

Incorporating Forecasts into the Brazos River Authority's Operational Model

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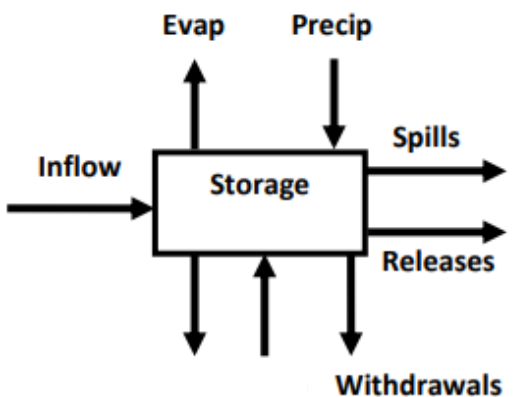


Outline

1. Configure the Williamson County Regional Raw Water System (WCRRWS) model:
 - Extend the model's water balance components to 2020
 - Gather operational data from BRA, USACE
2. Ingest suite of ensemble streamflow traces into the reservoir model to test multiple inflow scenarios for Hydrologic Ensemble Forecasting System (HEFS)
1. Preliminary assessment for reservoir operations
 - Apply observed inflows into the model to simulate observed reservoir operations for 2010 – 2019



BRA Model Adaptation



Reservoir Mass Balance



Model Overview

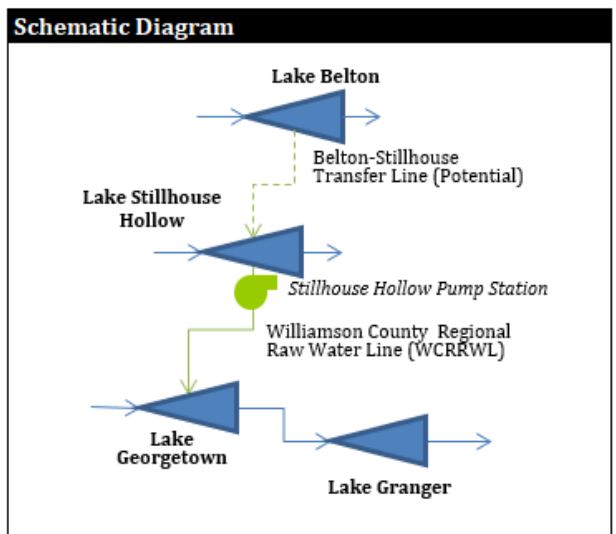
Description of modes and configuration worksheets

Simulation Modes	
Long-term	Continuous simulation over period of record (1941-2013) for pump phasing, and capital improvement strategies.
Mid-term	Simulation of 3-60 months for near-term operations and contract planning under specific expected hydrologic conditions.
Batch	Simulation over all 1-5 year historical periods based on current conditions for evaluating system performance under uncertain future hydrologic conditions.

Model Description

The Williamson County Regional Raw Water System Simulation Model is a planning tool for evaluating system performance in response to capital improvements, variable water demand, variable hydrologic conditions, alternative operational plans, and alternative electrical pricing structures.

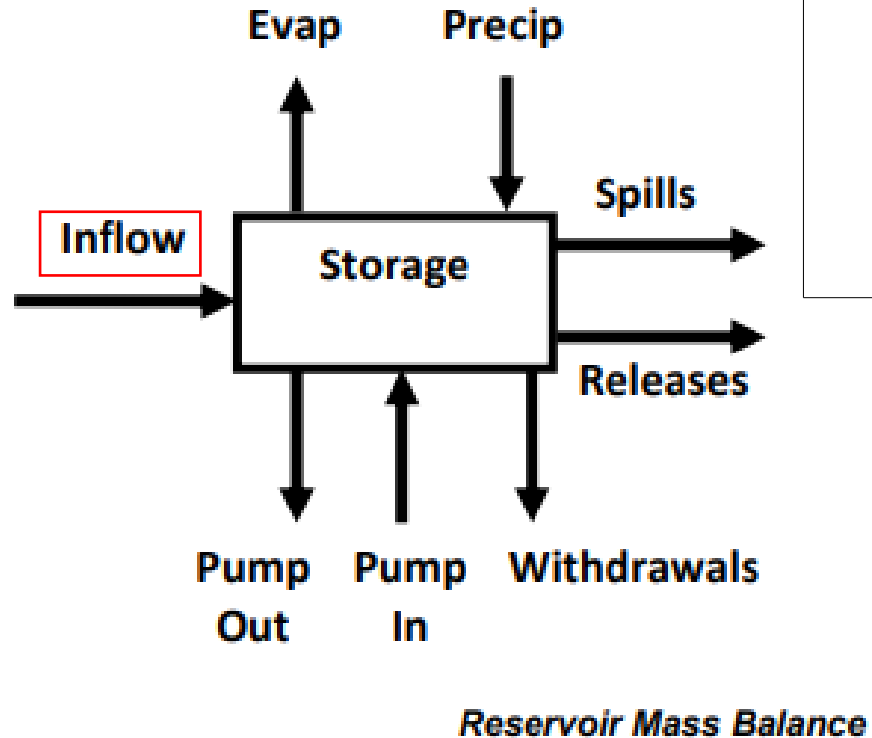
Model Configuration	
Demands	Input projected annual demands and monthly demand factors by customer
System	Set pump configurations, reservoir triggers, pipeline capacity and friction factor, dam leakage
Energy	Select energy cost structure and set prices
Reservoirs	Input elevation-area-capacity curves for each reservoir
Hydrology	Input hydrologic time series for each reservoir including inflows and net evaporation
User Pump	Specify user-defined pump operations for Mid-term or Batch modes (optional)



