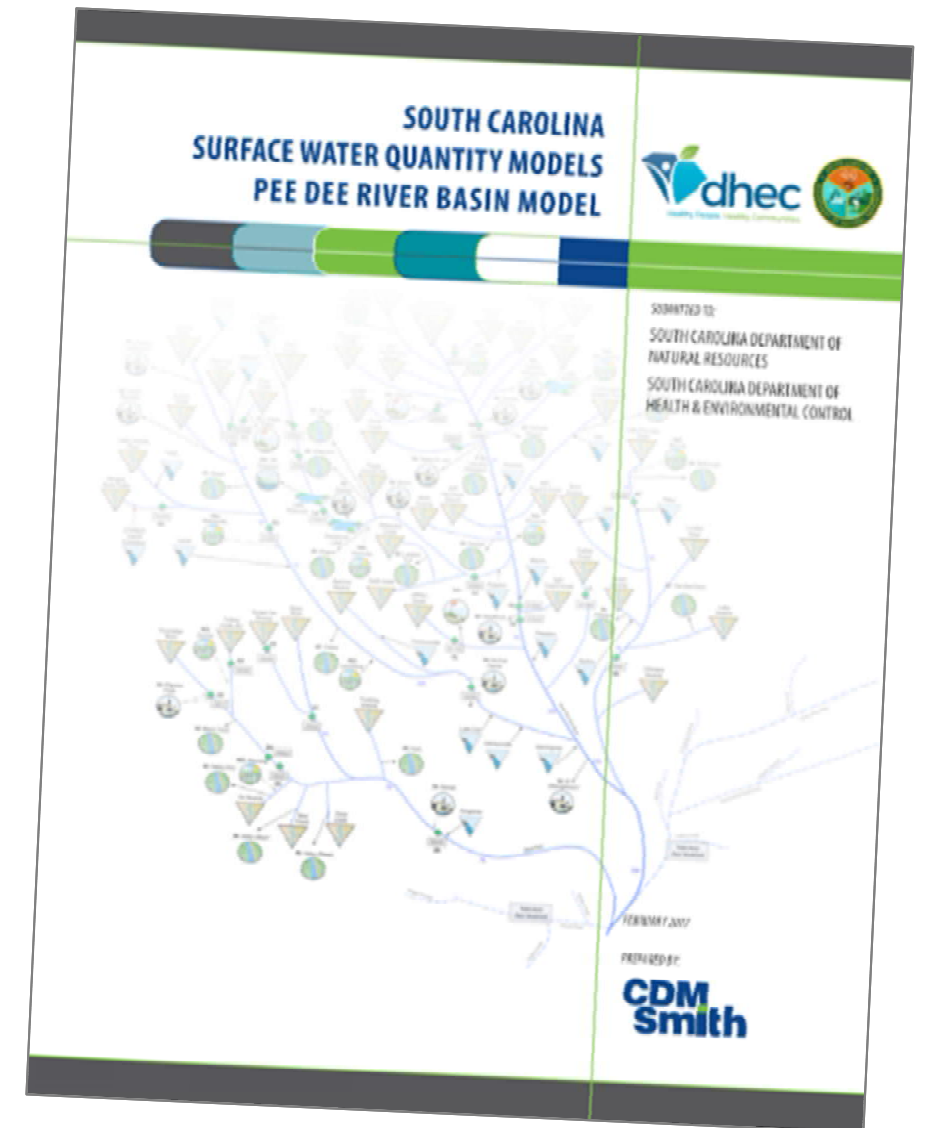


Overview of the Pee Dee Basin Surface Water Quantity Model

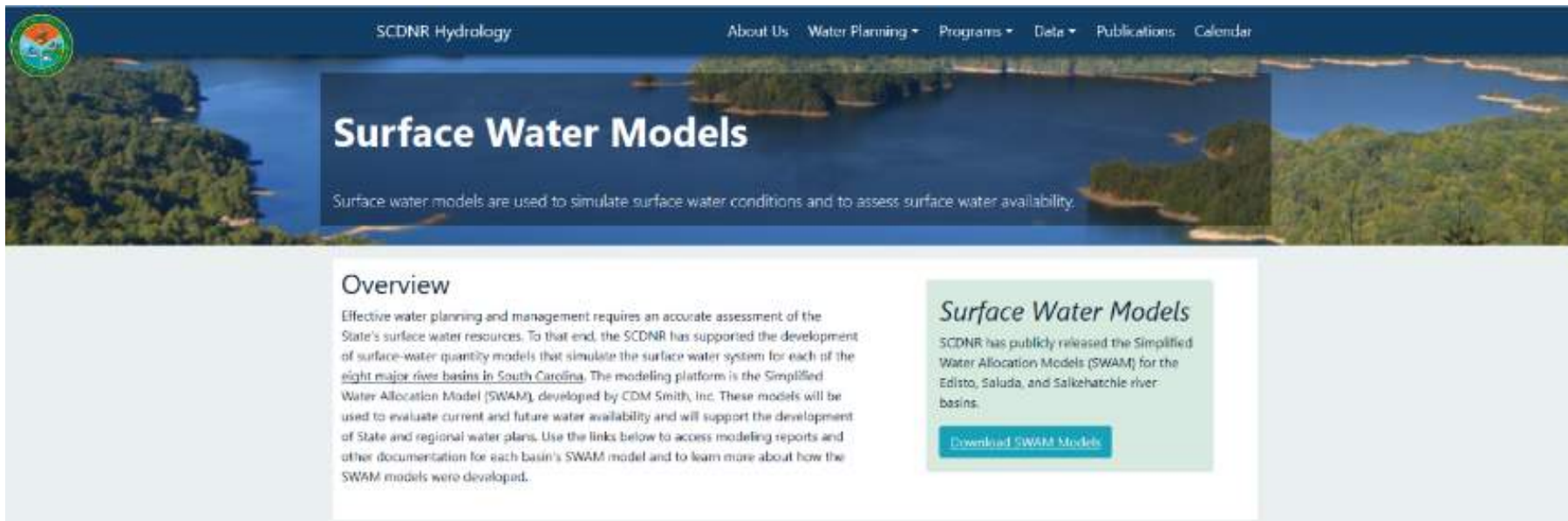
Simplified Water Allocation Model (SWAM)

- Developed as a desktop tool to facilitate regional and statewide water planning and allocation
- SWAM calculates physically and legally available water, diversions, storage, consumption and return flows at user-defined nodes
- From 2014 to 2017, all eight South Carolina surface water quantity models were built in the SWAM platform
- Model updates were performed in 2021



Surface Water Model Access

- Available for download at: <http://hydrology.dnr.sc.gov/surface-water-models.html>
- Also available for download:
 - SWAM User's Manual
 - Model reports for each basin
 - Supplementary technical memoranda



The screenshot shows the SCDNR Hydrology website. The header includes the SCDNR logo and navigation links: About Us, Water Planning, Programs, Data, Publications, and Calendar. The main heading is "Surface Water Models" with a subtext: "Surface water models are used to simulate surface water conditions and to assess surface water availability." Below this, there are two columns of text. The left column is titled "Overview" and describes the development of surface-water quantity models for eight major river basins in South Carolina. The right column is titled "Surface Water Models" and states that SCDNR has publicly released the Simplified Water Allocation Models (SWAM) for the Edisto, Saluda, and Salkehatchie river basins, with a "Download SWAM Models" button below it.

SCDNR Hydrology

About Us | Water Planning | Programs | Data | Publications | Calendar

Surface Water Models

Surface water models are used to simulate surface water conditions and to assess surface water availability.

Overview

Effective water planning and management requires an accurate assessment of the State's surface water resources. To that end, the SCDNR has supported the development of surface-water quantity models that simulate the surface water system for each of the eight major river basins in South Carolina. The modeling platform is the Simplified Water Allocation Model (SWAM), developed by CDM Smith, Inc. These models will be used to evaluate current and future water availability and will support the development of State and regional water plans. Use the links below to access modeling reports and other documentation for each basin's SWAM model and to learn more about how the SWAM models were developed.

Surface Water Models

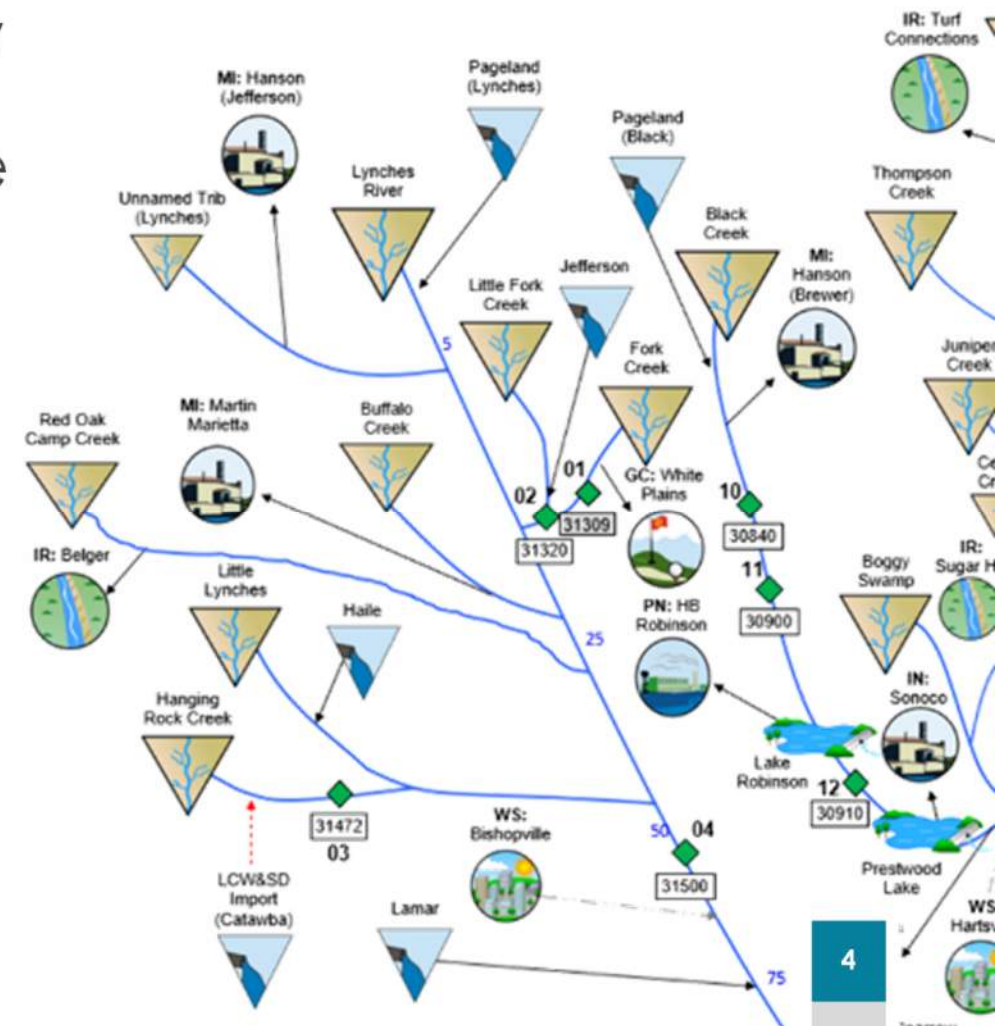
SCDNR has publicly released the Simplified Water Allocation Models (SWAM) for the Edisto, Saluda, and Salkehatchie river basins.

