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Memo

To: David Christian, P.E., Senior Project Manager, SJRWMD

From: Silong Lu, Ph.D., P.E., D.WRE, Dynamic Solutions, LLC.

Date: 1/31/2024

Re: **INDEPENDENT TECHNCIAL PEER REVIEW SERVICES**
REVIEW OF CRYSTAL LAKE HSPF MODEL-DEVELOPMENT, DOCUMENTATION, AND LONG-TERM SIMULATION

Introduction

The SJRWMD's Minimum Flows and Levels (MFLs) Program is a District-wide effort to establish MFLs for priority lakes, streams and rivers, wetlands, springs, and groundwater aquifers. MFLs designate the minimum hydrologic conditions that must be maintained in these systems to prevent significant harm resulting from permitted water withdrawals.

East and West Crystal Lakes are part of the Crystal Chain of Lakes (CCL). The CCL also includes Bel-Air Lake, Deforest Lake, and Armory Lake. These lakes are located four miles southwest of the City of Sanford in Seminole County, Florida. These lakes primarily receive water from direct precipitation, surface runoff, and base flow, and lose their water through evaporation and seepage to the Upper Floridan Aquifer (UFA).

District staff developed a continuous-simulation model for the CCL using a Hydrological Simulation Program – FORTRAN (HSPF) model to better understand the hydrologic processes and water budget components of the lakes. The HSPF model was set up for the period 1995 to 2019 and then calibrated and validated for the periods 2007 to 2019 and 1995 to 2006, respectively.

MFLs assessment requires frequency analysis of lake levels. It is necessary to perform frequency analysis using long-term lake levels so that the effect of short- and long-term climatic variations on lake levels can be captured. Therefore, long-term lake levels need to be simulated using a hydrologic model to ensure the MFLs are met. The long-term simulation model of Cystal

Lake developed by the SJRWMD (SJRWMD, 2023) extended the calibration and validation years (1995-2019) to a long-term simulation period of 1953 through 2019.

The Cystal Lake HSPF model was reviewed by Dynamic Solutions, LLC (DSLLC), with an emphasis on available data, model conceptualization, model parameter values, model assumptions, and model calibration and validation. Overall, the model development generally followed standard engineering practice, utilizes the best available data, and made reasonable assumptions.

This technical memorandum summarizes DSLLC's review of the HSPF models and associated model files including the following documentation:

- *Hydrological Modeling of the Crystal Chain of Lakes, Seminole County, Florida (SJRWMD, 2023)*

Scope of review of the HSPF model and the associated documentation report is to assess

- Adequacy and appropriateness of the data used in model development, calibration and long-term simulations;
- Validity, defensibility and appropriateness of the development, calibration, and long-term simulations of the model;
- Deficiencies, errors, or areas for improvements in model development, calibration, and long-term simulations; and
- Validity and appropriateness of all assumptions in the development of any statistical relationships used for the determination and /or assessment of MFLs.

Review Questions

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

1) Assess the adequacy and appropriateness of the data used in model development and calibration

Data used for hydrology model development and calibration for this study shall include

1. Basin boundary
2. Land use and land cover
3. Soil data
4. Topographic data
5. Lake bathymetries
6. Rainfall and potential evapotranspiration data
7. Lake stage data

8. Groundwater elevations in the UFA

The data and other information provided with the model input files and report were reviewed to determine if the best available data were utilized for the models, and ultimately for MFL development. The following datasets were reviewed for adequacy and appropriateness:

- Basin boundary
- Land use and land cover
- Soil data
- Topographic data
- Lake bathymetry data
- Rainfall and potential evapotranspiration data
- West and East Cystal Lake stage data
- UFA groundwater elevation data
- Leakance

Basin Boundary

Basin boundary for the Cystal Lake study area was presented in Figure B-2 of Appendix B (SJRWMD, 2023) with thirteen subbasins. The basin boundary and subbasin divides were developed using the district's detailed basin boundary coupling with the basin data from the previous ICPR model (CDM, 2002) and a site visit conducted on 6/21/2021. Based on the available topographic data, the basin boundary and subbasin divides appear to be reasonable with the exception of two locations where the basin boundary intercepting the waterbodies as shown in Figure 1 with the red circles which needs to be adjusted based on local topography. However, impact of the adjustment to the model results is expected to be negligible.

