5
30.0
27.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

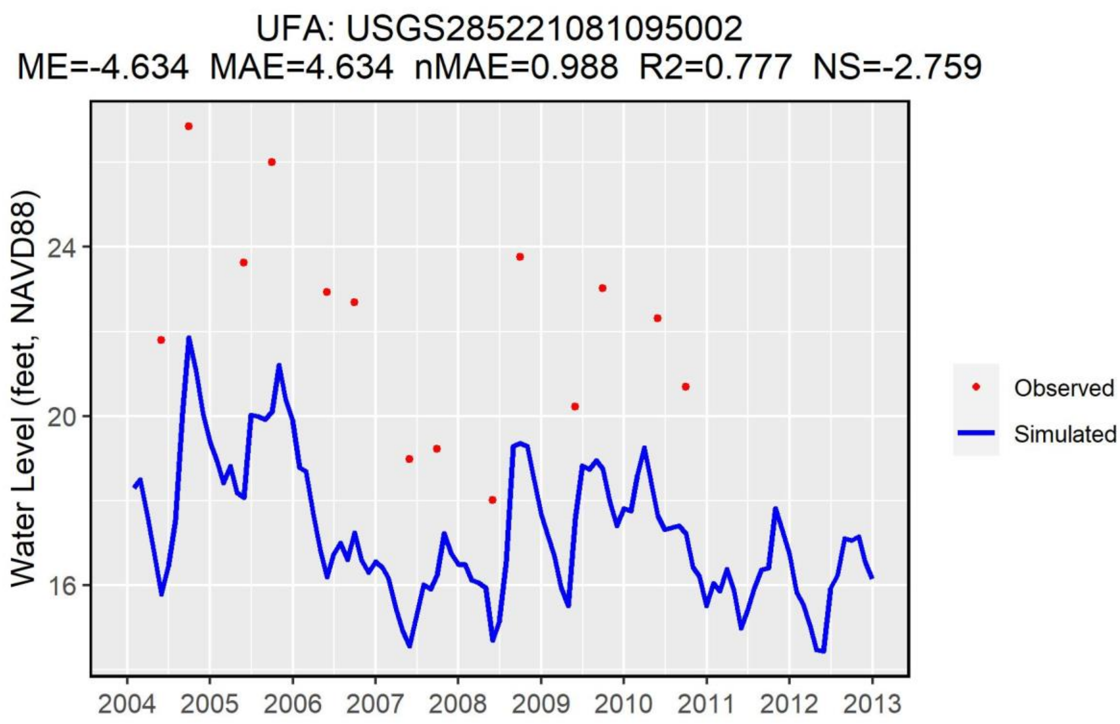

UFA: USGS284634081262004
ME=1.279 MAE=1.283 nMAE=0.698 R2=0.669 NS=0.025
Water Level (feet, NAVD88)
26
28
30
32
34
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

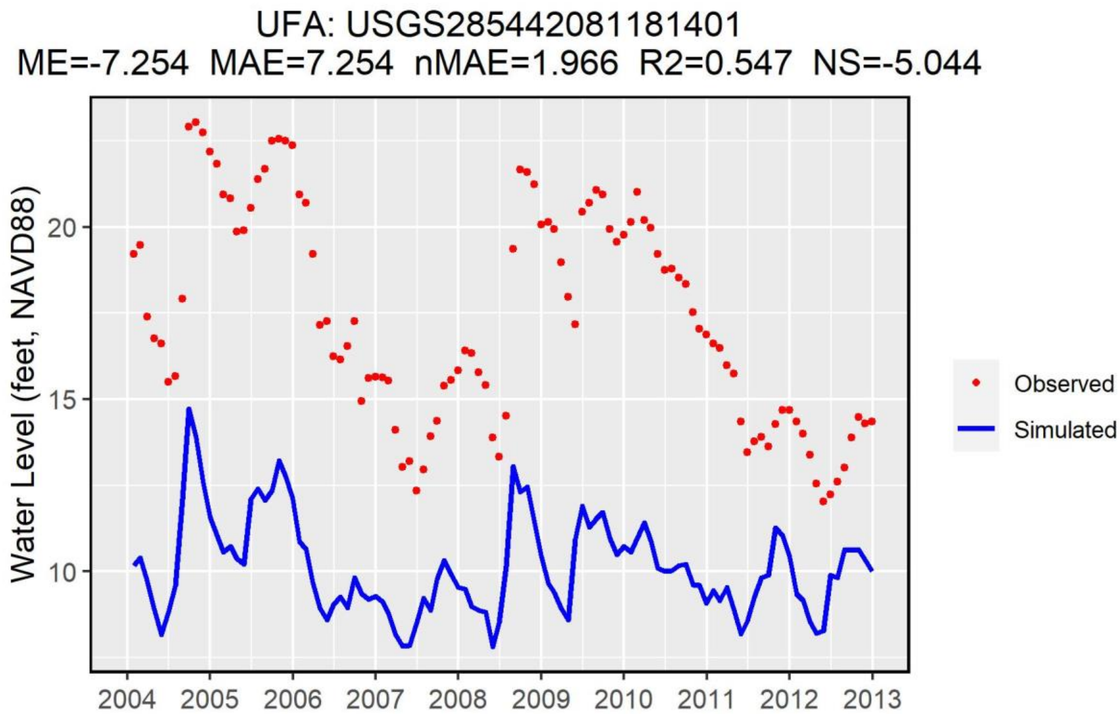

UFA: USGS284715081051802
ME=0.44 MAE=0.9 nMAE=0.775 R2=0.756 NS=0.575
Water Level (feet, NAVD88)
8
10
12
14
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

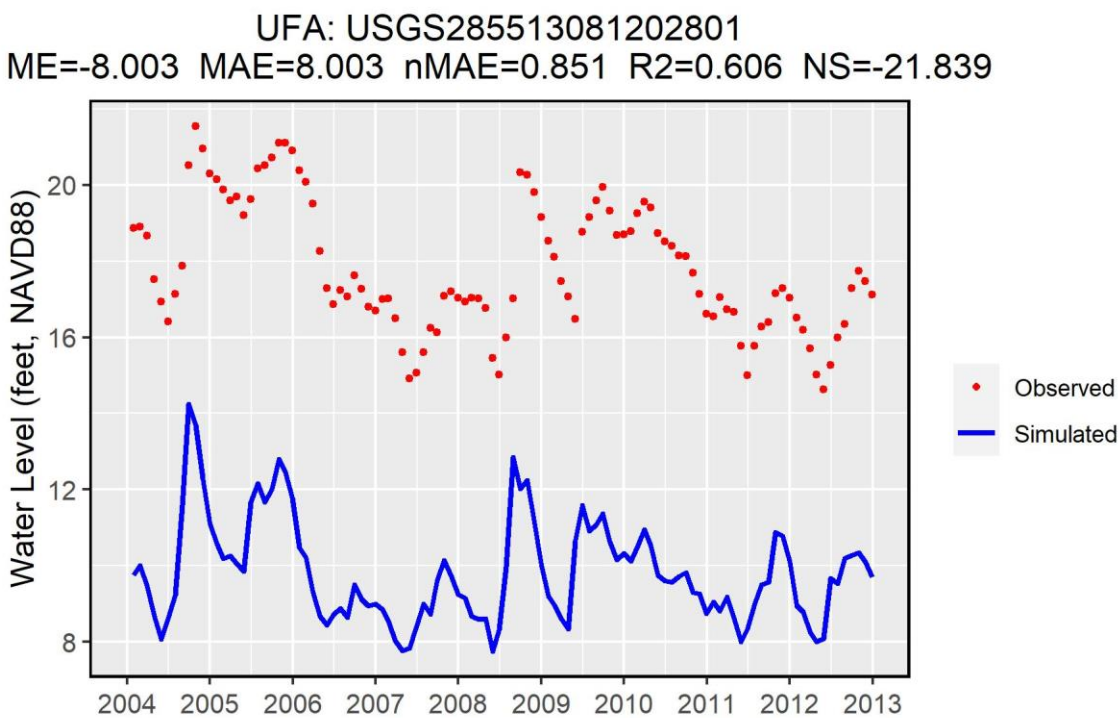

UFA: USGS284725081361901
ME=1.146 MAE=1.662 nMAE=1.552 R2=0.771 NS=0.65
Water Level (feet, NAVD88)
52
48
44
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

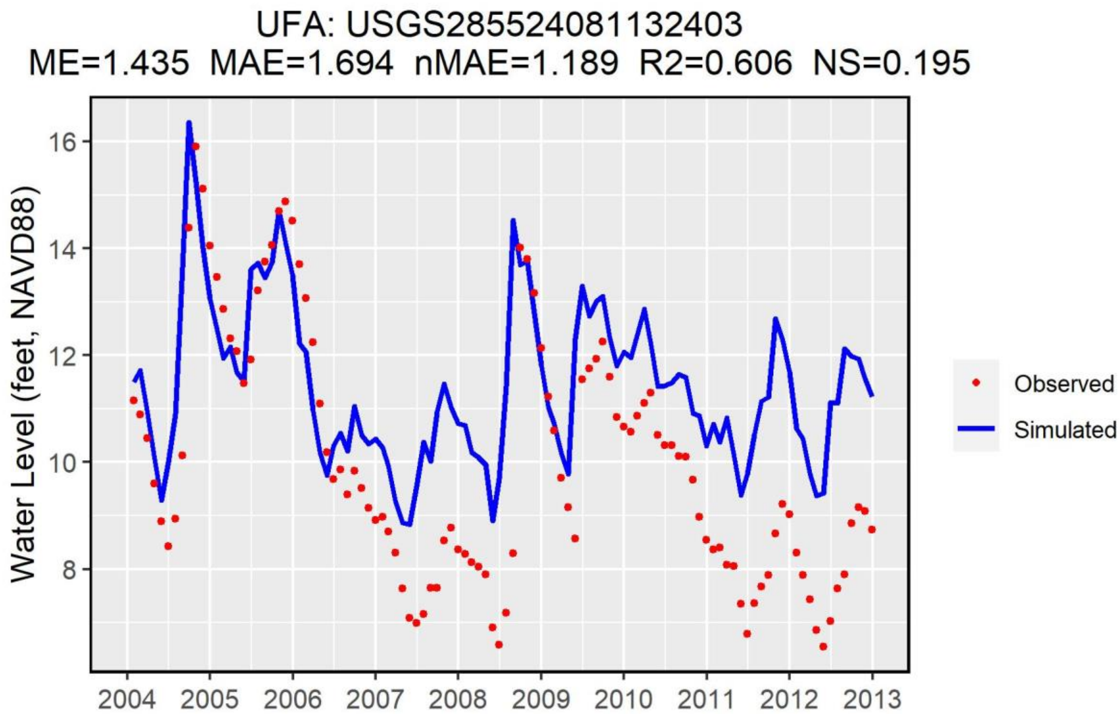

UFA: USGS284757081320701
ME=-0.136 MAE=1.042 nMAE=1.024 R2=0.836 NS=0.809
Water Level (feet, NAVD88)
50.0
47.5
45.0
42.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated


UFA: USGS284840081115701
ME=1.339 MAE=1.339 nMAE=0.35 R2=0.926 NS=0.207
Water Level (feet, NAVD88)
21
19
17
15
13
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

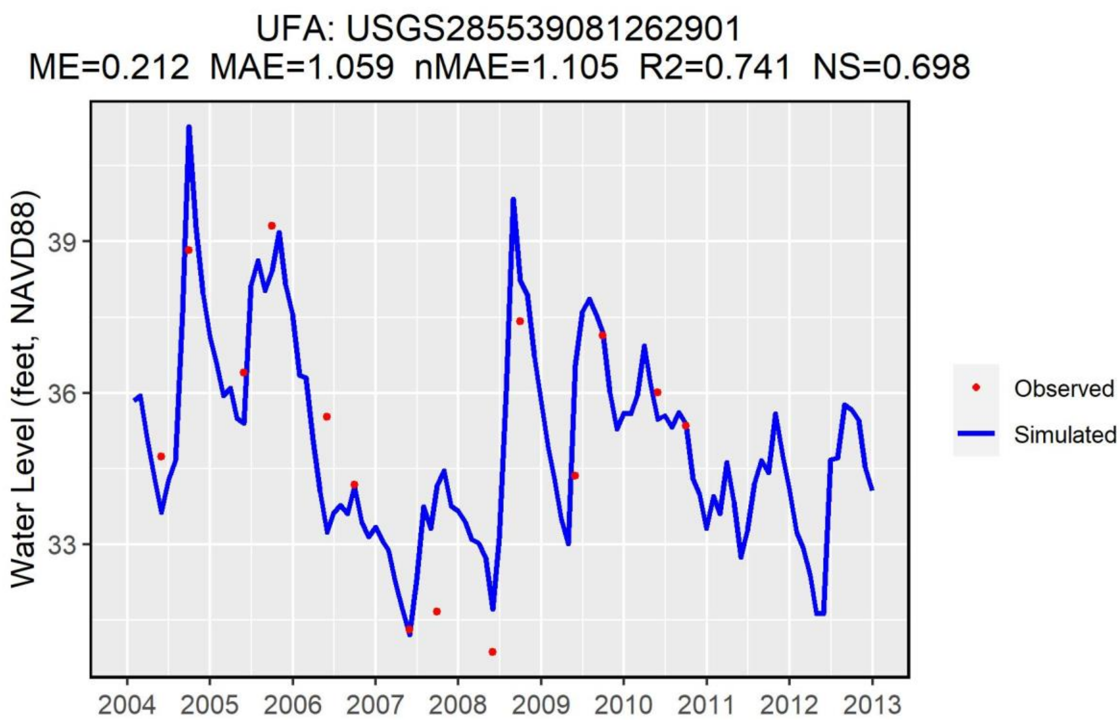

UFA: USGS285221081095002
ME=-4.634 MAE=4.634 nMAE=0.988 R2=0.777 NS=-2.759
Water Level (feet, NAVD88)
24
20
16
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated


UFA: USGS285442081181401
ME=-7.254 MAE=7.254 nMAE=1.966 R2=0.547 NS=-5.044
Water Level (feet, NAVD88)
10
15
20
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

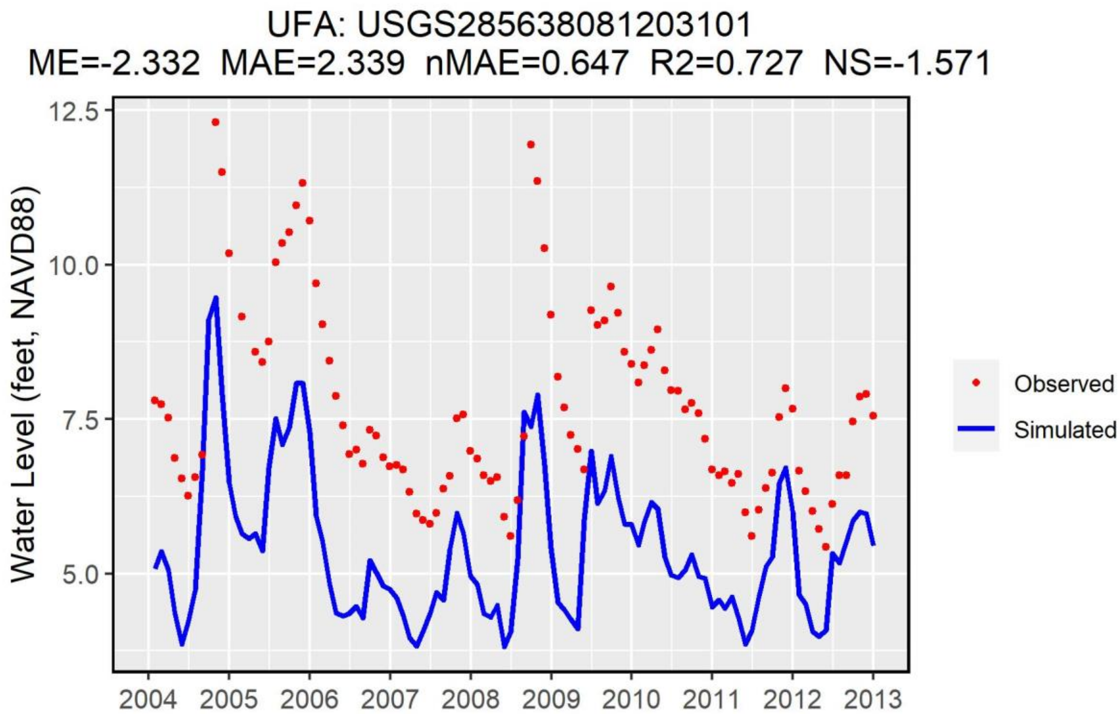

UFA: USGS285513081202801
ME=-8.003 MAE=8.003 nMAE=0.851 R2=0.606 NS=-21.839
Water Level (feet, NAVD88)
8
12
16
20
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

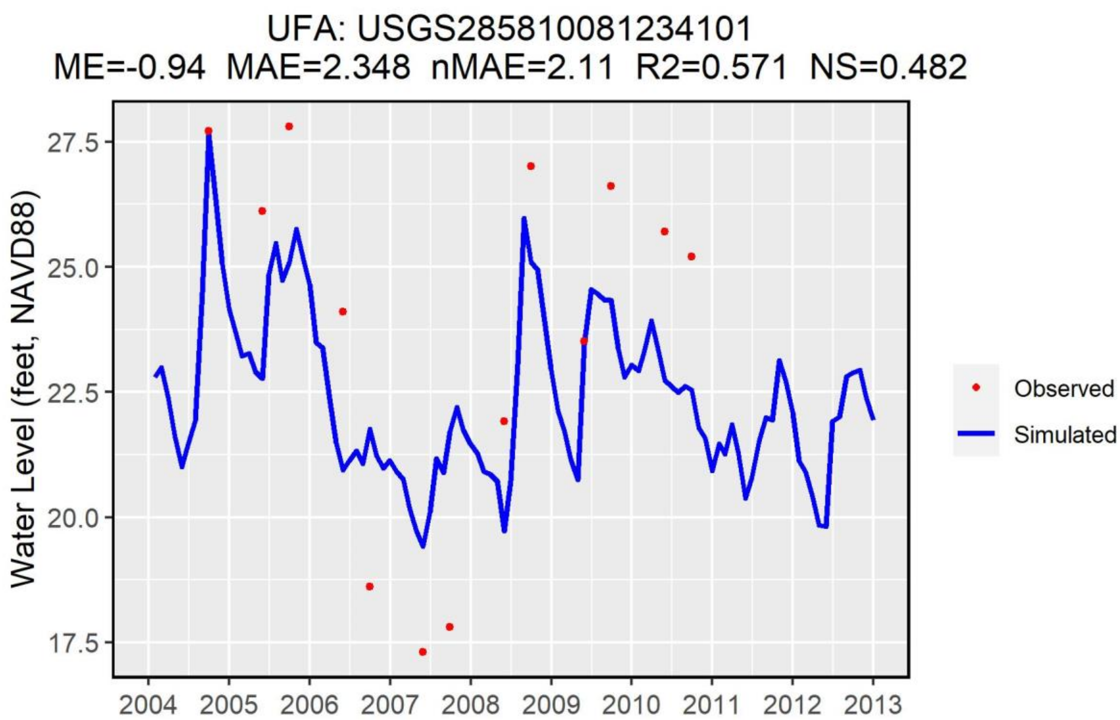


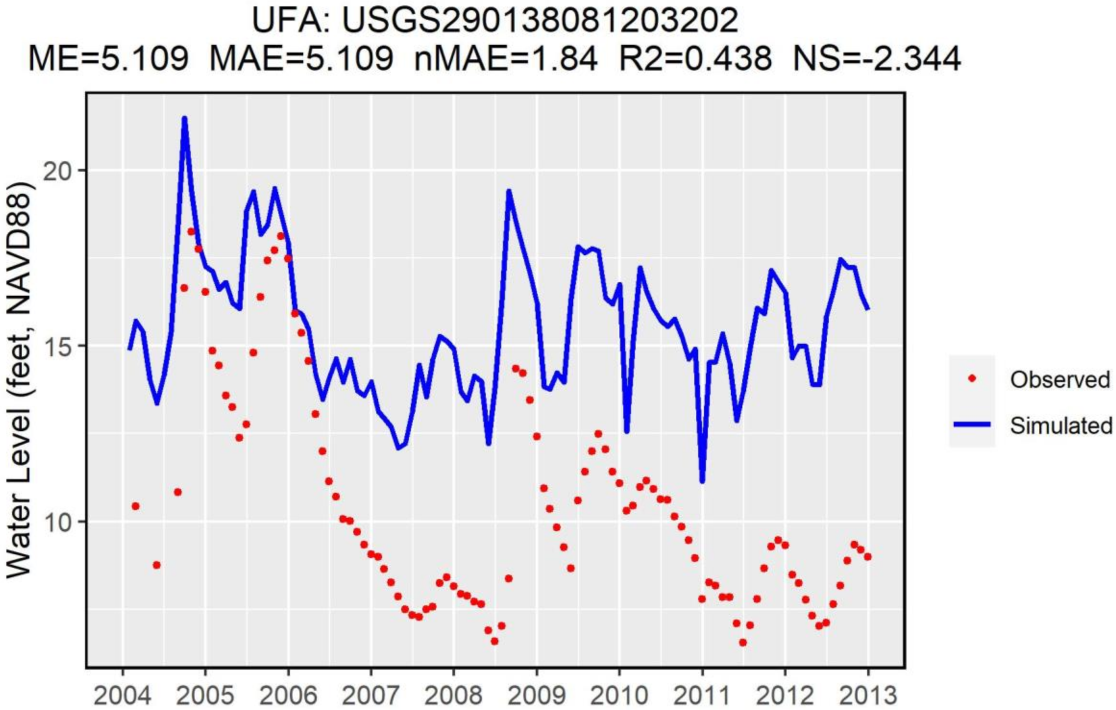
UFA: USGS285524081132403
ME=1.435 MAE=1.694 nMAE=1.189 R2=0.606 NS=0.195
Water Level (feet, NAVD88)
16
14
12
10
8
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

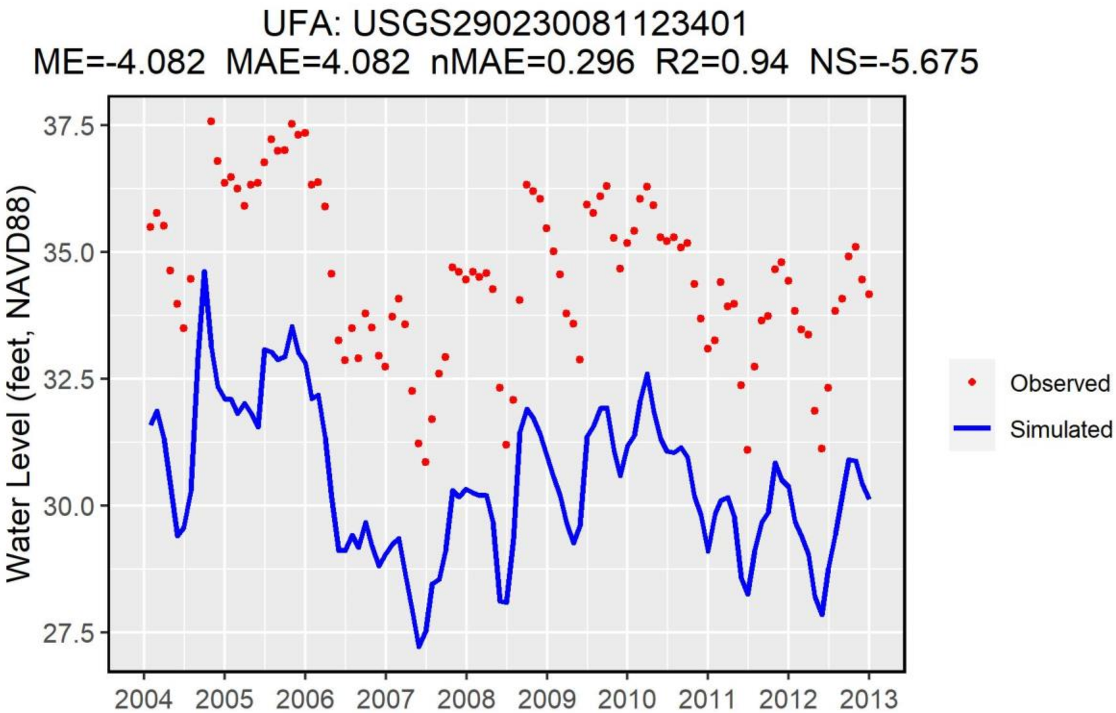


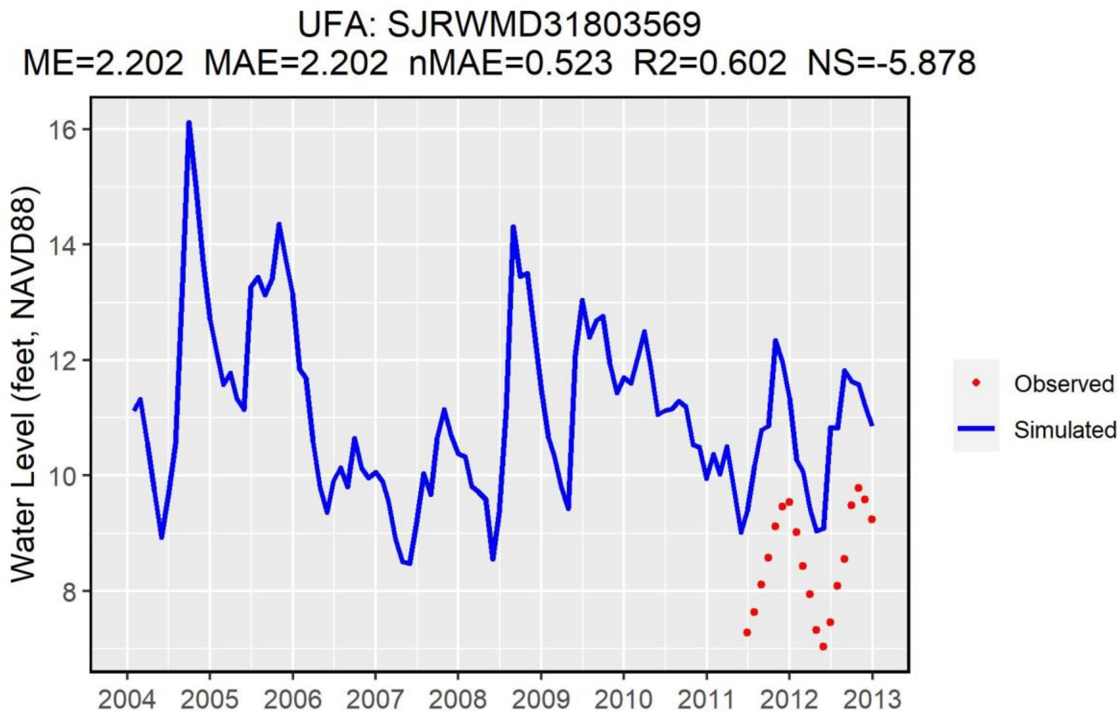
UFA: USGS285539081262901
ME=0.212 MAE=1.059 nMAE=1.105 R2=0.741 NS=0.698
Water Level (feet, NAVD88)
39
36
33
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

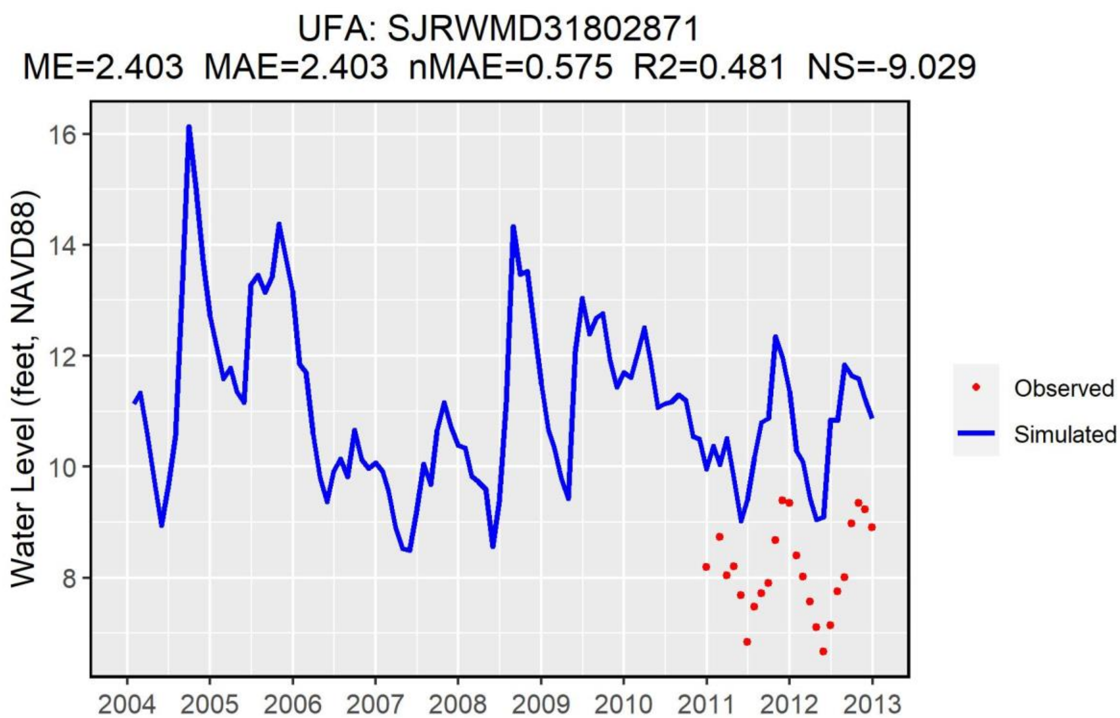

UFA: USGS285638081203101
ME=-2.332 MAE=2.339 nMAE=0.647 R2=0.727 NS=-1.571
Water Level (feet, NAVD88)
12.5
10.0
7.5
5.0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated


UFA: USGS285810081234101
ME=-0.94 MAE=2.348 nMAE=2.11 R2=0.571 NS=0.482
Water Level (feet, NAVD88)
27.5
25.0
22.5
20.0
17.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

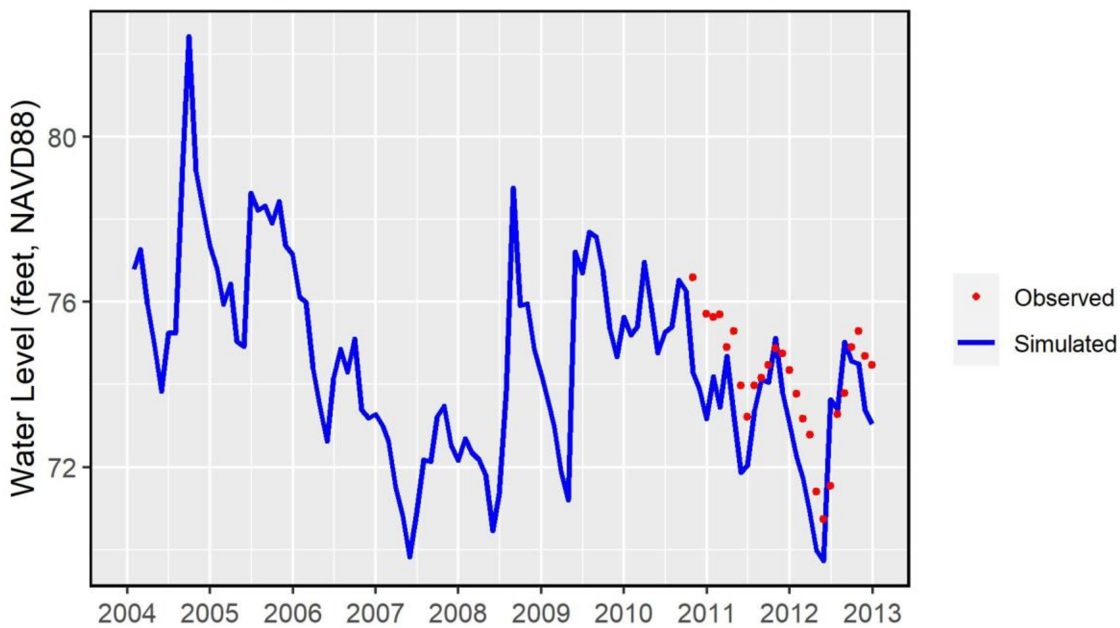

UFA: USGS290138081203202
ME=5.109 MAE=5.109 nMAE=1.84 R2=0.438 NS=-2.344
Water Level (feet, NAVD88)
20
15
10
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated


UFA: USGS290230081123401
ME=-4.082 MAE=4.082 nMAE=0.296 R2=0.94 NS=-5.675
Water Level (feet, NAVD88)
37.5
35.0
32.5
30.0
27.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

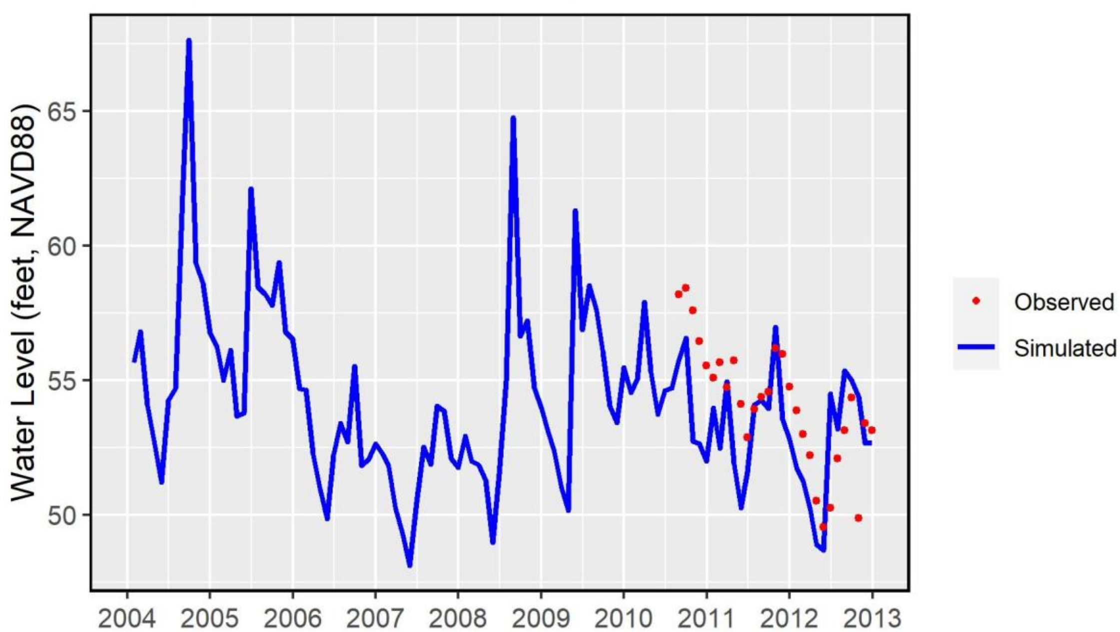

UFA: SJRWMD31803569
ME=2.202 MAE=2.202 nMAE=0.523 R2=0.602 NS=-5.878
Water Level (feet, NAVD88)
16
14
12
10
8
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

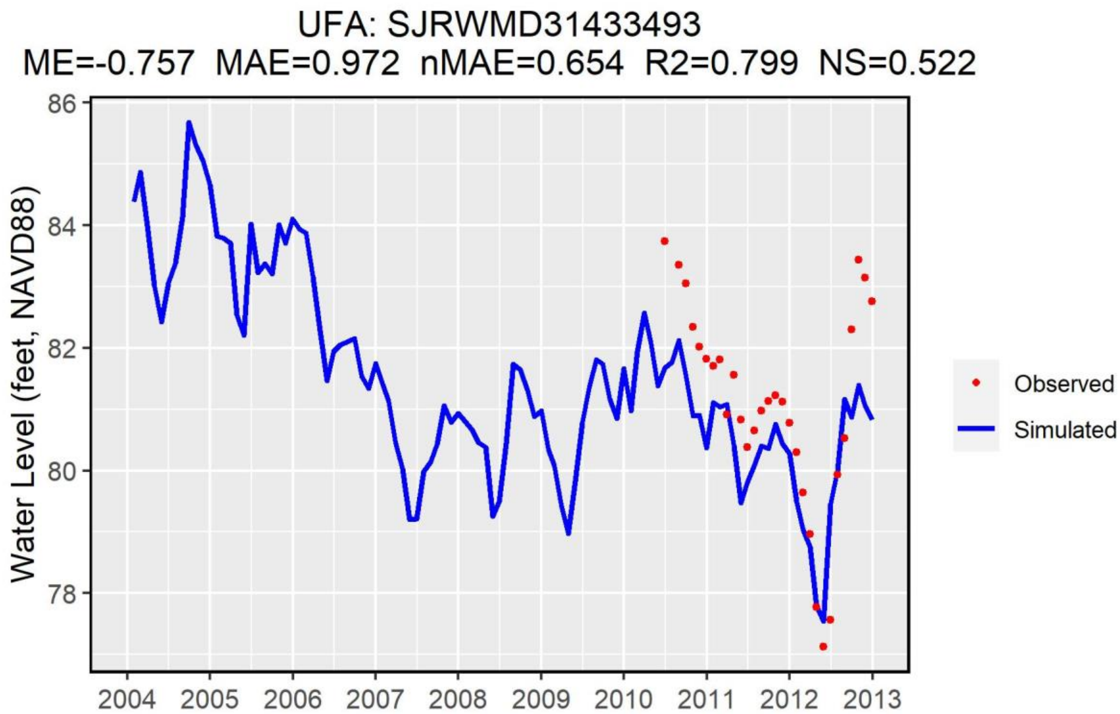

UFA: SJRWMD31802871
ME=2.403 MAE=2.403 nMAE=0.575 R2=0.481 NS=-9.029
Water Level (feet, NAVD88)
16
14
12
10
8
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