[Download SWAM Models](#)

Pee Dee Basin Surface Water Model Overview

Water Allocation Modeling *is*:

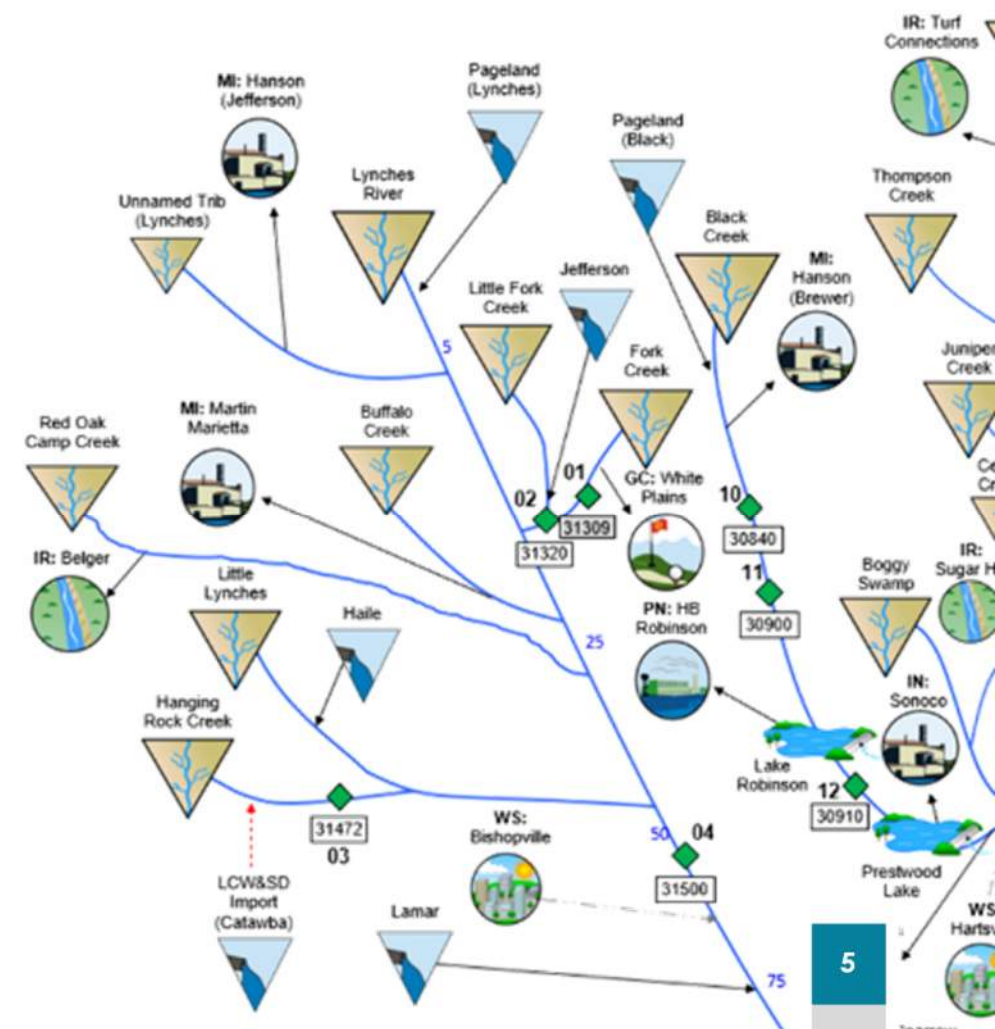
- Water balance calculations of physical flow
- Water rights calculations of legally available flow
- Demands, withdrawals, and return flows
- Reservoir storage
- Stream networks, multiple “nodes”
- Data intensive



Pee Dee Surface Water Model Overview

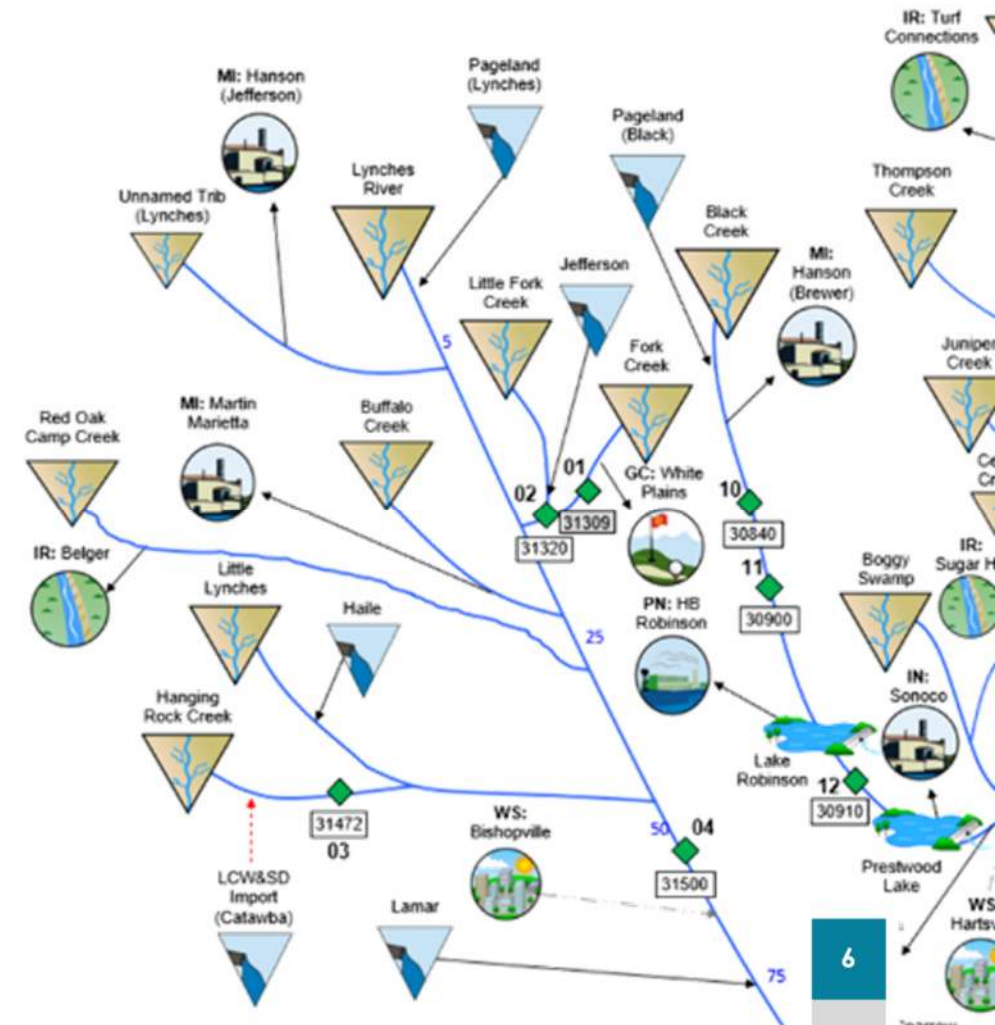
Water Allocation Modeling *is not*:

- Rainfall-runoff calculations
- Hydrologic routing calculations
- Groundwater hydrology modeling
- Water quality modeling



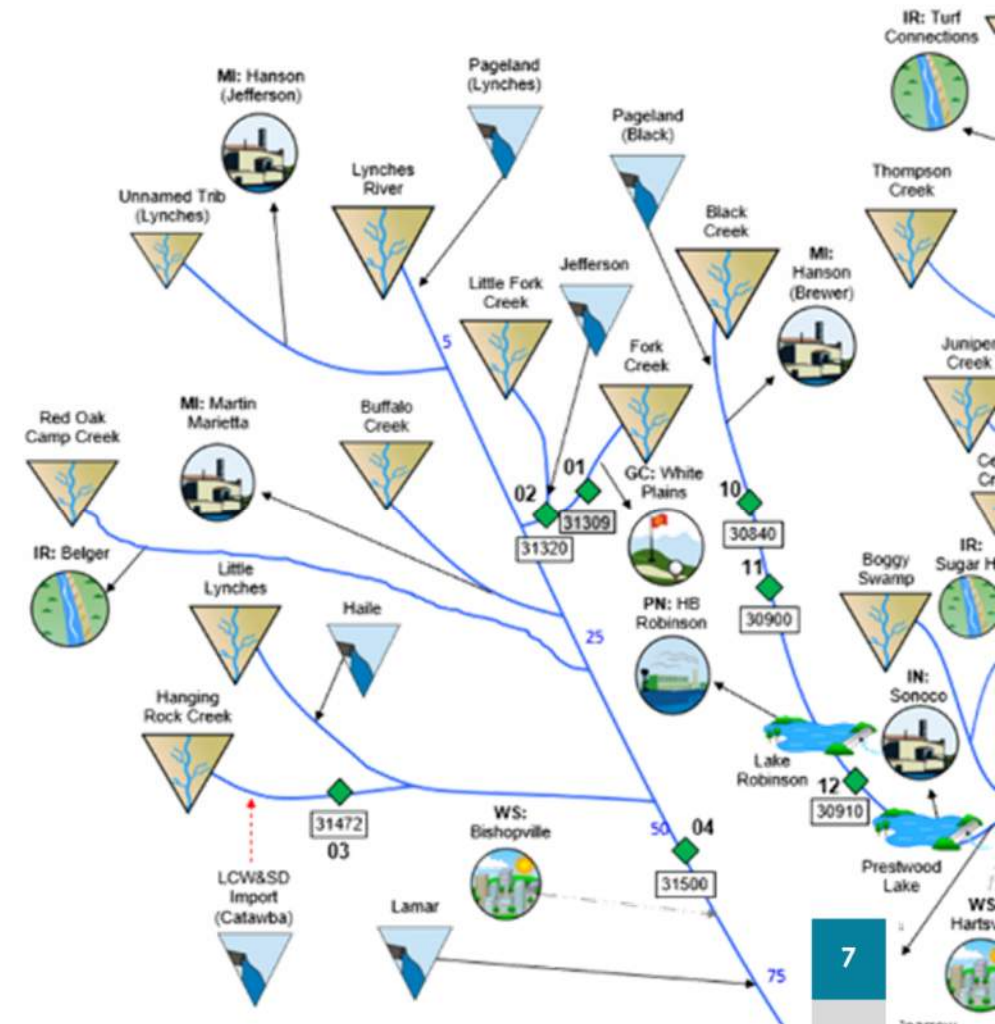
In Support of Pee Dee River Basin Planning, the Model Will be Used to:

- Assess current supply availability and shortages across a range of hydrologic conditions (1929 through 2018)
- Assess a range of future potential scenarios with respect to changes in growth
- Assess potential impacts of a “full allocation” scenario
- Test, evaluate and help prioritize water management strategies