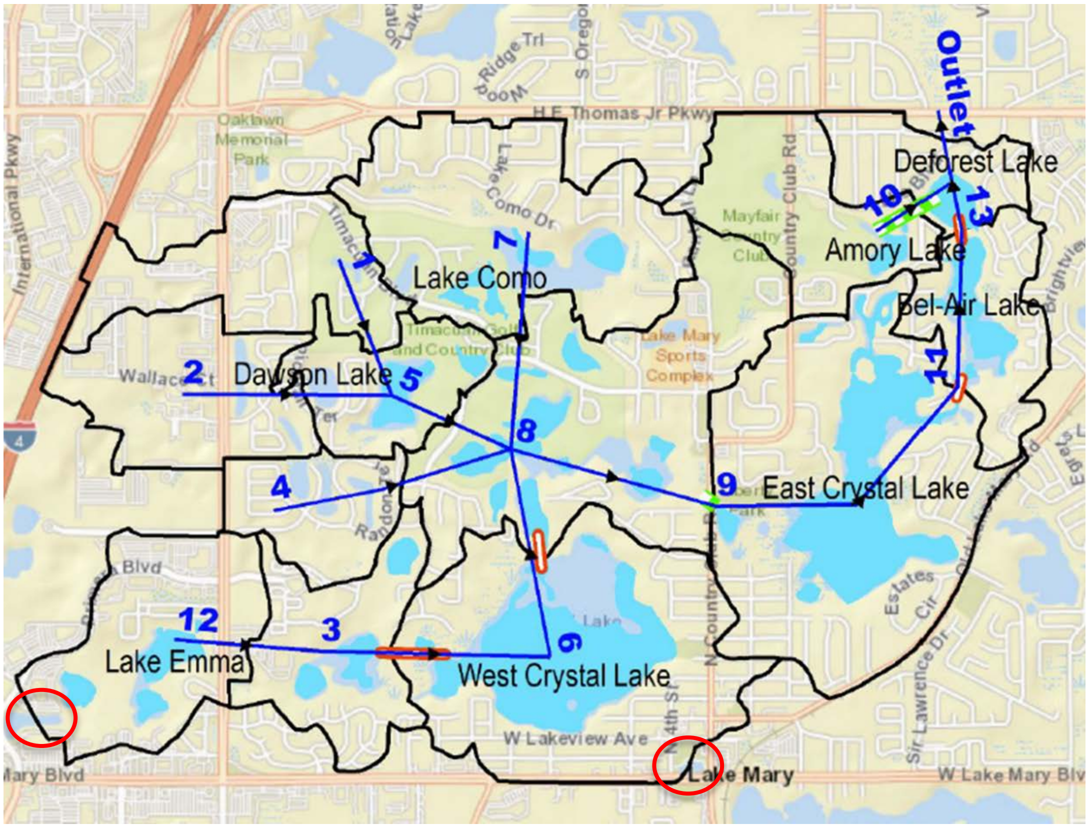


Figure 1 Two Locations Where Basin Boundary Intercepts Two Waterbodies

Land Use and Land Cover

Spatial distribution of land use and land cover presented in Figure B-3 of Appendix B (SJRWMD, 2023) was based on the district's 2014 land use coverage data. The primary land use is medium density residential (25.8%), followed by wetlands (17.1%), high density residential and commercial/industry (12.1%) as shown in Table B-1 of Appendix B (SJRWMD, 2023). Typical percent of impervious fraction for low, medium and high density residential and commercial/industry shown in Table B-2 of Appendix B (SJRWMD, 2023) were used in the HSPF model.

As the calibration period of the HSPF model is from 2007 to 20019, selection of the 2014 land use and land cover data appears to be an appropriate choice and adequate for the purpose of the study.

Land use data were used to develop model parameters including interception storage capacity, pervious and impervious land use areas, lower and upper zone nominal storages, Manning's n value, and lower zone ET parameter, etc.

Inconsistent percentages of land use and land cover presented in Table A-1 and Table B-1 need to be fixed.