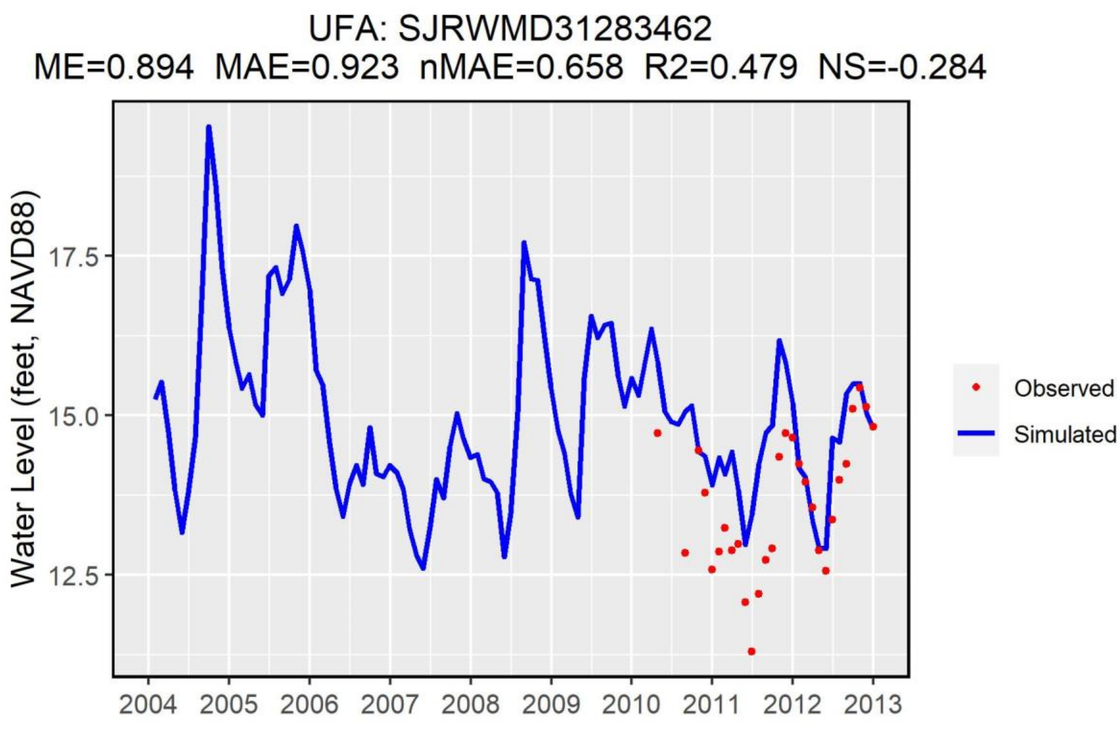
UFA: SJRWMD31792877
ME=-0.958 MAE=1.242 nMAE=0.835 R2=0.493 NS=-0.1

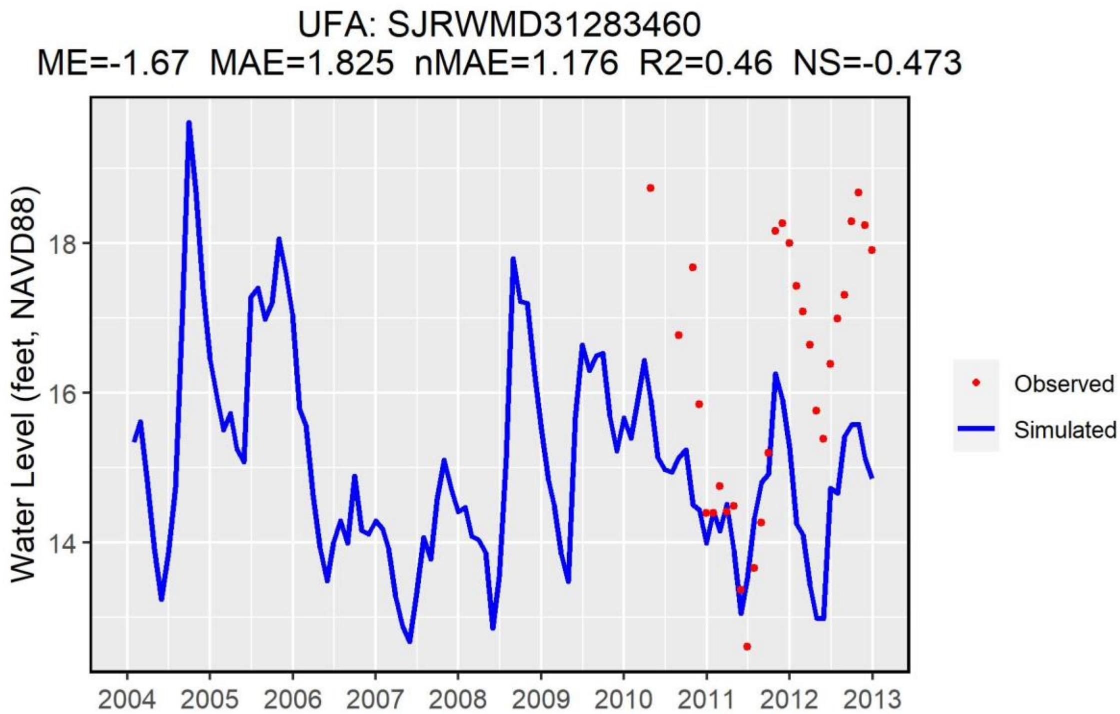


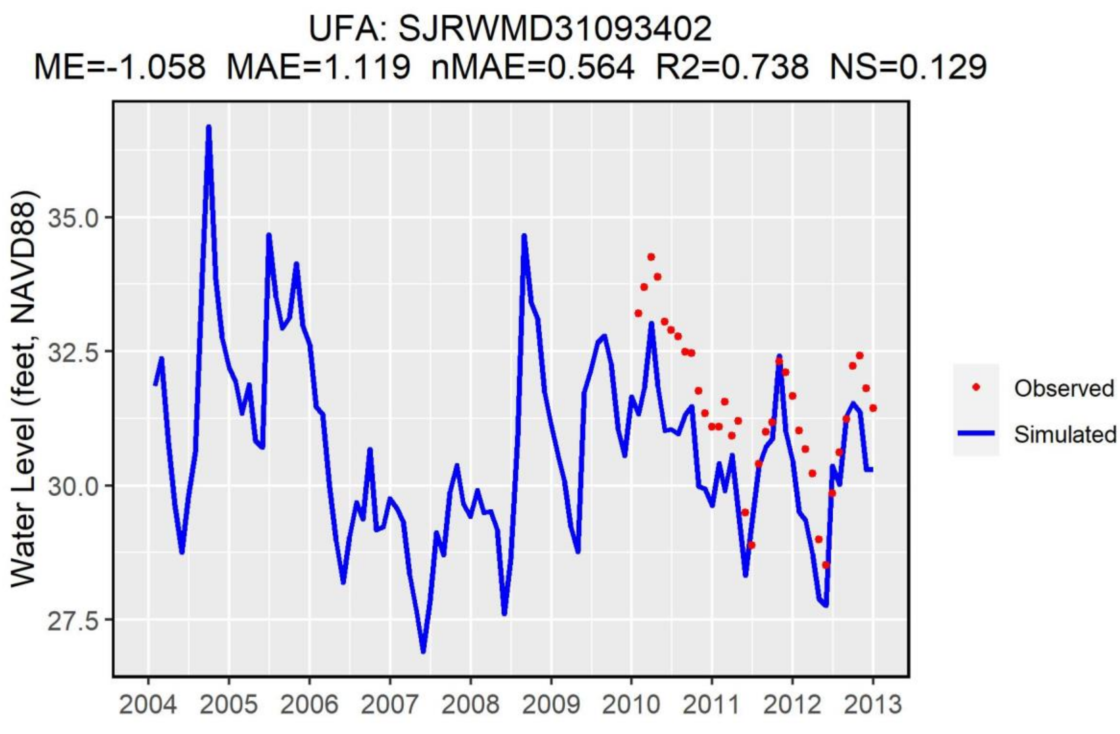
UFA: SJRWMD31713205
ME=-1.053 MAE=2.011 nMAE=1.71 R2=0.225 NS=-0.166

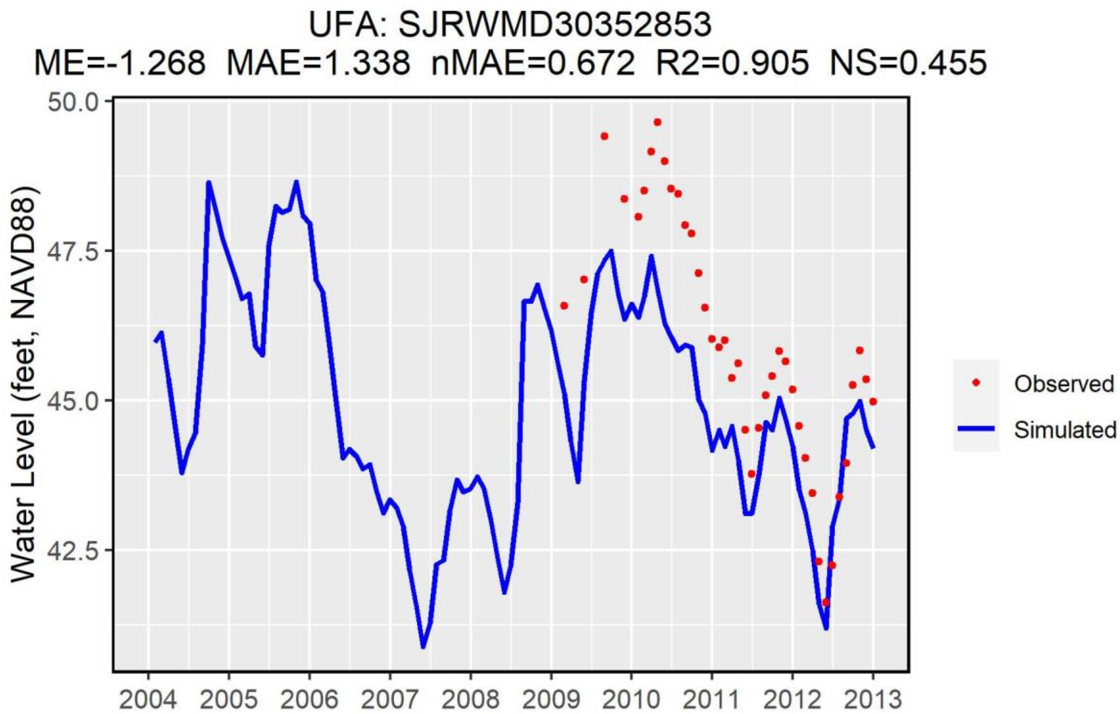


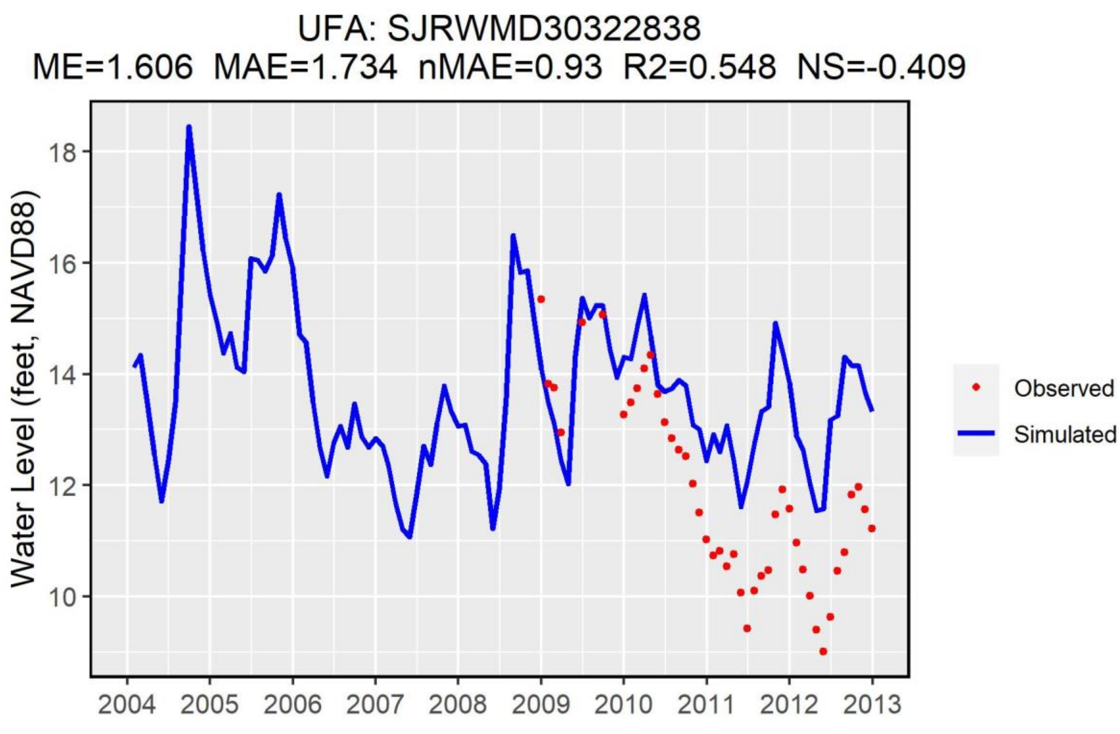

UFA: SJRWMD31433493
ME=-0.757 MAE=0.972 nMAE=0.654 R2=0.799 NS=0.522
Water Level (feet, NAVD88)
86
84
82
80
78
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

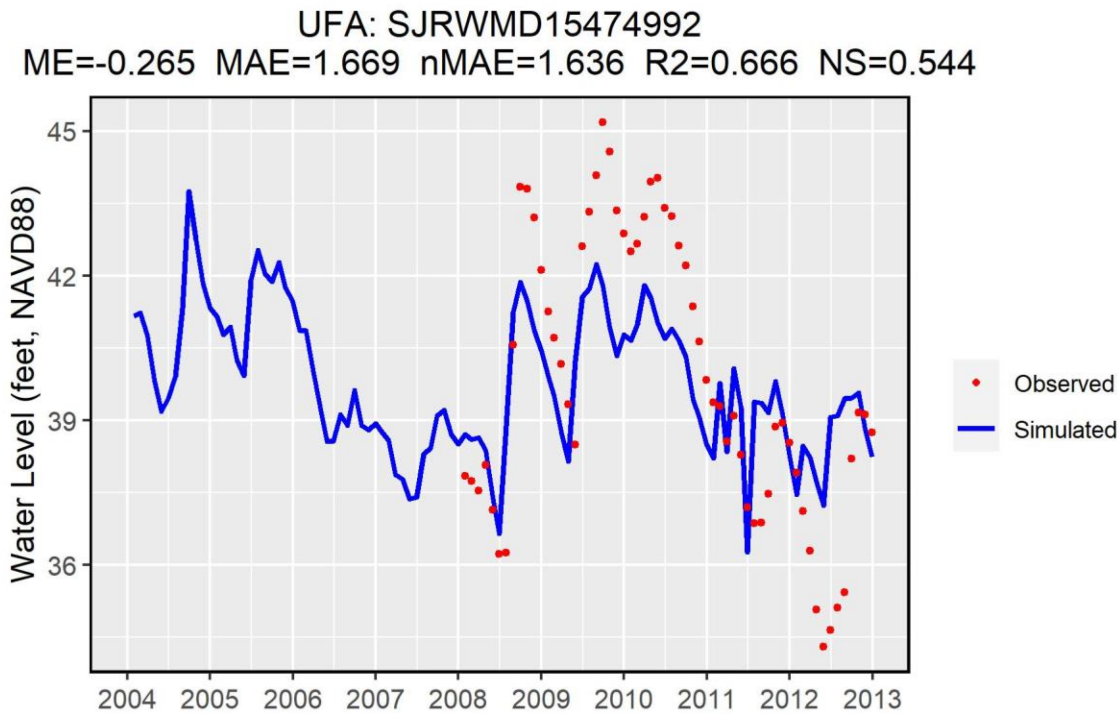

UFA: SJRWMD31283462
ME=0.894 MAE=0.923 nMAE=0.658 R2=0.479 NS=-0.284
Water Level (feet, NAVD88)
17.5
15.0
12.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

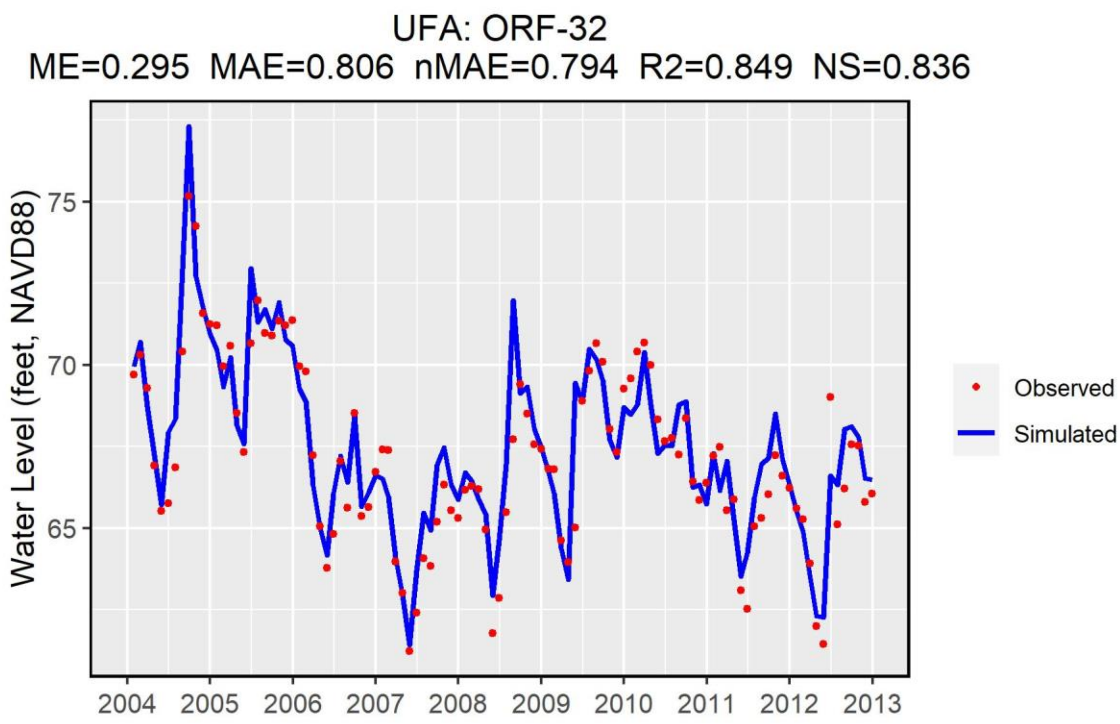

UFA: SJRWMD31283460
ME=-1.67 MAE=1.825 nMAE=1.176 R2=0.46 NS=-0.473
Water Level (feet, NAVD88)
18
16
14
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

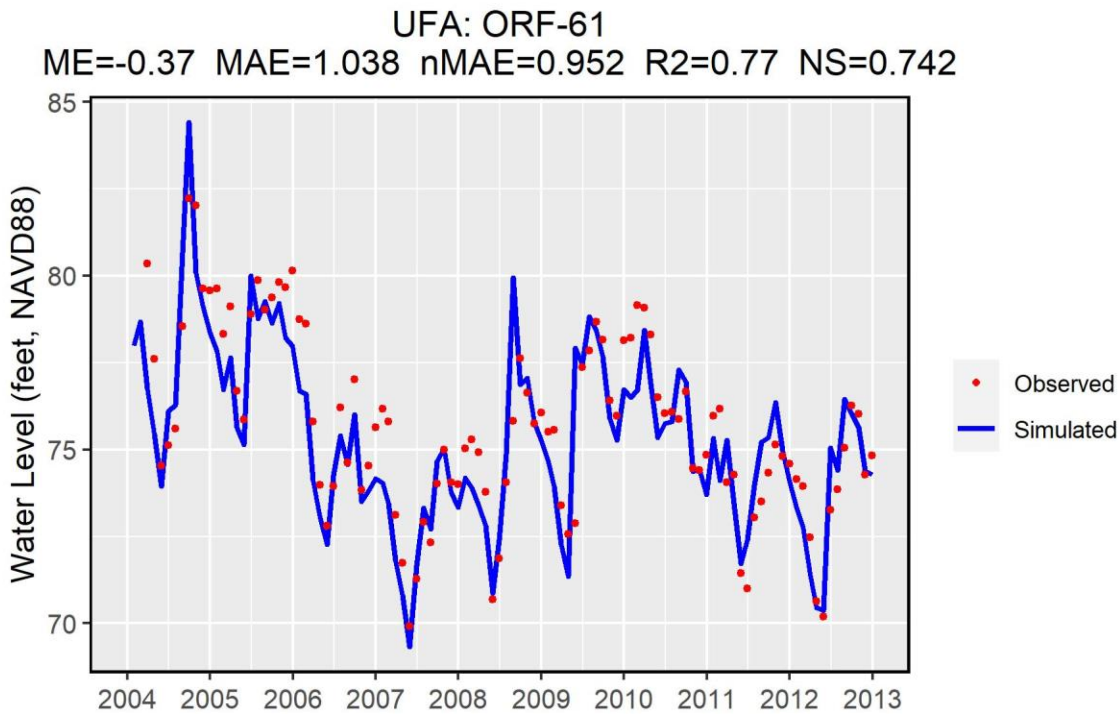

UFA: SJRWMD31093402
ME=-1.058 MAE=1.119 nMAE=0.564 R2=0.738 NS=0.129
Water Level (feet, NAVD88)
35.0
32.5
30.0
27.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated


UFA: SJRWMD30352853
ME=-1.268 MAE=1.338 nMAE=0.672 R2=0.905 NS=0.455
Water Level (feet, NAVD88)
50.0
47.5
45.0
42.5
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

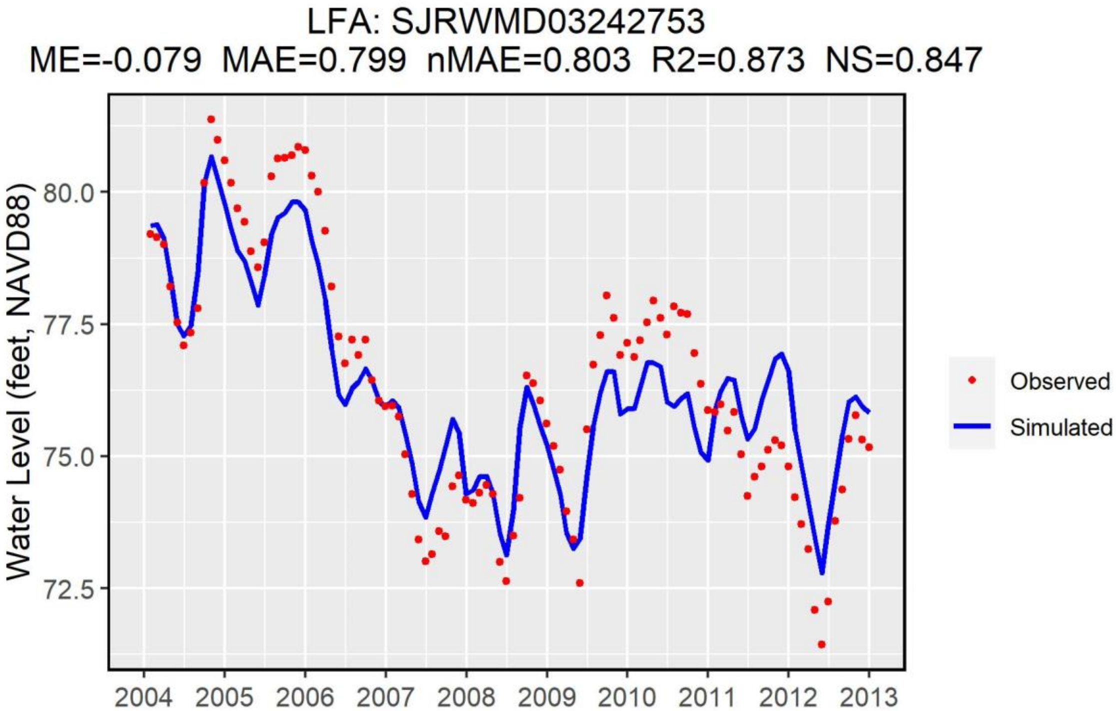

UFA: SJRWMD30322838
ME=1.606 MAE=1.734 nMAE=0.93 R2=0.548 NS=-0.409
Water Level (feet, NAVD88)
18
16
14
12
10
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

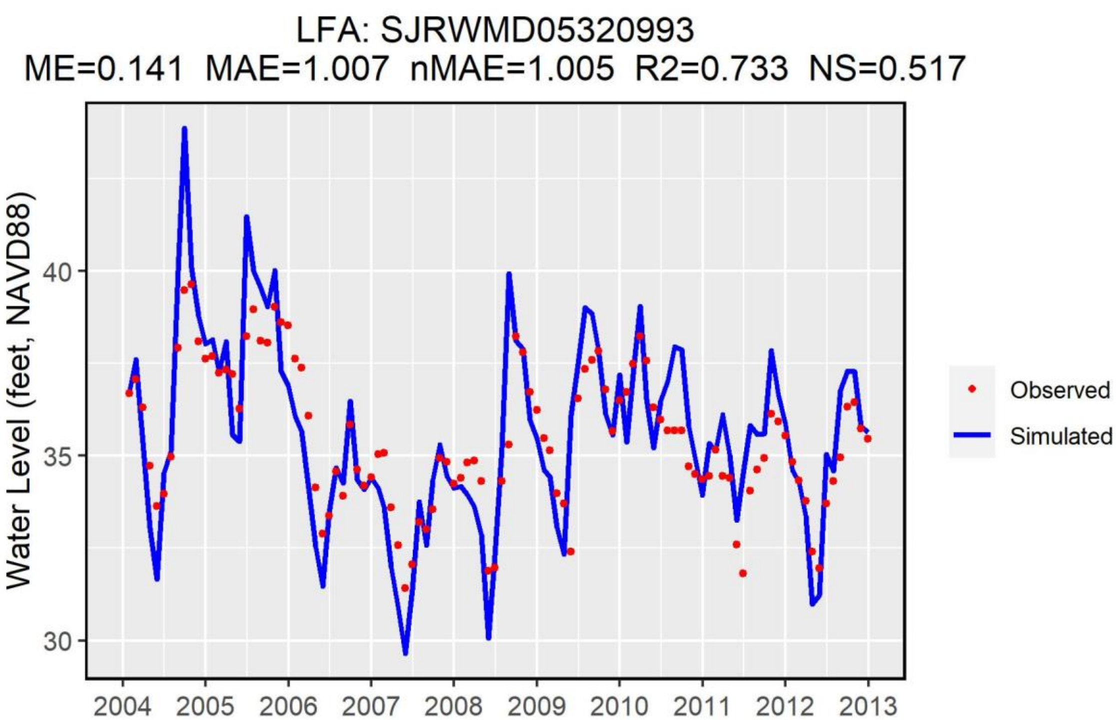

UFA: SJRWMD15474992
ME=-0.265 MAE=1.669 nMAE=1.636 R2=0.666 NS=0.544
Water Level (feet, NAVD88)
45
42
39
36
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

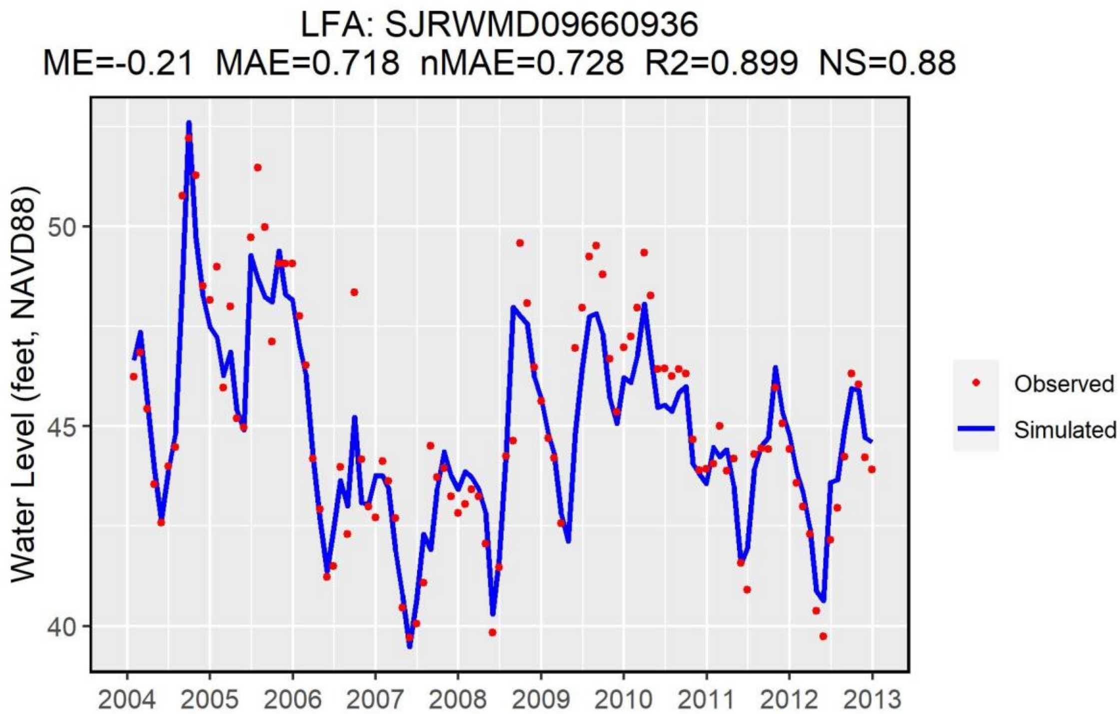

UFA: ORF-32
ME=0.295 MAE=0.806 nMAE=0.794 R2=0.849 NS=0.836
Water Level (feet, NAVD88)
75
70
65
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

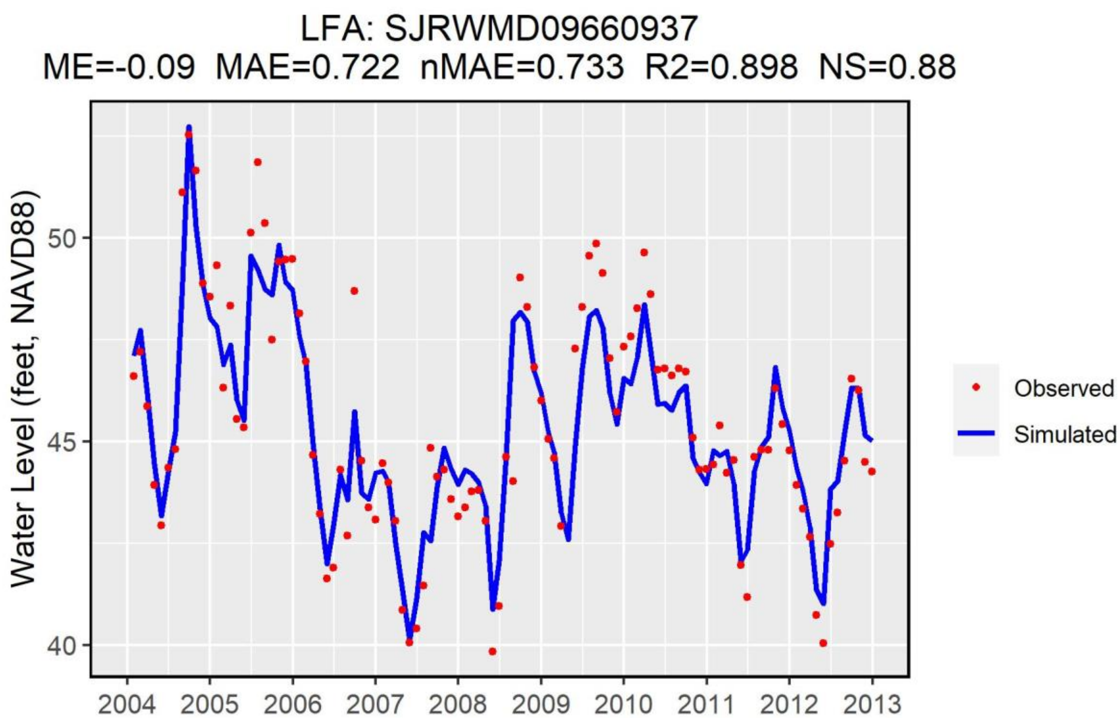

UFA: ORF-61
ME=-0.37 MAE=1.038 nMAE=0.952 R2=0.77 NS=0.742
Water Level (feet, NAVD88)
85
80
75
70
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

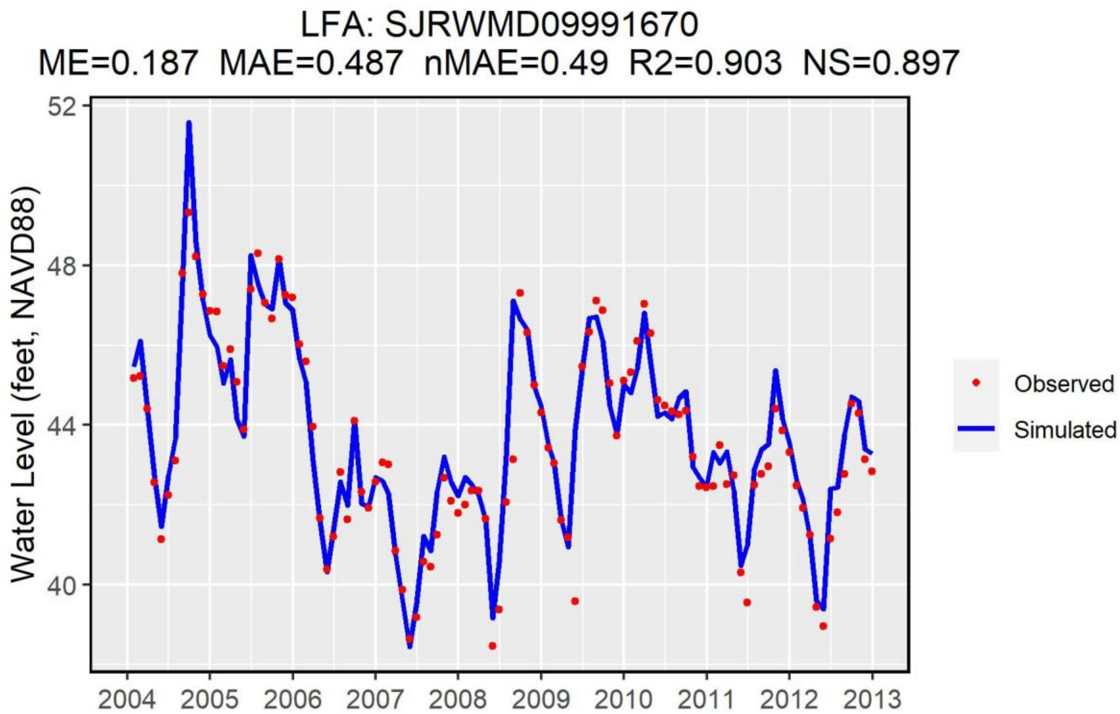
Lower Floridan Aquifer (LFA) Target Wells

