South Carolina Surface Water Quantity Modeling Project

Edisto Basin Meeting No. 2 – Introduction to the Draft Model

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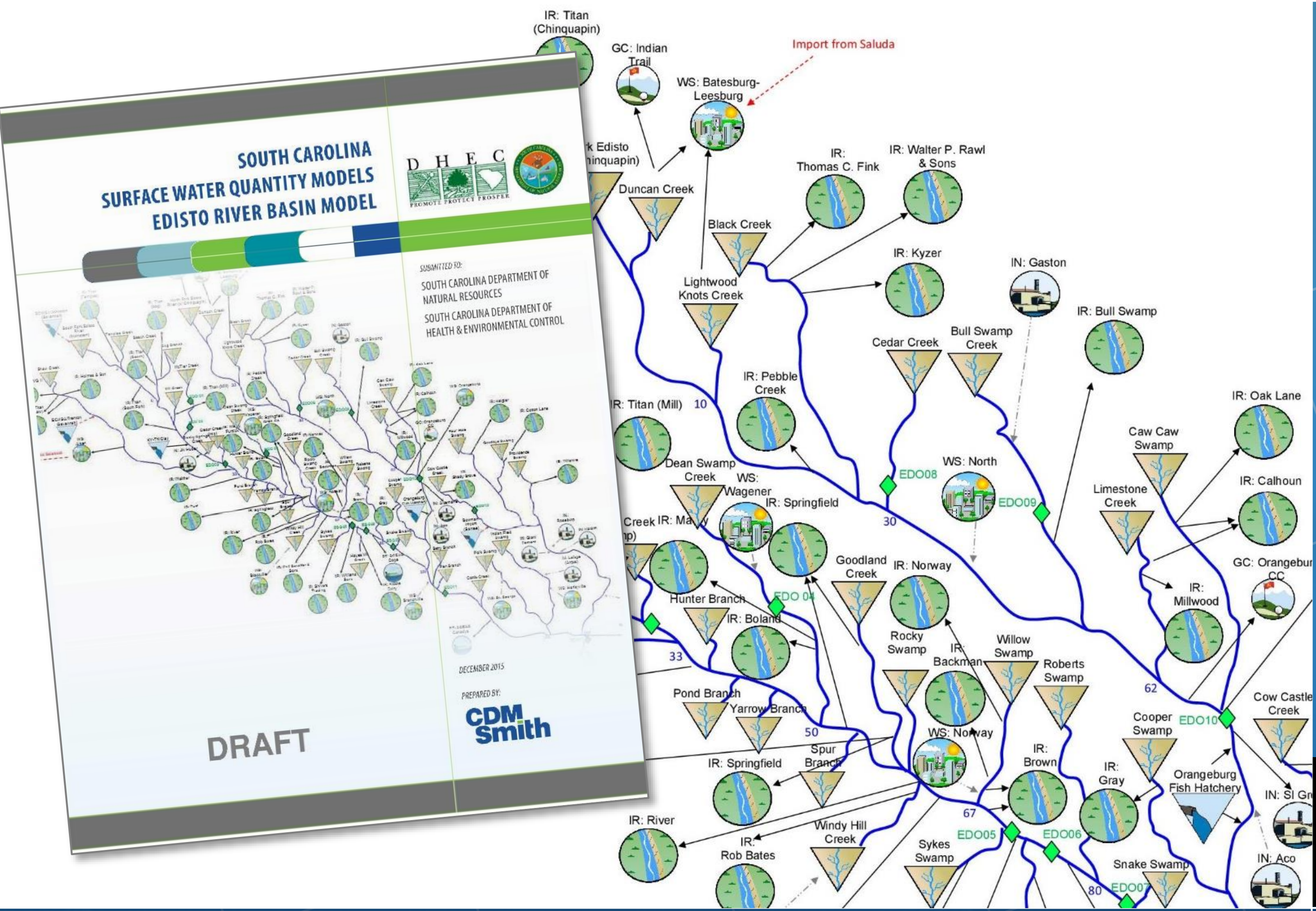
December 1, 2015



CDM Smith

Presentation Outline

- Project Background and Status
- Model Calibration/Verification
  - Calibration/Verification Philosophy and Approach
  - Calibration Results and Discussion
- Edisto Baseline Model
  - Overview and Uses

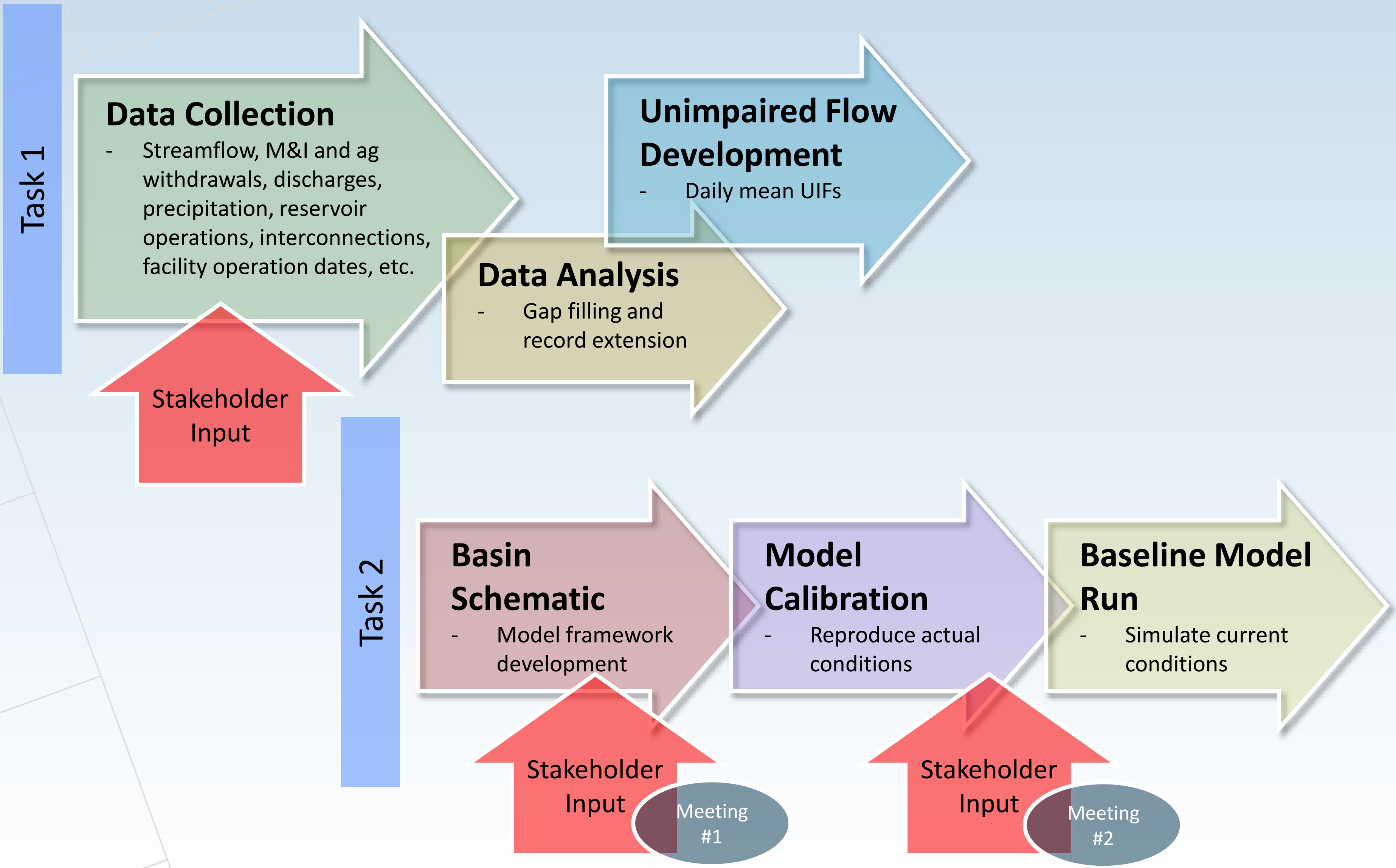
Project Purpose

- Build surface water quantity models capable of:
  - Accounting for inflows and outflows from a basin
  - Accurately simulating streamflows and reservoir levels over the historical inflow record
  - Conducting "What if" scenarios to evaluate future water demands, management strategies and system performance.

The Simplified Water Allocation Model is…

- A water accounting tool
    - *Calculates physically and legally available water*
    - *Traces water through a natural stream network, simulating withdrawals, discharges, storage, and hydroelectric operations*
- Not precipitation-runoff model (e.g., HEC-HMS)
- Not a hydraulic model (e.g. HEC-RAS)
- Not a water quality model (e.g., QUAL2K)
- Not an optimization model
- Not a groundwater flow model (e.g., MODFLOW)

Project Status – Edisto Basin



Calibration vs. Baseline Model

- **Calibration Model**
  - Purpose: Confirm models ability to accurately simulate river basin flows and storage amounts
  - Uses recent withdrawal, discharge and flow records

- **Baseline Model**
  - Purpose: Evaluate water availability under future conditions
  - Uses entire record of flow and most current withdrawals and discharges

Edisto Basin – SWAM Framework

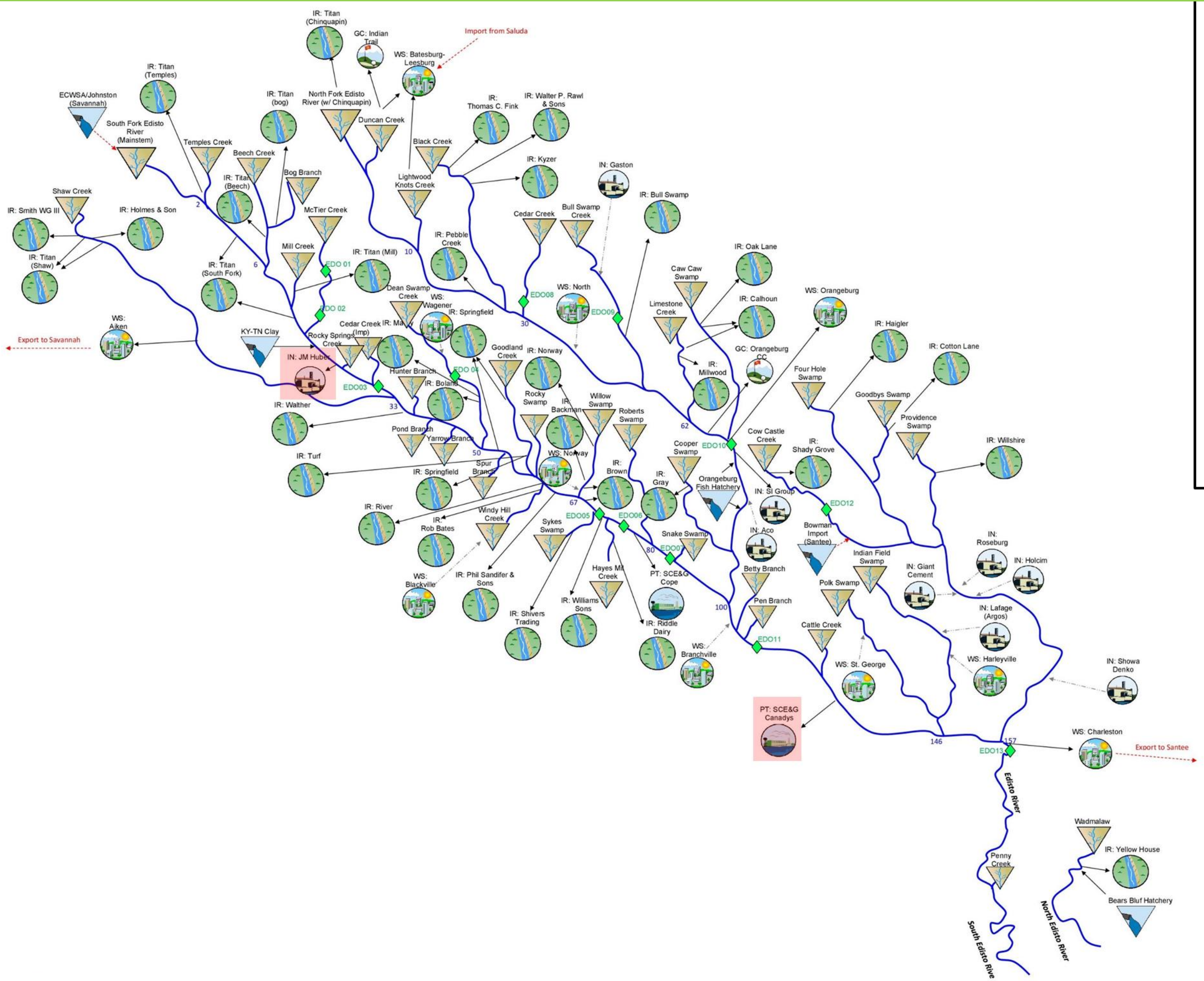


Figure 4-1. Edisto River Basin SWAM Model Framework

Model Objects

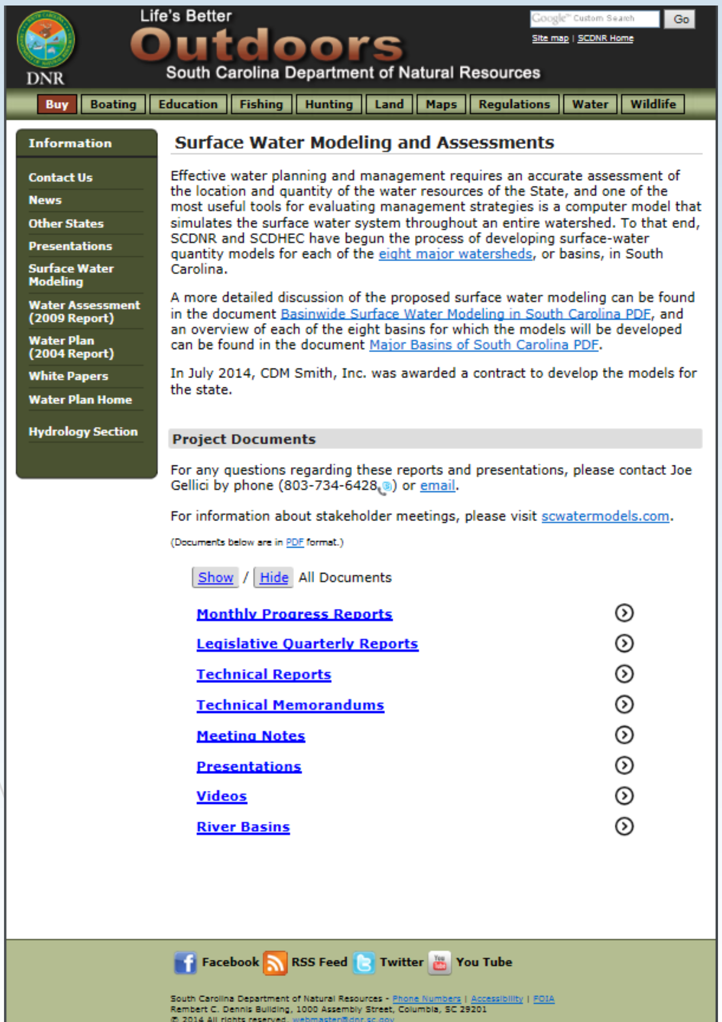
- Tributary
- Discharge
- USGS Stream Gage

Water User Objects

- Municipal
- Agriculture (Irrigation)
- Thermoelectric
- Industrial
- *Red shading indicates the Object is in the calibration model, but not the baseline model*
- Import or Export (Interbasin Transfer)

Modeling Report and Other Documents

- http://www.dnr.sc.gov/water/waterplan/surfacewater.html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Surface Water Modeling and Assessments

Effective water planning and management requires an accurate assessment of the location and quantity of the water resources of the State, and one of the most useful tools for evaluating management strategies is a computer model that simulates the surface water system throughout an entire watershed. To that end, SCDNR and SCDHEC have begun the process of developing surface-water quantity models for each of the eight major watersheds, or basins, in South Carolina.

A more detailed discussion of the proposed surface water modeling can be found in the document Basinwide Surface Water Modeling in South Carolina PDF, and an overview of each of the eight basins for which the models will be developed can be found in the document Major Basins of South Carolina PDF.

In July 2014, CDM Smith, Inc. was awarded a contract to develop the models for the state.

Project Documents

For any questions regarding these reports and presentations, please contact Joe Gellici by phone (803-734-6428) or email.

For information about stakeholder meetings, please visit scwatermodels.com.

(Documents below are in PDF format.)

Show / Hide All Documents

- Monthly Progress Reports
- Legislative Quarterly Reports
- Technical Reports
- Technical Memorandums
- Meeting Notes
- Presentations
- Videos
- River Basins

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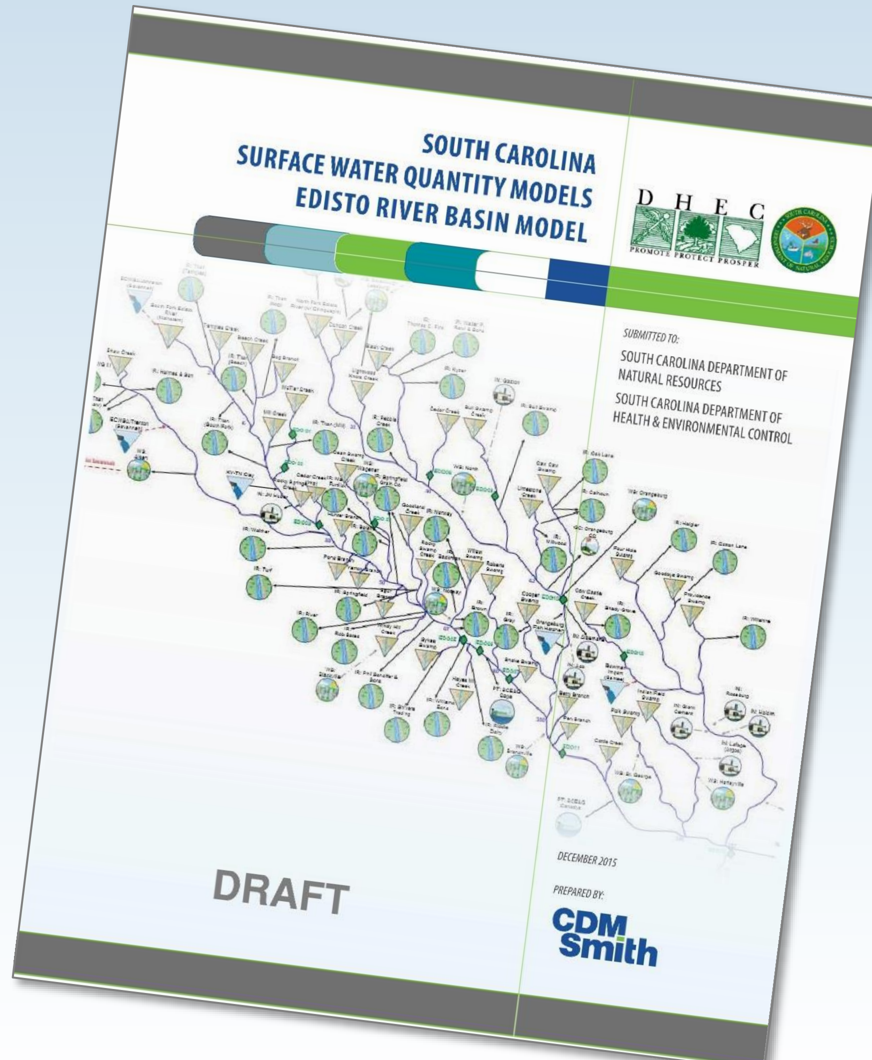
South Carolina Department of Natural Resources - Phone Numbers | Accessibility | FOIA
Rembert C. Dennis Building, 1000 Assembly Street, Columbia, SC 29201



Edisto River Basin

MODEL CALIBRATION/VERIFICATION

Calibration Objectives

1. Extend hydrologic inputs (headwater UIFs) spatially to adequately represent entire basin hydrology by parameterizing reach hydrologic inputs
2. Refine initial parameter estimates, as appropriate
   - E.g. reservoir operating rules, %Consumptive Use assumptions, return flow locations
3. Gain confidence in the model as a predictive tool by demonstrating its ability to adequately replicate past hydrologic conditions, operations, and water use
   - **without being overly prescriptive**

Potential Sources of Model Error and Uncertainty

- Gaged flow data (± 20%)
- Gaged reservoir levels (± ?%)
- Basin climate and hydrologic variability
- Reported withdrawal data
- Consumptive use percentages
- Return flow locations (outdoor use)
- Return flow lag times (if applicable, e.g. outdoor use)
- *Reach hydrology: gains, losses, local runoff and inflow*

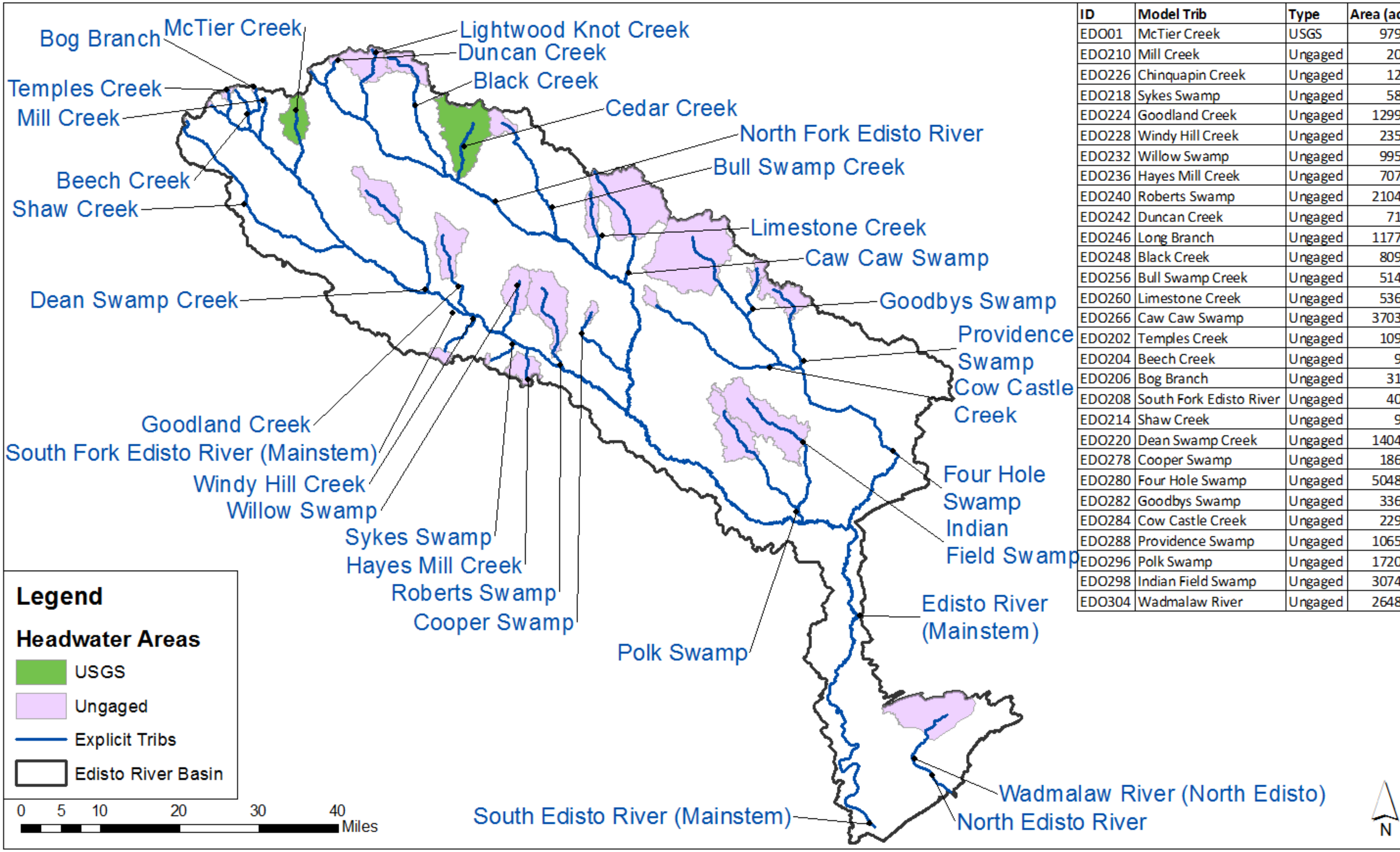
Calibration/Validation General Approach

- 1983 – 2013 hindcast period; monthly timestep
  - Includes droughts in both early and late 2000's
- Comparison to gaged (measured) flow data only
  - operations and impairments are implicit in that data
- Assess performance at (subject to gage data availability):
  - multiple mainstem and tributary locations
  - major reservoirs *(none in the Edisto)*
- Multiple model performance metrics, including:
  - timeseries plots (monthly and daily variability)
  - annual and monthly means (water balance and seasonality)
  - percentile plots (extremes and frequency)

