Crystal Lake HSPF Model Development, Documentation, and Long-Term Simulation Review

Initial Comments

for St. Johns River Management District

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Objectives

Provide independent technical peer review of *scientific and technical data*, *methodologies*, and *assumptions* related to the development and application of the CCL HSPF model including long-term simulations for the determination and/or assessment of MFLs

Outline

- Crystal Lake Model
- Documentation and Model Files
- Scope of Review
- Review Questions
- Summary

Crystal Lake Model

- Hydrologic HSPF model of the Crystal Channel of Lakes was developed by the District Staff in 2023

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Documentation and Model Files

- Report: Hydrological Modeling of the Crystal Chain of Lakes, Seminole County, Florida by Olkeba T. Leta, Yanbing Jia, and Tom Jobes at SJRWMD
- Model Files: EC_hspf_LT_nb.uci and associated WDM files

Note: both report and model files downloaded from *https://www.sjrwmd.com/minimumflowsandlevels/crystal-lake/*

Scope of Review

- *Assess the adequacy and appropriateness of the data* used in model development and calibration;
- *Assess the validity, defensibility and appropriateness* of the model development and calibration including
  - If the model is appropriate, defensible, and valid, given the District's MFLs approach;
  - Evaluating all assumptions used in the model development and calibration; and
  - Review of the model input and output data
- Development of an independent water budget.

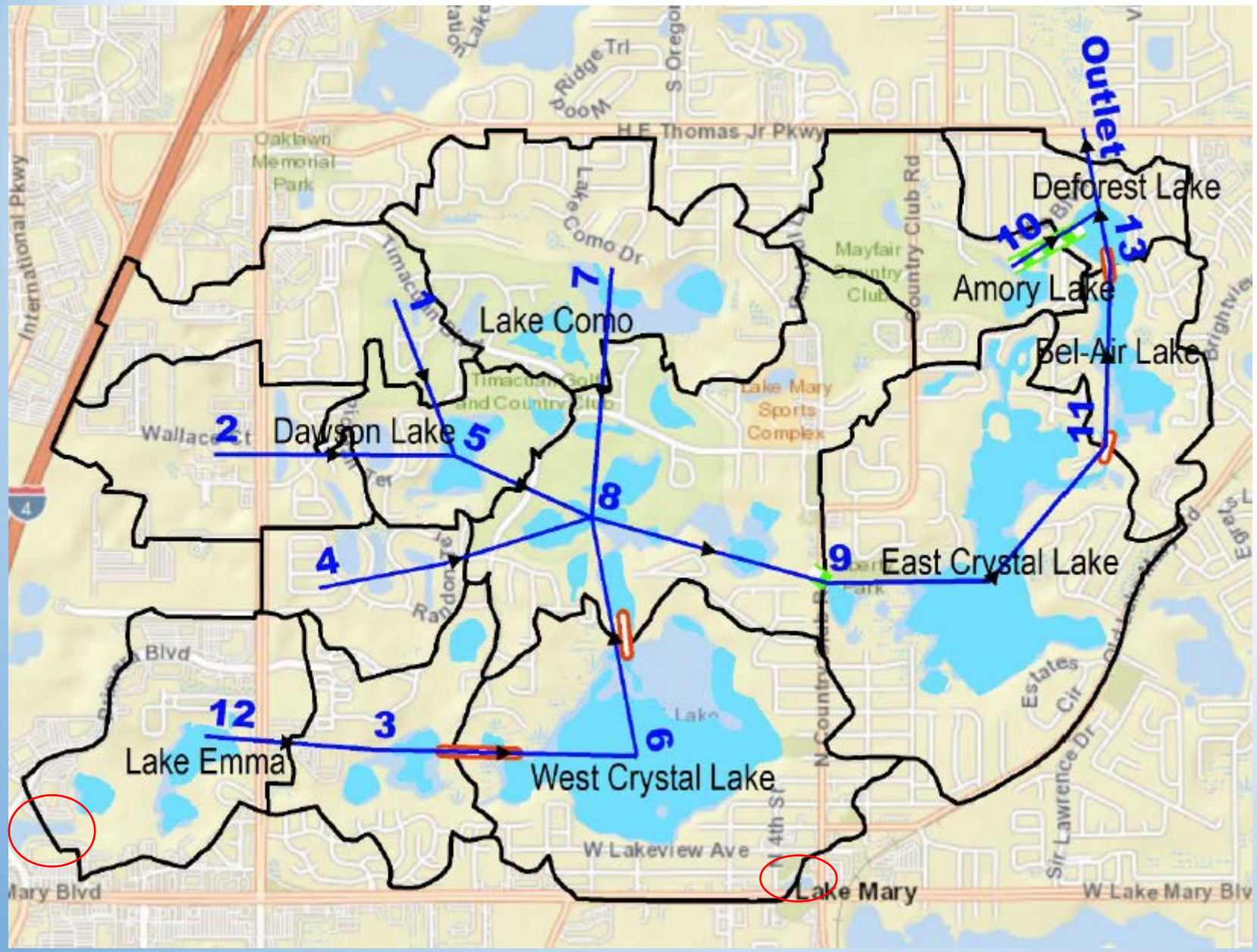
- **Assess the adequacy and appropriateness of the data used in model development and calibration**

