Recalibrating the South Carolina Atlantic Coastal Plain Groundwater Availability Model for the Simulation of Groundwater Flow and Water Budgets in the Pee Dee River Basin

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SAWSC: South Atlantic Water Science Center
UMWSC: Upper Midwest Water Science Center

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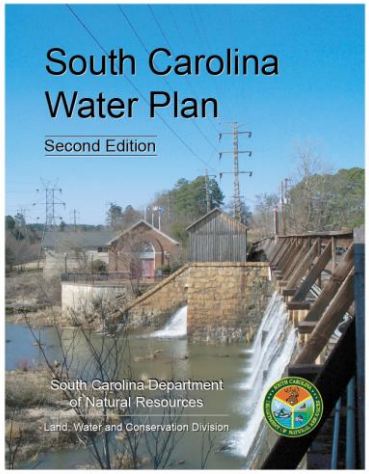
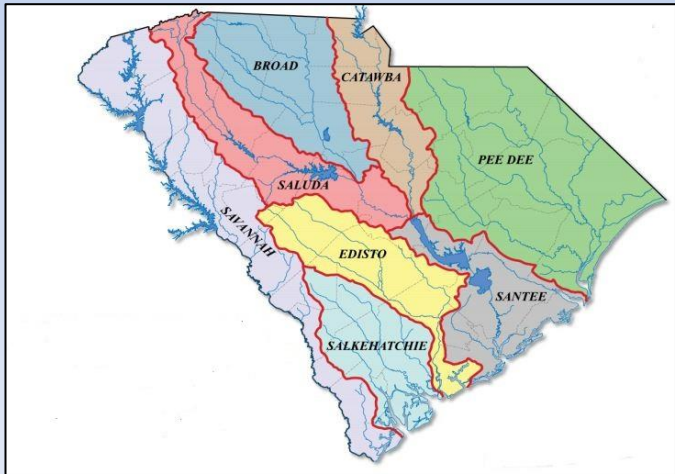
South Carolina Water Plan

South Carolina Department of Natural Resources



Recommendation from the SC Water Plan, 2nd Ed.:

"A comprehensive ground-water flow model of the Coastal Plain should be developed and used to predict the effect of future pumping and to determine optimal well spacings."



https://hydrology.dnr.sc.gov/pdfs/water-plan/SCWaterPlan2.pdf

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Overview

1) Why use a groundwater model?

2) What is a groundwater model?

3) Model limitations

4) How is the Pee Dee model being developed?

Why use a Groundwater Model?

Groundwater models are important for water resource management, answering questions such as:

- How will groundwater management decisions impact water levels over the next 50 years?
- How will groundwater withdrawal affect nearby river discharge?
- Are coastal communities' groundwater supply vulnerable to saltwater intrusion?
- Where are areas of concern in an aquifer that may need additional observations?

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What is a Groundwater Model?

A numerical representation of groundwater flow in space and time.

The structure of sediment layers is represented using a gridded mesh.

The groundwater flow equation is solved for each cell in the mesh at specified time intervals (time steps or stress periods).

[1]Langevin, et al, 2017.
[2]Aquaveo GMS

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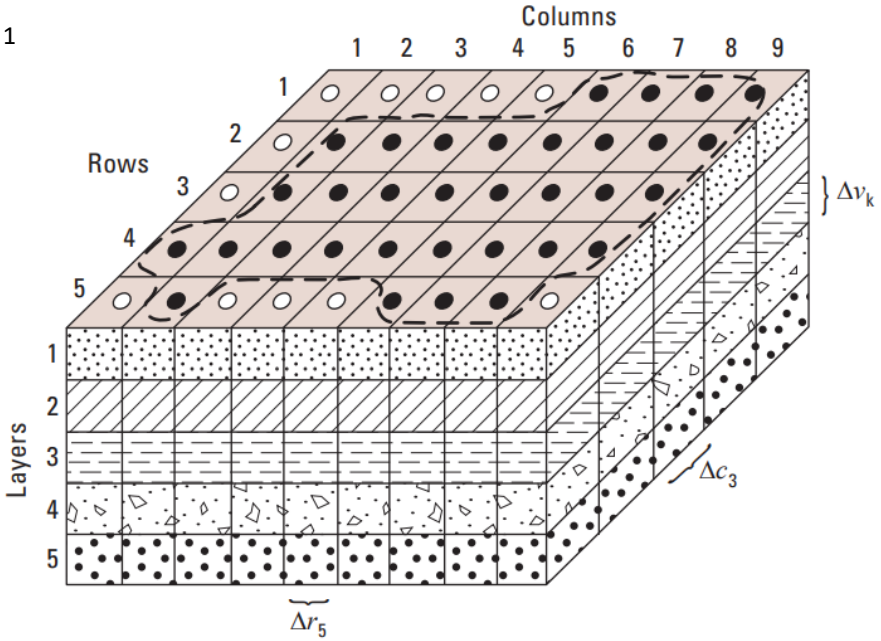