Calibration Methodology

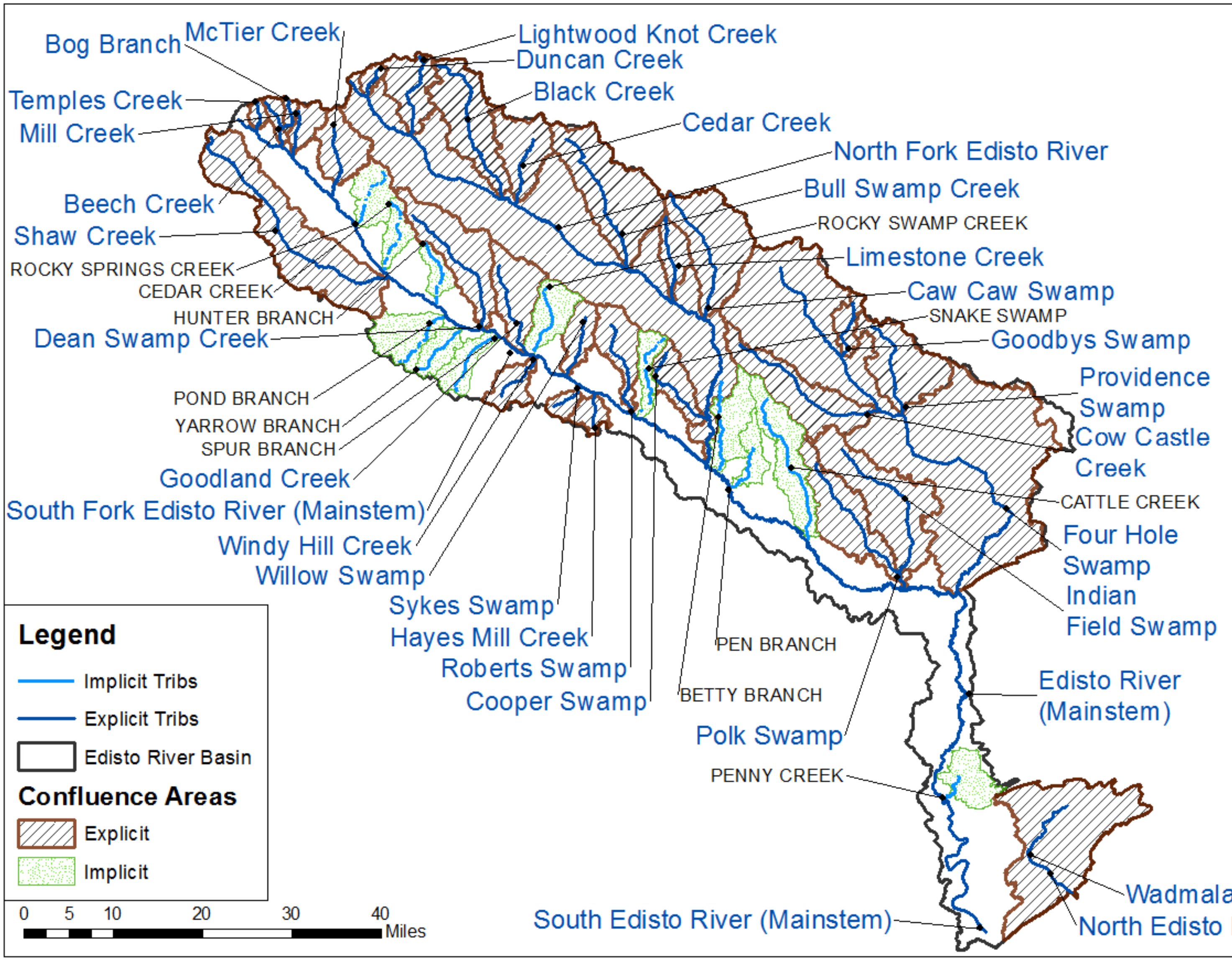
- Focus on characterizing natural hydrology throughout the basin by extending headwater flow inputs downstream
  - drainage area ratios for tributaries
  - gain/loss coefficients along the mainstem
  - adding in smaller ungaged tributaries (without nodes) as point sources
- If necessary, look at other “uncertain” parameters: e.g. reservoir operations (if applicable), %CU, return flow locations
- Limited number of calibration parameters (adjustment “knobs”) that are readily transferable to future applications

Calibration Steps: Flow Factors



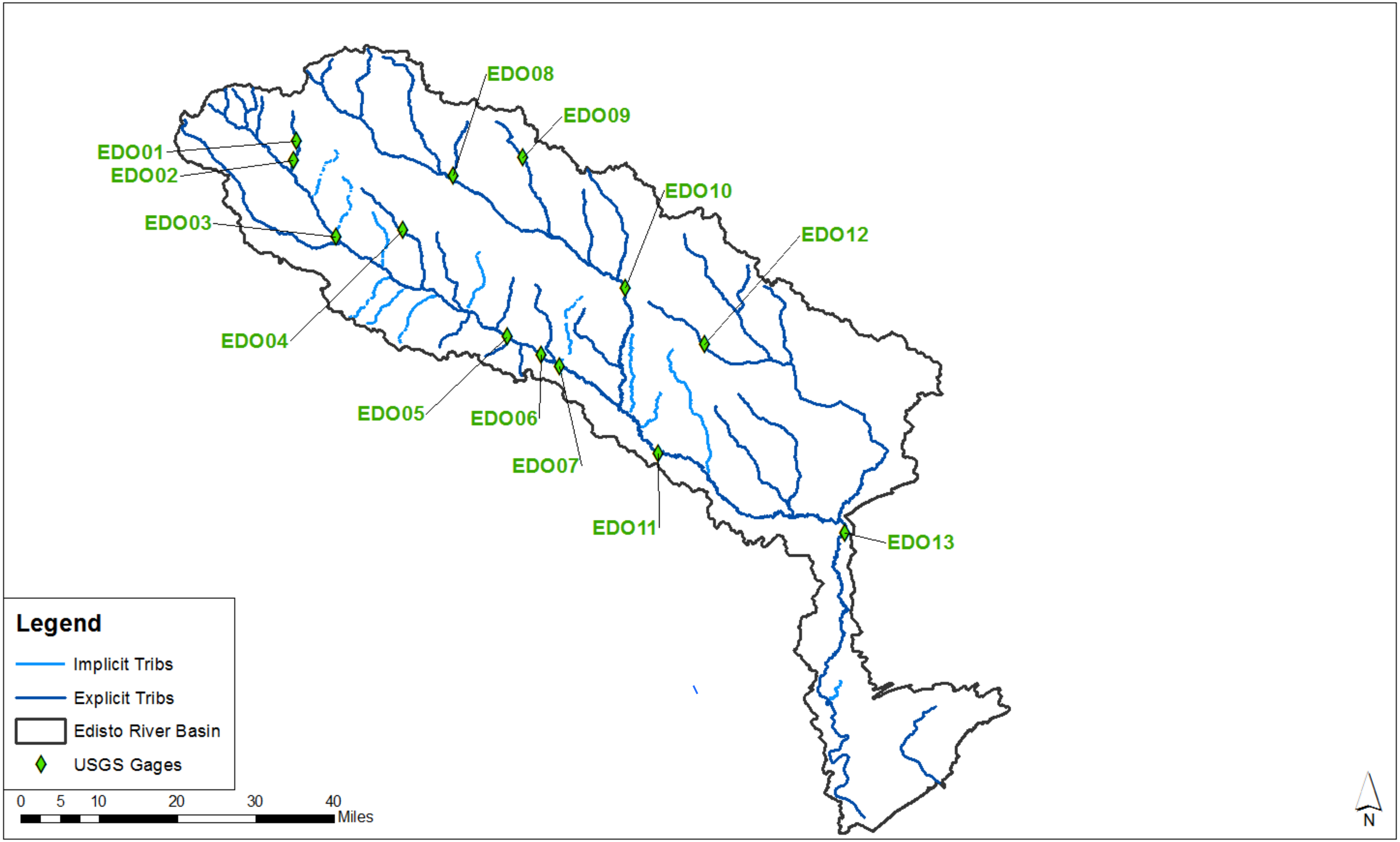
ID	Model Trib	Type	Area (ac)
EDO01	McTier Creek	USGS	9790
EDO210	Mill Creek	Ungaged	204
EDO226	Chinquapin Creek	Ungaged	121
EDO218	Sykes Swamp	Ungaged	580
EDO224	Goodland Creek	Ungaged	12995
EDO228	Windy Hill Creek	Ungaged	2350
EDO232	Willow Swamp	Ungaged	9955
EDO236	Hayes Mill Creek	Ungaged	7070
EDO240	Roberts Swamp	Ungaged	21047
EDO242	Duncan Creek	Ungaged	717
EDO246	Long Branch	Ungaged	11778
EDO248	Black Creek	Ungaged	8096
EDO256	Bull Swamp Creek	Ungaged	5142
EDO260	Limestone Creek	Ungaged	5361
EDO266	Caw Caw Swamp	Ungaged	37038
EDO202	Temples Creek	Ungaged	1093
EDO204	Beech Creek	Ungaged	96
EDO206	Bog Branch	Ungaged	311
EDO208	South Fork Edisto River	Ungaged	405
EDO214	Shaw Creek	Ungaged	97
EDO220	Dean Swamp Creek	Ungaged	14046
EDO278	Cooper Swamp	Ungaged	1869
EDO280	Four Hole Swamp	Ungaged	50480
EDO282	Goodbys Swamp	Ungaged	3366
EDO284	Cow Castle Creek	Ungaged	2296
EDO288	Providence Swamp	Ungaged	10659
EDO296	Polk Swamp	Ungaged	17202
EDO298	Indian Field Swamp	Ungaged	30743
EDO304	Wadmalaw River	Ungaged	26488

Calibration Steps: Flow Factors



ID	Model Trib	Trib Type	Area (ac)
EDO152	North Fork Edisto River	Explicit	489509
EDO160	Four Hole Swamp	Explicit	407245
EDO164	Polk Swamp	Explicit	100030
EDO172	North Edisto River	Explicit	94409
EDO110	Shaw Creek	Explicit	85370
EDO134	Bull Swamp Creek	Explicit	61543
EDO162	Indian Field Swamp	Explicit	59696
EDO148	Caw Caw Swamp	Explicit	51268
EDO130	Black Creek	Explicit	43746
EDO156	Cow Castle Creek	Explicit	43706
EDO111	Dean Swamp Creek	Explicit	41752
EDO158	Providence Swamp	Explicit	39712
EDO112	Goodland Creek	Explicit	28412
EDO08	Cedar Creek	Explicit	27372
EDO128	Long Branch	Explicit	23233
EDO122	Roberts Swamp	Explicit	22018
EDO02	McTier Creek	Explicit	21786
EDO150	Cooper Swamp	Explicit	17029
EDO116	Willow Swamp	Explicit	13812
EDO146	Limestone Creek	Explicit	12979
EDO114	Windy Hill Creek	Explicit	12388
EDO154	Goodbys Swamp	Explicit	9519
EDO108	Mill Creek	Explicit	9467
EDO106	Beech Creek	Explicit	8339
EDO120	Hayes Mill Creek	Explicit	7627
EDO118	Sykes Swamp	Explicit	5705
EDO124	Duncan Creek	Explicit	4179
EDO102	Temples Creek	Explicit	3533
EDO104	Bog Branch	Explicit	3188
EDO409	Cattle Creek	Implicit	33511
EDO403	Pond Branch	Implicit	22085
EDO408	Betty Branch	Implicit	20789
EDO406	Rocky Swamp Creek	Implicit	17699
EDO411	Penny Creek	Implicit	17439
EDO400	Rocky Springs Creek	Implicit	17277
EDO405	Spur Branch	Implicit	13577
EDO404	Yarrow Branch	Implicit	11468
EDO407	Snake Swamp	Implicit	10802
EDO401	Cedar Creek (Implicit)	Implicit	10585
EDO410	Pen Branch	Implicit	10489
EDO402	Hunter Branch	Implicit	8779

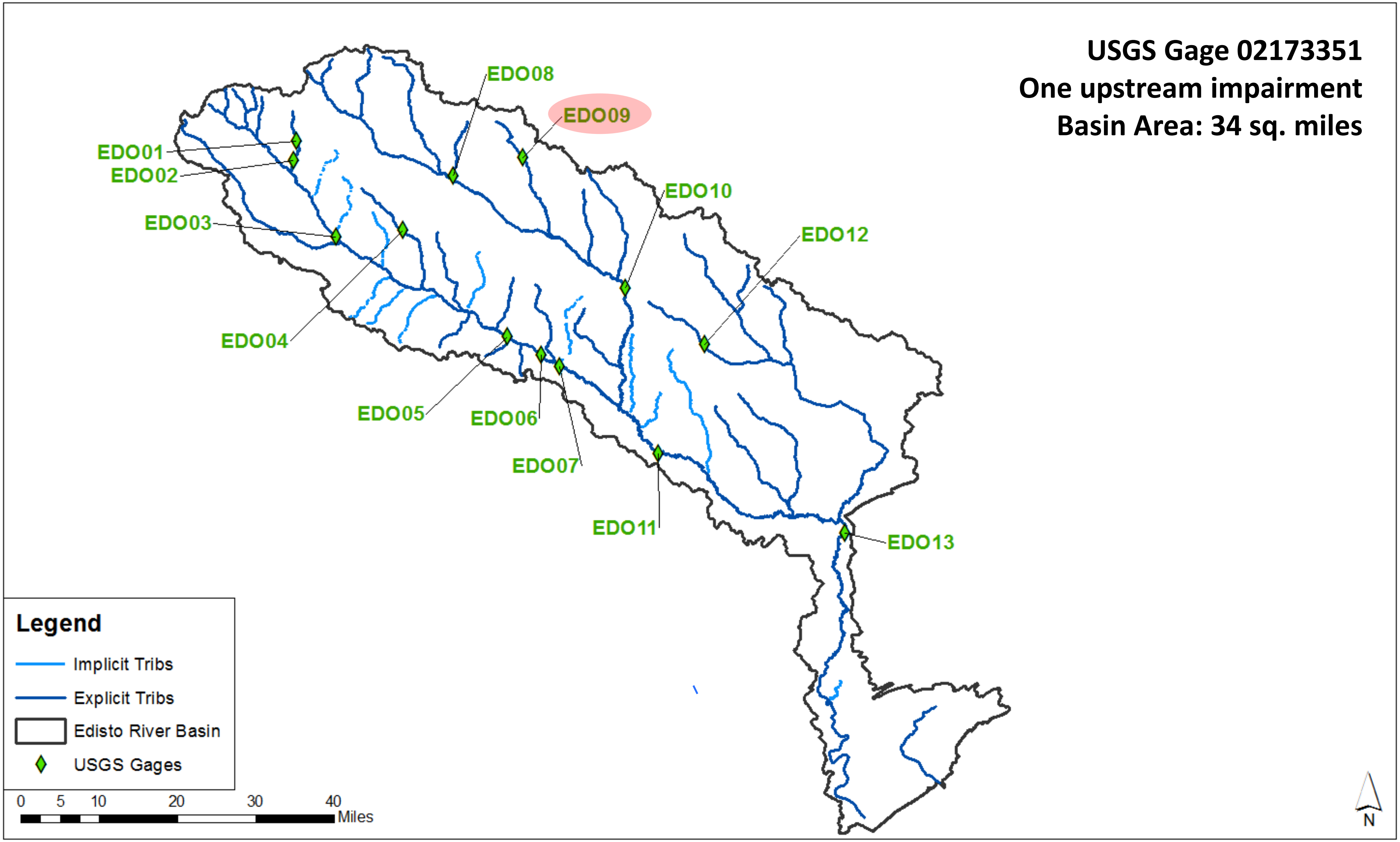
Calibration/Validation Locations



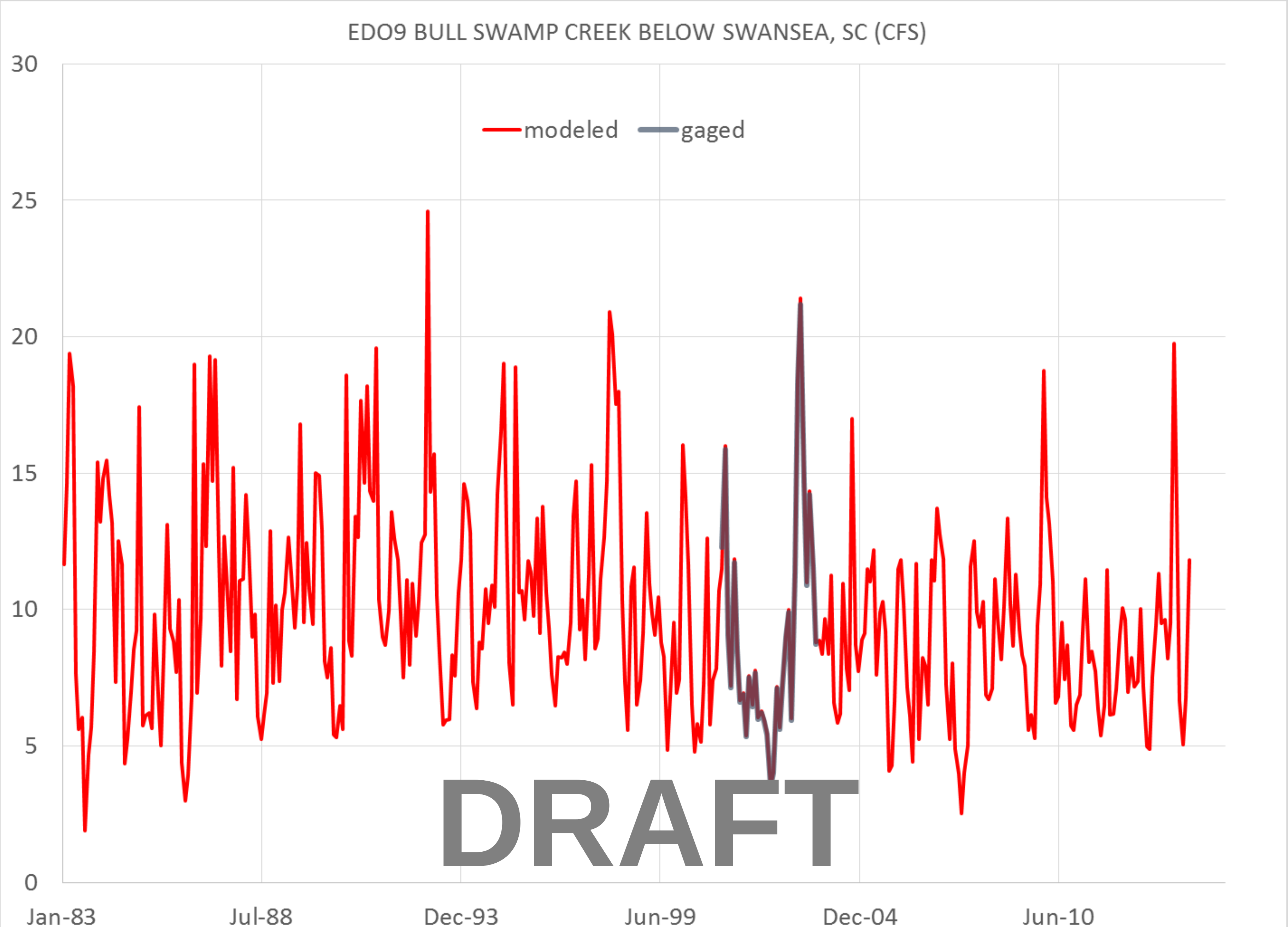
Bull Swamp Creek

Tributary to North Fork Edisto River

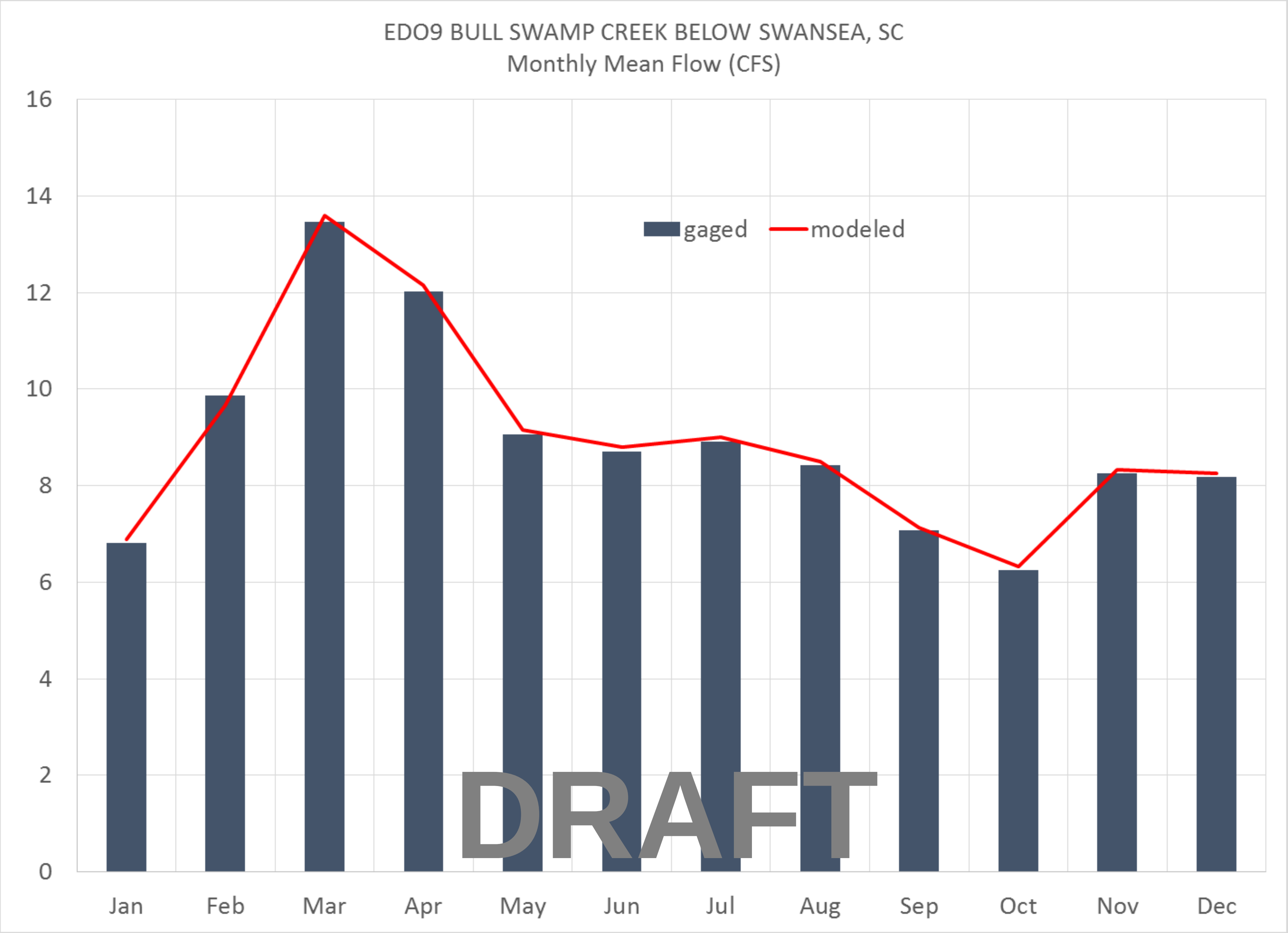
USGS Gage 02173351
One upstream impairment
Basin Area: 34 sq. miles