Soil Data

Spatial distribution of hydrologic soil groups was presented in Figure B-4 of Appendix B (SJRWMD, 2023). The primary hydrologic soil group is A group with 59.6%, followed by A/D group (27.9%), which indicates that high infiltration is expected. Hydrologic parameters such as INFILT (index to infiltration) was established accordingly in the HSPF model.

The hydrologic soil data used for the model development is adequate and appropriate.

Topographic Data

The topographic DEM data with a spatial resolution of 10 m from the district's GIS database was shown in Figure A-2 of Appendix A (SJRWMD, 2023). The DEM data was not used to delineate the basin and subbasin boundaries for this study. As discussed above, the basin and subbasin boundaries were developed based on the district's detailed basin boundary coupling with the basin data from a previous study and a site visit.

The topographic data can be used to verify the basin and subbasin boundaries and is considered to be adequate.

Lake Bathymetry Data

Bathymetry data of Amory, East Crystal, Bel-Air and Deforest lakes, along with the bathymetry data from the University of South Florida, the East Crystal Chain-of-Lakes Hydrologic/Nutrient Budgets & Management Plans study (ERD, 2014), were used to develop FTABLEs. In addition, the old stage-area data used in the ICPR model of the Monroe basin (CDM, 2002) were utilized as a secondary data. All bathymetry data were converted to NAVD88 which is consistent with the datum of the lake stages.

The available bathymetry data of the lakes along with the secondary data from the previous studies appear to be adequate and appropriate for development of the FTABLEs.

Rainfall and Potential Evapotranspiration Data

Both rainfall and potential evapotranspiration data are critical to accurately simulate watershed runoff. The daily rainfall data collected at Sanford Station from 1956 to present was available and were disaggregated based on hourly NEXRAD (since 1995) and nearby NOAA station (before 1995) data. The hourly rainfall data were provided by the district in a WDM file.

Hourly PET data was provided by the district in a WDM file. The daily PET data were calculated based on the Hargreaves equation using maximum and minimum air temperatures at Sanford Station, and then disaggregated to hourly values using WDMUtil.

Hourly precipitation data were used by the HSPF model to generate watershed surface runoff and to calculate direct rainfall on the waterbodies in the watershed while hourly PET data were used to calculate evapotranspiration loss from pervious and impervious land segments and waterbody surface direct loss.

Review of both hourly rainfall and PET data in the WDM file and annual total rainfall and PET presented in Figure D-3 of Appendix D (SJRWMD, 2023) and comparison of the NEXRAD data (since 1995) to the observed data at Sanford Station indicated both rainfall and PET data appear to be reasonable and are adequate and appropriate for the purpose of the study.

West and East Cystal Lake Stage Data

Lake stage data of East Crystal, West Crystal, DeForest, and Emma Lakes were available from the district and Seminole's county hydrologic databases. Irregular period of record data since 1993 were summarized in Table A-6 of Appendix A (SJRWMD, 2023). Lake stages of both East Crystal Lake and West Crystal Lake presented in Figure A-14 of Appendix A (SJRWMD, 2023) show similar trends and temporal patterns. The amount and duration of the data were adequate and appropriate for model calibration and validation.

UFA Groundwater Elevation Data

The UFA levels are needed to simulate lake leakage rates in the HSPF model using Special Actions. A number of daily UFA wells data within and around the basin were available for the period of 1953 to 2019 and their locations were shown in Figure A-10 of Appendix A (SJRWMD, 2023).

Among those UFA wells, S-0975 well is located within the basin and was selected to be used in the HSPF model. Irregular water levels at S-0975 were recorded since 1/29/2010. S-0125 well, which is located approximately 6 miles southwest of S-0975, had long-term POR since 1951 and generally shows similar temporal patterns and evolution with S-0975's data. A reasonable correlation between S-0975 and S-0125 wells was found with R^2 = 0.71. Therefore, daily groundwater levels at S-0975 were extended to the period of 1953 to 2019 with S-0125 well data based on monthly offsets between the two wells with line of organic correlation (LOC) method.