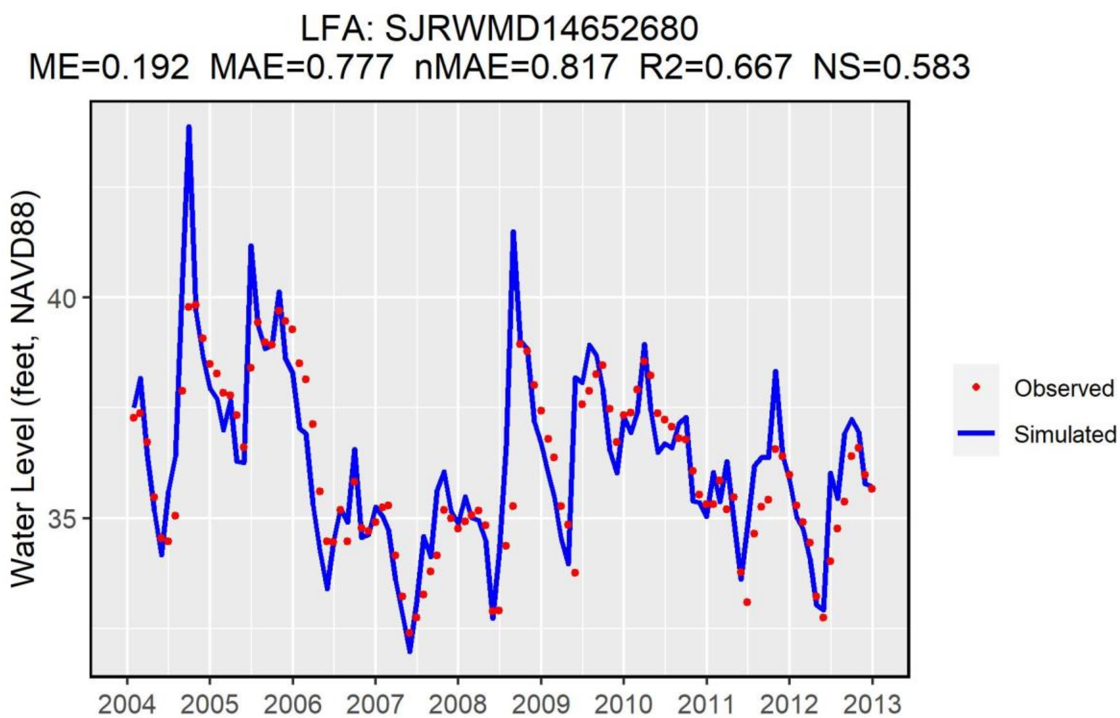


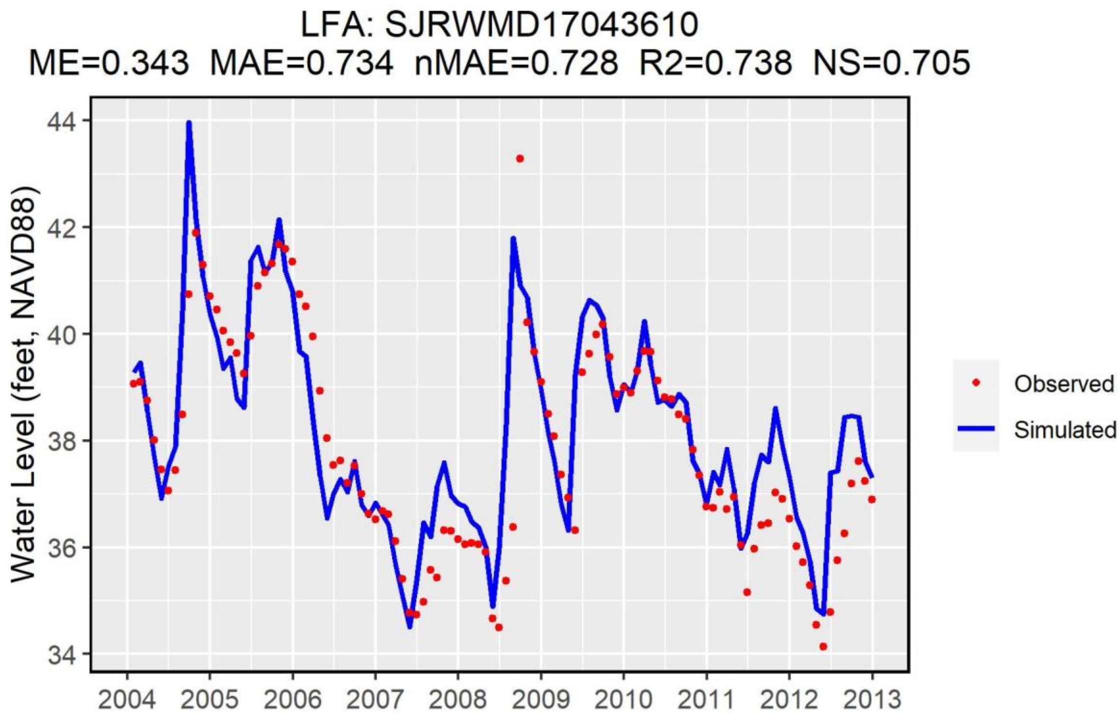


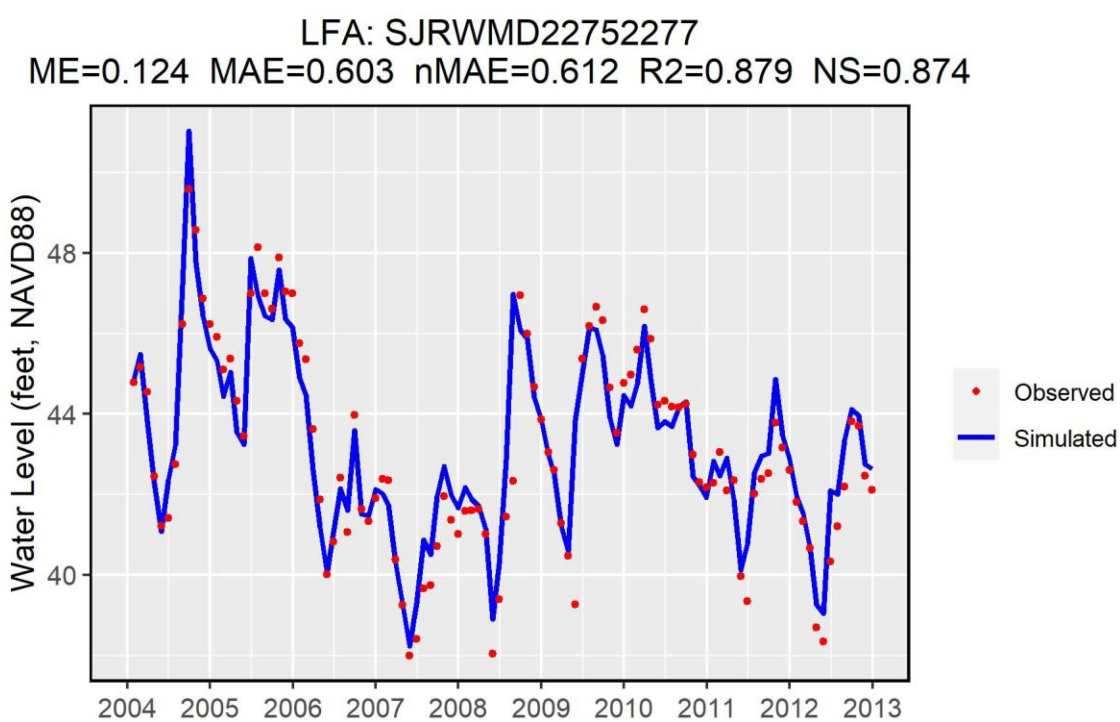

LFA: SJRWMD09660936
ME=-0.21 MAE=0.718 nMAE=0.728 R2=0.899 NS=0.88
Water Level (feet, NAVD88)
50
45
40
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated


LFA: SJRWMD09660937
ME=-0.09 MAE=0.722 nMAE=0.733 R2=0.898 NS=0.88
Water Level (feet, NAVD88)
50
45
40
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

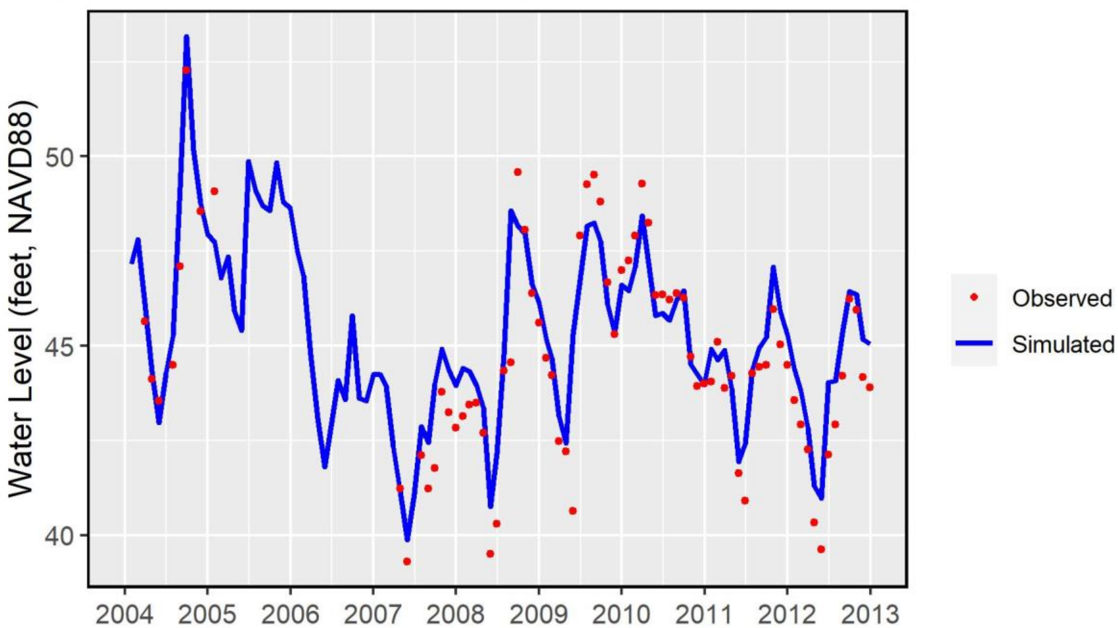

LFA: SJRWMD09991670
ME=0.187 MAE=0.487 nMAE=0.49 R2=0.903 NS=0.897
Water Level (feet, NAVD88)
52
48
44
40
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated


LFA: SJRWMD14652680
ME=0.192 MAE=0.777 nMAE=0.817 R2=0.667 NS=0.583
Water Level (feet, NAVD88)
40
35
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

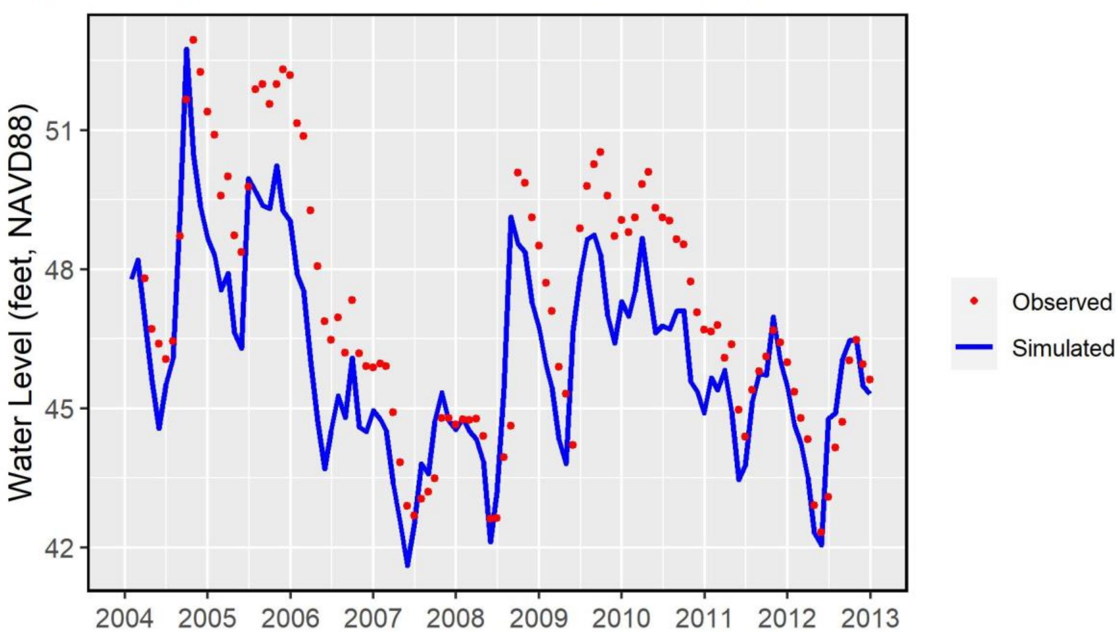

LFA: SJRWMD17043610
ME=0.343 MAE=0.734 nMAE=0.728 R2=0.738 NS=0.705
Water Level (feet, NAVD88)
44
42
40
38
36
34
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

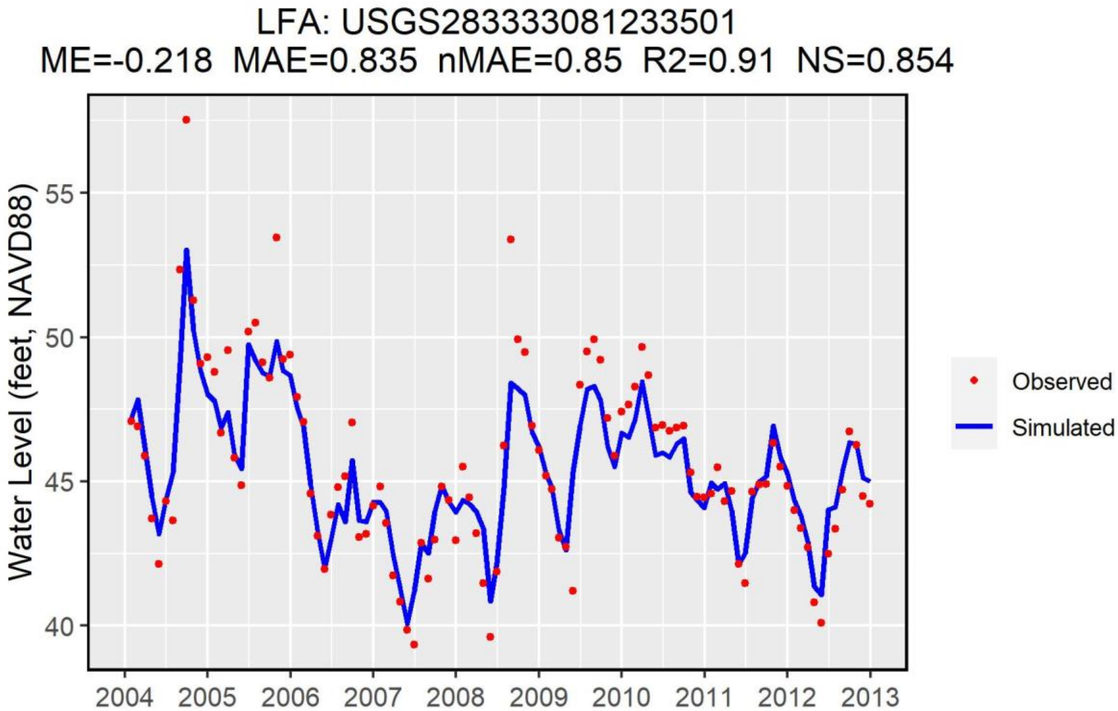

LFA: SJRWMD22752277
ME=0.124 MAE=0.603 nMAE=0.612 R2=0.879 NS=0.874
Water Level (feet, NAVD88)
48
44
40
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

LFA: SJRWMD29674178
ME=0.465 MAE=0.87 nMAE=0.758 R2=0.854 NS=0.815



LFA: SJRWMD51004173
ME=-1.096 MAE=1.44 nMAE=1.028 R2=0.767 NS=0.591




LFA: USGS283333081233501
ME=-0.218 MAE=0.835 nMAE=0.85 R2=0.91 NS=0.854
Water Level (feet, NAVD88)
55
50
45
40
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Observed
Simulated

Appendix C – Simulated Versus Observed Flow Hydrographs for Continuously Measured Springs

List of Figures

Figure 5. Simulated and observed flow at Alexander Spring for the model simulation period.

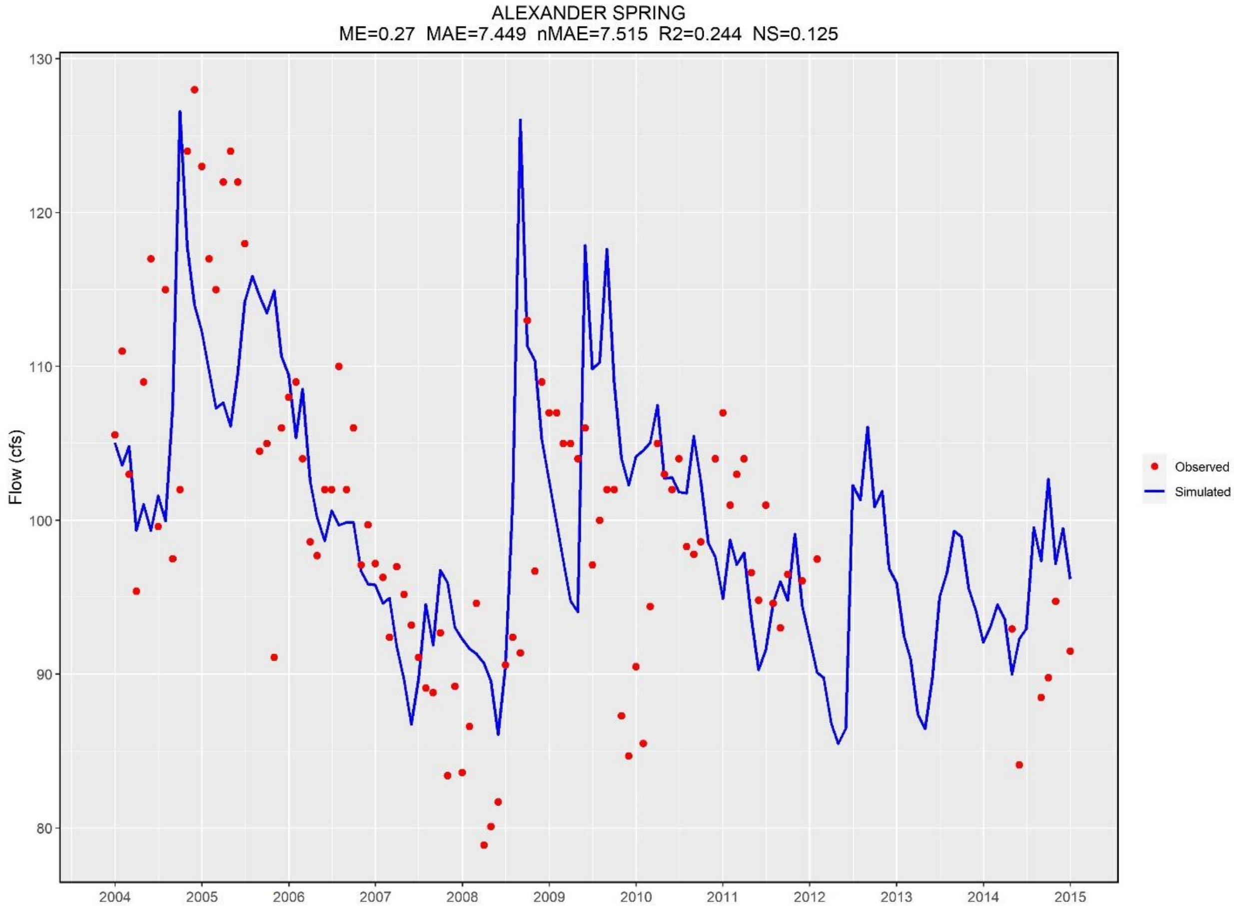


Figure 6. Simulated and observed flow at Apopka Spring for the model simulation period.

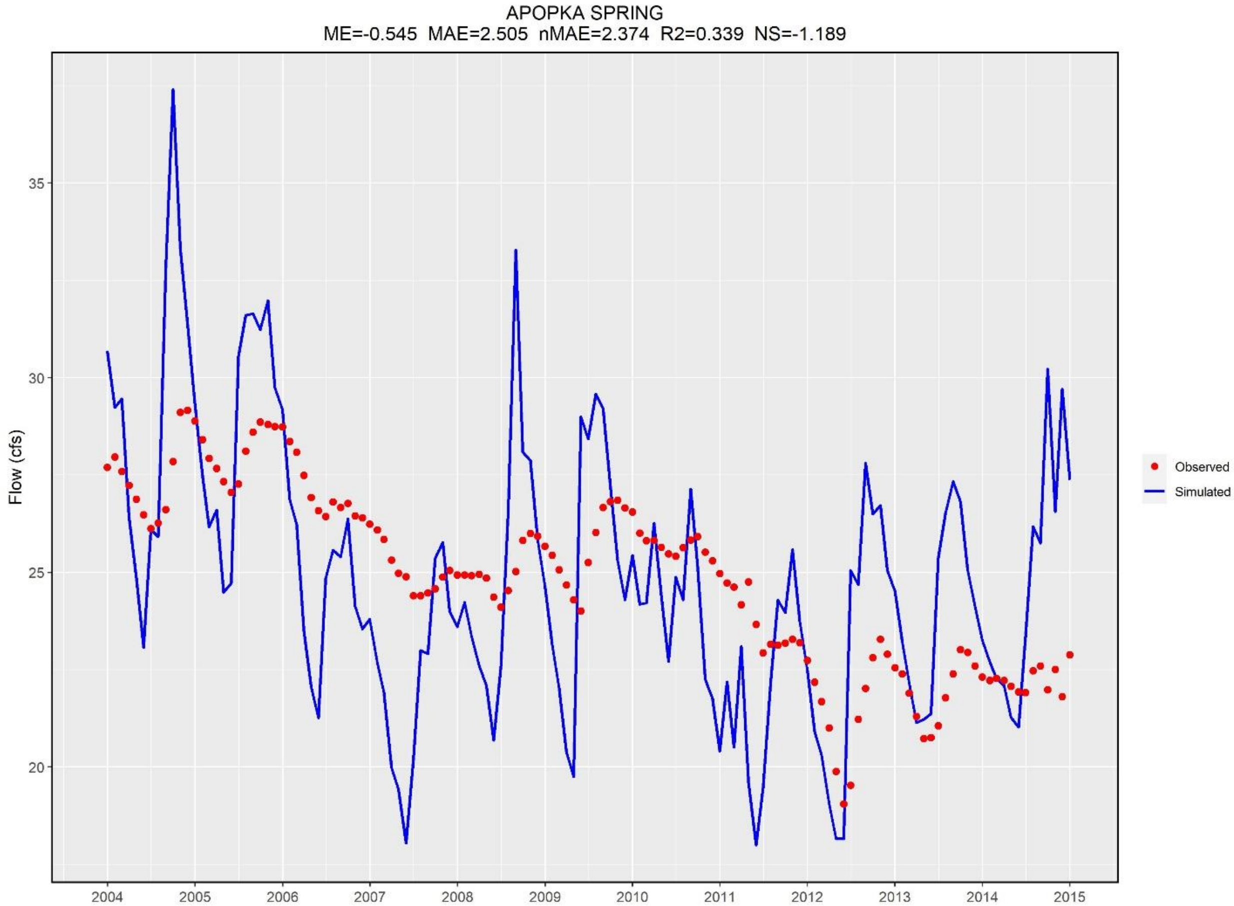


Figure 7. Simulated and observed flow at Buckhorn Main Spring for the model simulation period.

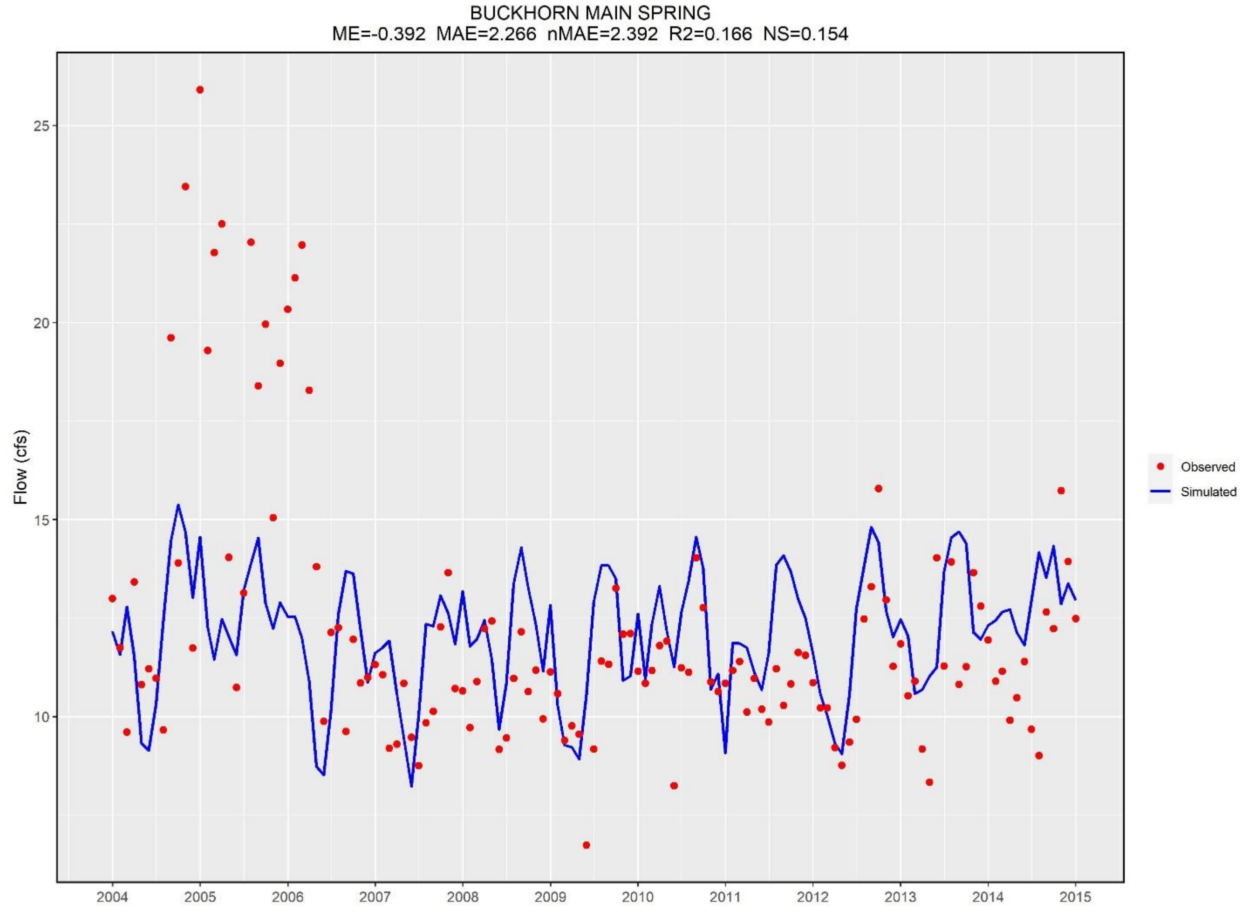


Figure 8. Simulated and observed flow at Bugg Spring for the model simulation period.

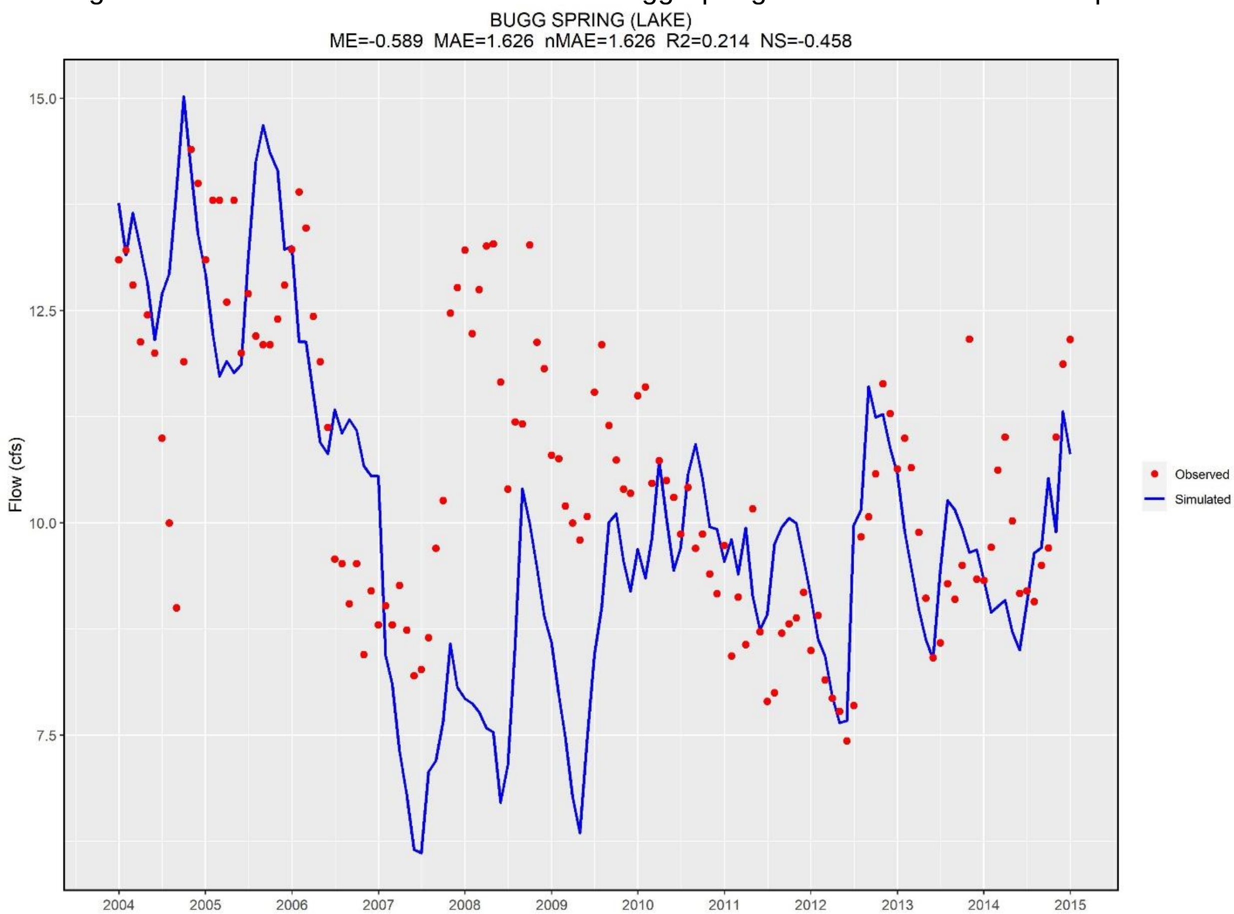


Figure 9. Simulated and observed flow at Chassahowitza Spring for the model simulation period.

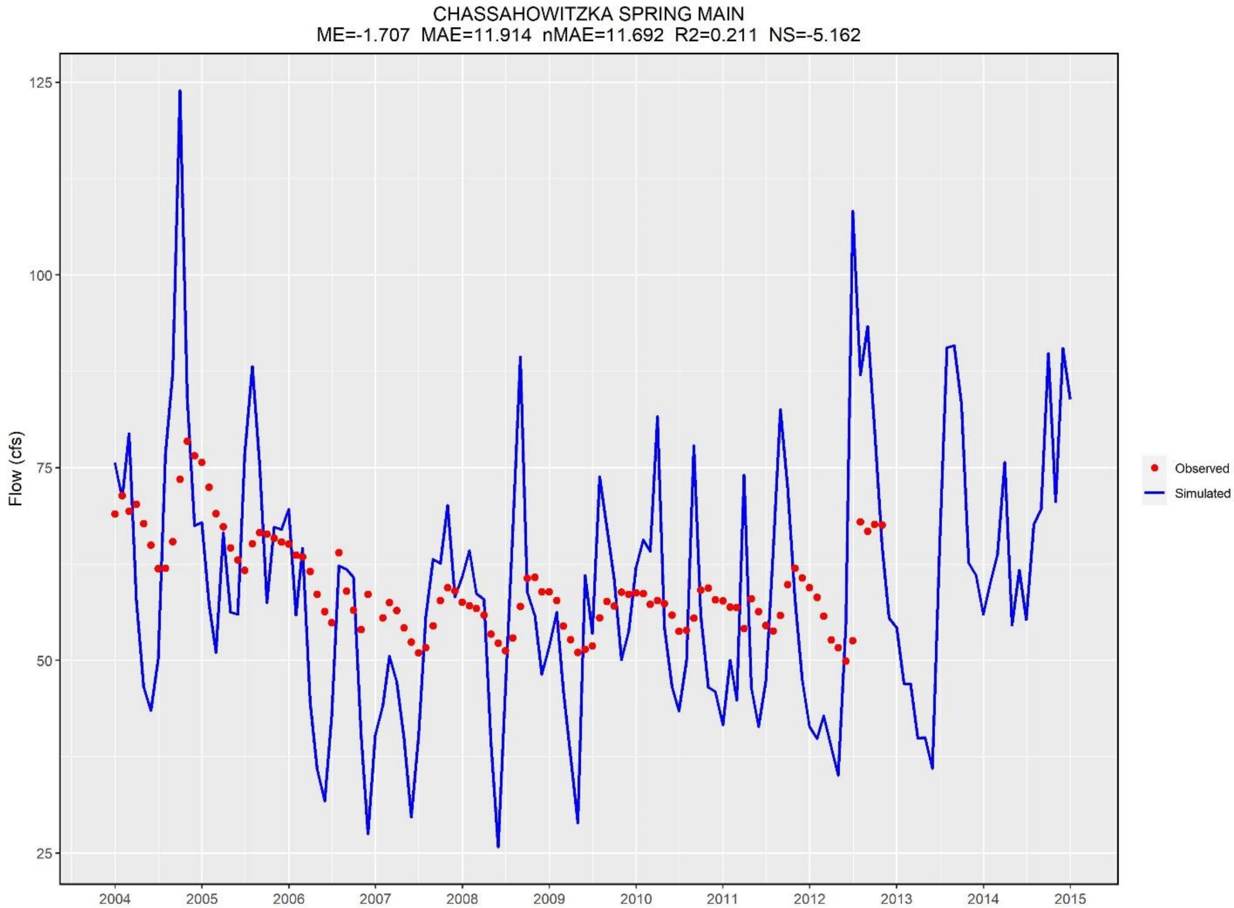


Figure 10. Simulated and observed flow at Crystal Main Spring for the model simulation period.

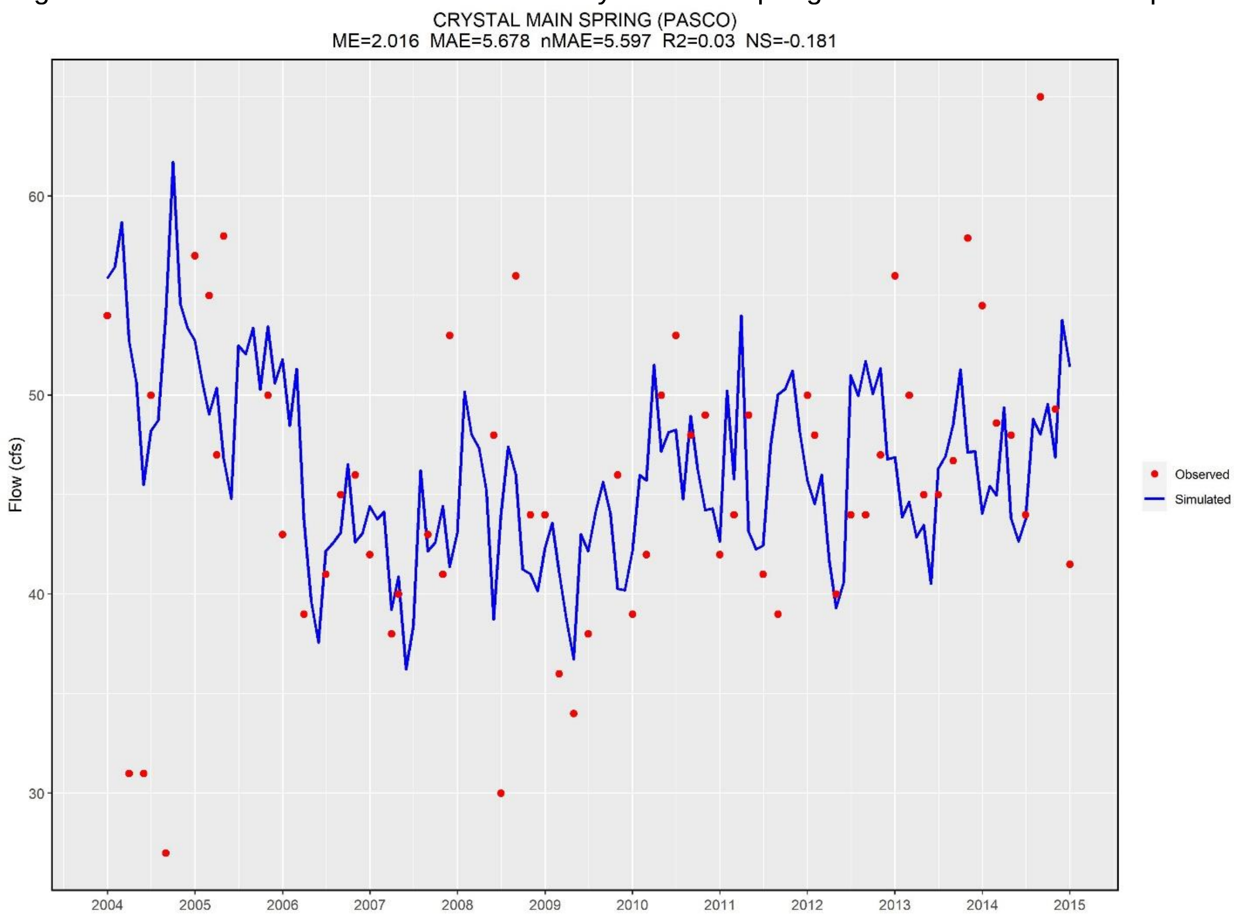


Figure 11. Simulated and observed flow at Gum Spring for the model simulation period.