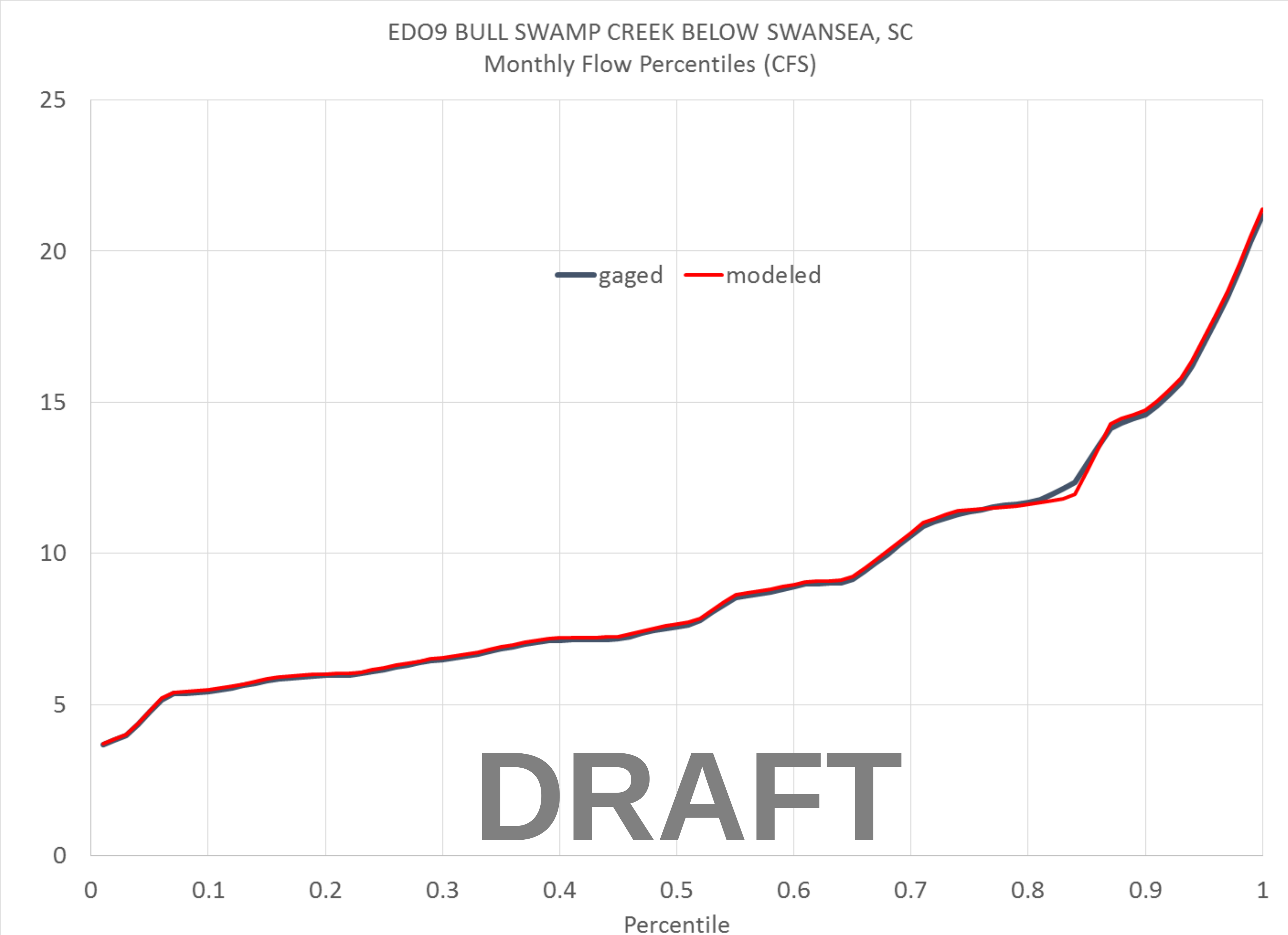
Monthly Flow Comparison



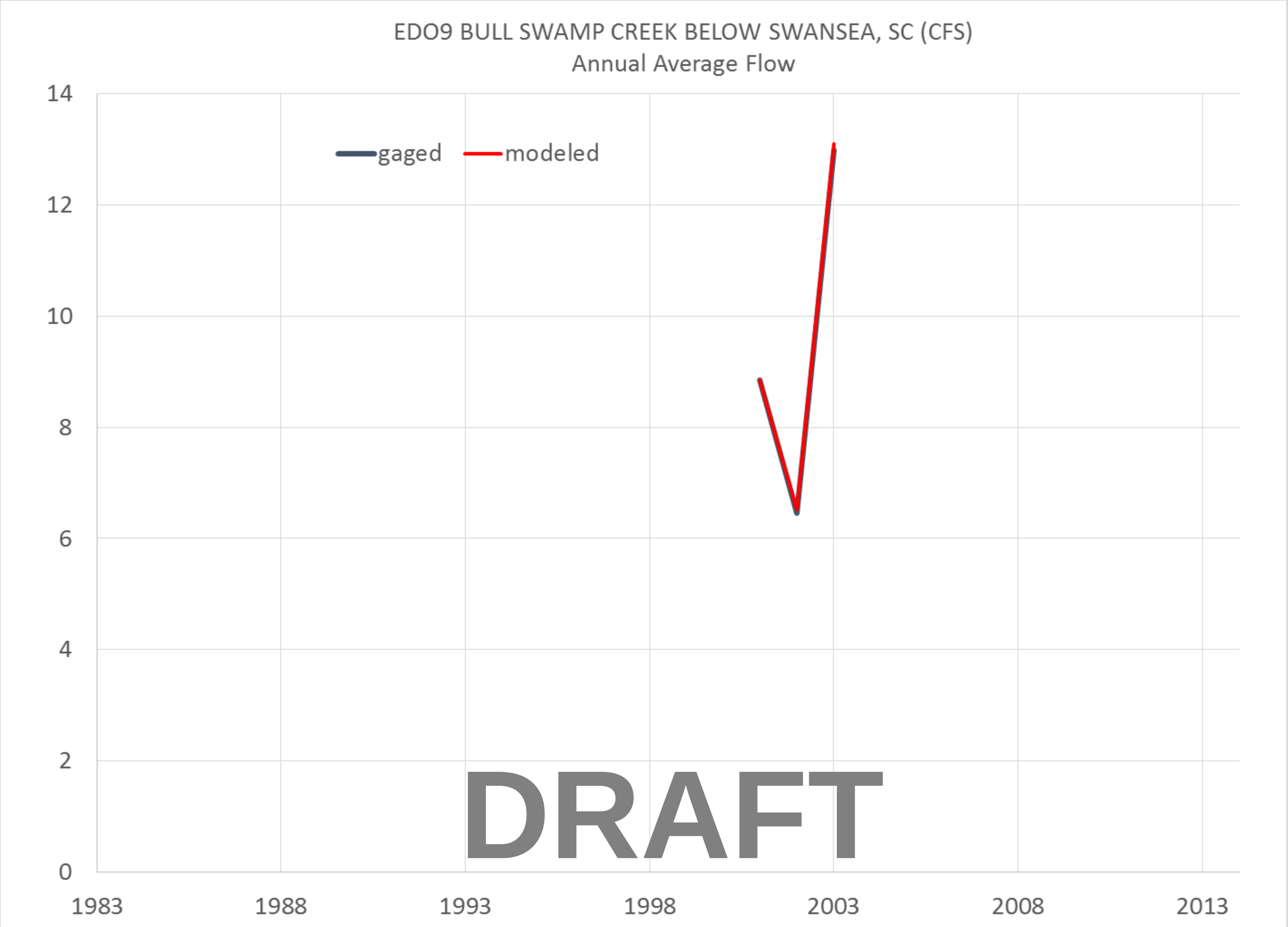
Monthly Mean Flow Comparison



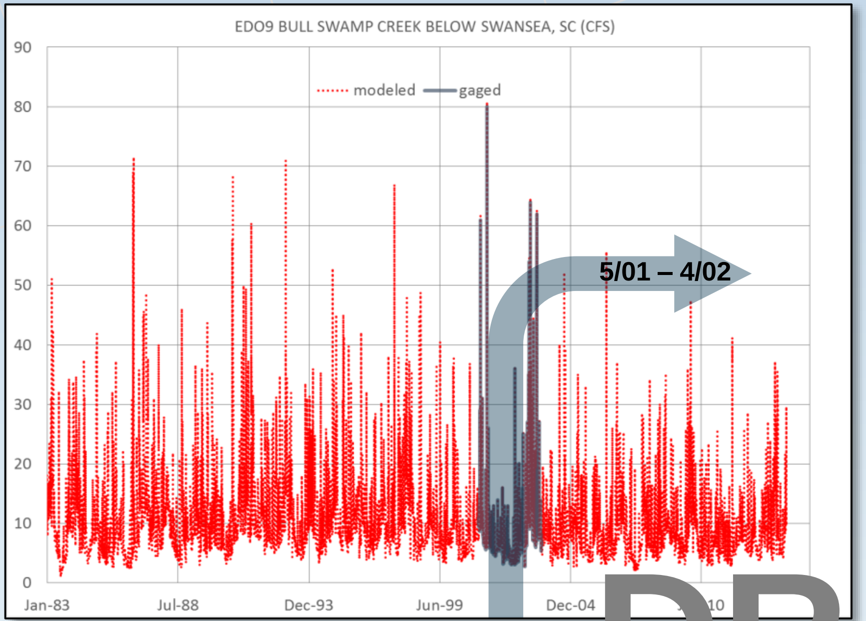
Monthly Flow Percentiles Comparison

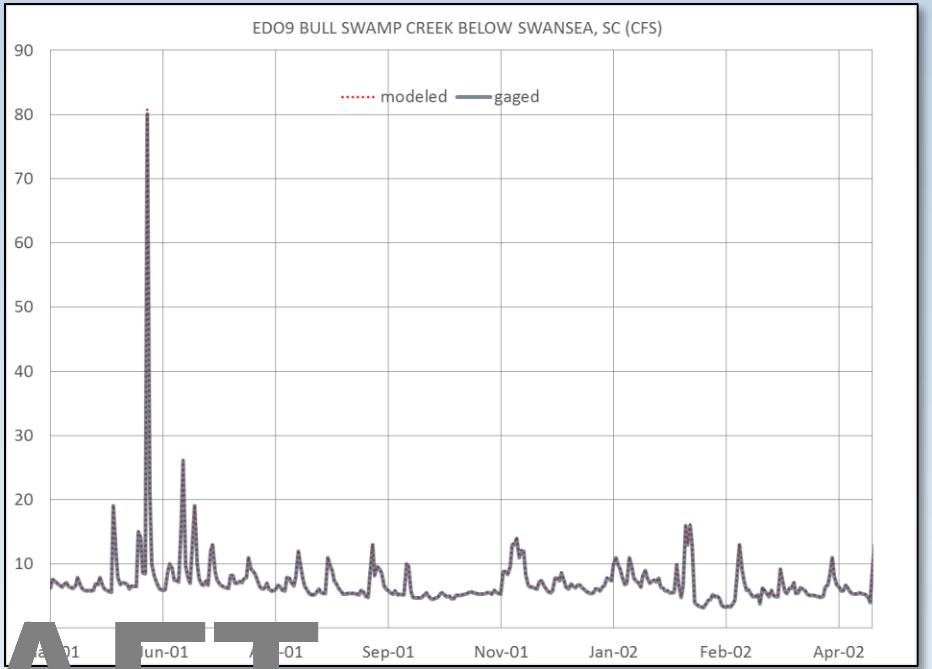


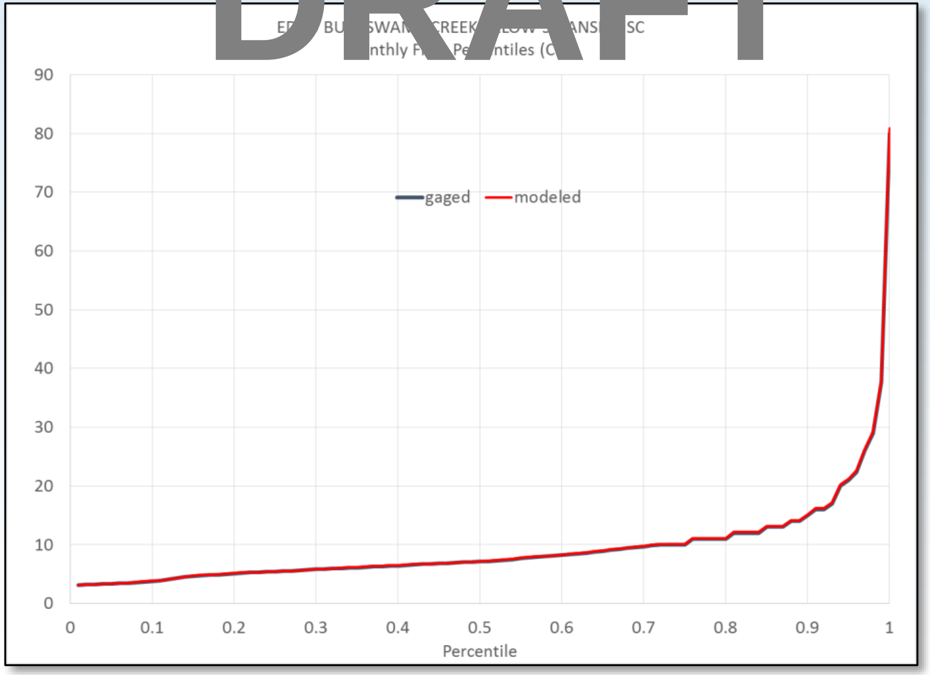
Annual Average Flow Comparison



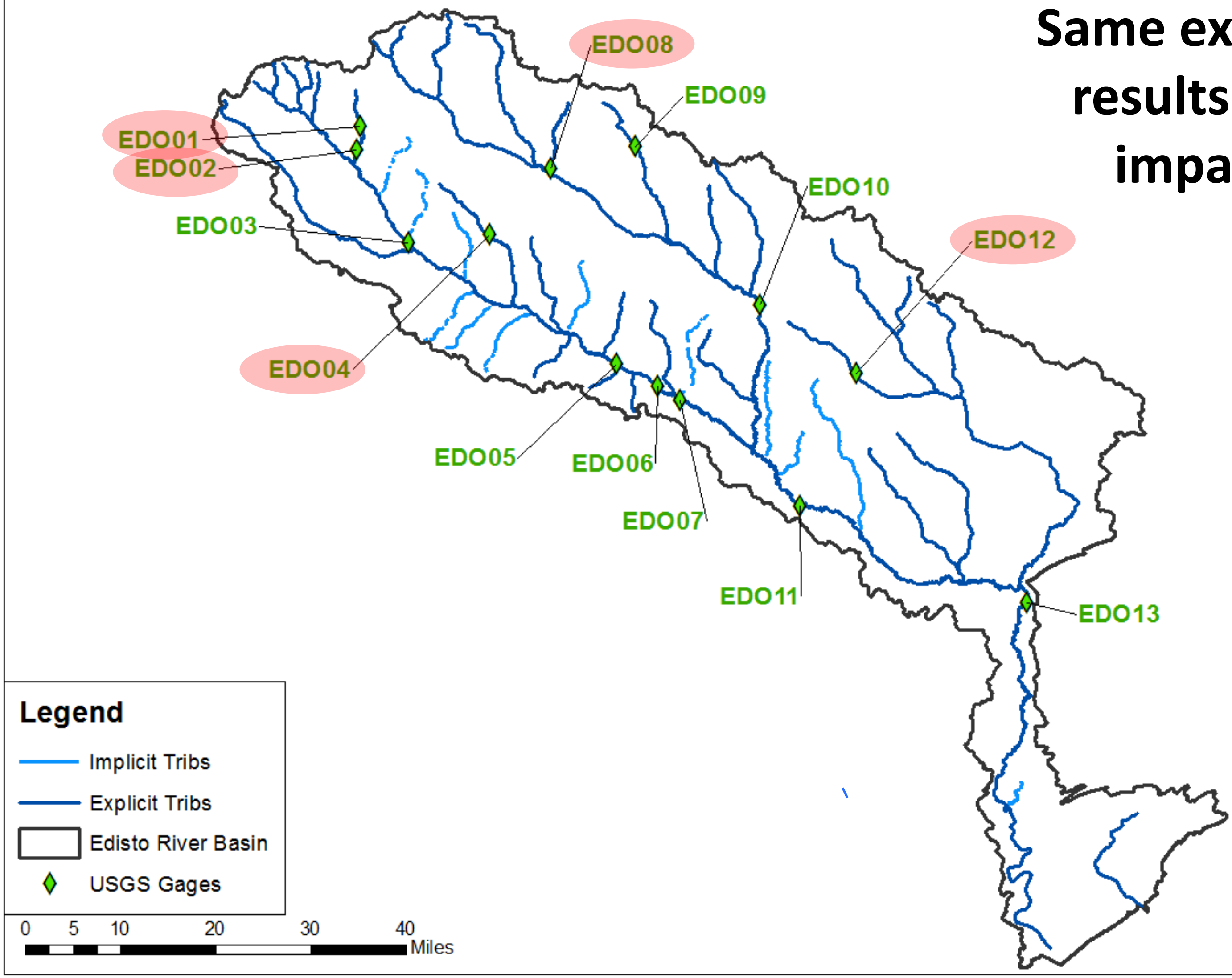
Daily Comparison







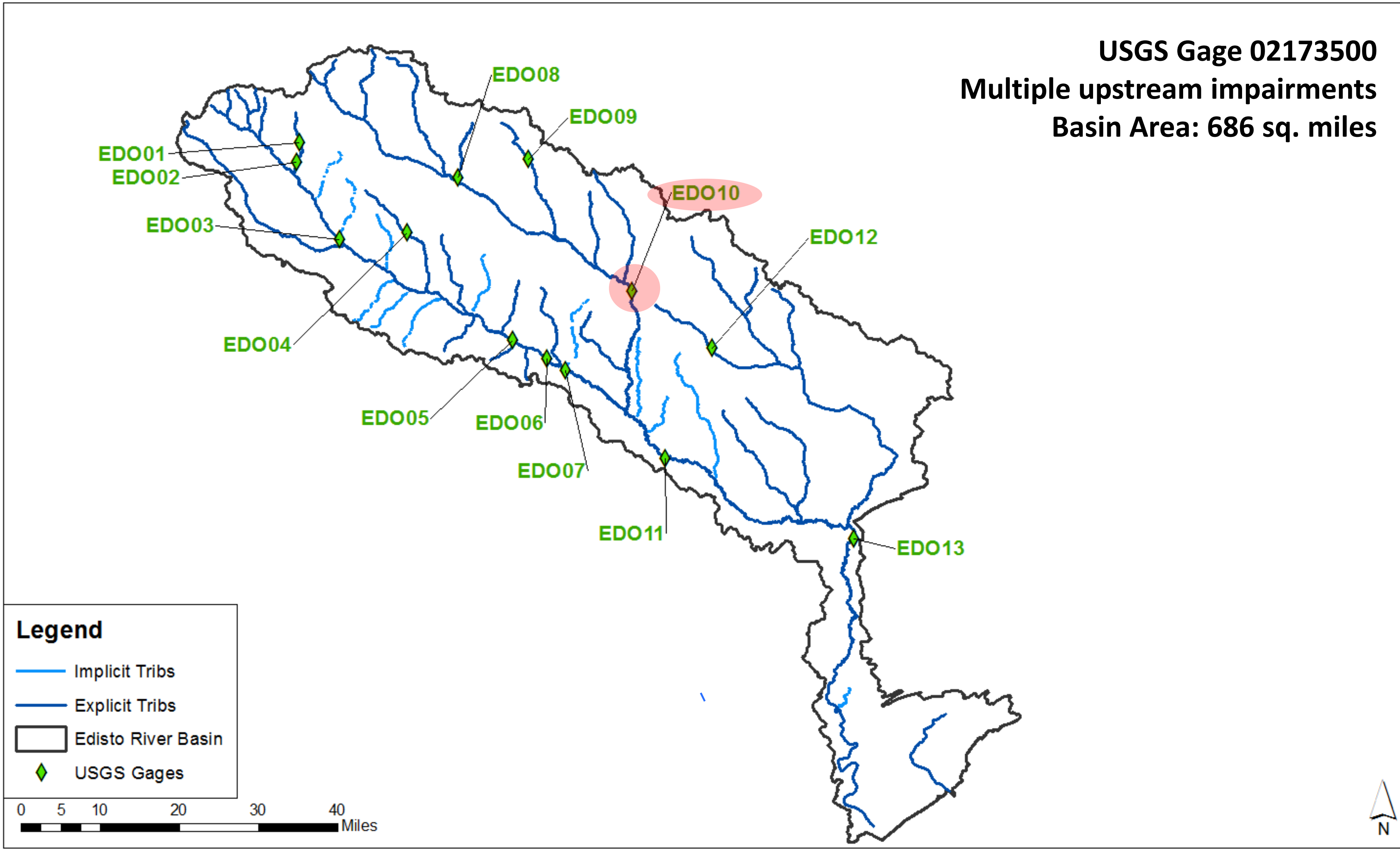
Other Tributaries to N/S Forks and Edisto River



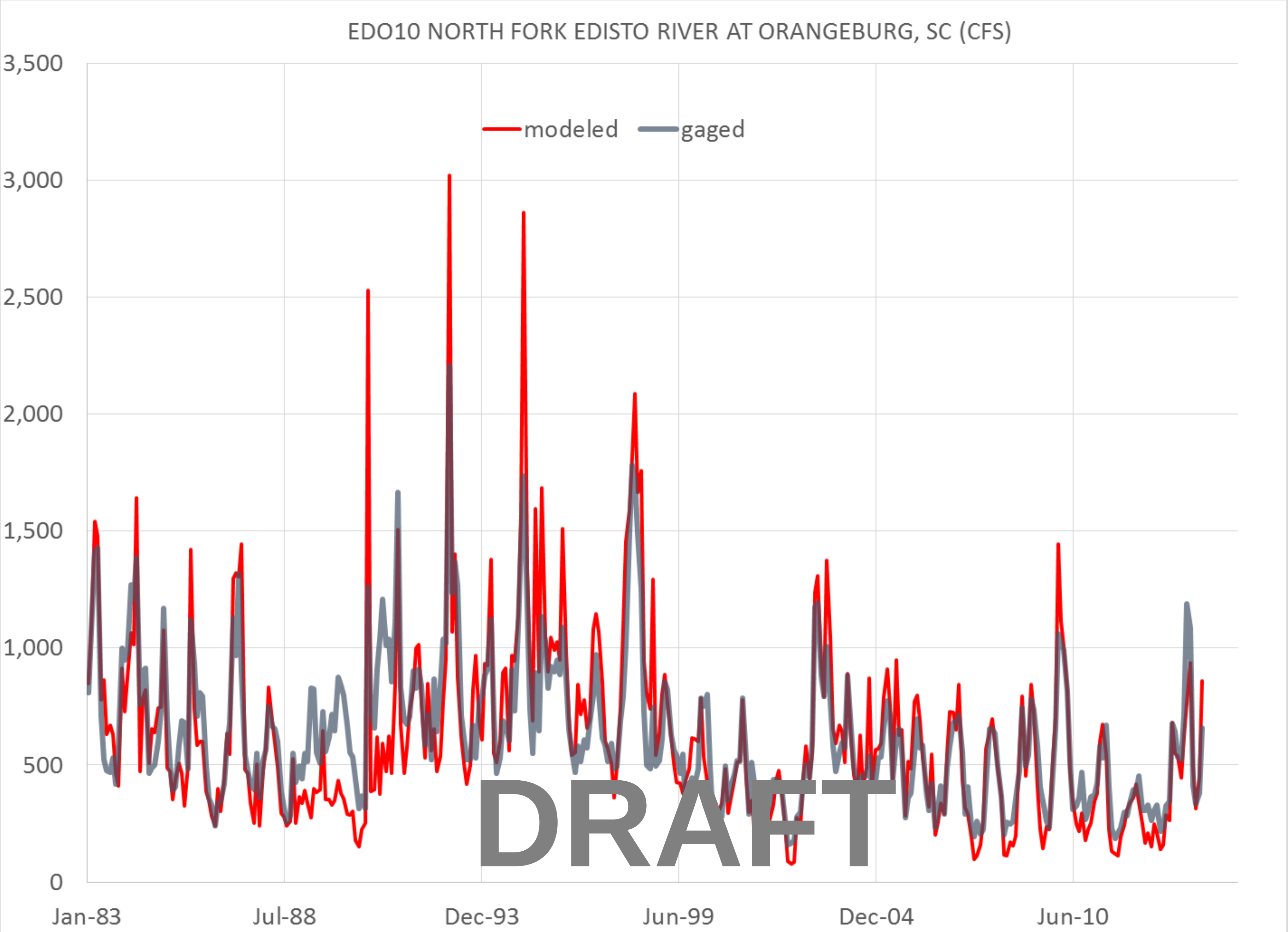
Same excellent calibration results due to little or no impairments and small drainage area

North Fork Edisto River at Orangeburg

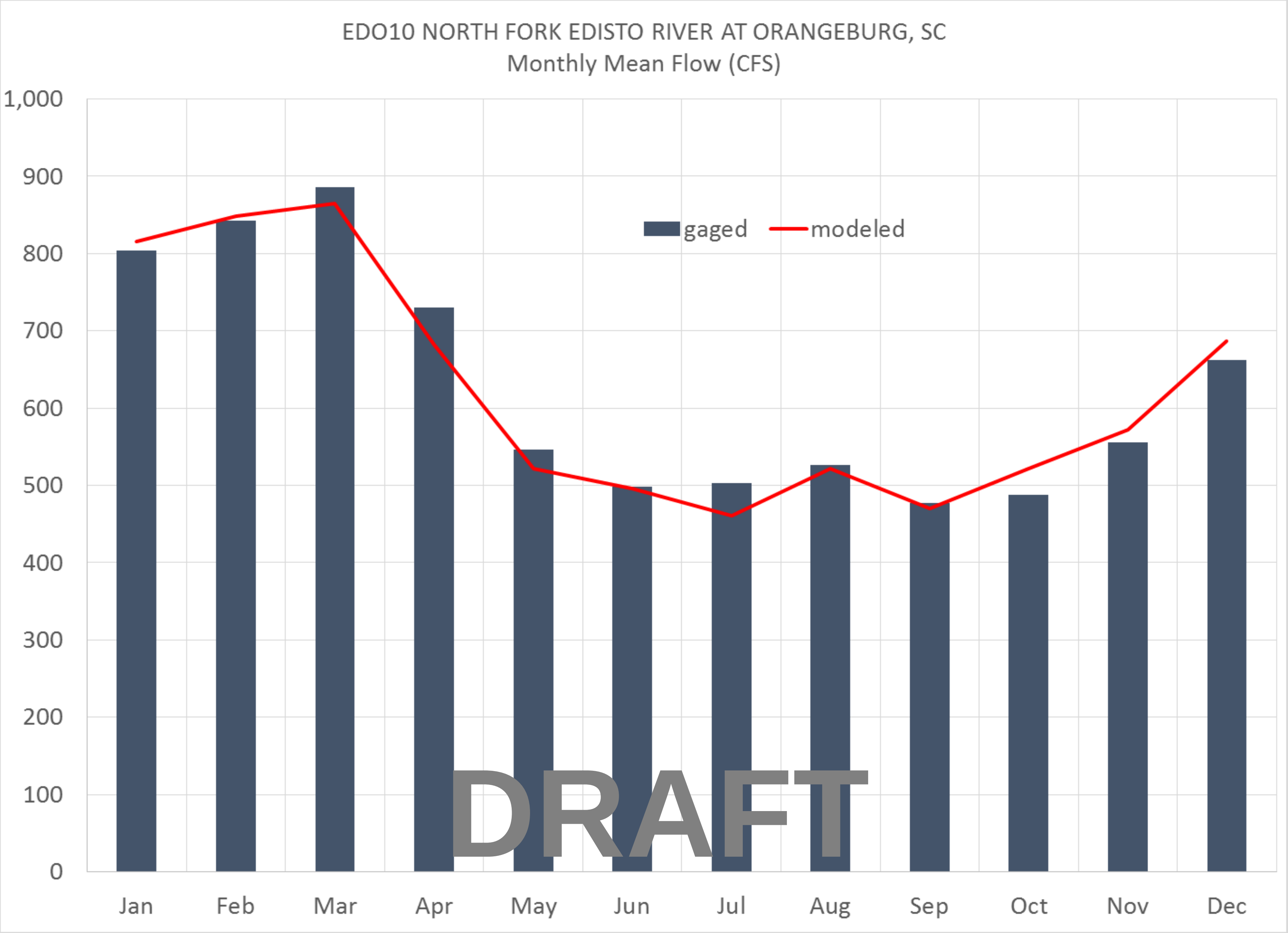
USGS Gage 02173500
Multiple upstream impairments
Basin Area: 686 sq. miles