The UFA level records at S-0975 for the period January 2010 to present and synthesized data for the missing period using the records from S-0125 well and the extension method are considered to be adequate and appropriate for the purpose of the study.

Leakance Data

To model leakage rates of the lakes, the leakance values used in the East-Central Florida Transient (ECFTX) groundwater model were used as initial values in the HSPF model and then adjusted during model calibration. The leakance data were considered to be adequate and appropriate for model development.

a) **Was "best information available" utilized to develop and calibrate the HSPF model?**

The best information available was used to develop and calibrate the hydrologic HSPF model.

b) **Are there any deficiencies regarding data availability?**

Based on adequacy of the data discussed above, there are no apparent deficiencies regarding data availability for the hydrology model. Missing and/or data gaps were resolved properly.

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

Based on the data presented in the documentation and knowledge of additional data sources, it is concluded that no other relevant information was available that was discarded without appropriate justification.

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

a) **Determined if the model is appropriate, defensible, and valid, given the district's MFLs approach.**

Development of the hydrologic HSPF Cystal Lake model utilized the following key datasets:

- the 2014 land use and land cover regrouped into thirteen (13) standard land use categories that the district prefers;
- basin and sub-basin boundaries developed using the district's detailed basin boundary coupling with the basin data from the previous ICPR model and a site visit;
- daily rainfall data from Sanford Station and then disaggregated into hourly data based on hourly NEXRAD (since 1995) and nearby NOAA station (before 1995);
- hourly PET data which were calculated on a daily basis using maximum and minimum air temperature from Sanford Station using the Hargreaves equation, and then disaggregated into hourly data;
- FTABLEs developed based on available lake bathymetry data from various sources along with the old stage-area data used in the ICPR model of the Monroe basin; and
- daily UFA groundwater level data at well S-0975 within the basin used to compute lake seepage to the UFA. The dataset was back extended from January of 2010 to 1953 by using a good correlation relationship and monthly offsets between this well and well S-0125.

Using those datasets for model setup and simulation appears to be appropriate and defensible.

Special Actions options in HSPF were used to account for variable PERLND and RCHRES surface areas to eliminate some double counting of rainfall and evaporation when lake water levels are high and some undercounting when lake water levels are low for accurate model simulations. Special Actions were also used to simulate lake seepages to the UFA and reverse flows when tailwaters were higher to accurately account for the inflows to and outflows from each lake in the basin.

The model was manually calibrated and validated with acceptable range of possible parameter values including key parameters of LZSN, INFILT, CEPSC, UZSN, LZETP, and DEEPFR in the hydrological models summarized in Table 1.

Table 1 Key Hydrologic Parameter Values in the CCL HSPF Model

Land Use Type	LZSN (inches)	INFILT (in./hr.)	CEPSC (inches)	UZSN (inches)	LZETP	DEEPR
Low density residential	4.0	0.18	0.05	0.40	0.50	0.4-0.6
Medium density residential	4.0	0.18	0.05	0.40	0.50	0.4-0.6
High density residential	4.0	0.18	0.05	0.40	0.50	0.4-0.6
Commerical/Industrial	4.0	0.18	0.05	0.40	0.50	0.4-0.6
Open	2.0	0.257	0.02	0.20	0.30	0.4-0.6
Pasture	4.5	0.257	0.08	0.45	0.55	0.4-0.6
General agriculture	5.0	0.309	0.08	0.50	0.70	0.4-0.6
Range/Shrub	4.5	0.257	0.08	0.45	0.60	0.4-0.6
Forest	6.0	0.386	0.12	0.60	0.80	0.4-0.6
Water	0.5	0.01	0.12	0.10	0.95	0.4-0.6
Wetland	0.5	0.01	0.12	0.10	0.95	0.4-0.6

Model results for the 13-year calibration period (2007 to 2019) and the 12-year validation period (1995 to 2006) that included dry, average, and wet years were evaluated both graphically and statistically. Extension of the model simulation period is believed to be sufficient for purpose of the hydrological model simulations. Time series plots and frequency-exceedance curve plots of the observed lake stages versus HSPF simulated lake stages, statistical parameters of RMSE, NSE, ME and percentage of +/- 1 ft bracket were provided for visual comparison and evaluation. Overall, the hydrologic HSPF models simulated lake stages well for both calibration and validation periods.