Notes

Cell Color Schemes	Sheet Protection
User Input (Activated)	All non-User Input cells are locked
User Input (Deactivated)	To unlock a sheet go to:
Drop-Down Menu	Review > Unprotect Sheet...
	(Alternative) File > Info > Permissions...

Mass-balance components

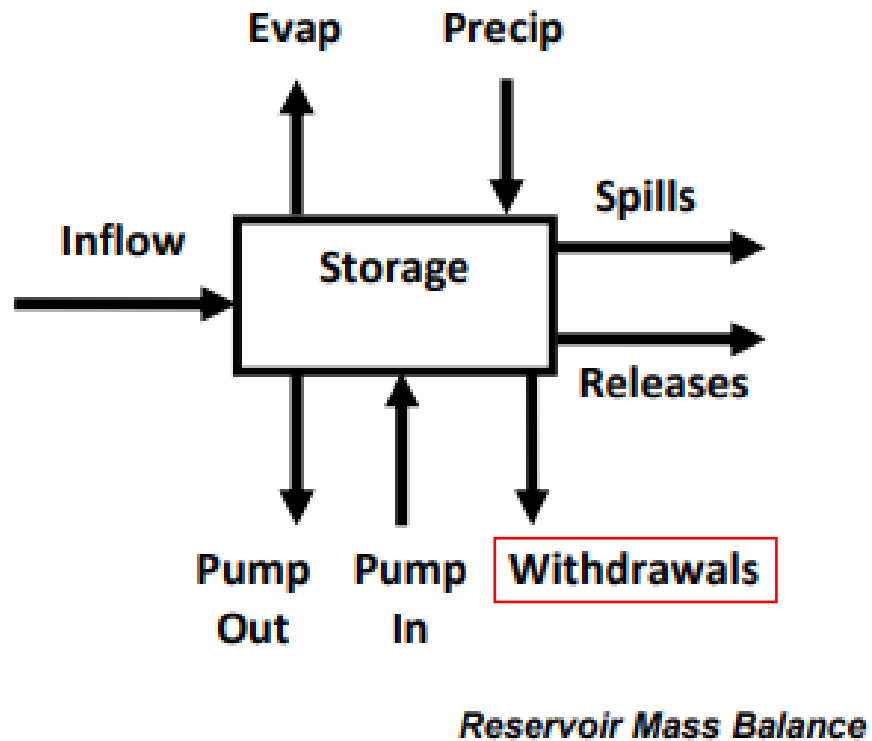


Time series of HEFS ensemble output (41 traces) shown in grays, vs **USACE observed inflows**