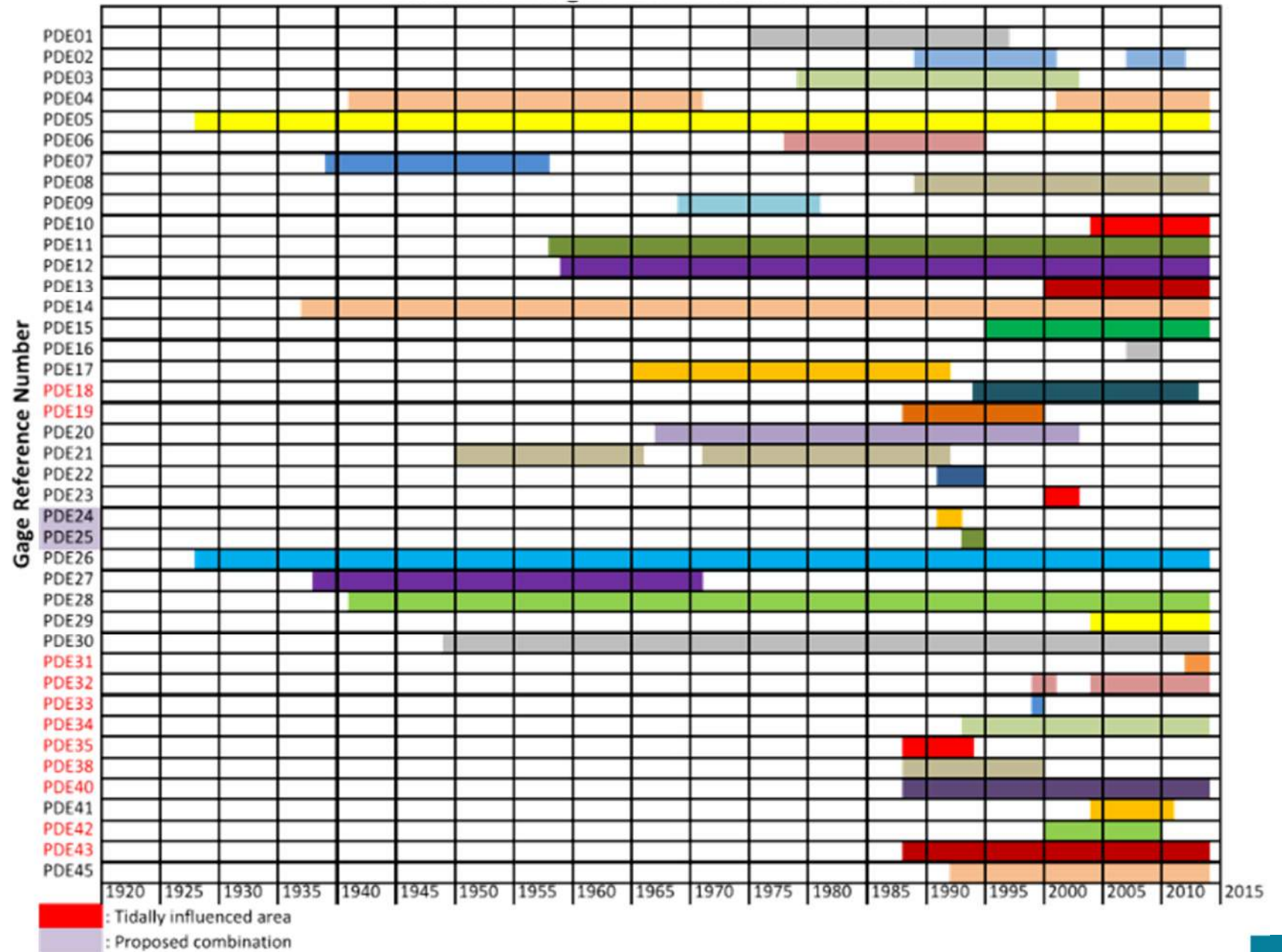
Pee Dee Model Inputs and Supporting Information

- USGS daily flow records
- Historical operational data
 - Withdrawals (municipal, industrial, thermoelectric, agricultural, golf courses, hatcheries)
 - Wastewater discharges and return flows
 - Transfers in and out of the basin
- Reservoir characteristics and operating rules
- Subbasin characteristics
 - Drainage area, land use, and slope



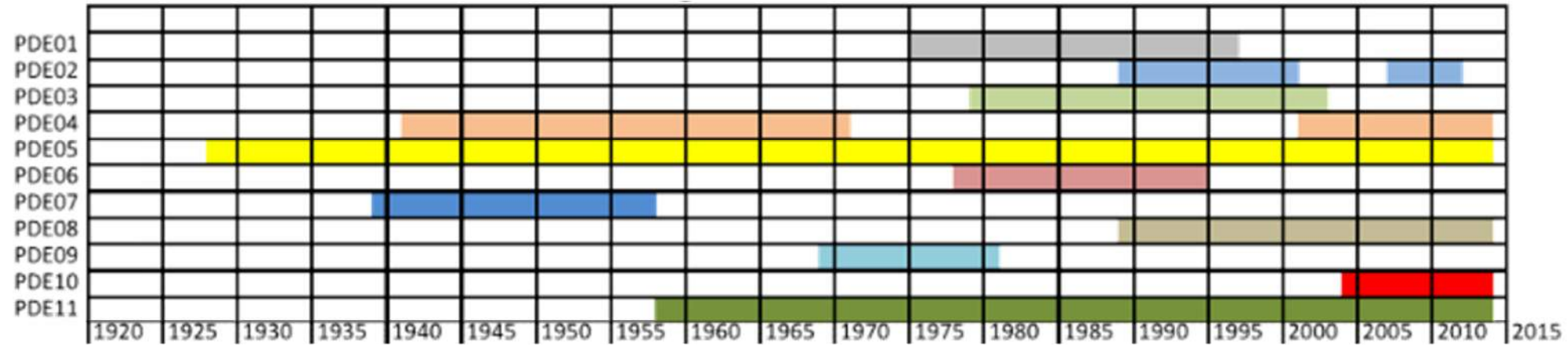
Timeline of Daily Flow Records in the Pee Dee Basin

USGS Gage Timeline – Pee Dee River Basin

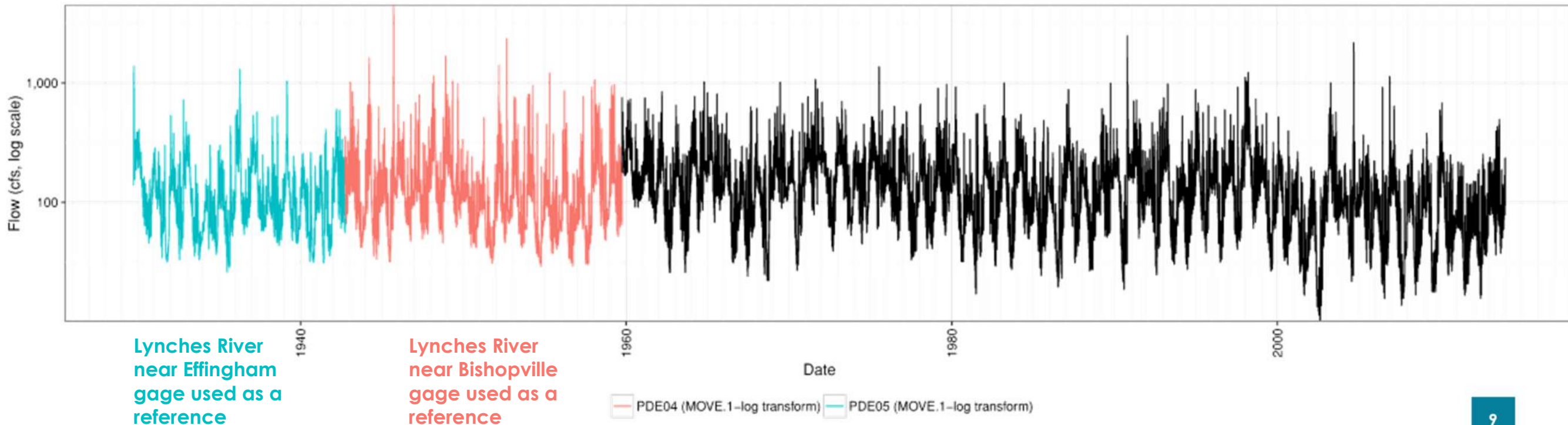


Filling in Gaps in Flow Data

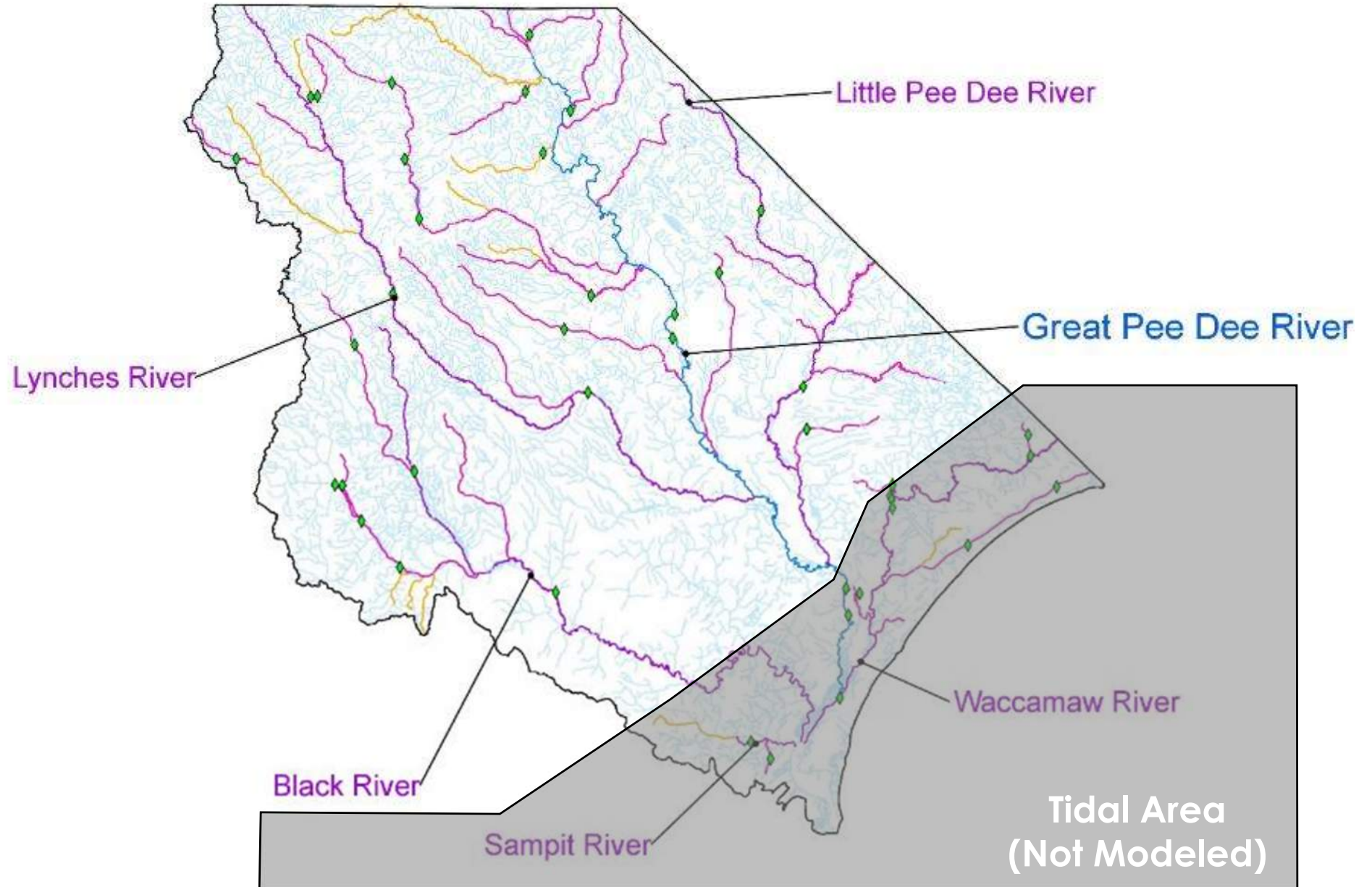
USGS Gage Timeline – Pee Dee River Basin