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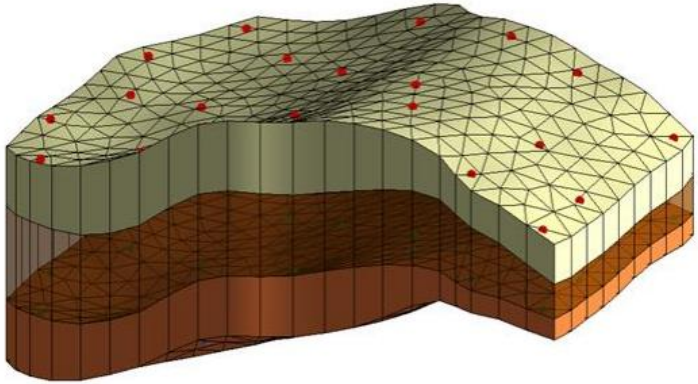

Model Limitations

What causes uncertainty in a groundwater model?

- Underlying concept of the system and how it works
  - Simplification of the actual groundwater flow system

- Model Parameters
  - The bulk properties of the aquifers and confining units – ease of flow, water storage, etc.

- Observation data
  - Groundwater withdrawal, water-level measurements, stream baseflow, recharge

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What does Model Calibration mean?

Model calibration is used to estimate the aquifer properties we do not know in the locations we have not measured.

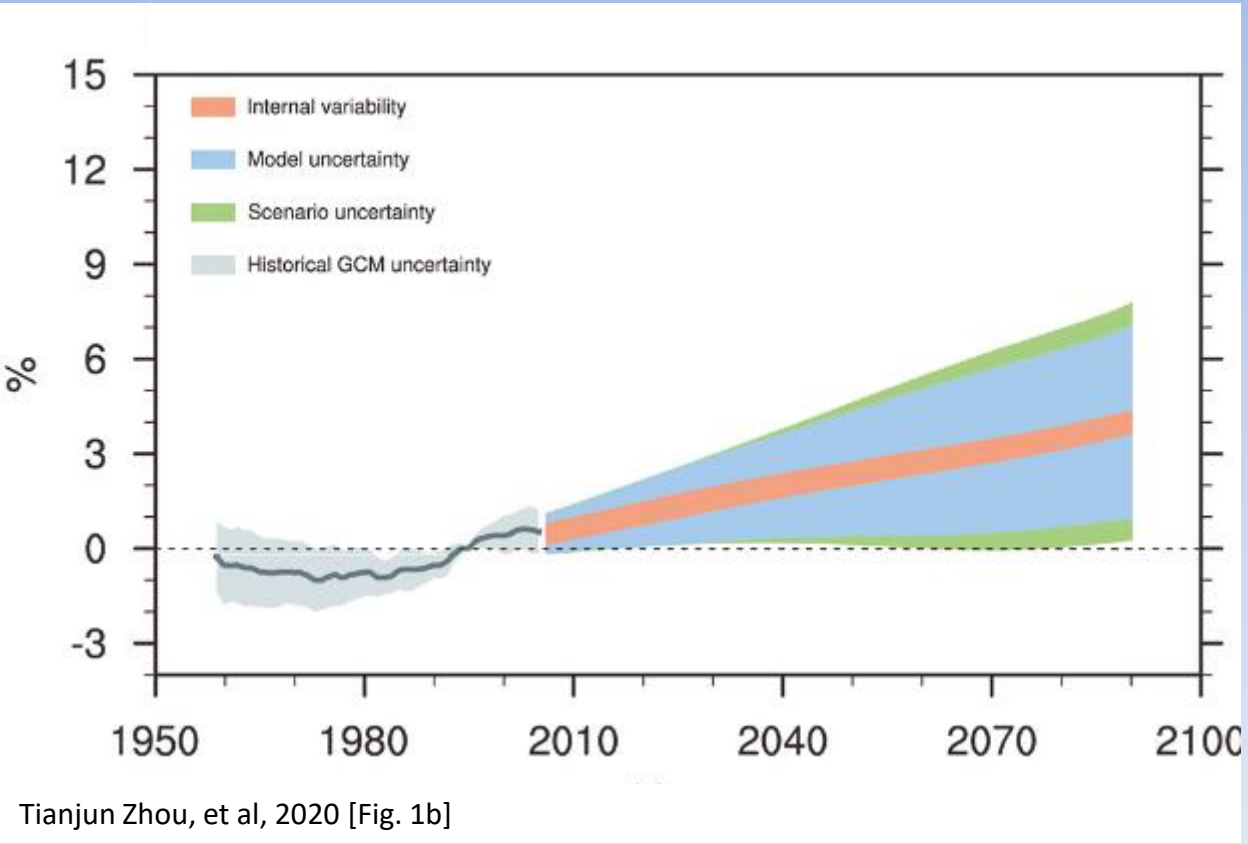
How easily does water move through the aquifer? (Hydraulic Conductivity)

