South Carolina Surface Water Quantity Modeling Project

Pee Dee Basin Meeting No. 2 – Introduction to the Draft Model

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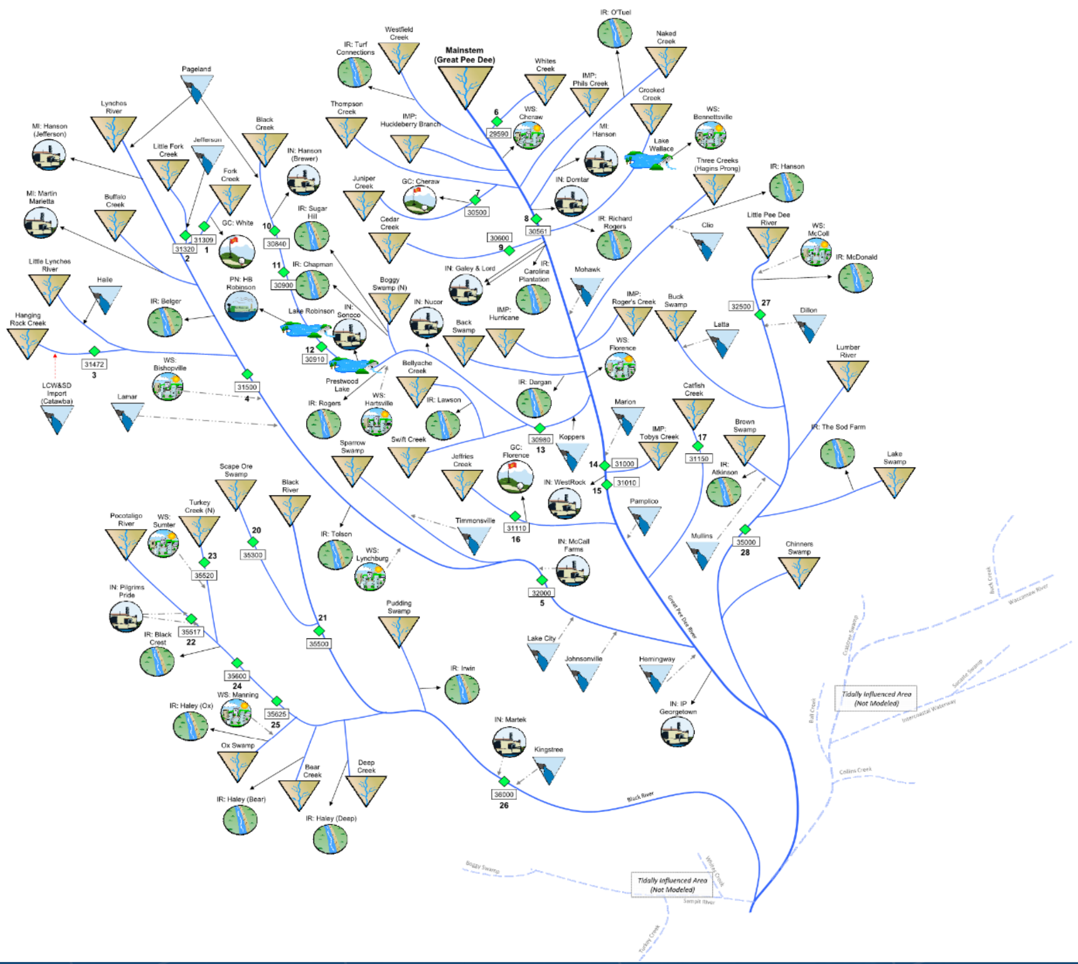


CDM Smith

Presentation Outline

- Project Background and Status
- Model Calibration/Verification
  - Calibration/Verification Philosophy and Approach
  - Calibration Results and Discussion
- Overview and Demonstration of Pee Dee Basin Model

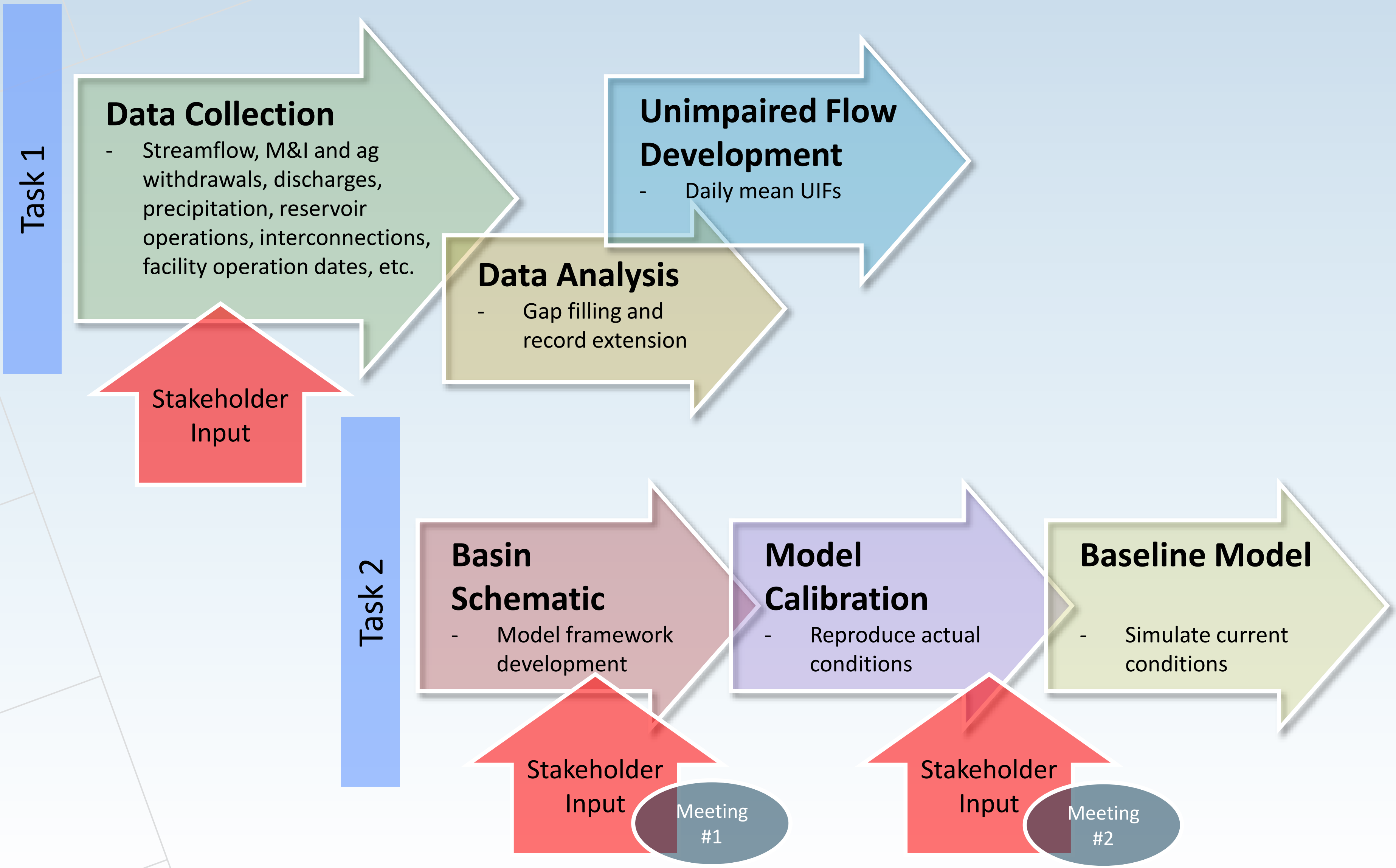
Project Purpose

- 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.

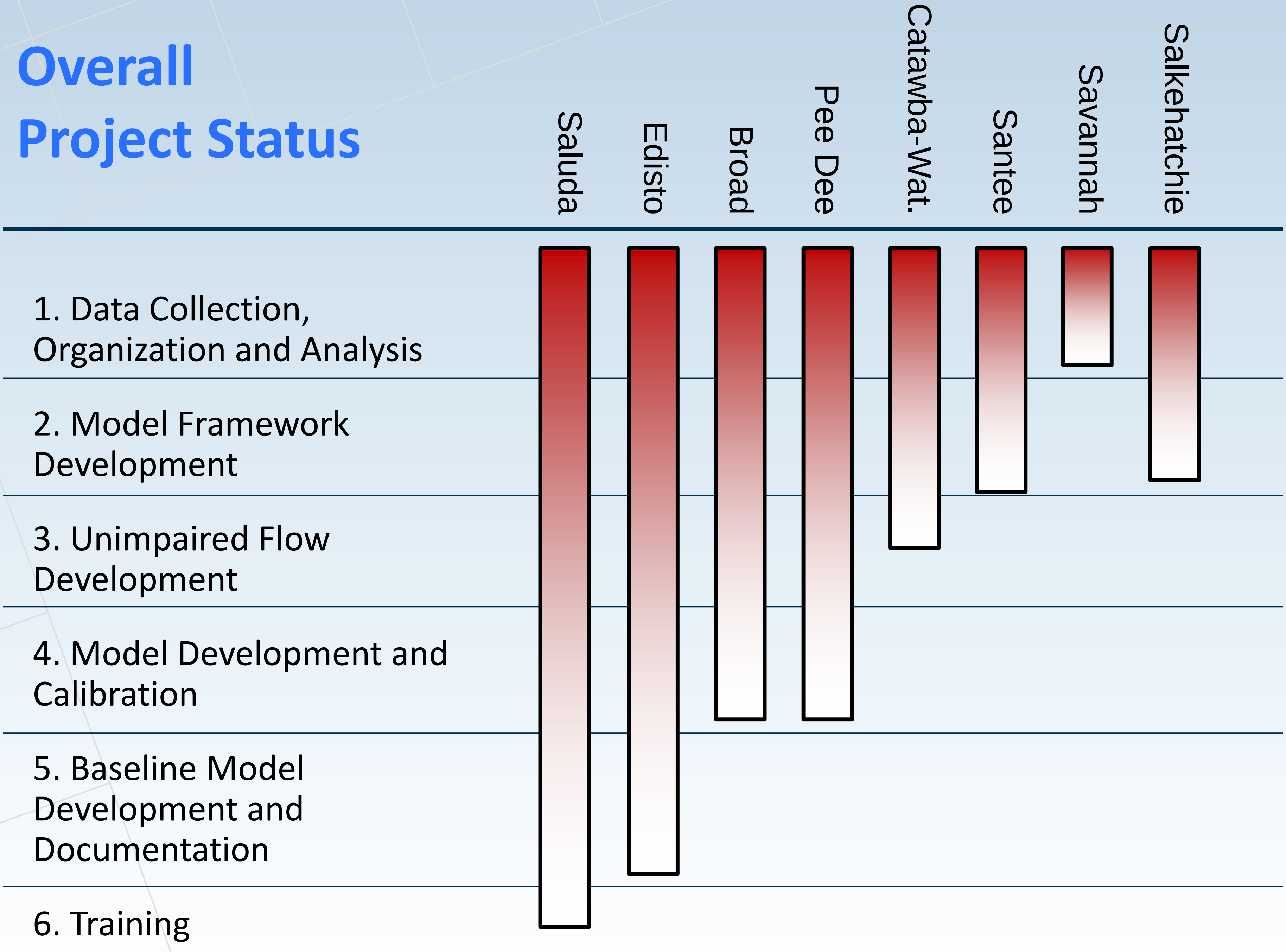
The Simplified Water Allocation Model is…

- 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 a 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 – Pee Dee Basin



