Surface Water Quantity Models

Progress Meeting Agenda

March 7, 2016 – Teleconference

Attendees: **CDM Smith**: John Boyer, Tim Cox, Kirk Westphal, Nina Caraway
SCDNR: Joe Gellici, Andy Wachob, Scott Harder, Alex Pellet, Bill Clendenin
DHEC: Leigh Anne Monroe, Chuck Gorman
Clemson: Jeff Allen
Technical Advisory Committee: Eddie Twilley, Ed Bruce, K.C. Price, Heather Nix, Andy Fairey, Mike Harrelson
Guest: William Gaither (Santee Cooper)

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1. **Saluda Basin Model**
    a. Lake Murray Verification Exercise (slides)
    - John Boyer summarized the results of the Lake Murray verification exercise. Lake Murray model releases were set to be equal to the historical release, and the model was run to check that the combination of inflow, evaporation, and withdrawals/discharges result in a reasonable match of historical lake levels/storage. The results showed that the modeled lake volume, particularly after 2004, trended higher than actual lake volume. This was also reflected in gaged data, which showed that modeled flow was consistently, if only slightly, higher than gaged flow. After similar testing on Lake Greenwood, it was determined that minor reference gage adjustments resulted in lower flows during the 2004-2013 period and a better match of observed lake volume for both lakes Greenwood and Murray.
    - Ed Bruce commented that the results looked promising.
    - Scott Harder asked if, after making the reference gage adjustments, the comparison of gaged and modeled flow still looked good at calibration points.
    - Tim Cox responded that, based on the monthly calibration model, the results still looked very similar, if not slightly better. Slight adjustments were made to reach gains/losses. The daily calibration model was still being updated.

- Scott Harder asked for further explanation regarding the “reset” points shown on the Lake Murray comparison of storage volumes.
- Tim Cox noted that at several times during the calibration period, there were short-duration differences in modeled vs. measured inflow, which resulted in an increase in lake volume/level. Since the releases are fixed in this exercise, this extra volume remains in the lake, and the volume/level remains elevated for the remainder of the run. The “resets” account for these several, short duration differences, and provide for a more meaningful comparison.
- John Boyer noted that the Saluda Model Report will be updated to document the results of the verification exercise and the corresponding model adjustments. The Unimpaired Flow (UIF) dataset and results memorandum will also be updated.

2. Edisto Basin

a. South Fork Edisto Verification Exercise (slides)

- John Boyer summarized the results of South Fork Edisto verification exercise. The exercise was performed based on the suggestion from Scott Harder to compare modeled and measured flows at the Montmorenci gage, which was active from 1940 to 1966. Two different versions of both the daily and monthly calibration model were run over the period 1940-1966. One version (Scenario A) used EDO5 on the South Fork Edisto as the reference gage for all South Fork Edisto headwater tributaries. The other run (Scenario B, which reflects the current calibration model), used McTier Creek as the reference gage for all South Fork Edisto headwater tributaries, except the mainstem headwater. The results indicated that over the 1940-1966 period, Scenario A had a reasonable match of low flows, but under-predicted peak flows. Scenario B under-predicted low flows, over-predicted the infrequent and short duration high flows, and matches the average flows reasonably. Cumulative measured flows in both scenarios exceeded cumulative modeled flows over the period. John noted that by making a slight adjustment to the South Fork Edisto reach gain for Scenario B, the match of low flows was significantly improved, and the bias for under predicting cumulative flows was removed. John also noted that the model does not account for the attenuating effects of the many small impoundments that are located on the tributaries, and this could account for the fact that modeled peak flows exceed measured peak flows.

- Joe Gellici offered a variation of that theory, suggesting that the impoundments may have more of an effect on low flows, and could be the cause of differences in modeled vs. measured low flows.
- Scott Harder noted that, because of a lack of sufficient streamflow gaging information in the Edisto, the model is likely as good as it can be at this point. Scott further suggested that some type of routing would be necessary, if further improvements where desired.
- Tim Cox agreed that only with additional streamflow data, could possible model improvements be made; however, the current model still shows a very good match of measured and modeled flows, at the available calibration points, and especially at the more important low flows.
- Alex Pellet noted that through UIF testing and model calibration, area proration has limitations in this basin.
- Eddie Twilley asked, given these latest results, how do we know the model is producing reasonable results and will be a useful tool?
- John Boyer responded, that even before the minor reach gain adjustment was made as a result of this verification exercise, the Edisto model had a very good match of measured and modeled flows at locations where gage data was available. He noted there will be always be some uncertainty, especially in basins like the Edisto, where there is very little gage data available on the tributaries which feed the north and south forks of the Edisto.

3. Other Basins

a. Pee Dee Basin

i. Incorporation of flows from North Carolina

- Kirk Westphal explained that there are three primary sub-basins in the Pee Dee which receive flow from North Carolina (NC). The largest flows come from the Yadkin. Here, we have UIFs calculated at Blewett Falls for the period 1955-2013. These were developed by HDR to support the Yadkin River basin CHEOPS model. CDM Smith will use these UIFs. The Little Pee Dee River also received flow from tributaries that drain directly to the Little Pee Dee and from the Lumber River. Since UIFs for these sub-basins are not yet available (the NC Lumber River Basin model is still being developed), CDM Smith proposes to use the managed flows.
- Scott Harder asked if CDM Smith was aware of what impairments might exist in the Little Pee Dee/Lumber River sub-basins in NC.

- John Boyer responded that most water users in these sub-basins withdrawal groundwater, then discharge to surface water. The City of Lumberton does use surface water from the Lumber, in addition to groundwater.
- DNR agreed with the proposed approach to use UIFs from the Yadkin, and managed flows from NC draining to the Little Pee Dee.

ii. UIF Status

- John Boyer noted that the unextended UIFs are nearly complete in the Pee Dee, and that the extension process would begin soon. Updates to lake evaporation were also being incorporated.

b. Broad Basin

i. UIF Status

- John Boyer noted that the unextended UIFs were complete and that some of the extensions had been completed on the major tributaries to the Broad. Updates to lake evaporation were also being incorporated.