Data Reviewed and Assessed

- Watershed boundary – SJRWMD's GIS database coupling with site visit and previous studies;
- Land use and land cover – 2014 LULC from SJRWMD;
- Soil data – NRC SSURGO soil hydrologic groups A and A/D;
- Topo data – 10 m resolution of DEM data from SJRWMD;
- Lake bathymetry – Amory, E. Crystal, Bel-Air and DeForest from USF and ERD (2014). ICPR model by CDM 2002 as secondary data;
- Rainfall data – NEXRAD (1995-2019), NOAA Sanford station (1956-present), and other SJRWMD's stations (discontinued records);

Data Reviewed and Assessed (*cont.*)

- PET data – using the Hargreaves's method and min and max temperature data from NOAA's Sanford station;
- Groundwater levels – daily UFA S-0975 well (since 2010) within the basin, extended to 1953 to 2019 with S-0125 well (since 1951) based on monthly offsets with line of organic correlation (LOC) method;
- Lake levels – East and West Crystal, DeForest, and Emma (irregular POR since 1993) from SJRWMD's and Seminole's hydrologic databases; and
- Leakance – ECFTX groundwater model.



Minor Comment:

- Sub-basin boundary intercepting with a waterbody (with a red circle) needs to be adjusted.
- Impact of the adjustment to the model results should be negligible.

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Review Questions

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

   Yes.

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

   No. 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?**

   No. No.

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

a. **Determine if the model is appropriate, defensible, and valid, given the District's MFLs approach.**

- Datasets for model setup and simulation;
- Key parameters of INFILT, CEPSC, UZSN, LZETP, LZSN, DEEPFR and leakance K with acceptable range of possible values;
- Special Actions for riparian wetlands (variable PERLND and RCHRES surface areas), lake and UFA interactions, and reverse flows;
- Calibration (2007-2019) and validation (1995-2006) included dry, avg and wet years;

a. **Determine if the model is appropriate, defensible, and valid, given the District's MFLs approach** *(cont.).*

- FTABLEs derived from ICPR model and available bathymetry data;
- Culvert and weir flows under different tailwater conditions;
- Lake stages were well calibrated and validated – TS plots, exceedance curves, statistical parameters NSE, RMSE, ME and +/- 1 ft bracket;
- Simulated deep recharge is within the ranges of the values on the District-provided recharge map; and
- Water budget by land use category are reasonable.

Average Annual Flow by Major Land Use Category
(2007-2019)

Flow (in/yr/ac)	Medium Density Residential	High Density Residential	Commercial/ Industrial	Wetland
Rainfall	52.8	52.8	52.8	52.8
Deep Recharge	6.1	5.8	6.1	7.0
AET	32.5	27.5	23.8	42.9
Runoff	15.1	21.4	25.9	2.6
Baseflow	6.5	6.8	6.5	2.5

Lake Water Budget

West Crystal Lake Annual Avg water Budget (ac-ft)

Lake	Period	Direct Rainfall	Watershed Inflow	Evaporation	Seepage	Surface Outflow	Total Inflow	Total Outflow	Storage Change
West Crystal	Calibration	512.5	762.1	489.1	523.9	245.5	1274.5	1258.5	16.0
	Percent	40.2	59.8	38.4	41.1	19.3			1.3
	Validation	670.6	2590.6	623.0	820.8	1897.2	3261.2	3340.9	-79.8
	Percent	20.6	79.4	19.1	25.2	58.2			-2.4

- Model simulated significant surface outflow from WCL. However, obs stages indicated no surface outflow from WCL for both calibration and validation periods (Note: WCL starts to discharge when its stage is greater than 42.7 ft NAVD88)
- Statistically, model-simulated long-term WCL stages appear to be acceptable for development of MFLs