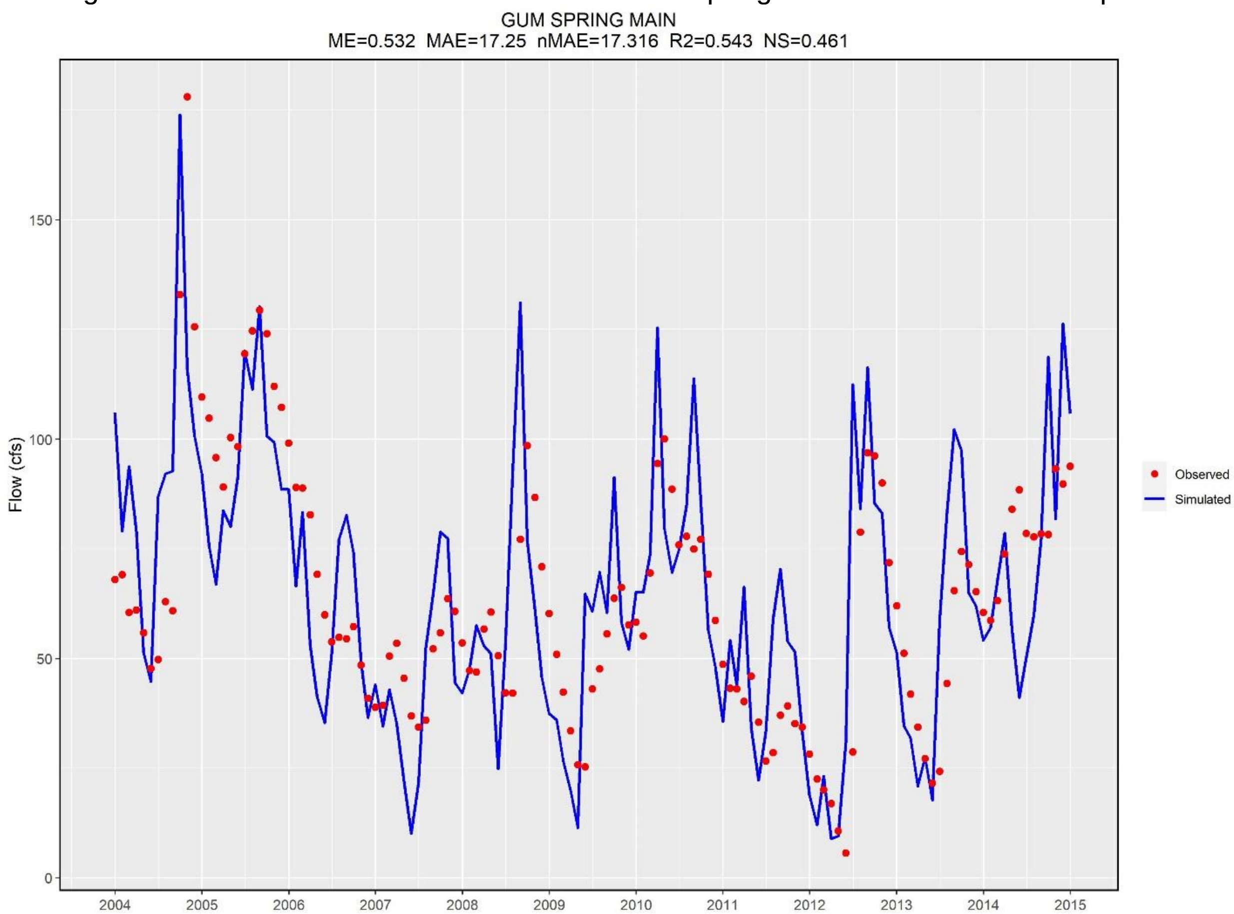


Figure 12. Simulated and observed flow at Homosassa Spring for the model simulation period.

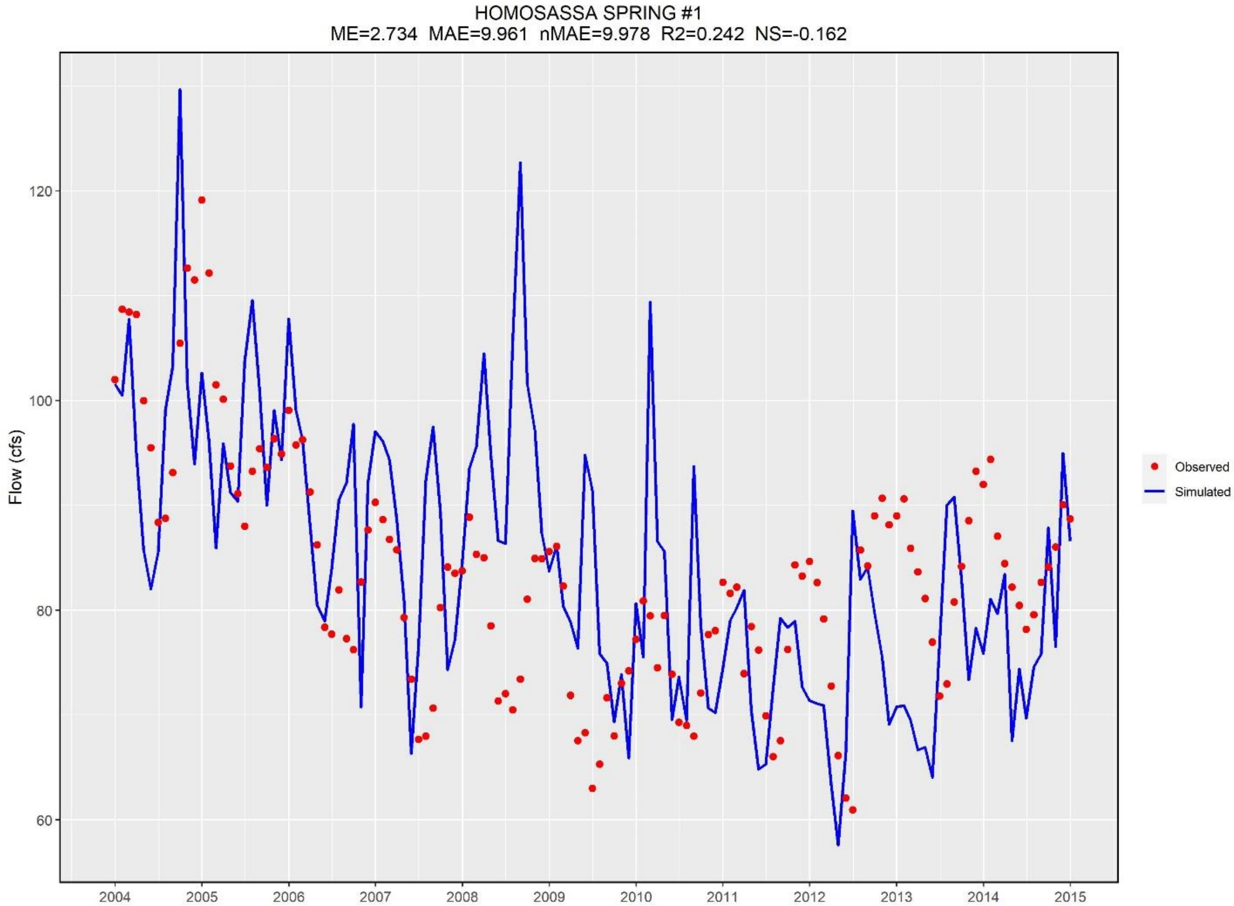


Figure 13. Simulated and observed flow at Lithia Spring for the model simulation period.

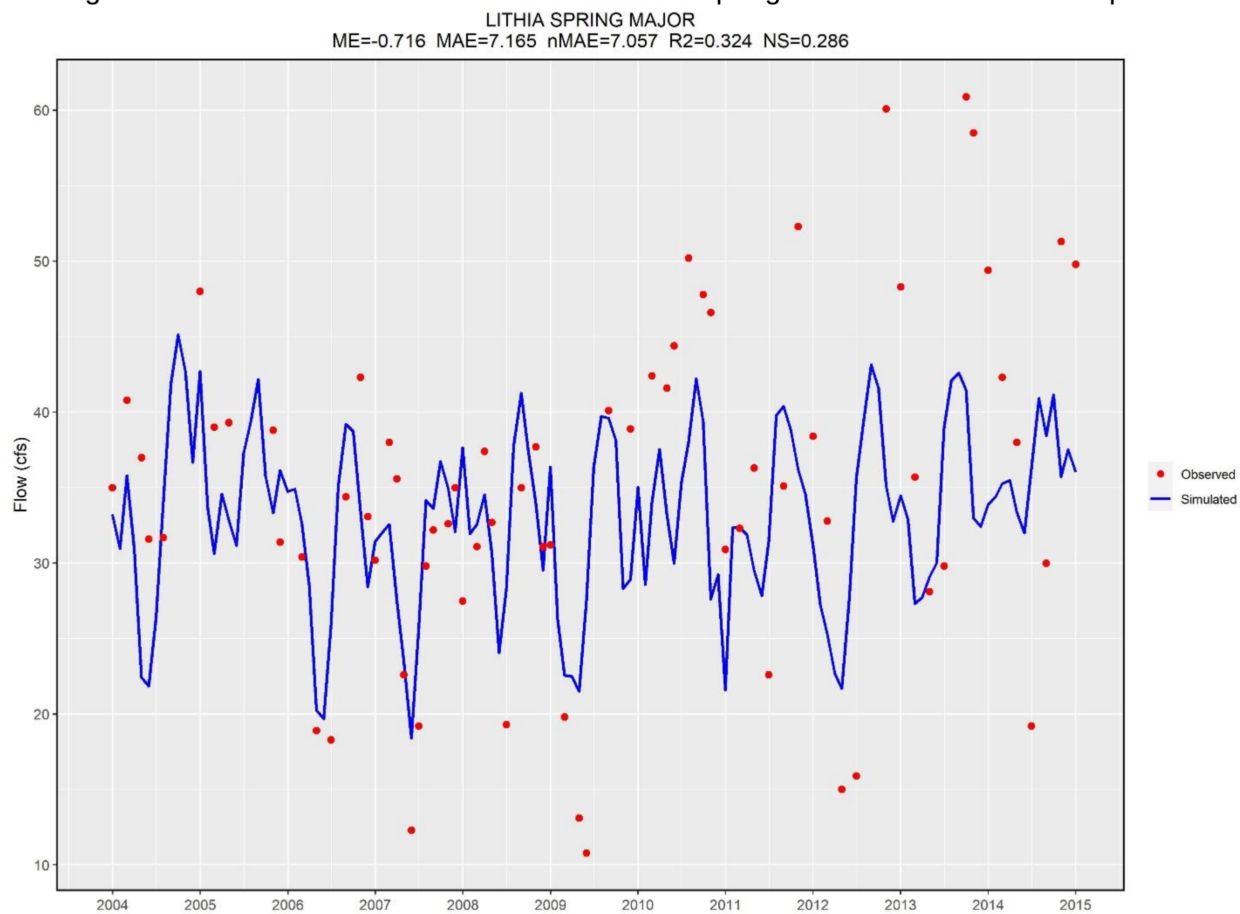


Figure 14. Simulated and observed flow at Rainbow Spring for the model simulation period.

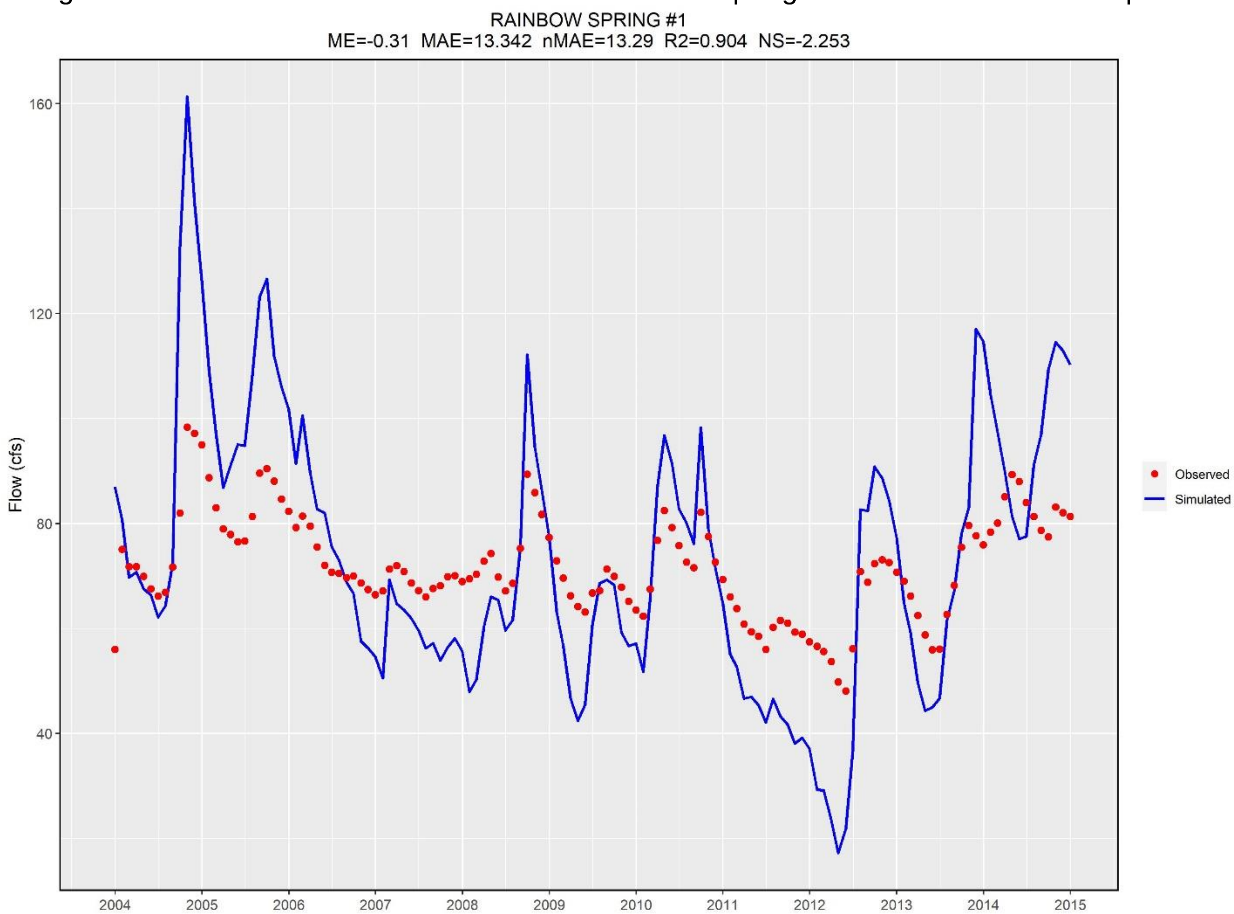


Figure 15. Simulated and observed flow at Rock Springs for the model simulation period.

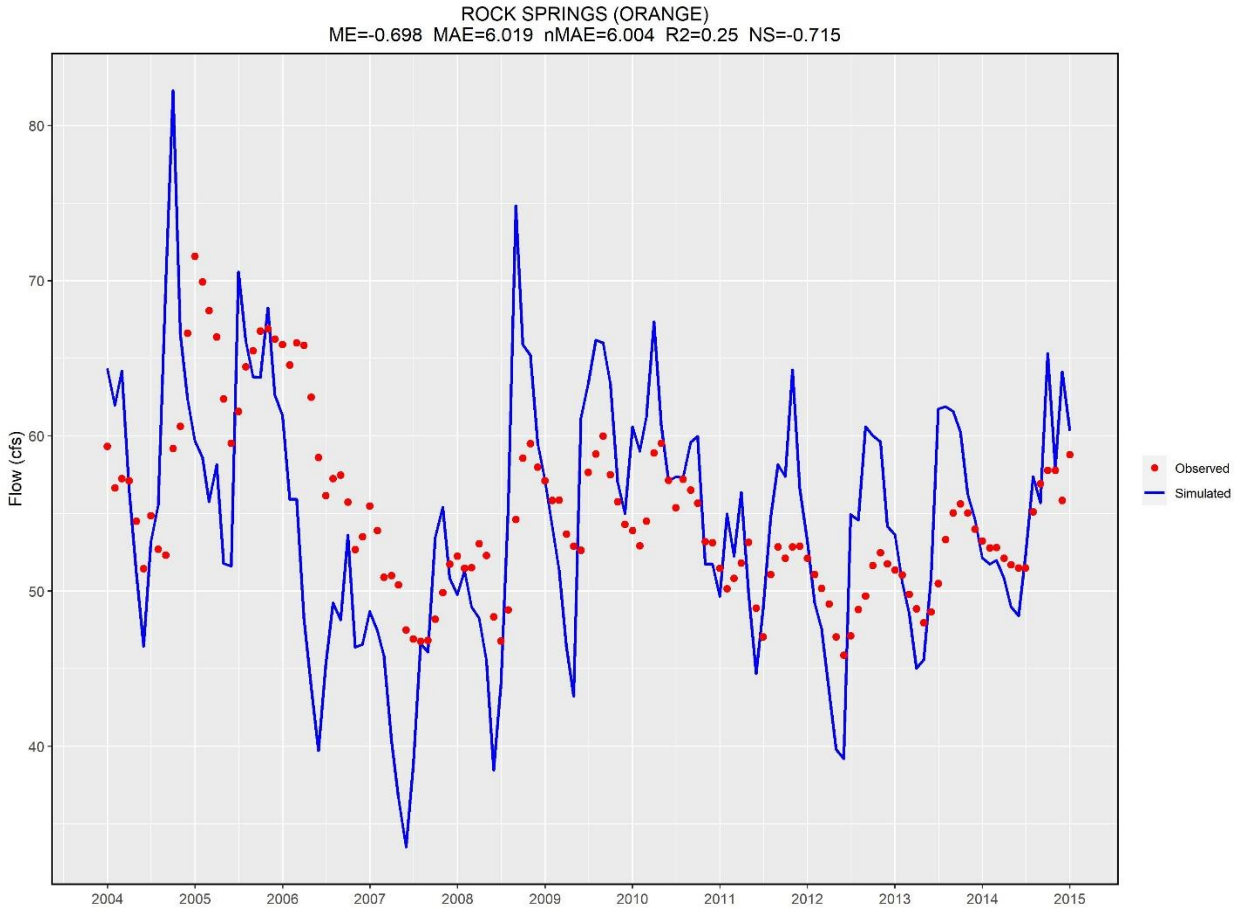


Figure 16. Simulated and observed flow at Sanlando Spring for the model simulation period.

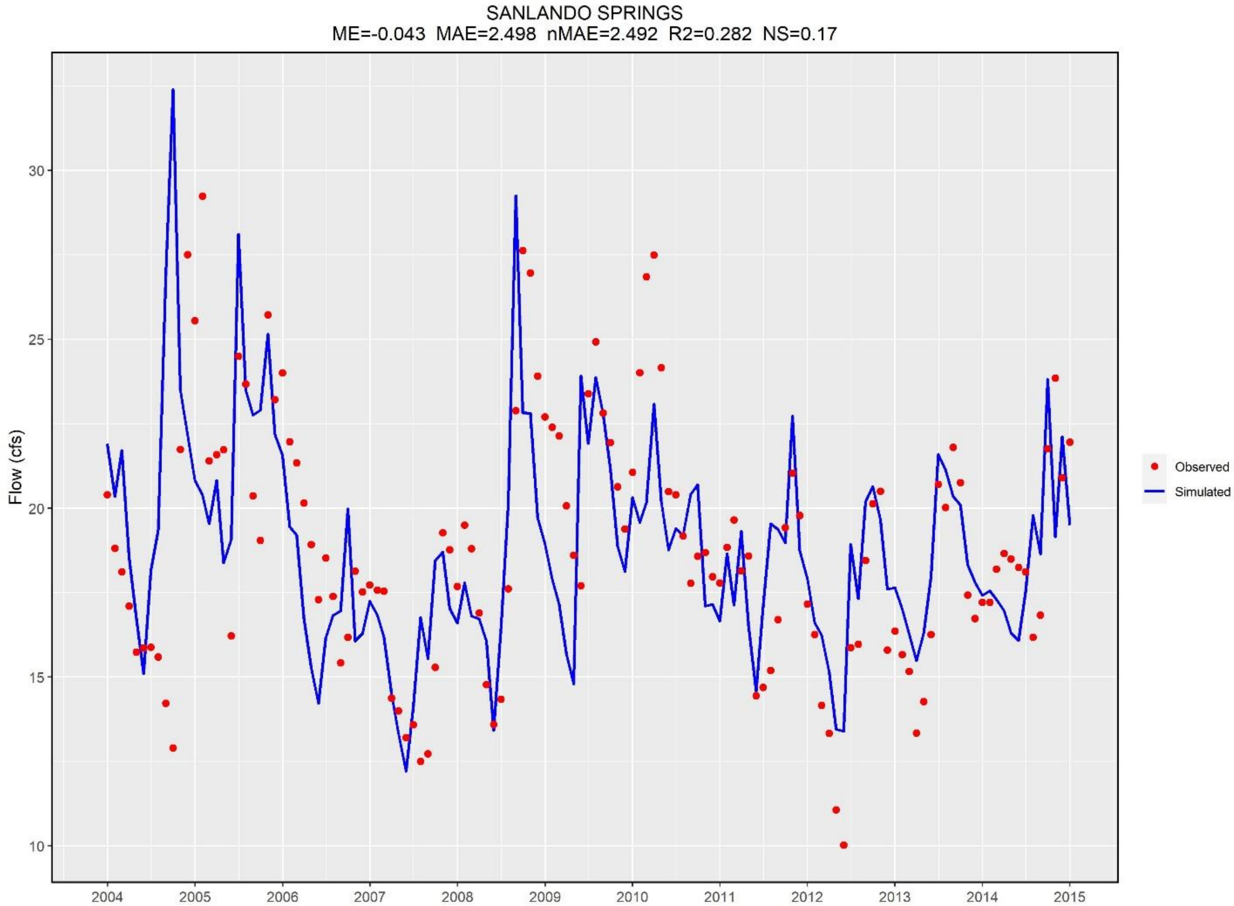


Figure 17. Simulated and observed flow at Starbuck Spring for the model simulation period.

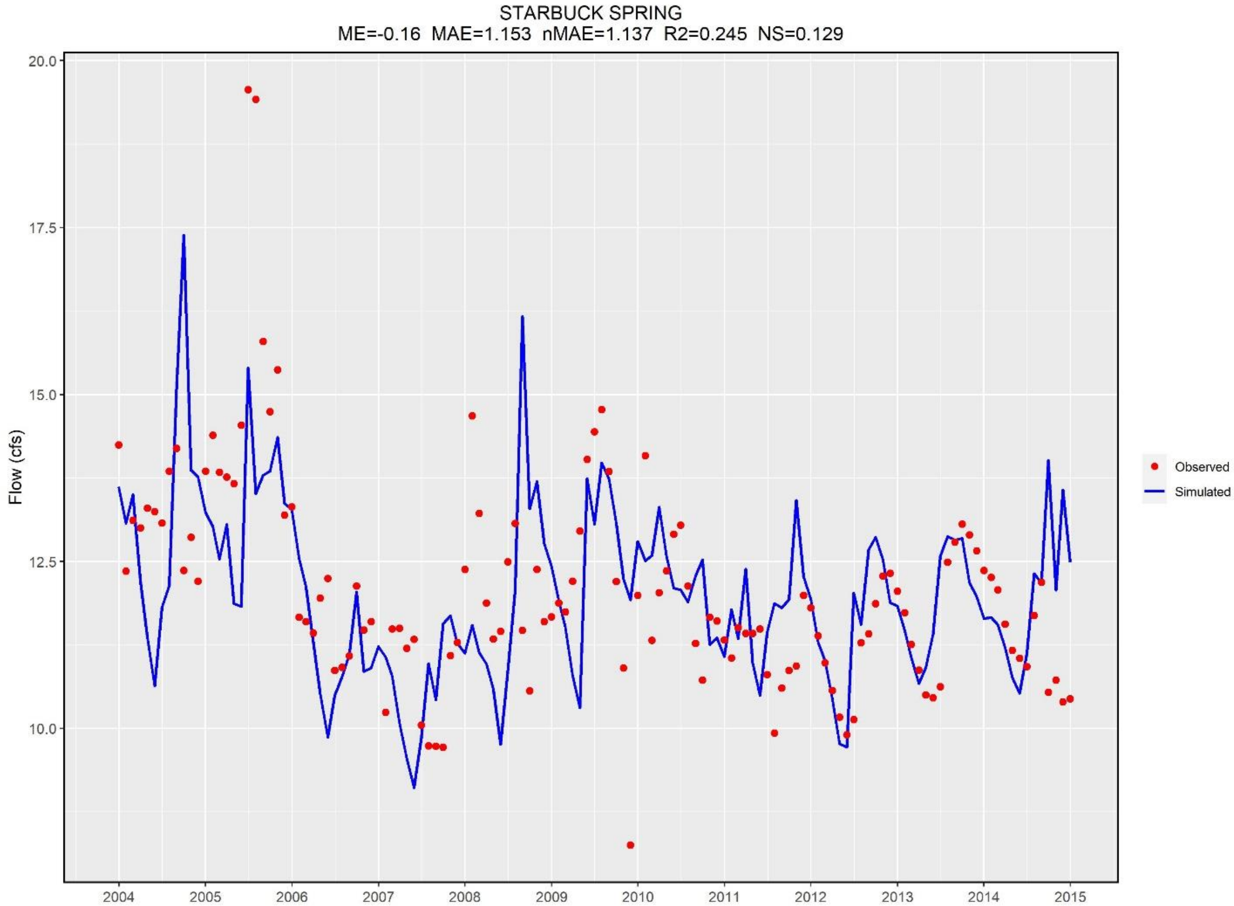


Figure 18. Simulated and observed flow at Sulphur Spring for the model simulation period.

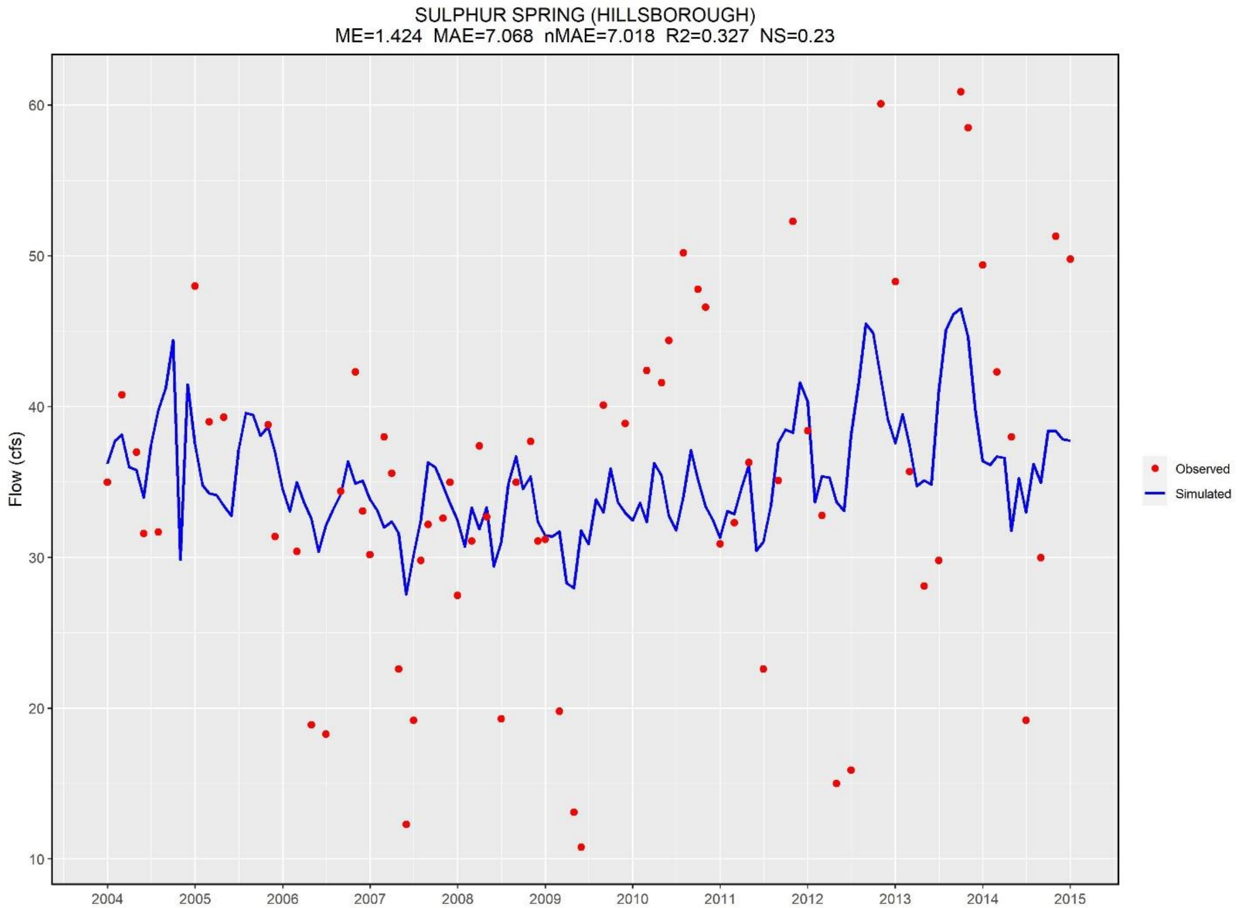


Figure 19. Simulated and observed flow at Volusia Blue Spring for the model simulation period.

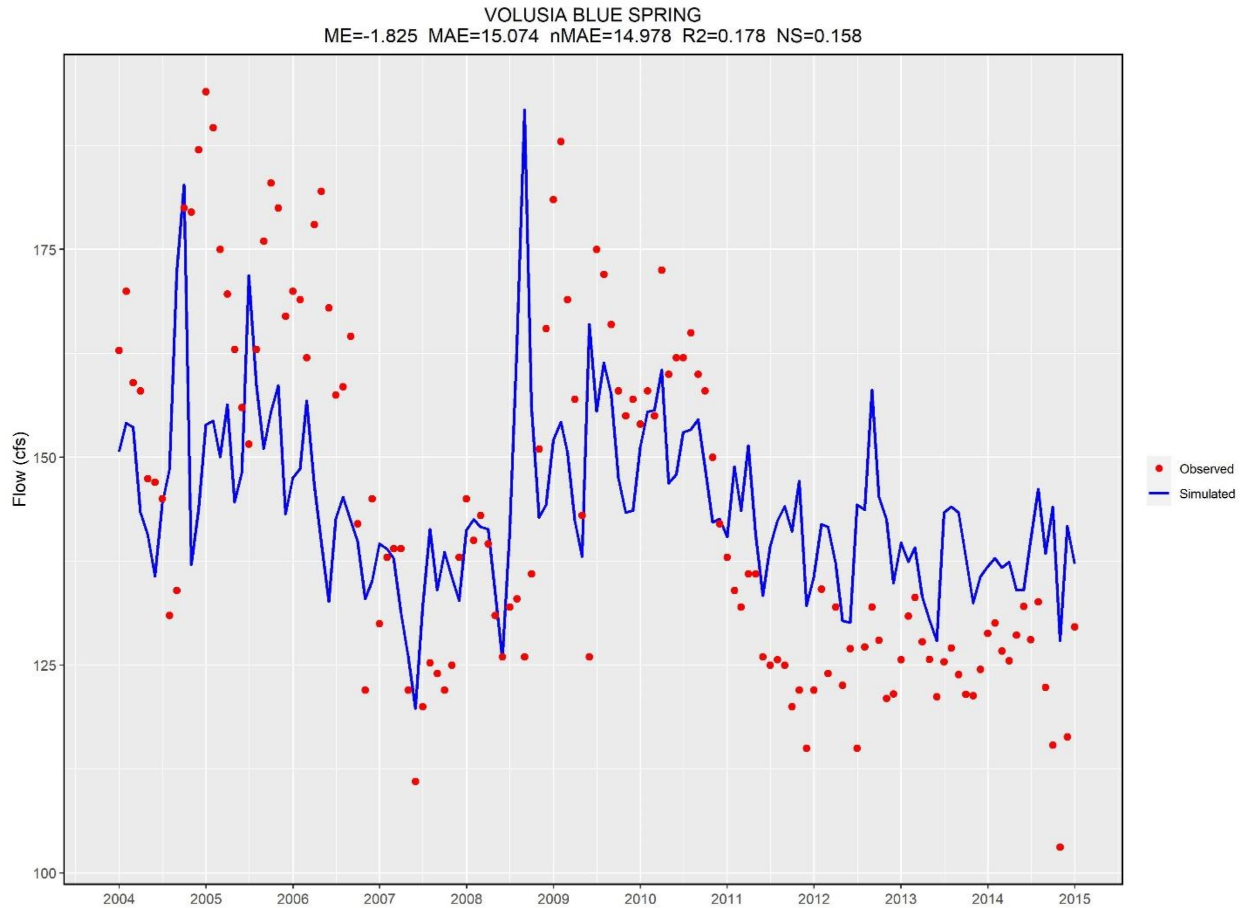


Figure 20. Simulated and observed flow at Weeki Wachee Spring for the model simulation period.

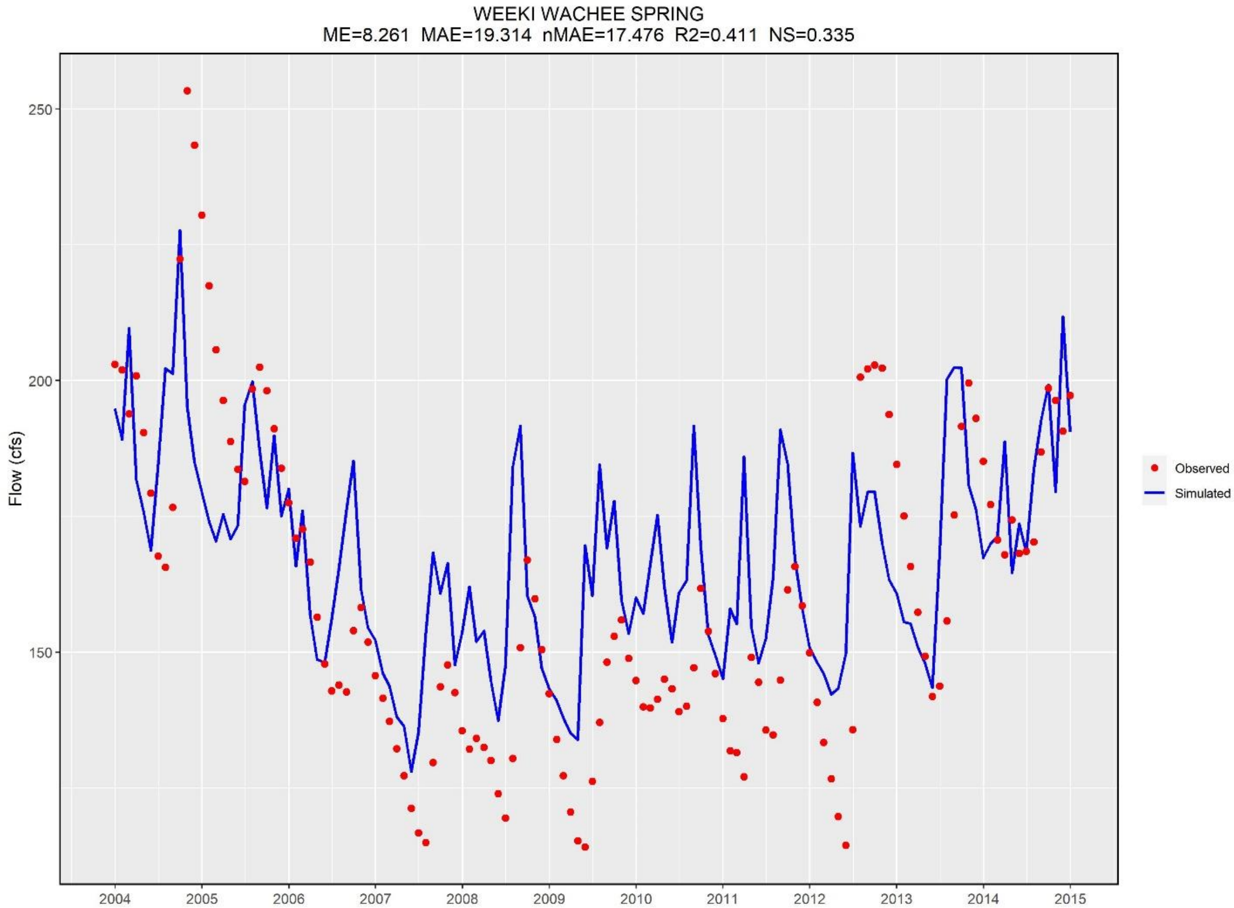


Figure 21. Simulated and observed flow at Wekiva Falls for the model simulation period.

