Lake Weir HSPF Model Report

Contract Number 27847:
Hydrology, Hydraulic, Hydrodynamics, and Groundwater Quantity and Water Quality

Work Order #4 – Hydrologic Modeling Services, Lake Weir Minimum Flows and Levels Evaluation

St. Johns River Water Management District
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November 30, 2016

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This report is respectfully provided to help inform any interested parties in their assessment and understanding of the hydrological response of Lake Weir associated with the watershed runoff and the interaction of the lake and groundwater in Marion County, Florida.

The findings included herein are presented for the St. Johns River Water Management District (SJRWMD) and are based upon sound hydrological principals and hydrological and hydrogeological data available at the time model analysis was performed. The information presented is considered to be accurate and is certified pursuant to Chapter 471, Florida Statutes (FS), and Chapter 61G15, Florida Administrative Code, F.A.C.

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Lake Weir Minimum Flows and Levels Evaluation

Executive Summary

This executive summary report and attached documents summarize the work completed for the St. Johns River Water Management District (SJRWMD) by Dynamic Solutions, LLC (DSLLC) for the Lake Weir Minimum Flows and Levels (MFL) Evaluation, under Work Order #4 of Contract #27847.

The work order included five tasks (A through E). This final report, which is Task E, consists of an executive summary and attachments that reflect the work from Task A, B, and C. Task D which consisted of a long-term simulation and comparison to MFLs was an optional task not exercised as part of the scope of work. The work order started on June 16, 2016. The expiration date of this work order was November 30, 2016.

Background

Lake Weir is located in Marion County, Florida and the contributing sub-basin area includes part of Marion County, Sumter County, and Lake County, as shown in Figure 1. Lake Weir is located within the SJRWMD water resource caution area.

A historical hydrological model was developed by the SJRWMD using the Streamflow Syntheses and Reservoir Regulation (SSARR) model to evaluate the MFLs set for Lake Weir. To facilitate an update to the MFL evaluation a new hydrologic model using the Hydrological Simulation Program -FORTRAN (HSPF) software was developed. The HSPF model was developed to evaluate the potential effects of the groundwater withdrawals from the Upper Floridan Aquifer (UFA) on Lake Weir water levels.

The SJRWMD requested assistance from DSLLC with hydrologic modeling in support of Lake Weir MFLs evaluation. DSLLC reviewed the data provided by the SJRWMD, set up and calibrated the HSPF model for Lake Weir.