Overall Project Status

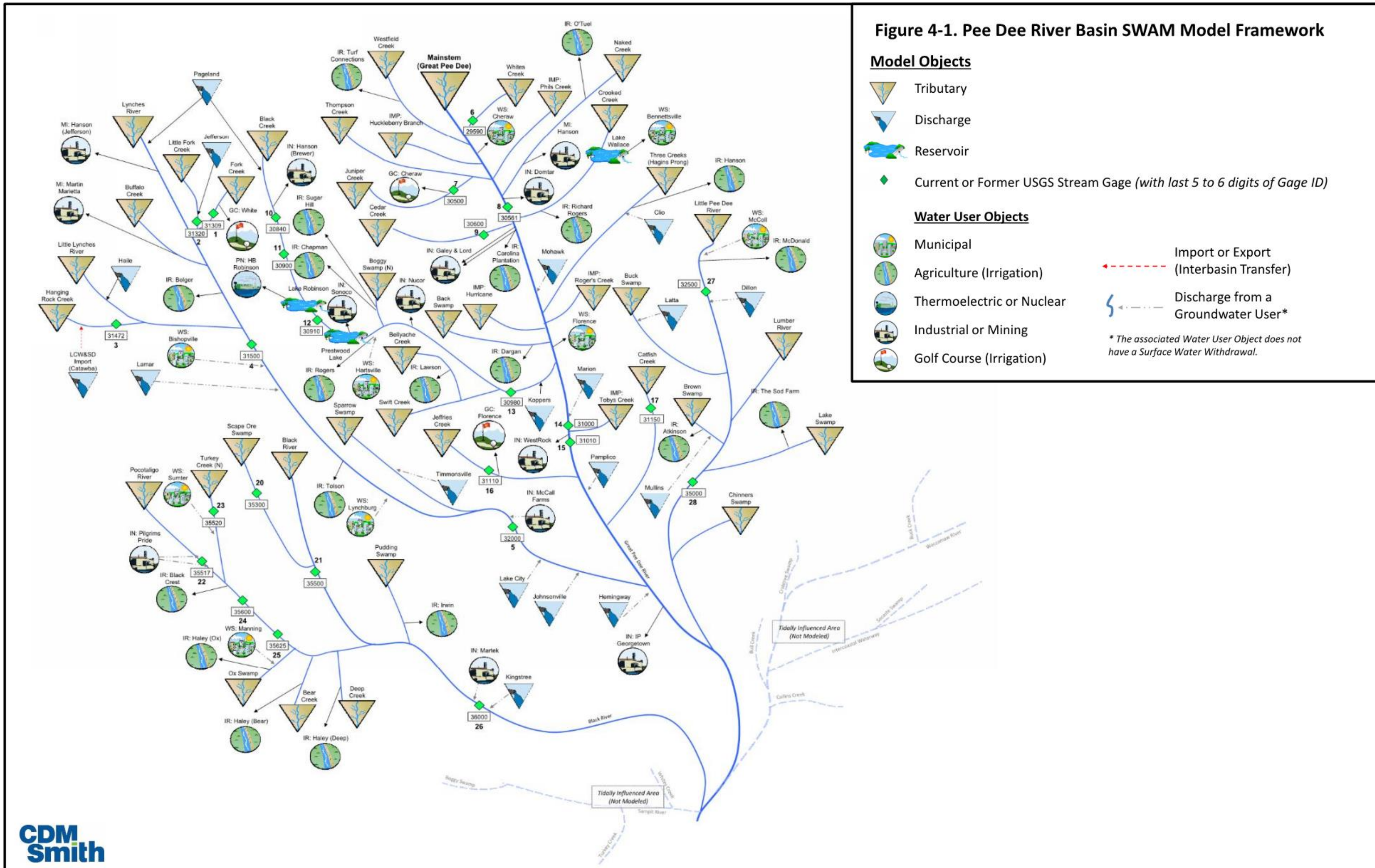


Calibration vs. Baseline Model

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

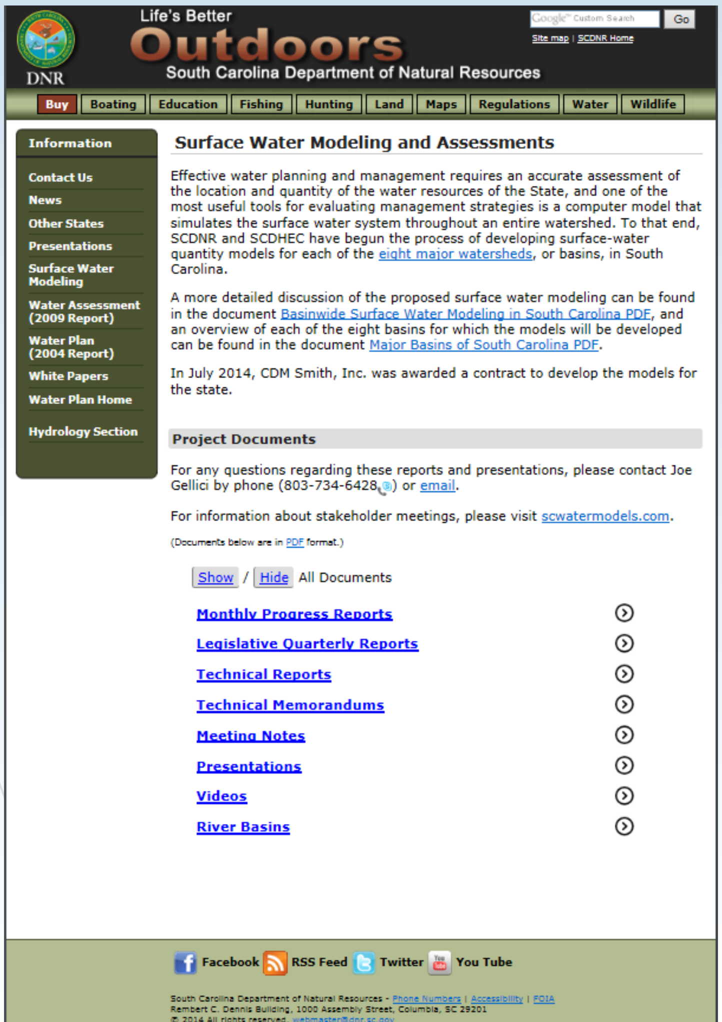
- **Baseline Model**
  - Purpose: Evaluate water availability under future conditions
  - Uses entire record of flow and most current withdrawals and discharges

Pee Dee Basin – SWAM Framework



Modeling Report and Other Documents

- http://www.dnr.sc.gov/water/waterplan/surfacewater.html



Pee Dee 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**

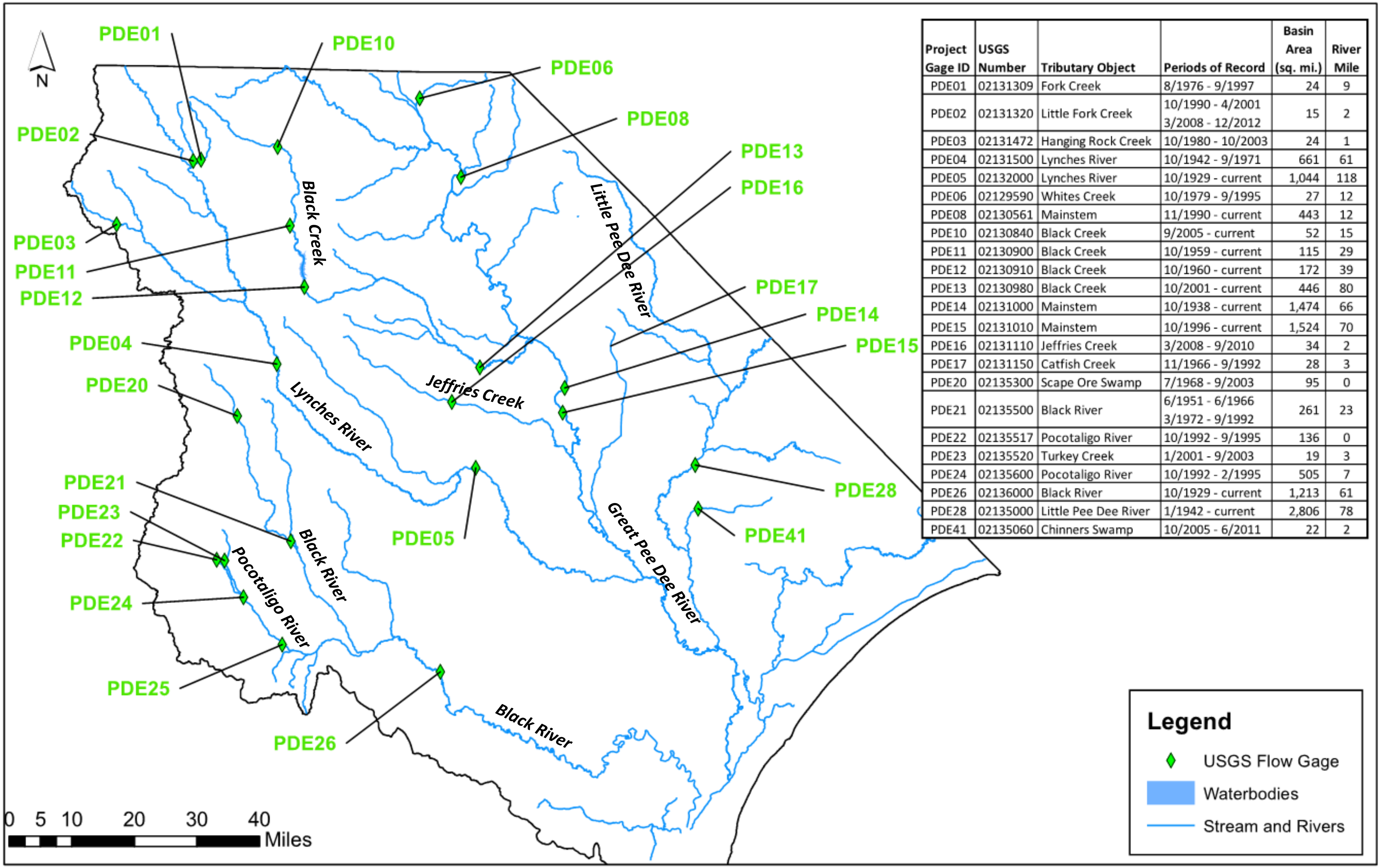
Potential Sources of Model Error and Uncertainty

- 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)
- *Reservoir operations (operator decision making)*
- *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 locations
  - all tributary confluence locations
  - major reservoirs (where levels/storage are available)
- Multiple model performance metrics, including:
  - timeseries plots (monthly and daily variability)
  - annual and monthly means (water balance and seasonality)
  - percentile plots (extremes and frequency)

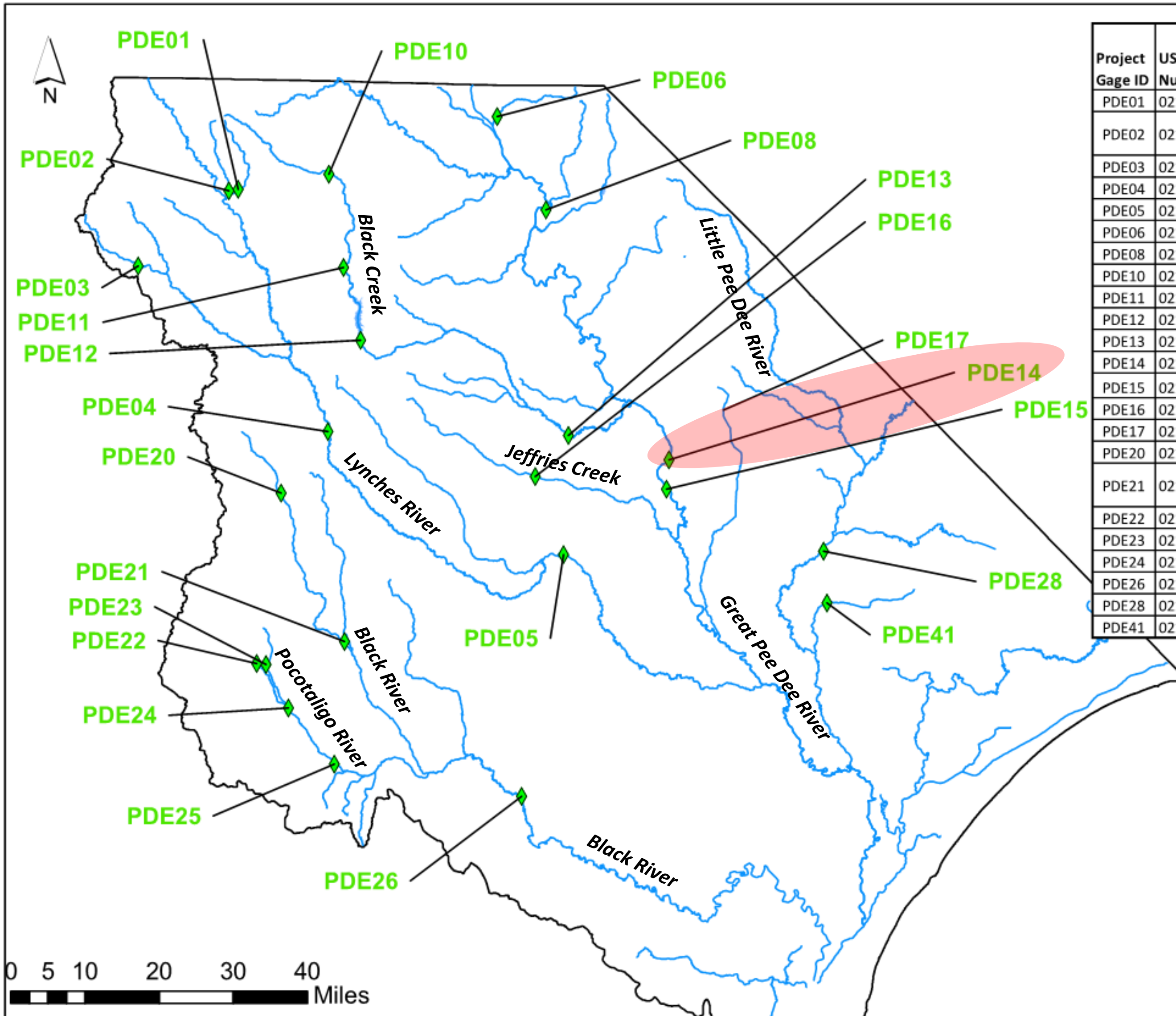
Calibration/Validation Locations



Project Gage ID	USGS Number	Tributary Object	Periods of Record	Basin Area (sq. mi.)	River Mile
PDE01	02131309	Fork Creek	8/1976 - 9/1997	24	9
PDE02	02131320	Little Fork Creek	10/1990 - 4/2001 3/2008 - 12/2012	15	2
PDE03	02131472	Hanging Rock Creek	10/1980 - 10/2003	24	1
PDE04	02131500	Lynches River	10/1942 - 9/1971	661	61
PDE05	02132000	Lynches River	10/1929 - current	1,044	118
PDE06	02129590	Whites Creek	10/1979 - 9/1995	27	12
PDE08	02130561	Mainstem	11/1990 - current	443	12
PDE10	02130840	Black Creek	9/2005 - current	52	15
PDE11	02130900	Black Creek	10/1959 - current	115	29
PDE12	02130910	Black Creek	10/1960 - current	172	39
PDE13	02130980	Black Creek	10/2001 - current	446	80
PDE14	02131000	Mainstem	10/1938 - current	1,474	66
PDE15	02131010	Mainstem	10/1996 - current	1,524	70
PDE16	02131110	Jeffries Creek	3/2008 - 9/2010	34	2
PDE17	02131150	Catfish Creek	11/1966 - 9/1992	28	3
PDE20	02135300	Scape Ore Swamp	7/1968 - 9/2003	95	0
PDE21	02135500	Black River	6/1951 - 6/1966 3/1972 - 9/1992	261	23
PDE22	02135517	Pocotaligo River	10/1992 - 9/1995	136	0
PDE23	02135520	Turkey Creek	1/2001 - 9/2003	19	3
PDE24	02135600	Pocotaligo River	10/1992 - 2/1995	505	7
PDE26	02136000	Black River	10/1929 - current	1,213	61
PDE28	02135000	Little Pee Dee River	1/1942 - current	2,806	78
PDE41	02135060	Chinners Swamp	10/2005 - 6/2011	22	2