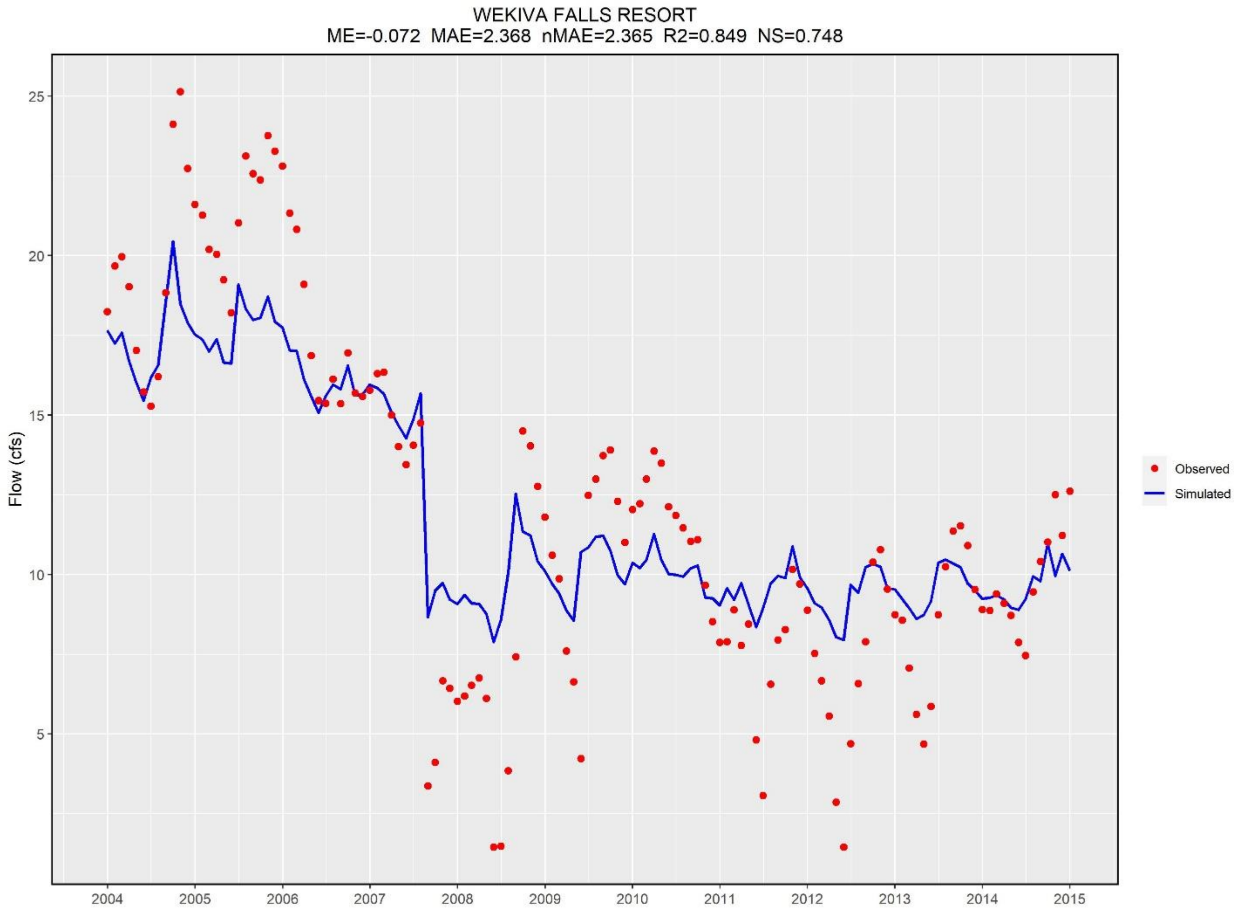
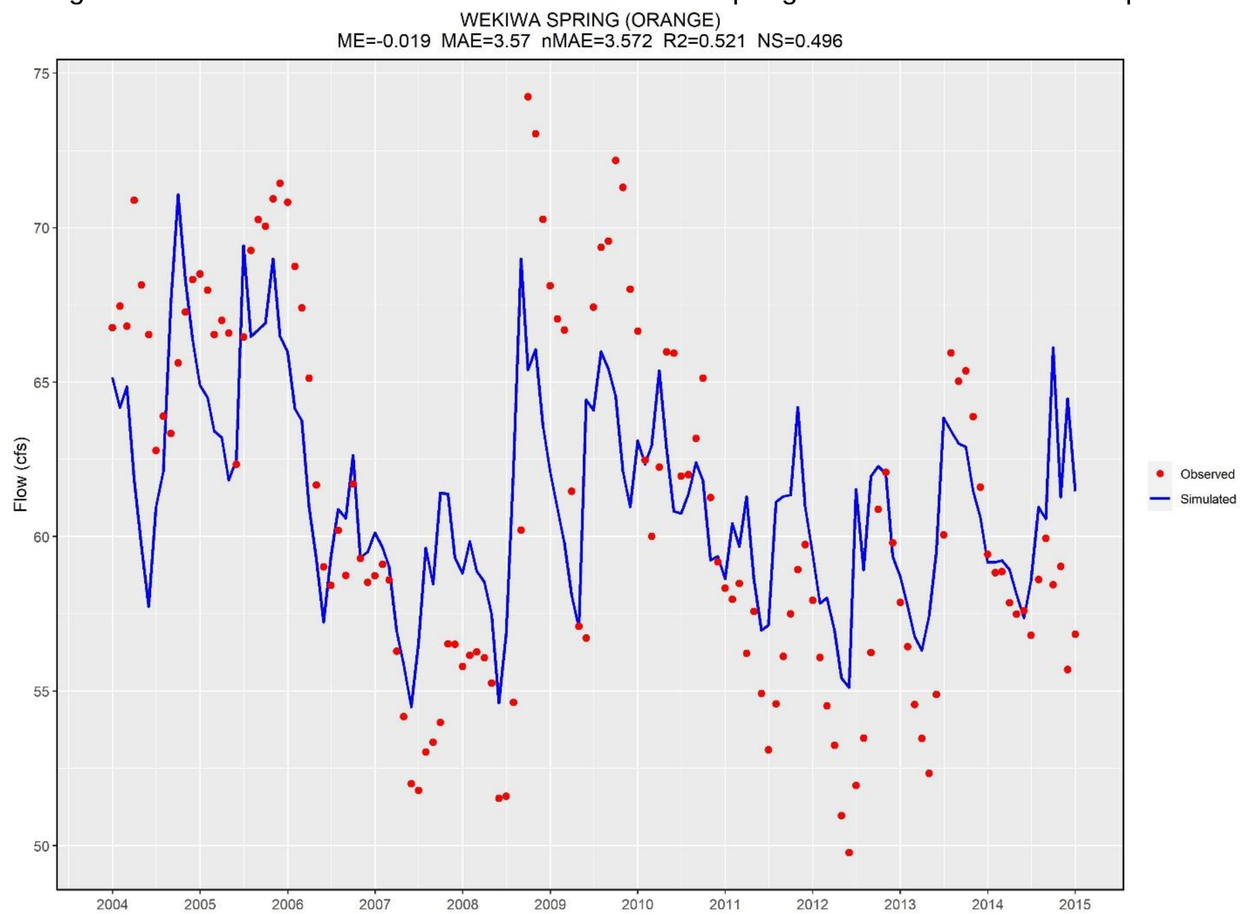


Figure 22. Simulated and observed flow at Wekiwa Spring for the model simulation period.



Appendix D – Aquifer and Confining Unit Properties

Figures

Figure 23. Hydraulic conductivity values for model layer 1 in the focus area.

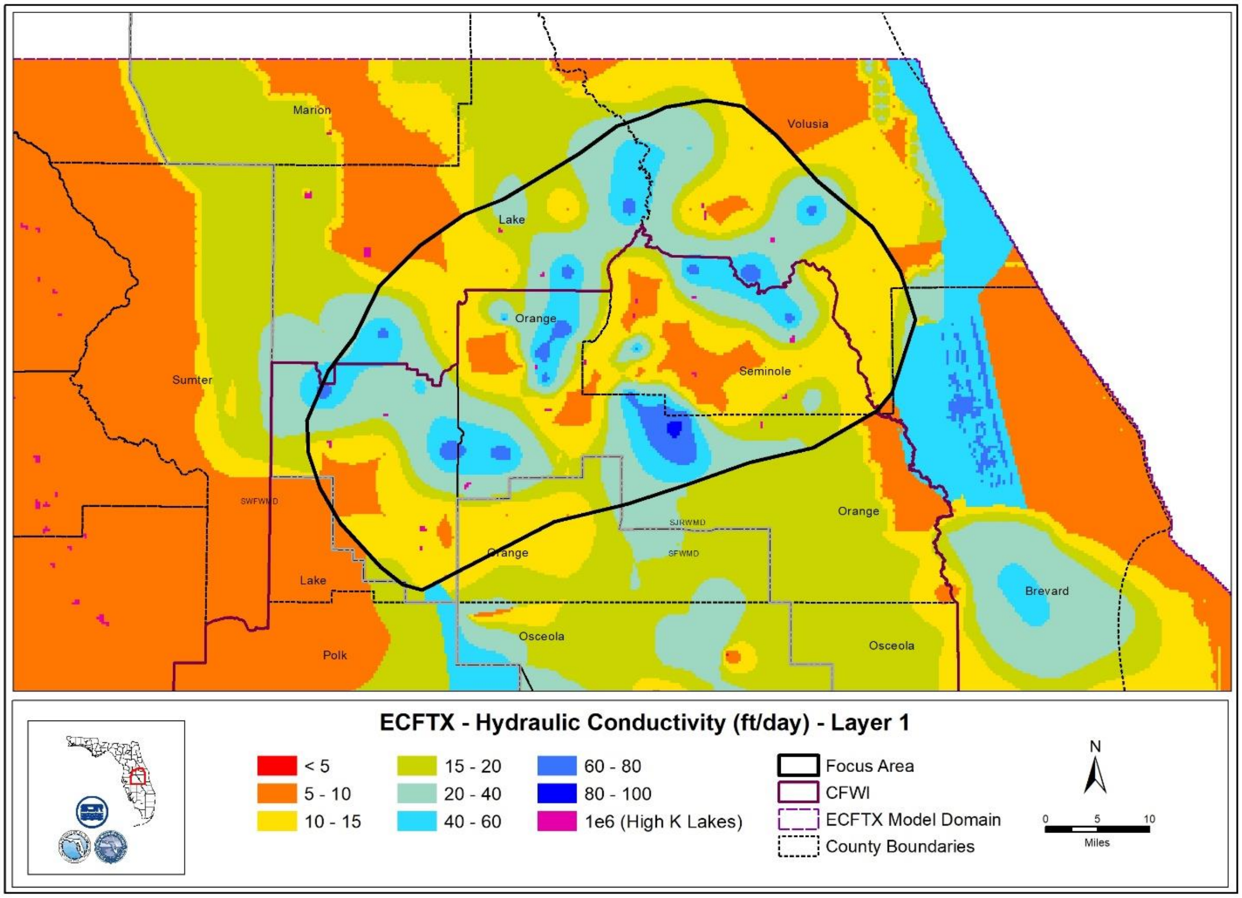


Figure 24. Hydraulic conductivity values for model layer 2 in the focus area.

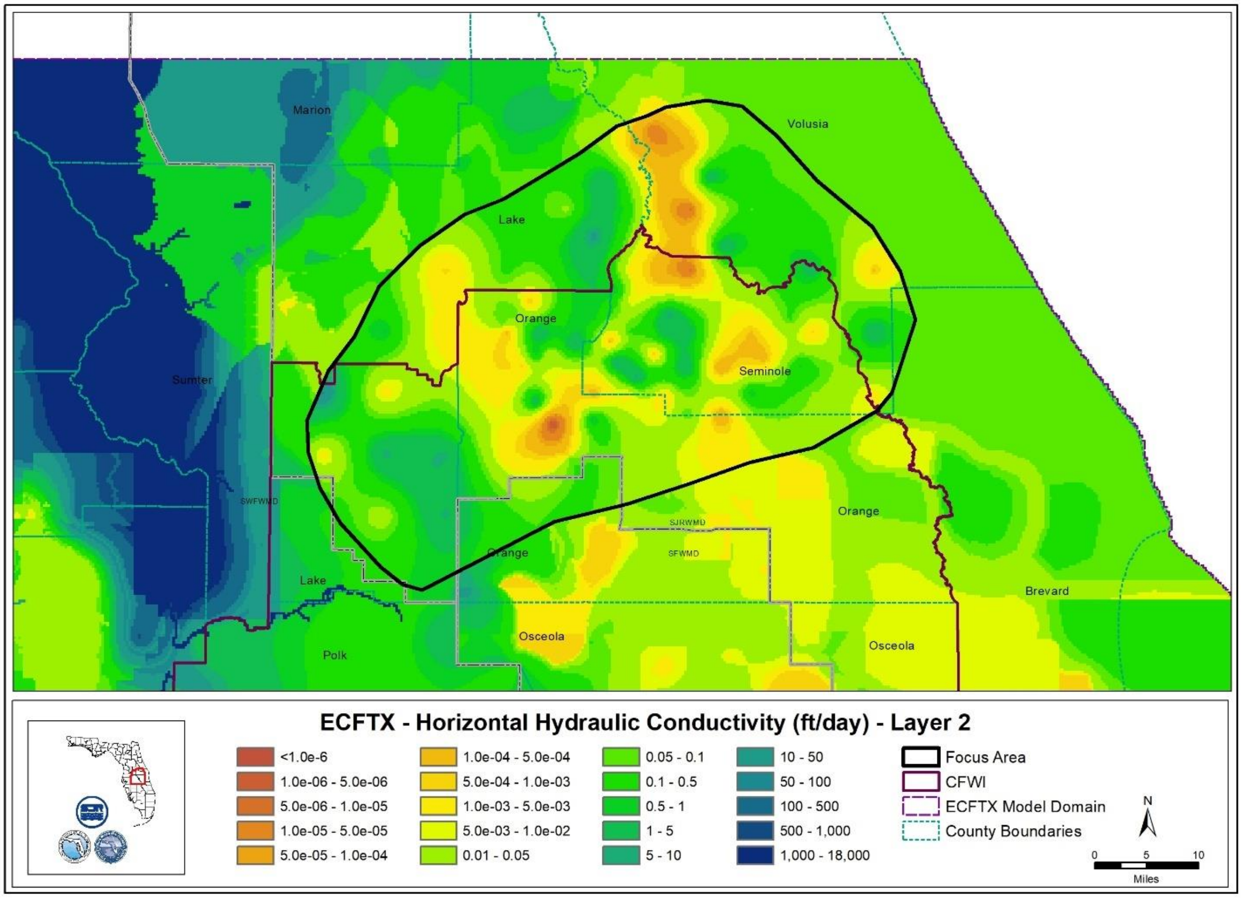


Figure 25. Leakance coefficient for model layer 2 in the focus area.

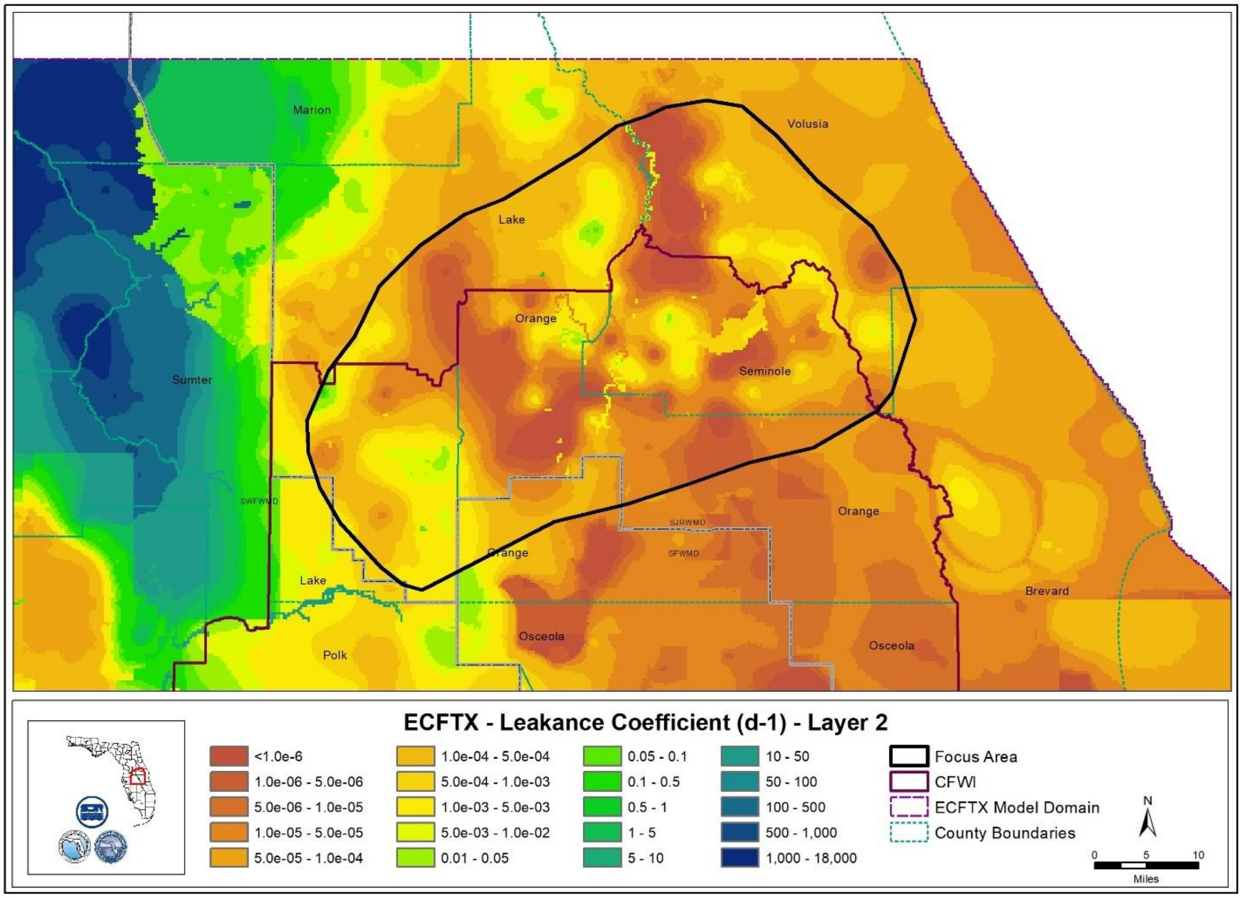


Figure 26. Hydraulic conductivity values for model layer 3 in the focus area.

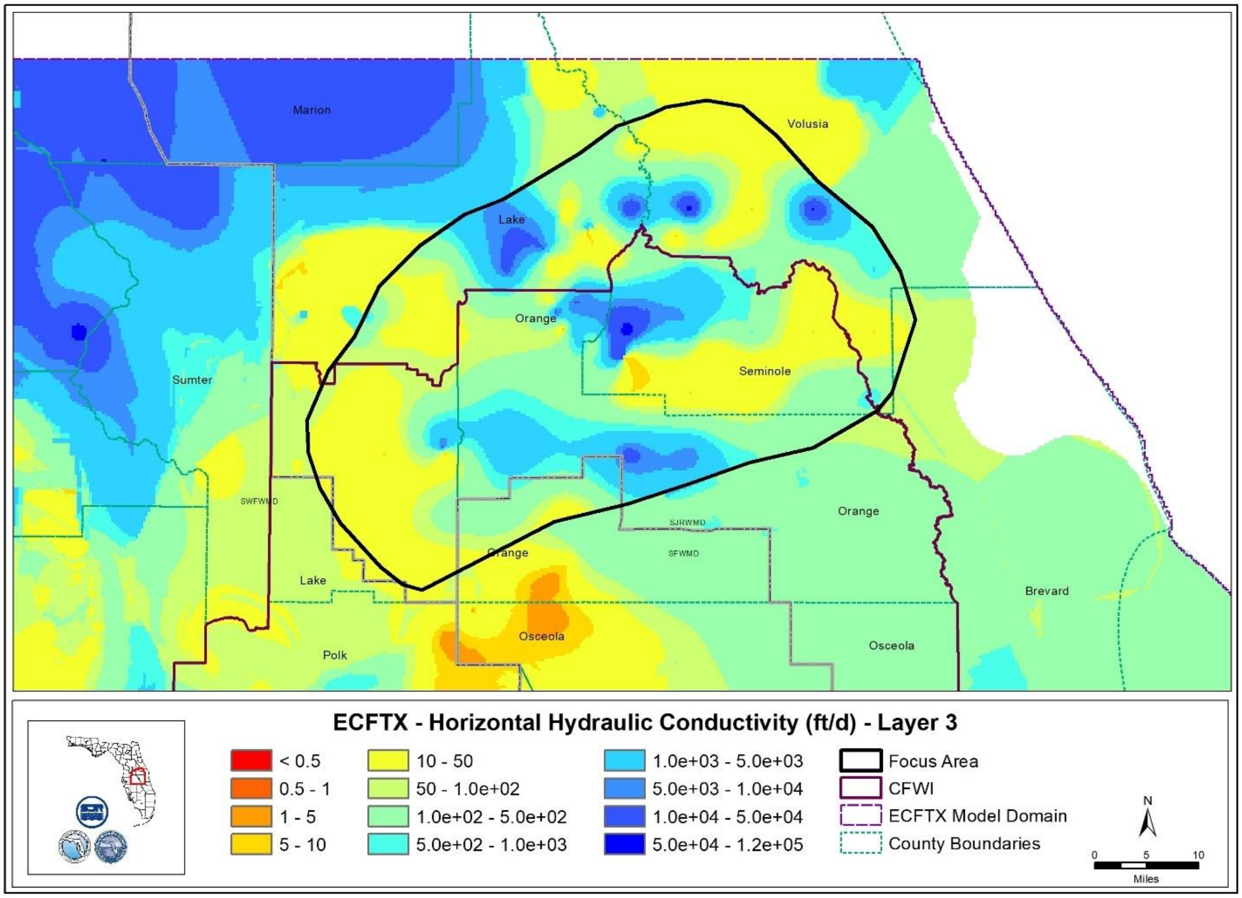


Figure 27. Hydraulic conductivity values for model layer 4 in the focus area.

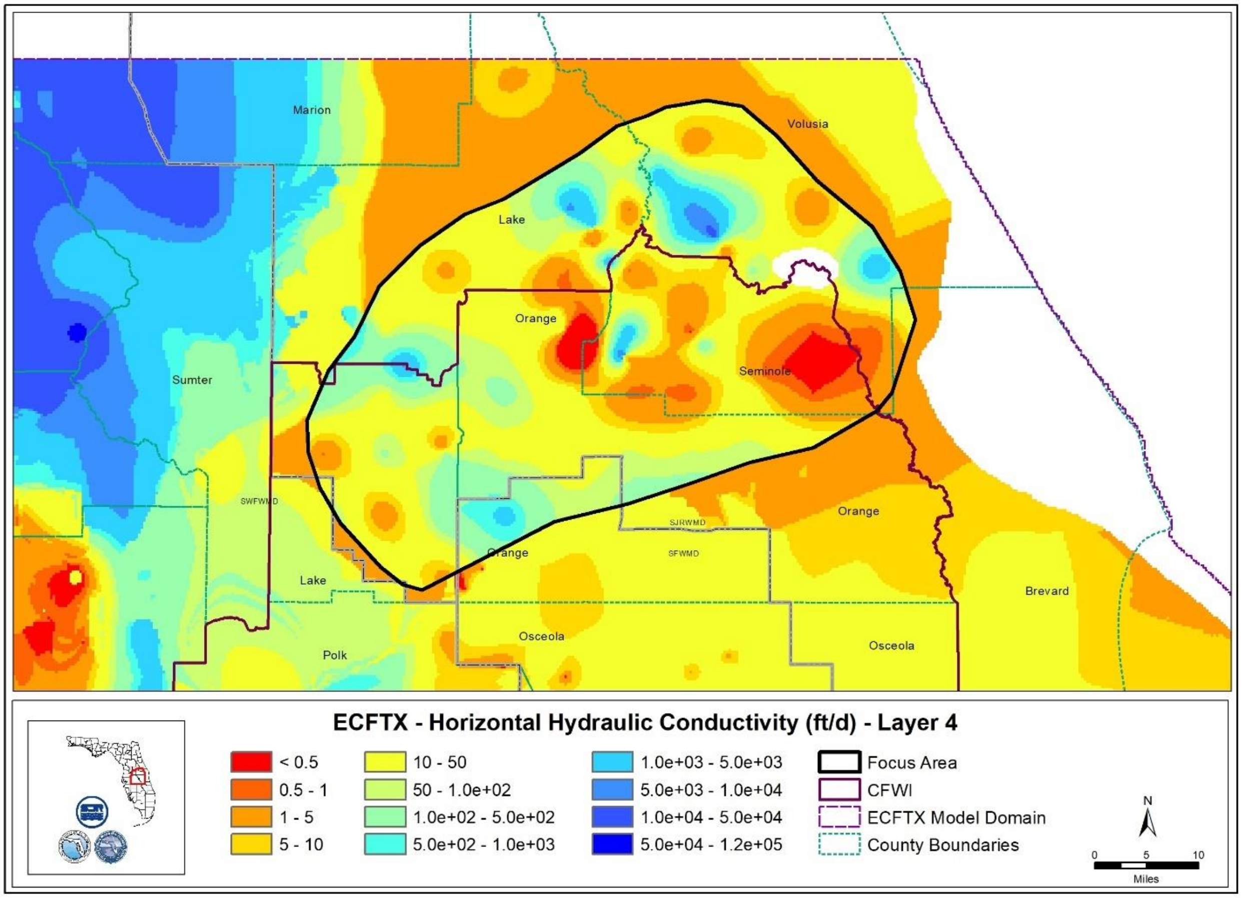


Figure 28. Hydraulic conductivity values for model layer 5 in the focus area.

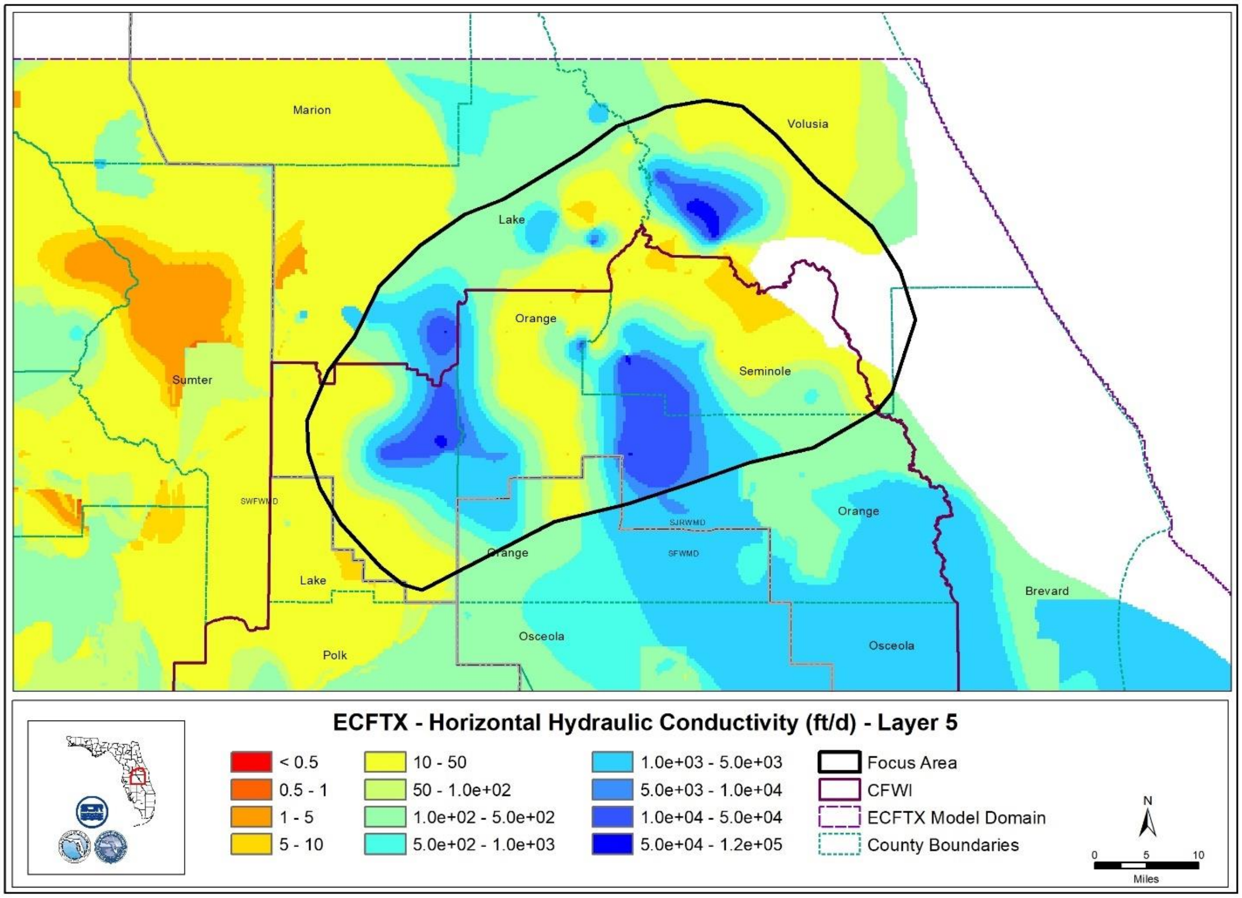


Figure 29. Hydraulic conductivity values for model layer 6 in the focus area.

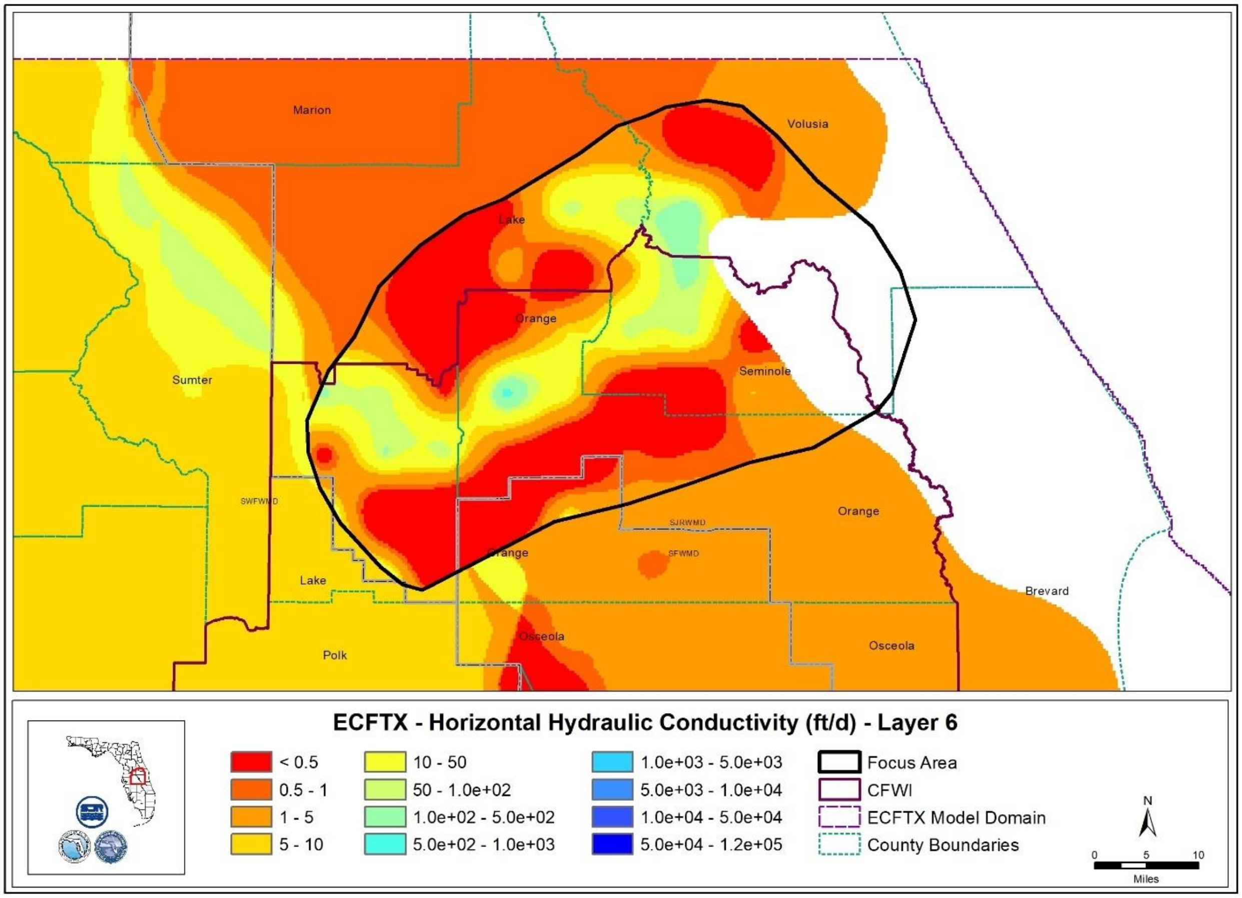


Figure 30. Leakance coefficient for model layer 6 in the focus area.

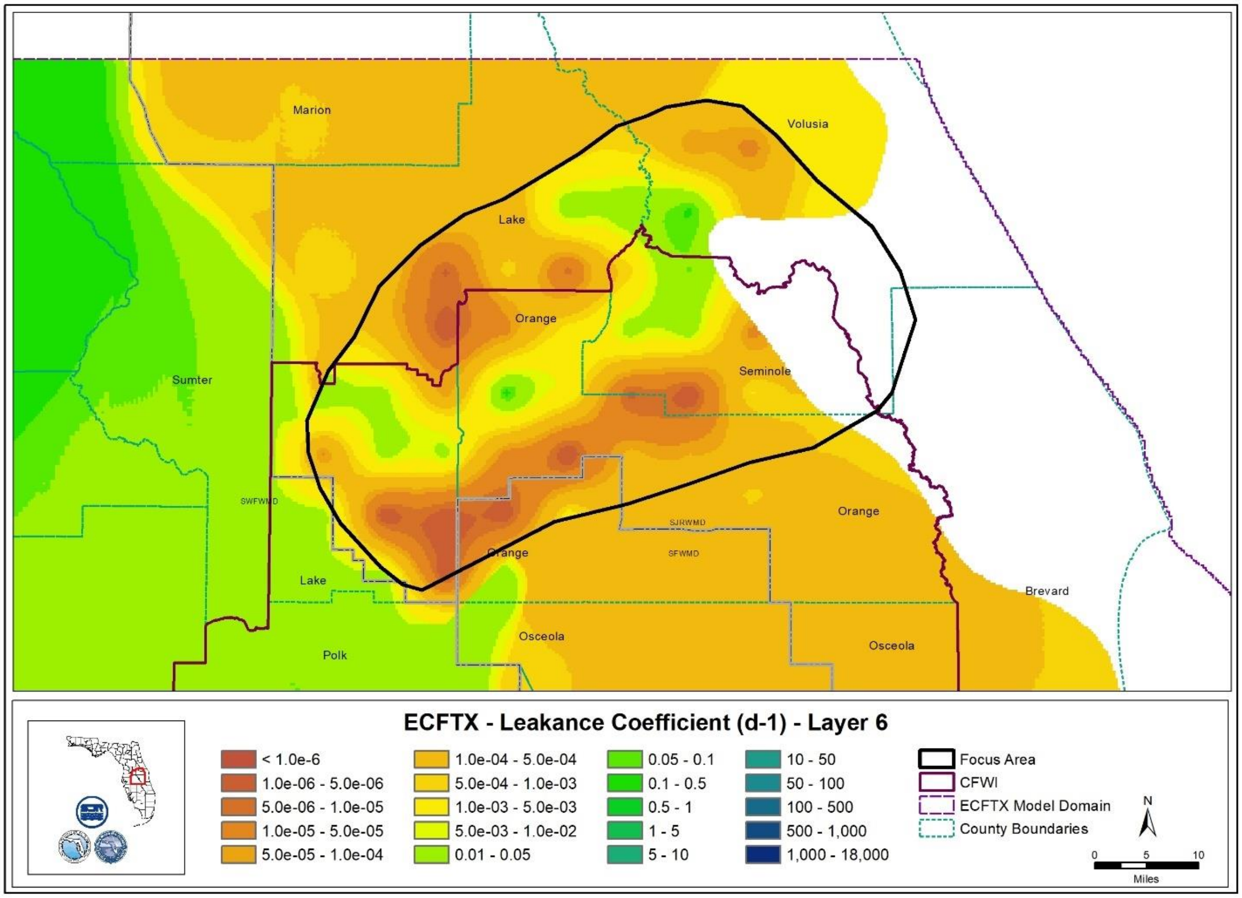


Figure 31. Hydraulic conductivity values for model layer 7 in the focus area.