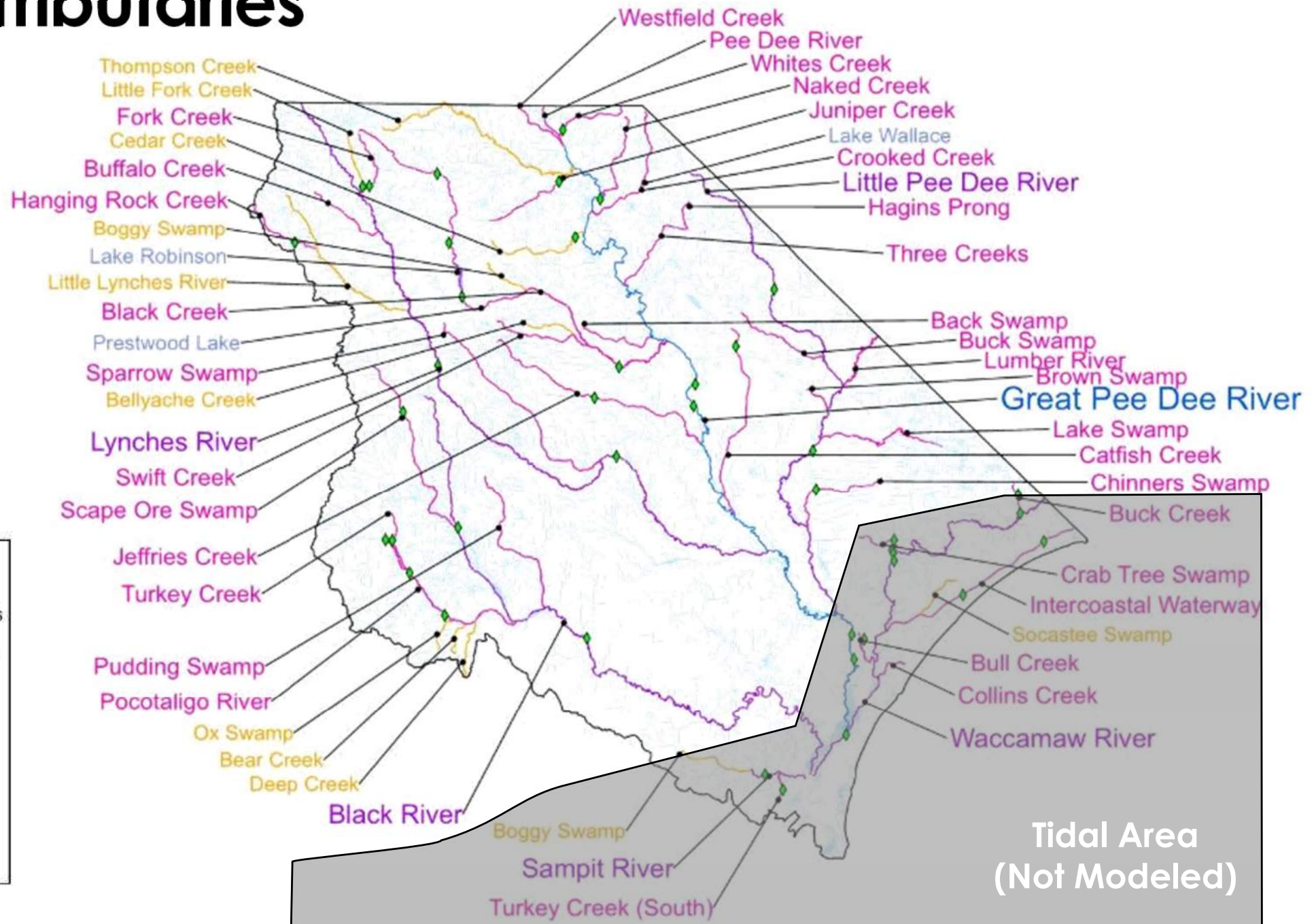
Extended Timeseries for PDE11 (Black Creek near McBee Gage)