Pee Dee River at Pee Dee

USGS Gage 02131000



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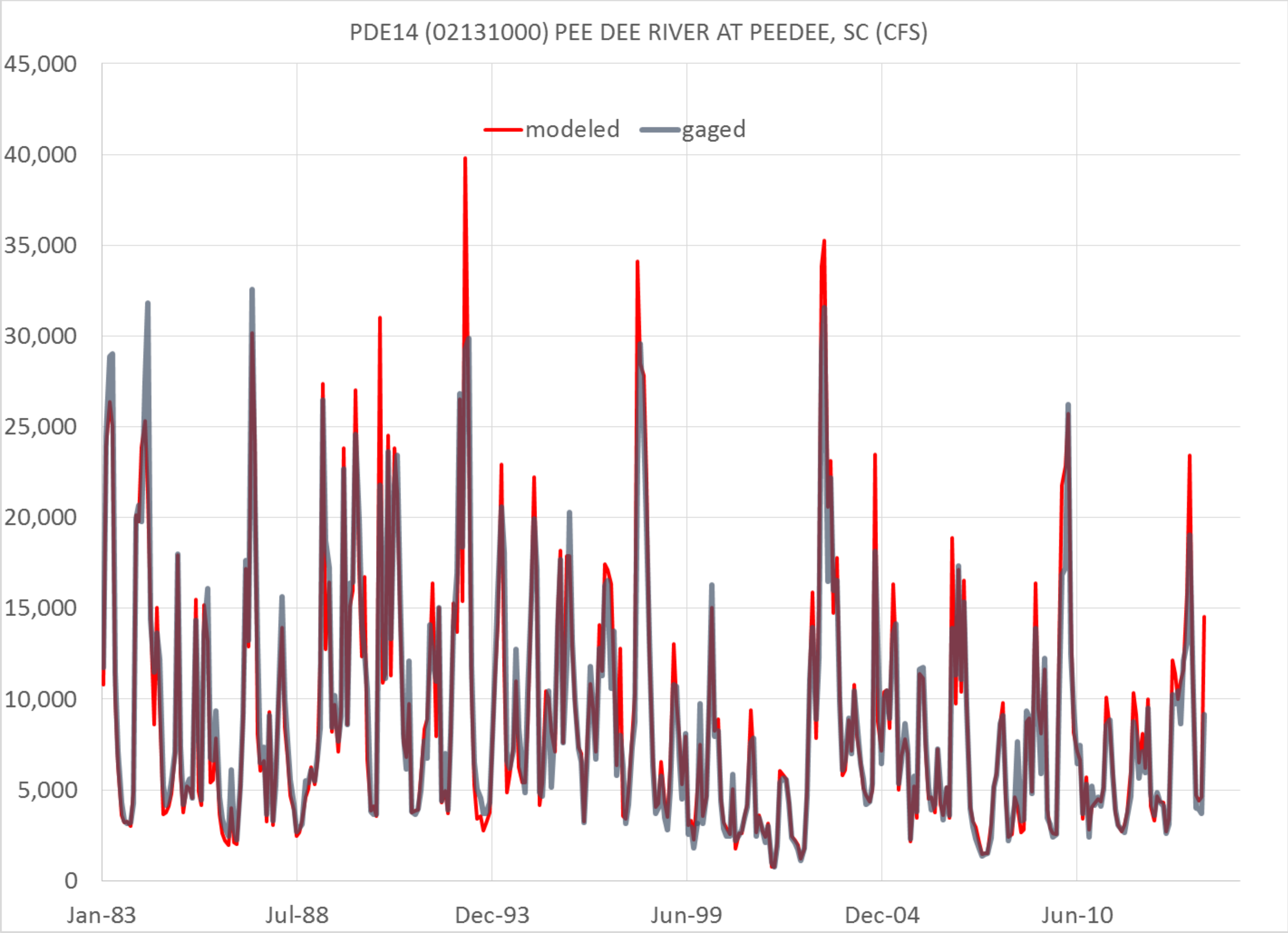
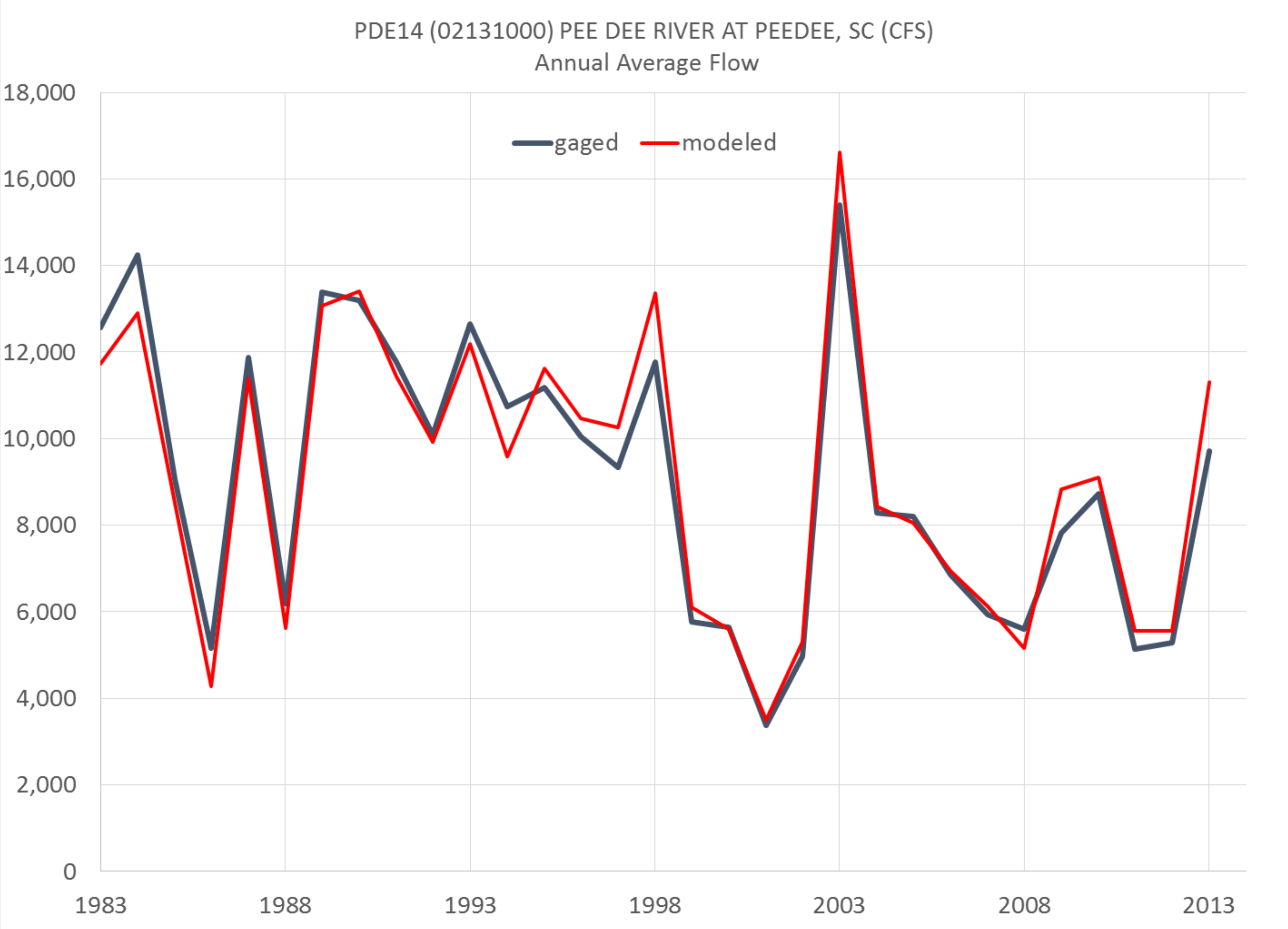
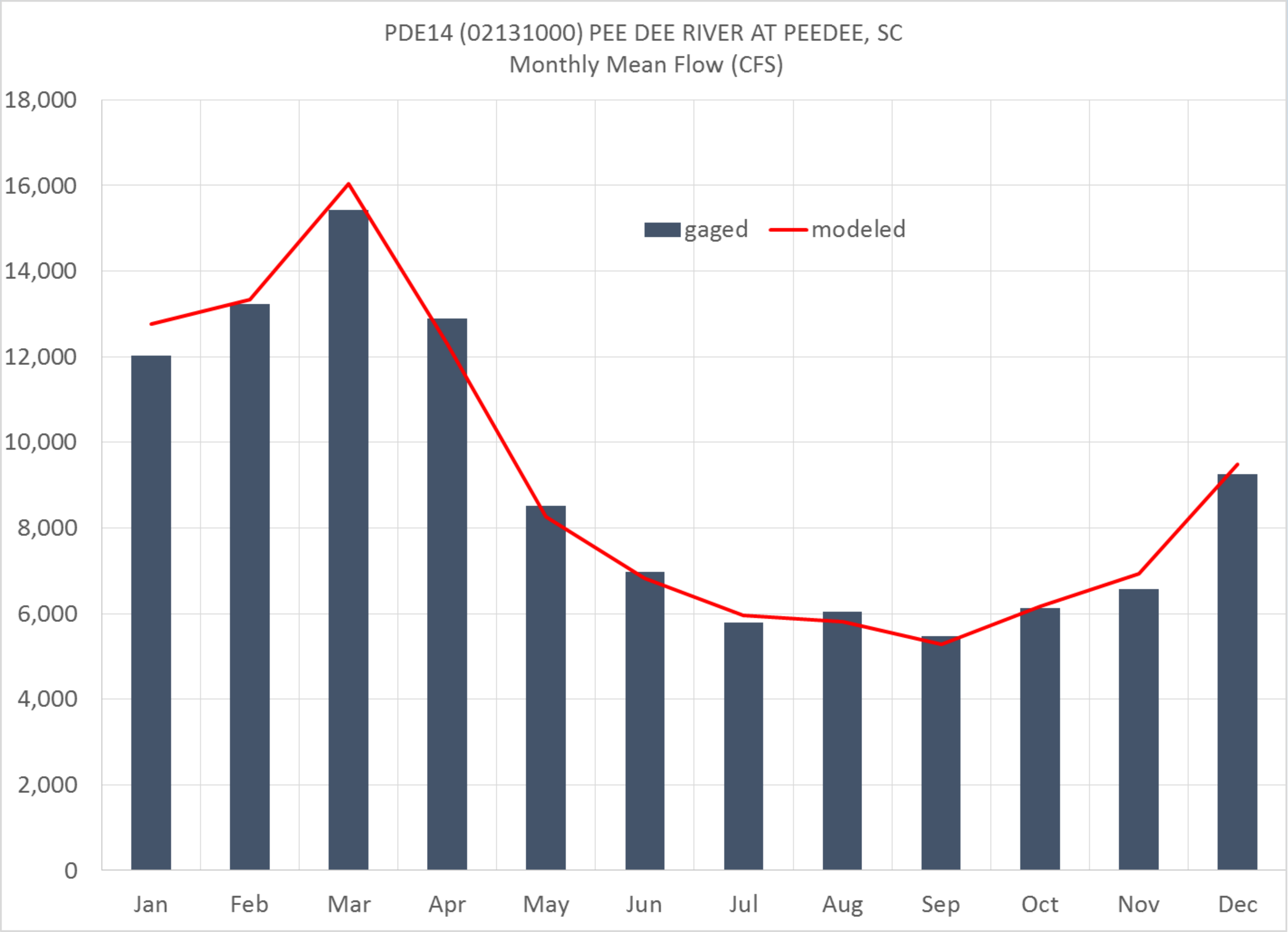
Monthly Flow Comparison