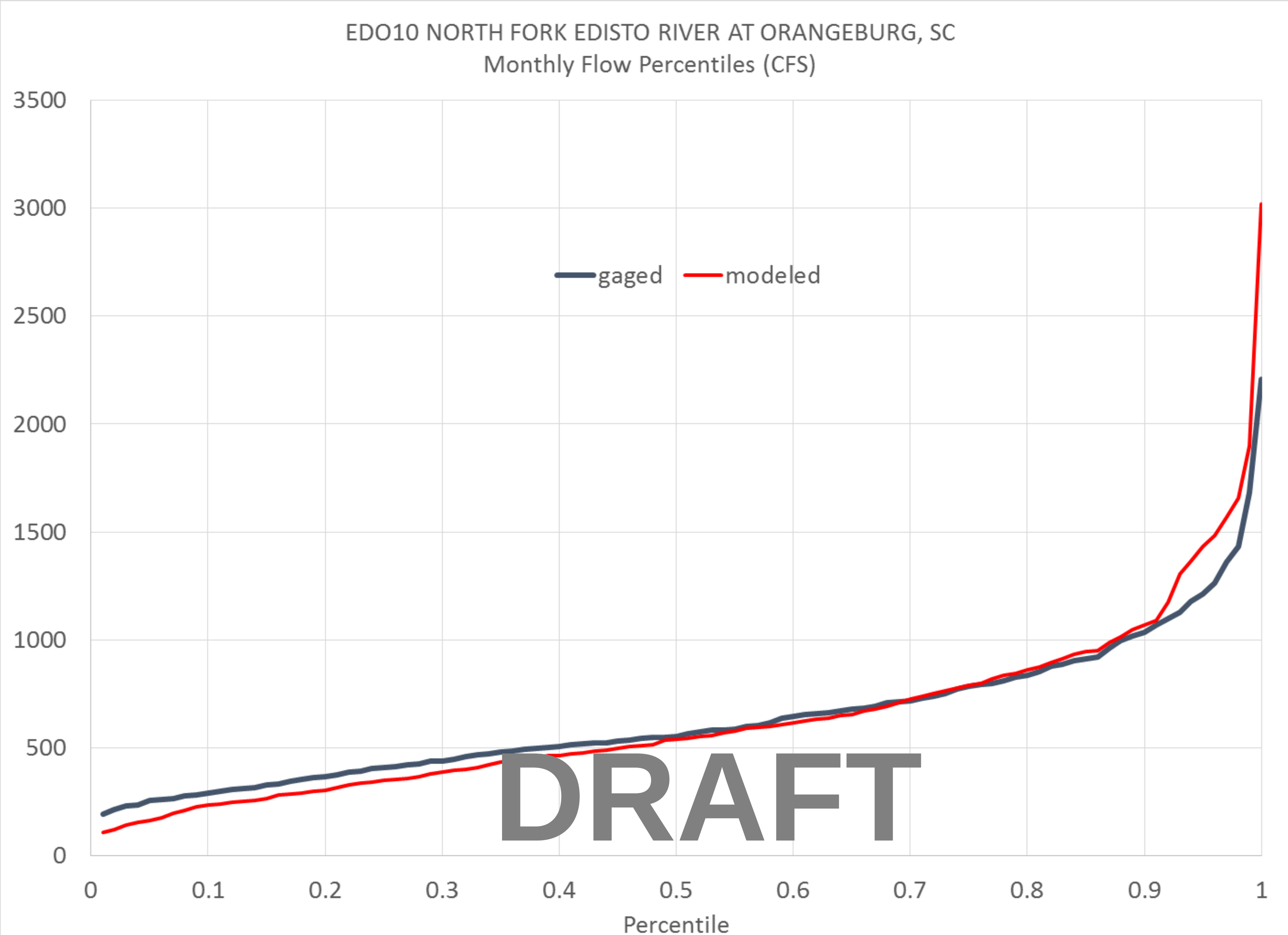
Monthly Flow Comparison



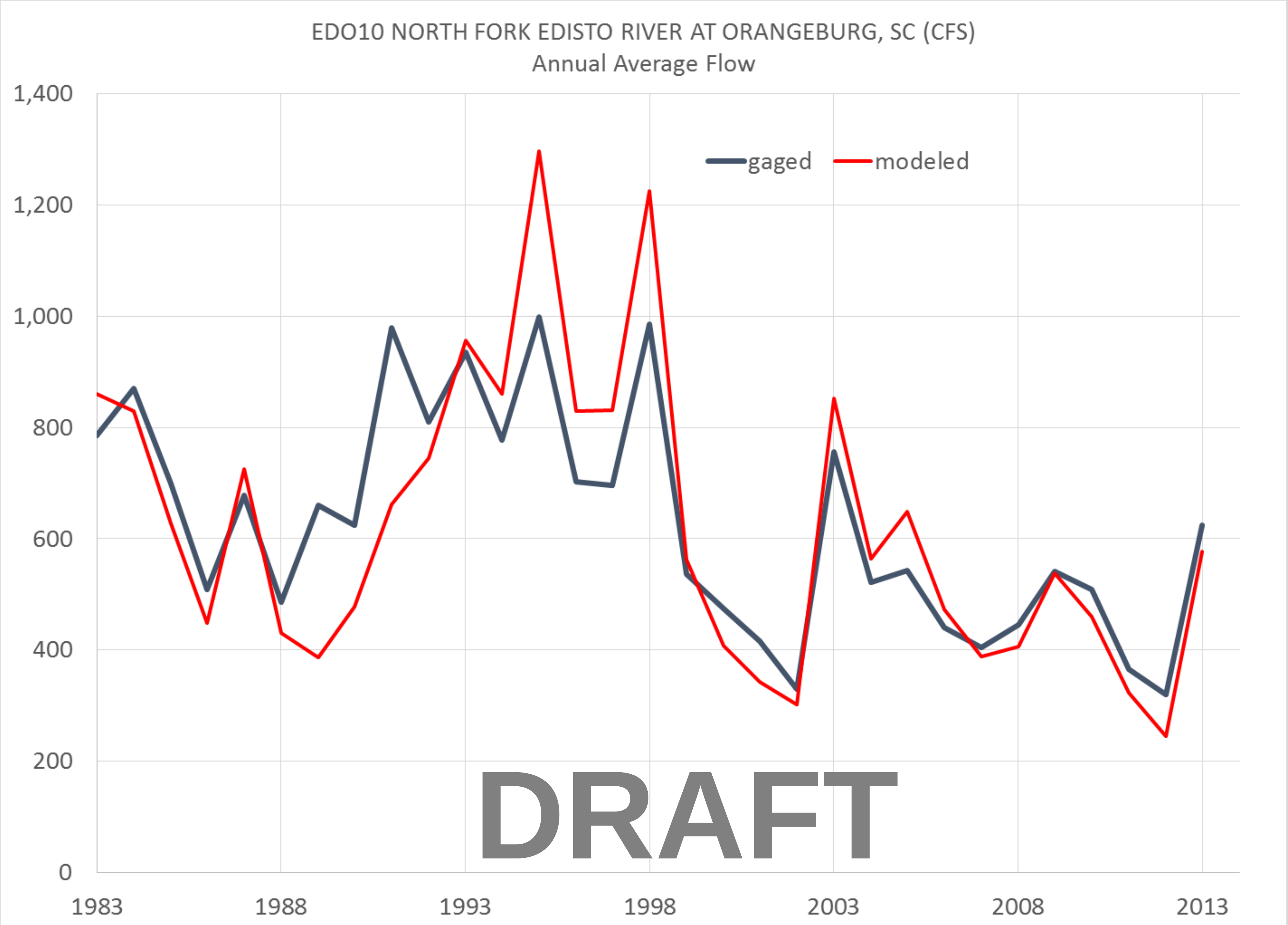
Monthly Mean Flow Comparison



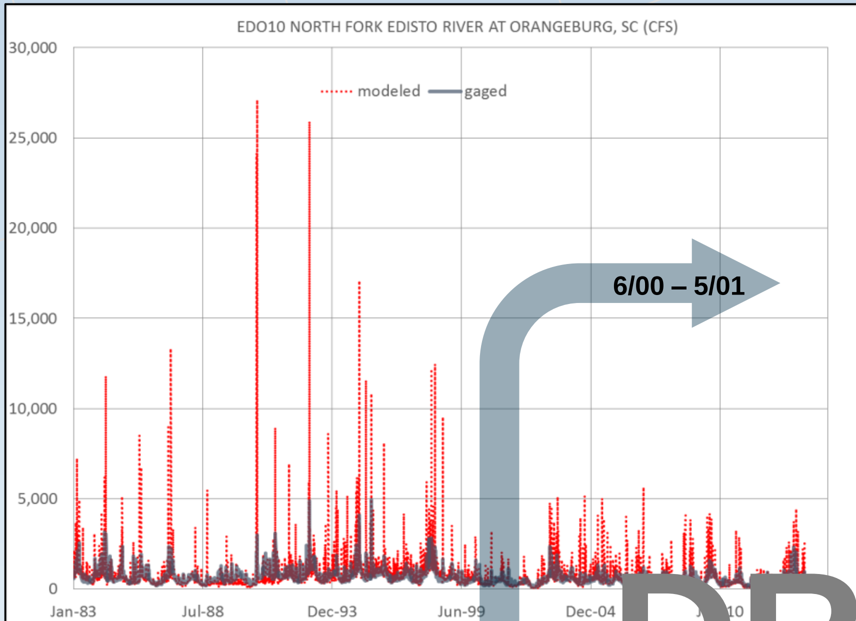
Monthly Flow Percentiles Comparison

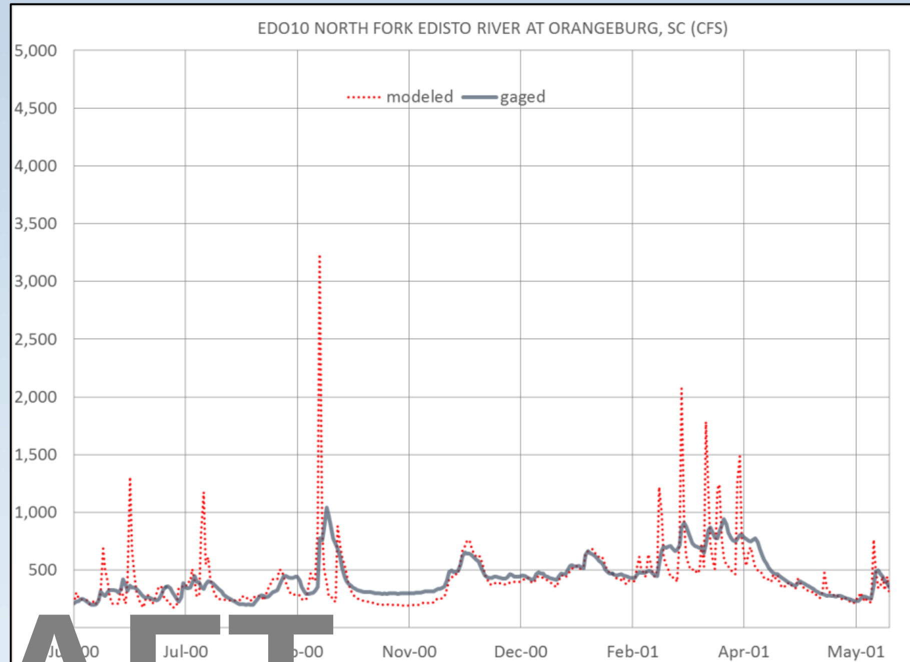


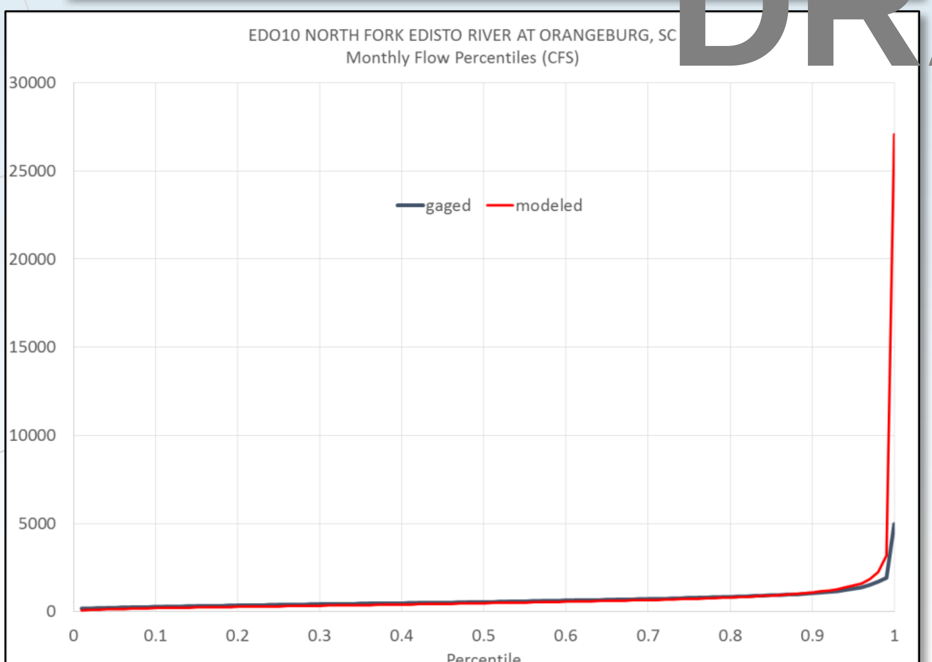
Annual Average Flow Comparison

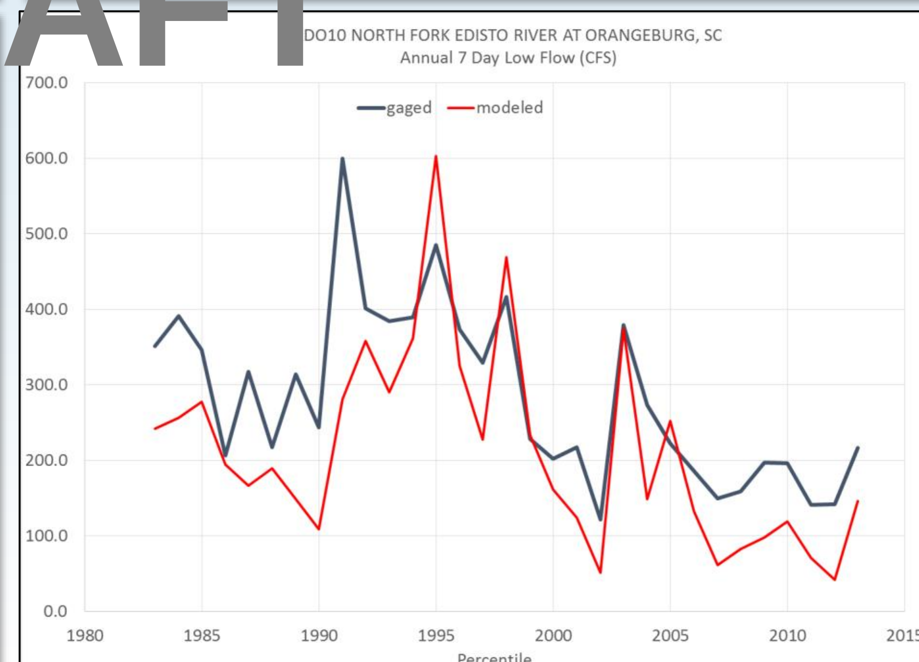


Daily Comparison

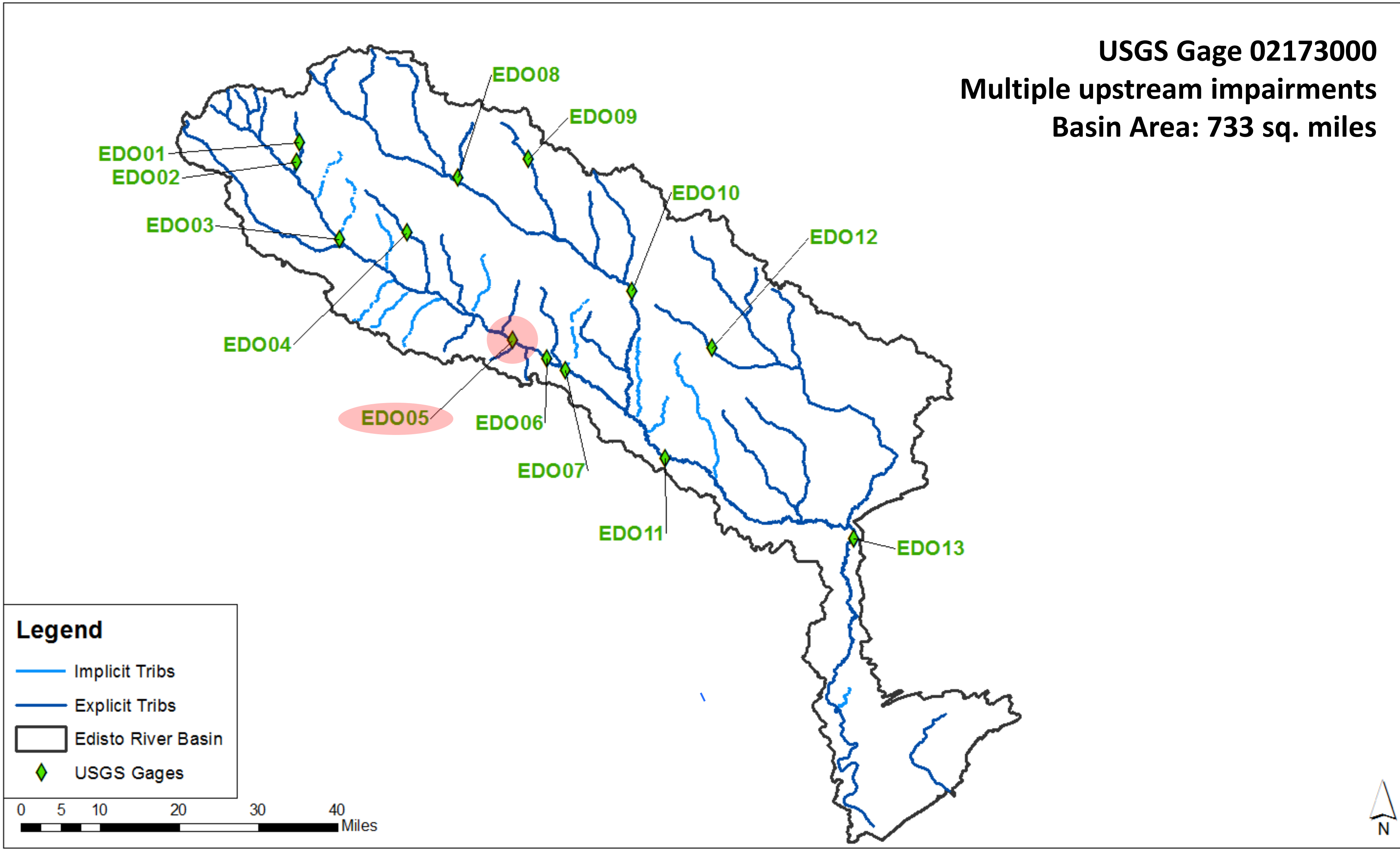




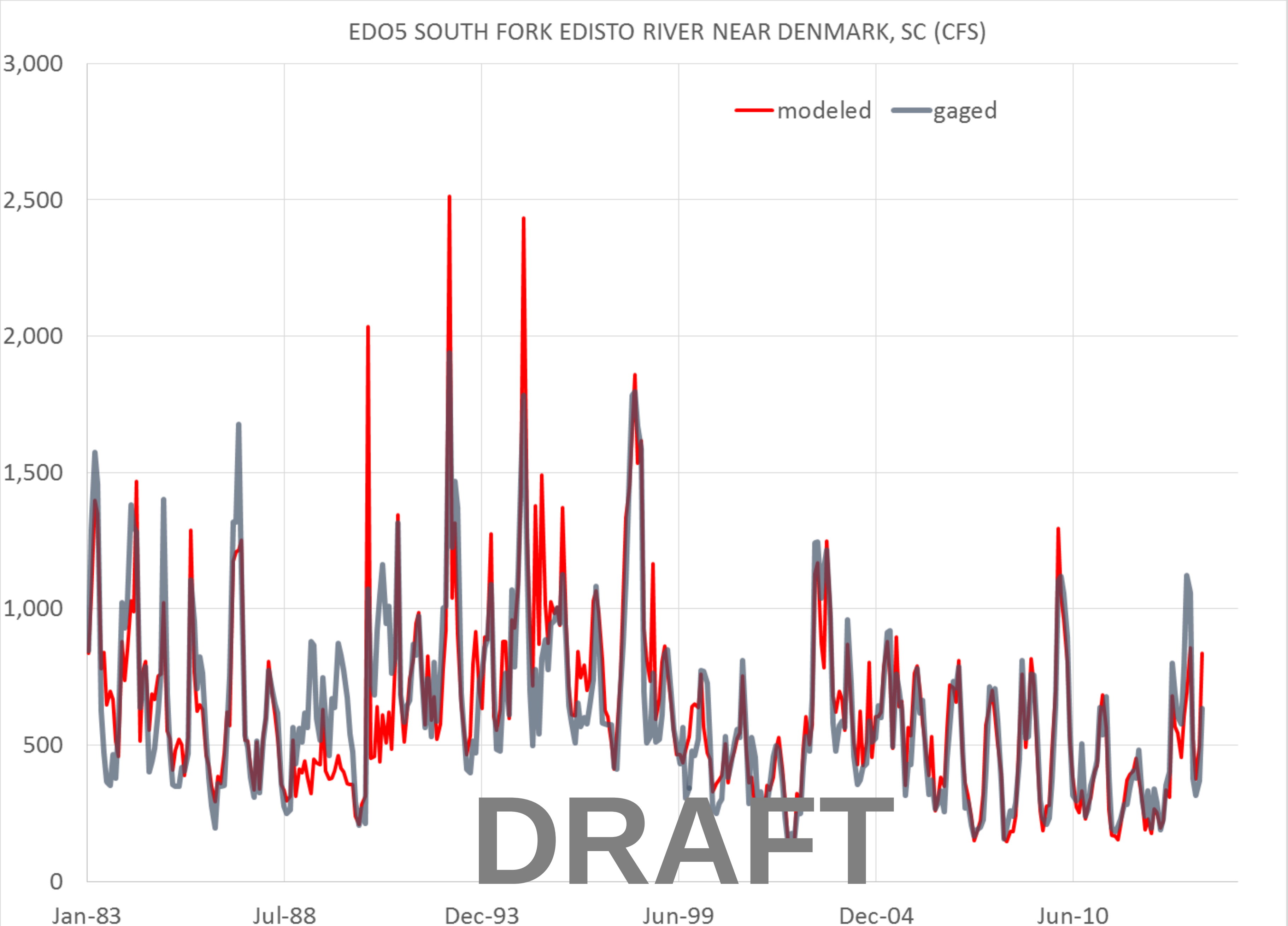




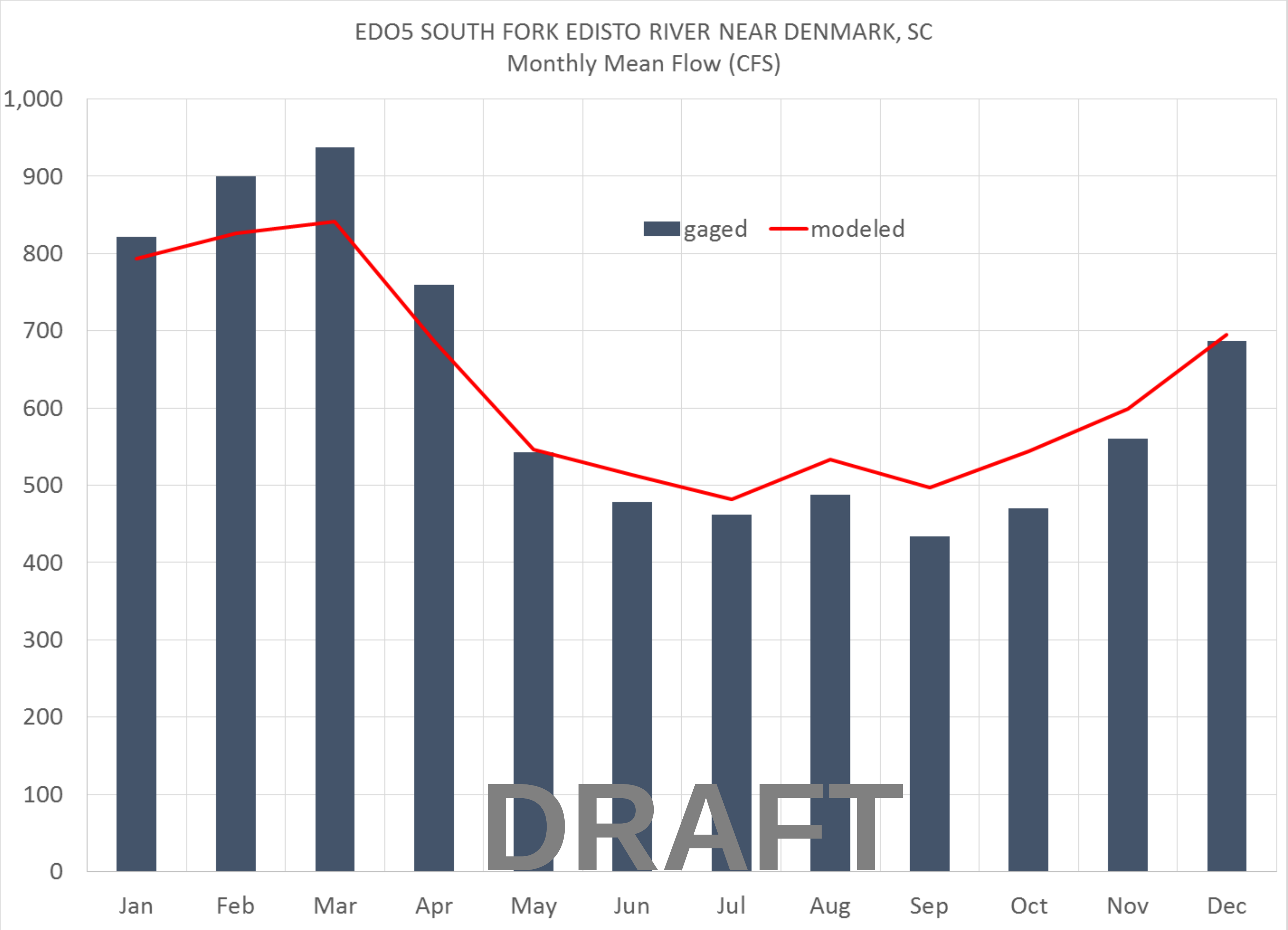
South Fork Edisto River near Denmark



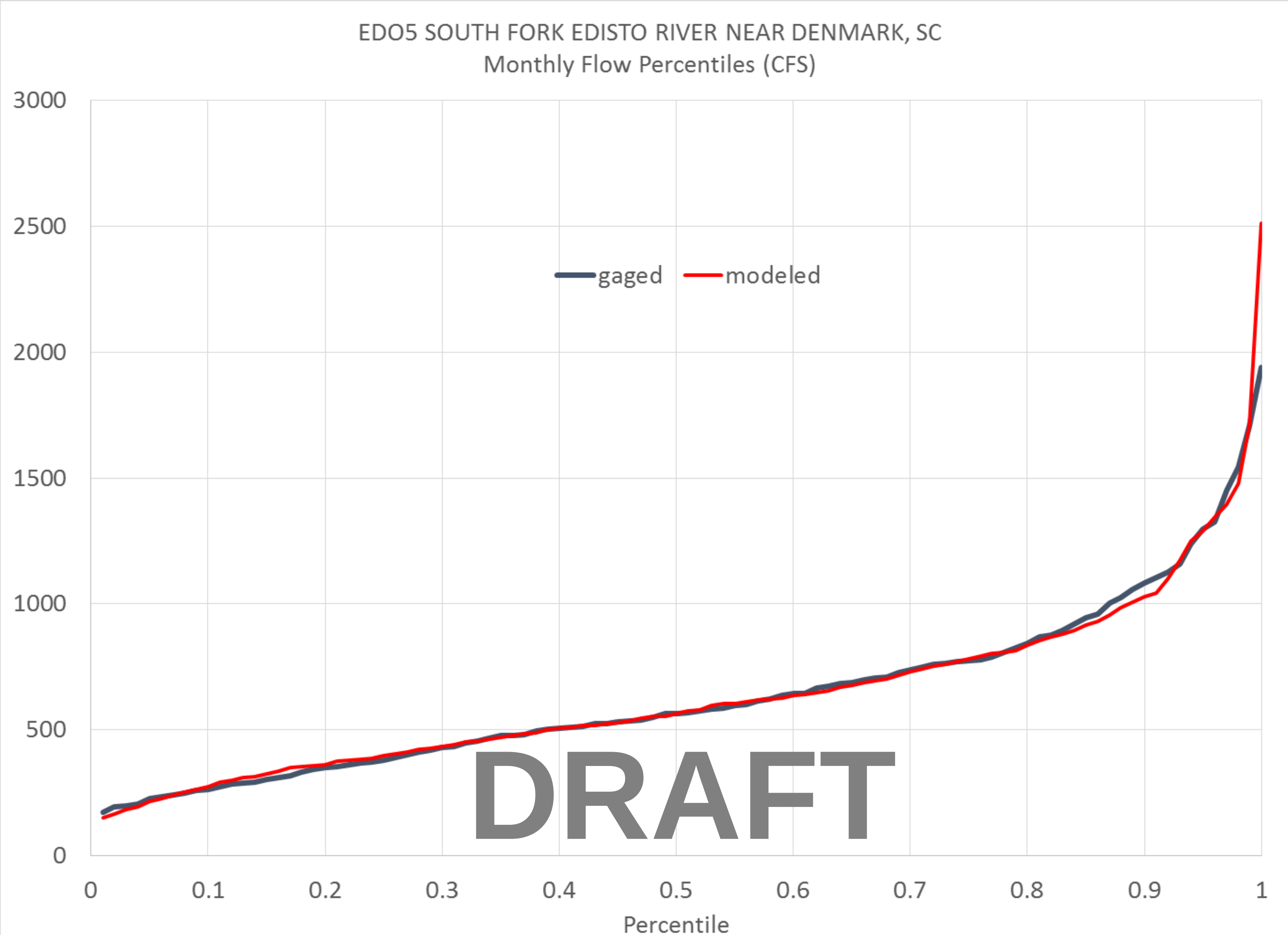
Monthly Flow Comparison



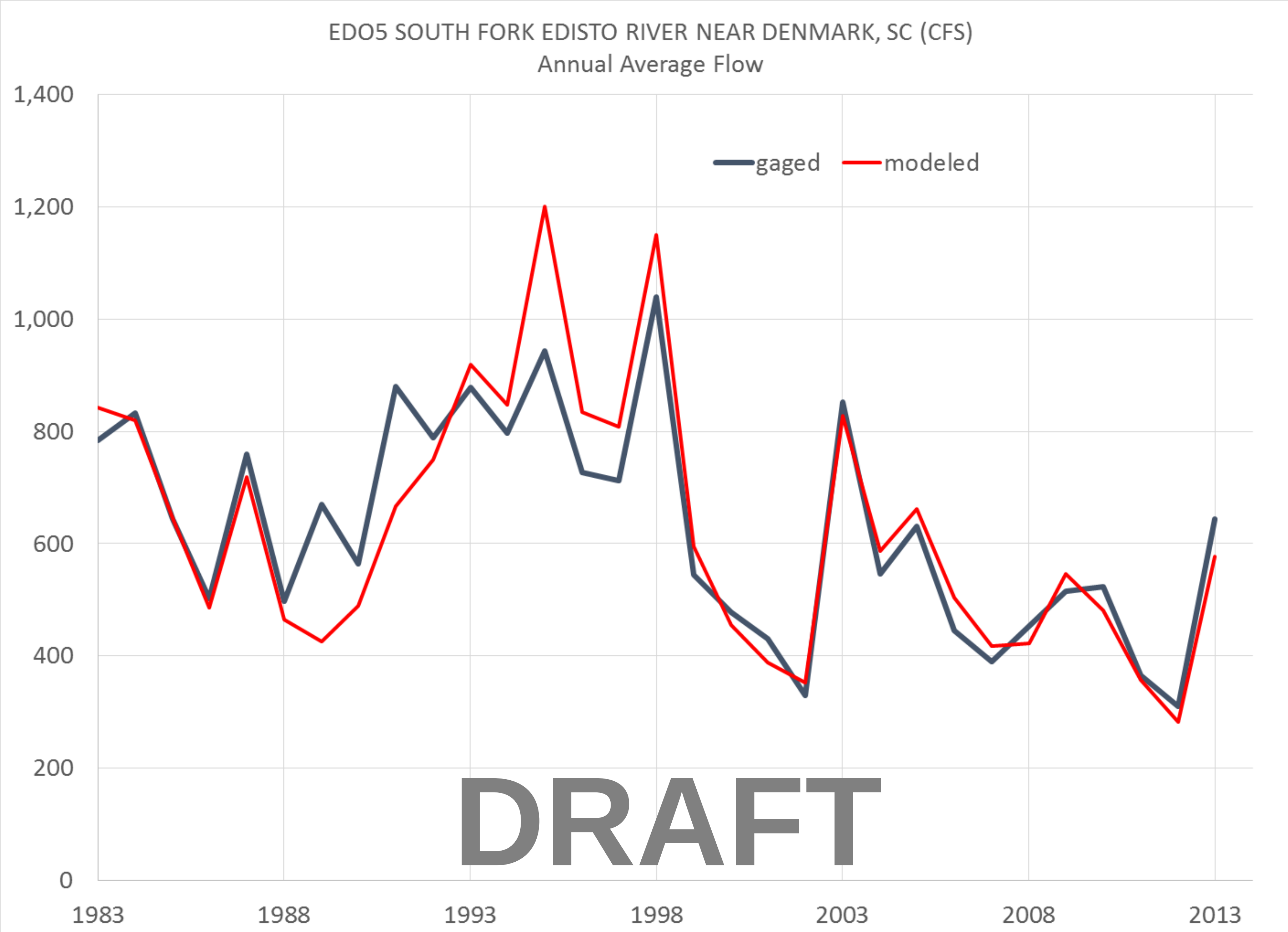
Monthly Mean Flow Comparison



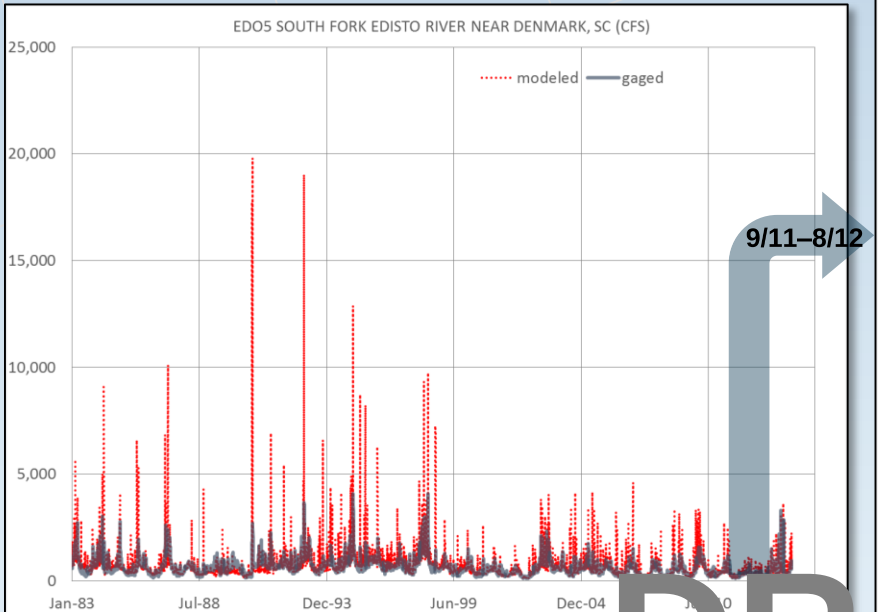
Monthly Flow Percentiles Comparison

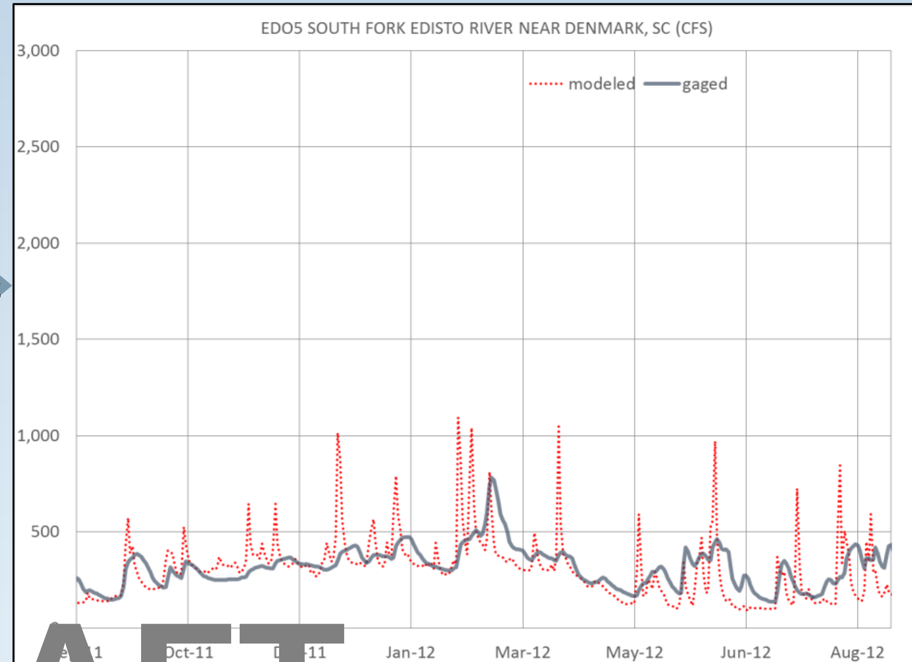


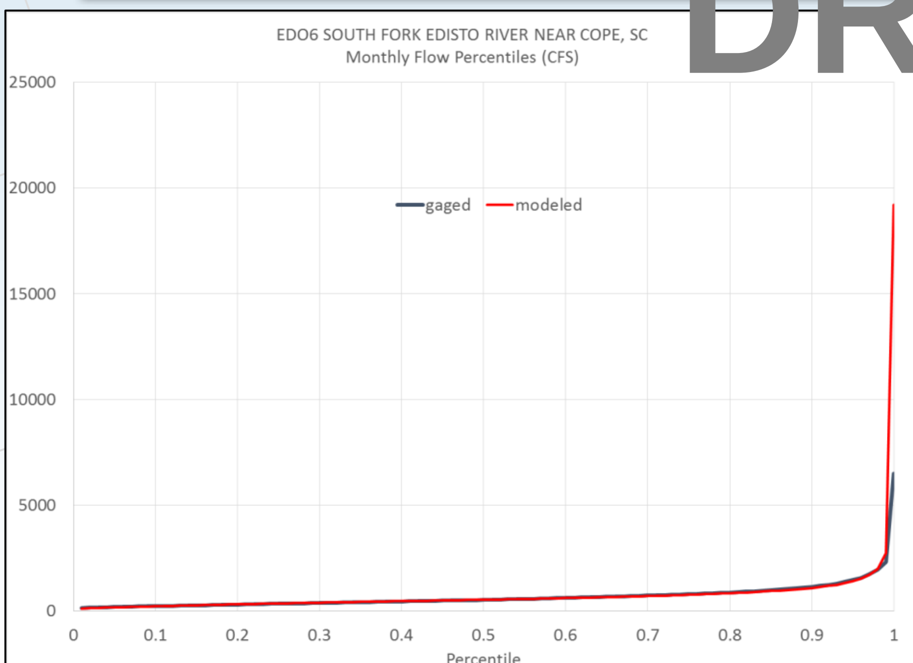
Annual Average Flow Comparison

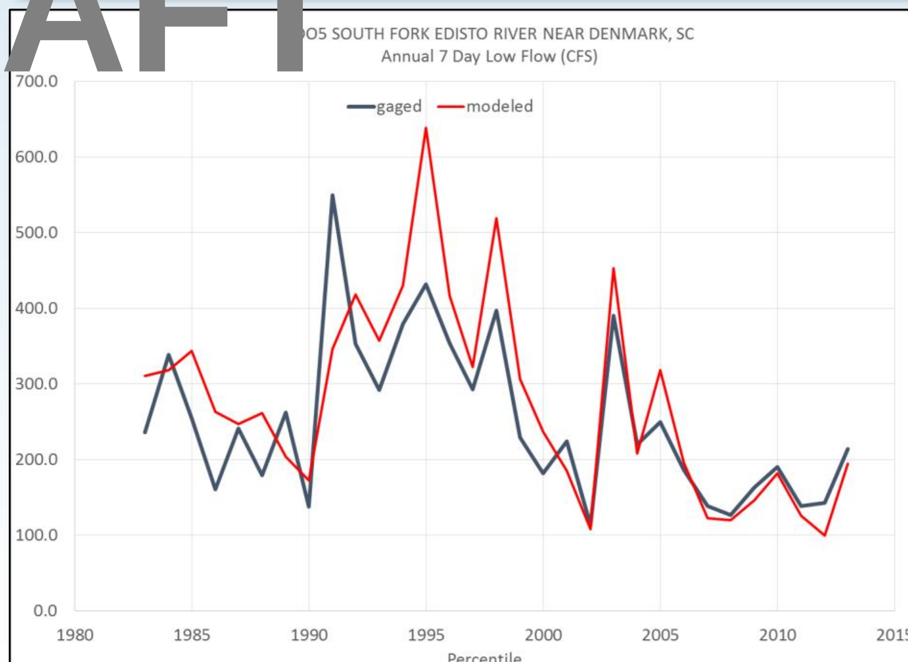


Daily Comparison

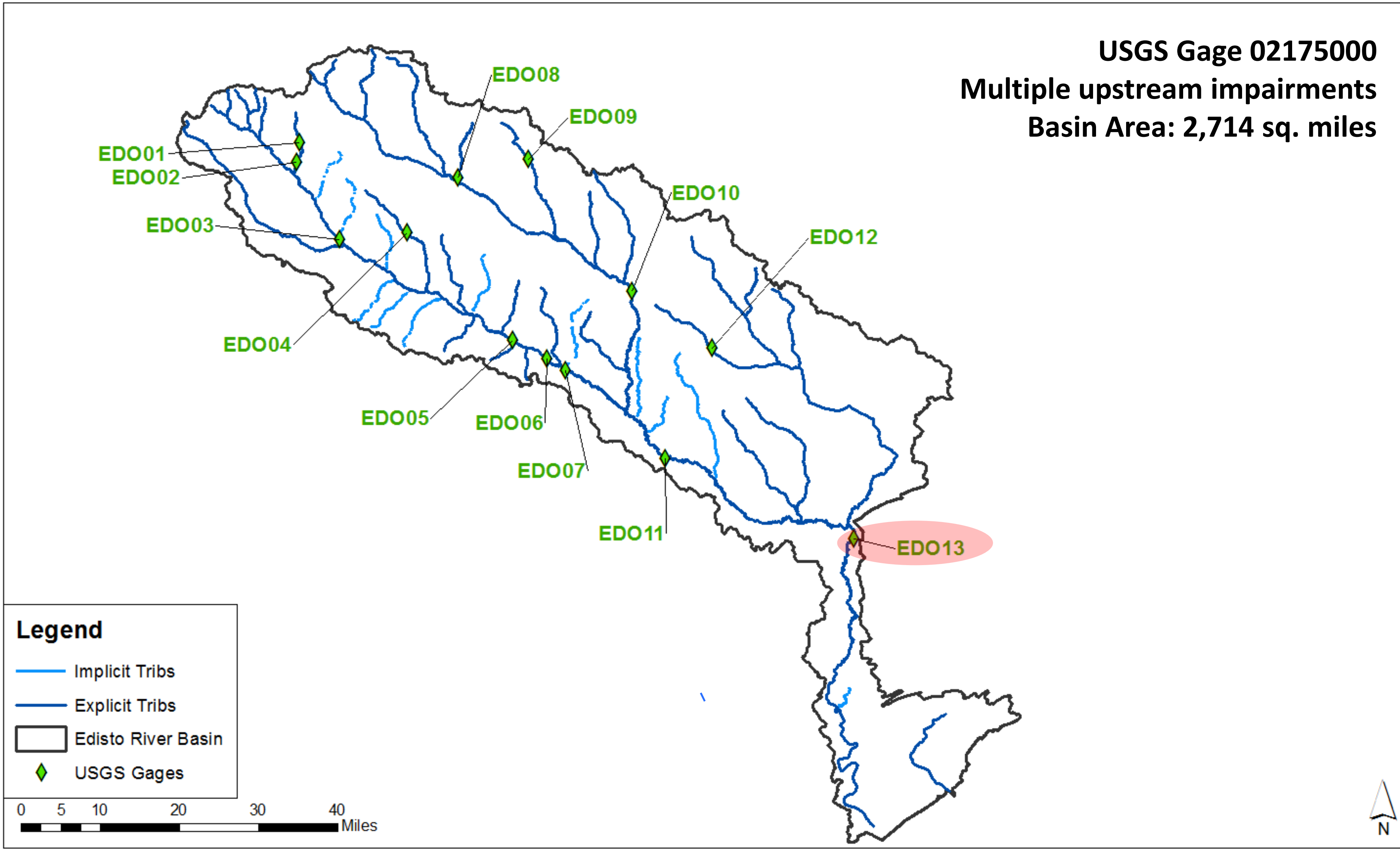




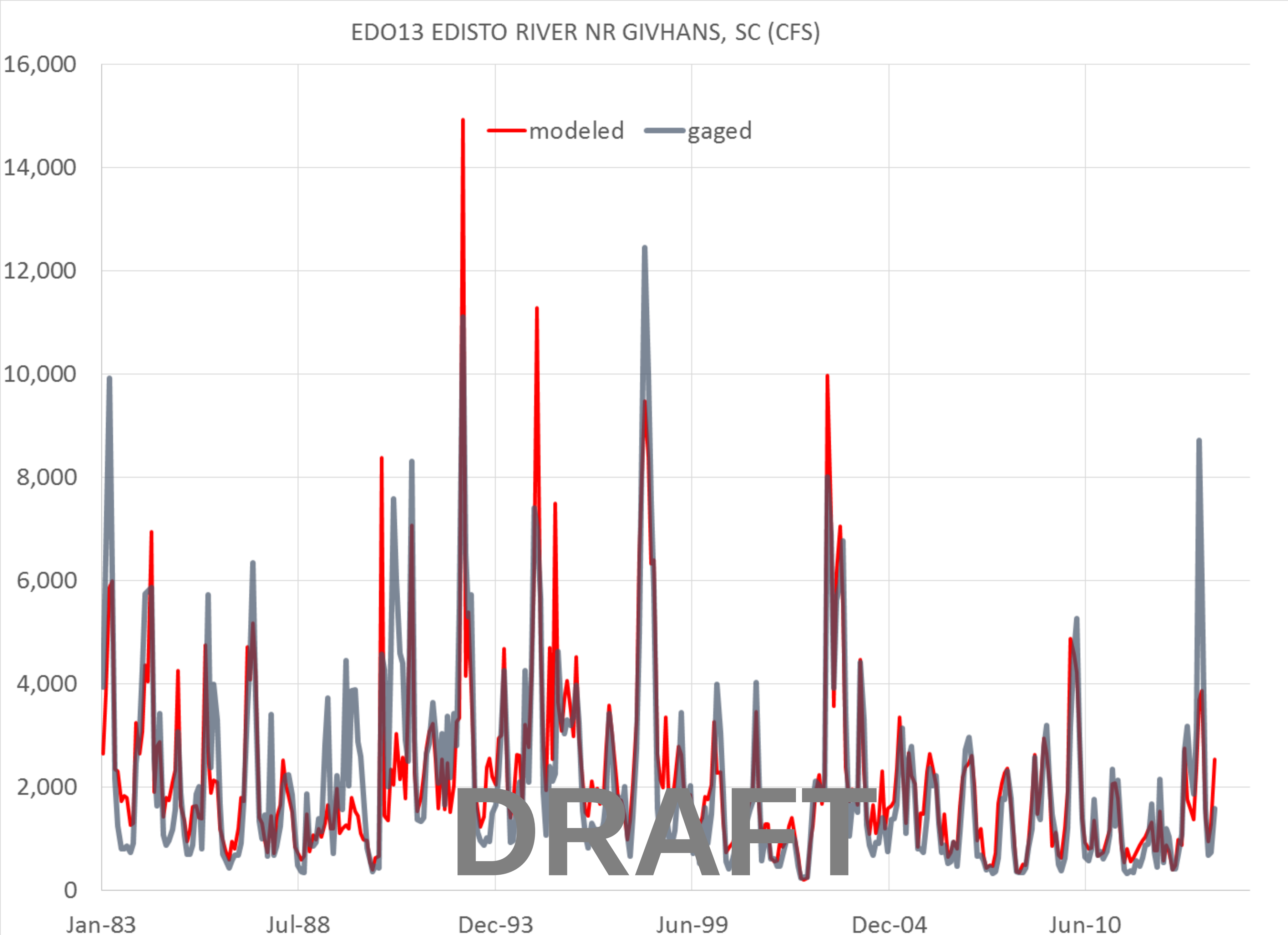




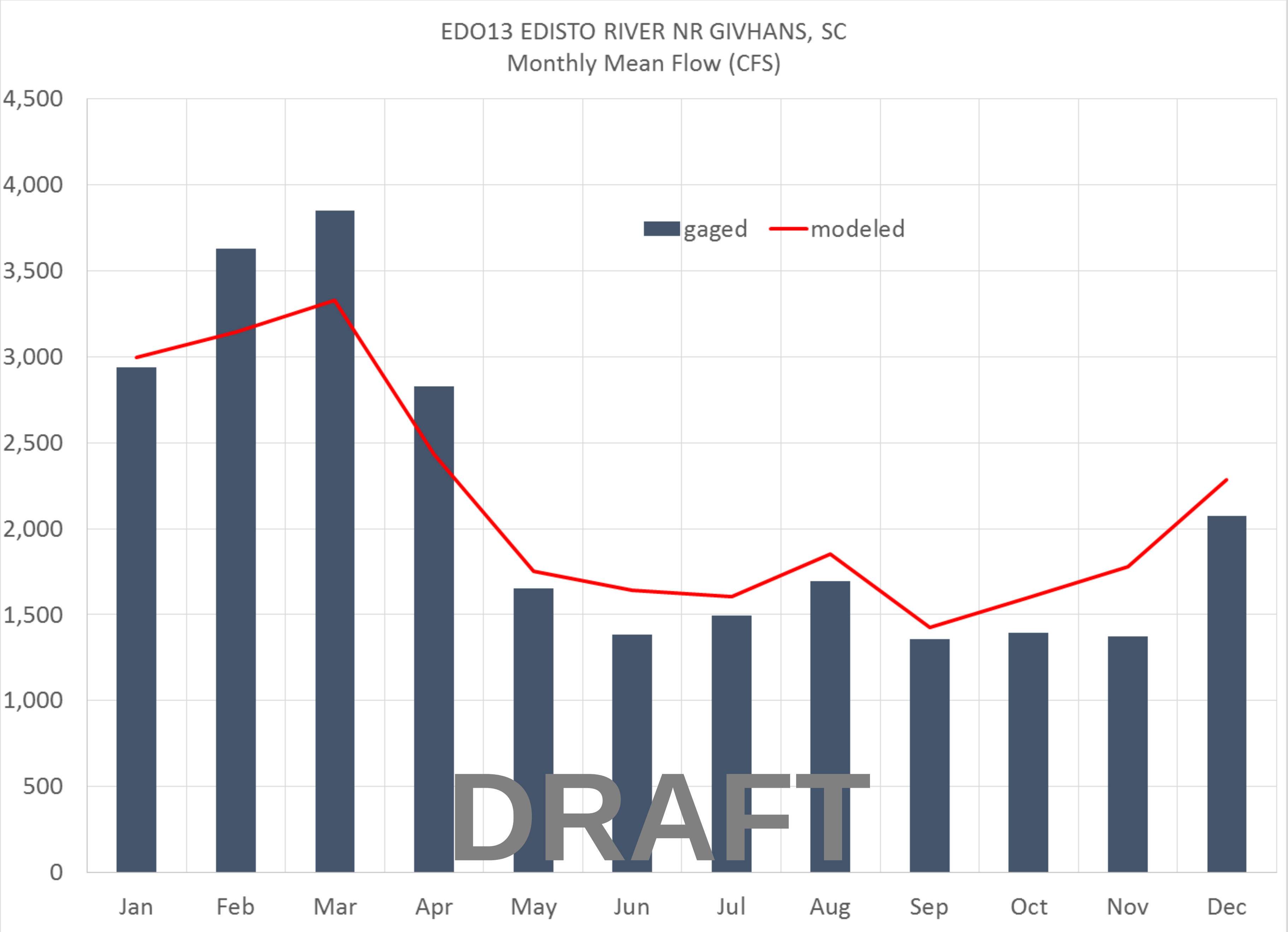
Edisto River Near Givhans



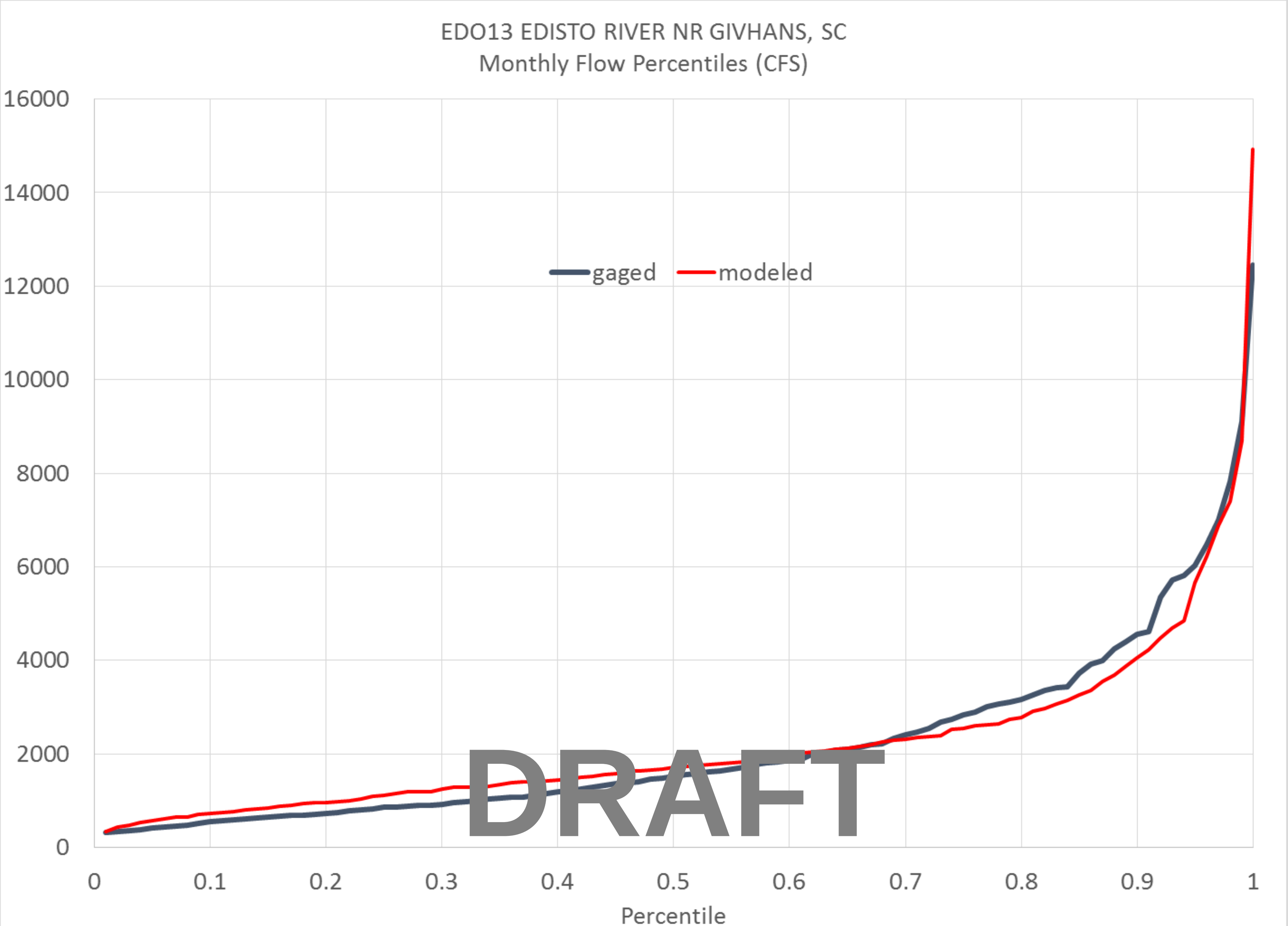
Monthly Flow Comparison



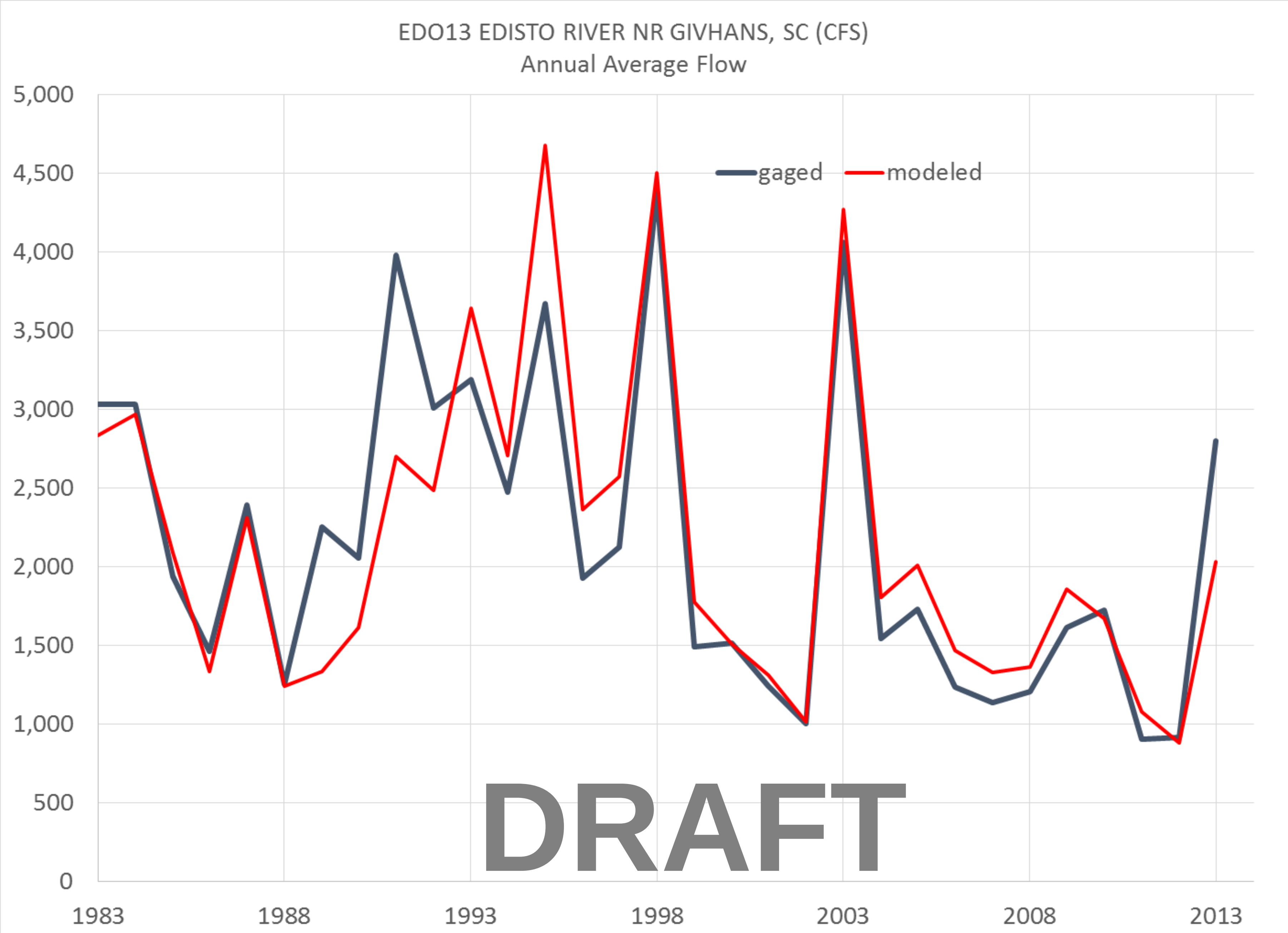
Monthly Mean Flow Comparison



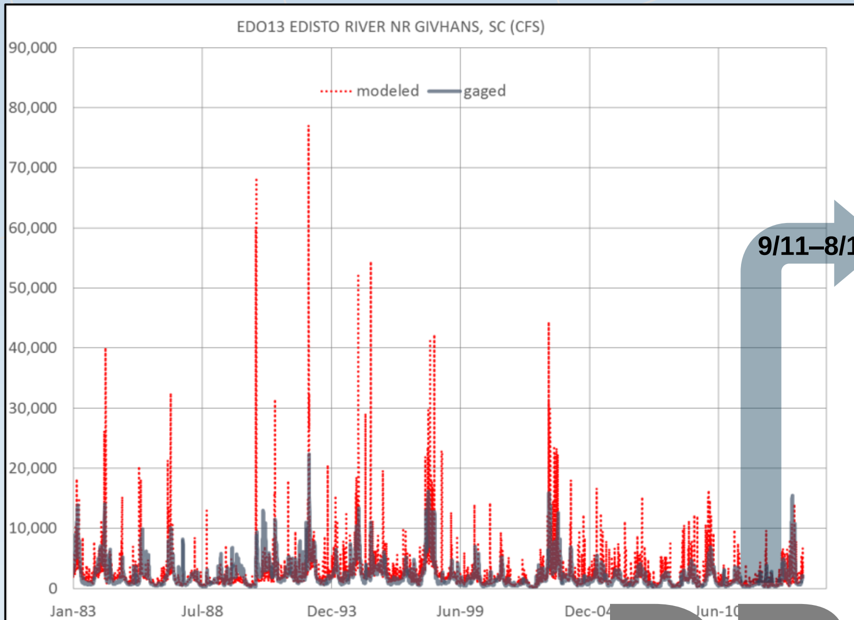