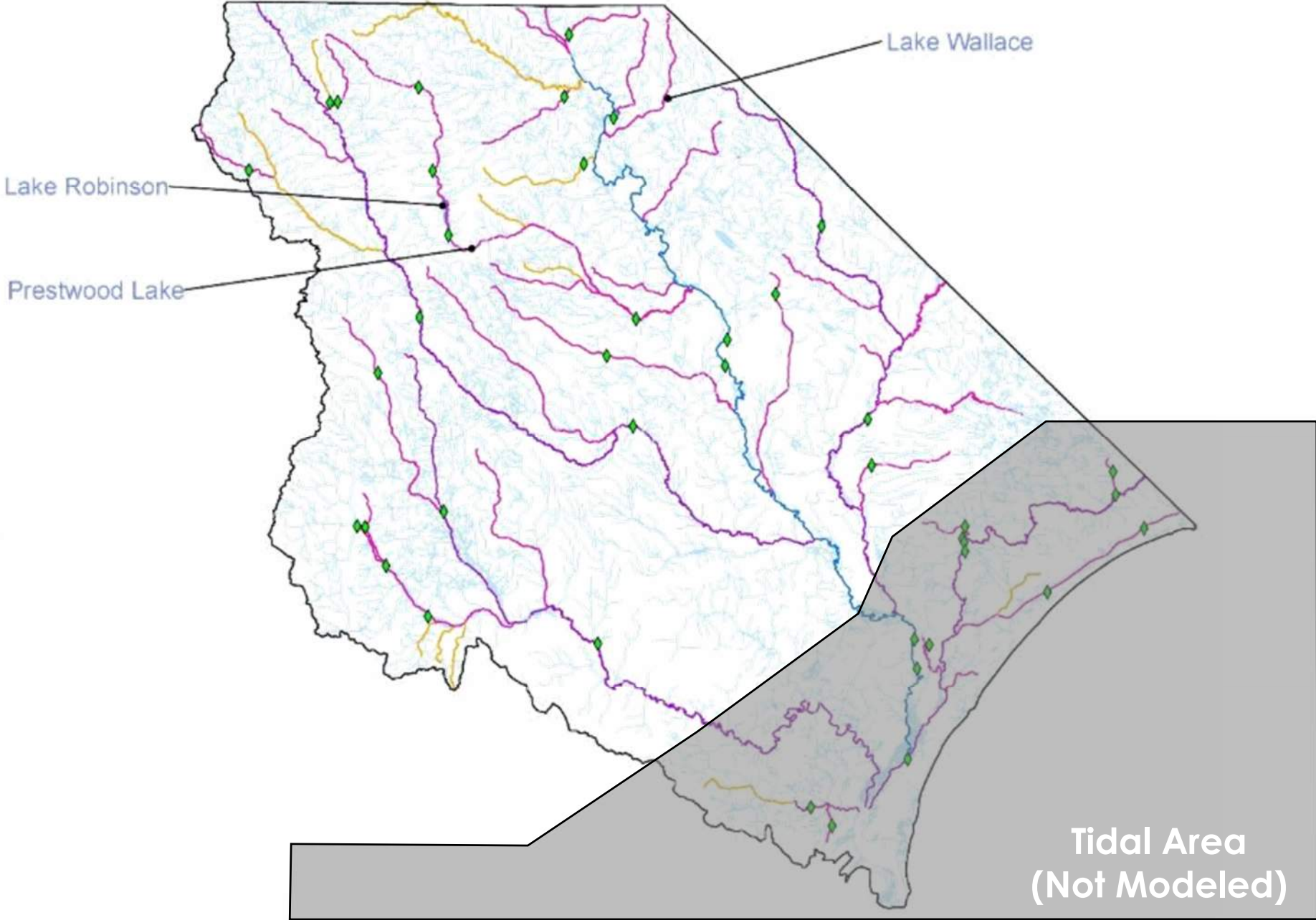
Main Stem and Major Branches



Primary Tributaries



Reservoirs



Municipal, Industrial, and Thermoelectric Withdrawals



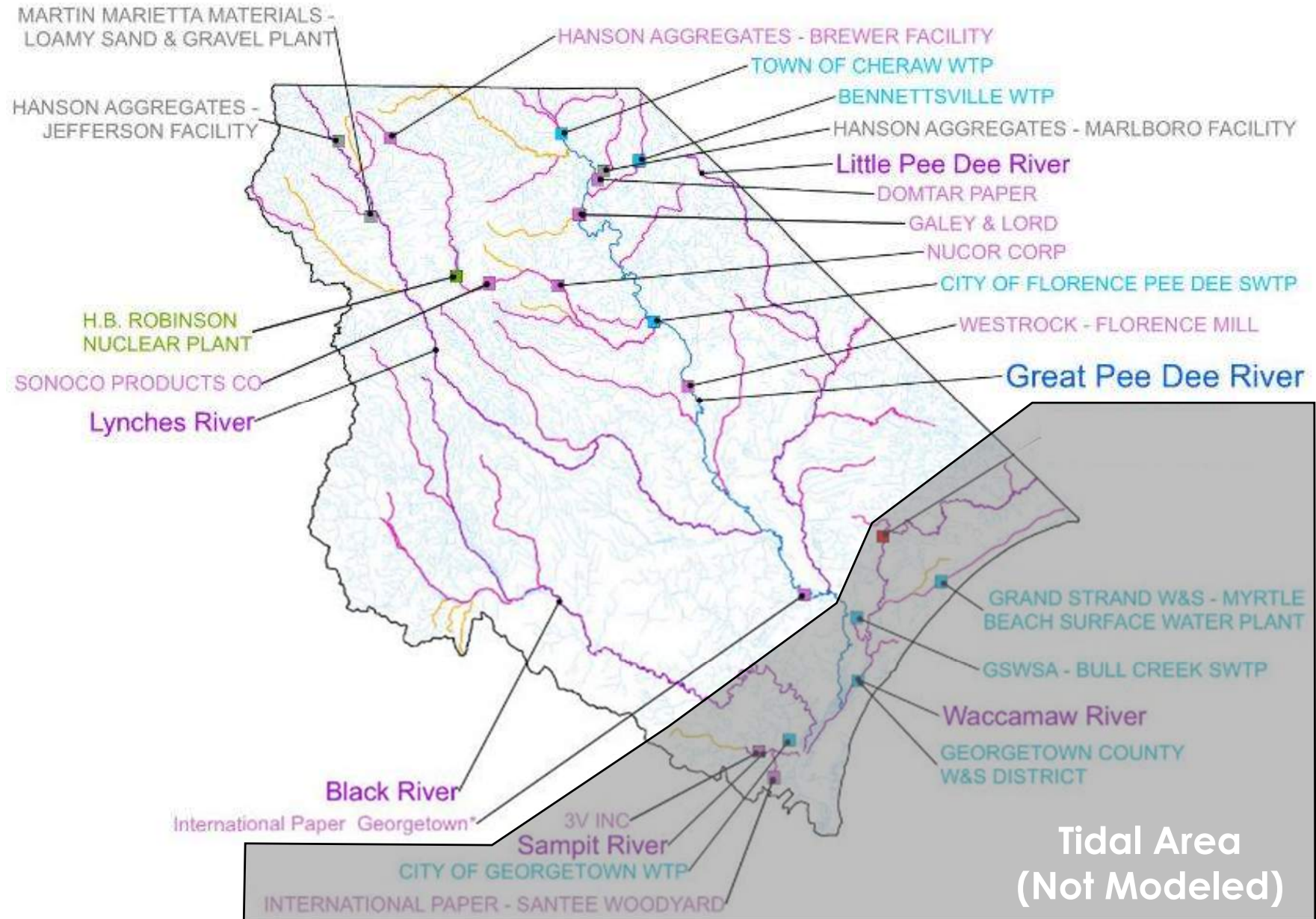
MUNICIPAL



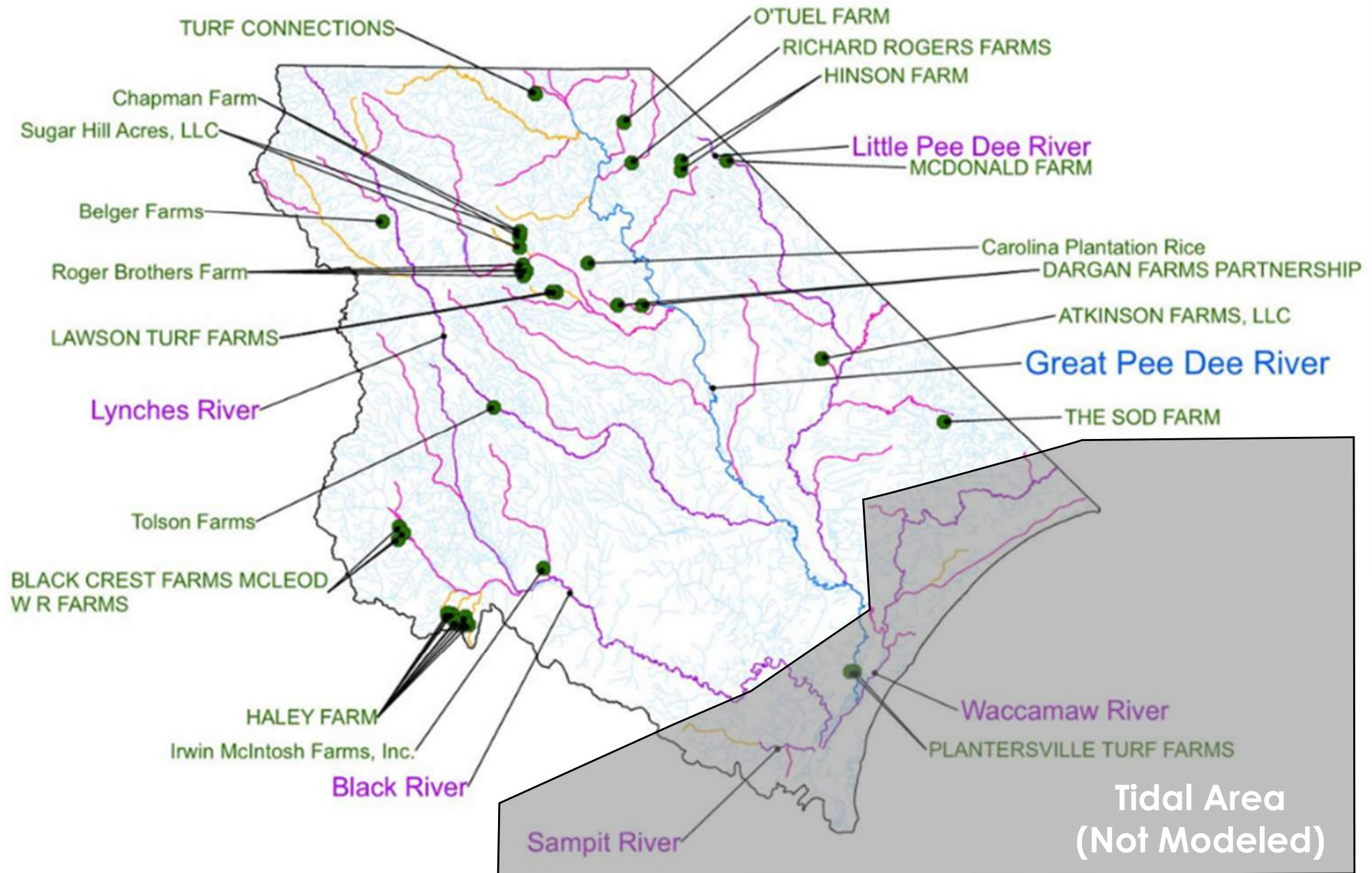
INDUSTRIAL/
MINING



THERMO-
ELECTRIC



Agriculture Withdrawals



Golf Course Withdrawals



WHITE PLAINS COUNTRY CLUB

CHERAW STATE PARK

Little Pee Dee River

FLORENCE COUNTRY CLUB

Lynches River

Great Pee Dee River

SHAFTESBURY GLEN GOLF & FISH CLUB

BURNING RIDGE GOLF CLUB

- BLACK BEAR GOLF CLUB
- ABERDEEN COUNTRY CLUB
- RIVER HILLS GOLF & COUNTRY CLUB
- HEATHER GLEN GOLF LINKS
- BAREFOOT GOLF
- WATERWAY HILLS GOLF CLUB
- ARCADIAN SHORES GOLF COURSE
- DUNES GOLF & BEACH CLUB
- GRANDE DUNES VILLAGE
- TRANSFER STATION
- MYRTLEWOOD GOLF COURSE
- ARROWHEAD COUNTRY CLUB
- BLACKMOOR CLUB
- TPC OF MYRTLE BEACH
- Waccamaw River
- THE RESERVE GOLF CLUB
- WILLBROOK PLANTATION
- THE RESERVE AT LITCHFIELD COMMUNITY ASSOCIATION
- THE TRADITION GOLF CLUB
- RIVER CLUB
- CALEDONIA GOLF & FISH CLUB
- TRUE BLUE PLANTATION GOLF

Black River

Sampit River

WORLD TOUR GOLF LINKS
RIVER OAKS GOLF PLANTATION

FOUNDERS CLUB
HERITAGE CLUB - PAWLEYS ISLAND

Tidal Area
(Not Modeled)

Legend

- Golf Course
- Model Tributary Objects**
- Pee Dee
- Major Branch
- Primary
- Secondary
- Higher Order Tribs