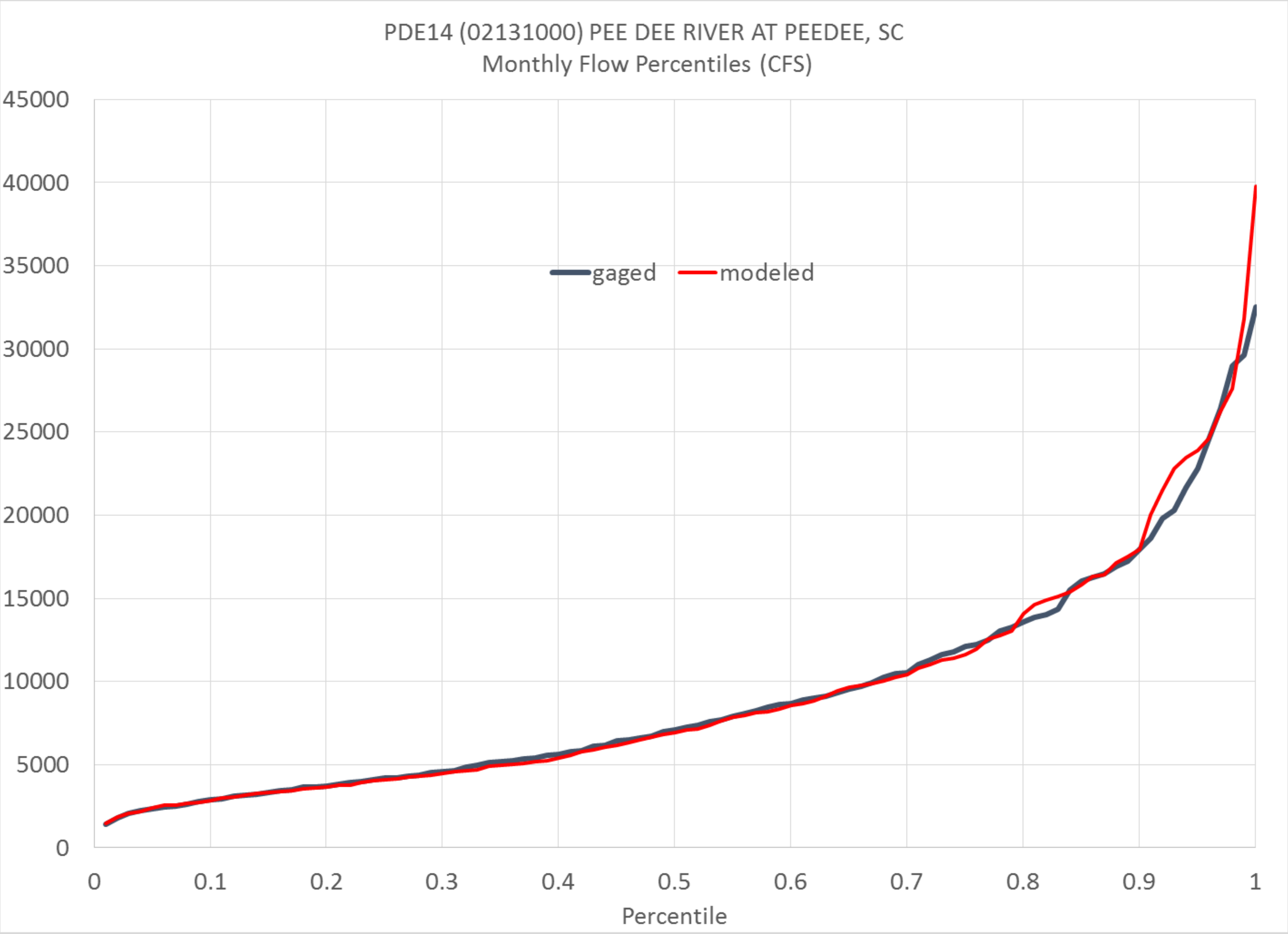
Annual Average Flow Comparison



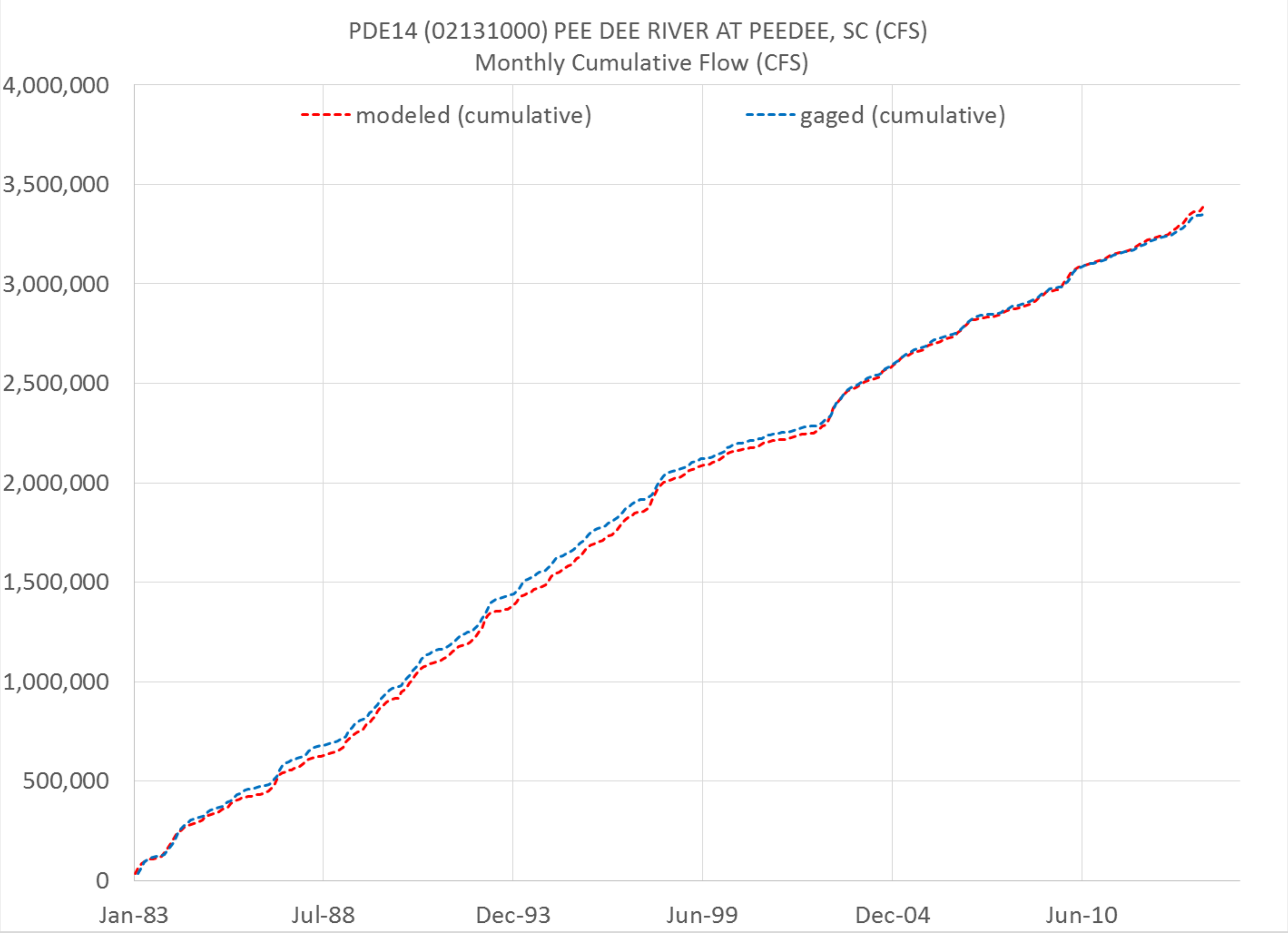
Monthly Mean Flow Comparison



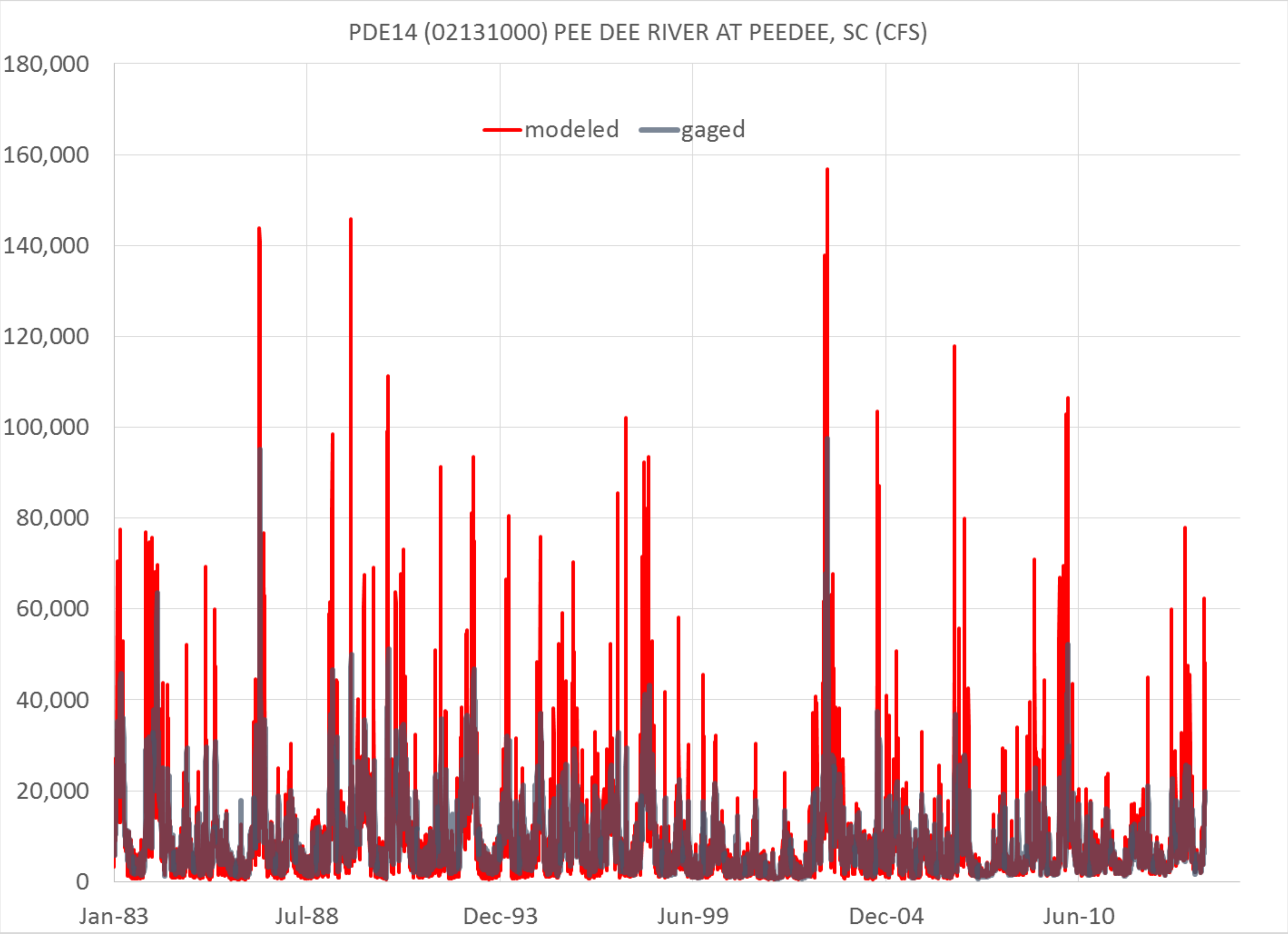
Monthly Flow Percentiles Comparison



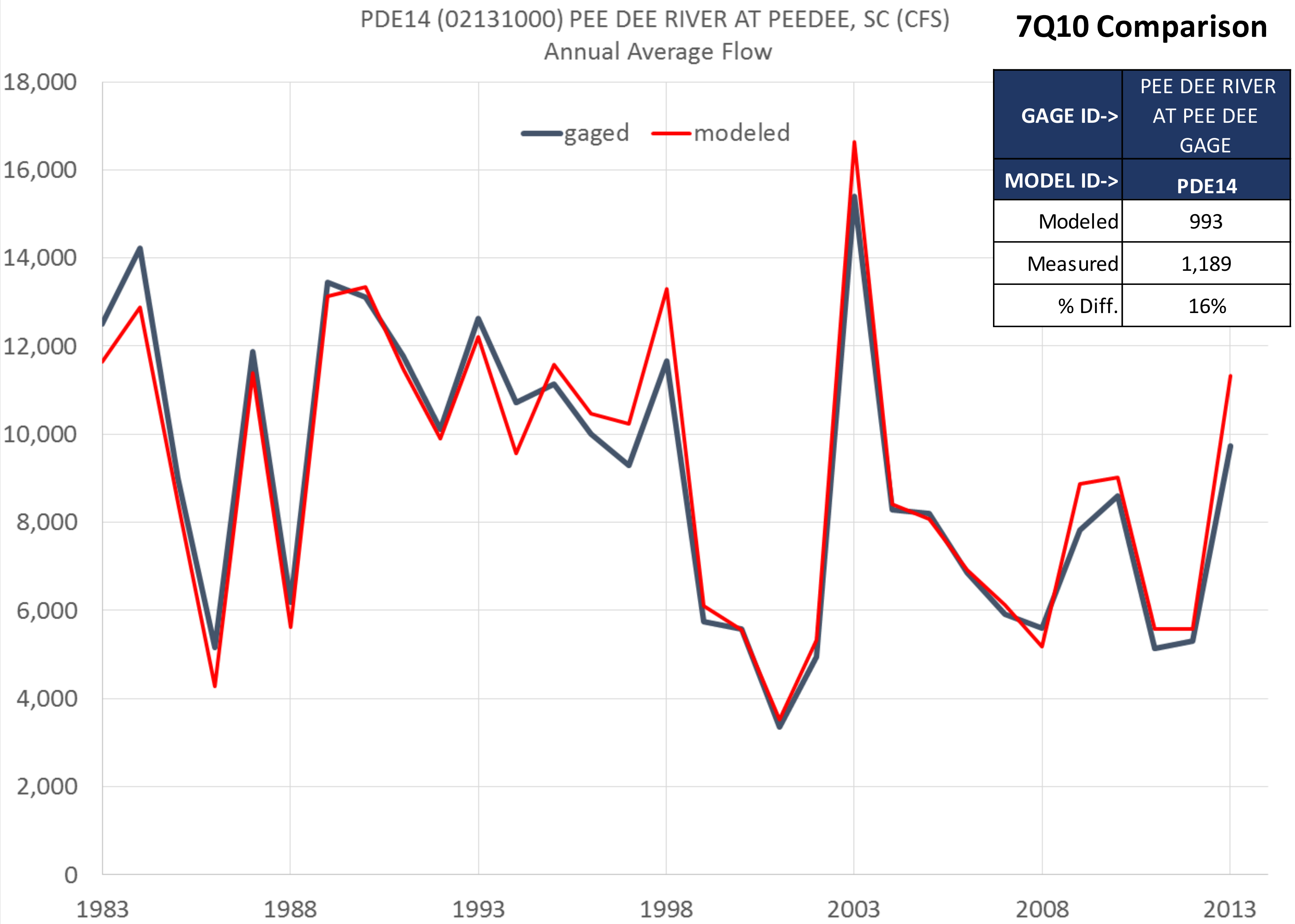
Cumulative Flow Comparison



Daily Flow Comparison



Annual 7 Day Low Flows



7Q10 Comparison

GAGE ID->	PEE DEE RIVER AT PEE DEE GAGE
MODEL ID->	PDE14
Modeled	993
Measured	1,189
% Diff.	16%

SWAM Calibration/Validation Summary

- For most sites, modeled mean flow values, averaged over the full period of record, are within within 1% of measured mean flows

ID	Station	Modeled (cfs)	Measured (cfs)	% Difference	Years to compare
PDE41	CHINNERS SWAMP NEAR AYNOR	18	21	-15.0%	6
PDE10	BLACK CREEK BELOW CHESTERFIELD	40	43	-7.9%	9
PDE24.25	POCOTALIGO IVER NR SUMTER & MANNING	495	522	-5.4%	4
PDE21	BLACK RIVER NEAR GABLE	375	386	-3.2%	10
PDE05	LYNCHES RIVER AT EFFINGHAM	908	933	-2.8%	31
PDE28	LITTLE PEE DEE AT GALIVANTS FERRY	2,553	2,565	-0.5%	31
PDE04	LYNCHES RIVER NEAR BISHOPVILLE	481	482	-0.2%	12
PDE23	TURKEY CREEK (HWY 521) AT SUMTER	10	10	0.1%	3
PDE06	WHITES CREEK NEAR WALLACE	30	30	0.2%	13
PDE02	LITTLE FORK CREEK AT JEFFERSON	15	15	0.4%	16
PDE17	CATFISH CANAL AT SELLERS	21	21	0.4%	31
PDE13	BLACK CREEK NEAR QUINBY	353	351	0.5%	13
PDE26	BLACK RIVER AT KINGSTREE	909	903	0.6%	31
PDE11	BLACK CREEK NEAR MCBEE	127	126	0.7%	31
PDE20	SCAPE ORE SWAMP NEAR BISHOPVILLE	93	92	0.7%	21
PDE14	PEE DEE RIVER AT PEEDEE	9,097	9,031	0.7%	31
PDE03	HANGING ROCK CREEK NR KERSHAW	25	25	0.9%	21
PDE12	BLACK CREEK NEAR HARTSVILLE	182	180	1.0%	31
PDE16	JEFFRIES CREEK ABOVE FLORENCE	34	33	1.8%	4
PDE08	PEE DEE RIVER NR BENNETTSVILLE	7,416	7,251	2.2%	24
PDE15	PEE DEE RIVER BELOW PEE DEE	7,990	7,804	2.3%	18
PDE22	POCOTALIGO RIVER AT SUMTER	193	183	5.5%	4
PDE01	FORK CREEK AT JEFFERSON	29	26	9.4%	15

>5% difference

5% or less diff.

1% or less difference

5% or less diff.

>5% difference

SWAM Calibration/Validation Summary

- Monthly mean flows percentile deviations are all generally within 10-20% with no clear bias
- Modeled low flow values (as represented by 7Q10 flows) are within:
  - 8% and 16% on the Great Pee Dee River;
  - 2% to11% on Black Creek
  - 15% to 33% on the Lynches River
- The model adequately hindcasts delivered water supply for each water user in the model (no significant shortfalls).