How much water is released from the aquifer or confining layer when the water level drops? (Specific Storage and Specific Yield)

During calibration, these parameters are adjusted until the best match possible is achieved with field measurements of:

- Water level
- Stream baseflow (the groundwater contribution to stream discharge)

Model Uncertainty and Projections



Tianjun Zhou, et al, 2020 [Fig. 1b]

A) Model Fit to Historic Data

    1) Better Data = Better Fit

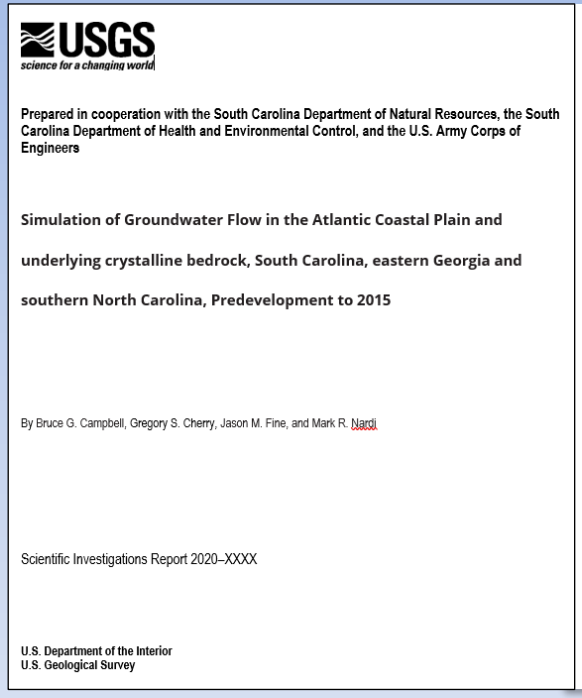
B. Projection Uncertainty:

    1) Internal Data Variability
    2) Model Uncertainty
    3) Scenario Uncertainty

USGS Model: MODFLOW-NWT

Model Description

- Data from 1900 – 2015
- Extent from GA to NC
- Regular mesh
- 16 Layers
- 2000 ft x 2000 ft cells
- Annual stress periods
- Updated with data from 2016 through 2020 for the Edisto River Basin



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Prepared in cooperation with the South Carolina Department of Natural Resources, the South Carolina Department of Health and Environmental Control, and the U.S. Army Corps of Engineers

Simulation of Groundwater Flow in the Atlantic Coastal Plain and underlying crystalline bedrock, South Carolina, eastern Georgia and southern North Carolina, Predevelopment to 2015