Discharges to Surface Water



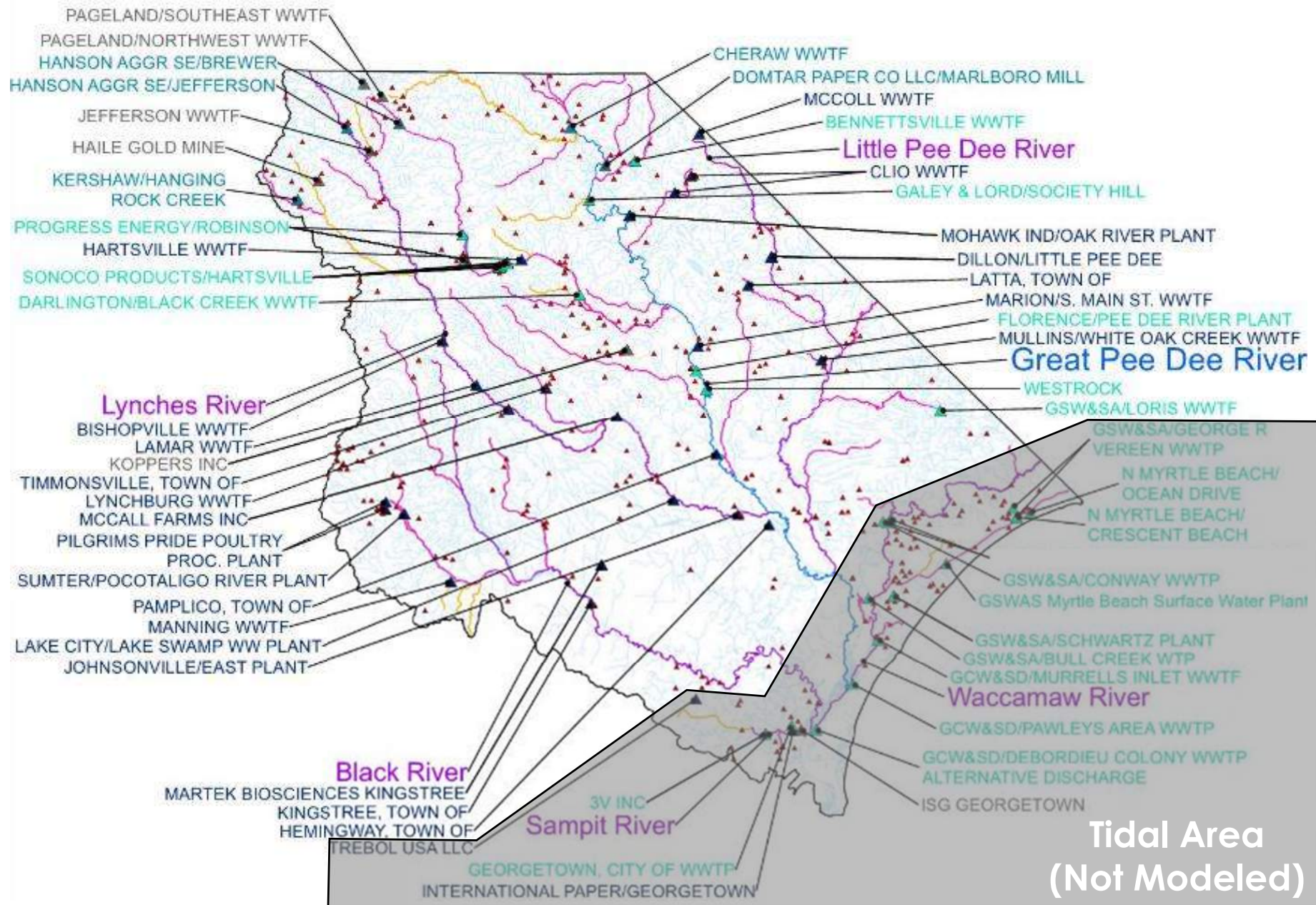
Legend

Significant Dischargers

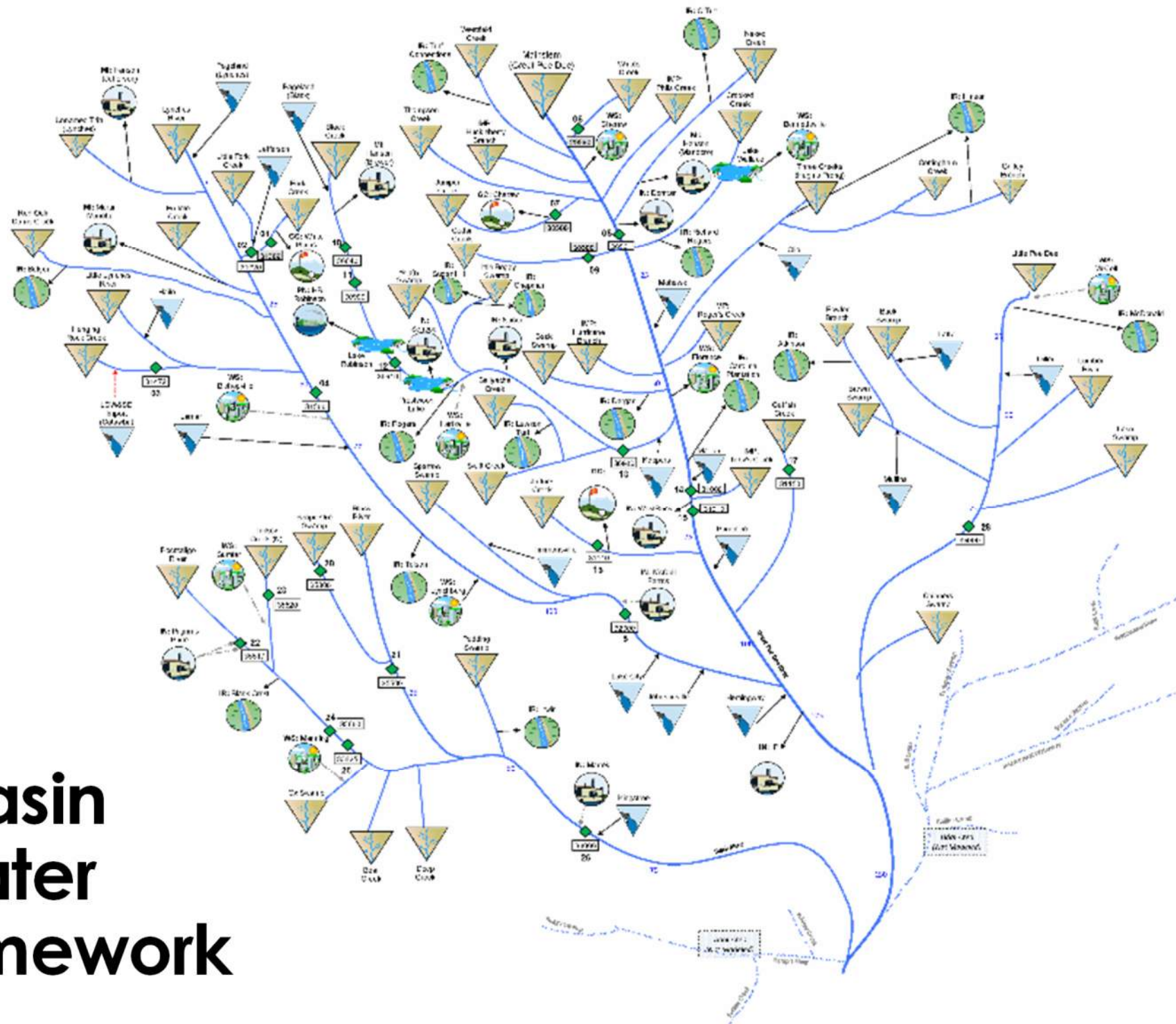
- ▲ Not Included, Insignificant
- ▲ Included, No Withdrawal Permit or Registration
- ▲ Included, Has GW Withdrawal Registration
- ▲ Included, Has SW Withdrawal Permit
- ▲ Included, Has both SW Withdrawal Permit & GW Withdrawal Registration

Model Tributary Objects

- Pee Dee
- Major Branch
- Primary
- Secondary
- Higher Order Tribs

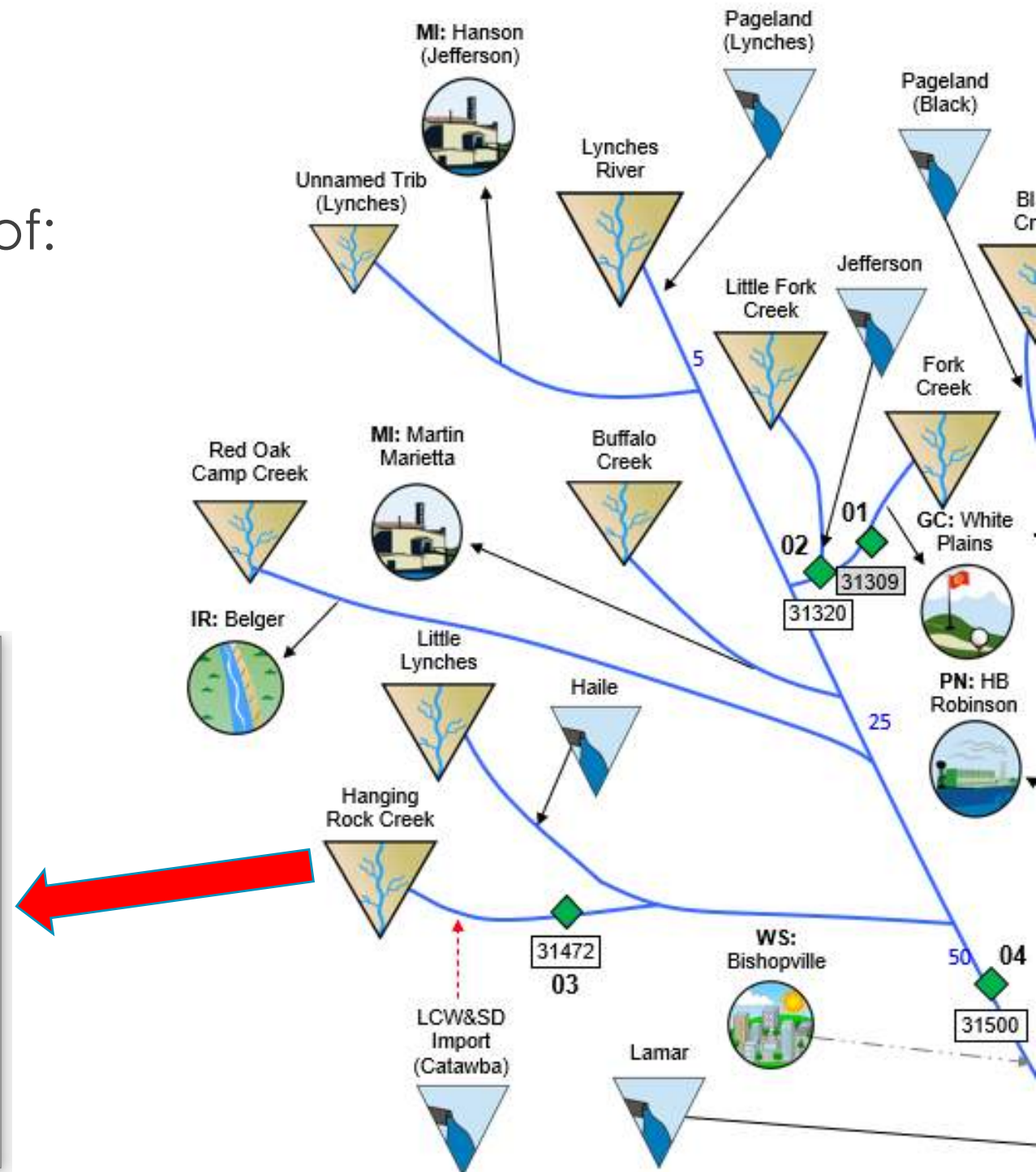


Pee Dee Basin Surface Water Model Framework



SWAM Calculations: Supply

- **Physically available** flow is a function of:
 - upstream tributary inflows,
 - reach gains and losses,
 - upstream diversions, withdrawals, returns, and storage



Year (YYYY)	Month (MMM)	Monthly Flow (CFS)
1929	Oct	61.06
1929	Nov	21.24
1929	Dec	35.81
1930	Jan	31.60
1930	Feb	27.60
1930	Mar	16.52
1930	Apr	9.90
1930	May	5.68
1930	Jun	4.55
1930	Jul	4.12
1930	Aug	3.26
1930	Sep	4.70
1930	Oct	2.64
1930	Nov	8.79
1930	Dec	15.70
1931	Jan	22.83

Tributary ×

Tributary Name: Hanging Rock Creek **Delete Tributary** **Headwater Flows**

Confluence Stream: Little Lynchies River **Confluence Location**

11.3 (mi)

Spatial Flow Changes

Subbasin Flow Factors (unitless)

end mile:	1.4	5	0	0	0	0	0	0	0
factor:	1.75	2.2	0	0	0	0	0	0	0

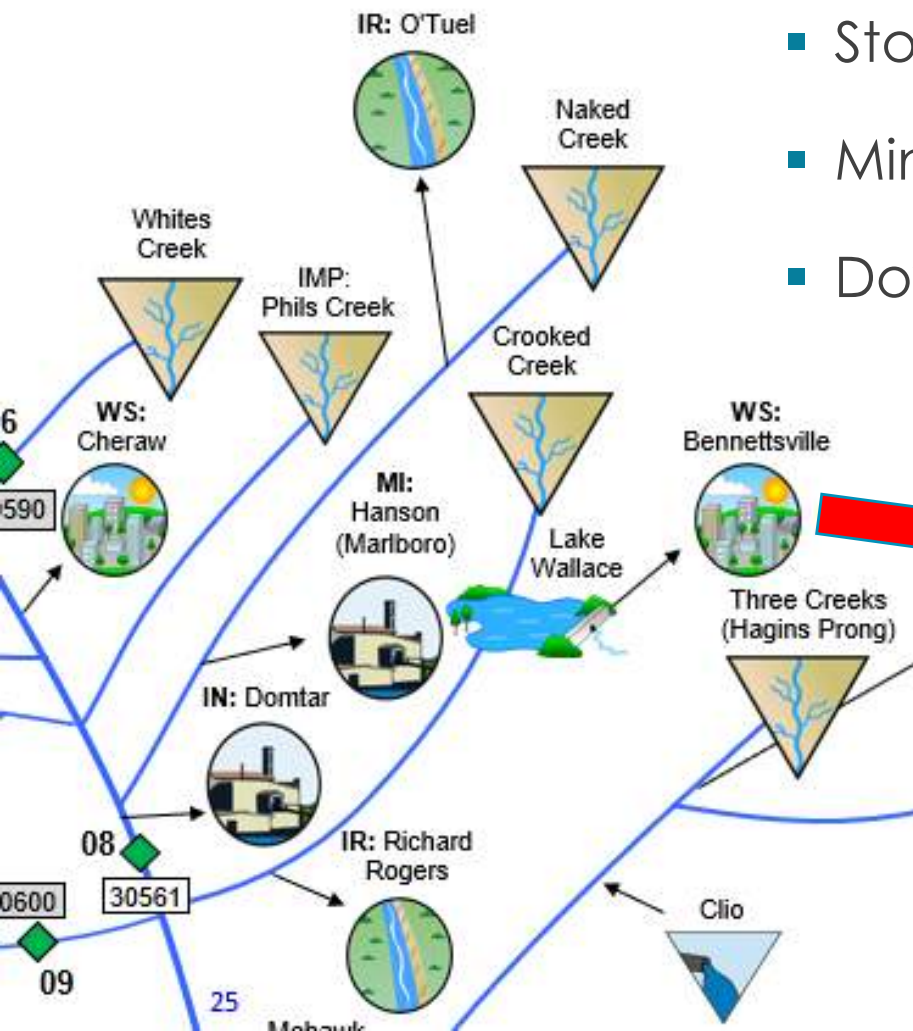
Temporally Variable Factors

Comments: UIF ID PDE204.