Monthly Flow Percentiles Comparison

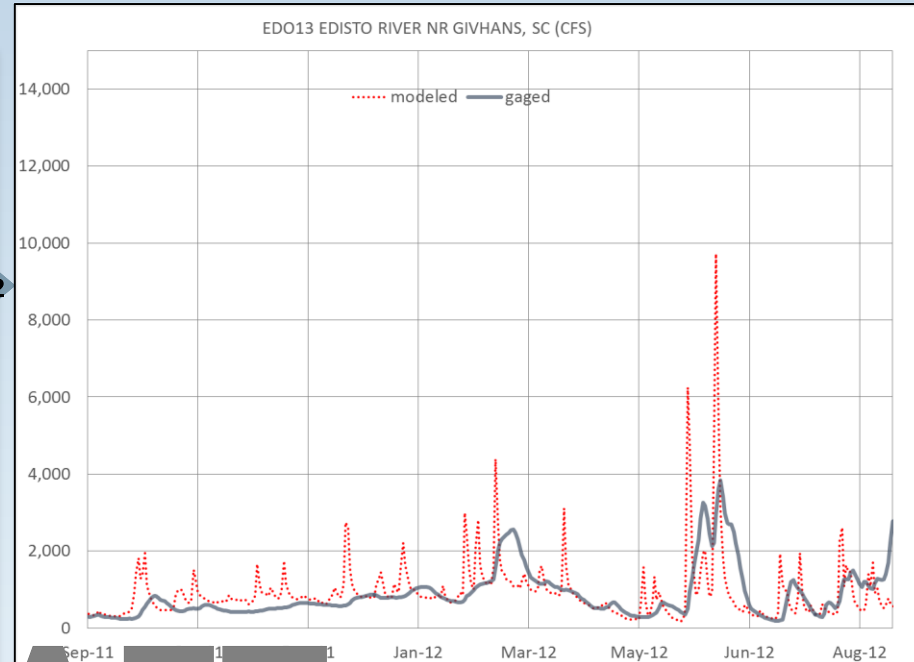


Annual Average Flow Comparison



Daily Comparison





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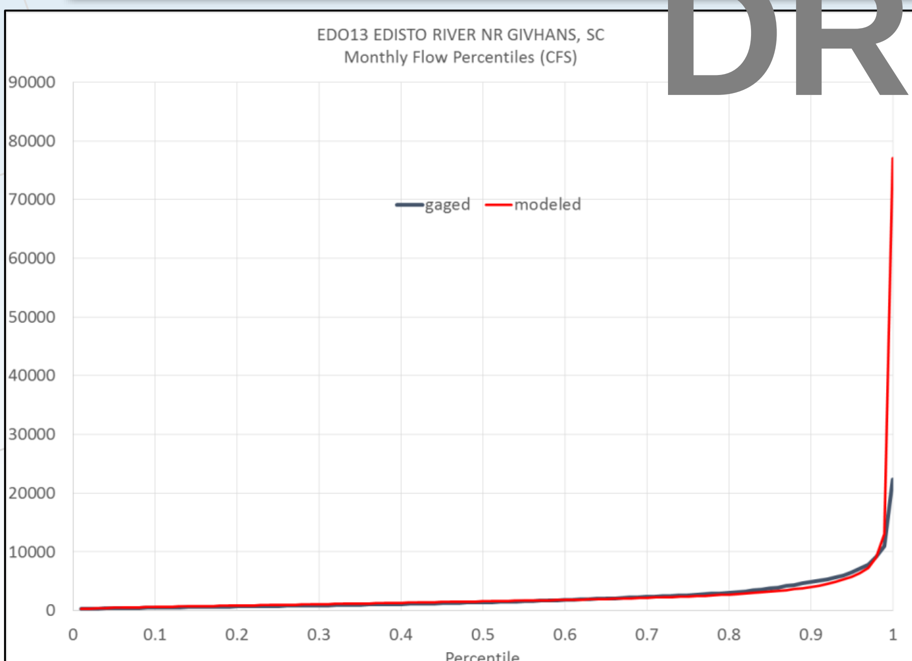
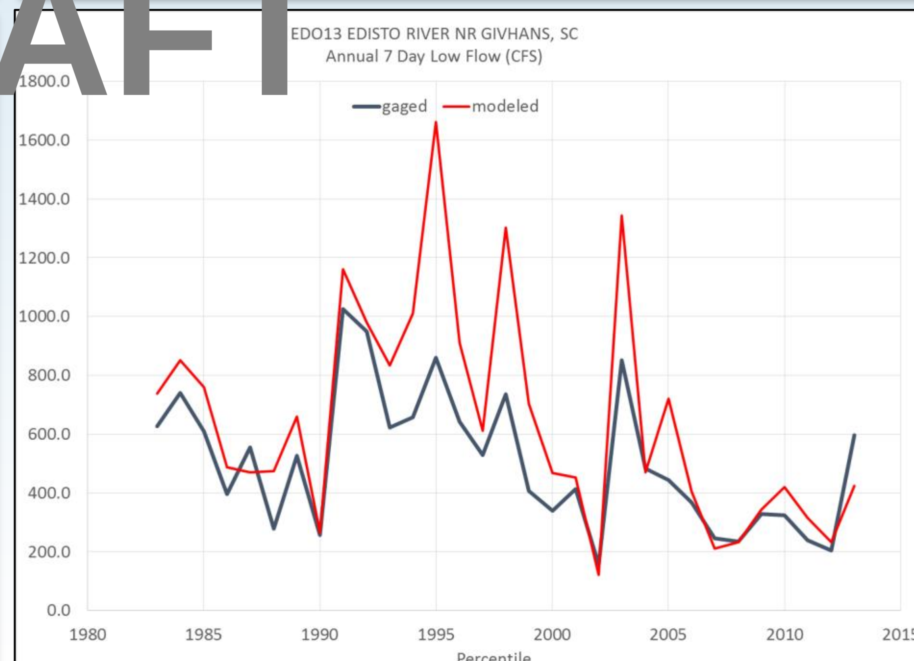




SWAM Calibration/Validation Summary

- For all sites, modeled mean flow values, averaged over the full period of record, are within 2% of measured mean flows
- Monthly mean flows percentile deviations are all generally within 10-20% with no clear bias at most locations
  - S. Fork gages show slight summer/winter bias
- Modeled low flow values (as represented by 7Q10 flows) are within 10% of measured values at mainstem gages EDO 06 and EDO13; 15% at EDO 05 and EDO 07; and 50% at EDO 10
- The model adequately hindcasts delivered water supply for water user in the model (no significant shortfalls).
  - Select ag withdrawals near headwaters of tributaries are one exception

Draft to Final Model – Areas of Focus

- Modeled peak flows > observed peak flows
  - Investigate alternative reference gages for UIFs
- 1988 - 1991 modeled flows < observed flows along N and S Fork Edisto
- Slight seasonal bias along S Fork Edisto River and Edisto River
- Modeled ag shortages in headwaters of select tributaries