Pee Dee River Basin

BASELINE MODEL AND USES

Baseline Model

- Will represent current demands and operations combined with an extended period of estimated hydrology
  - Most demands reflect 2004-2013 averages
  - Estimated hydrology from 1929 to 2013
  - Inactive users are not included
  - Users on tidally-influenced areas are not included
- The baseline model serves as the starting point for future predictive simulations

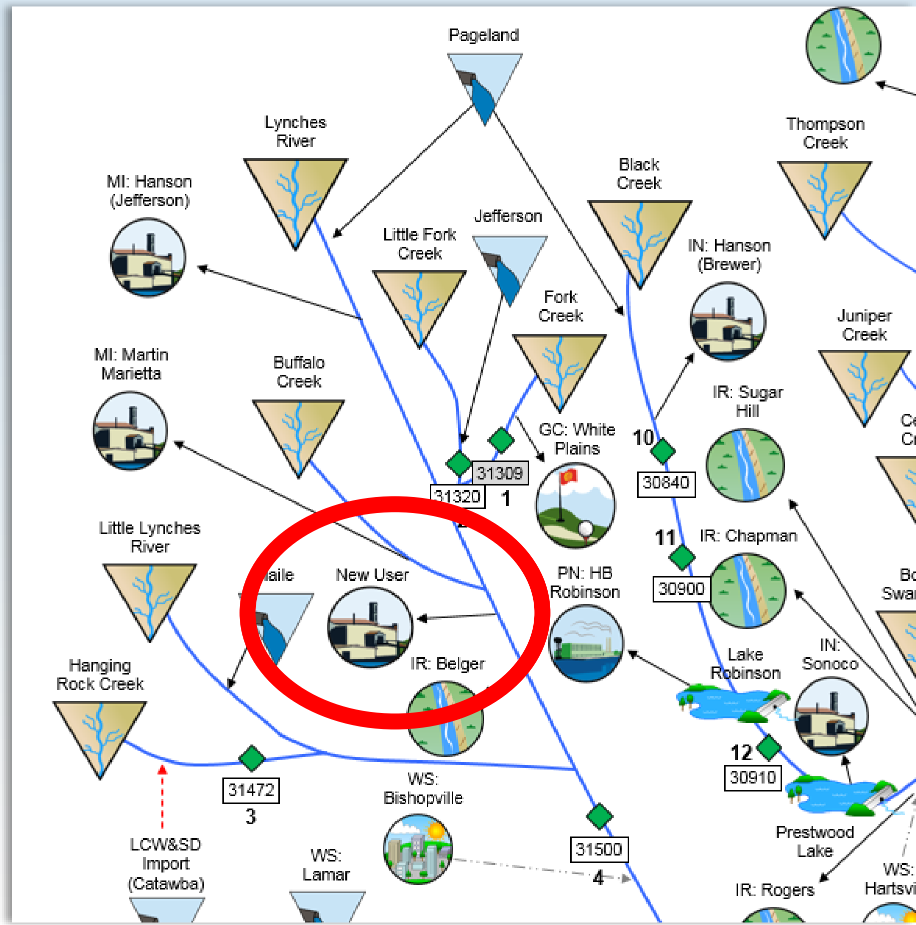
The Models Can Be Used To…

- 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

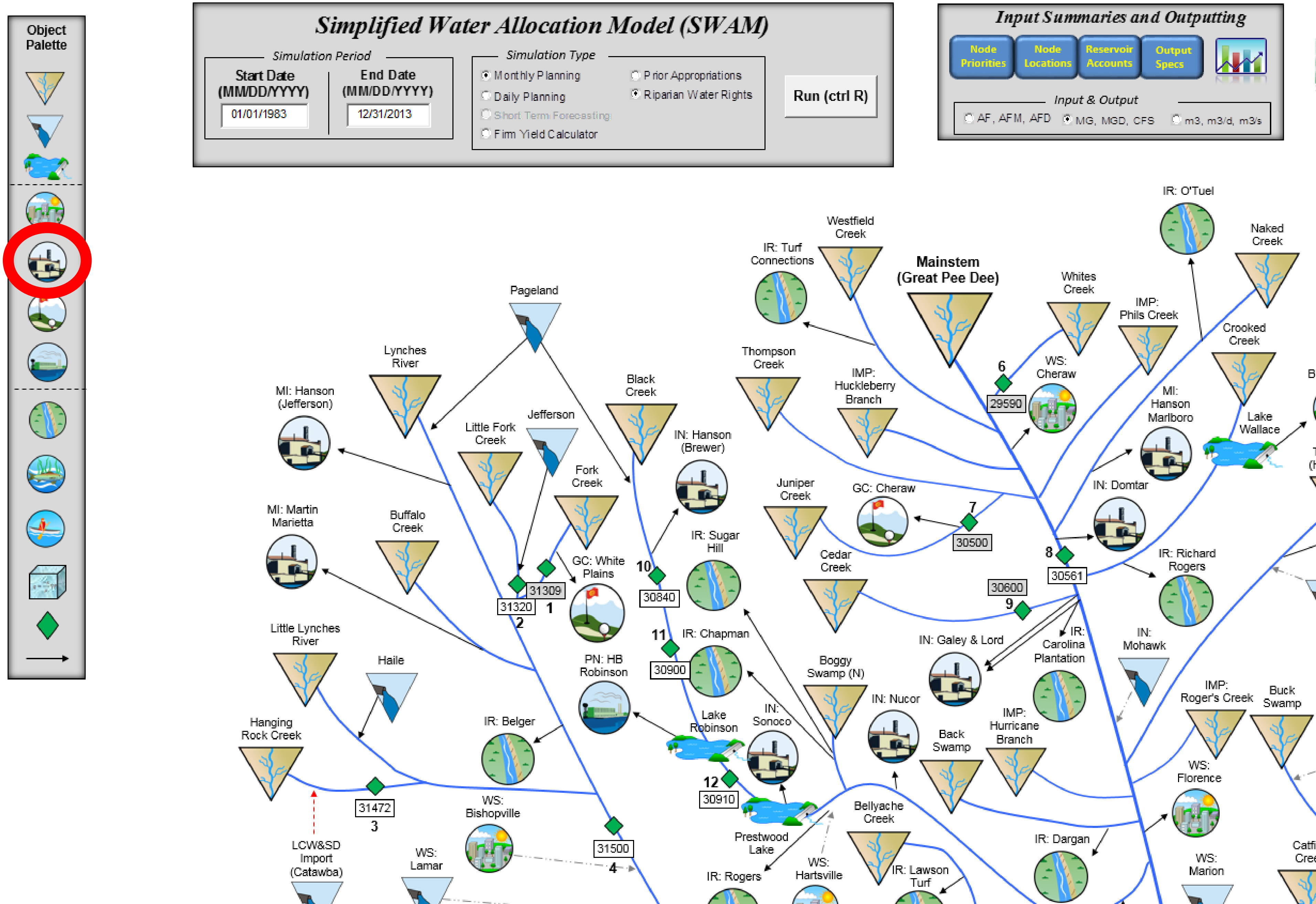
Example Use
Adding a New User

- Add a new M&I permittee on the Lynches River
  - Demand = 20 mgd
  - Consumptive Use = 50% (return to Lynches River)

- *Is there enough water to support the new user?*
- *Does the new withdrawal cause shortages for downstream users?*



Add an Industrial Water User Object from the Palette



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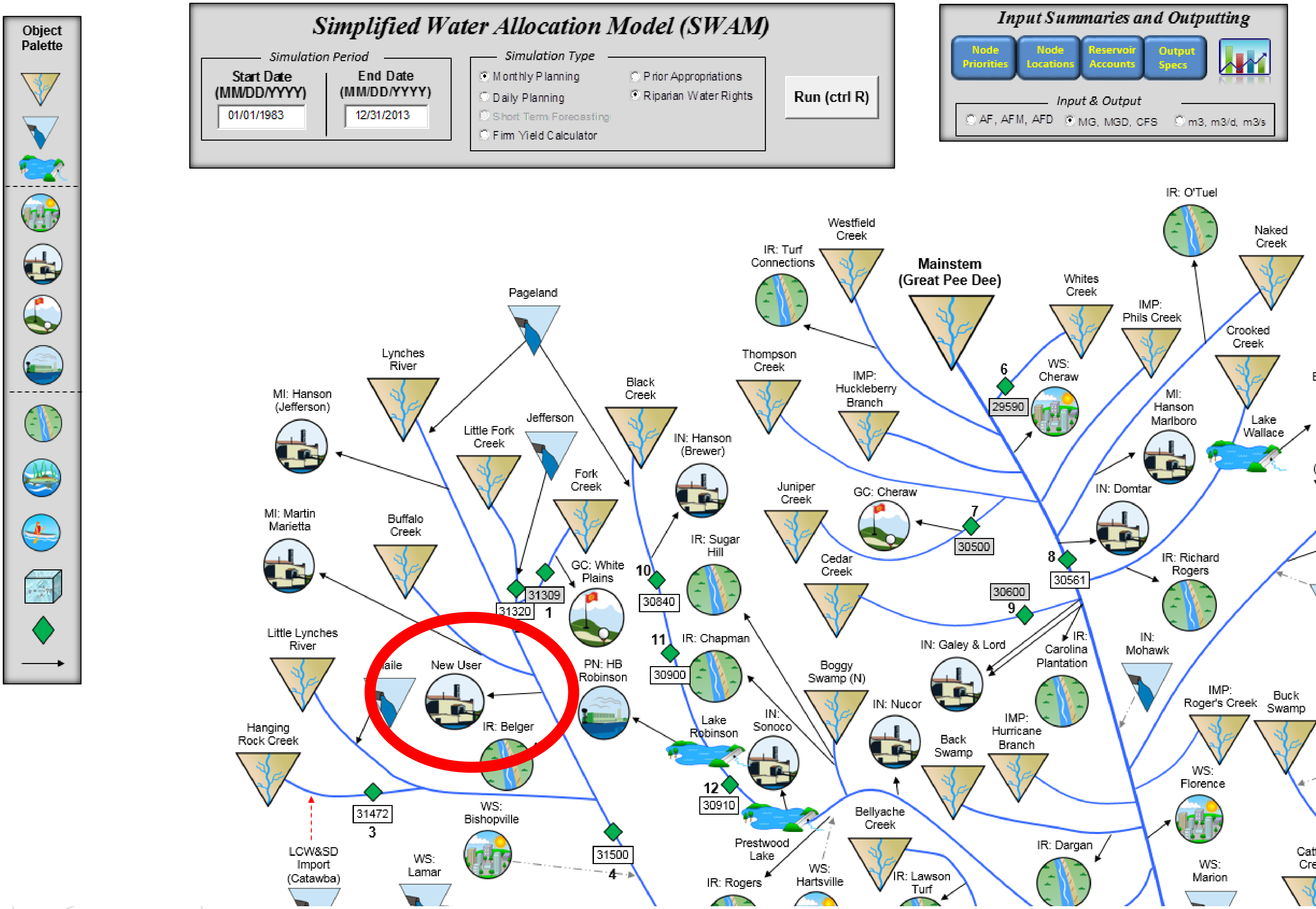
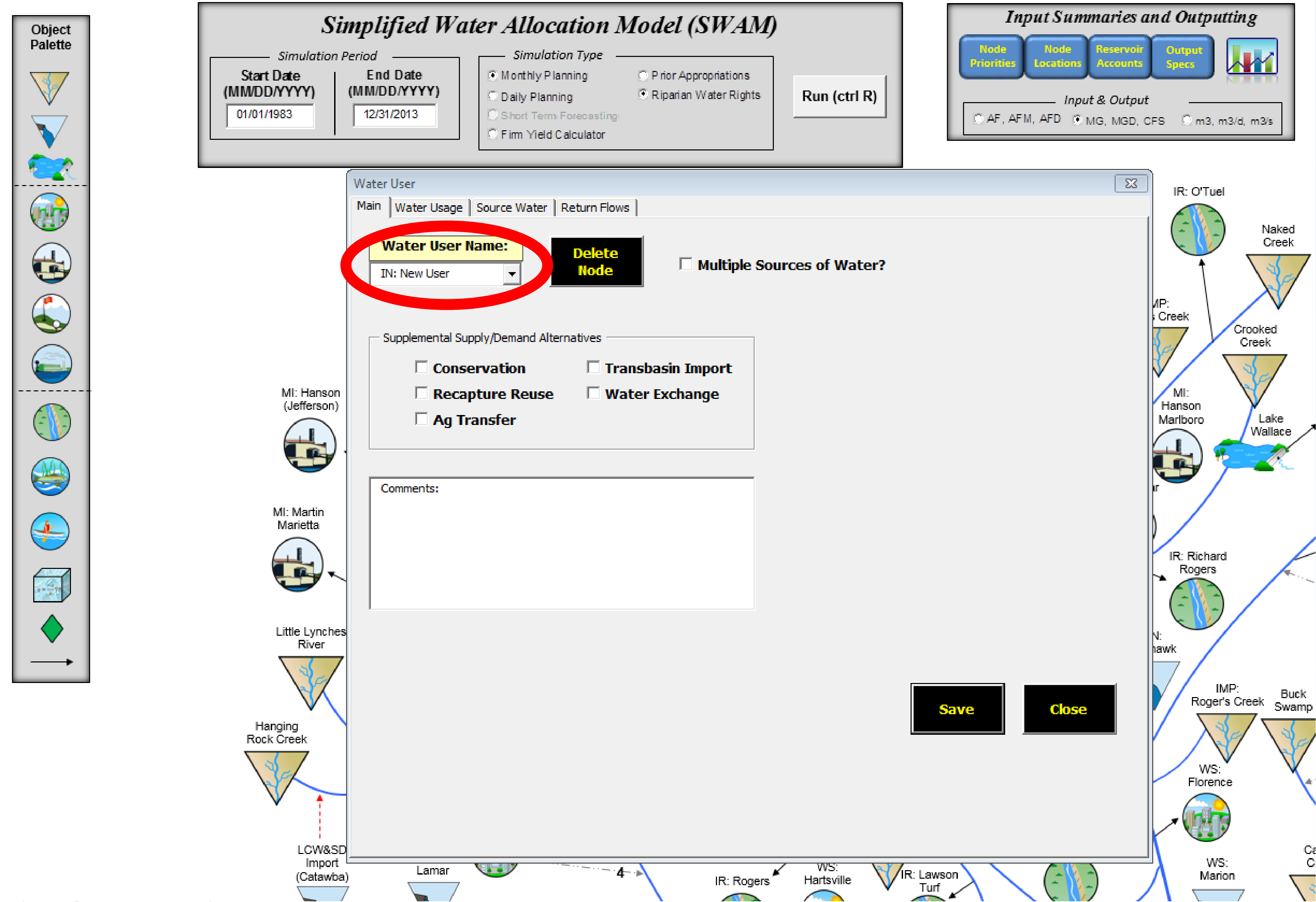
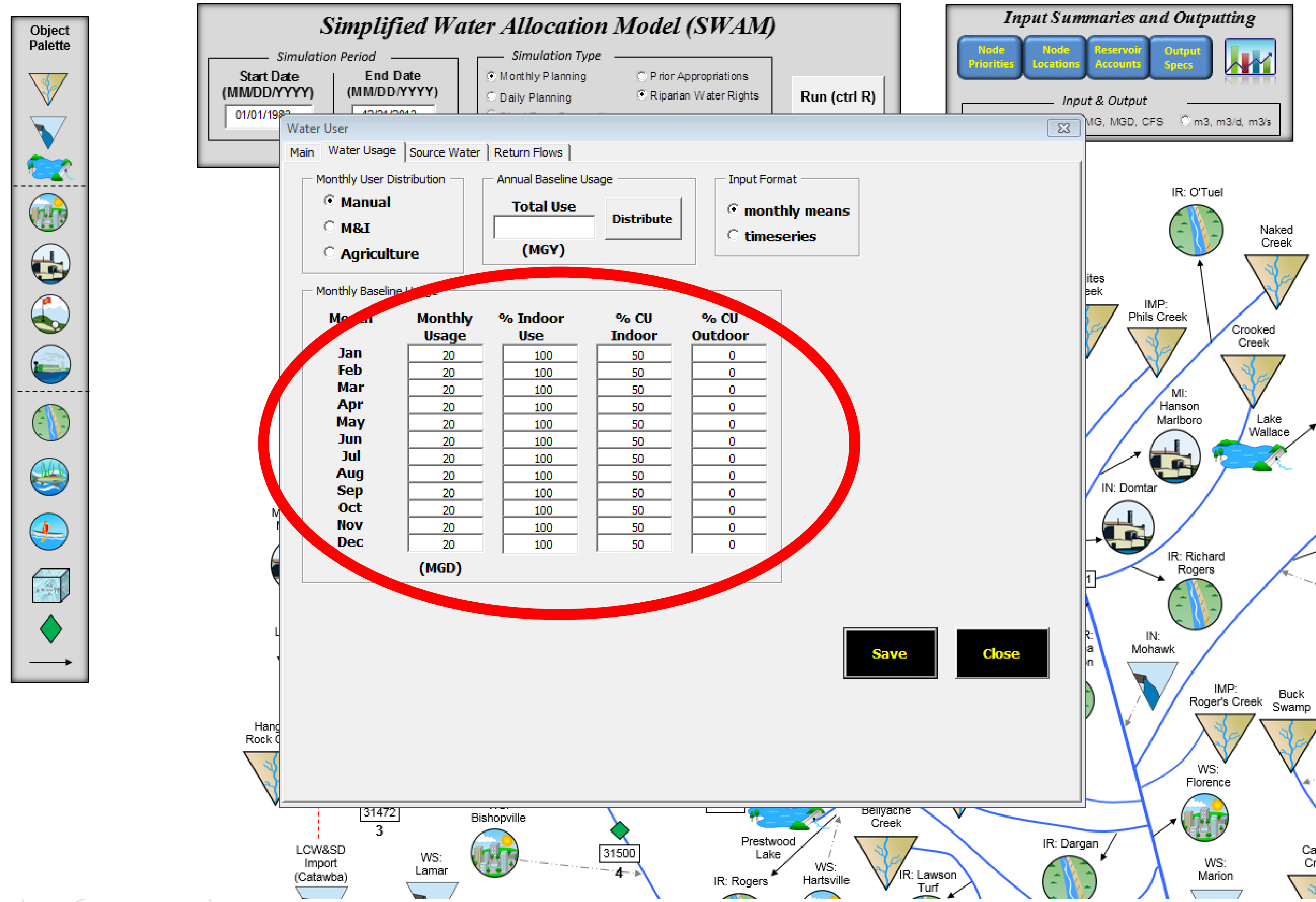