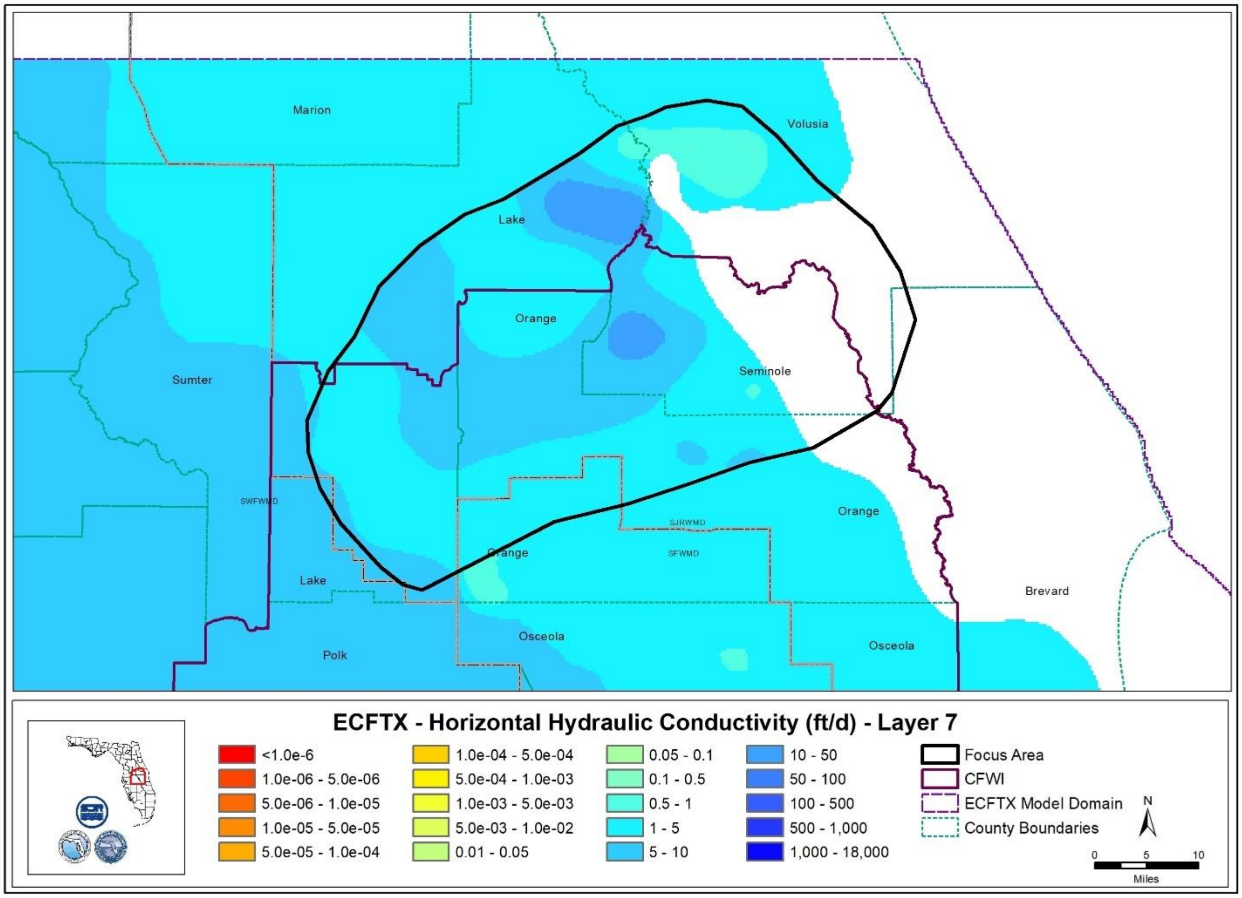


Figure 32. Hydraulic conductivity values for model layer 8 in the focus area.

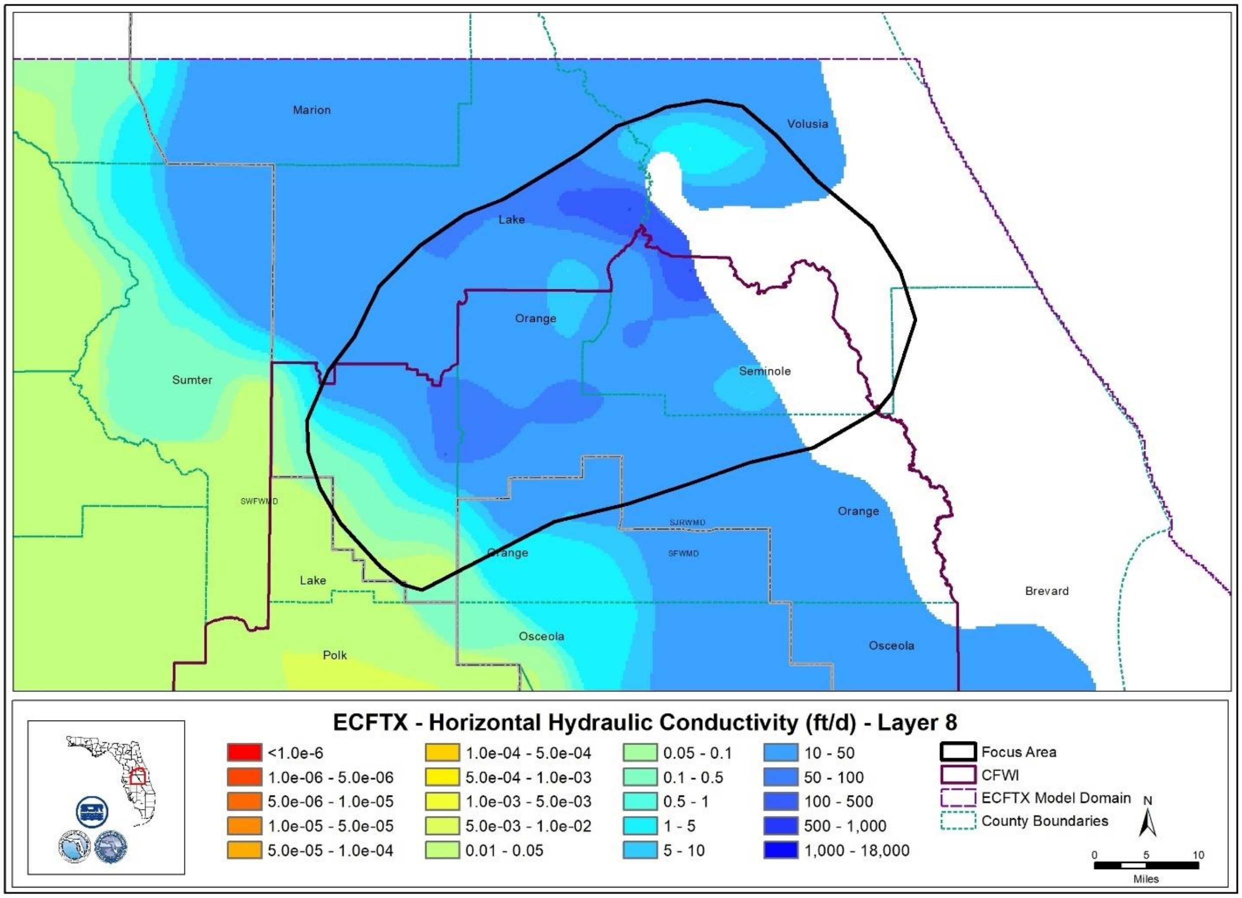


Figure 33. Leakance coefficient for model layer 8 in the focus area.

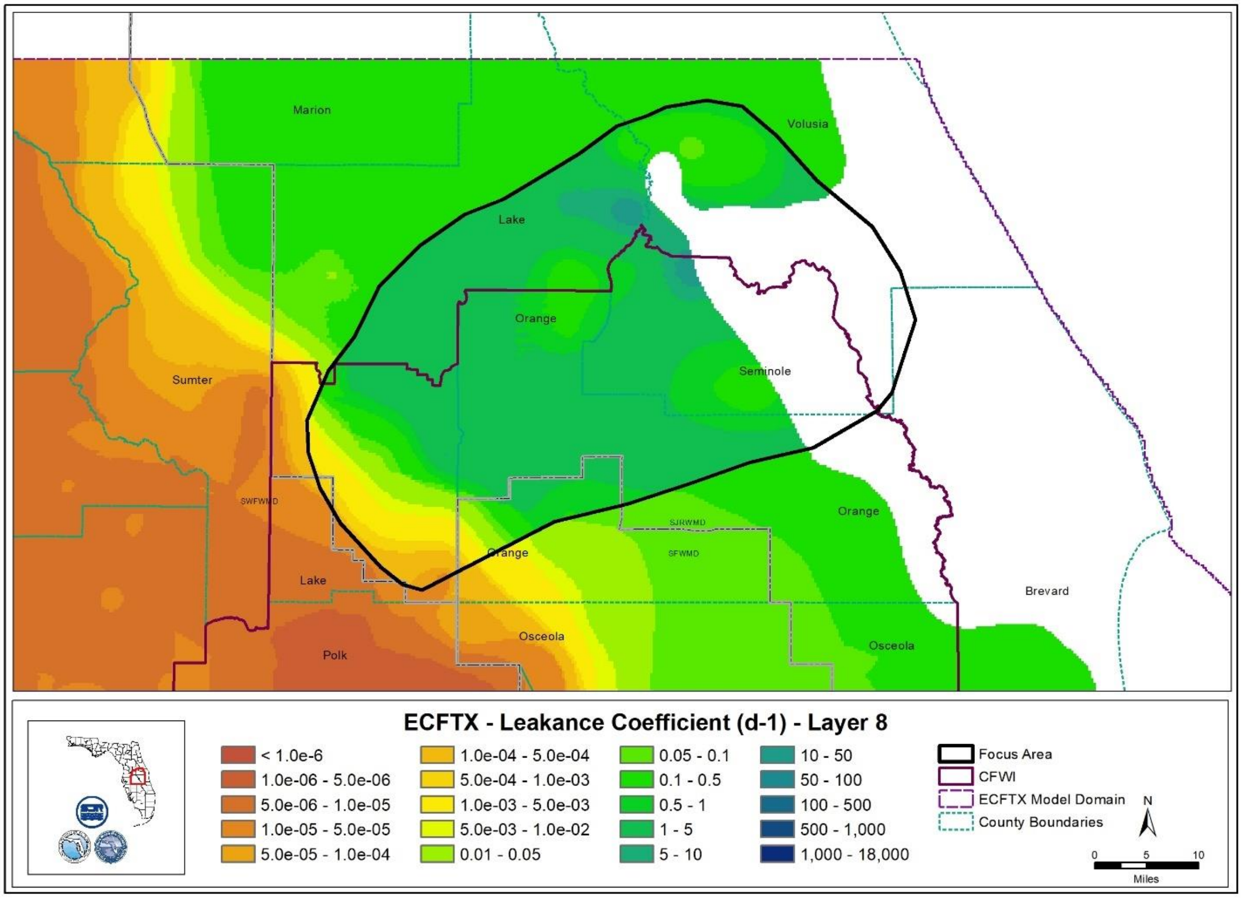


Figure 34. Hydraulic conductivity values for model layer 9 in the focus area.

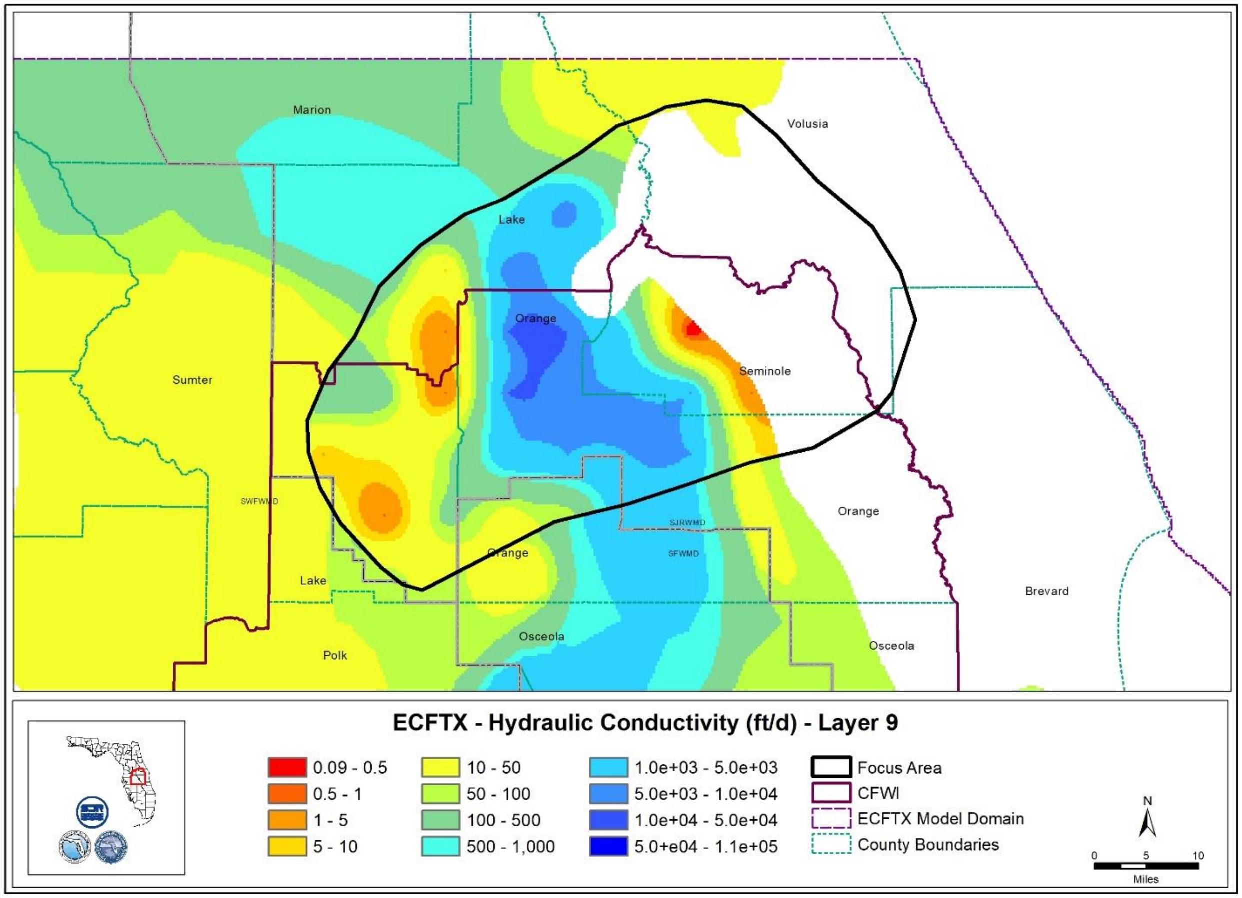


Figure 35. Hydraulic conductivity values for model layer 10 in the focus area.

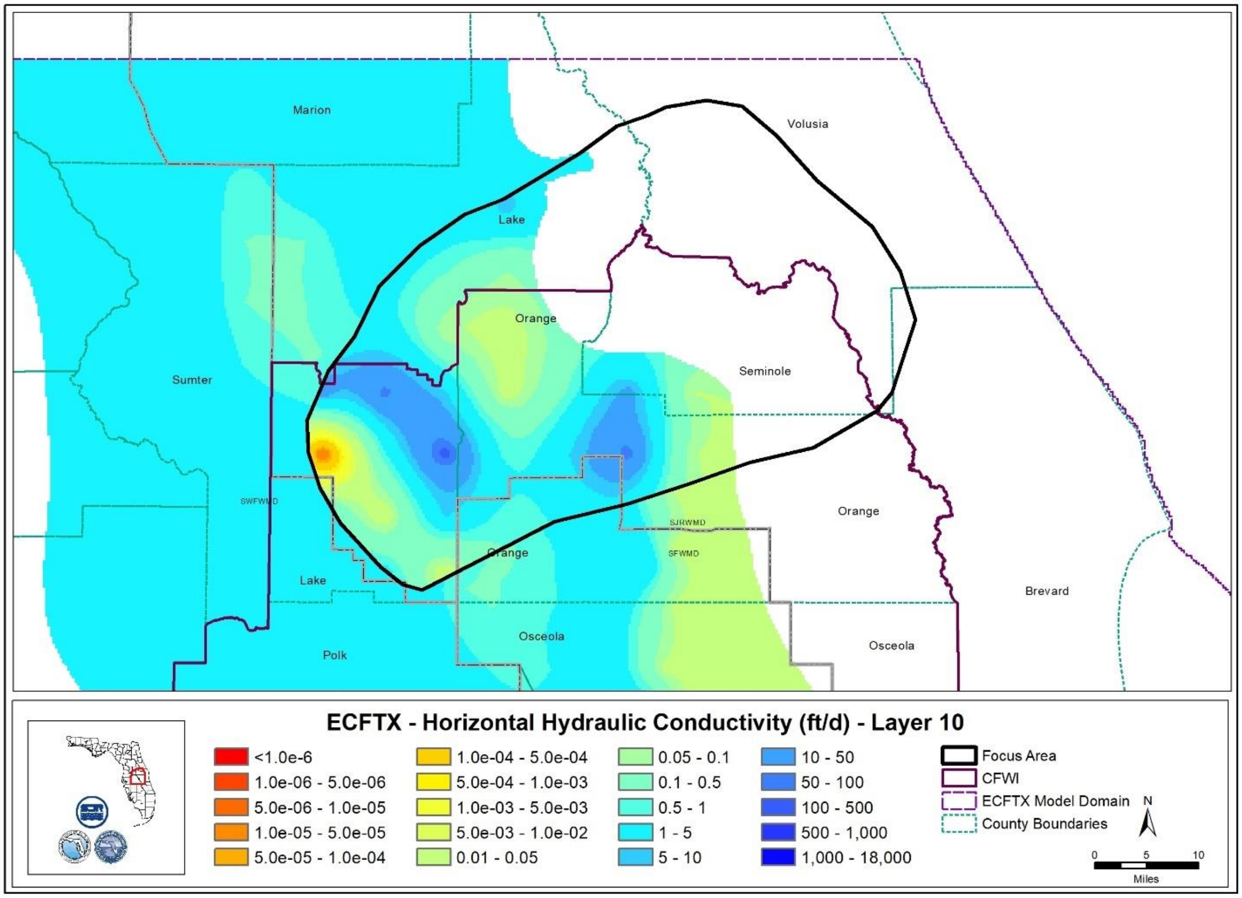


Figure 36. Leakance coefficient for model layer 10 in the focus area.

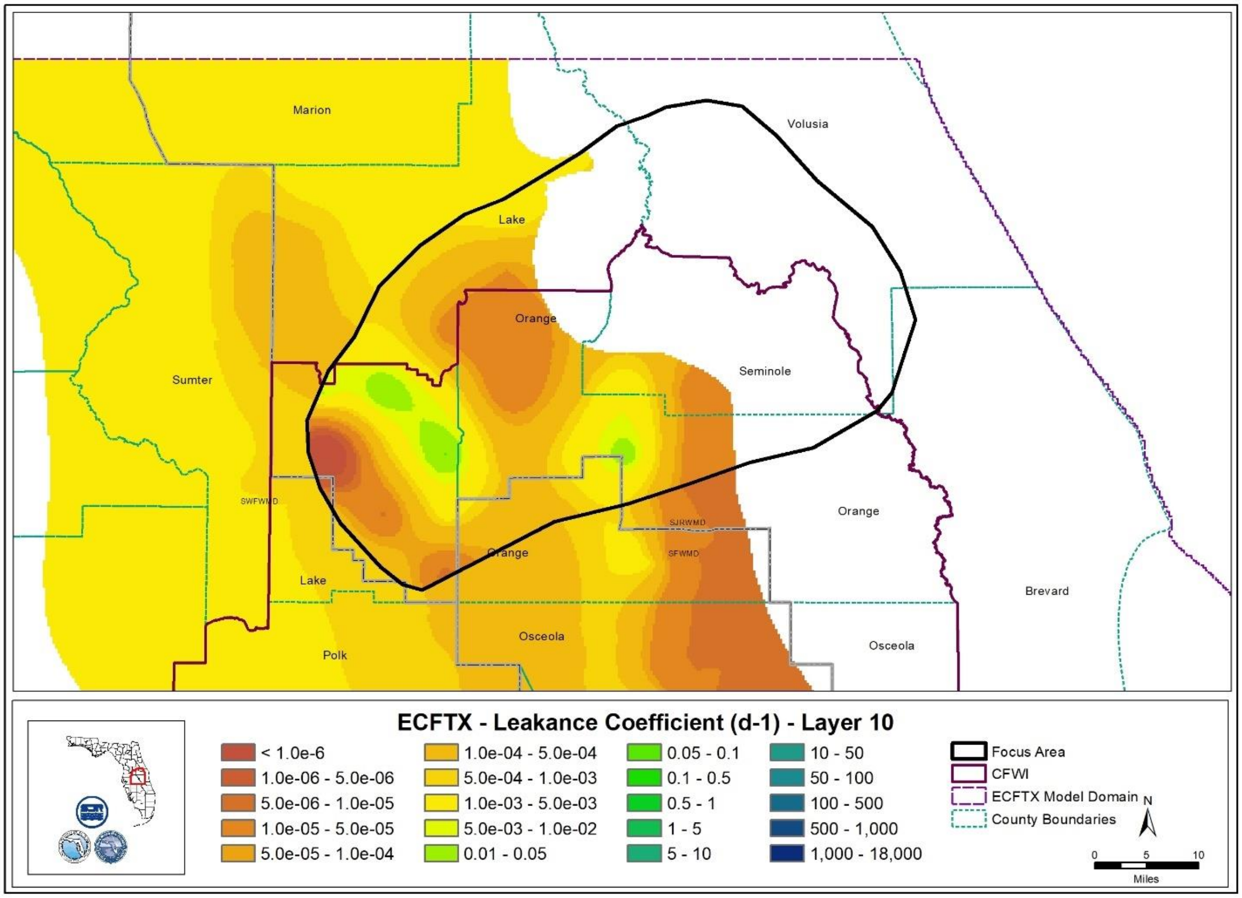
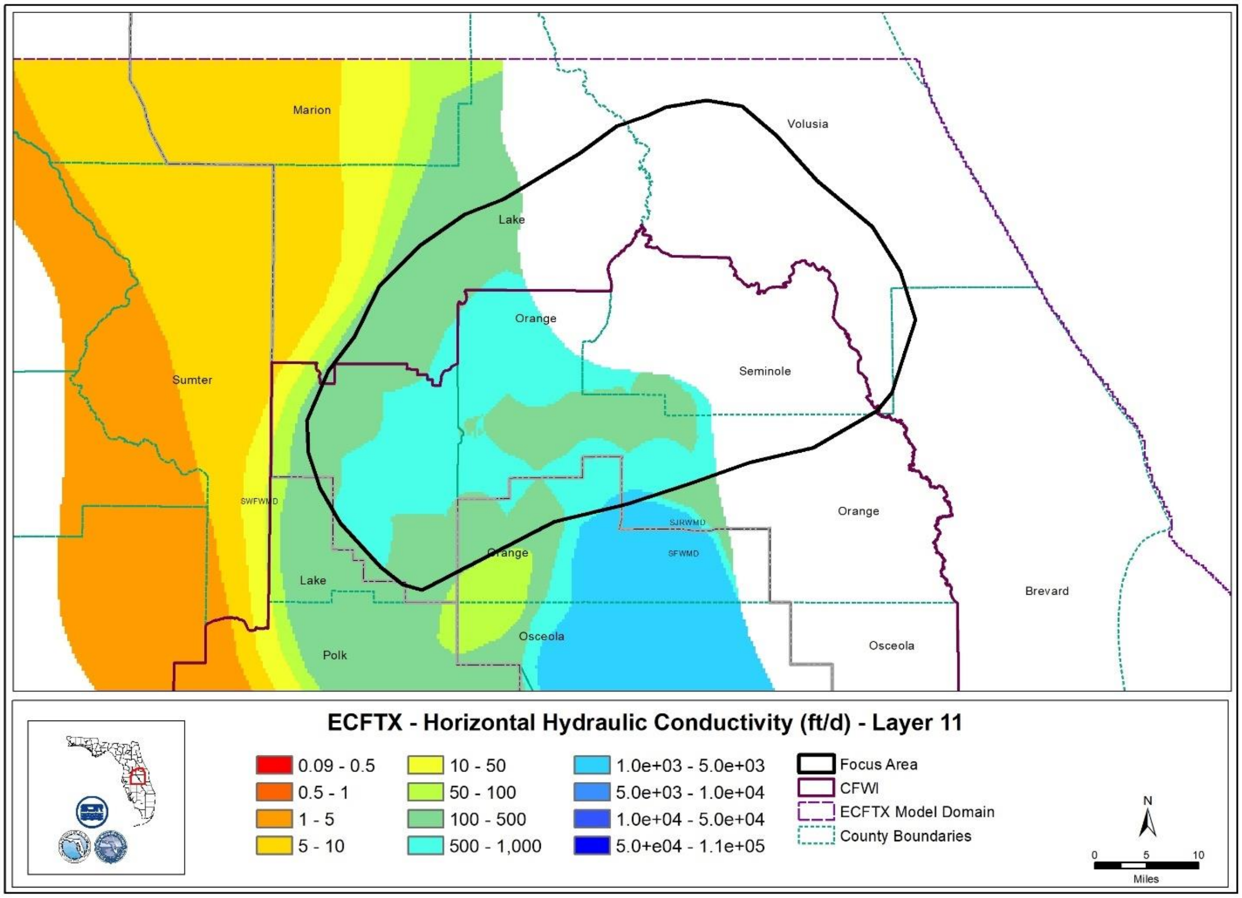


Figure 37. Hydraulic conductivity values for model layer 11 in the focus area.



Appendix E – Recharge Sensitivity Analysis

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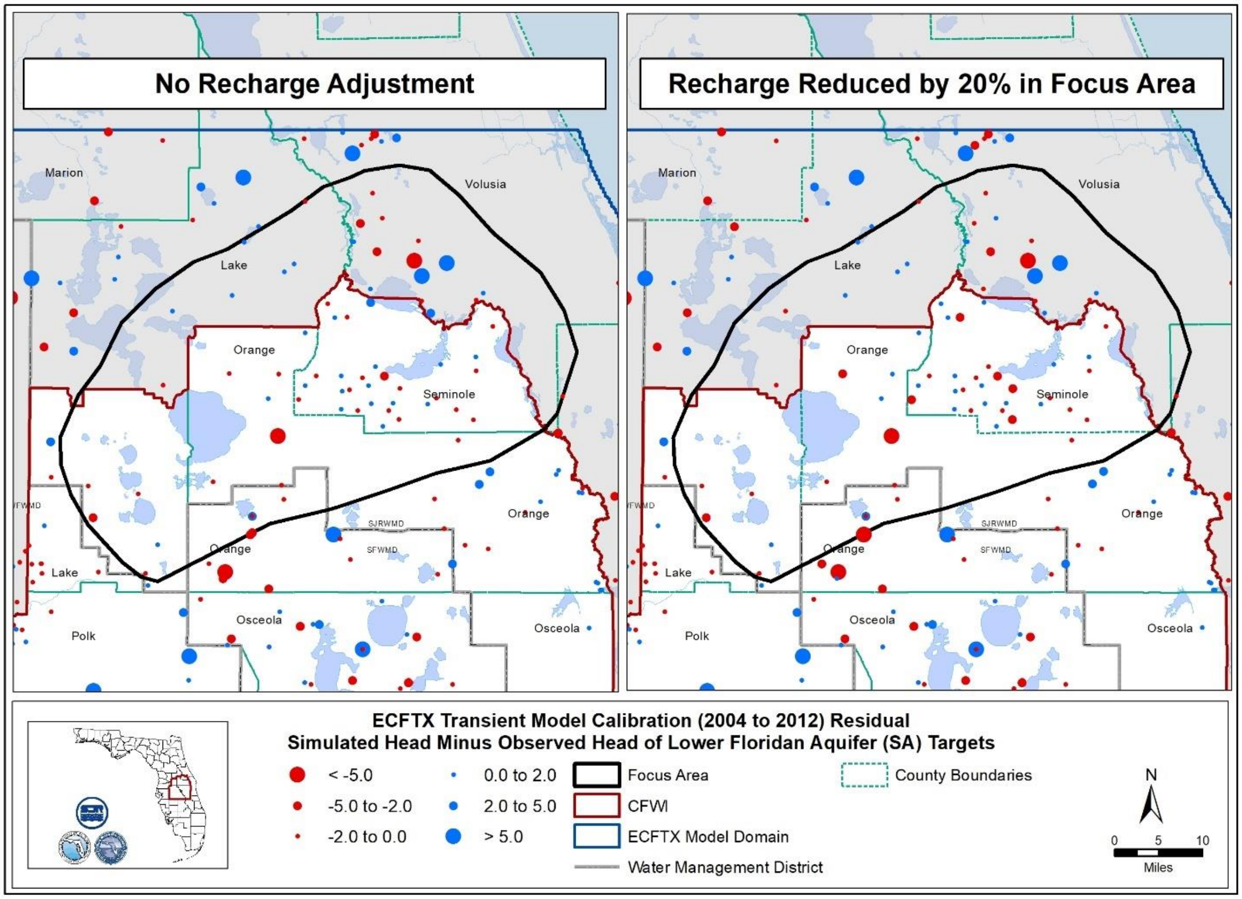


Figure 38. Spatial distribution of mean error for the SA targets within the focus area in the ECFTX transient recharge sensitivity simulation without any recharge rate adjustment (left) and with recharge adjustment (right).

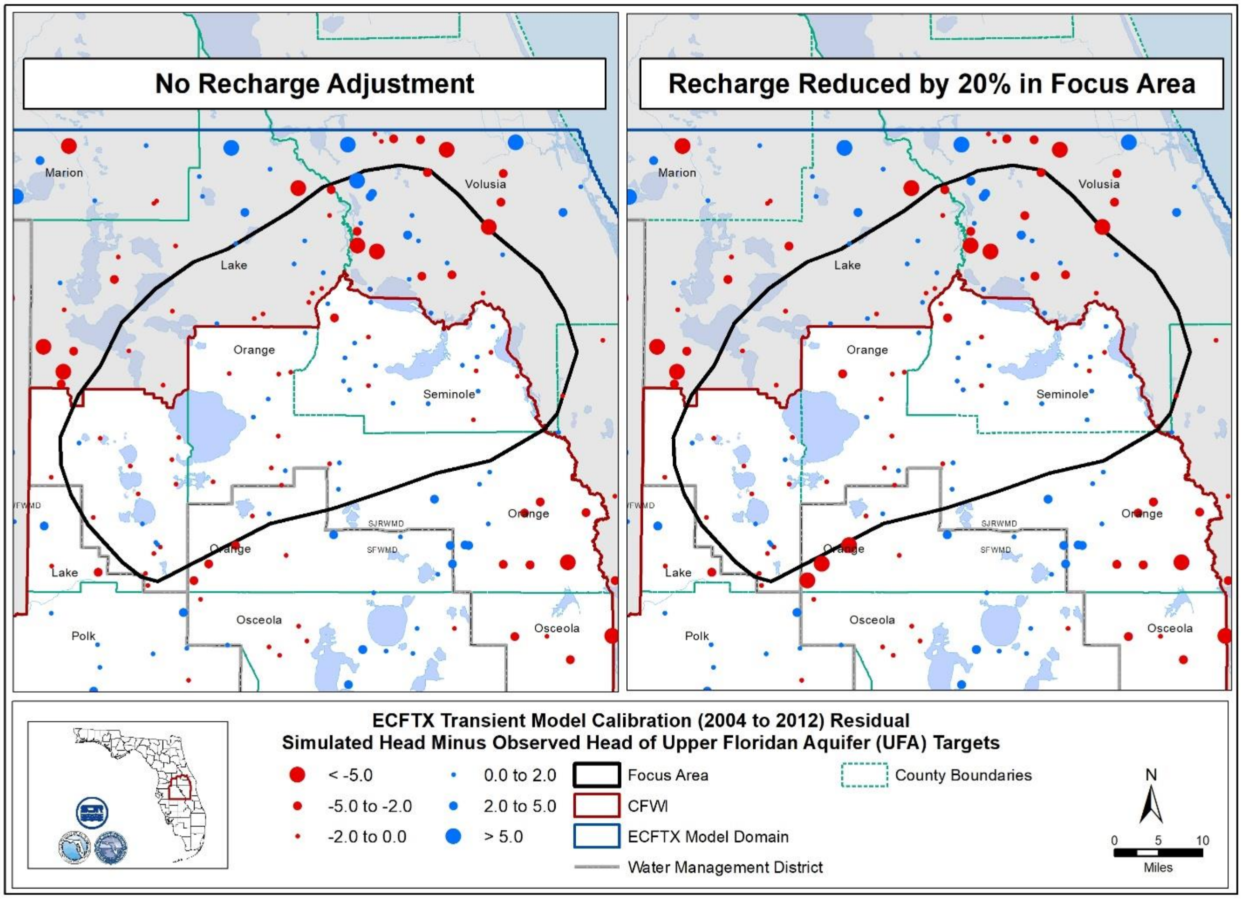


Figure 39. Spatial distribution of mean error for the UFA targets within the focus area in the ECFTX transient recharge sensitivity simulation without any recharge rate adjustment (left) and with recharge adjustment (right).

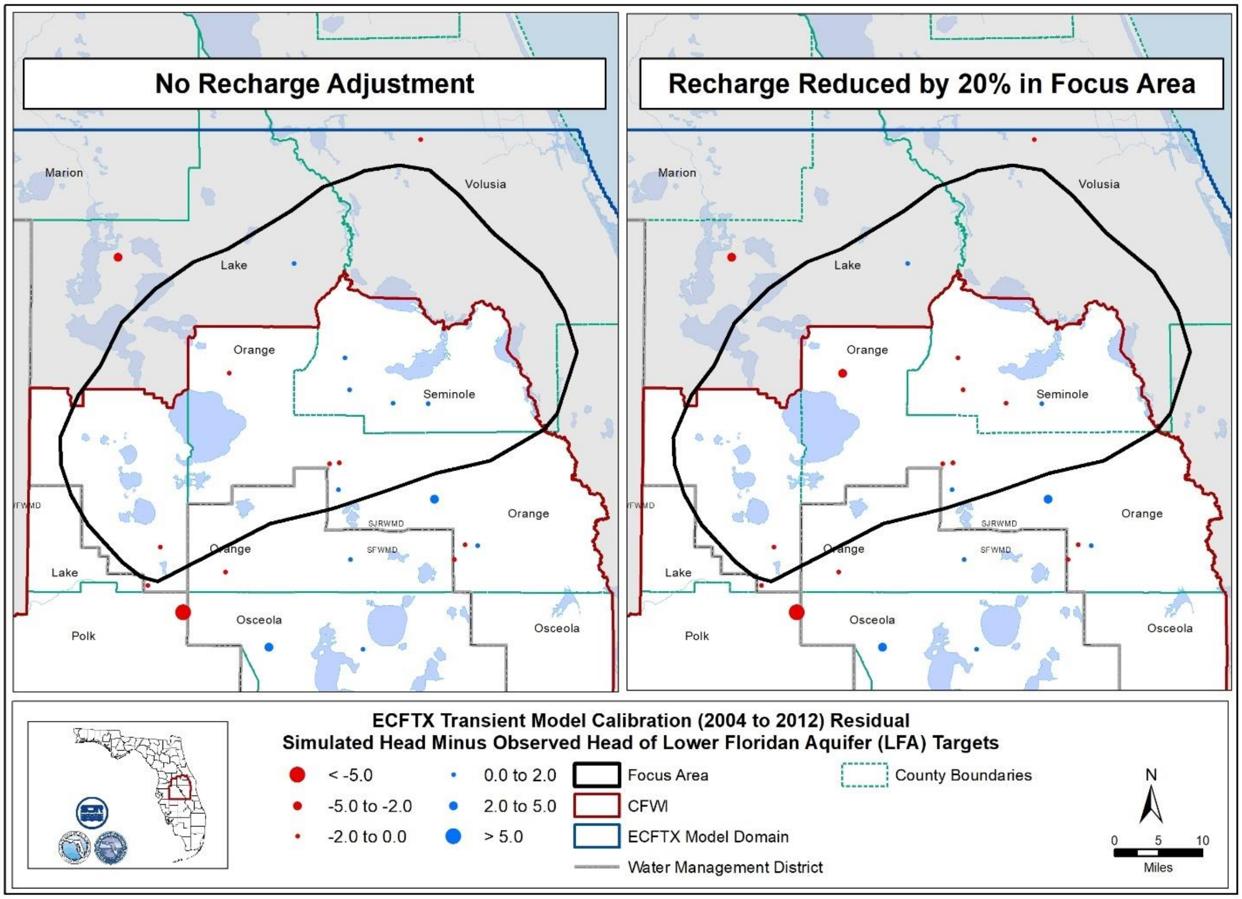


Figure 40. Spatial distribution of mean error for the LFA targets within the focus area in the ECFTX transient recharge sensitivity simulation without any recharge rate adjustment (left) and with recharge reduced in the focus area (right).