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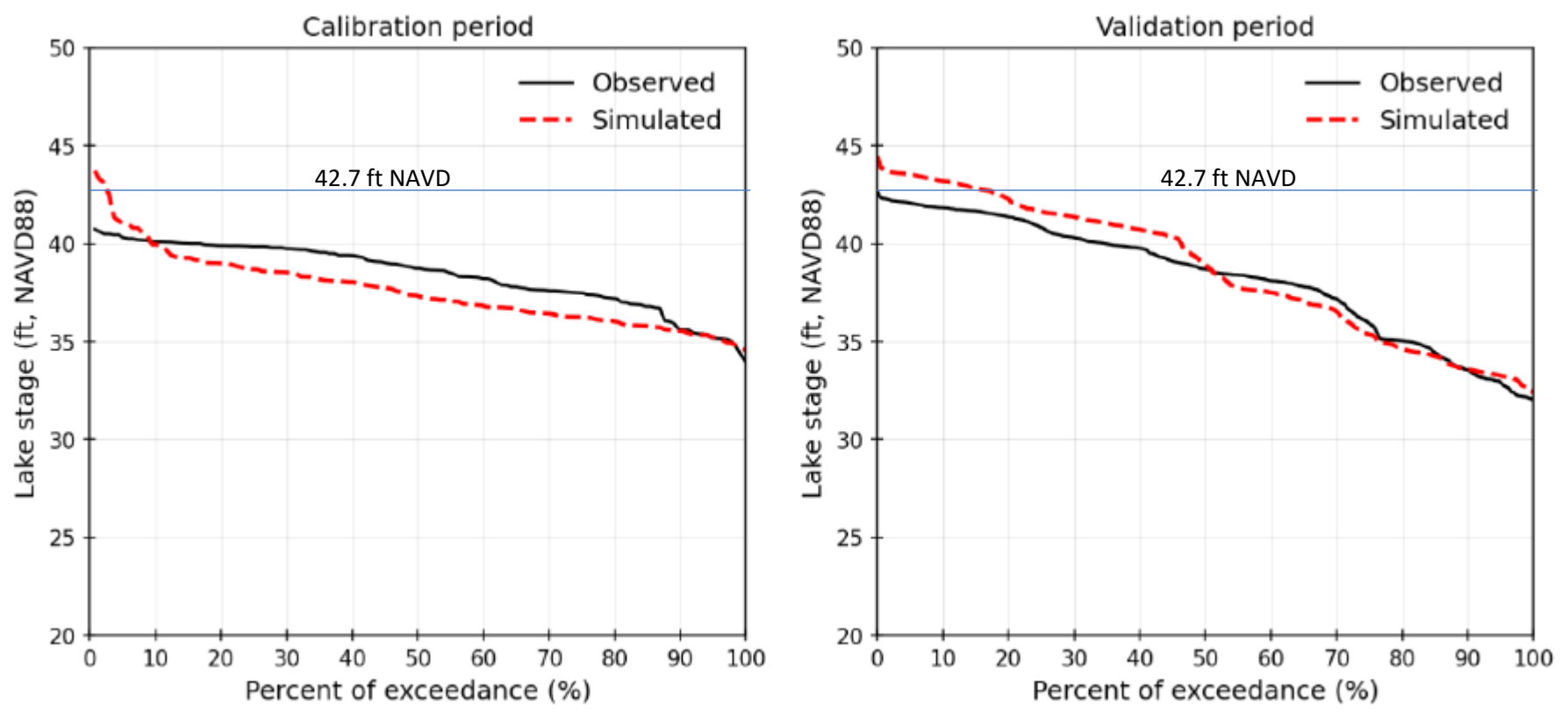
West Crystal Lake Stages – Obs v.s. Sim