4. Other Items

a. SWAM Reservoir Enhancements – Testing Phase

- John Boyer noted that Tim Cox has completed his initial updates to SWAM, which focused on increasing the user's ability to test alternative reservoir rules. CDM Smith is now testing the updates. Joe Gellici noted that the change order covering the reservoir enhancements is still being processed, but DNR is working to get it approved.

b. Next Stakeholder Meetings – Broad and Pee Dee second meetings (late April)

- John Boyer said that the tentative dates for the next two stakeholder meetings was still late April, and that these would be the 2nd meetings in the Broad and Pee Dee.

March 7th Progress Meeting Materials

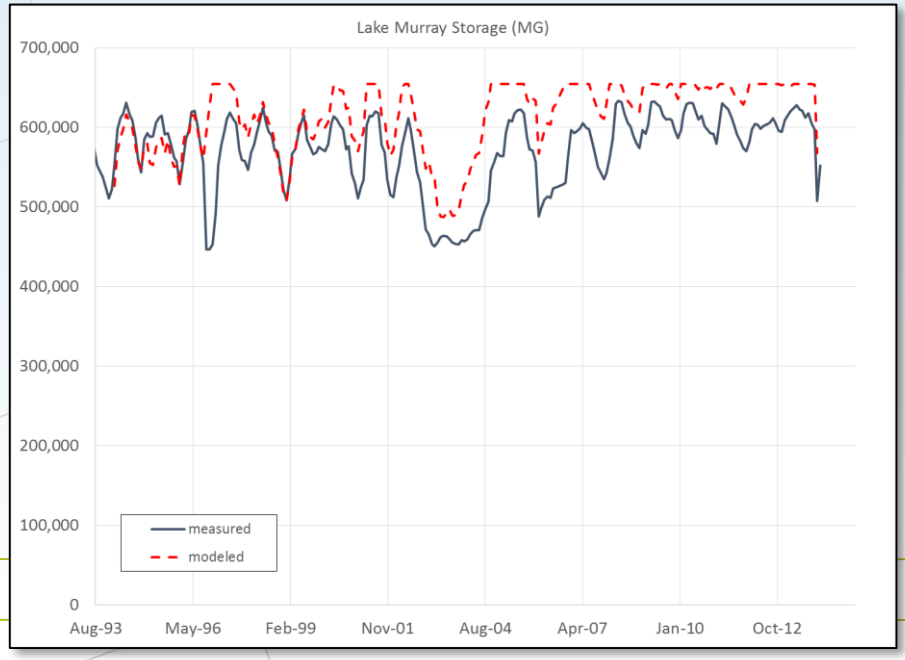
South Carolina Surface Water Quantity Modeling Project

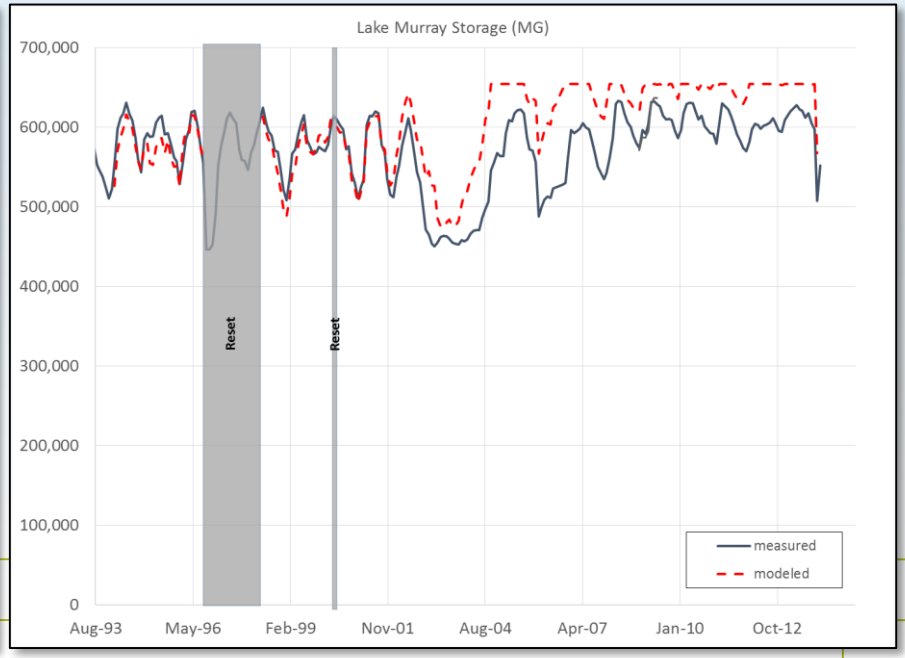
1. Saluda Basin
   - Lake Murray Verification Exercise
2. Edisto Basin
   - South Fork Edisto Verification Exercise
3. Pee Dee Basin
   - Incorporation of flows from North Carolina

Agenda Item 1
Lake Murray Verification Exercise

- **Approach**: Set the Lake Murray release equal to the historical release, then run the model to check that the combination of inflow, evaporation, and withdrawals/discharges result in a reasonable match of historical lake levels/storage.