  - Investigate disaggregating withdrawal locations
  - Investigate inclusion of storage where small impoundments exist
  - Use segmented reach gain/loss factor

Edisto River Basin

BASELINE MODEL

Baseline Model

- Represents current demands and operations combined with an extended period of estimated hydrology
  - Most demands reflect 2005-2014 averages
  - Estimated hydrology from 1931 to 2013
  - Inactive users are not included
- The baseline model serves as the starting point for future predictive simulations

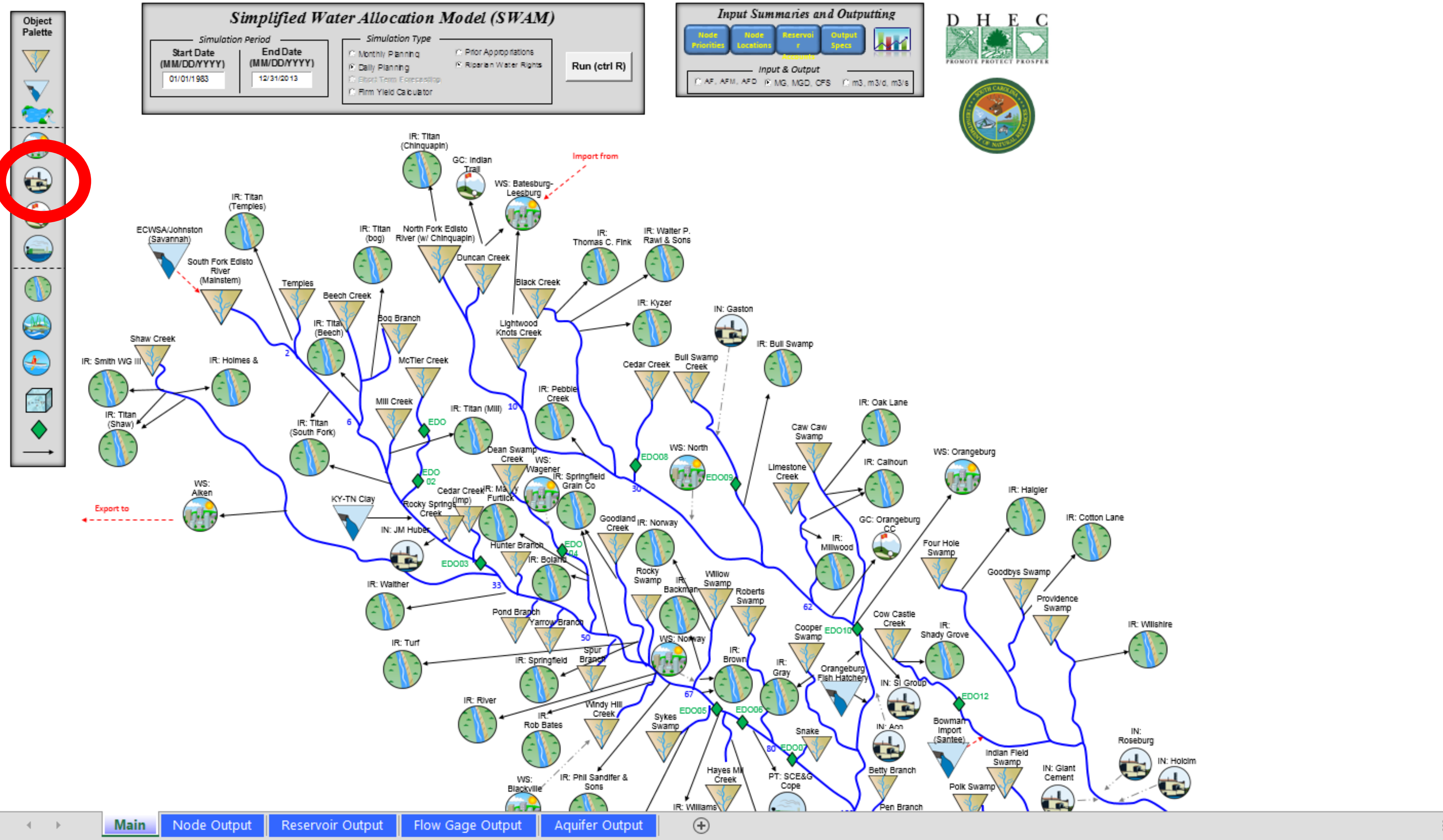
The Models Can Be Used To…

- Determine surface-water availability
- Predict where and when future water shortages would occur
- Test alternative water management strategies, new operating rules, and “what-if” scenarios
- Evaluate the impacts of future withdrawals on instream flow needs
- Evaluate interbasin transfers
- Support development of Drought Management Plans
- Compare managed flows to natural flows
- Consolidate hydrologic data

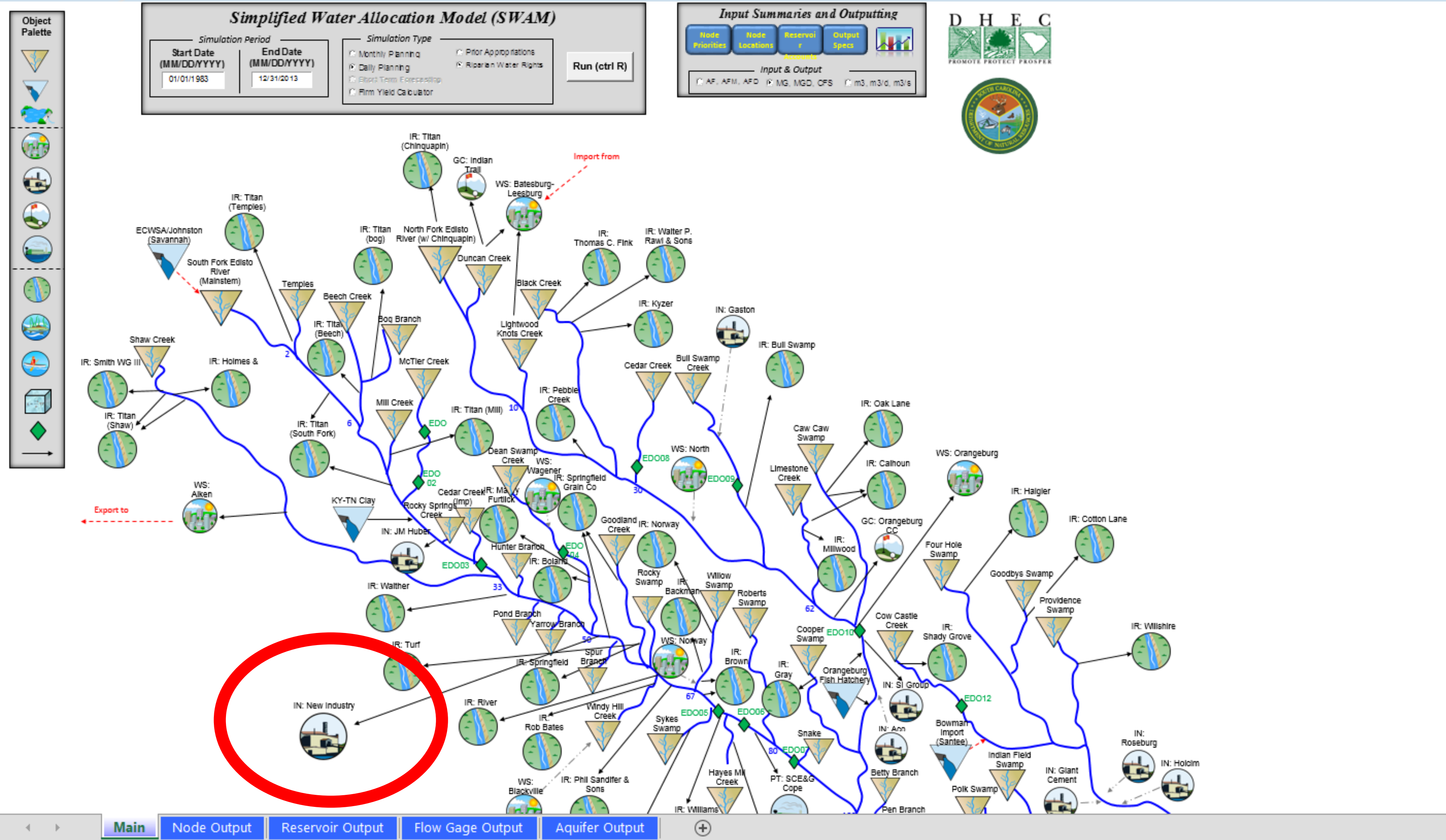
Example Use
Adding a New Industry

- Add a new M&I permittee on the South Fork Edisto River
  - Demand = 7,000 MGY (19 mgd)
  - *Is there enough water for the new industry?*
- Add a new Instream Flow Object downstream
  - Instream Flow Target = 300 cfs
  - *Can this also be satisfied?*