Water budgets for four major land use in the basin for the calibration period are summarized in Table 2 below based on Table C-6 of Appendix C (SJRWMD, 3023). The ratio of the average annual runoff by land use category to the average annual rainfall flow budget is reasonable and consistent with our experience in Central Florida given the types of soil and land use in the basin. The average annual accumulative total ET loss and total surface runoff for each land use category appears to be reasonable within typical ranges of the values found in central Florida. By land use category, the highest total ET loss was associated with the wetland land use and the highest surface runoff occurred for commercial/industry land use and land cover which was expected.

Table 2 Average Annual Flow (in inch/year) by Major Land Use Category

Flow (in/ac/yr)	Medium Density Residential	Wetland	High Density Residential	Commercial/ Industry
Surface Runoff	15.1	2.6	21.4	25.9
Baseflow	6.5	2.5	6.8	6.5
Rainfall	52.8	52.8	52.8	52.8
Leakage to Inactive Deep Groundwater	6.1	7.0	5.8	6.1
Total Simulated ET	32.5	42.9	27.5	25.9

Table C-7 of Appendix C (SJRWMD, 2023) shows average annual average West and East Cystal Lakes water budget for model calibration and validation periods. Percent of inflow from direct rainfall to the lake surface, inflows from local basin, and percent of lake evaporation and lake seepage to the UFA appeared to be reasonable.

Overall, the calibrated and validated hydrological HSPF model is considered to be appropriate, defensible, and valid, given the district's MFLs approach, with some comments and questions provided in the Summary section below.

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

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

There are three (3) key assumptions used in the hydrologic HSPF model development including:

- No flow contribution from Lake Emma subbasin to downstream West Crystal Lake so Lake Emma subbasin was excluded in the HSPF model;
- In terms of temporal trends, it was assumed that lake stages of West Crystal Lake and East Crystal Lake are similar to those of Sylvan Lake such that observed long-term lake stages of Sylvan Lake were used to qualitatively compare to the simulated lake stages of both West and East Crystal Lakes to confirm the performance of the model;
- Well levels at well S-0975 within the basin were assumed to be correlated with the UFA levels at well S-0125 which is about 6 miles southwest of S-0975; therefore, derived regression equation along with the monthly offsets was used

to extend the well levels at S-0975 for the missing period using the well data at S-0125.

It is reasonable to assume that Lake Emma subbasin does not contribute flow to downstream West Crystal Lake due to its surrounding topography and no direct man-made hydraulic connection.

Temporal trends of the observed lake stages at West Crystal Lake, East Crystal Lake and Sylvan Lake appear to be similar for the same period where the lake stages of the three lakes are available (Figures D-7 and D-8 of Appendix D, SJRWMD 2023). Therefore, it is reasonable that observed long-term lake stages of Sylvan Lake were used to qualitatively compare to the simulated lake stages of both West and East Crystal Lakes to confirm the performance of the model.

Using the derived equation based on a good correlation relationship (R^2=0.71) between the well levels at well S-0975 within the basin and the well levels at another UFA well S-0125 for data extension at well S-0975 appears to be scientifically defensible and reasonable.

In short, all the assumptions used in the hydrologic HSPF model appear to be reasonable and consistent given the best information available.

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

To my knowledge, there is no other information available that could have been used to eliminate any of the assumptions used in the hydrologic HSPF model.

It is important to recognize that assumptions are inevitably needed to complete modeling excise for various reasons including data limitation. Potentially, model assumptions may change results of the model simulations. However, the use of this additional information should not substantially change the model results.

c) Review of HSPF model input and output data includes an examination of:

- **Model elevations vs collected data to verify same datum used consistently**

  Raw lake stage data and bathymetry data were not provided for review. However, the West Cystal Lake and East Crystal Lake stage data in ft NAVD88 were downloaded from the district's website and Seminole County Wateratlas website, respectively, for comparison with the lake stage data presented in Figure A-14 of Appendix A (SJRWMD, 2023). It appears they are identical. Review of the FTABLEs of the West and East Cystal Lakes in the UCI file and bottom elevations of the lakes, it appears that both the lake stage data and lake bathymetry are in the same datum of NAVD88.