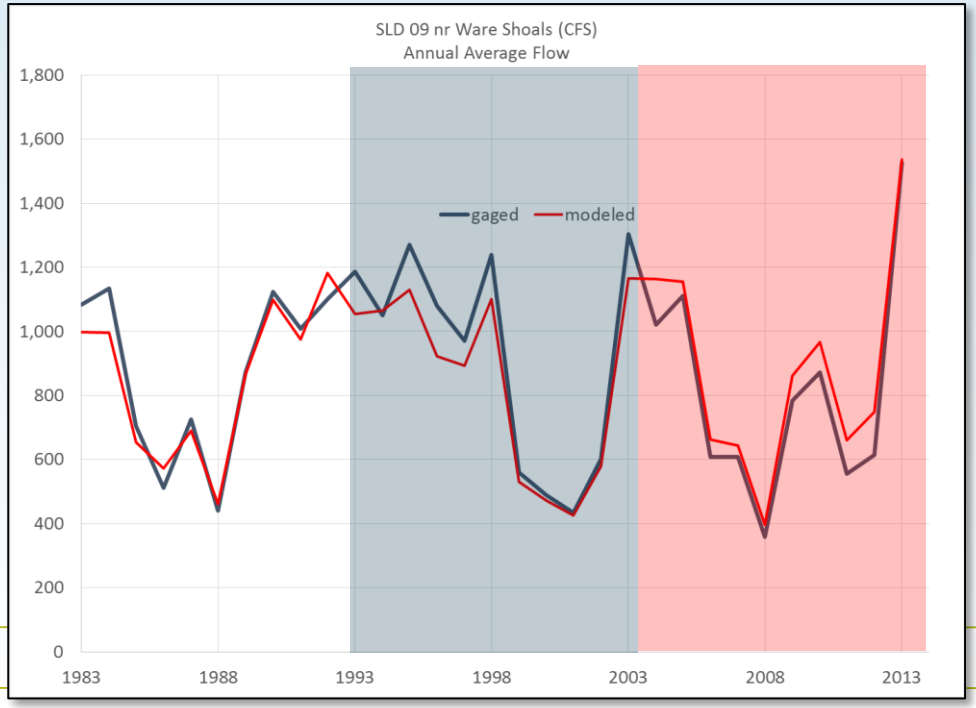
- **Observations:** Modeled lake storage was consistently higher than observed storage, even when storage was "reset" at select points.





Lake Murray Verification Exercise

- **Observations:** A closer look at calibration points upstream of Lake Murray and Lake Greenwood shows that:
  - Modeled flow is generally **less than** gaged flow from 1990 – 2003; and
  - Modeled flow is generally **greater than** gaged flow from 2004 – 2013.



Lake Murray Verification Exercise

- **Observations:** Precipitation was lower in 2004-2013 compared to 1994-2003, and the difference was greater as you move down the basin.

	Avg. Precip (in/yr)		
Period	N. Saluda	Greenwood	Murray
1994-2003	57.25	47.73	45.656
2004-2013	54.73	44.71	40.97
Difference	5%	7%	11%

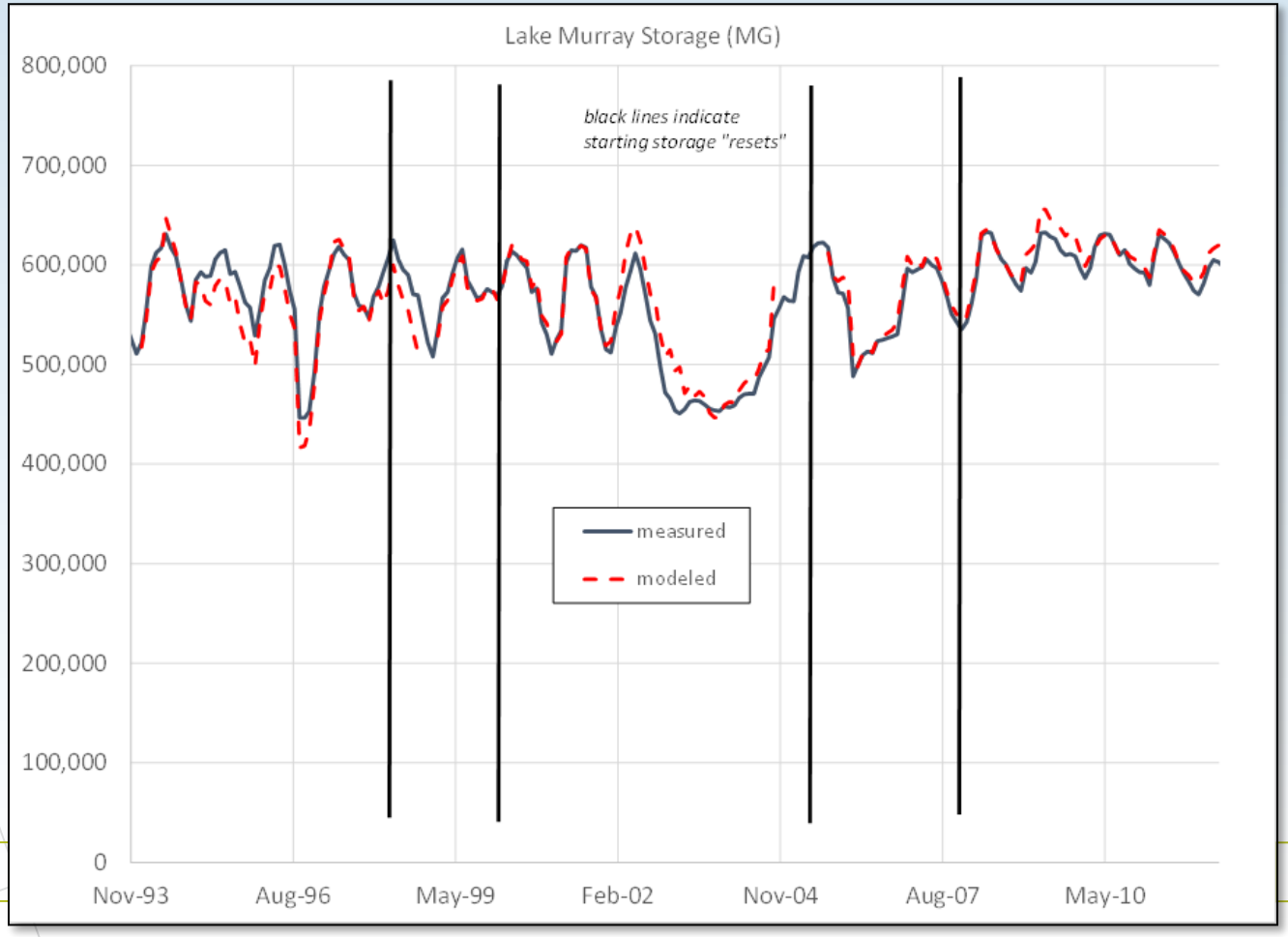
- **Theory:** The fact that the model over-predict flows in the 2004-2013 period in the lower part of the basin suggests that our headwater UIFs are perhaps too reliant on reference gages in the upper part of the basin and/or the mainstem.