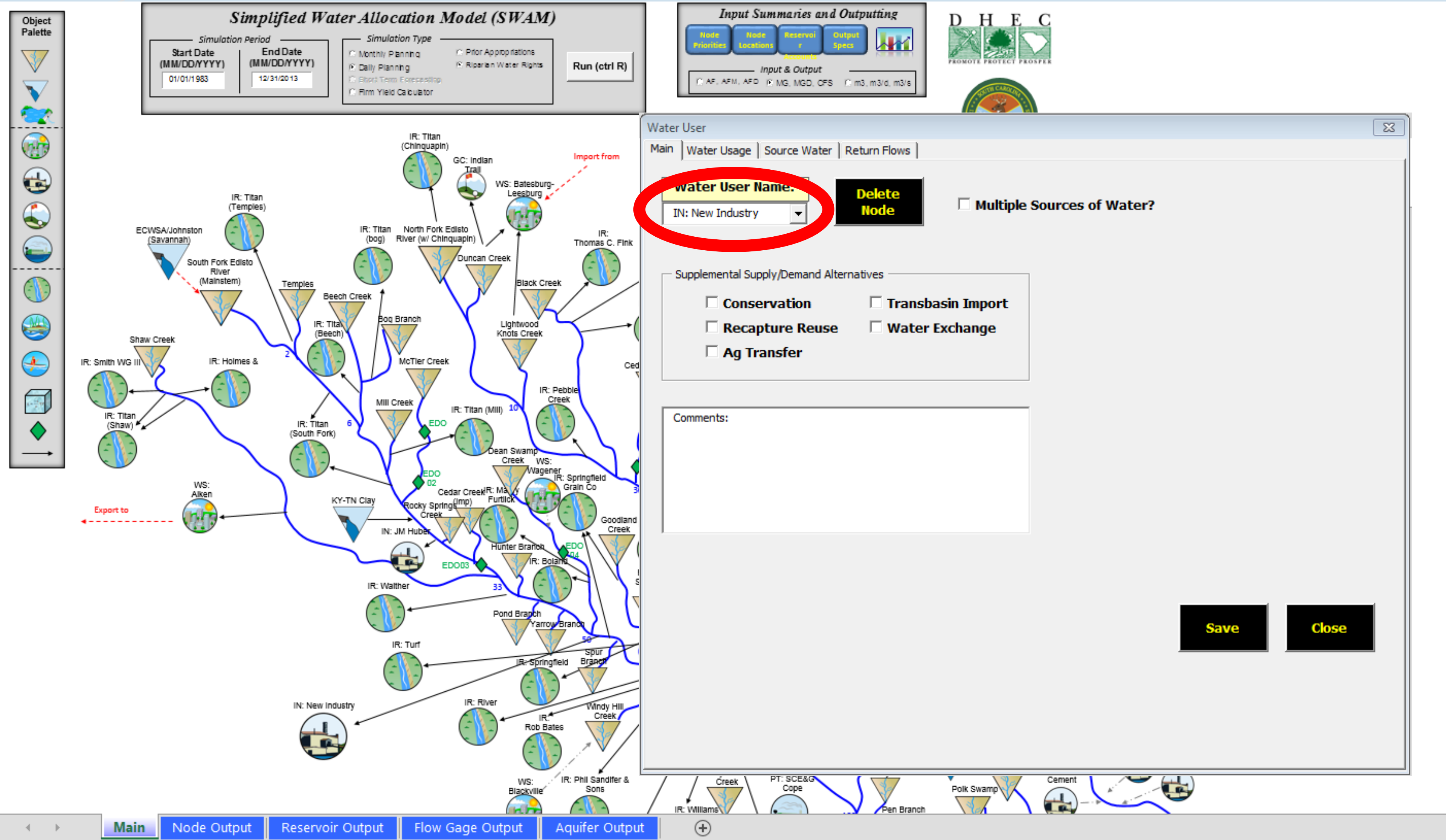
Add an Industrial Water User Object from the Palette



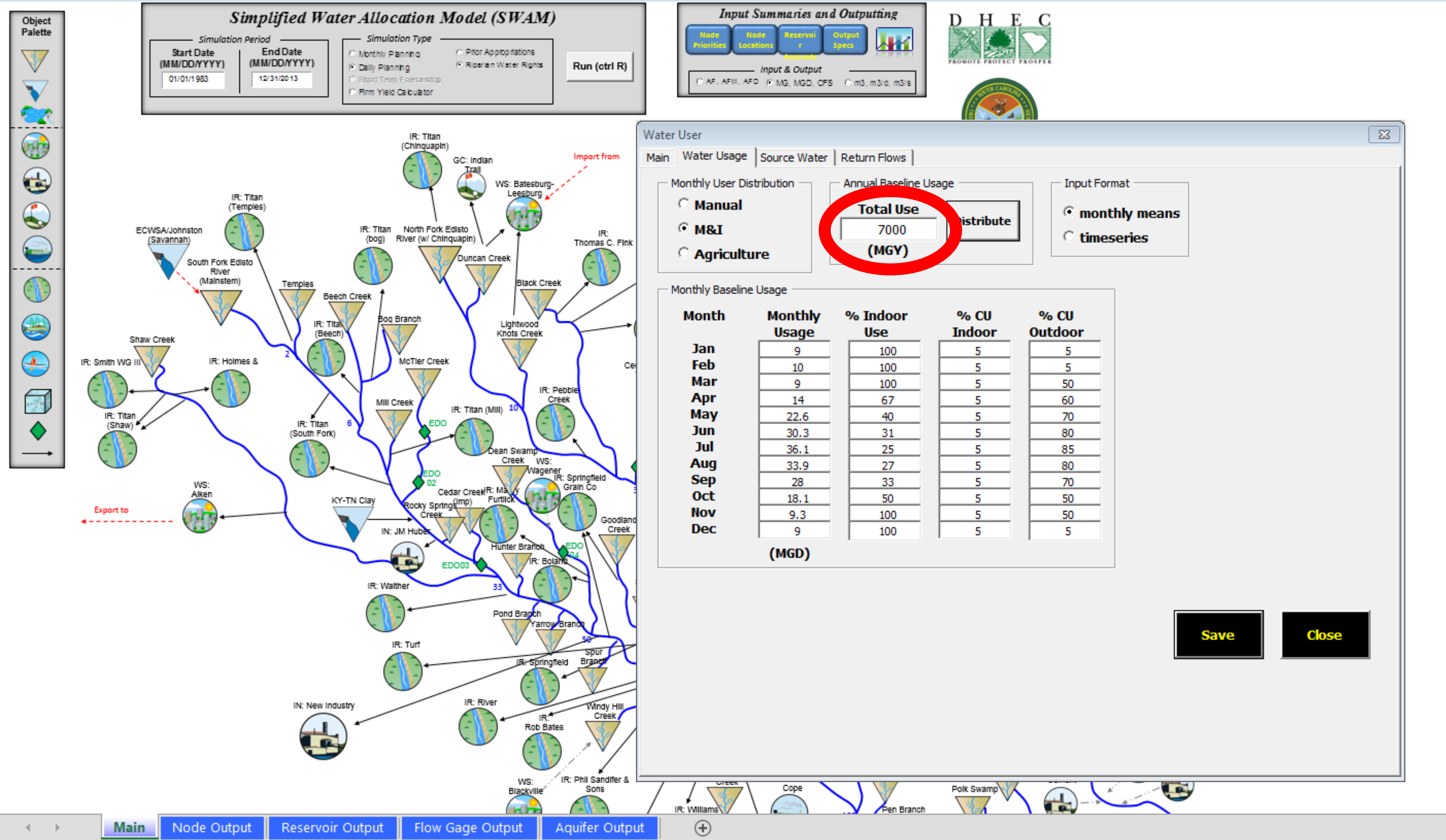
Add an Industrial Water User Object from the Palette



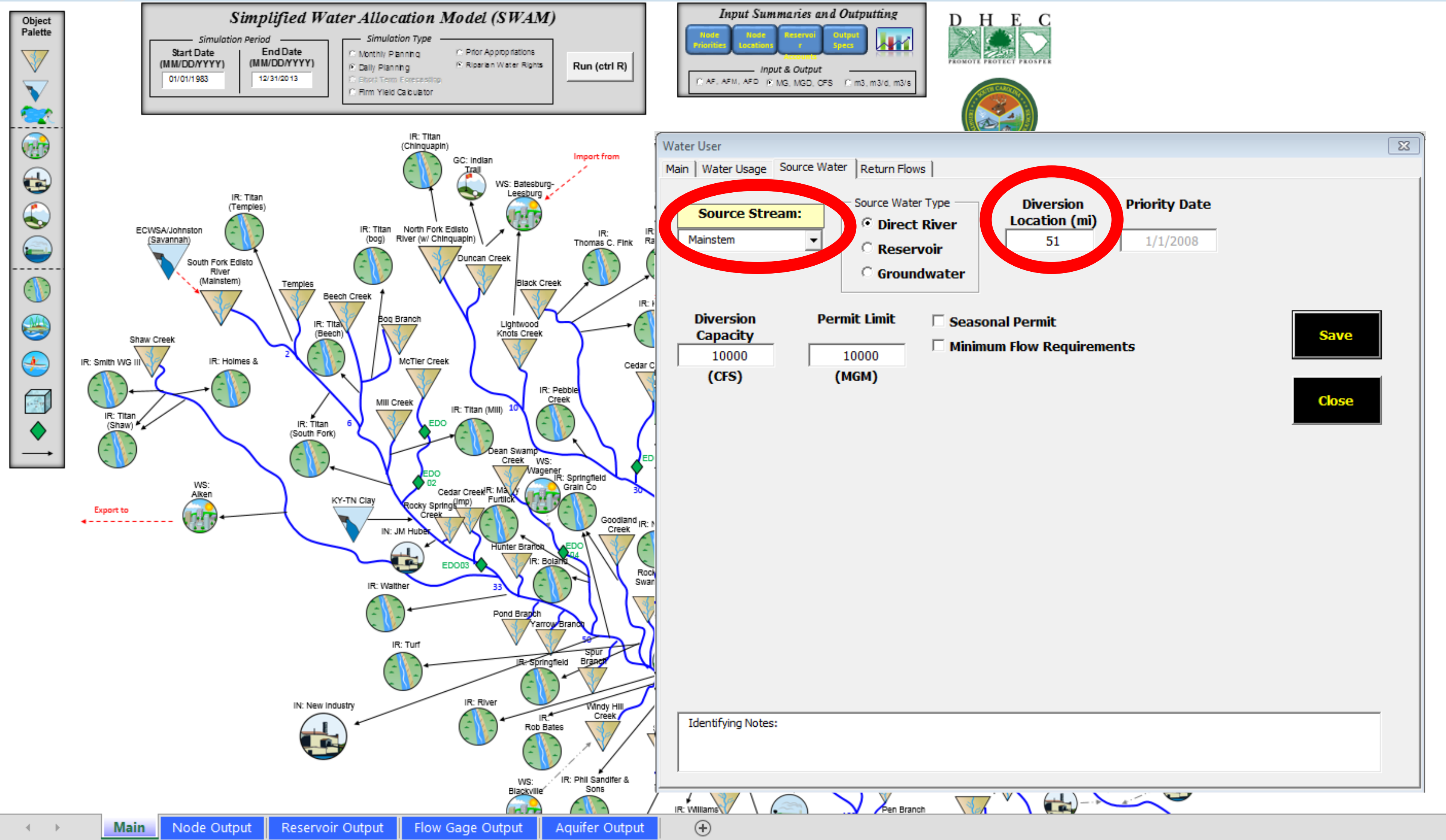
Add the New Industry in the Water User Dialogue



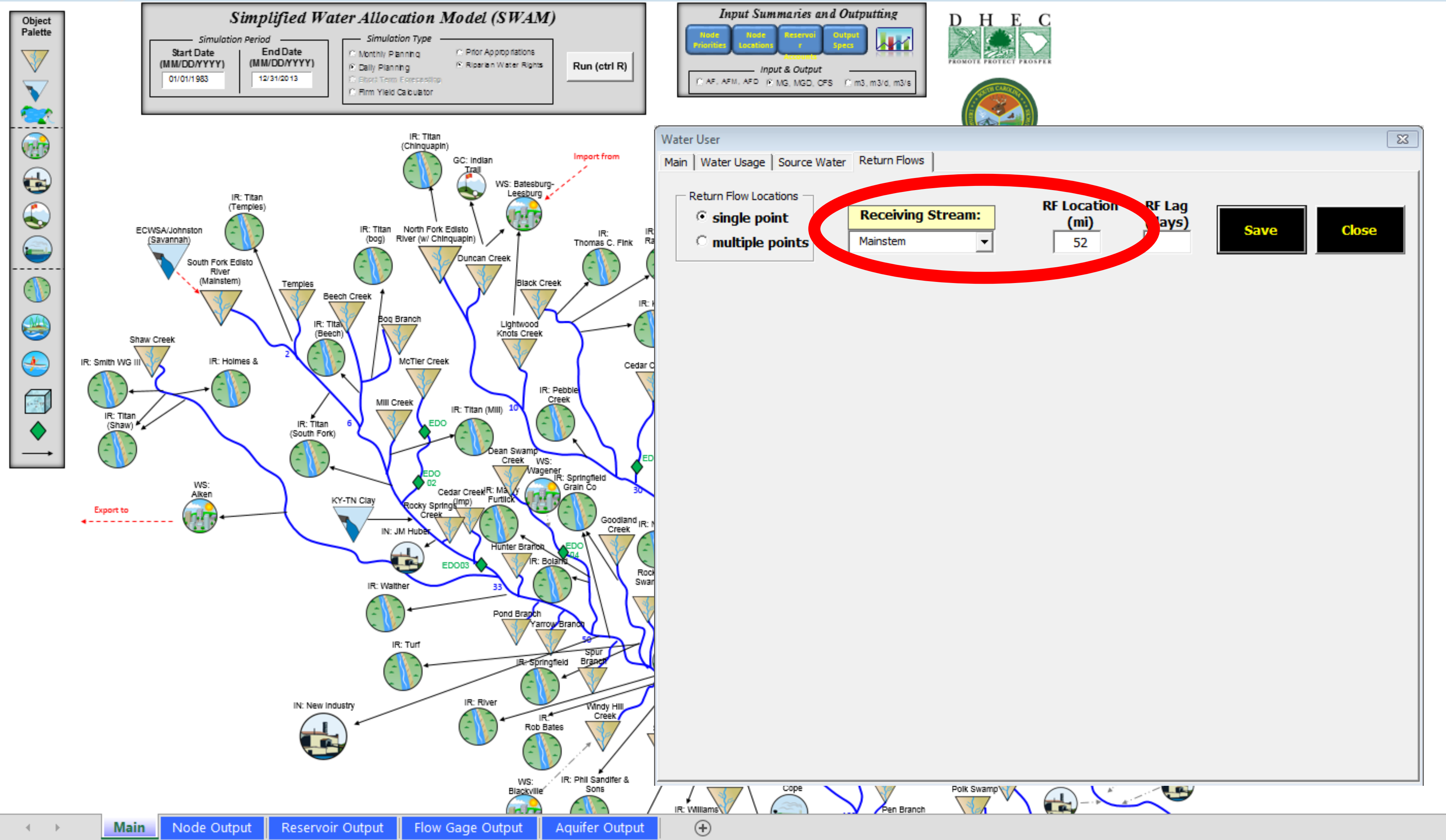
Specify Water Use



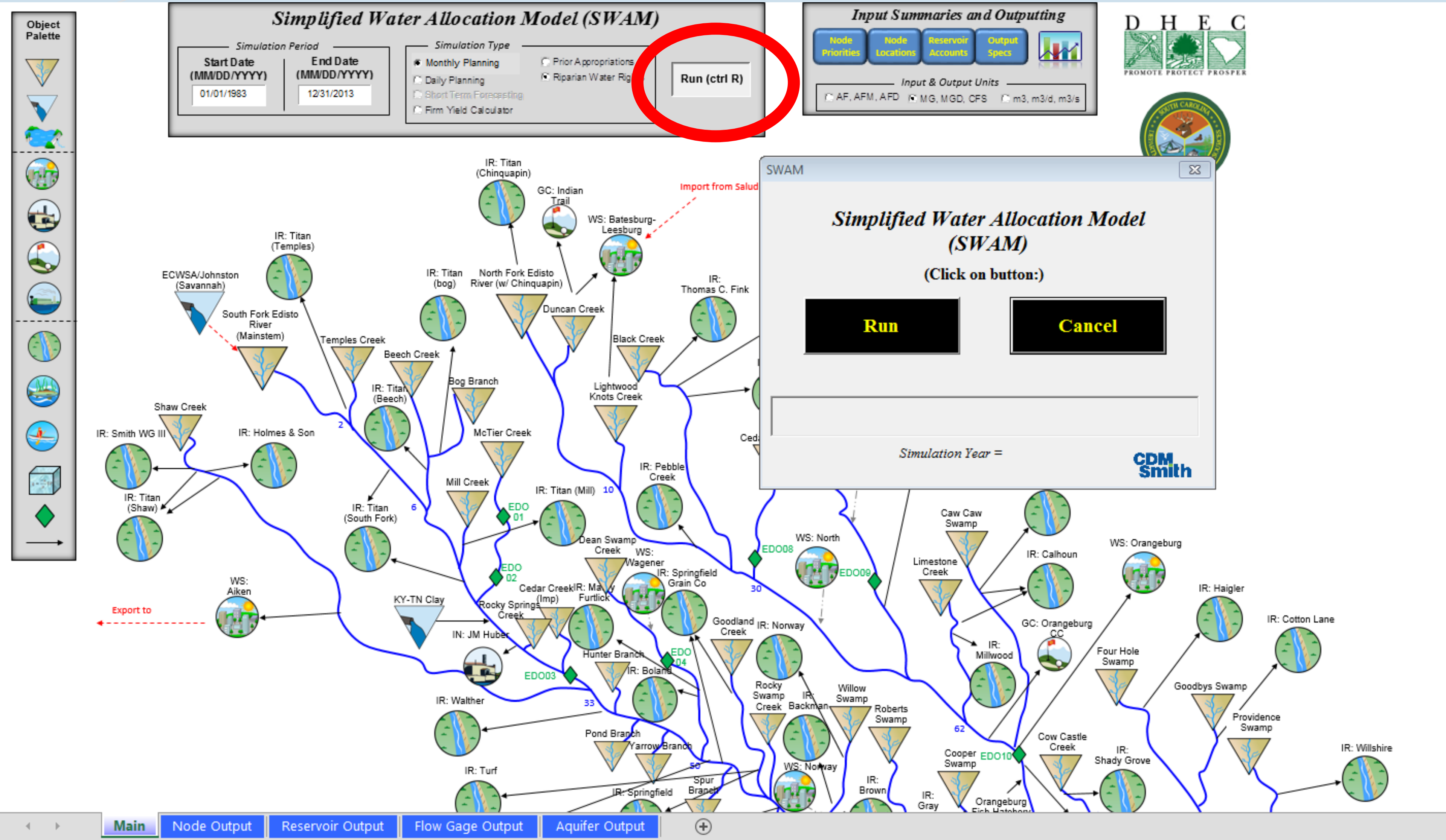
Specify the Source and Diversion Location