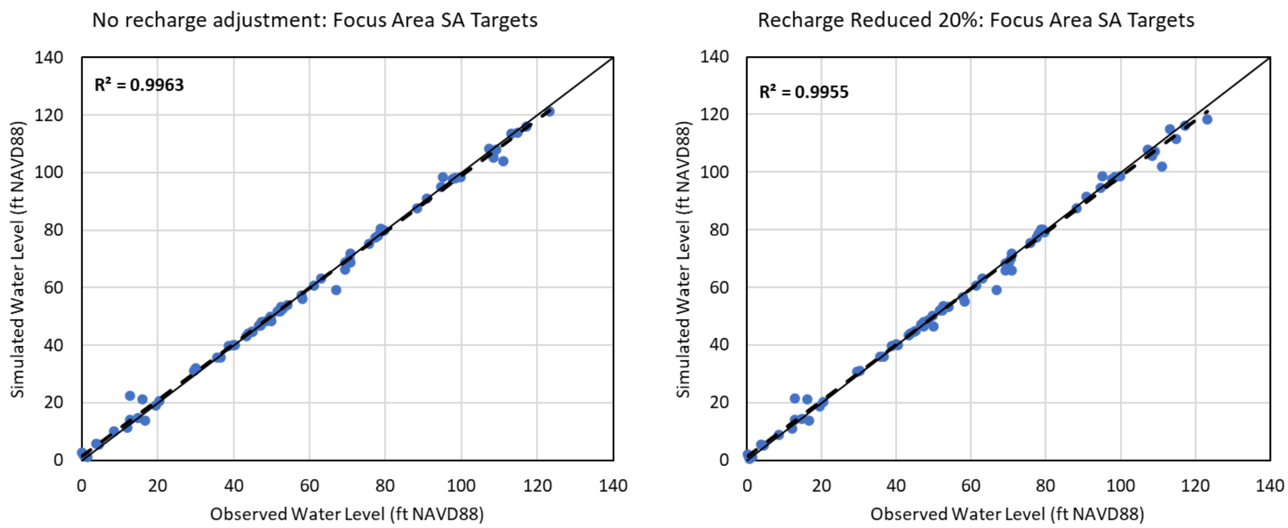


Figure 41. Mean simulated versus observed water levels for the SA within the focus area for simulation without recharge adjustment (left) and with recharge reduced in the focus area (right). (Note: Solid line is 1:1 relation between simulated and observed water levels; dashed line is linear regression of simulated versus observed water levels from target wells)

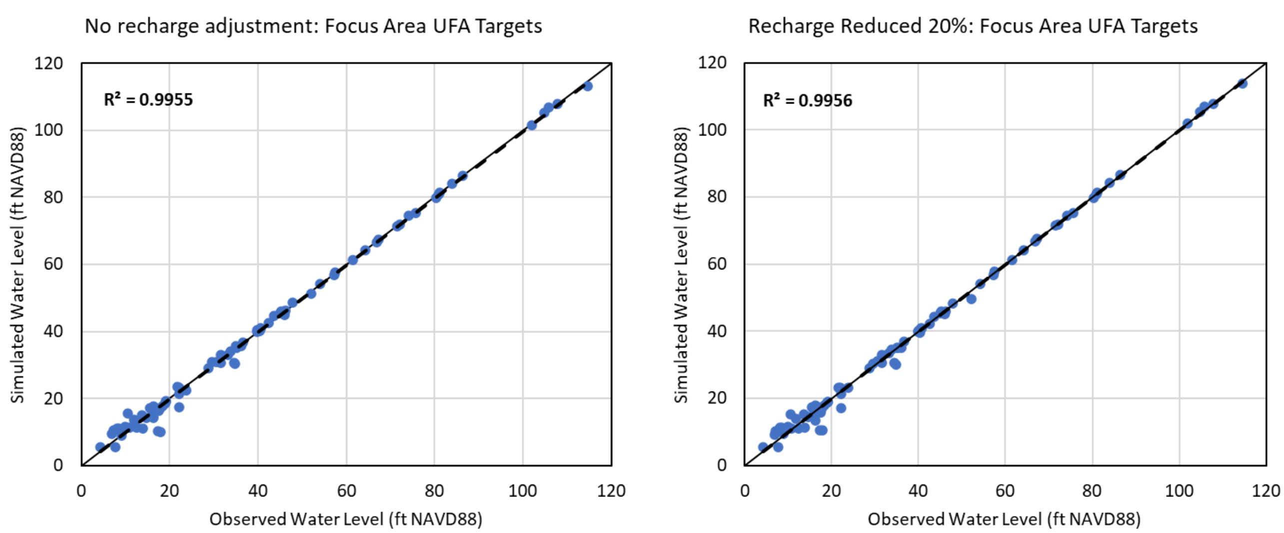


Figure 42. Mean simulated versus observed water levels for the UFA within the focus area for simulation without recharge adjustment (left) and with recharge reduced in the focus area (right). (Note: Solid line is 1:1 relation between simulated and observed water levels; dashed line is linear regression of simulated versus observed water levels from target wells)

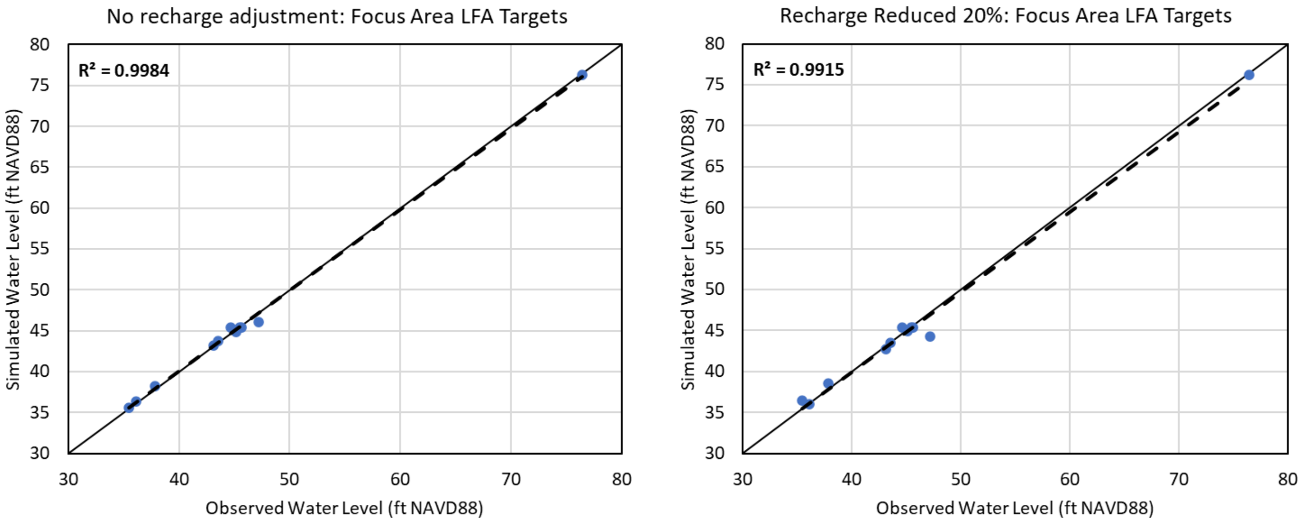
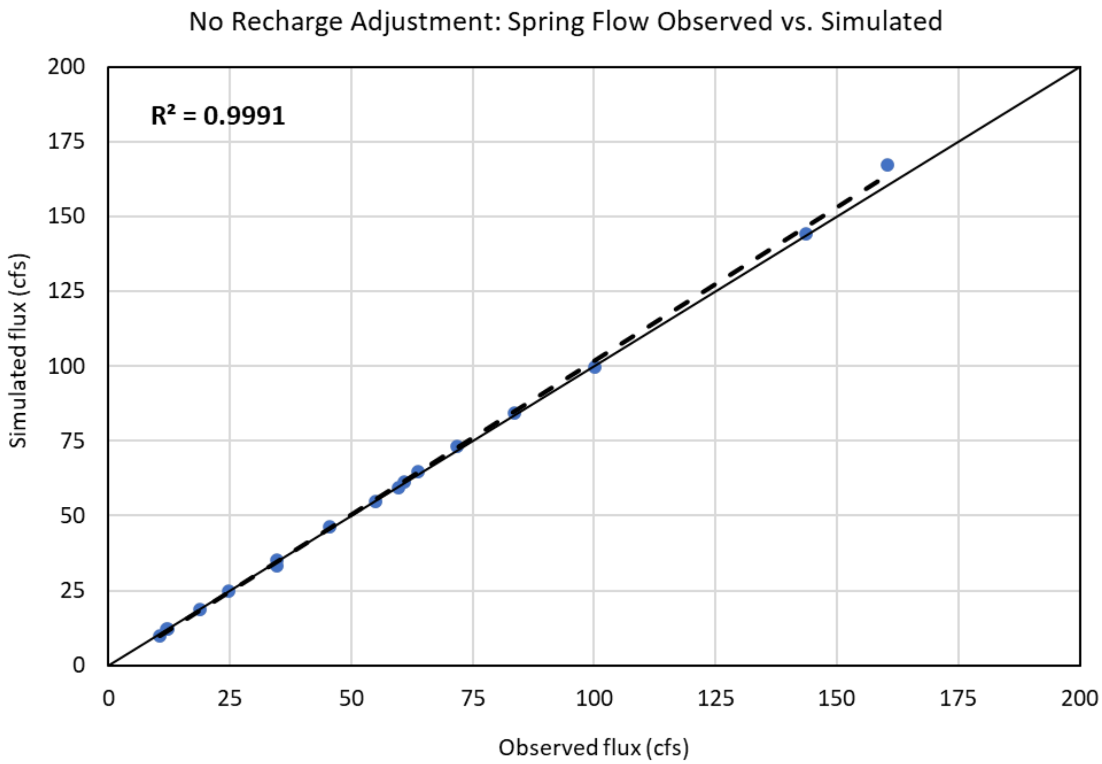


Figure 43. Mean simulated versus observed water levels for the LFA within the focus area for simulation without recharge adjustment (left) and with recharge reduced in the focus area (right). (Note: Solid line is 1:1 relation between simulated and observed water levels; dashed line is linear regression of simulated versus observed water levels from target wells)


No Recharge Adjustment: Spring Flow Observed vs. Simulated
R² = 0.9991
Simulated flux (cfs)
Observed flux (cfs)
0
25
50
75
100
125
150
175
200

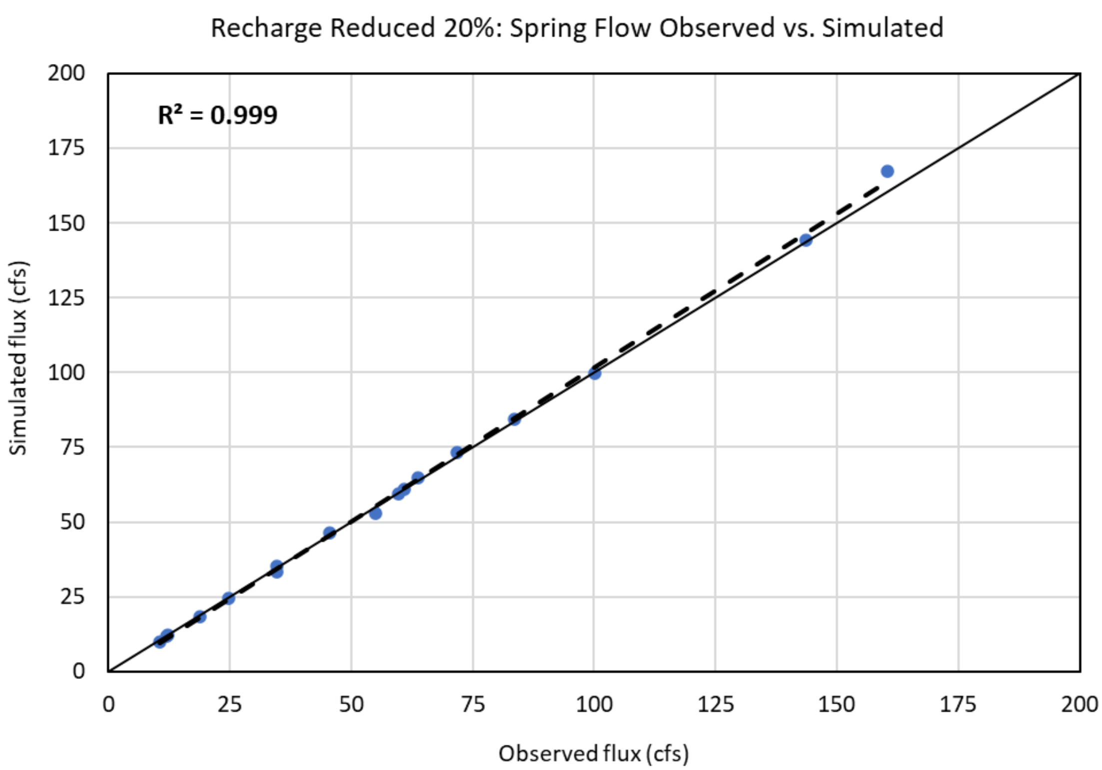

Recharge Reduced 20%: Spring Flow Observed vs. Simulated
R² = 0.999
Simulated flux (cfs)
Observed flux (cfs)
0
25
50
75
100
125
150
175
200

Figure 44. Mean simulated versus observed flow for magnitude 1 and 2 springs within the ECFTX model domain for simulation without recharge adjustment (top) and with recharge reduced in the focus area (bottom). (Note: Solid line is 1:1 relation between simulated and observed head differences; dashed line is linear regression of simulated versus observed head differences).

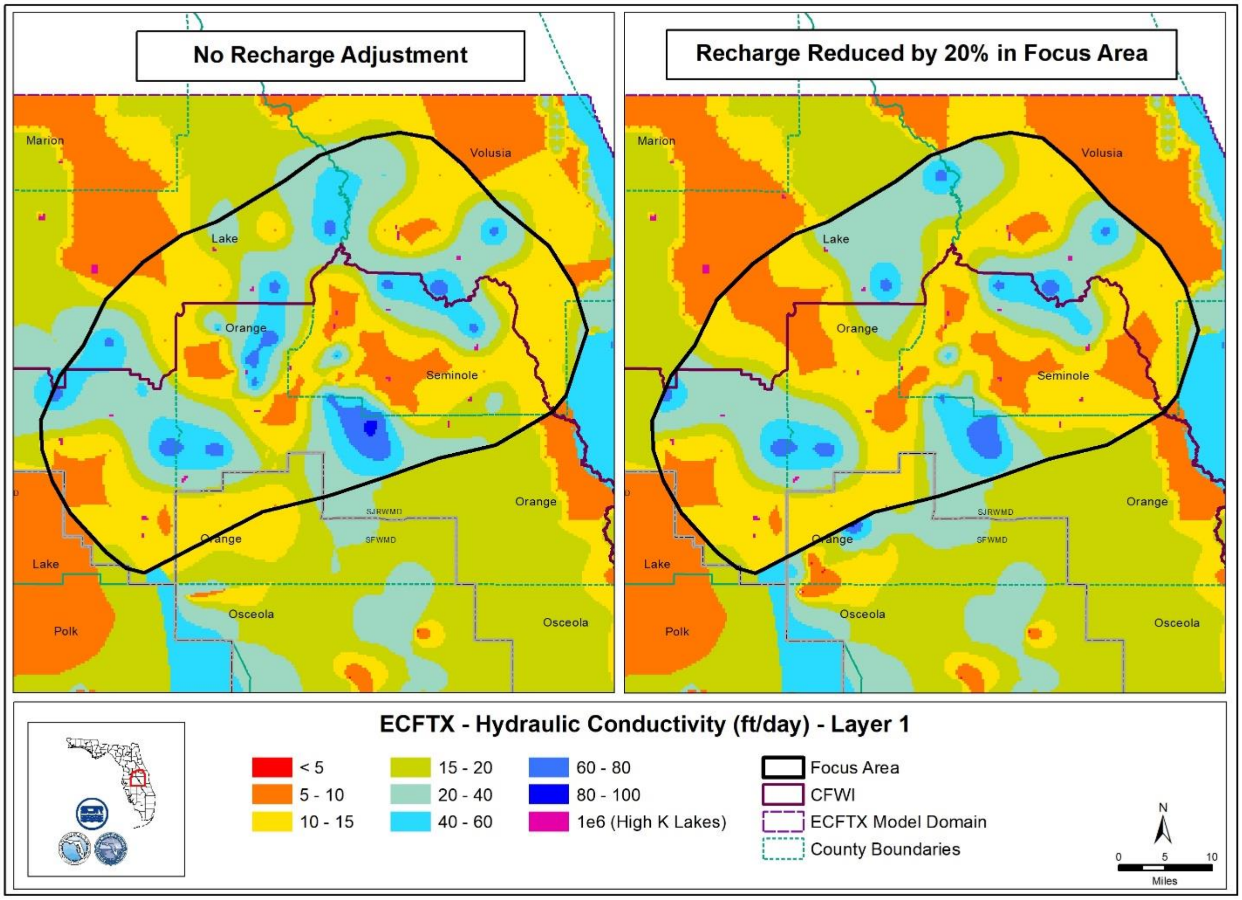


Figure 45. Hydraulic conductivity values in layer 1 in the focus area for ECFTX transient simulation without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

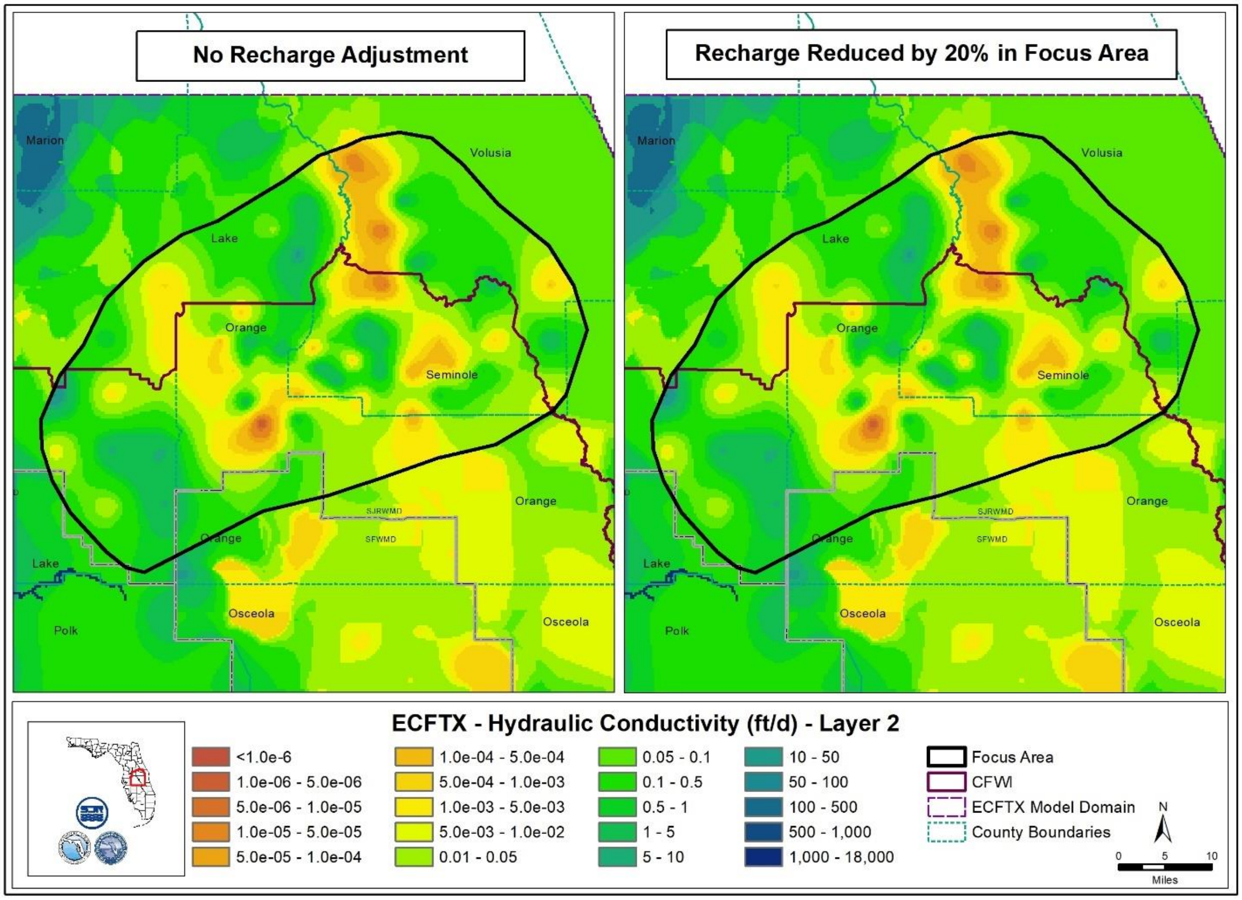


Figure 46. Horizontal hydraulic conductivity values for model layer 2 in the focus area without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

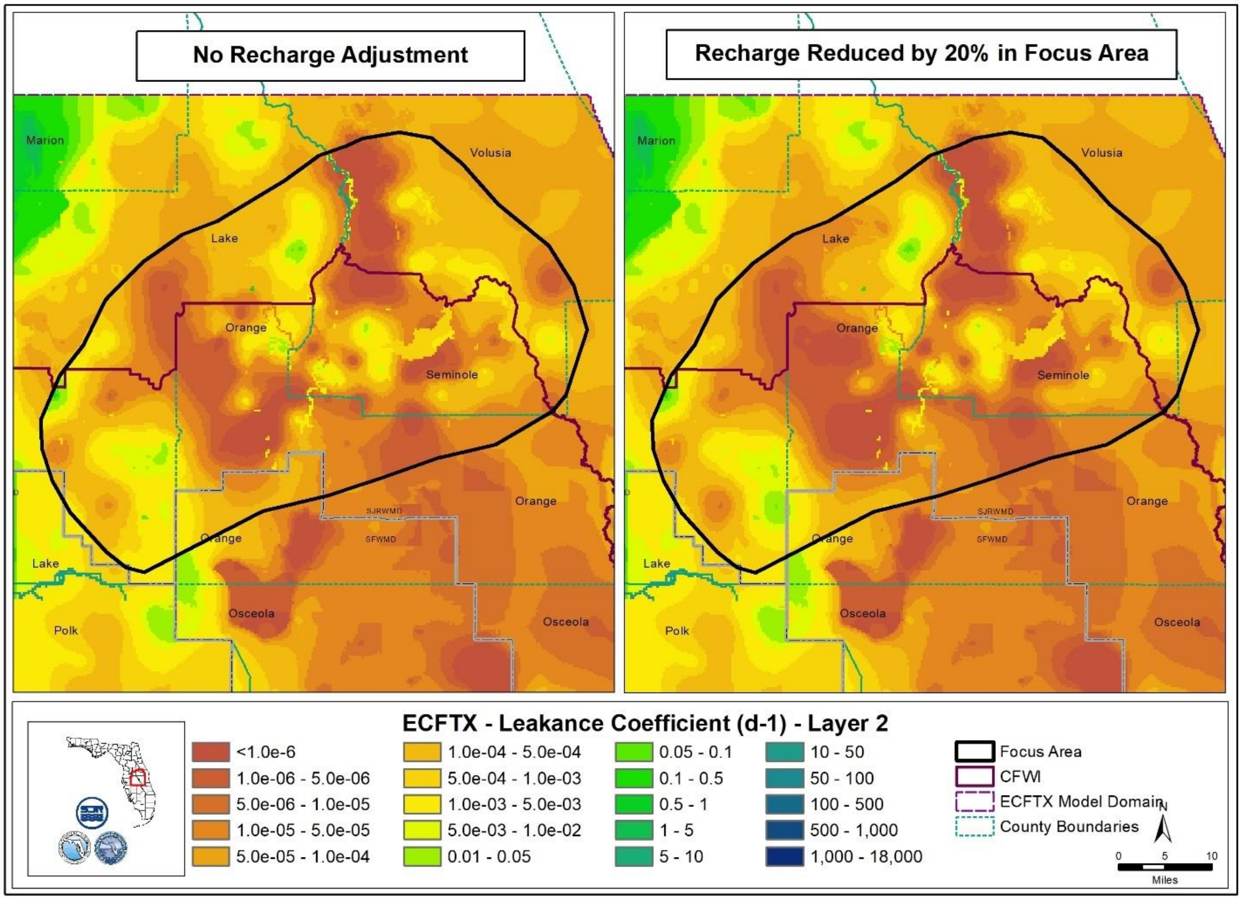


Figure 47. Leakance coefficient distribution in model layer 2 without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

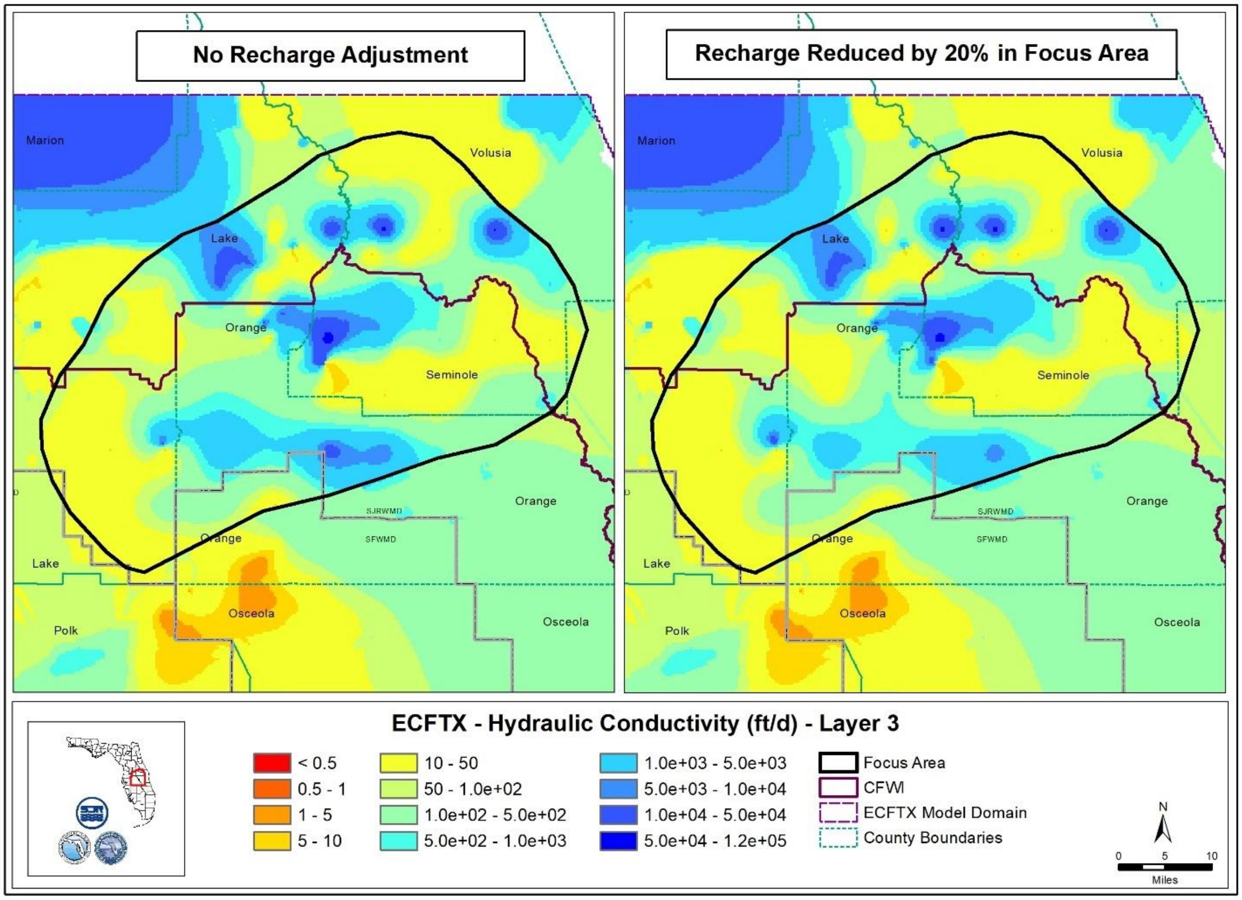


Figure 48. Horizontal hydraulic conductivity values for model layer 3 in the focus area without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

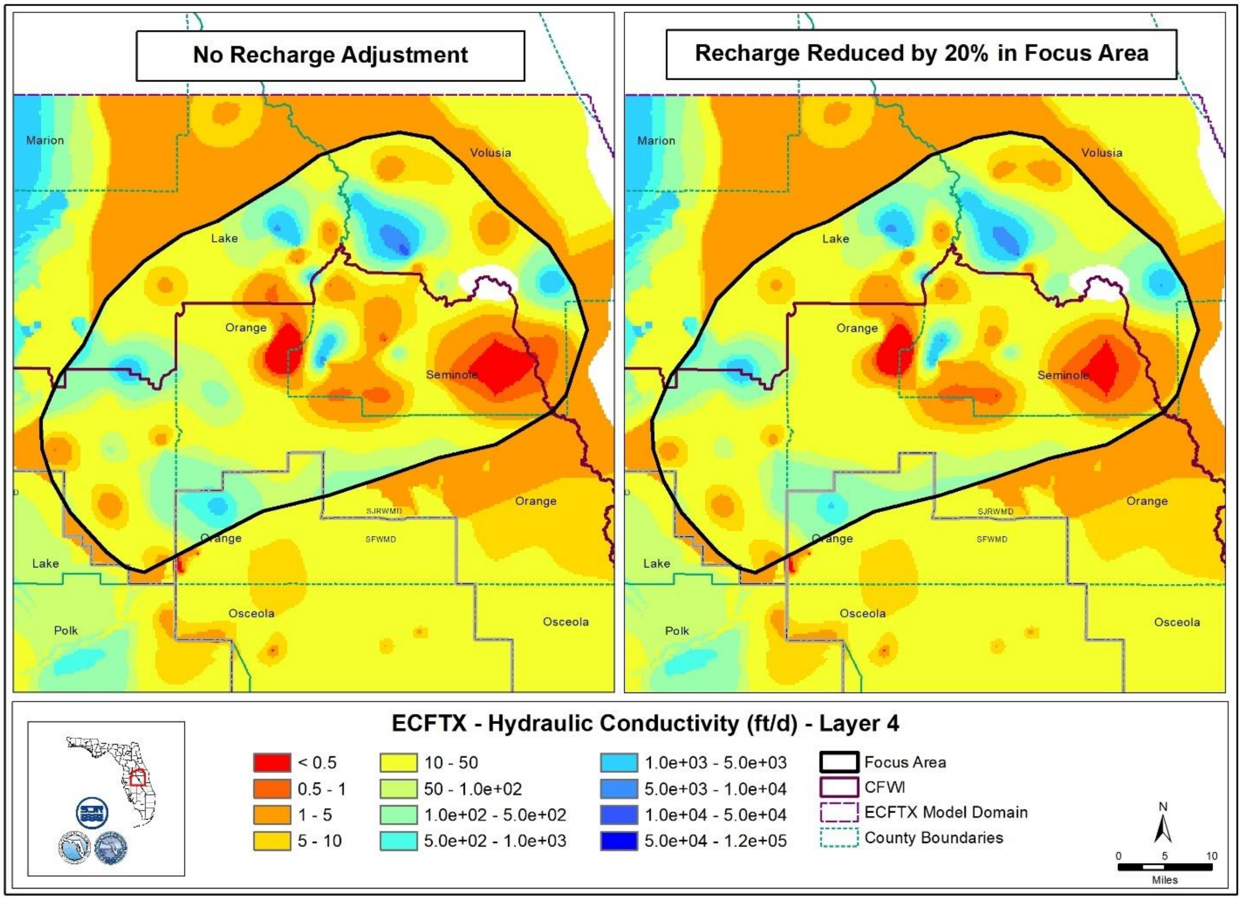


Figure 49. Horizontal hydraulic conductivity values for model layer 4 in the focus area without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

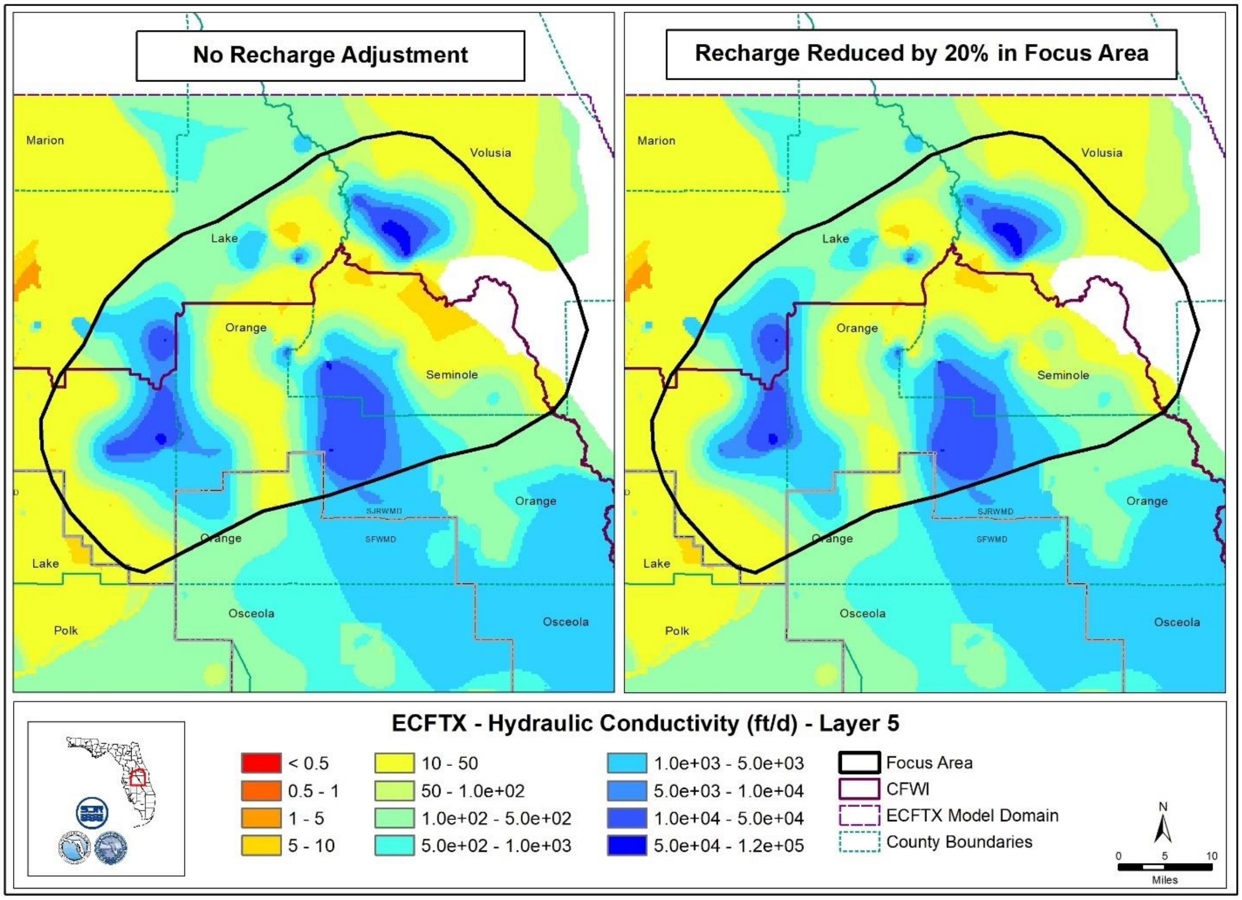


Figure 50. Horizontal hydraulic conductivity values for model layer 5 in the focus area without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

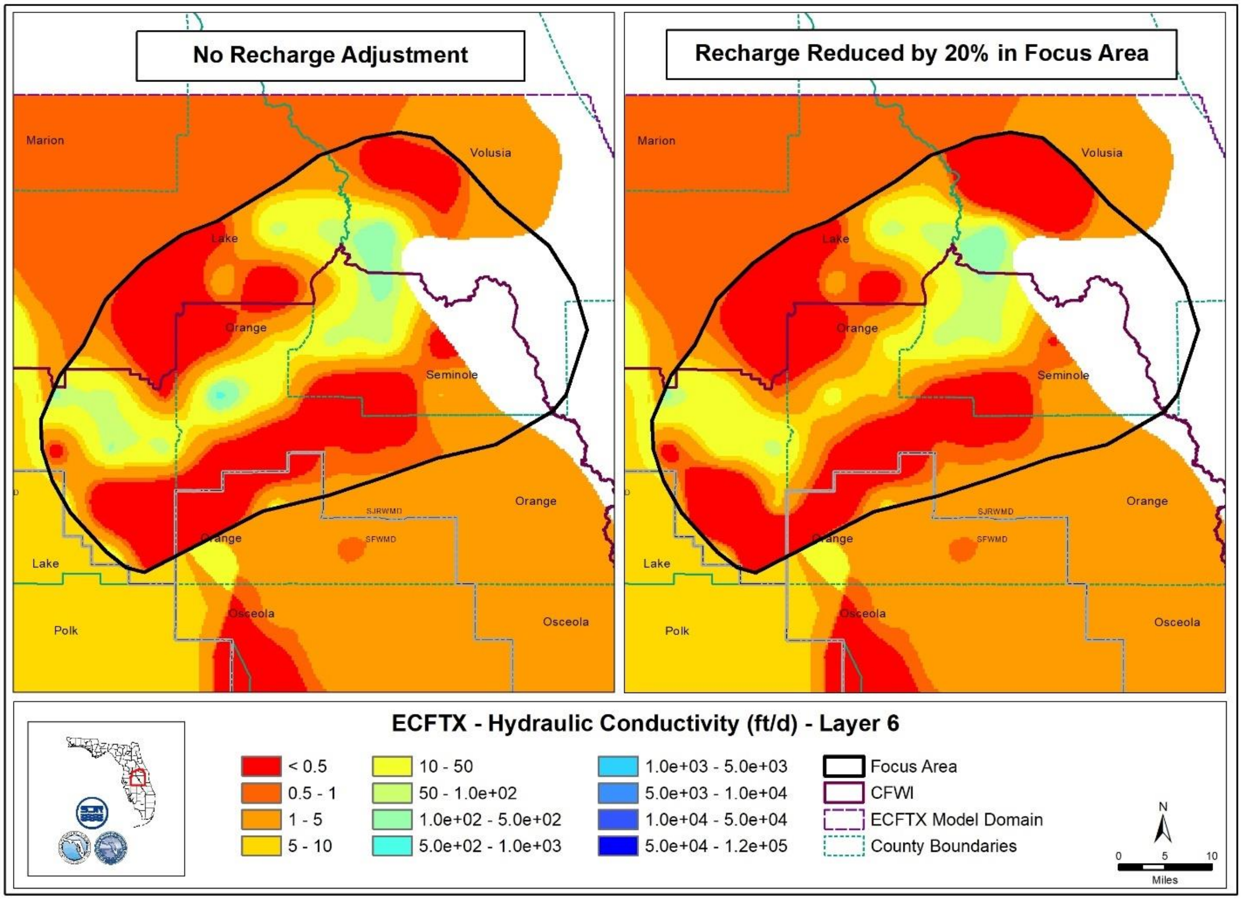


Figure 51. Horizontal hydraulic conductivity values for model layer 6 in the focus area without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