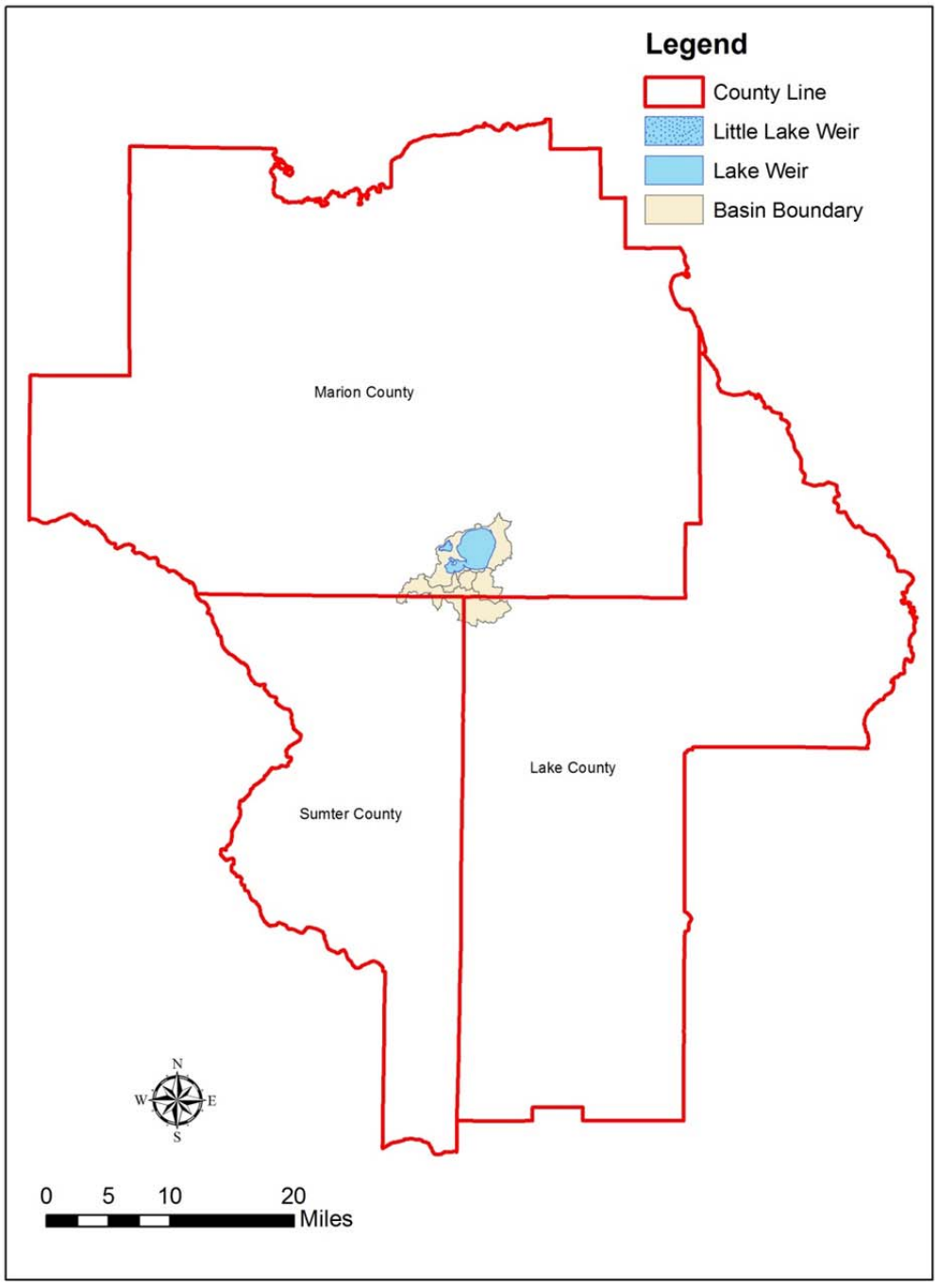

Figure 1 – Location of Lake Weir and Contributing Sub-basins

Data Review

In Task A, DSLLC reviewed the data required for the development and calibration of HSPF model. Detailed information of the summary of data review is included in **Appendix A**.

DSLLC reviewed the data provided by the SJRWMD, listed as follows.

- Lake stage
- Lake bathymetry
- Hourly rainfall and evapotranspiration (ET)
- Surface water withdrawals
- District 2015 recharge map
- Land cover data
- Soil distribution
- Watershed boundary
- 10-m DEM data
- USGS quad map
- DEM contour map

Through the data review process, it was determined that the data provided by the SJRWMD was sufficient to develop and calibrate the HSPF hydrologic model of Lake Weir. After discussions with the SJRWMD staff, the following two decisions were made regarding the modeling approach.

- **Calibration Period**. The proposed model calibration period for the Lake Weir HSPF model was from year 2003 to year 2014, which covers all three hydrologic conditions (dry, average, and wet conditions). Year 2003 was used as the model spin-up year.

- **Watershed Boundary**. Based on the analysis of annual and seasonal general groundwater flow directions using the potentiometric maps of the Surficial Aquifer (SA) and UFA, the Morriston sub-basin was included within the basin boundary, however, it does not contribute surface runoff and interflow to Lake Weir. A small percentage of the Morriston sub-basin base flow was routed into Lake Weir as part of the calibration process. The Bowers Lake, Smith Lake and Tiger Lake Sub-basins were not included within the final watershed boundary based on the ArcHydro analysis, District basin delineation and specific local drainage knowledge.

HSPF Model Setup

For Task B, the data review as part of Task A was used to set up the HSPF model of Lake Weir. Detailed information of the HSPF model setup is given in **Appendix B**.

A brief description of the HSPF model setup for Lake Weir is given below.

- **Model time step**. The developed HSPF model runs on an hourly time step.
- **Simulation period**. The model simulation period was from 2003 to 2014, with year 2003 representing the spin-up year.
- **Land use**. The 2009 land cover data provided by the SJRWMD were used in the HSPF model setup. These 67 SJRWMD landuse categories were re-grouped into 13 categories for the HSPF application.
- **Sub-basin slope calculation**. The average slope for each sub-basin was calculated based on the 10-m DEM data provided by the SJRWMD using the Spatial Analyst Tools of ArcGIS.
- **Riparian wetland simulation**. The shrinking and expansion of the riparian wetland area was simulated using the Special Action developed by the SJRWMD.
- **Seepage flow calculation**. The complex water exchange between Lake Weir and the UFA was simplified with a water exchange relationship between UFA and Lake Weir based on Darcy's law. The calculation of seepage flow was achieved in the Special Action block.

HSPF Model Calibration

In Task C, the developed Lake Weir HSPF model was calibrated to match the observed lake stage data. Detailed information of the HSPF model calibration results is given in **Appendix C**. The model calibration procedure is given as follows.