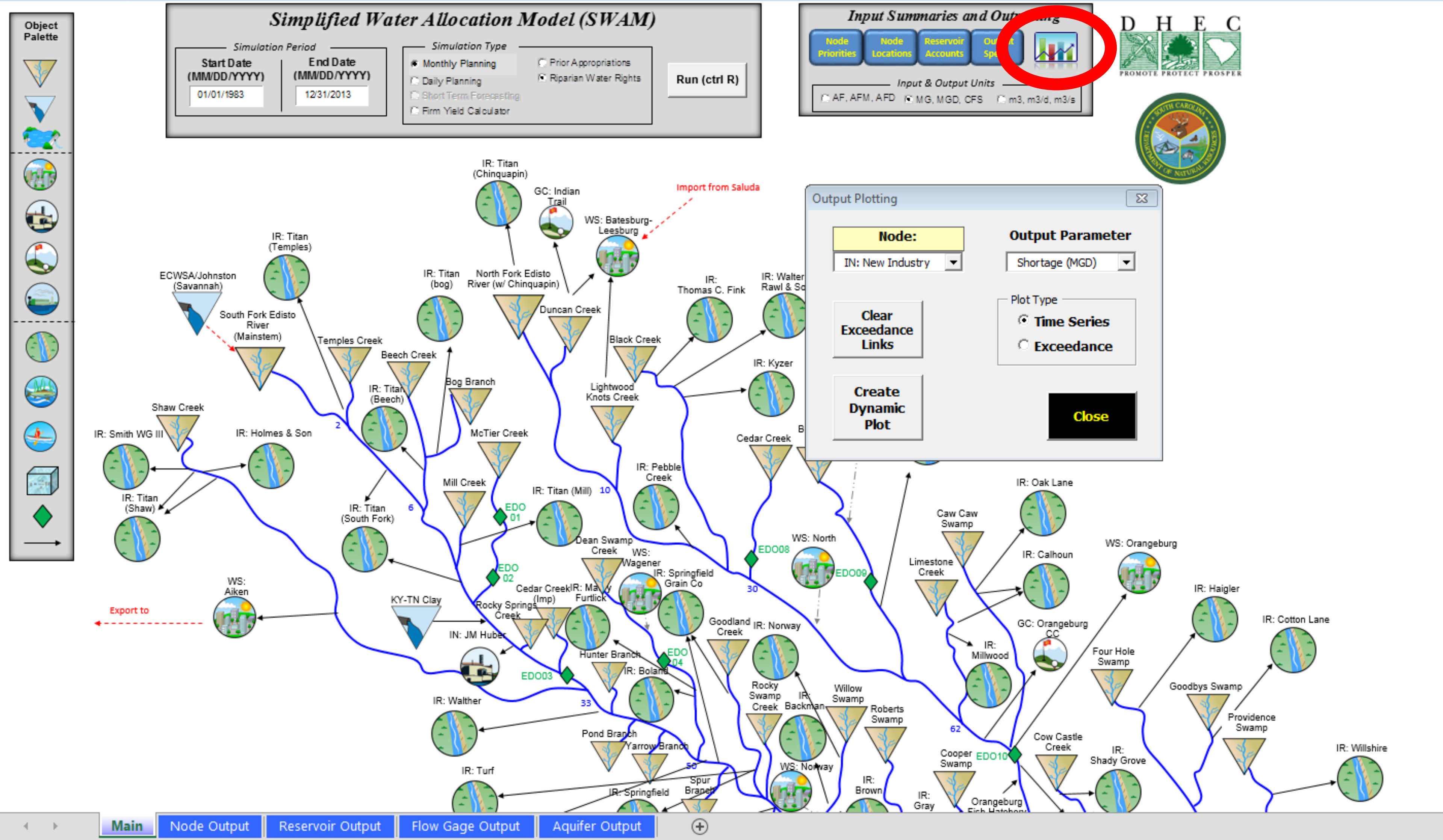
Specify the Return Location



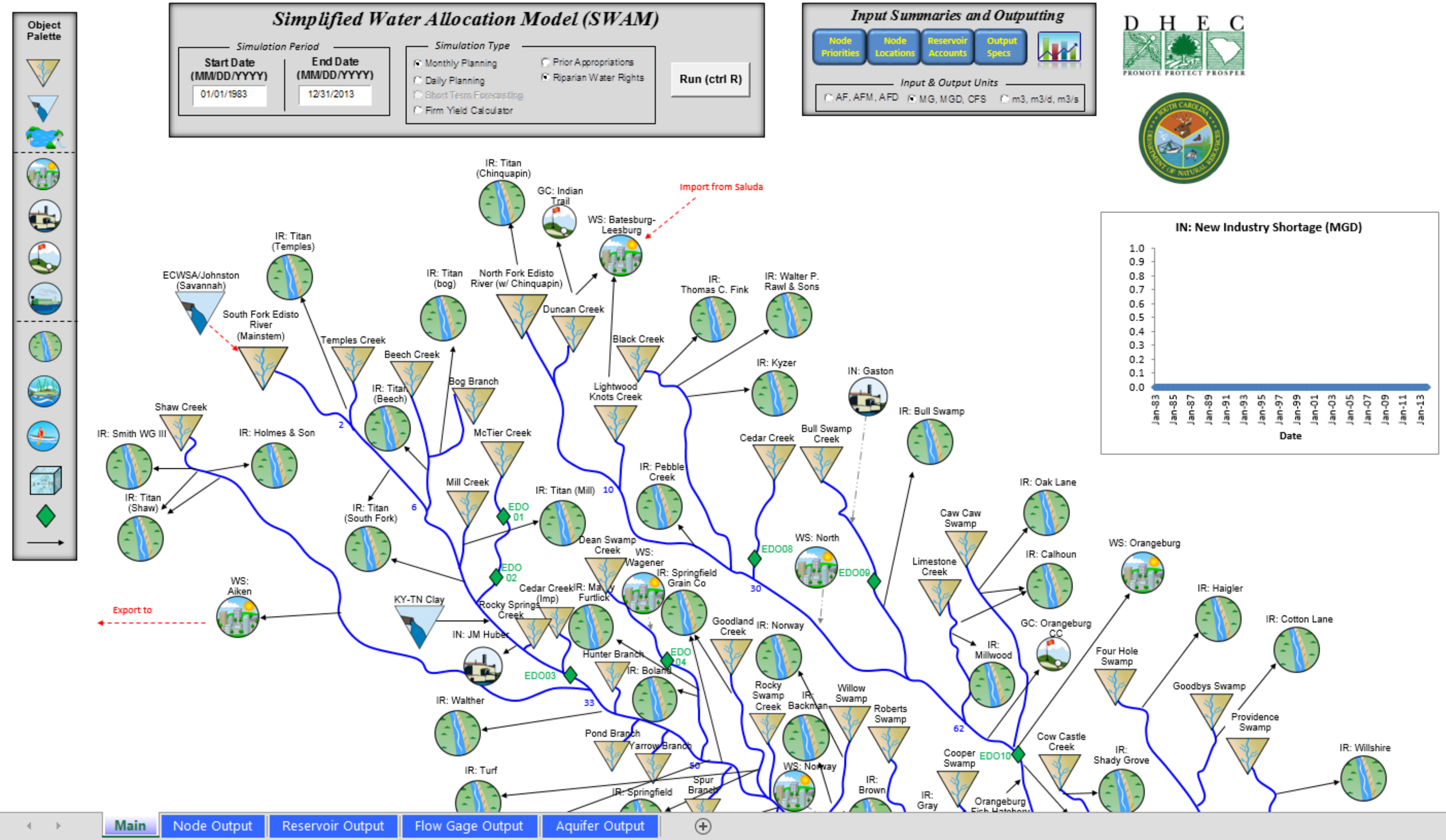
Run the Model Scenario



Build a Shortage Plot for the New Industry



Build a Shortage Plot for the New Industry

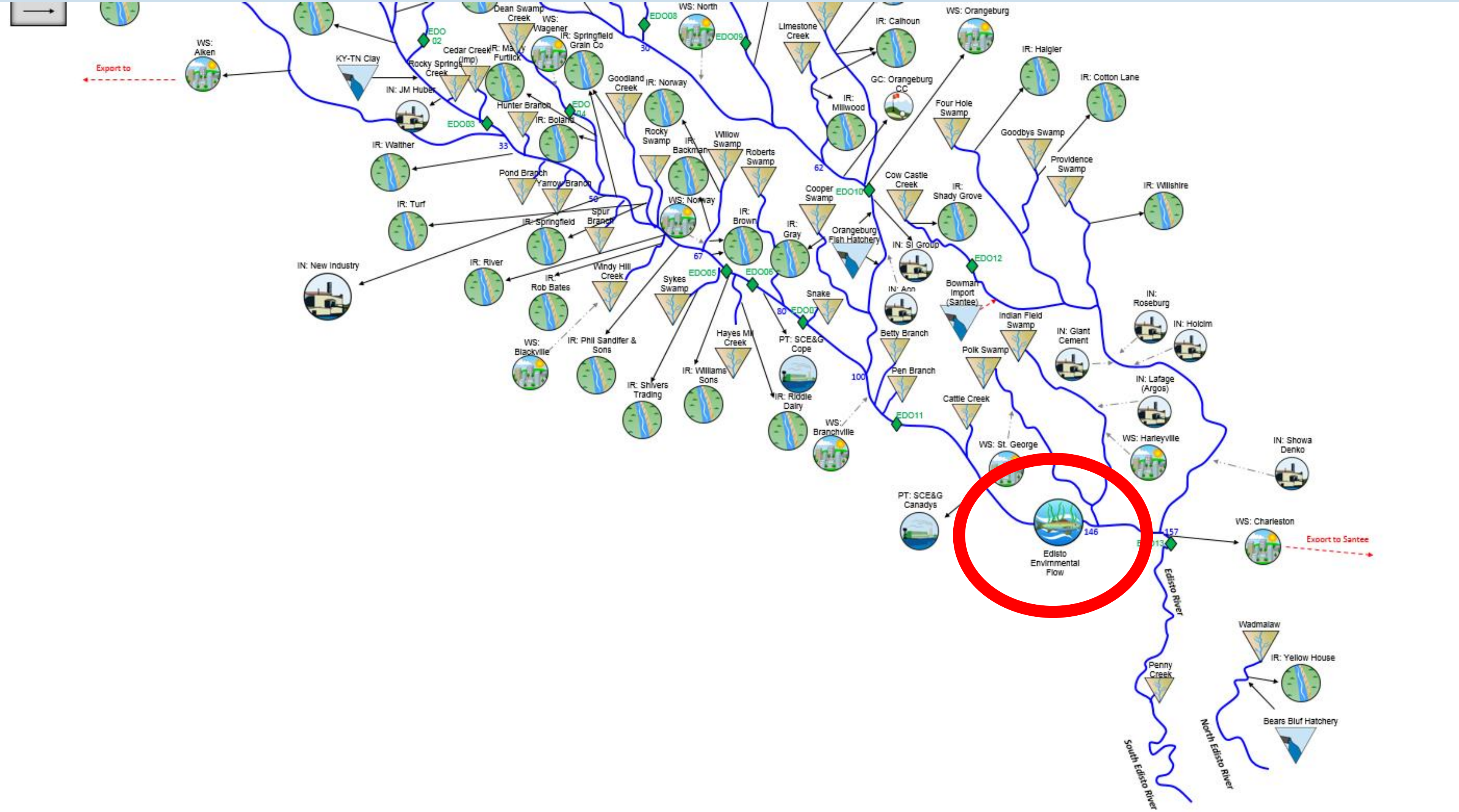


Shortages are Also Listed in the Node Output Table

	A	B	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ
1	Output			Priority Rank	Reach	Location	Permit Limit (MGM)	Ditch Capacity (CFS)	Storage Capacity (MG)	Storage Withdrawal Permit (MGM)					Priority Rank	Reach	Location	Permit Limit (MGM)
2			*IN: New Industry*	*58*	*Mainstem*	*51*	*10000*	*10000*	*0*	*325829*			*IR: Springfield Grain Co Totals*					*20000*
3		Date	Physically Avail. (MGD)	Legally Avail. (MGD)	Diverted (MGD)	Storage (MG)	GW Pumping (MGD)	Demand (MGD)	Shortage (MGD)	Return Flow (MGD)	Release (MGD)	Evap Losses (MGD)		Physically Avail. (MGD)	Legally Avail. (MGD)	Diverted (MGD)	Storage (MG)	GW Pumping (MGD)
4		Min	50	50	9	0	0	9	0	9	0	0		35	35	0	0	0
5		Max	1346	357	36	0	0	36	0	14	0	0		1382	378	3	0	0
6		Avg	308	250	19	0	0	19	0	11	0	0		315	257	0	0	0
7		1/31/83	416	323	9	0	0	9	0	9	0	0		434	336	0	0	0
8		2/28/83	533	357	10	0	0	10	0	10	0	0		553	372	0	0	0
9		3/31/83	726	323	9	0	0	9	0	9	0	0		751	340	0	0	0
10		4/30/83	698	333	14	0	0	14	0	11	0	0		719	350	0	0	0
11		5/31/83	385	323	23	0	0	23	0	13	0	0		393	336	1	0	0
12		6/30/83	418	333	30	0	0	30	0	13	0	0		420	347	1	0	0
13		7/31/83	314	314	36	0	0	36	0	13	0	0		306	306	1	0	0
14		8/31/83	339	323	34	0	0	34	0	14	0	0		335	335	1	0	0
15		9/30/83	323	323	28	0	0	28	0	14	0	0		326	326	0	0	0
16		10/31/83	243	243	18	0	0	18	0	13	0	0		251	251	0	0	0
17		11/30/83	214	214	9	0	0	9	0	9	0	0		226	226	0	0	0
18		12/31/83	440	323	9	0	0	9	0	9	0	0		458	336	0	0	0
19		1/31/84	361	323	9	0	0	9	0	9	0	0		378	335	0	0	0
20		2/28/84	424	357	10	0	0	10	0	10	0	0		442	371	0	0	0
21		3/31/84	523	323	9	0	0	9	0	9	0	0		542	337	0	0	0
22		4/30/84	500	333	14	0	0	14	0	11	0	0		517	348	0	0	0
23		5/31/84	764	323	23	0	0	23	0	13	0	0		779	339	0	0	0
24		6/30/84	247	247	30	0	0	30	0	13	0	0		244	244	1	0	0
25		7/31/84	379	323	36	0	0	36	0	13	0	0		373	336	1	0	0
26		8/31/84	399	323	34	0	0	34	0	14	0	0		397	336	1	0	0
27		9/30/84	264	264	28	0	0	28	0	14	0	0		265	265	1	0	0
28		10/31/84	333	323	18	0	0	18	0	13	0	0		344	335	0	0	0
29		11/30/84	322	322	9	0	0	9	0	9	0	0		338	338	0	0	0
30		12/31/84	369	323	9	0	0	9	0	9	0	0		386	336	0	0	0
31		1/31/85	374	323	9	0	0	9	0	9	0	0		390	336	0	0	0
32		2/28/85	522	357	10	0	0	10	0	10	0	0		541	371	0	0	0
33		3/31/85	263	263	9	0	0	9	0	9	0	0		277	277	0	0	0
34		4/30/85	247	247	14	0	0	14	0	11	0	0		257	257	0	0	0
35		5/31/85	187	187	23	0	0	23	0	13	0	0		188	188	1	0	0
36		6/30/85	226	226	30	0	0	30	0	13	0	0		222	222	1	0	0
37		7/31/85	247	247	36	0	0	36	0	13	0	0		237	237	1	0	0
38		8/31/85	238	238	34	0	0	34	0	14	0	0		230	230	1	0	0
39		9/30/85	178	178	28	0	0	28	0	14	0	0		176	176	1	0	0

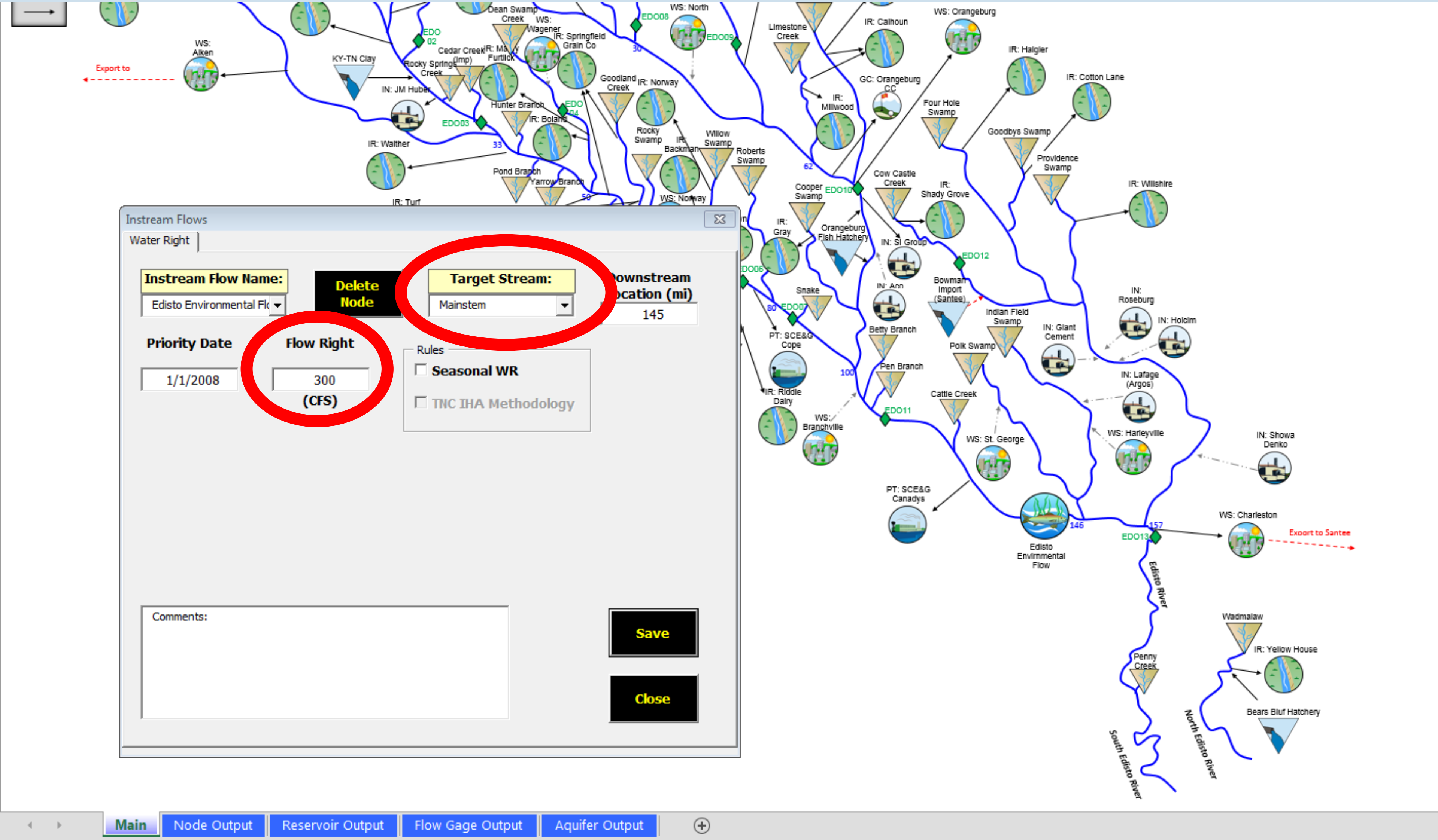
Main | Node Output | Reservoir Output | Flow Gage Output | Aquifer Output

Add an Instream Flow Object from the Palette

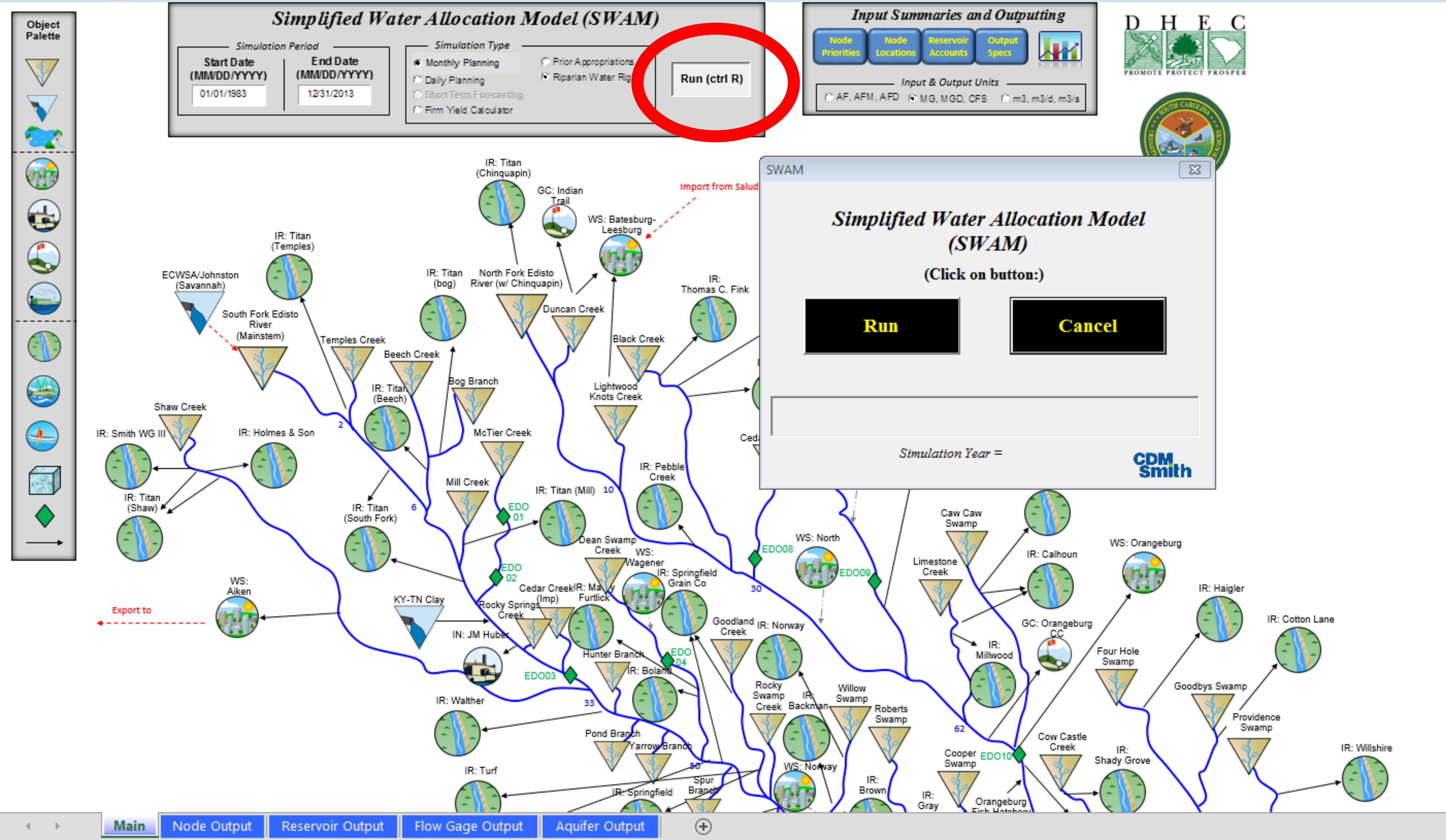


Main | Node Output | Reservoir Output | Flow Gage Output | Aquifer Output

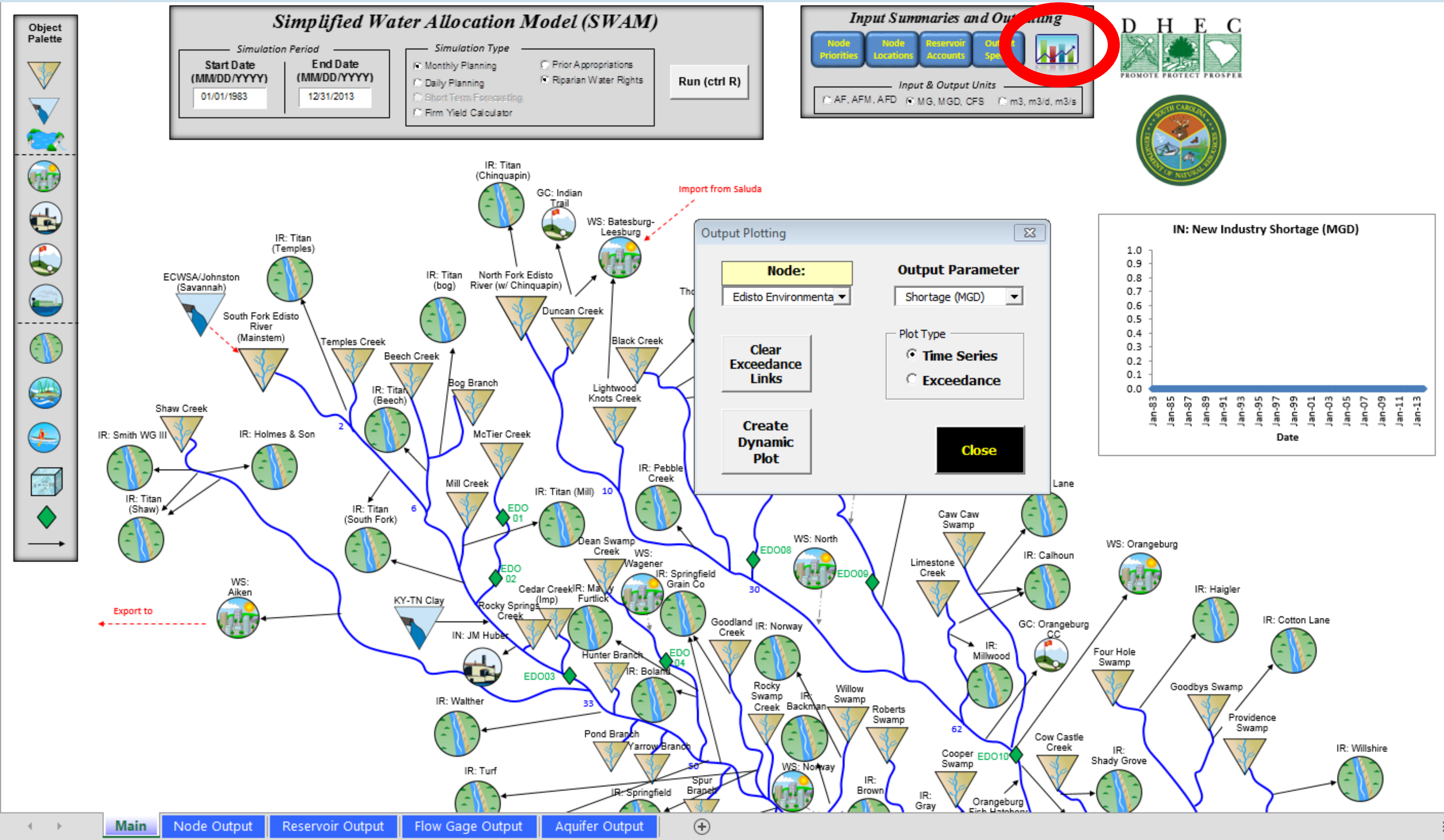
Specify the Instream Flow Amount and Target Stream



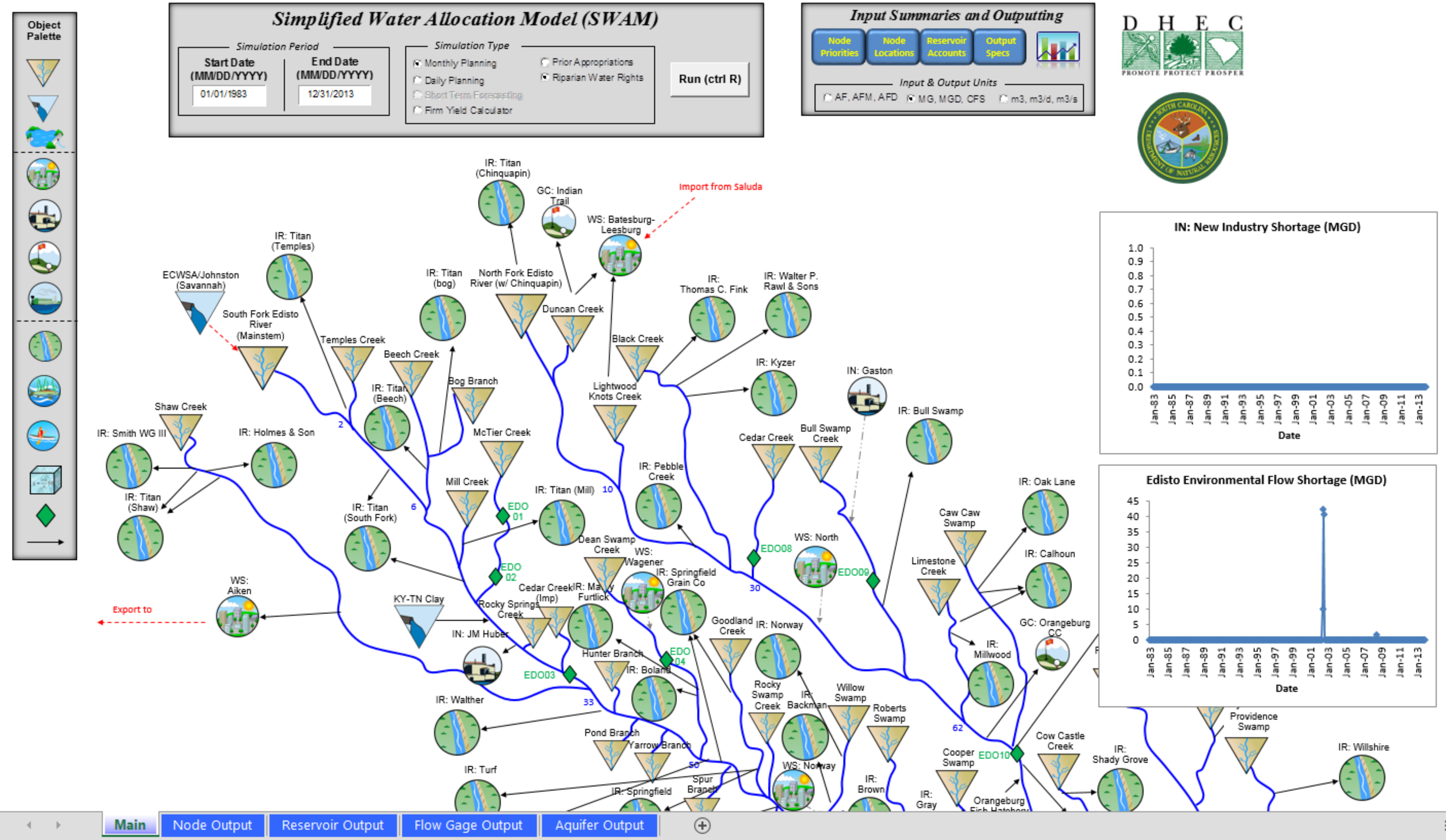
Run the Model Scenario



Build a Shortage Plot for the Instream Flow Object



Build a Shortage Plot for the Instream Flow Object



Demonstrations and Q&A

- Station 1 (Tim)

  Evaluating an increase in WS User demands

- Station 2 (John)

  Evaluating a withdrawal with a minimum instream flow constraint

- Station 3 (Kirk)

  Adding new M&I user and an instream flow object

Edisto River Basin

THANK YOU