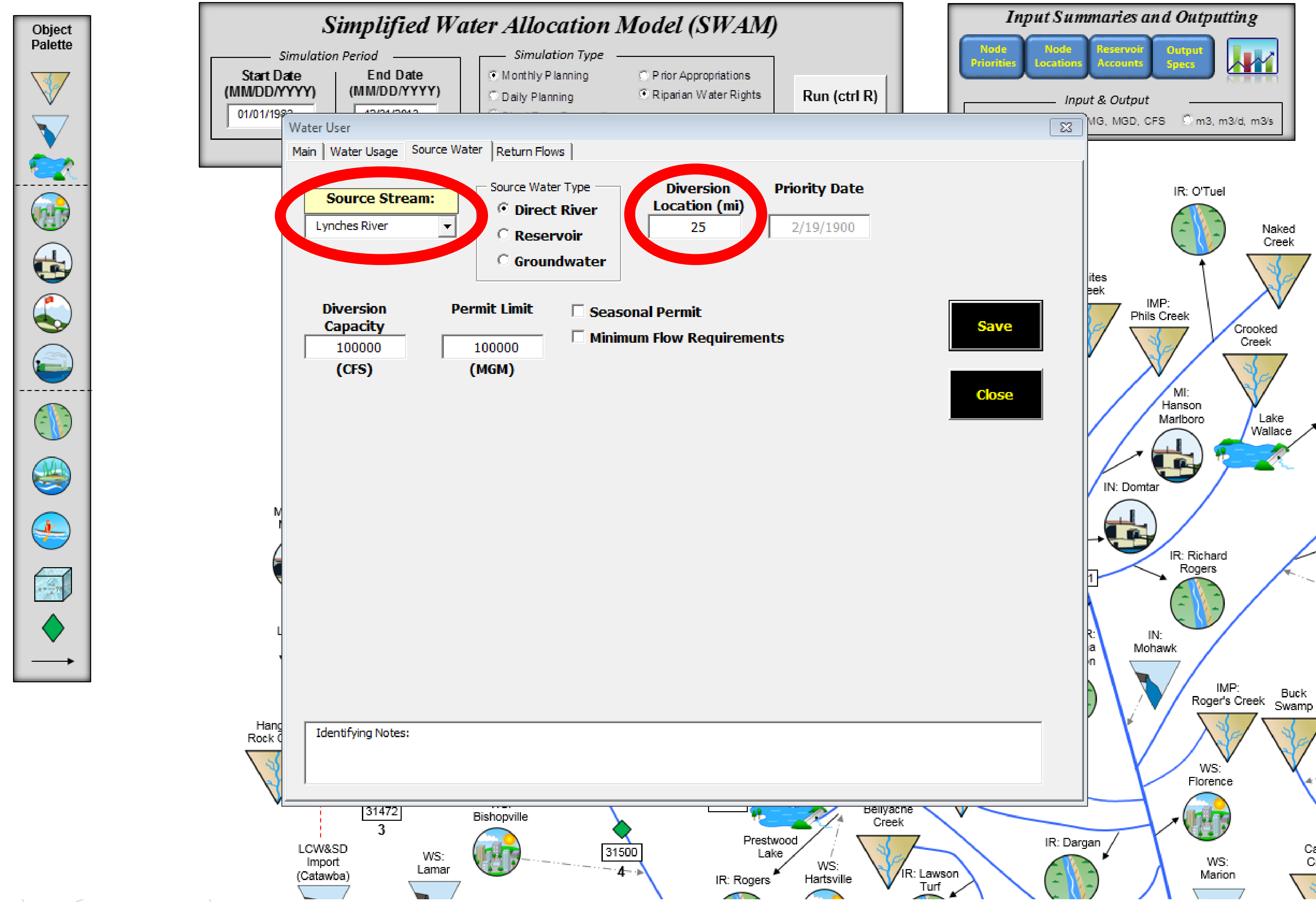
Add the New User in the Water User Dialogue