1) Estimation of initial model input parameters
2) Estimation of initial seepage rate
3) Adjustment of hydrological parameters
4) Adjustment of the fraction of baseflow from Morriston to Lake Weir
5) Calculation of annual water budget

The simulated lake stages by the HSPF model were compared to the observed lake stage data, as shown in Figure 2. The following criteria were used to evaluate the Lake Weir HSPF model performance.

I. Maximize (at least 85%) the number of modeled lake stages within ±0.5 feet of measured values;
II. Model Nash-Sutcliffe coefficient (NSE) should be at least 0.85.

The developed Lake Weir HSPF model achieved a value of 83.9% modeled stages within +/- 0.5 feet of measured values, which does not meet the 85% model calibration criteria. At the 85% level, the

difference between daily observed and modeled stages was +/- 0.6 feet. The calibrated HSPF model did achieve a value of 0.93 for the NSE, which meets the minimum NSE of at least 0.85.

Lake Weir discharges into Marshall Swamp in the north via a flow control weir structure. There were no outflows through the flow control weir during the whole calibration period. Hence, Lake Weir was acting like a ponding lake without outlets for the calibration period. Under this condition, any errors in the major hydrological components could cause long-term accumulating errors for the watershed model.

The most possible reasons for the discrepancy between the modeled and observed water stages include 1) the difference between the actual rainfall in Lake Weir watershed and gauge rainfall used in the model, especially for the localized storm events; 2) the difference between the actual PET in Lake Weir watershed and the calculated PET using Hargreaves approach from the closest station of Ocala, which may not be representative of Lake Weir for some particular time periods; and 3) the difficulties in representing the complex water exchanges among Lake Weir, the SA, and the UFA due to data limitation.

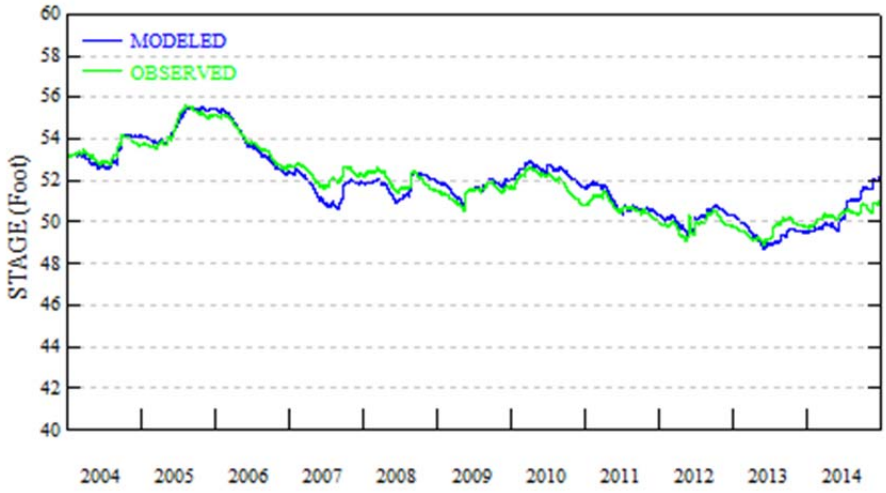

Figure 2 - Comparison of Observed and Modeled Lake Stages of Lake Weir

Based on the calibrated Lake Weir HSPF model, the average annual rainfall, total runoff, ET and seepage from Lake Weir to the UFA are 22,382 , 6,805, 23,891 and 5,841 acre-feet, respectively. The annual water budget results are given in Table 1.

Table 1 – Estimated Annual Water Budget based on the Lake Weir HSPF Model

Year	ΔVolume	Rainfall	Runoff	ET	Overflow	Seepage
2004	5,600	26,700	8,590	24,300	0	5,390
2005	8,000	27,800	9,010	24,500	0	4,310
2006	-18,000	12,800	1,960	25,700	0	7,060
2007	-2,900	22,000	6,270	23,600	0	7,570
2008	200	21,600	8,190	23,400	0	6,190
2009	300	23,600	6,820	24,000	0	6,120
2010	-2,300	21,300	6,780	24,400	0	5,980
2011	-7,200	20,200	4,680	24,500	0	7,580
2012	0	22,400	7,090	23,200	0	6,290
2013	-4,700	17,900	4,360	22,400	0	4,560
2014	15,000	29,900	11,100	22,800	0	3,200
Average	-545	22,382	6,805	23,891	0	5,841

Note: Unit is acre-feet; sign – means that lake loses water.