By Bruce G. Campbell, Gregory S. Cherry, Jason M. Fine, and Mark R. Nardi

Scientific Investigations Report 2020–XXXX

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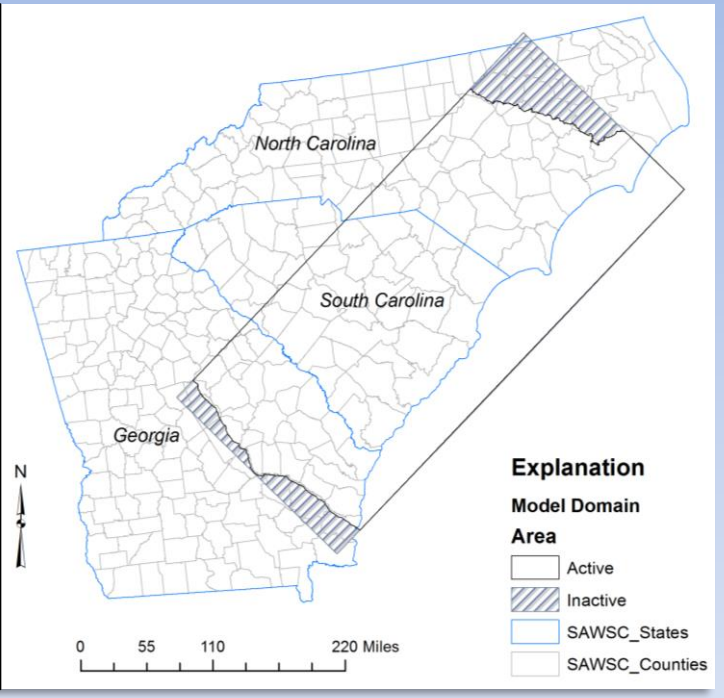


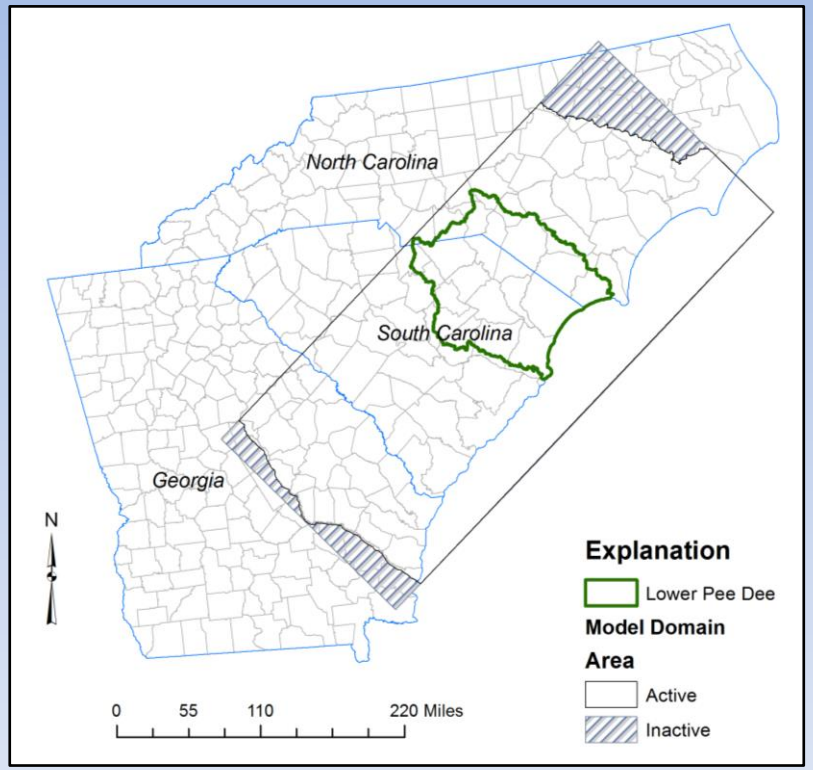
Campbell, Cherry, Fine, and Nardi, In Press

Developing the Pee Dee Model:

- Transfer model from MODFLOW-NWT to MODFLOW 6.
  - Local grid refinement: that is, smaller cell size.
  - All groundwater use, water-level, stream baseflow, and recharge updated through 2022.
  - Shorter time steps.

- Calibration will be performed using parameter estimation (PEST++ Version 5).
  - The calibration period will run from 2002 to 2022 to take advantage of the highest quality groundwater withdrawal and water-level data.