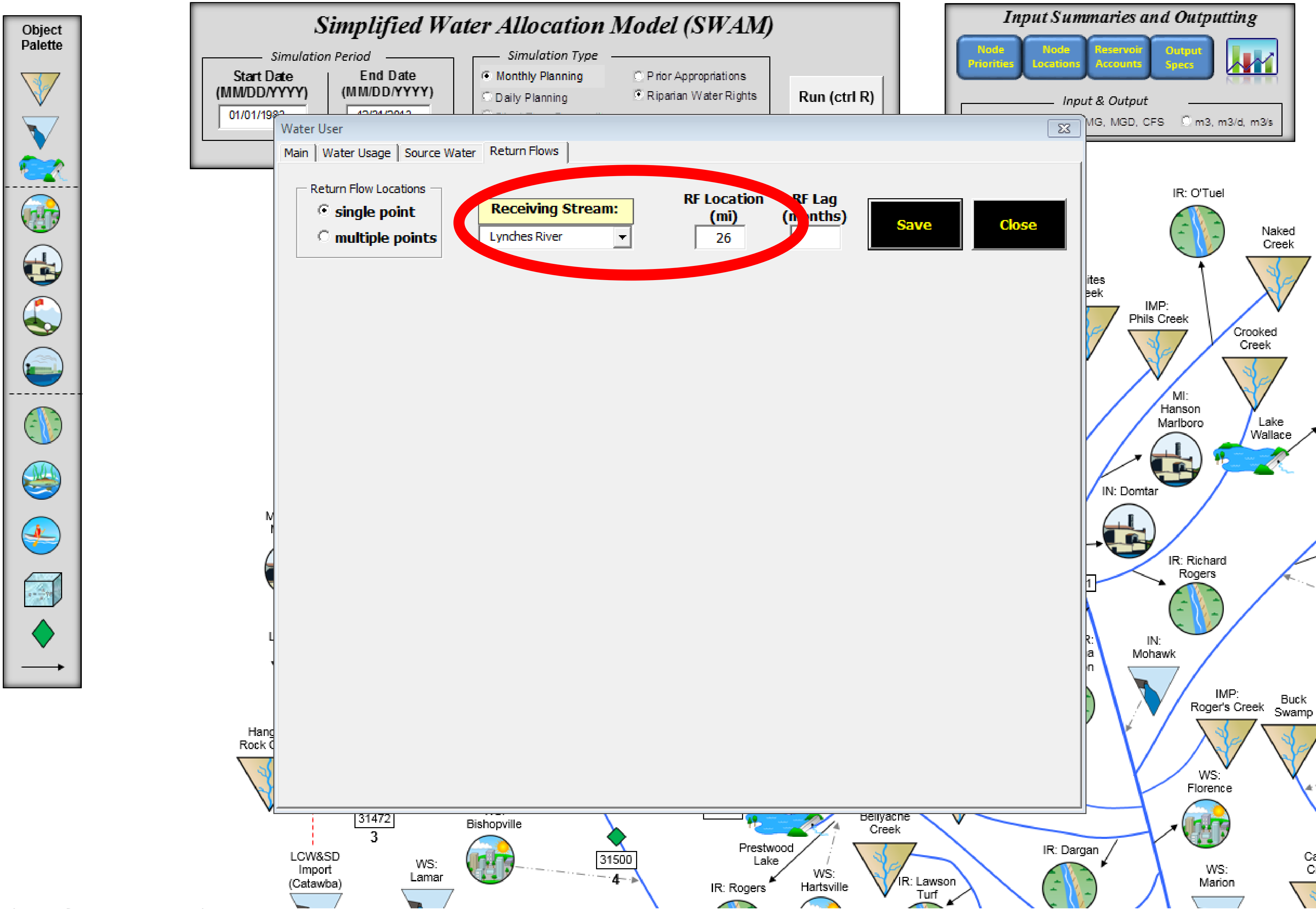
Specify Water Use



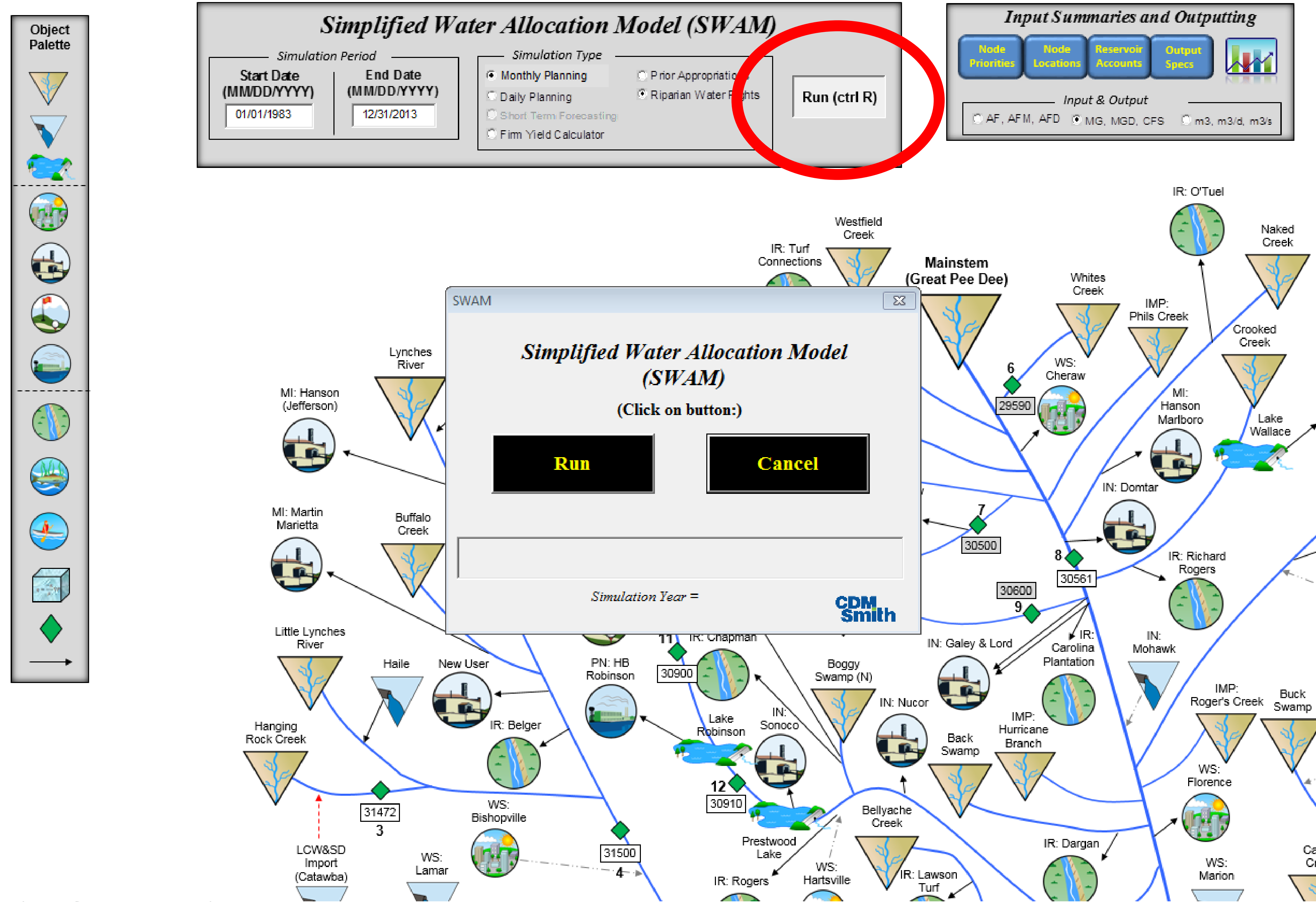
Specify Source and Withdrawal Location



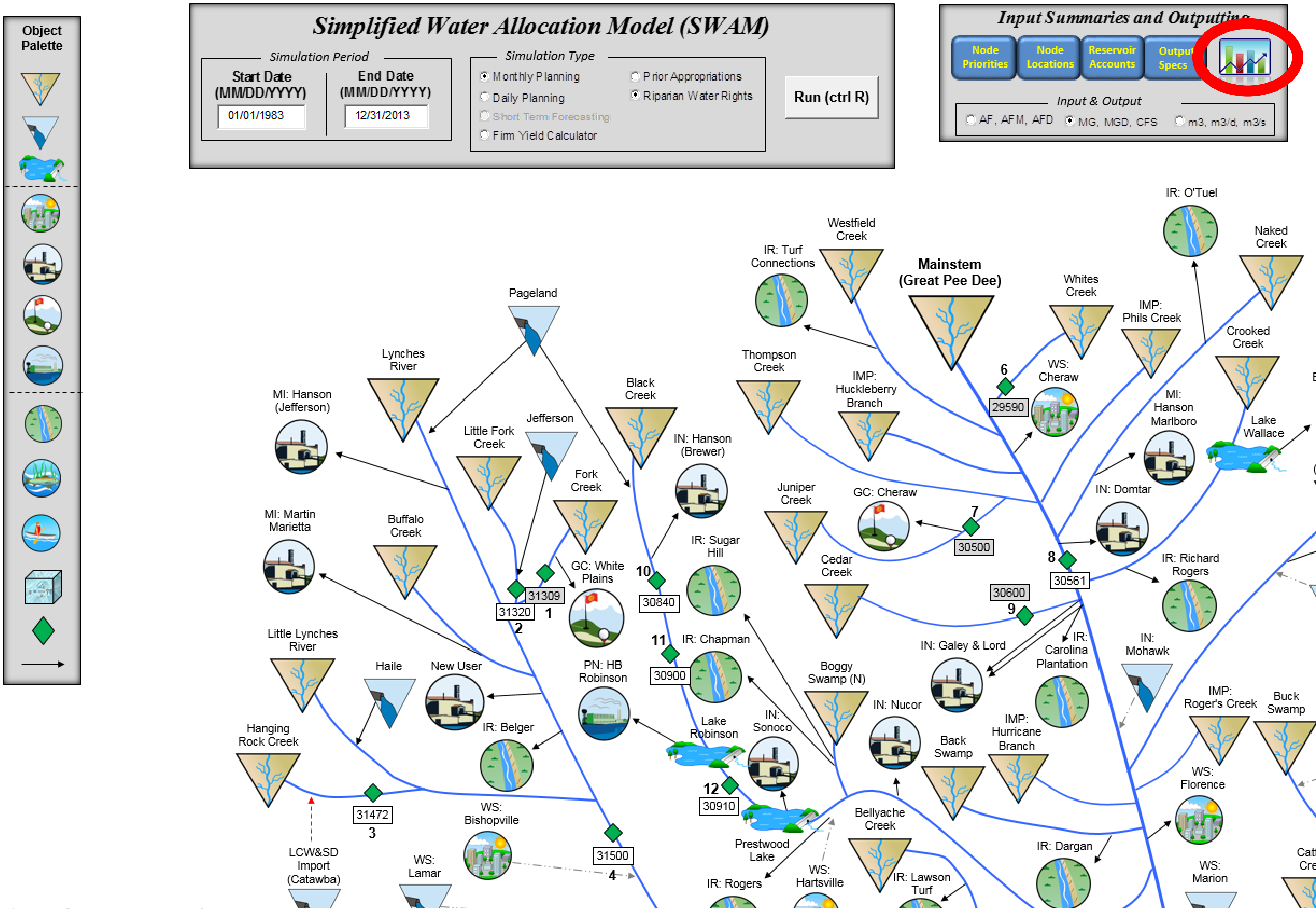
Specify Source the Return Location



Run the Model Scenario



Build a Shortage Plot for the New User



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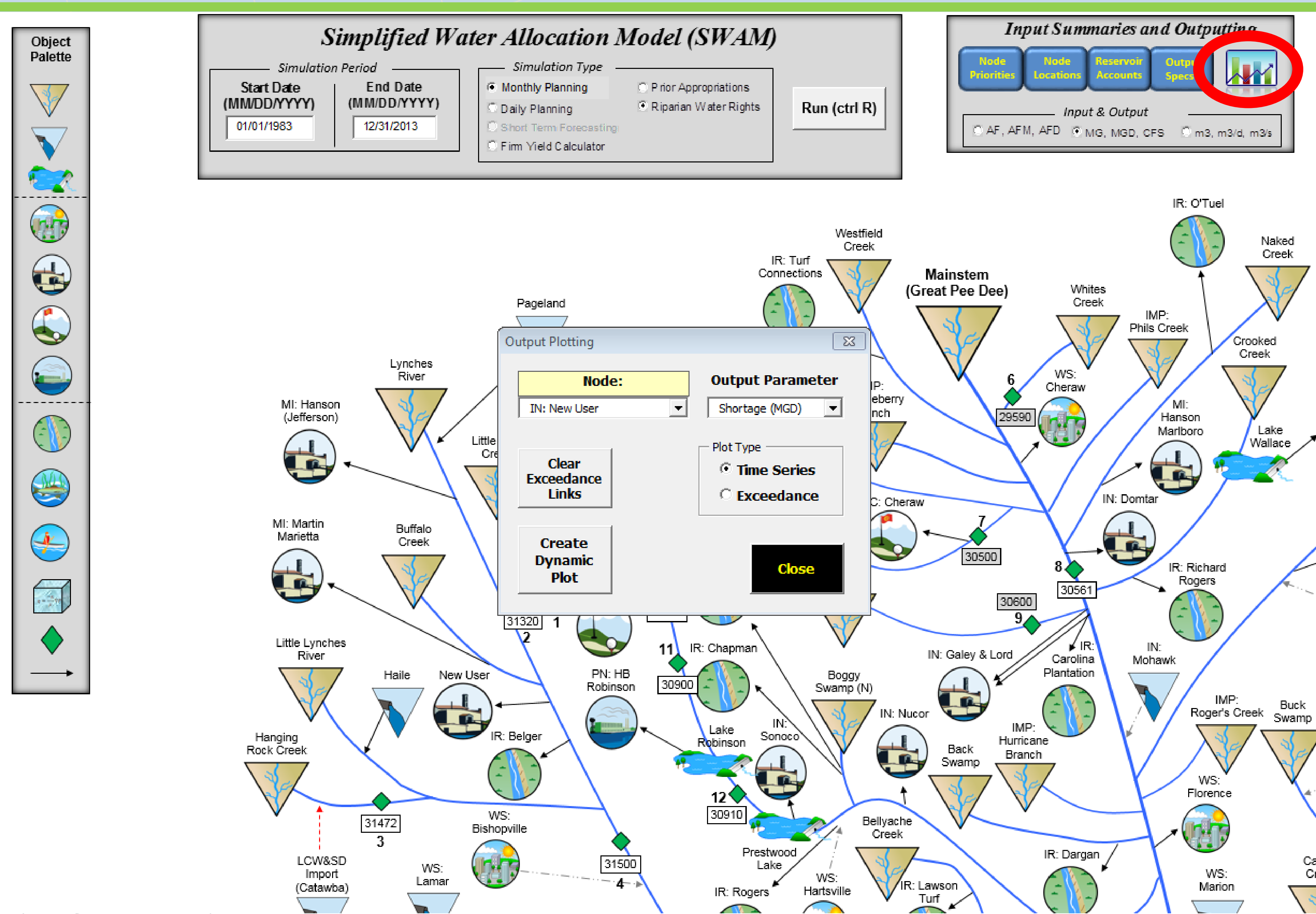

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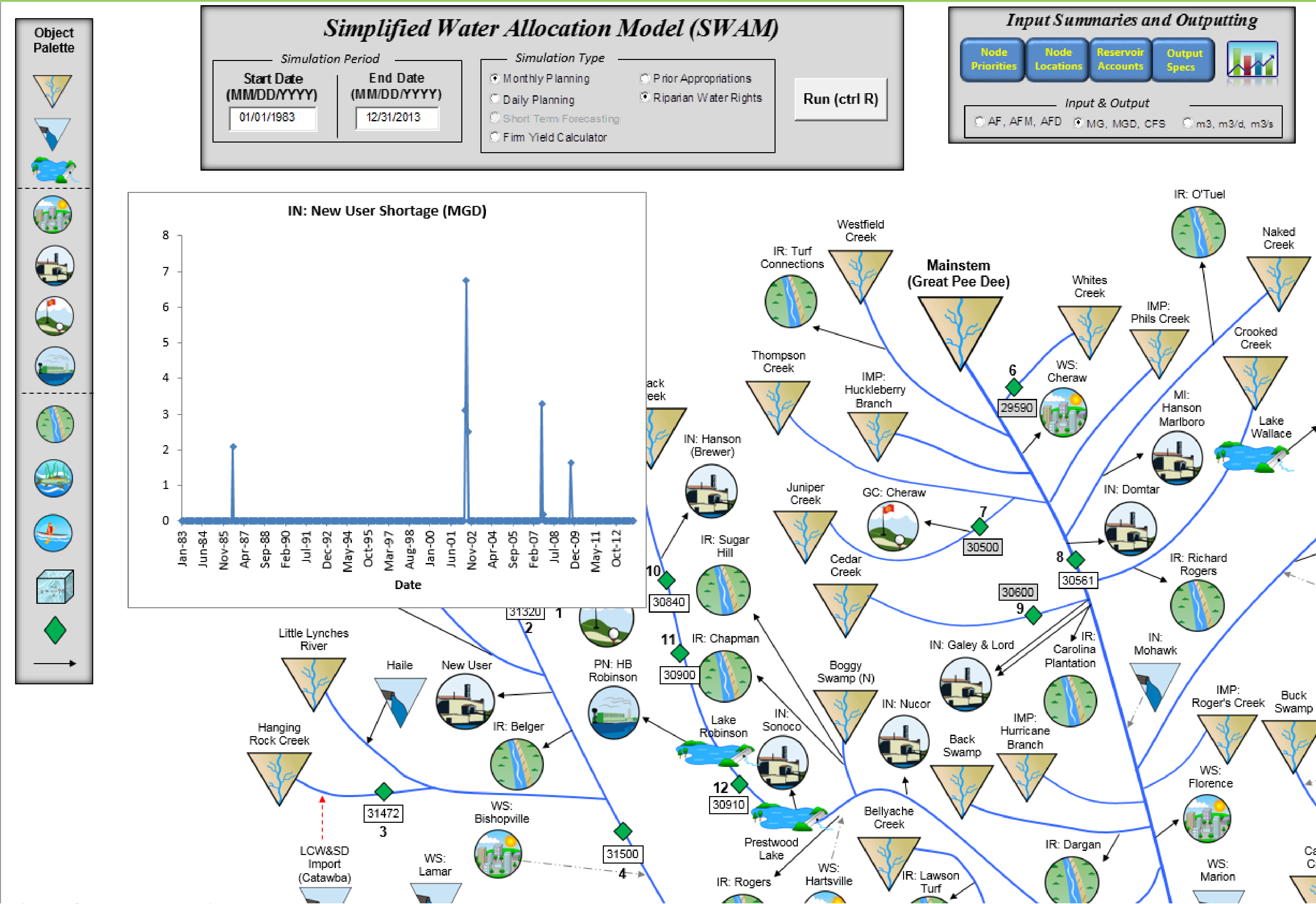
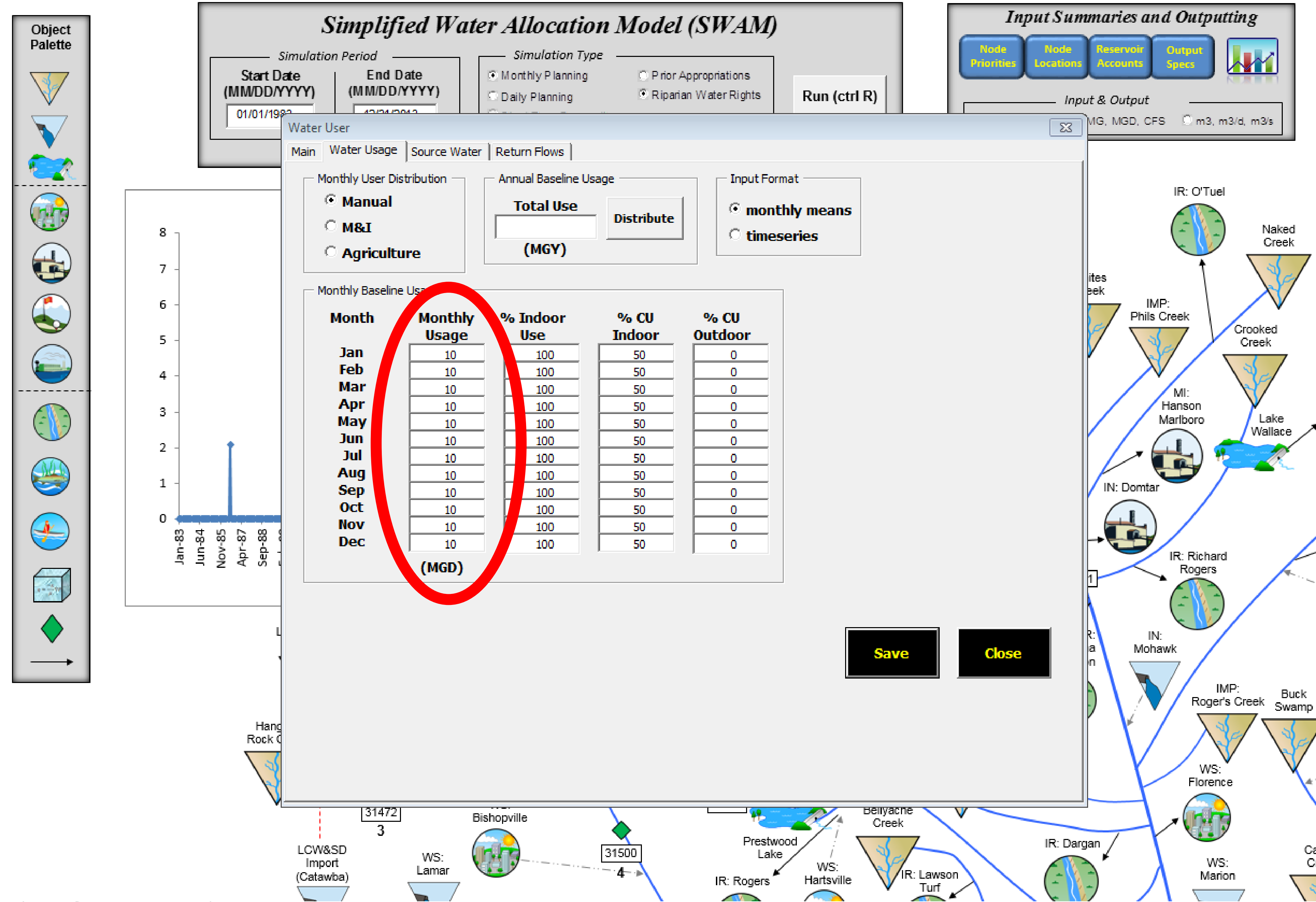