Lake Murray Verification Exercise

- **Adjustments:**
  - **Clouds Creek and Little Saluda Creek:** use Little River as reference gage instead of SLD25 on the mainstem
  - **Greenwood and Murray Local Inflows:** use Little River as reference gage instead of SLD25 on the mainstem
  - **North, Middle & South Saluda:** Instead of MOVE.1, use area proration of SLD04 (first mainstem gage downstream of their confluence)
  - **Reedy River:** use SLD12/13 (closer to confluence) instead of SLD10 for headwater UIF.

Lake Murray Verification Exercise

- **Results:** Better match of modeled and measured Lake Murray storage

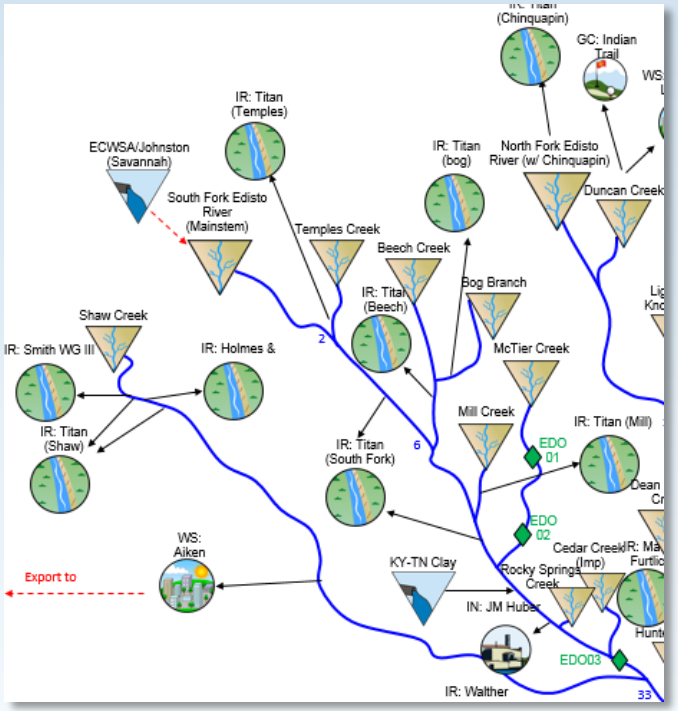


Agenda Item 2

Edisto Basin Comparison Using Different Headwater UIFs for 1940-1966 at EDO03 (Montmorenci)

Two Scenarios: **A** (from Dec 5th) **B** (from Feb 1st)

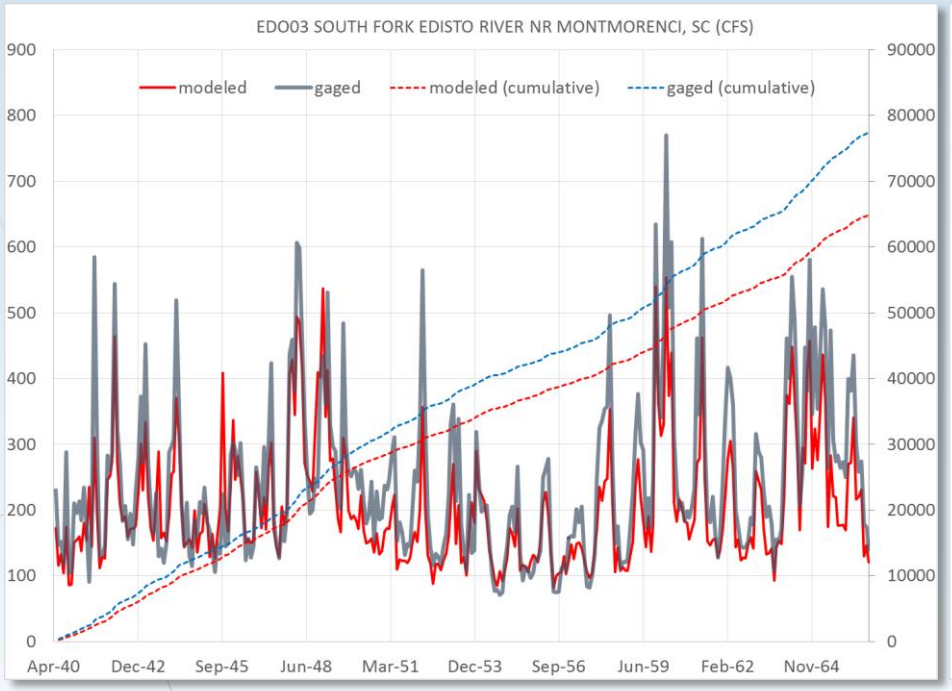
		USGS Reference Gage (Unimpaired)			
		SCENARIO A		SCENARIO B	
Project ID	SWAM Tributary	Project Gage ID	Stream	Project Gage ID	Stream
EDO202	Temples Creek	EDO05	S. Fork Edisto	EDO01	McTier Creek
EDO204	Beech Creek	EDO05	S. Fork Edisto	EDO01	McTier Creek
EDO206	Bog Branch	EDO05	S. Fork Edisto	EDO01	McTier Creek
EDO210	Mill Creek	EDO05	S. Fork Edisto	EDO01	McTier Creek
EDO218	Sykes Swamp	EDO05	S. Fork Edisto	EDO01	McTier Creek
EDO224	Goodland Creek	EDO05	S. Fork Edisto	EDO01	McTier Creek
EDO228	Windy Hill Creek	EDO05	S. Fork Edisto	EDO01	McTier Creek
EDO232	Willow Swamp	EDO05	S. Fork Edisto	EDO01	McTier Creek
EDO236	Hayes Mill Creek	EDO05	S. Fork Edisto	EDO01	McTier Creek
EDO242	Duncan Creek	EDO05	S. Fork Edisto	EDO01	McTier Creek
EDO246	Long Branch	EDO05	S. Fork Edisto	EDO01	McTier Creek
EDO248	Black Creek	EDO05	S. Fork Edisto	EDO01	McTier Creek
EDO208	S. Fork Edisto River (Mainstem)	EDO05	S. Fork Edisto	EDO05	S. Fork Edisto



Withdrawals and discharges were not included in the 1940-1966 period. Where present, they were insignificant.