Targeted Approach



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Target a Specific Basin

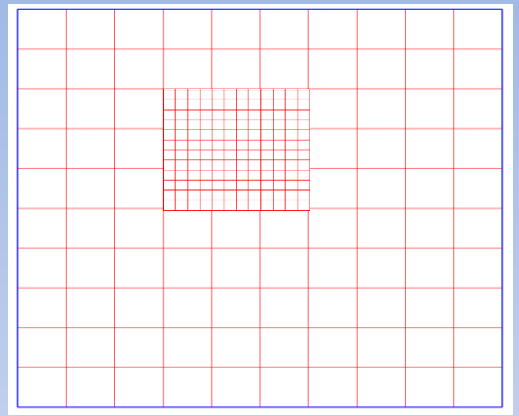
Focusing on a smaller area within the larger model can:

- ☑ Reduce Calibration Time
- ☑ Reduce Model Scenario Runtime
- ☑ Improve Accuracy

NOTE: Difference in Basin Boundaries

Provisional – All data is considered provisional and subject to revision.

Benefits of Targeted Approach



Inset Spatial Refinement Goal

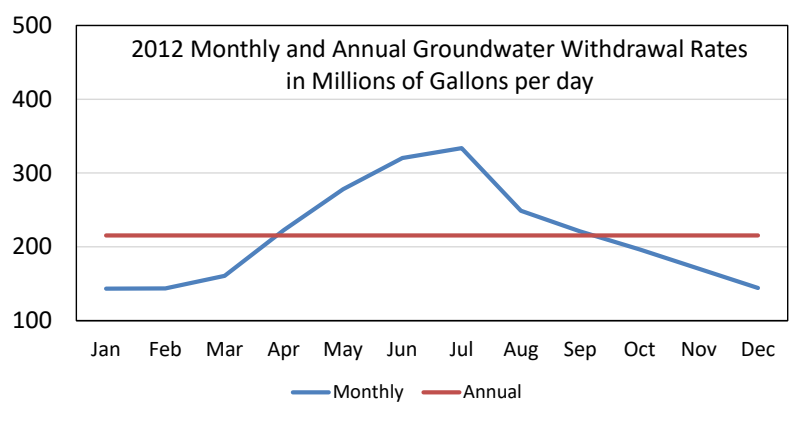
500-ft x 500-ft grid cells

Time Step (Stress Period) Refinement Goal

Monthly Stress Periods

Data Updates

Water use, water level, stream baseflow, and recharge through 2022



South Carolina Department of Health and Environmental Control (SCDHEC)
Water Quantity Permitting

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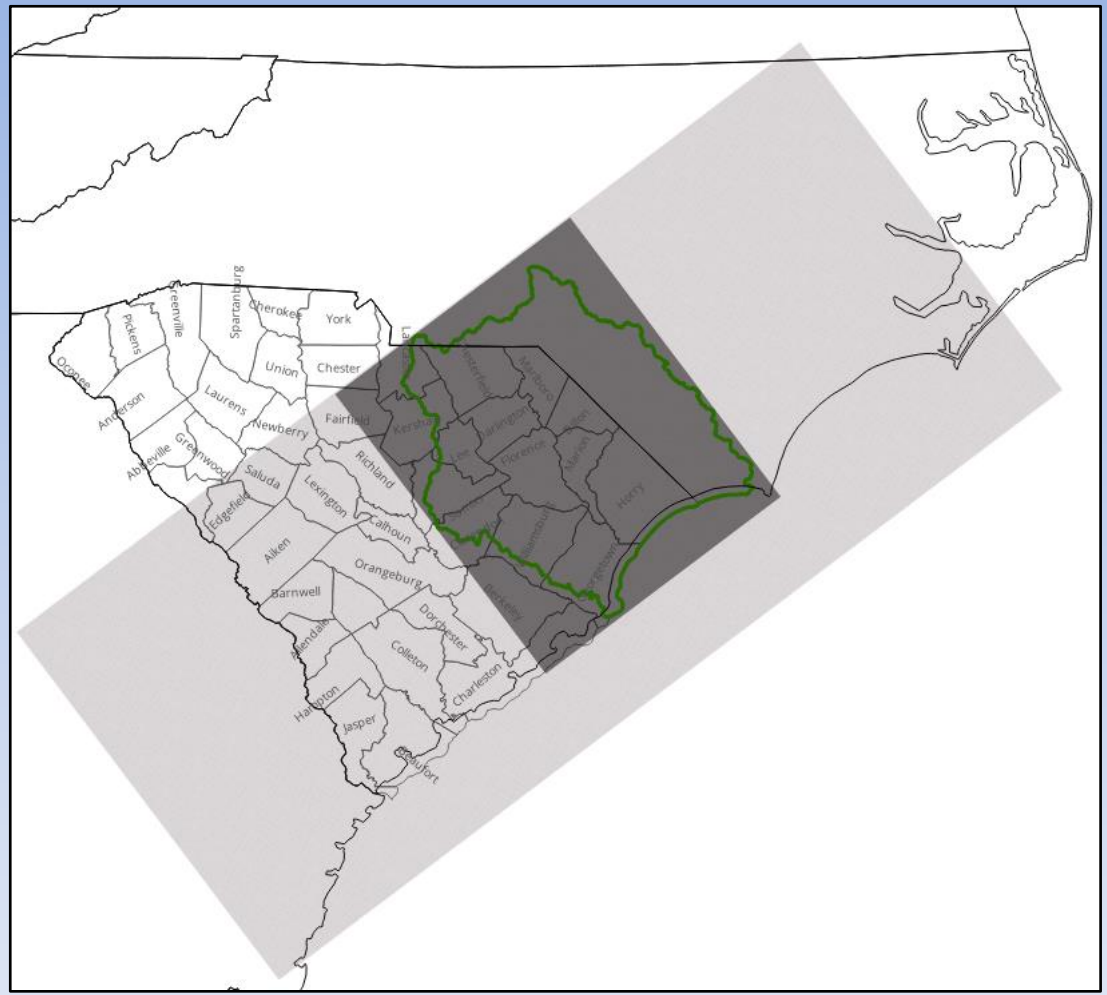
Inset Model Domain