Save **Close**

SWAM Calculations: Supply

- **Legally available** flow is a function of:
 - Permit limits / water rights
 - Storage rights
 - Minimum Instream flow requirements
 - Downstream priority water uses



Water User

Main | Water Usage | Source Water 1 | **Source Water 2** | Source Water 3 | Source Water 4 | Source Water 5 | Return Flows

Preference #2

Source Stream: Crooked Creek	Source Water Type <input type="radio"/> Direct River <input checked="" type="radio"/> Reservoir <input type="radio"/> Groundwater	Diversion Location 1.998000025 (mi)	Priority Date 1/9/1900
Diversion Capacity 1000000 (CFS)	Permit Limit 120 (MGM)	<input type="checkbox"/> Seasonal Permit	<input type="checkbox"/> Minimum Flow Requirements
		<input checked="" type="checkbox"/> Storage Withdrawal Permit	

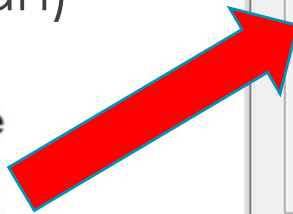
Save

Close

SWAM Calculations: Demand

■ WS: User Object:

- Node based withdrawals and returns
- Municipal water demands (prescribed monthly mean)



Water User

Main | Water Usage | Source Water 1 | Source Water 2 | Source Water 3 | Source Water 4 | Source Water 5 | Return Flows

Monthly User Distribution

Manual
 M&I
 Agriculture

Annual Baseline Usage

Total Use: 5184.68 (MGY)

Input Format

monthly means
 timeseries

Monthly Baseline Usage

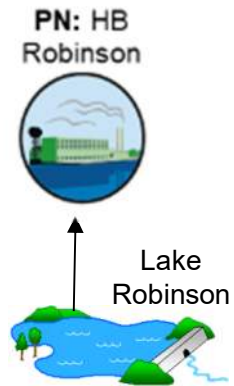
Month	Monthly Usage	% Indoor Use	% CU Indoor	% CU Outdoor
Jan	13.95	100	19	100
Feb	13.68	100	10	100
Mar	13.37	100	8	100
Apr	13.61	100	11	100
May	14.26	100	21	100
Jun	15.22	100	29	100
Jul	15.39	100	30	100
Aug	15.24	100	31	100
Sep	14.97	100	30	100
Oct	14.05	100	25	100
Nov	13.5	100	23	100
Dec	13.18	100	17	100

(MGD)

SWAM Calculations: Reservoirs

■ Reservoir Object:

- Dynamic water balance, water supply pool, customized operating rules



Reservoir

Main

Reservoir Name: Lake Robinson **Delete Node**

Storage Capacity: 10101 (MG) **Initial Storage:** 10000 (MG) **Dead Pool:** 0 (MG)

Offline Online

Evaporation: Monthly Mean % Volume Input Timeseries **Edit Timeseries**

Reservoir Operations: **Receiving Stream:** Black Creek Simple Advanced

Release Location: 38.5 (mi)

User Defined Releases:

Month	Min. Release (CFS)
Jan	0
Feb	0
Mar	0
Apr	0
May	0
Jun	0
Jul	0
Aug	0
Sep	0
Oct	0
Nov	0
Dec	0

Area-Capacity Table: Simple Detailed

Volume (MG)	Area (Ac)
0	0
10101	2250

Flood Control Outflow:

% Vol	Outflow (CFS)
0	0
100	0

Save **Close**

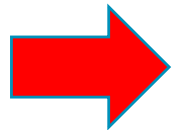
Comments: Lake Robinson reservoir came online in 1960. Supports withdrawal from H.B. Robinson Nuclear Plant (Permits 16PN001S2 and -S01). No minimum releases or storage targets. Evap rates extended and updated in 2020.

SWAM Calculations: Demand

- Ag User Object:

- Agricultural water demands (prescribed monthly mean – repeated time series)

IR: Belger



Agricultural Water User

Main | Source Water | Return Flows

User Name:
IR: Belger Delete Node

Multiple Sources of Water ?

Supplemental Supply/Demand Alternatives

Transbasin Import

Groundwater

Demands

user-defined

ag calculations

Edit Demands

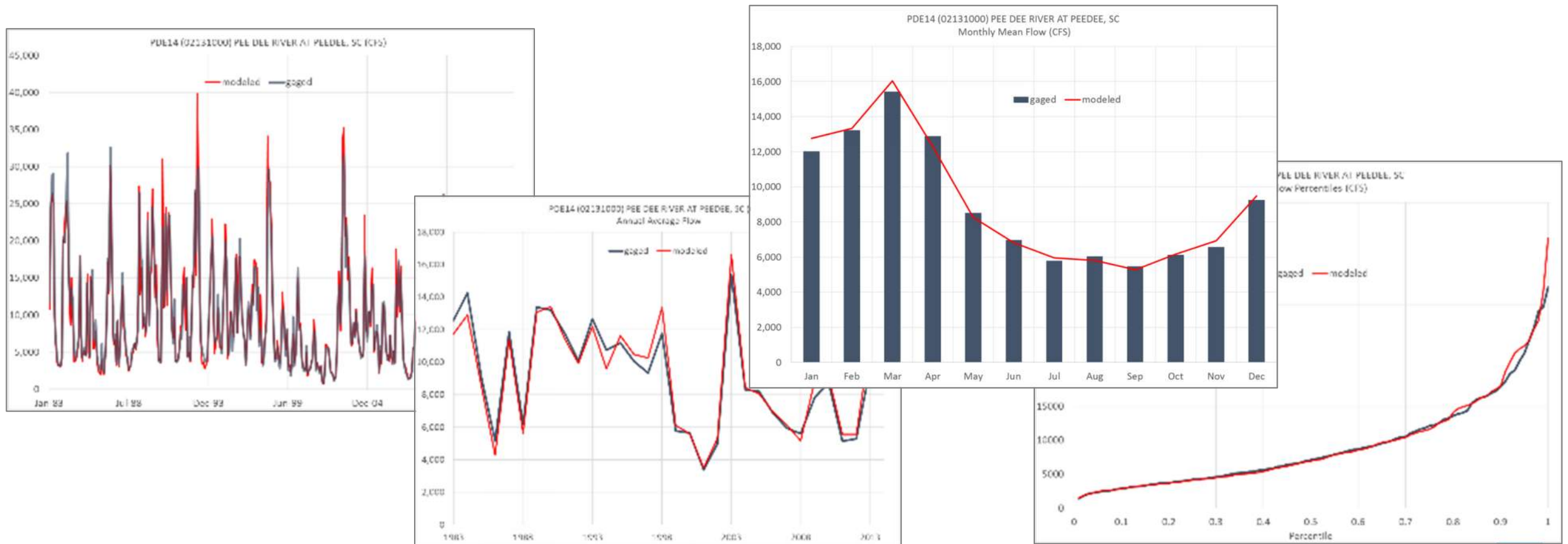
Comments: 28IR011S03. Changed source water to Red Oak Camp Creek as part of 2020 update.



Year (YYYY)	Month (MMM)	Monthly Demand (MGD)
1929	Jan	0.00
1929	Feb	0.00
1929	Mar	0.00
1929	Apr	0.00
1929	May	0.00
1929	Jun	0.00
1929	Jul	0.00
1929	Aug	0.00
1929	Sep	0.00
1929	Oct	0.00
1929	Nov	0.00
1929	Dec	0.00
1930	Jan	0.00
1930	Feb	0.00
1930	Mar	0.00
1930	Apr	0.00
1930	May	0.00

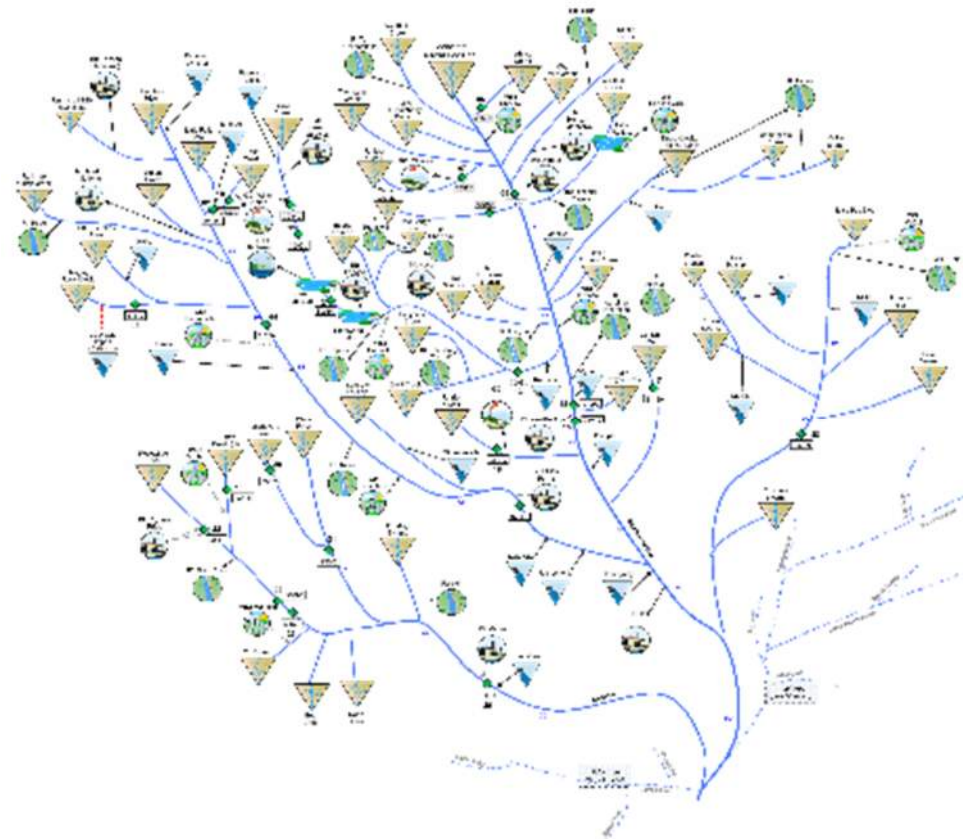
Model Calibration

- Calibration performed for multiple sites across wide range of hydrologic conditions
- Key calibration parameters = reach gain/loss factors (hydrology)