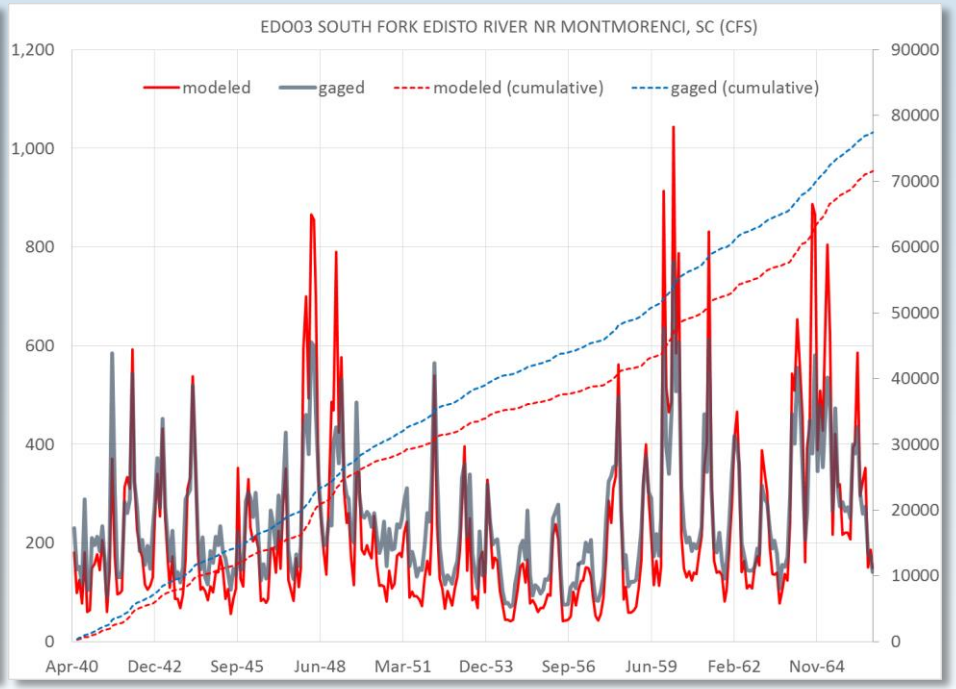
Monthly Flow Comparison

Scenario A



- *Reasonable match of low flows*
- *Model under-predicts peak flows*

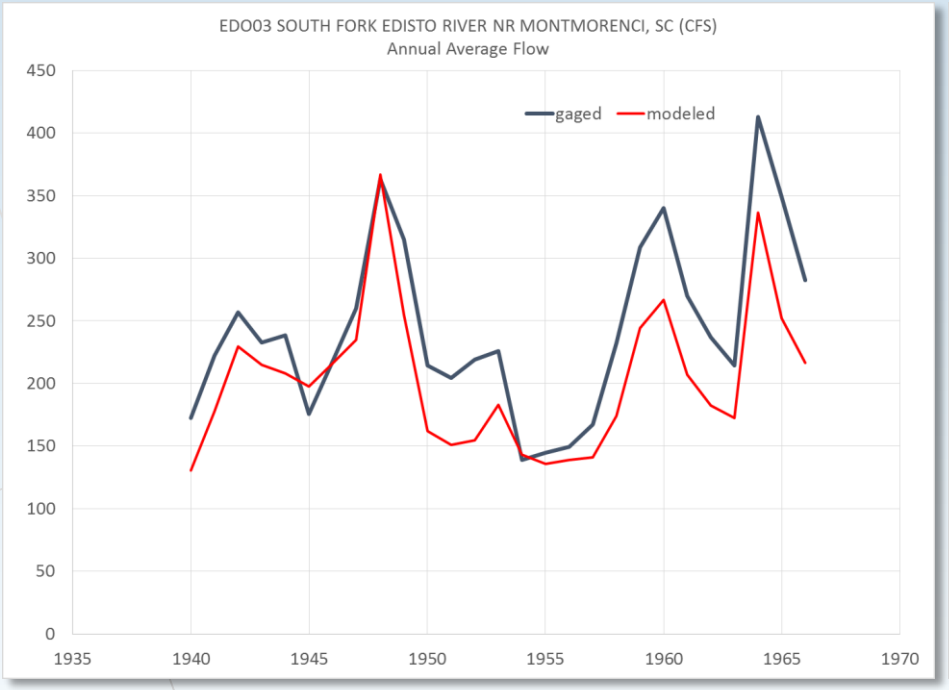
Scenario B



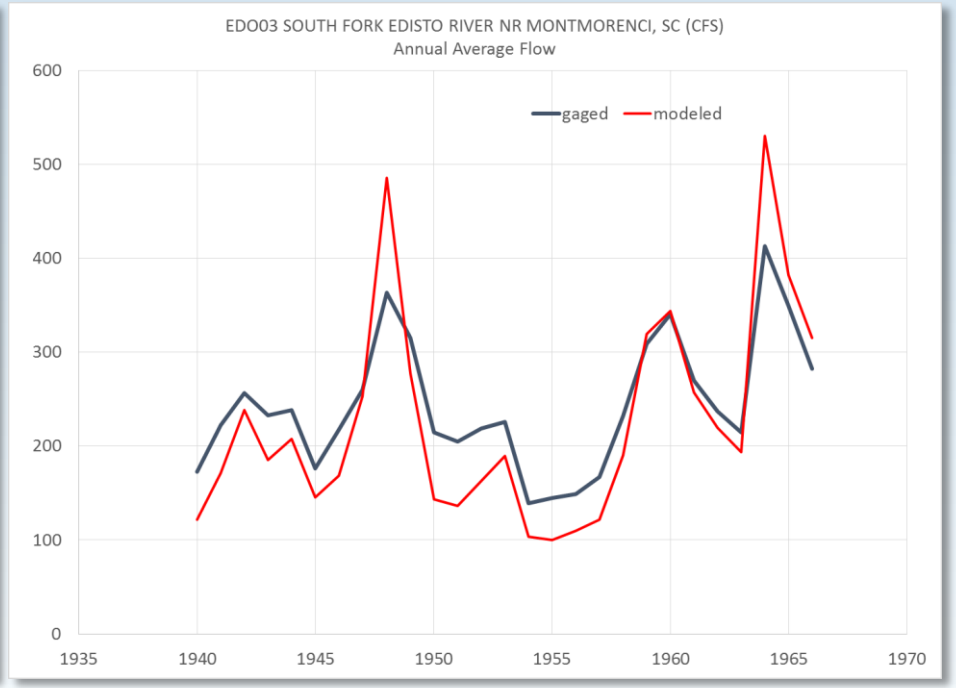
- *Model under-predicts low flows*
- *Model over-predicts high flows*