Raw groundwater level data were not provided for review either. However, those groundwater level data were downloaded from the district's website. Groundwater level data at well S-0975 and well S-0125 were downloaded for comparison with the well level data presented in Figure A-11 of Appendix A (SJRWMD, 2023) and in the WDM file. It appears that both well S-0975 and well S-0125 level data are in the same datum of NAVD88 as the lake stage data.

In short, modeled lake elevations, observed lake stage, lake bathymetry, and groundwater level data are in the same datum of NAVD88.

- **Flow/stage plots to look for model instabilities**

  By carefully examining the hydrological model-simulated instream flow and lake stage, no model instabilities were observed in the hydrologic HSPF models. It should be noted that the simulated reach/lake stages are dependent on the bottom elevations of the reach/lake the modeler specified.

- **Output file for model warnings (full flow channels, flooded nodes, etc.) and flow classification summary**

  One warning about FTABLE extrapolation for RCHRES 11 was found in the output file. This warning unlikely caused any noticeable errors in model results.

- **Continuity error and convergence data**

  No continuity or convergence errors were found in the HSPF model.

- **Runoff and infiltration volumes to check for reasonableness**

  The HSPF UCI file was modified to output surface runoff and infiltration volumes by landuse category for the basin. The annual average surface runoff and infiltration from the basin over the model calibration and validation period of 1995 to 2019 are 3.00 and 25.61 inches, respectively.

  In the basin, most of the hydrologic soils group are A group with a high infiltration rate; therefore, higher infiltration was expected. About 48.02% of annual average rainfall was infiltrated vertically and some of the infiltration was converted as baseflow and some of the infiltration was further percolated into lower zone and lost into the deep inactive groundwater aquifer.

  The primary land use in the basin is medium density residential (25.8%), followed by wetlands (17.1%), high density residential (12.1%) and commercial/industry (12.1%) (Table B-1 of Appendix B, SJRWMD, 2023). Fifteen, thirty-five and fifty percents of the medium density residential, high density residential, and commercial/industry, respectively, were treated as direct impervious connected area (DCIA) (Table B-2 of Appendix B, SJRWMD, 2023). Factoring in high infiltration A soils group, lower surface runoff from the basin was expected.

In brief, model simulated runoff and infiltration were reasonable for the study area.

- **Values assigned to model parameters to check for reasonableness**

  As discussed in the previous Section 2), values of the key parameters of LZSN, INFILT, CEPSC, UZSN, LZETP, and DEEPFR by land use category used in the calibrated hydrologic model were set within the range of values suggested by *BASINS Technical Note 6: Estimating Hydrology and Hydraulic Parameters of HSPF* (EPA, 2000) and within the acceptable ranges for the Central Florida region.

- **How groundwater data was used in model inputs**

  Local UFA well S-0975 data was used to dynamically compute lake seepages to the UFA using Darcy Law with the Special Actions. Specifically, lake seepages in the model were calculated as a function of the lake surface area and the head difference between the lake stage and the well elevation.

- **Methodologies used to develop input data for long-term simulations**

  Input data for the long-term simulation of 1953 through 2019 include hourly rainfall, hourly PET, and daily UFA groundwater levels. The same methods discussed earlier in Section 1) were used to extend the data.

  The hourly rainfall data for the long-term simulation simply extend the Sanford station back to the beginning of 1953. The extended hourly rainfall data were disaggregated from daily records at Sanford station based on hourly NEXRAD (since 1995) and nearby NOAA station (before 1995).

  The daily PET data were estimated based on the Hargreaves's method using daily maximum and minimum temperature data at Sanford station, and then disaggregated to the hourly PET data used in the long-term HSPF simulation model.

  Daily groundwater levels at S-0975 were extended back to the beginning of 1953 with S-0125 well data based on the correlation equation and monthly offsets between S-0975 and S-0125 with line of organic correlation (LOC) method.

  The methodologies used for extension of the input data discussed above for the long-term simulation appear to be consistent and technically sound.