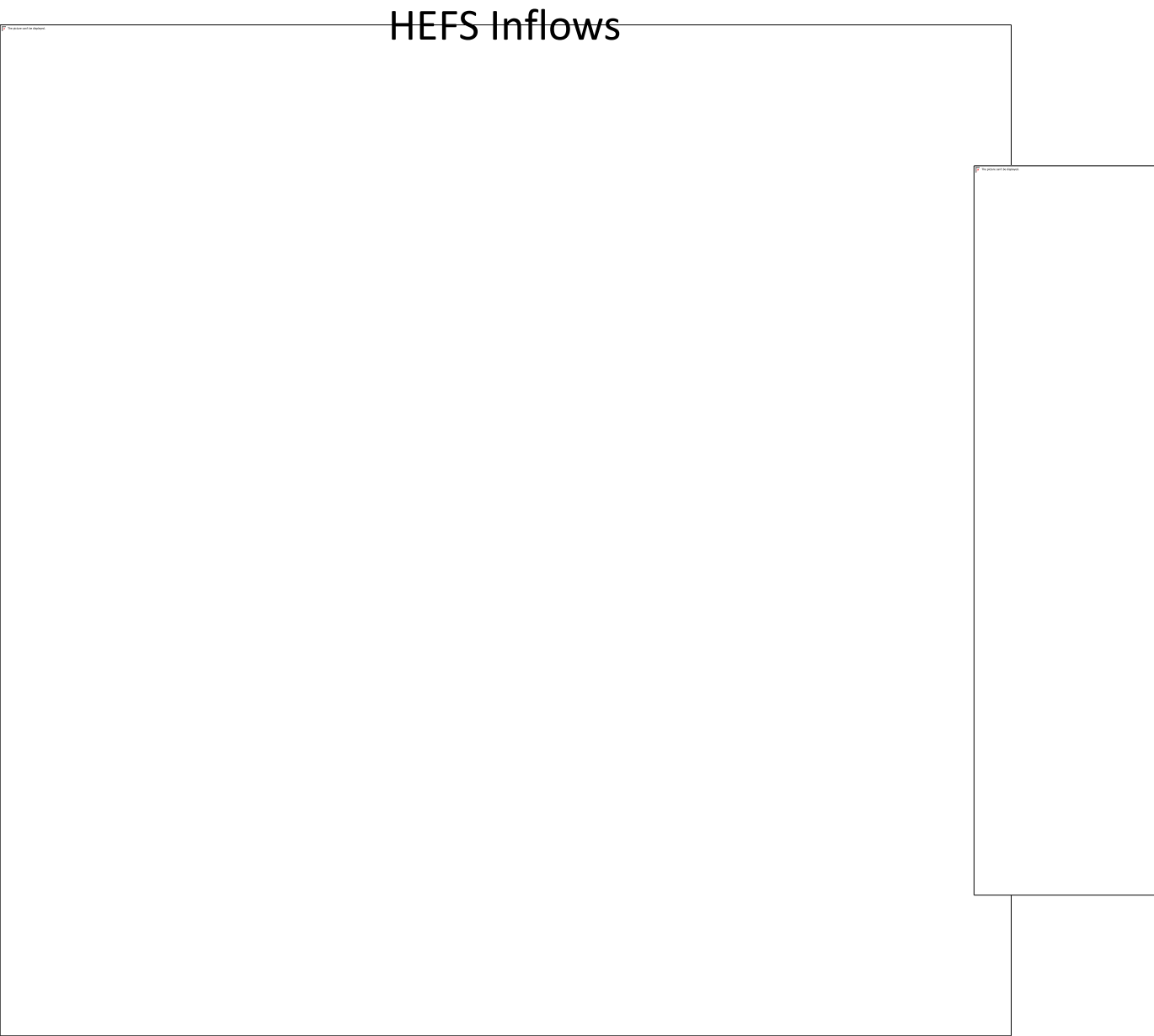
Inflows

- ~40 ensemble streamflow traces produced by Hydrologic Ensemble Forecast service (HEFS) based on resampled climatology
- OR historical estimated inflows
 - The model includes estimates from 1941 to 2013
 - USACE estimates inserted and extended to 2020
- Initial lake levels from USACE