Average Annual Flow Comparison

Scenario A



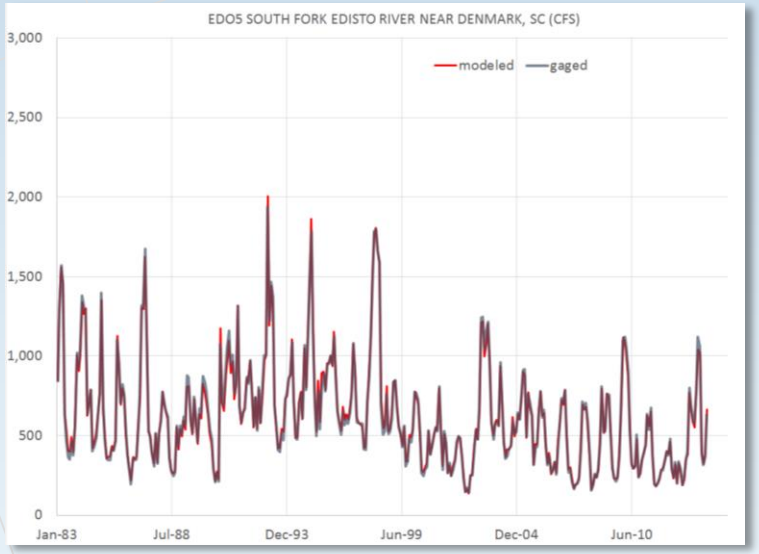
Scenario B

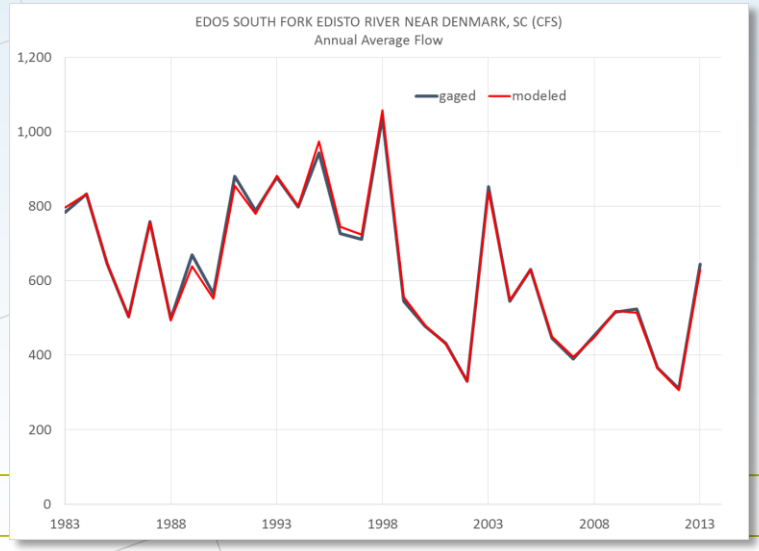


Monthly & Annual Flows, 1983 -2014 at EDO05

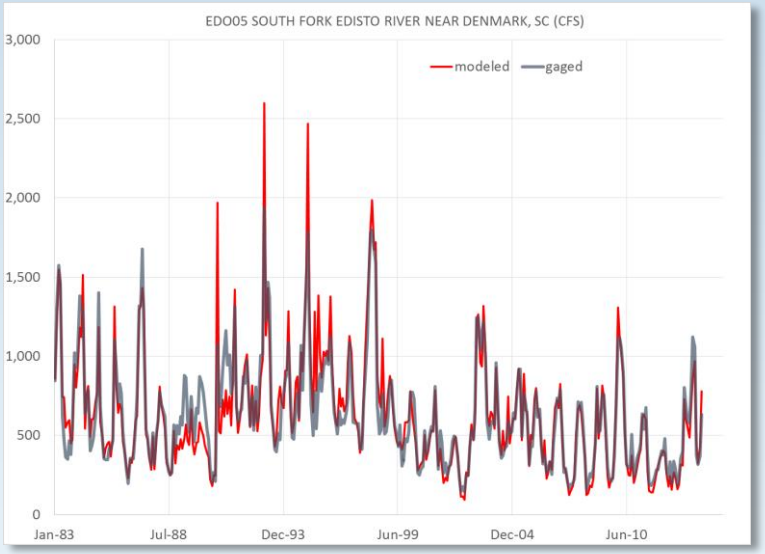
(near Denmark)