- **Long-term simulation results to check for reasonableness**

  Compared to the observed lake stages, simulated long-term West and East Cystal Lakes stages shown in Figures D-7 and D-8 of Appendix D (SJRWMD, 2023), respectively, appear to be well simulated and reasonably follow the data trends with the exception of a few high lake stages for the West Crystal Lake where the simulated lake stages are much higher than the observed. Statistical parameters of Nash-Sutcliffe Efficiency and Root Mean Squared Error in Table D-1 of Appendix D (SJRWMD, 2023) indicate that the lake stages of the two lakes were reasonably simulated.

  Furthermore, the simulated lake stages adequately tracked the observed lake stages of Sylvan Lake for the period where no observed lake stages of West and East Crystal Lakes were available, indicating the long-term stages of both lakes were reasonably simulated with the HSPF model.

d) Development of an independent water budget

The UCI file was modified to output West and East Cystal Lakes water budget including direct rainfall to the lake surface, evaporation from the lake, total watershed inflow to the lake, and lake surface discharge for the period of 1955 to 2019 (a total of 65 years). Modeled average annual water budgets for the lakes are summarized in Table 3 below. Compared to the water budgets in Table C-7 of Appendix C (SJRWMD, 2023) for the model calibration and validation period of 1995 to 2019, most of the inflows and outflows components are very comparable with smaller values of the seepage to the UFA as the result of different model simulation periods.

Table 3 Average Annual West and East Cystal Lakes Water Budget for the Period of 1955 to 2019 (65 years)

West Crystal Lake

Lake Inflows	Average Annual Volume (ac-ft)	Average Annual Value (inches over lake surface)	Percent of Inflow or Outflows
Direct Rainfall to Lake	596.4	51.1	23.8%
Total Watershed Inflow	1,908.3	163.6	76.2%
Total	2,504.7	214.7	100%
Lake Outflows			
Evaporation from Lake	589.0	50.5	21.4%
Lake Seepage to the UFA	232.5	19.9	8.5%
Lake Surface Discharge	1,927.6	165.2	70.1%
Total	2,749.1	235.6	100%

Values in inches based on average lake surface area during the period of 1955 to 2019 (140.0 acres)

East Crystal Lake

Lake Inflows	Average Annual Volume (ac-ft)	Average Annual Value (inches over lake surface)	Percent of Inflow or Outflows
Direct Rainfall to Lake	502.0	51.5	31.7%
Total Watershed Inflow	1083.3	111.1	68.3%
Total	1585.3	162.6	100%
Lake Outflows			
Evaporation from Lake	486.5	49.9	28.0%
Lake Seepage to the UFA	150.2	15.4	8.6%
Lake Surface Discharge	1102.2	113.0	63.4%
Total	1738.9	178.3	100%

Values in inches based on average lake surface area during the period of 1955 to 2019 (117.0 acres)

Summary

In development and calibration of the hydrologic HSPF of the Cystal Channel of Lakes model, the best information/data available were utilized. No apparent deficiencies regarding data availability were found.

The methodology used to extend the UFA groundwater level dataset when needed is appropriate and defensible given the best data available. Using the Special Actions options in HSPF to calculate variable areas of the wetlands and surface areas of the lakes, lake seepages to the UFA, and reverse flows when tailwater stages were higher is valid and appropriate.