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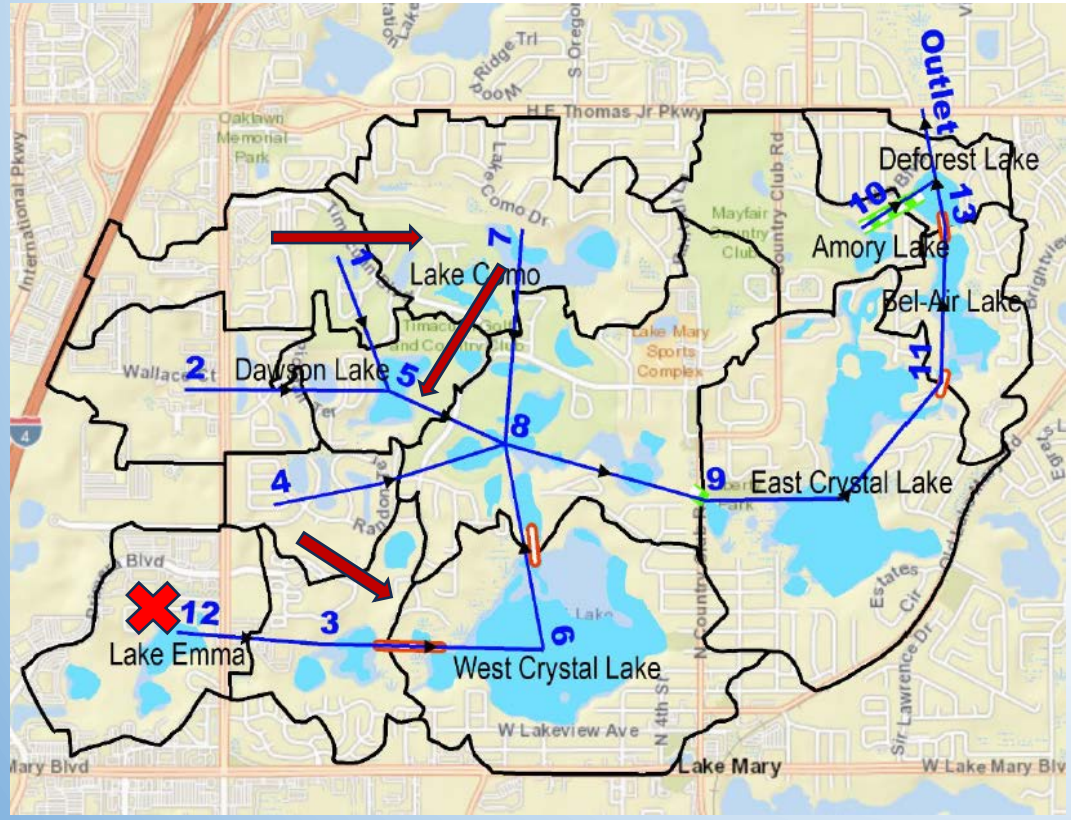
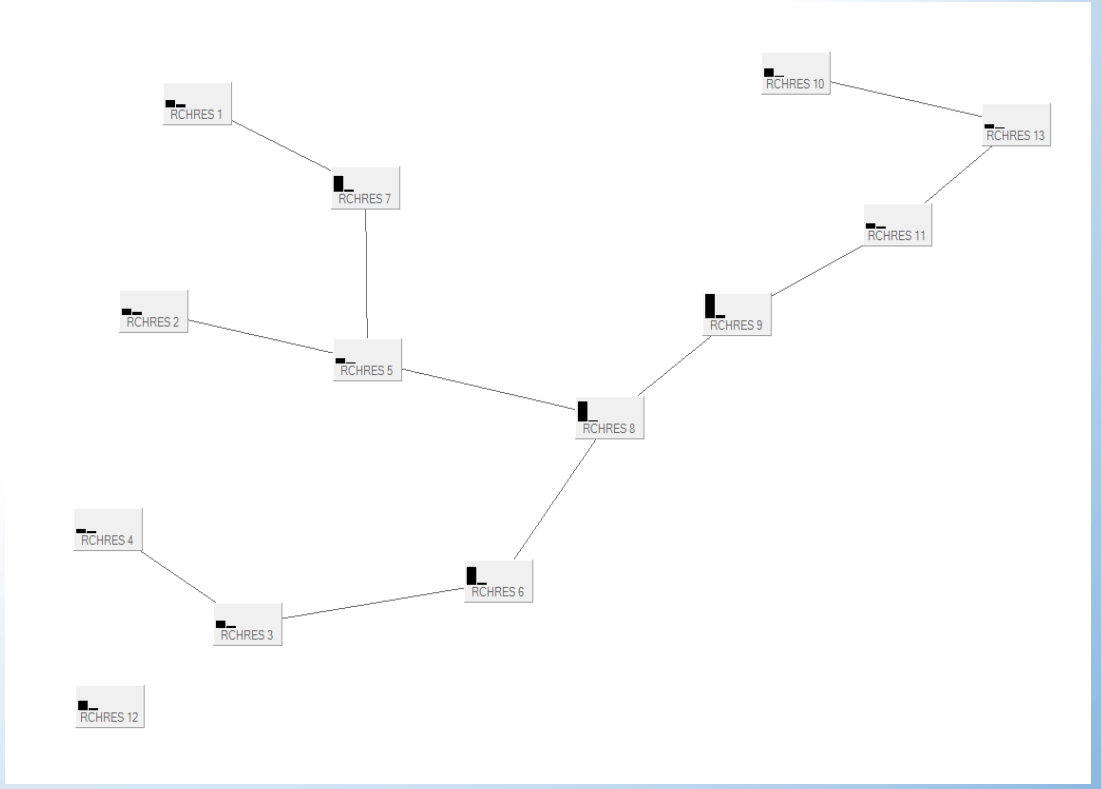
Inconsistent Reach Connection- Report v.s. UCI File