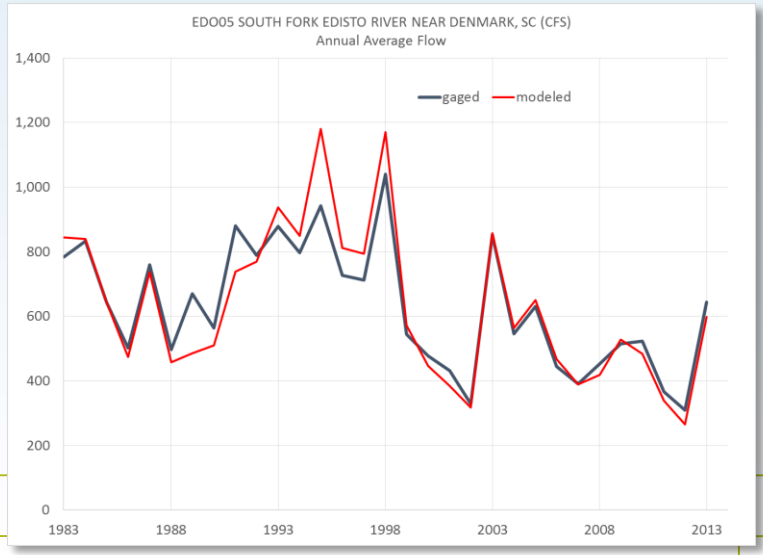
Scenario A





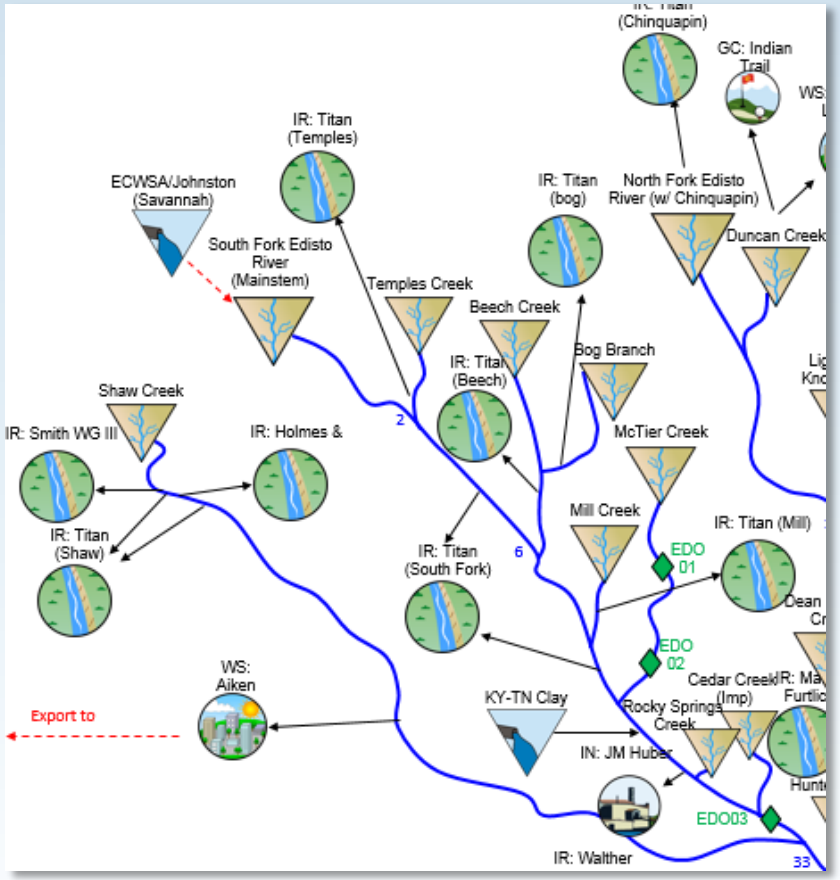
Scenario B





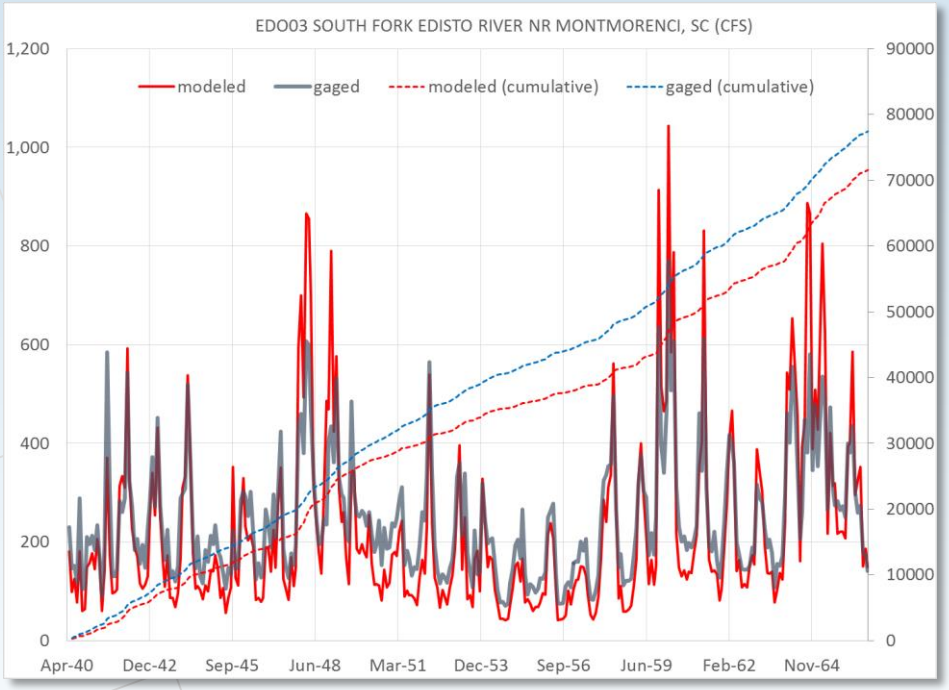
Scenario B
Can be improved through Mainstem Gain Adjustment

End Mile	Gain	Note
69.3	3.3	original (Scenario B)
43.1	5.3	new (Scenario B adj gain)