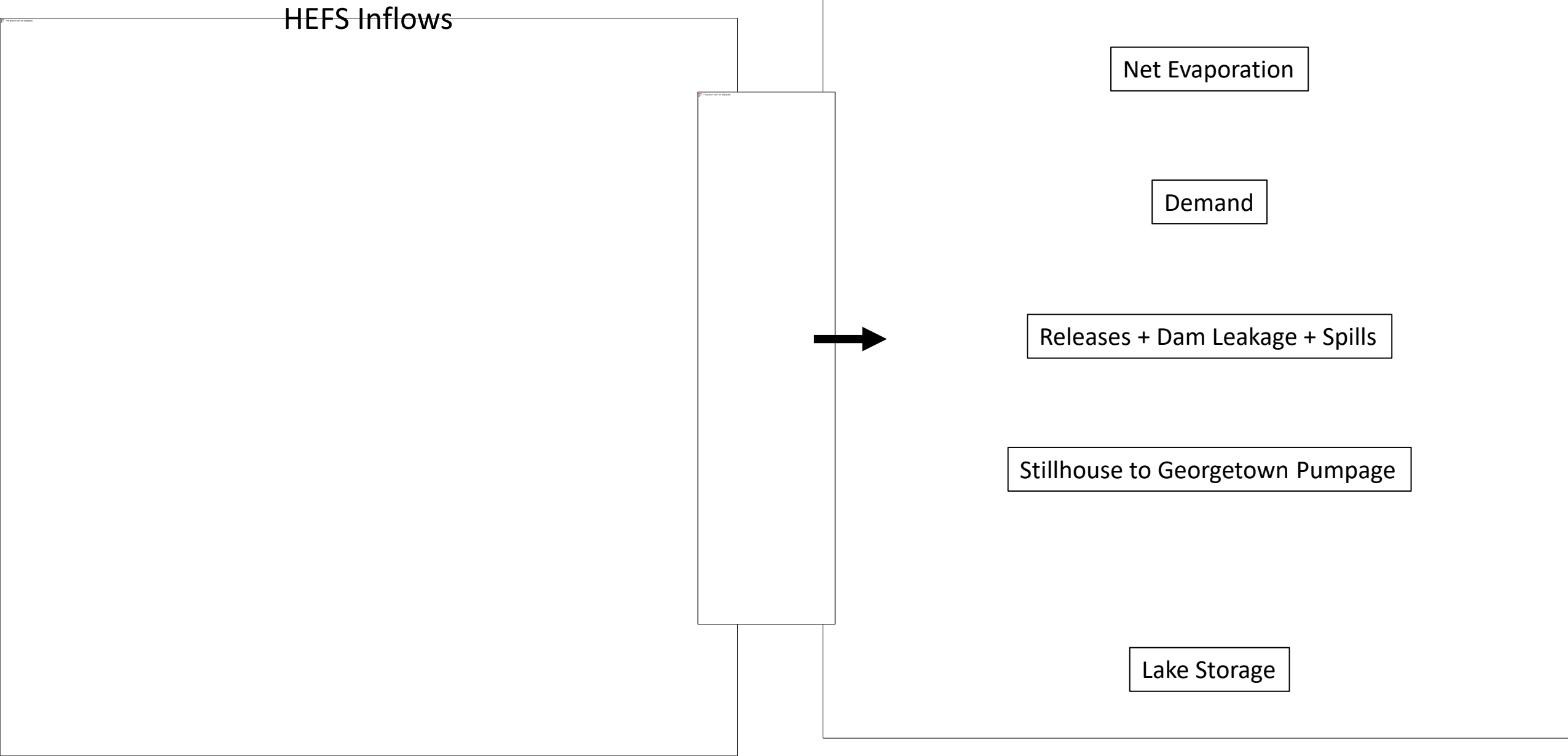
Mass-balance components



Example Model Simulation



Example Model Simulation



How well can the model represent reservoir operations?

Year 2015

Goal: Verify water balance by ingesting USACE inflow estimates into the WCRROWS model