Excluding Lake Emma appears reasonable

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Comments and Questions

- The model appeared to simulate too much surface outflow from WCL to downstream ECL due to higher WCL stages.
- Does too much contributing area cause higher WCL stages? Any other isolated subbasins need to be excluded?
- Statistically, model-simulated long-term WCL stages are acceptable for development of MFLs.

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

Three Key Assumptions

1) Exclusion of Lake Emma subbasin (in UCI file) - no flow contribution to WCL
2) Correlation of UFA groundwater levels and monthly offsets between Wells S-0975 and S-0125
3) In terms of temporal trends, Lake stages of WCL and ECL are similar to those of Sylvan Lake

Review Questions

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

  Yes.

- **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?**

  No other info available. No, it should not.

c. Review of HSPF Model Input and Output

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

  In the same datum of NAVD88 ft.
- **Flow/stage plots to look for model instabilities**

  No model instabilities were observed.
- **Output file for model warnings (full flow channels, flooded nodes, etc.) and flow classification summary**

  One warning about FTABLE extrapolation for RCHRES 11, which unlikely caused any errors in model results.

- **Continuity error and convergence data**

  No continuity error and convergence data

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

  i. Annual avg 15.2 inches runoff vs 6.3 inches deep recharge /infiltration for the period of 1995 to 2019.

  ii. Considered to be reasonable for the type of soils (mostly A type) and land use (MDR, HDR, and Commercial/Industrial accounts for 50%).

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

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

- **How groundwater data was used in model inputs**
  i. Local UFA well S-0975 data used to dynamically compute lake seepage to the UFA using Darcy Law in the Special Action.
- **Methodologies used to develop input data for long-term simulations**
  i. Used the same methods from the cal/val model for PET and groundwater levels extensions back to 1953.
  ii. Hourly rainfall disaggregated from daily records at Sanford Station back to 1953 based on hourly NEXRAD (since 1995) and nearby NOAAA station (before 1995).

- **Long-term simulation results to check for reasonableness**
  i. Well simulated and reasonably follow the data trend with the exception of some higher stages of WCL.
  ii. Provided statistics such as Nash-Sutcliffe score to confirm model performance.
  iii. Comparison of the simulated stages of WCL and ECL to the long-term observed lake stages of Sylvan Lake for reasonableness.

c. Development of an Independent Water Budget

- Not yet completed but expect that similar results will be obtained compared to those in the report

Review Summary

- ✓The best info/data available were utilized. No apparent deficiencies regarding data availability were found.
- ✓The methodology used to extend the groundwater level dataset is appropriate and defensible given the best data available.
- ✓Using the Special Actions to calculate variable areas of the wetlands and surface areas of the lake, lake seepage to UFA, and reverse flow for high tailwaters are valid and appropriate.
- ✓The average annual water budgets by land use category are reasonable.

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Review Summary *(cont.)*

- ✓The model appeared to simulate too much surface outflow from WCL to downstream ECL due to higher WCL stages.
- ✓Statistically, model-simulated long-term WCL stages appear to be acceptable for development of MFLs.
- ✓The assumptions used in the model development are reasonable and consistent given the best info/data available.
- ✓The hydrologic CCL Lake model was well calibrated and validated.

Review Summary *(cont.)*

- ✓The model is considered to be appropriate, defensible, and valid given the District's MFLs approach.

Some General Comments

- Was the new stage-vol relationship also replaced in the model (page 5)?
- 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.
- Basin boundary intercepting with two lakes/ponds in Figure B-2 and related figures.
- Unit for K in the Darcy's law equation should be L/T (page 49).
- 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 incorrect 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.