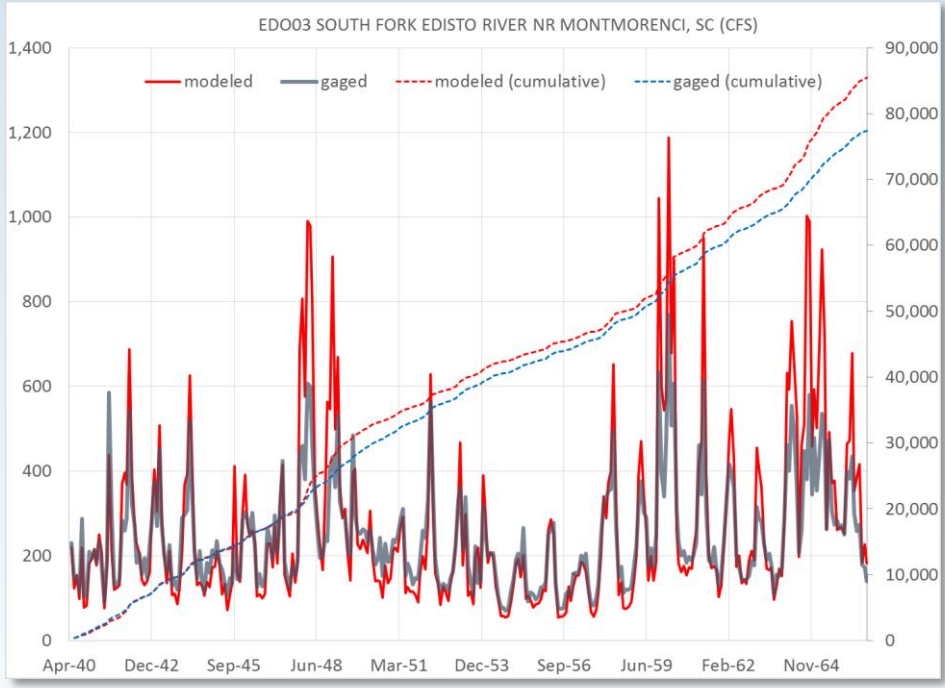


Monthly Flow Comparison

Scenario B

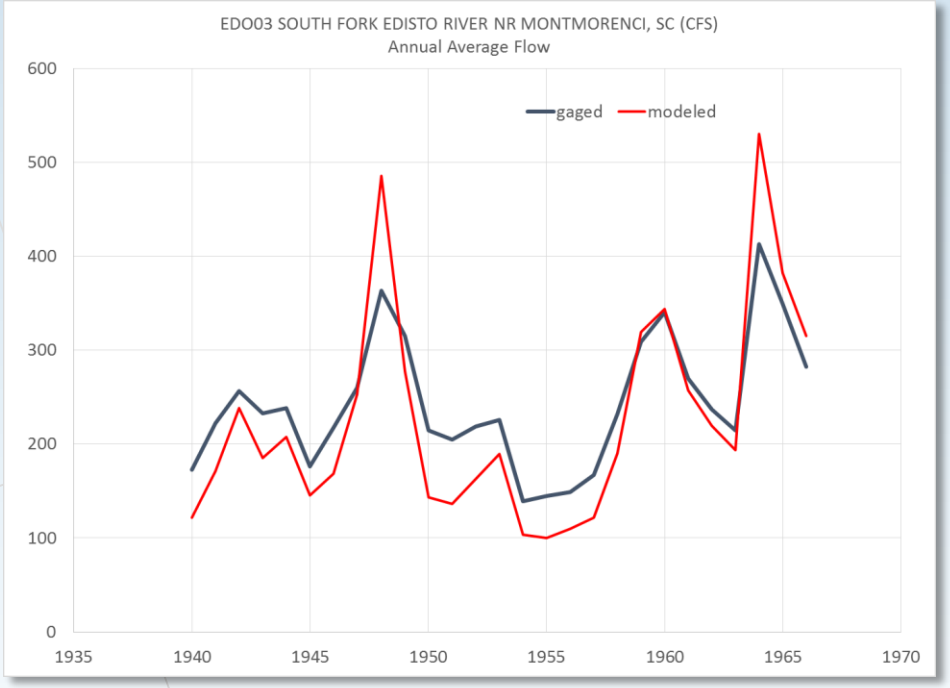


Scenario B (adj gain)

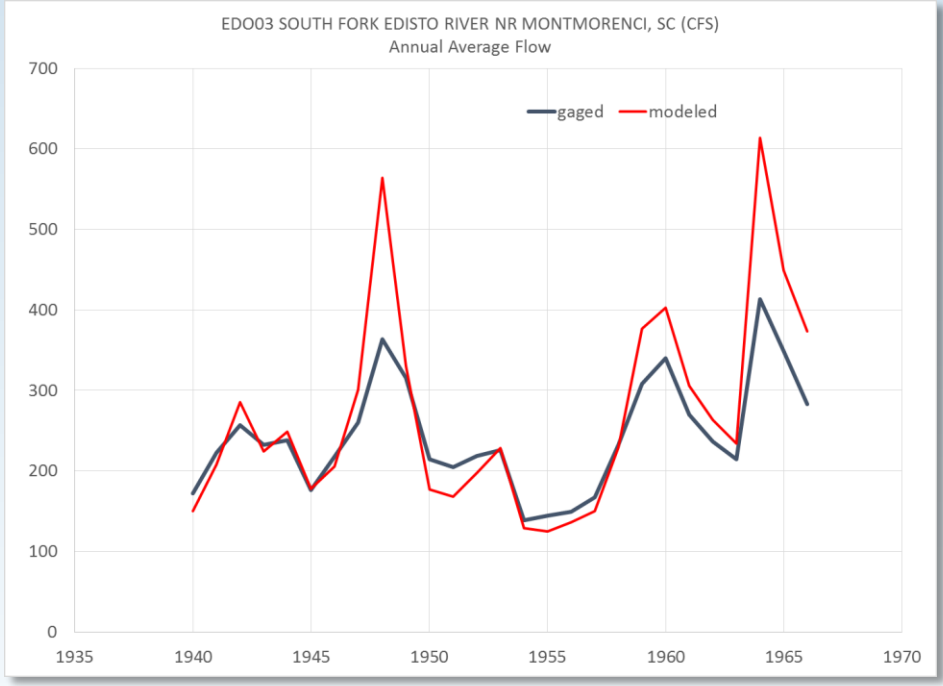


Average Annual Flow Comparison

Scenario B



Scenario B (adj gain)



Edisto S. Fork Verification Exercise and Calibration Notes

- **Calibration Goal**: achieve the right balance between "flashy" tributary and attenuated mainstem flows that best reflect the Edisto's complex hydrology.
- Emphasis was placed on low flow metrics such as drought periods, annual 7-day low flows, and 7Q10s.
- Emphasis was also given to using reference gages for headwaters tributaries that are expected to best represent their hydrology (**as in Scenario B**)
- Flashiness is likely attenuated by presence of small, irrigation ponds in headwater areas. Using McTier as reference gage exaggerates the flashiness, but likely gives better match of low flows on the tributaries (although we have no gages to check this).

Agenda Item 3
Pee Dee Flows from North Carolina

- Yadkin – Pee Dee Flows
  - UIFs available at Blewett Falls from 1955-2013
- Little Pee Dee
  - only managed flows available
- Lumber River
  - only managed flows available