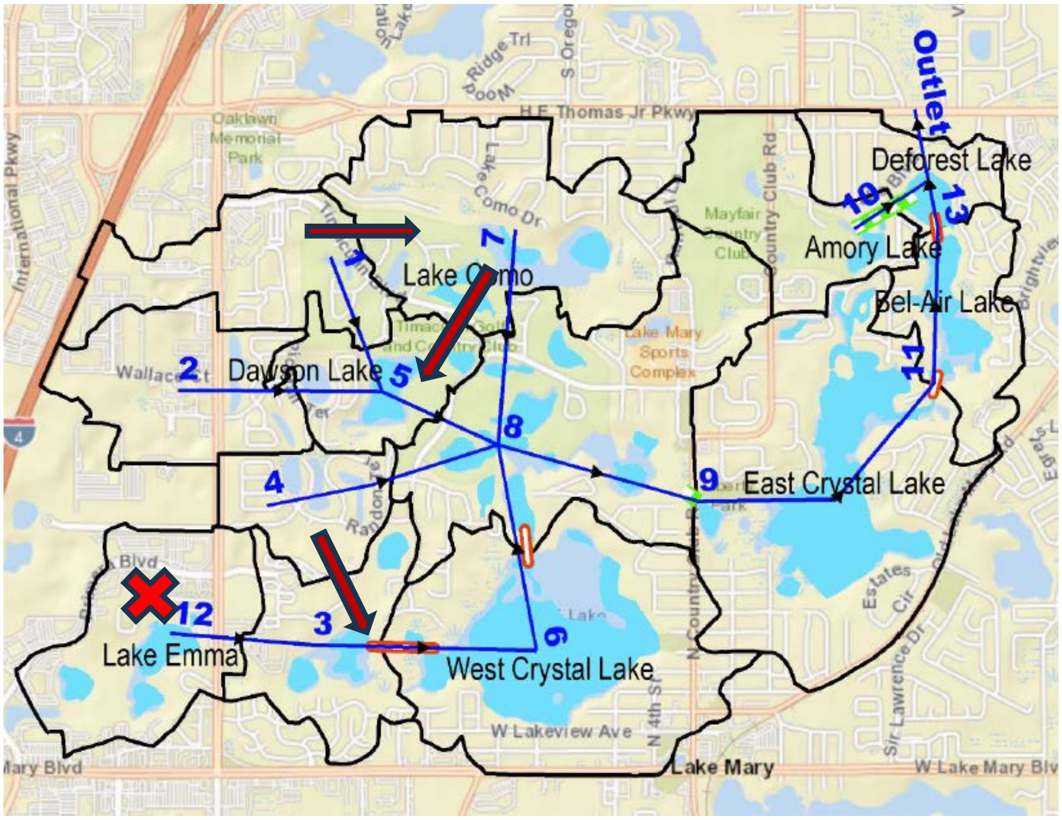
The average annual water budgets by land use category are considered to be reasonable for the area of the study. The average annual inflows and outflows to/from the lakes also appear to be reasonable.

The assumptions used in the model development are reasonable and consistent given the best information/data available. The hydrologic HSPF Cystal Lake model was calibrated and validated reasonably well. Overall, the long-term simulation model performed better statistically than the calibration and validation model.

In summary, the model is considered to be appropriate, defensible, and valid given the district's MFLs approach with the following comments and questions:

- The model appeared to simulate too much surface outflow from West Crystal Lake (WCL) to downstream East Crystal Lake due to higher WCL stages.
- Does too much contributing area cause higher WCL stages? Any other isolated subbasins need to be excluded?
- The statement "The storage change is less than 1%, indicating the reasonable simulation of lake's water budget elements (Table D - 3) (page 85)" is inaccurate as the storage change less or greater than 1% solely depends on how much difference in the lake stages between the beginning and end of the model simulation.
- It would be helpful to provide a table to document key hydrological parameter values for the calibration/validation model in the report.
- Was the new stage-vol relationship also replaced in the model (page 5)?
- Basin boundary intercepting with two lakes/ponds in Figure B-2 and related figures.
- Numbers in Table H-2 are inconsistent with those Table C-5.
- Numbers in Table H-3 are inconsistent with those Table C-7.
- Numbers in Table H-4 are inconsistent with those Table D-1.
- Numbers in Table A-1 are inconsistent with those Table B-1.
- Unit for K in the Darcy's law equation should be L/T (page 49).
- Inconsistent reach connections presented in the report and in the UCI file as shown in the figure below (Note: the red arrows represent the reach connections in the UCI file

with exclusion of subbasin Lake Emma marked with the red cross. The blue lines/arrows represent the reach connections in the report.)



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SJRWMD, 2023. Hydrological Modeling of the Crystal Chain of Lakes, Seminole County, Florida by Olkeba T. Leta, Yanbing Jia, and Tom Jobes

EPA, 2000. BASINS Technical Note 6: Estimating Hydrology and Hydraulic Parameters of HSPF