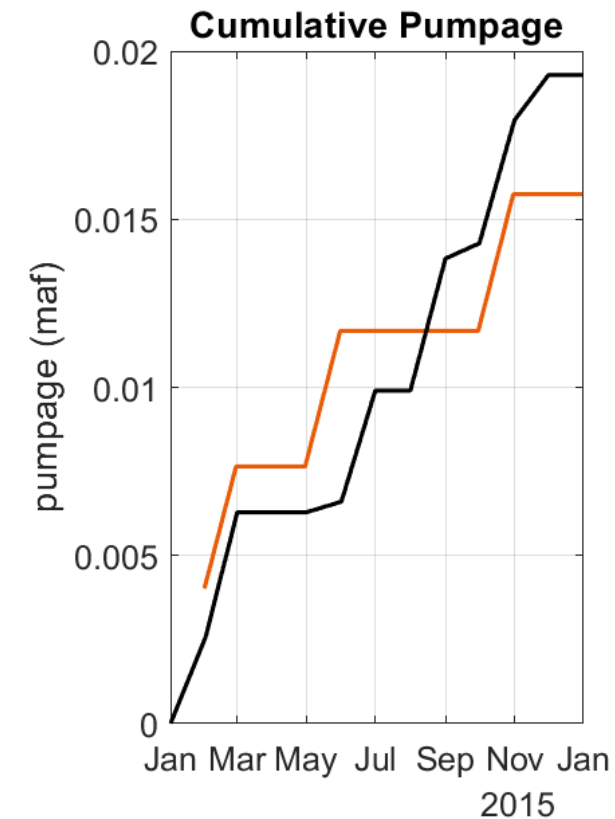
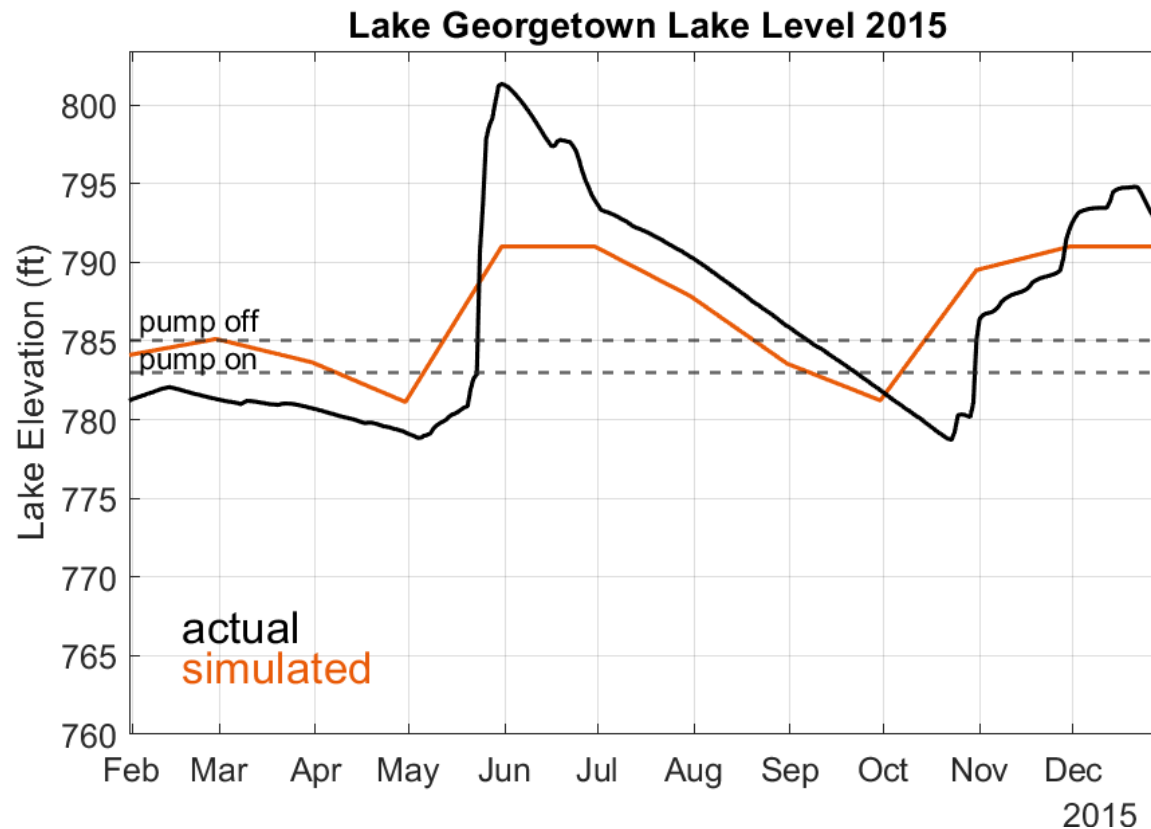
- Modeled lake level estimates tend to be conservative (i.e., underestimating extreme highs and lows)
- Model won't let lake levels exceed conservation pool
- Belton comes out of drought stage in late May

How well can the model represent reservoir operations?

Year 2015

Goal: Verify water balance by ingesting USACE inflow estimates into the WCRROWS model

- Modeled lake level estimates don't capture extreme drought
 - Extreme low lake levels, and high pump demands not captured by simulation



How well can the model represent reservoir operations?

Year 2015

Goal: Verify water balance by ingesting USACE inflow estimates into the WCRRWS model

- Some overestimation of spills and releases, due to water levels not exceeding conservation pool in model



How well can the model represent reservoir operations?

Year 2011

Goal: Verify water balance by
ingesting USACE inflow estimates
into the WCRRWS model

- For very dry year – model does not capture total decline in lake levels
- Drought stages exceeded for Belton and Granger

Conclusions

Using simple programming tools, reservoir operations models can be adapted to ingest ensemble inflow forecasts to test different scenarios

- Monthly resolution data do not always adequately capture inflows and reservoir operations for sub-monthly storm events
- Reservoir operations, in actuality, are not always according to script (maintenance issues, emergencies, etc.)

These results represent a starting point for using hydrologic science to improve reservoir management in the future

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