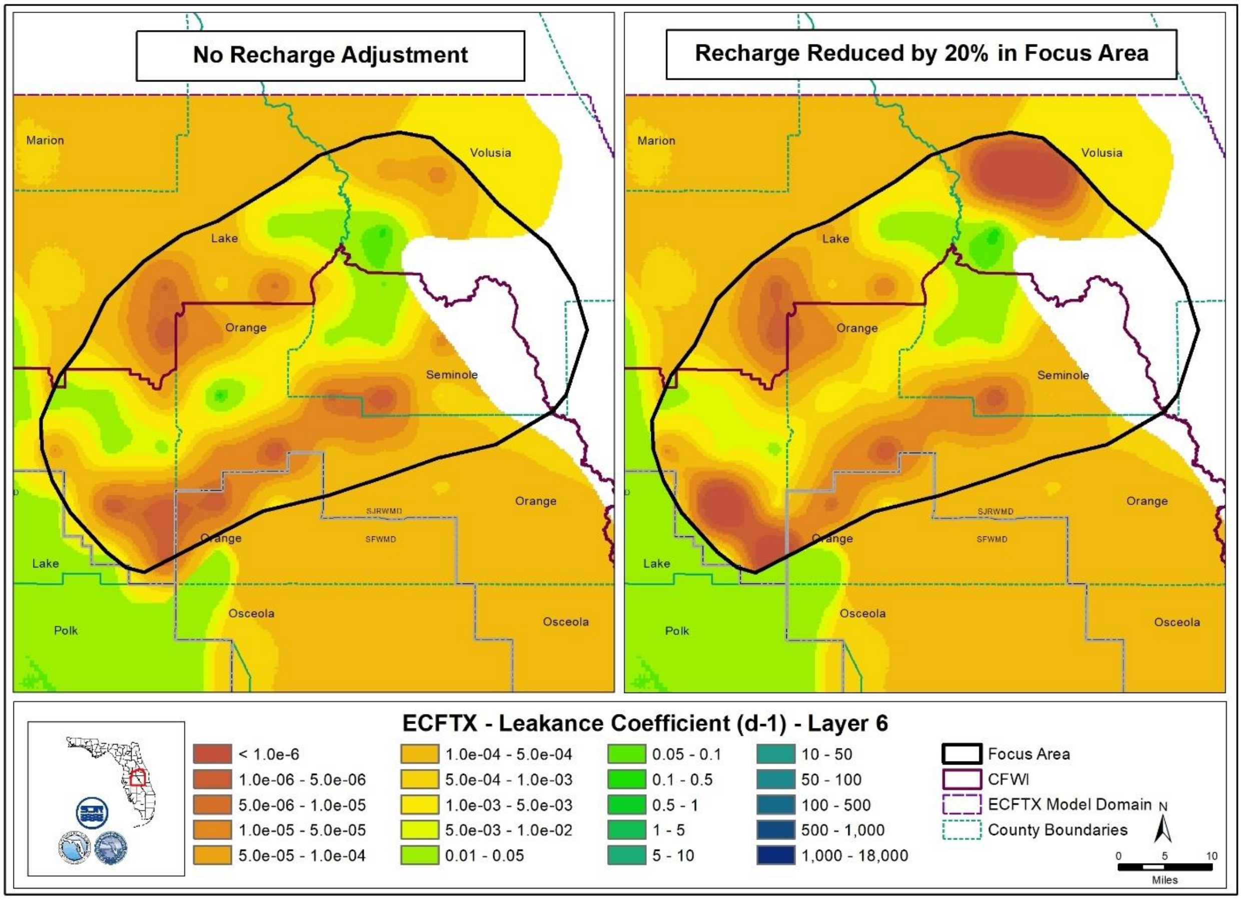


Figure 52. Leakance coefficient distribution in model layer 6 without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

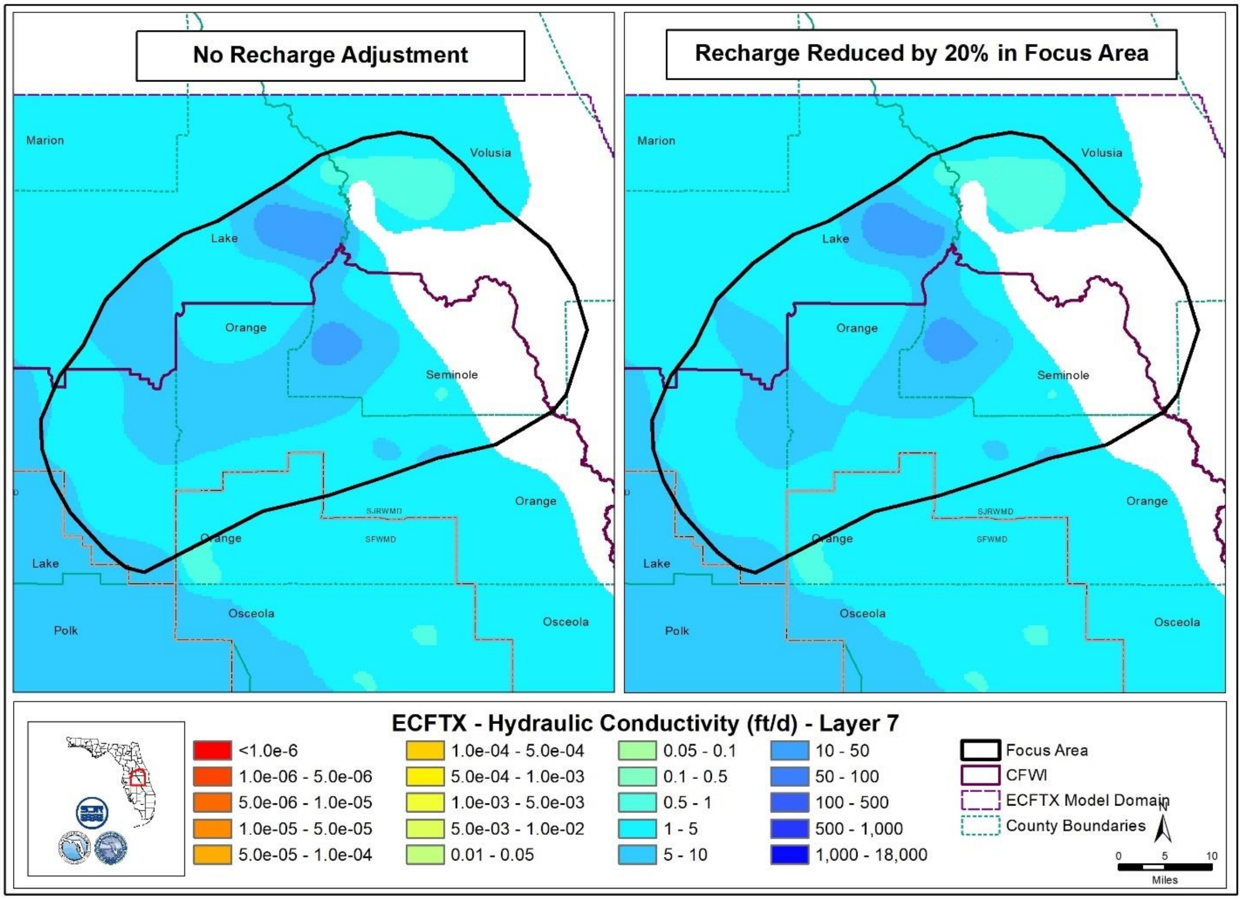


Figure 53. Horizontal hydraulic conductivity values for model layer 7 in the focus area without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

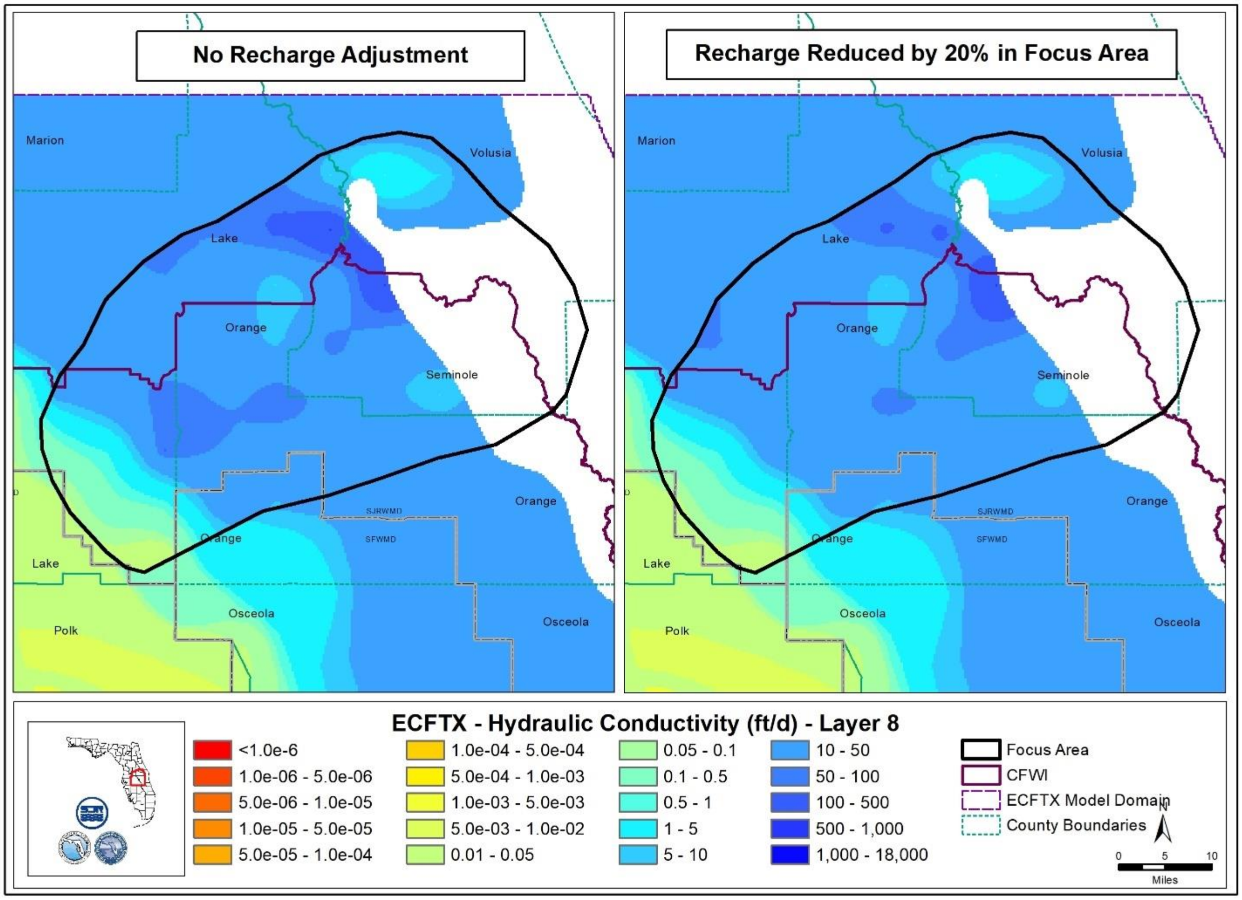


Figure 54. Horizontal hydraulic conductivity values for model layer 8 in the focus area without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

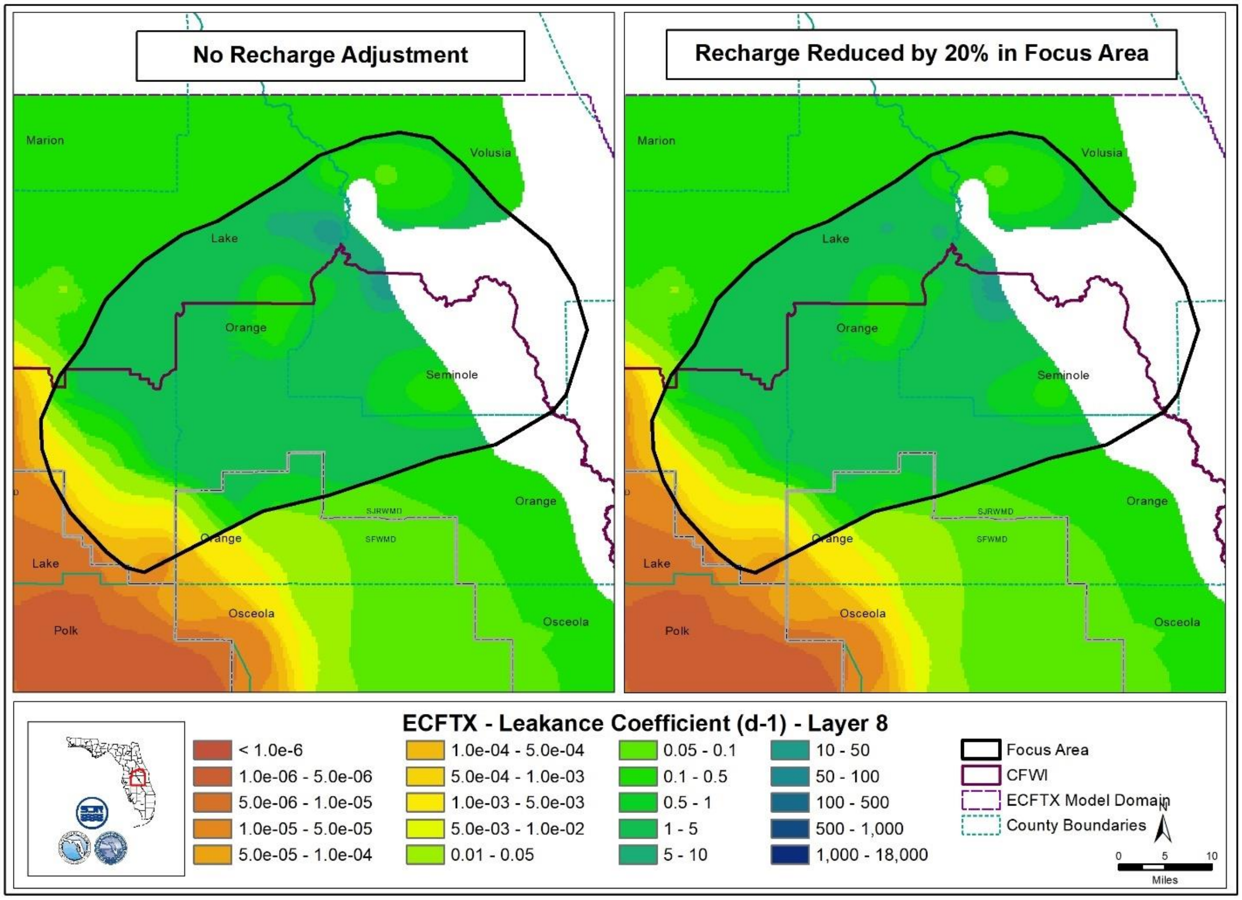


Figure 55. Leakance coefficient distribution in model layer 8 without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

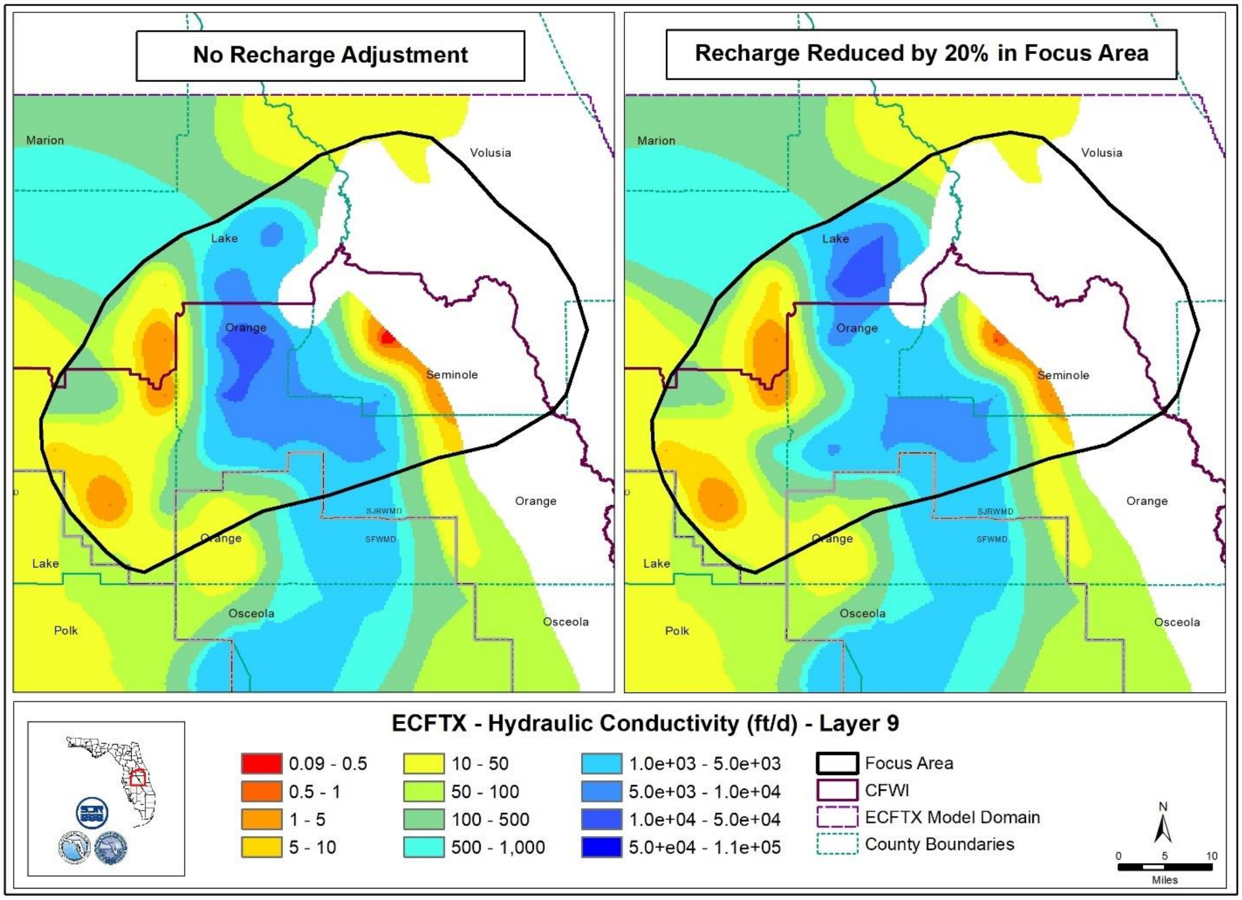


Figure 56. Horizontal hydraulic conductivity values for model layer 9 in the focus area without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

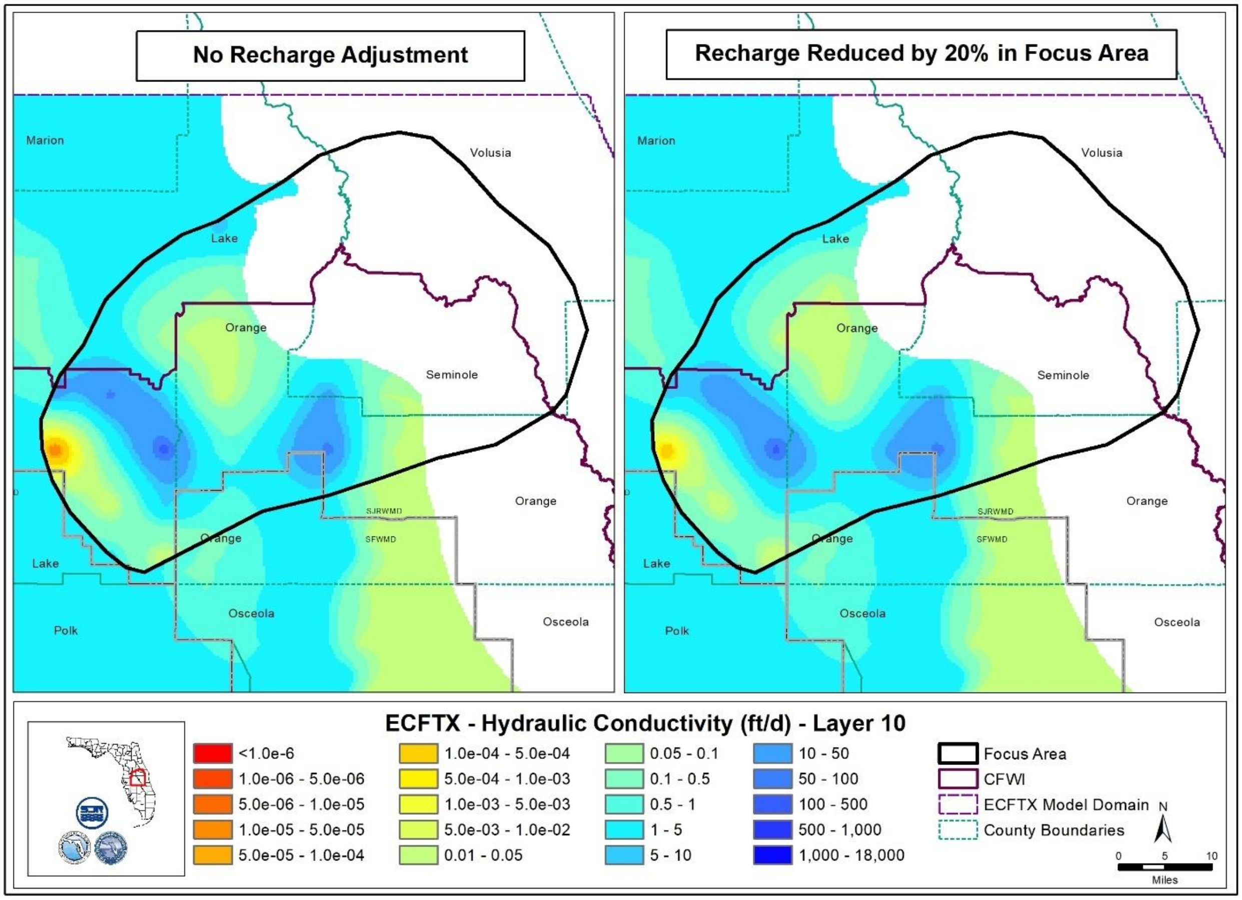


Figure 57. Horizontal hydraulic conductivity values for model layer 10 in the focus area without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

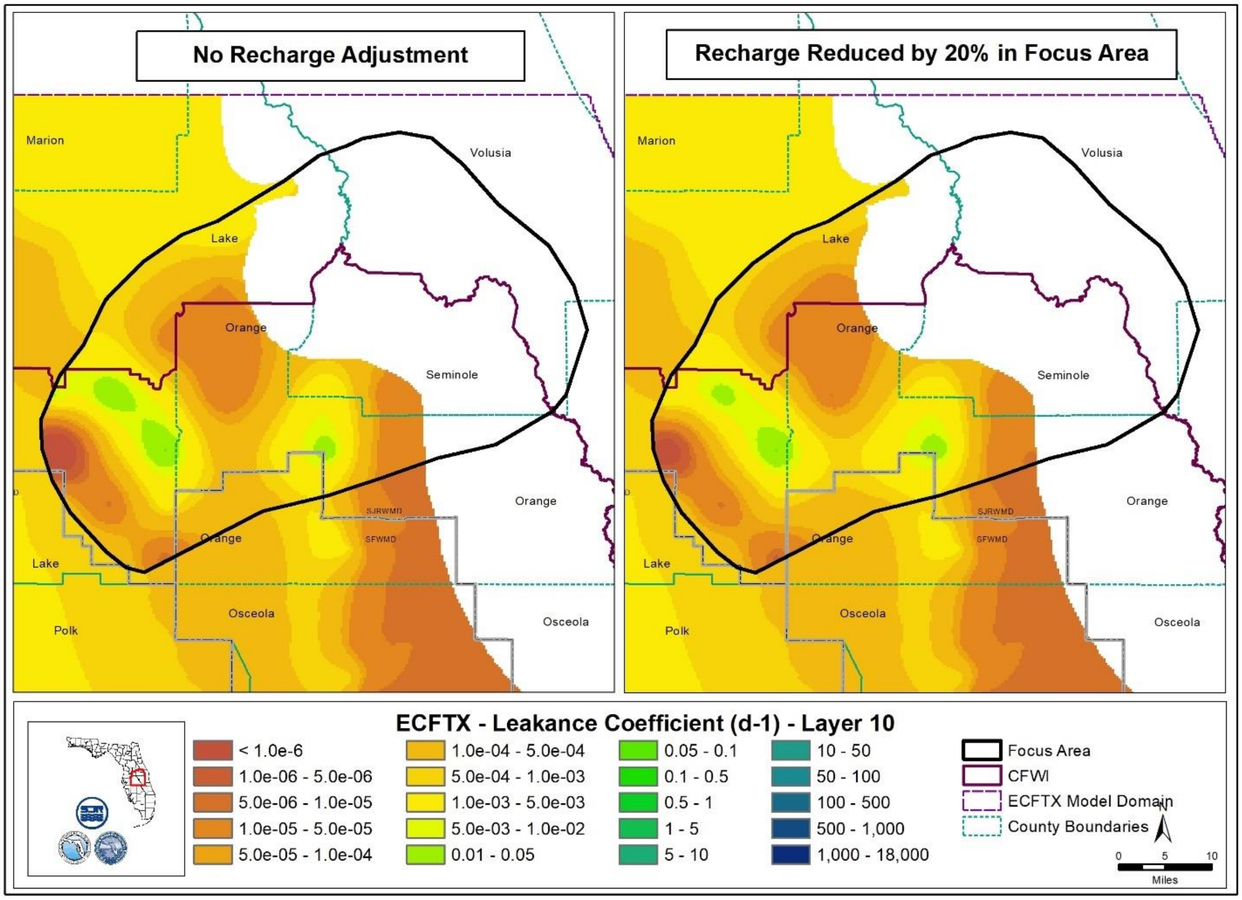


Figure 58. Leakance coefficient distribution in model layer 10 without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

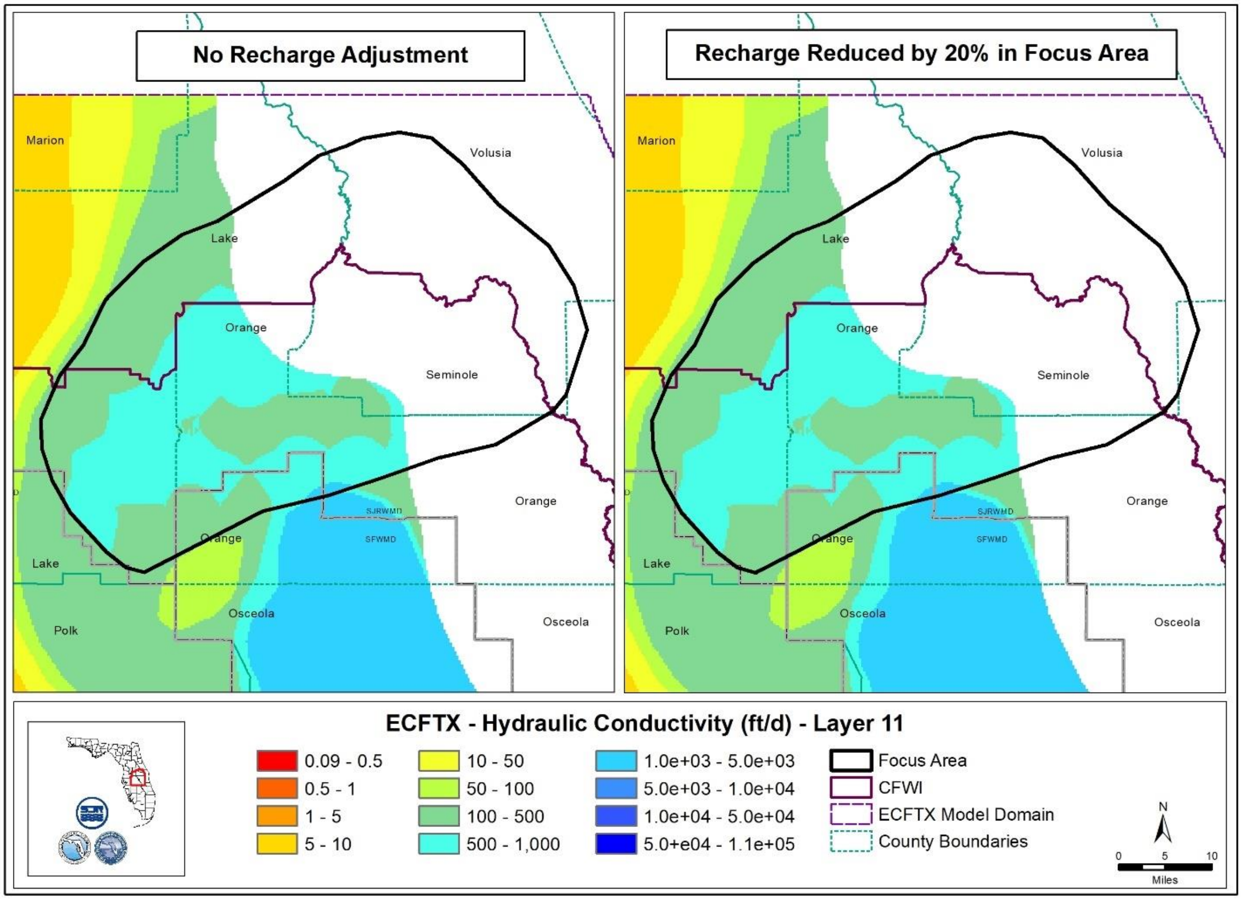


Figure 59. Horizontal hydraulic conductivity values for model layer 11 in the focus area without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

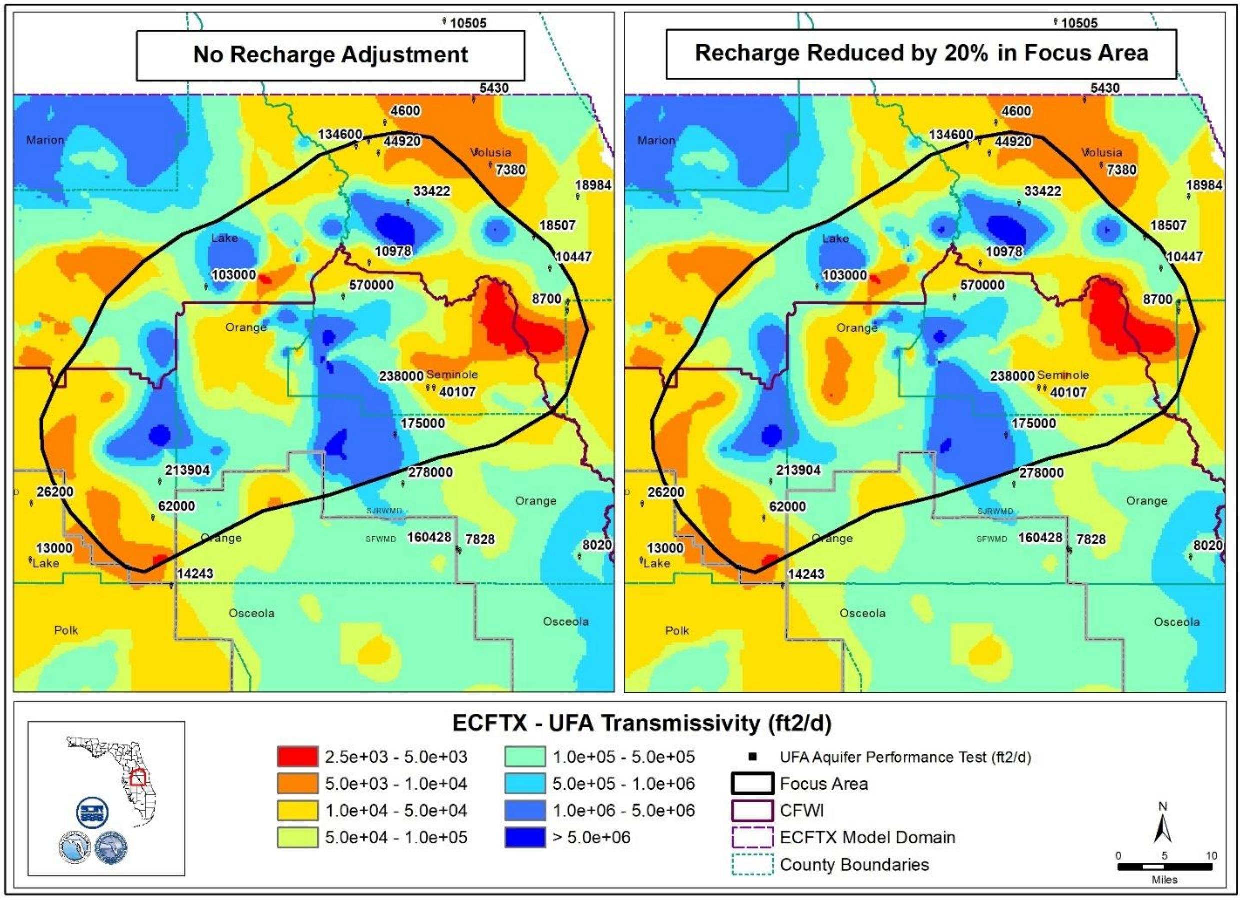


Figure 60. UFA Transmissivity distribution in the focus area for ECFTX transient simulation without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).

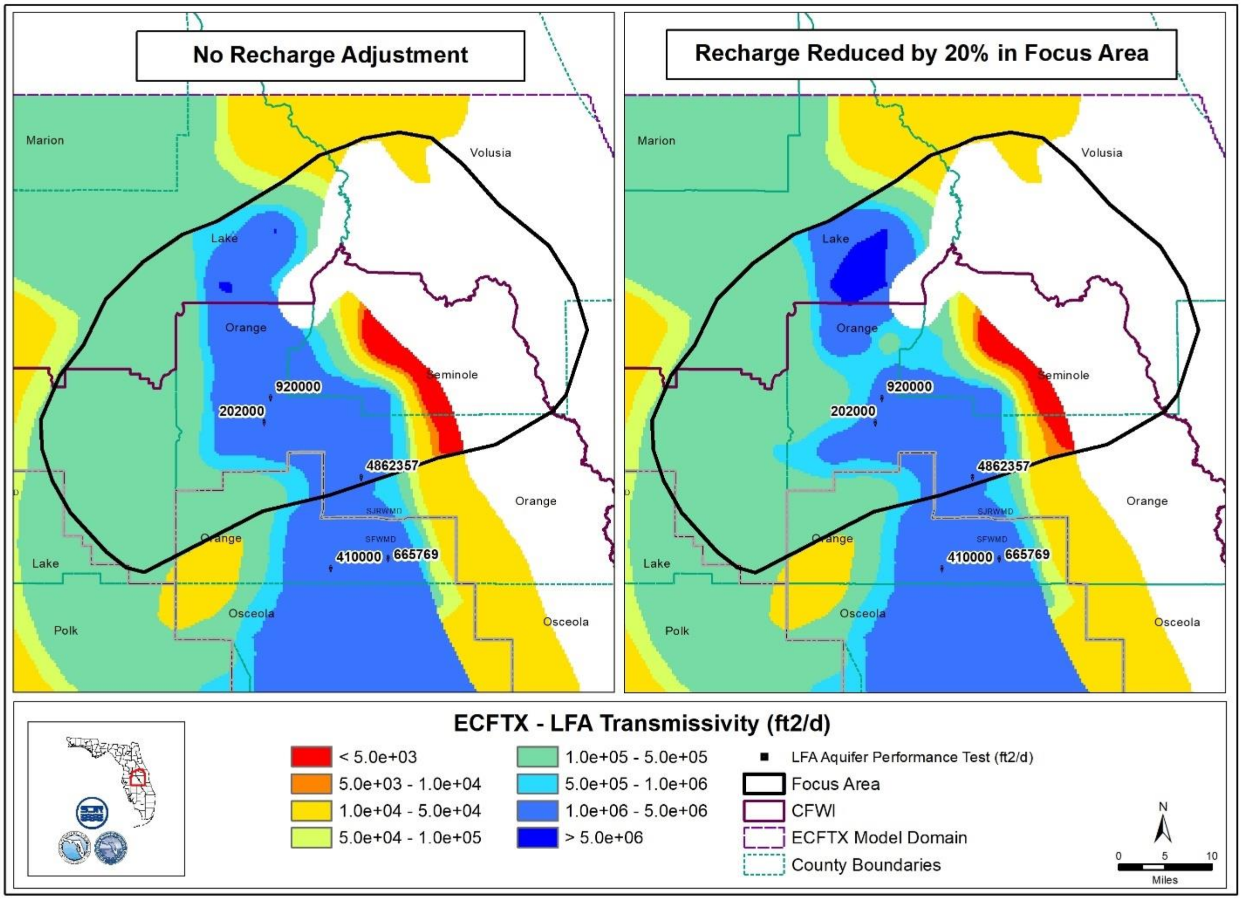


Figure 61. LFA Transmissivity distribution in the focus area for ECFTX transient simulation without recharge adjustment (left) and with recharge reduced by 20% in the focus area (right).