2021 Surface Water Model Updates

- Extended baseline hydrology through 2018 (added 5 years)
- Updated monthly mean water demands based on recent water use data
- Updated permit and intake location information
- Removed inactive permittees
- Added new registrations
- Software update

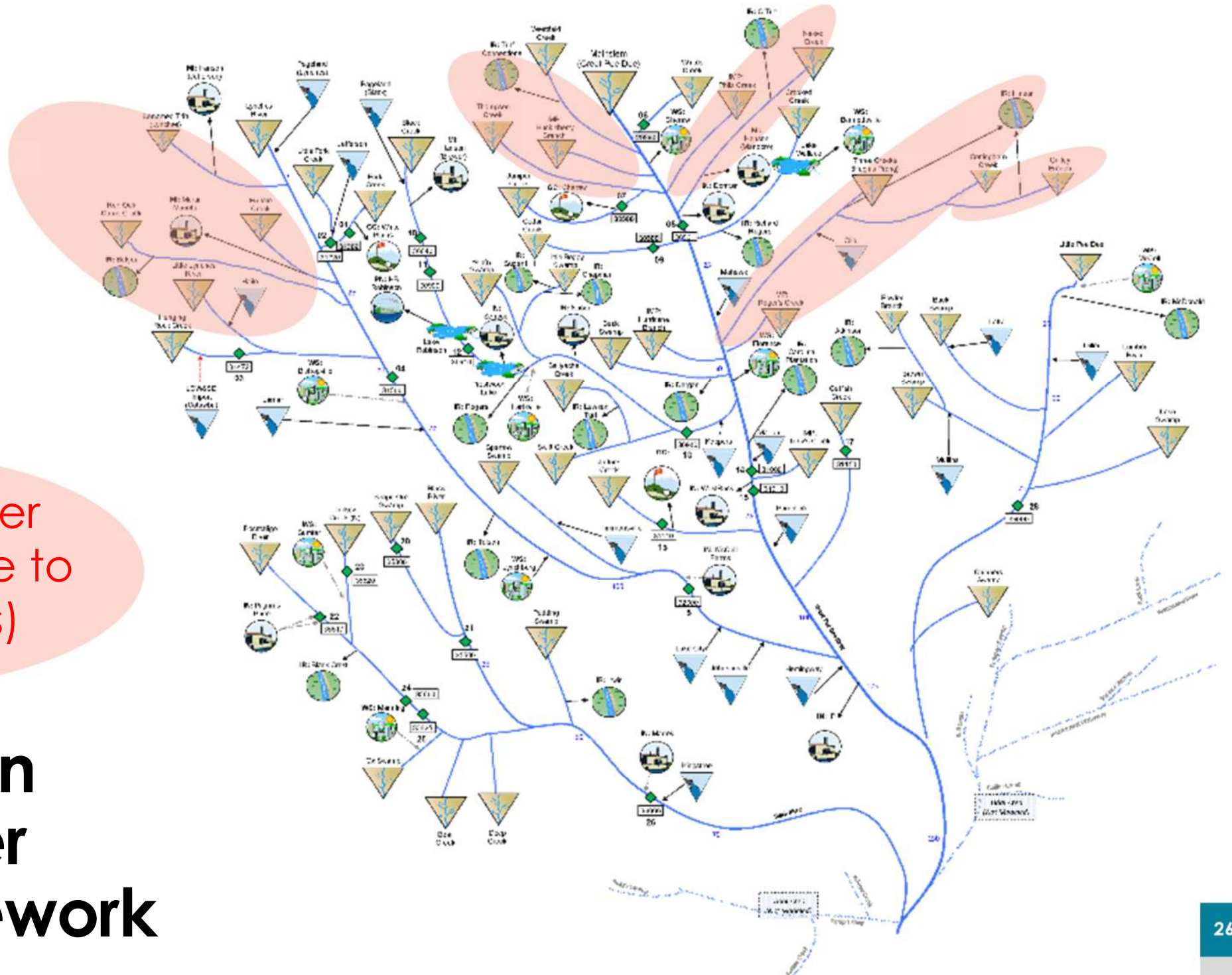


Model Limitations

- Greater uncertainty in predictions for ungaged reaches compared to gaged
- Model not designed for reach routing of flow changes at a daily or sub-daily timestep
- Greater uncertainty in supply availability (and “shortage”) predictions associated with small stream withdrawals compared to larger river and reservoir withdrawals
 - e.g. offline irrigation ponds
- Baseline model assumes past hydrologic variability is representative of future hydrologic variability (stationary climate)

Areas of greater uncertainty (due to lack of gages)

Pee Dee Basin Surface Water Model Framework



Surface Water Scenarios

Base Scenarios

- Current Surface Water Use Scenario
 - *Uses most recent 10-yr average withdrawals (as reported by month)*
- Permitted and Registered Surface Water Use Scenario
 - *Uses current fully-permitted and registered amounts*
- Business-as-Usual Water Demand Projection Scenario
 - *Future water demand projection based on moderate growth and normal climate*
- High Water-Demand Projection Scenario
 - *Future water demand projection based on high growth and hot/dry climate*

Additional scenarios may be identified and requested by the RBC

Performance Measures

Assessment of simulation results will focus on quantifying key performance measures for multiple reaches of interest across the basin.

Example / Suggestions:

- Percent change in a monthly minimum flow, 5th percentile flow, mean, and/or median flow
- Percent change in seasonal or monthly flows
- Percent change in surface water supply
- Percent change in mean annual shortage or mean percent shortage
- Change in the number and magnitude of excursions below 20, 30 and 40 percent mean annual daily flows and/or 7Q10 flow
- Change in number of water users experience a shortage
- Change in the average frequency of shortage
- Percent of time recreational facilities were unavailable on a stream reach

Strategic Node Possibilities

PDE08
PEE DEE RIVER NEAR
BENNETTSVILLE

PDE04
LYNCHEs RIVER NEAR
BISHOPVILLE

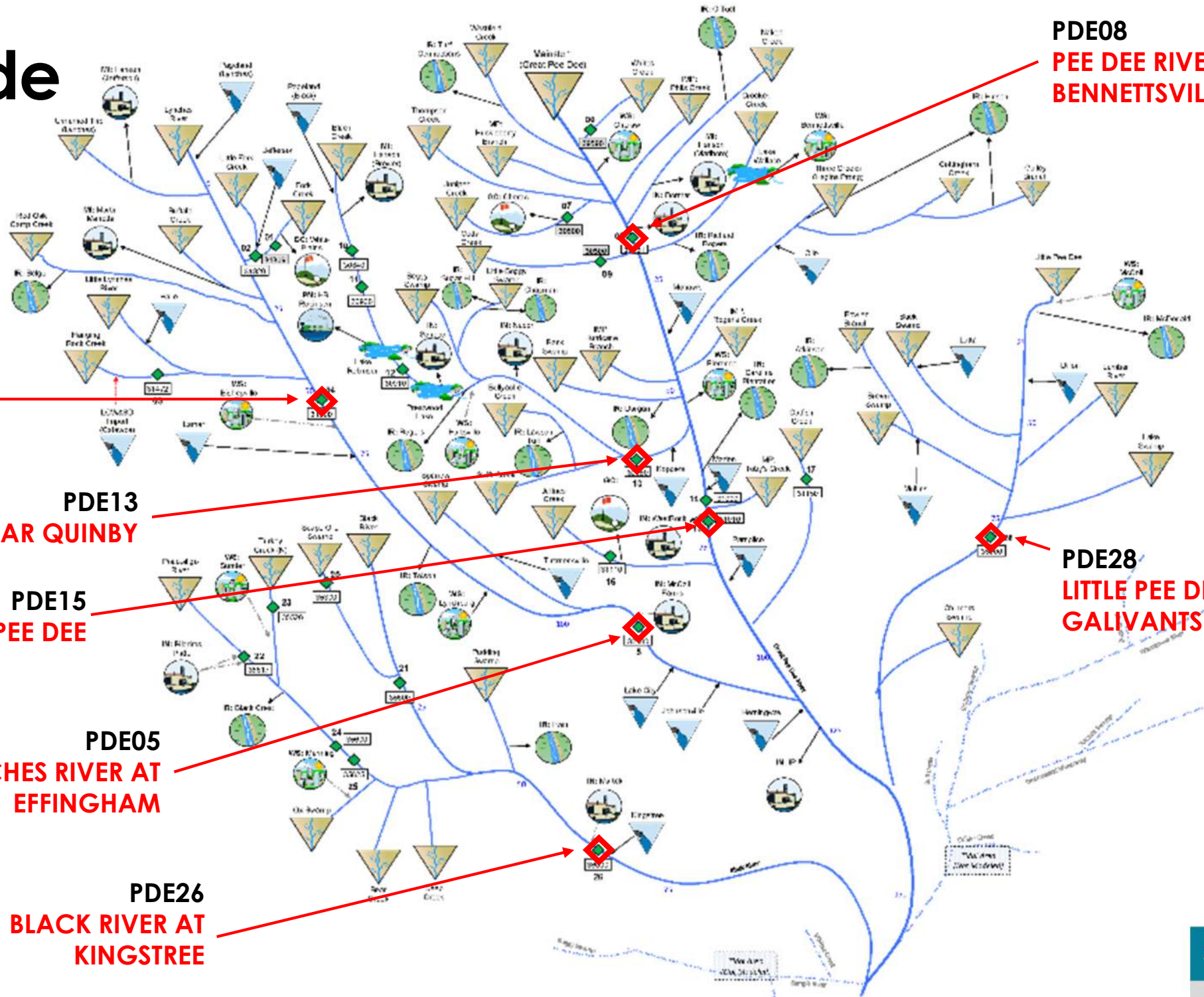
PDE13
BLACK CREEK NEAR
QUINBY

PDE15
PEE DEE RIVER BELOW
PEE DEE

PDE05
LYNCHEs RIVER AT
EFFINGHAM

PDE26
BLACK RIVER AT
KINGSTREE

PDE28
LITTLE PEE DEE R. AT
GALIVANTS FERRY



Reaches of Interest

Specific stream reaches that may have no identified *Surface Water Shortage* but experience undesired impacts, environmental or otherwise, determined from current or future water-demand scenarios or proposed water management strategies.

Could be related to:

- Recreational flows
- Ecological / in-stream flows
- Designation as a Scenic River



Training

- Training for interested RBC members will be offered in early January
- RBC Preferred Dates?