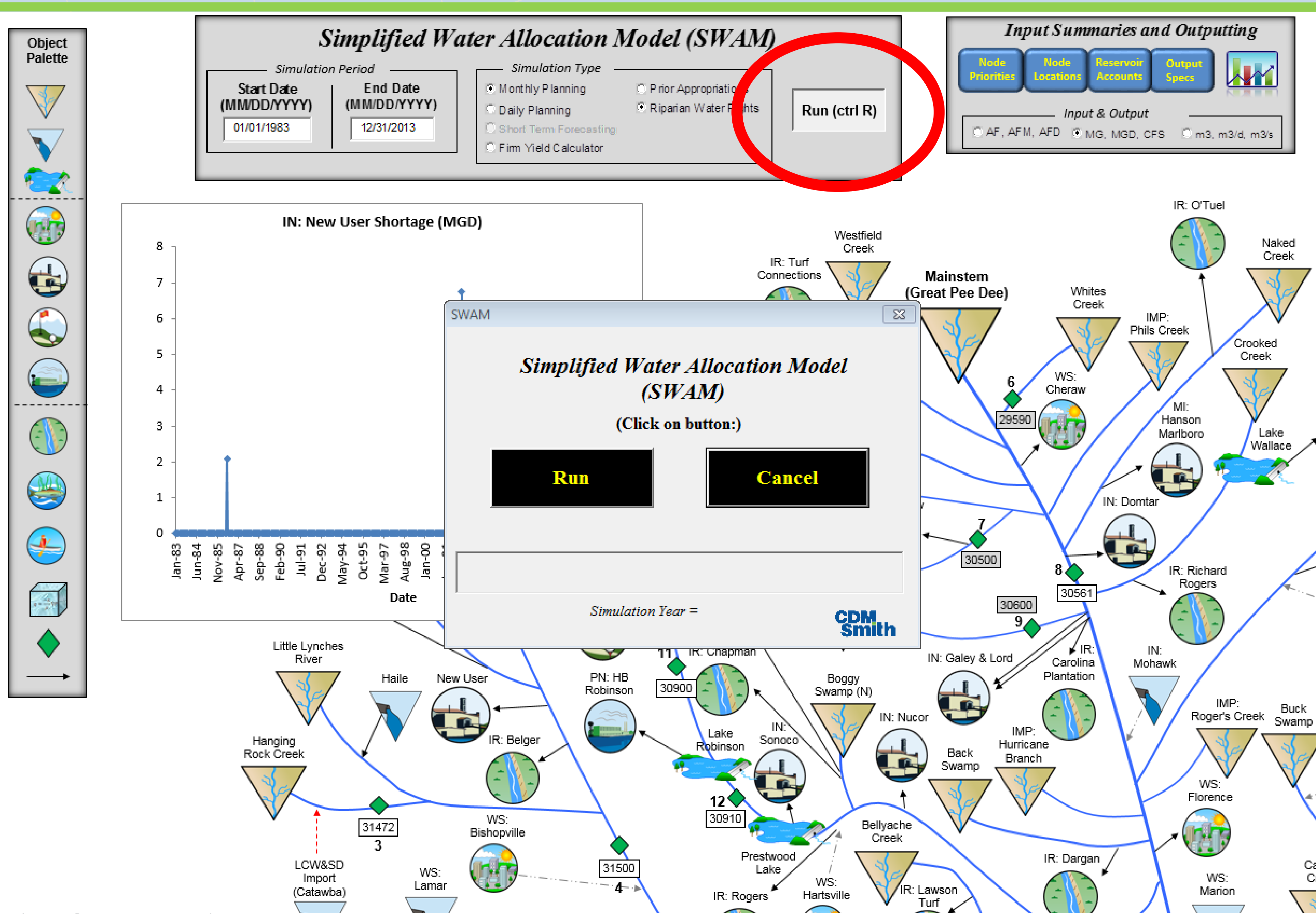
Shortages are Also Listed in the Node Output Table

	A	B	NI	NJ	NK	NL	NM	NN	NO	NP	NQ	NR	NS	NT	NU	NV
1	Output			Priority Rank	Reach	Location	Permit Limit (MGM)	Diversion Capacity (CFS)	Storage Capacity (MG)	Reservoir Withdrawal Permit (MGM)			Priority Rank	Reach	Location	Permit Limit (MGM)
2			*IN: New User*	*52*	*ynches Rive*	*25*	*100000*	*100000*	*0*			*IR: Belger*	*55*	*ynches Rive*	*31*	*10000*
3		Date	Physically Avail. (MGD)	Legally Avail. (MGD)	Demand (MGD)	River Withdrawal (MGD)	Storage (MG)	Groundwater Withdrawal (MGD)	Shortage (MGD)	Return Flow (MGD)		Physically Avail. (MGD)	Legally Avail. (MGD)	Demand (MGD)	River Withdrawal (MGD)	Storage (MG)
4		Min	13	13	20	13	0	0	0	7		9	9	0	0	0
5		Max	967	967	20	20	0	0	7	10		1097	357	0	0	0
6		Avg	177	177	20	20	0	0	0	10		192	158	0	0	0
229		7/31/01	45	45	20	20	0	0	0	10		43	43	0	0	0
230		8/31/01	26	26	20	20	0	0	0	10		21	21	0	0	0
231		9/30/01	22	22	20	20	0	0	0	10		16	16	0	0	0
232		10/31/01	22	22	20	20	0	0	0	10		16	16	0	0	0
233		11/30/01	25	25	20	20	0	0	0	10		19	19	0	0	0
234		12/31/01	32	32	20	20	0	0	0	10		27	27	0	0	0
235		1/31/02	74	74	20	20	0	0	0	10		75	75	0	0	0
236		2/28/02	87	87	20	20	0	0	0	10		90	90	0	0	0
237		3/31/02	81	81	20	20	0	0	0	10		84	84	0	0	0
238		4/30/02	86	86	20	20	0	0	0	10		89	89	0	0	0
239		5/31/02	37	37	20	20	0	0	0	10		32	32	0	0	0
240		6/30/02	17	17	20	17	0	0	3	8		11	11	0	0	0
241		7/31/02	13	13	20	13	0	0	7	7		9	9	0	0	0
242		8/31/02	17	17	20	17	0	0	3	9		11	11	0	0	0
243		9/30/02	54	54	20	20	0	0	0	10		53	53	0	0	0
244		10/31/02	61	61	20	20	0	0	0	10		62	62	0	0	0
245		11/30/02	121	121	20	20	0	0	0	10		131	131	0	0	0
246		12/31/02	171	171	20	20	0	0	0	10		185	185	0	0	0
247		1/31/03	139	139	20	20	0	0	0	10		150	150	0	0	0
248		2/28/03	295	295	20	20	0	0	0	10		324	324	0	0	0
249		3/31/03	729	729	20	20	0	0	0	10		820	323	0	0	0
250		4/30/03	530	530	20	20	0	0	0	10		595	333	0	0	0
251		5/31/03	199	199	20	20	0	0	0	10		215	215	0	0	0
252		6/30/03	208	208	20	20	0	0	0	10		229	229	0	0	0
253		7/31/03	259	259	20	20	0	0	0	10		285	285	0	0	0
254		8/31/03	229	229	20	20	0	0	0	10		252	252	0	0	0
255		9/30/03	70	70	20	20	0	0	0	10		70	70	0	0	0
256		10/31/03	67	67	20	20	0	0	0	10		66	66	0	0	0
257		11/30/03	84	84	20	20	0	0	0	10		87	87	0	0	0
258		12/31/03	103	103	20	20	0	0	0	10		108	108	0	0	0
259		1/31/04	80	80	20	20	0	0	0	10		82	82	0	0	0
260		2/28/04	207	207	20	20	0	0	0	10		228	228	0	0	0
261		3/31/04	167	167	20	20	0	0	0	10		183	183	0	0	0
262		4/30/04	71	71	20	20	0	0	0	10		72	72	0	0	0
263		5/31/04	52	52	20	20	0	0	0	10		49	49	0	0	0
264		6/30/04	30	30	20	20	0	0	0	10		24	24	0	0	0
265		7/31/04	43	43	20	20	0	0	0	10		39	39	0	0	0
266		8/31/04	76	76	20	20	0	0	0	10		77	77	0	0	0

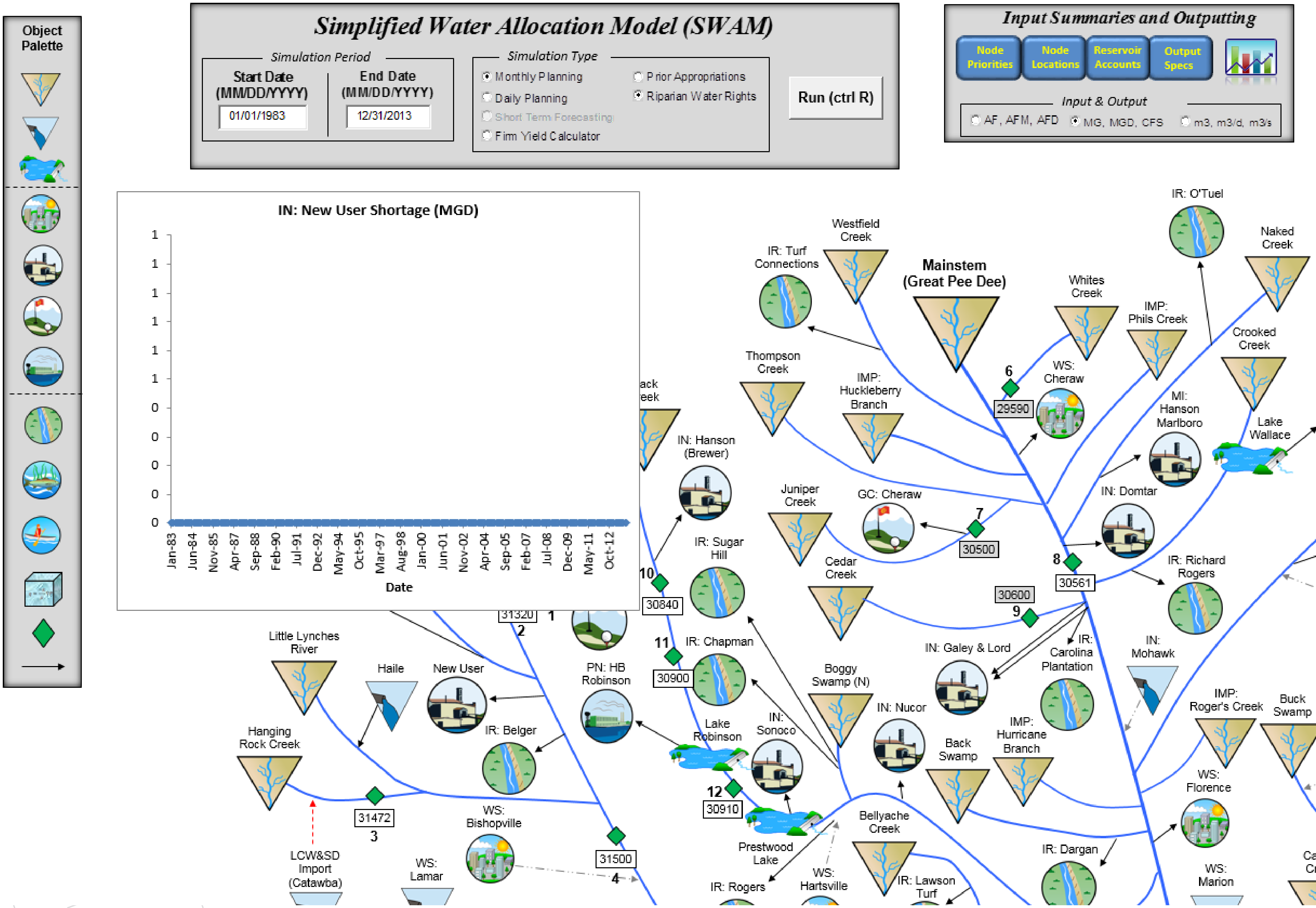
Reduce the New Users Total Water User to 10 mgd



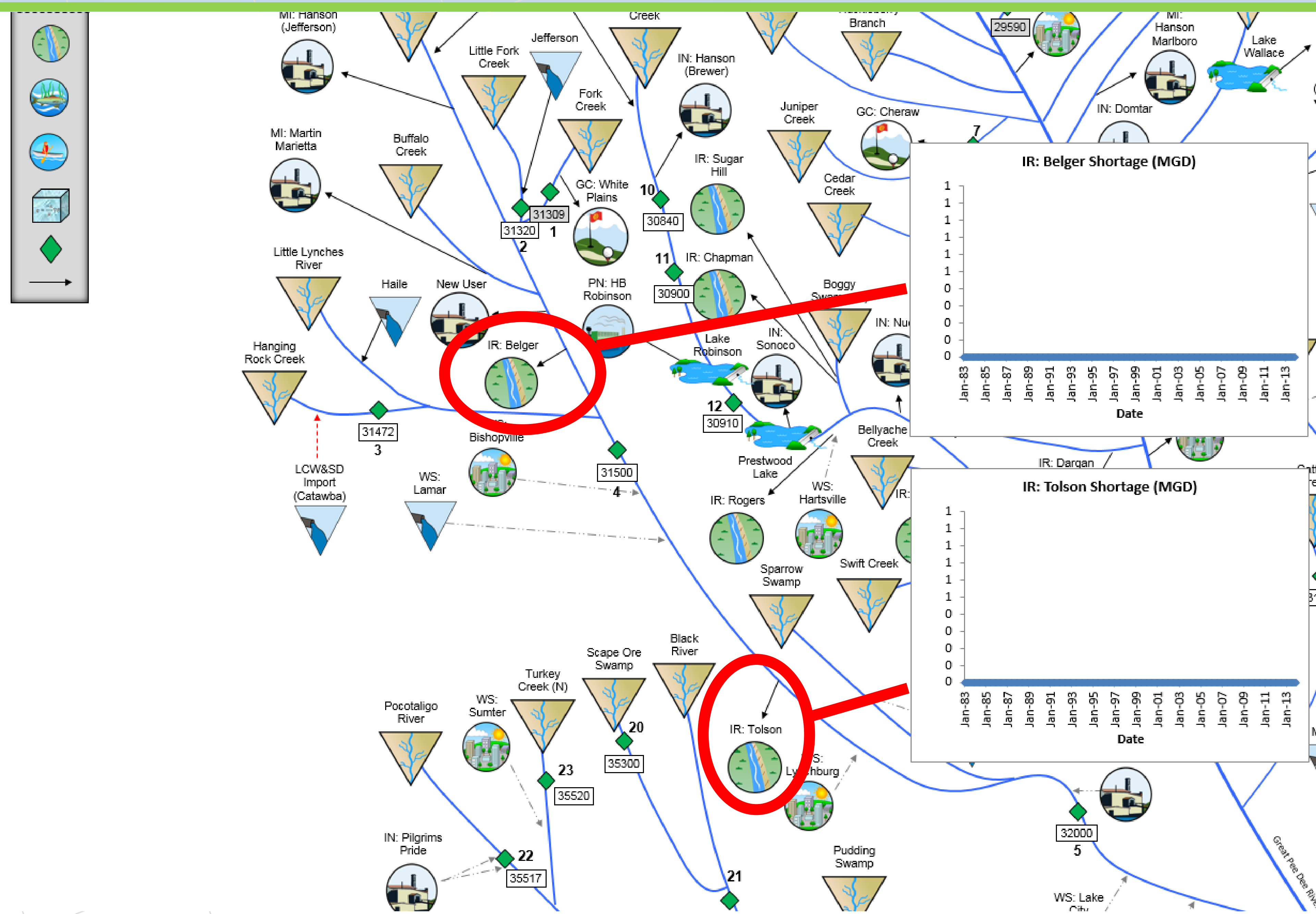
Rerun the Model Scenario



Dynamic Shortage Plots Update Automatically



Check for Shortages for Downstream Users



Demonstrations and Q&A

- Station 1 (Tim)

  Evaluate an increase in Ag User demands

- Station 2 (John)

  Evaluate a proposed new municipal water supply withdrawal

- Station 3 (Kirk)

  Evaluate new industrial user and compare against instream flow requirements

Pee Dee River Basin

THANK YOU