Light Gray: Parent Model

Dark Gray: Area of mesh refinement (reduction of model cell size)



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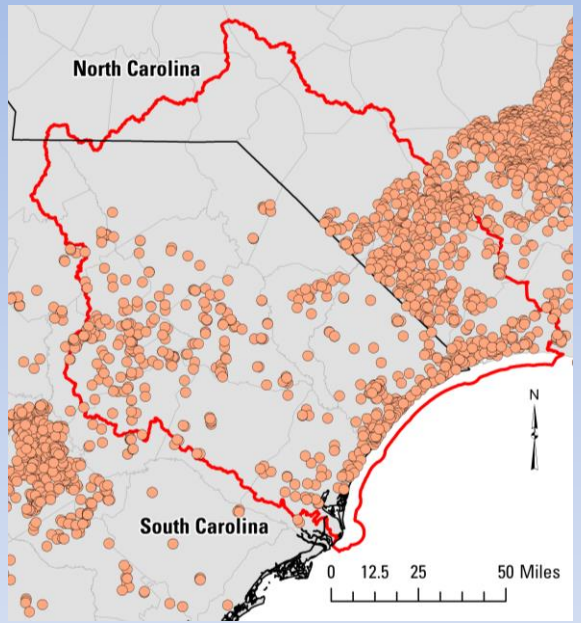
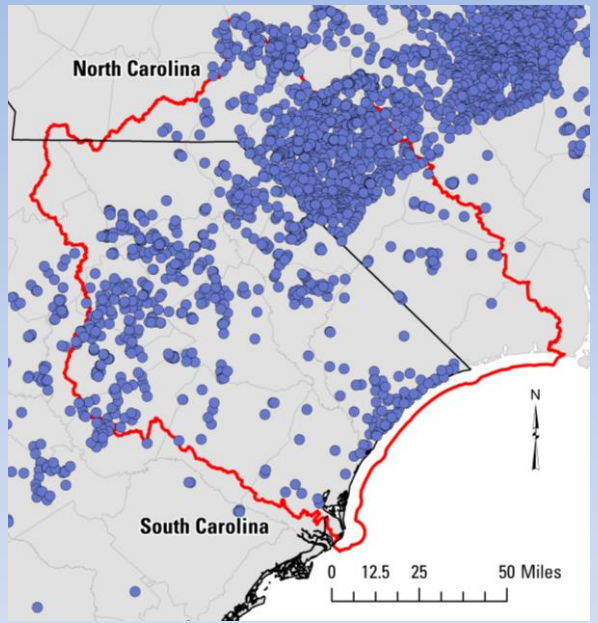
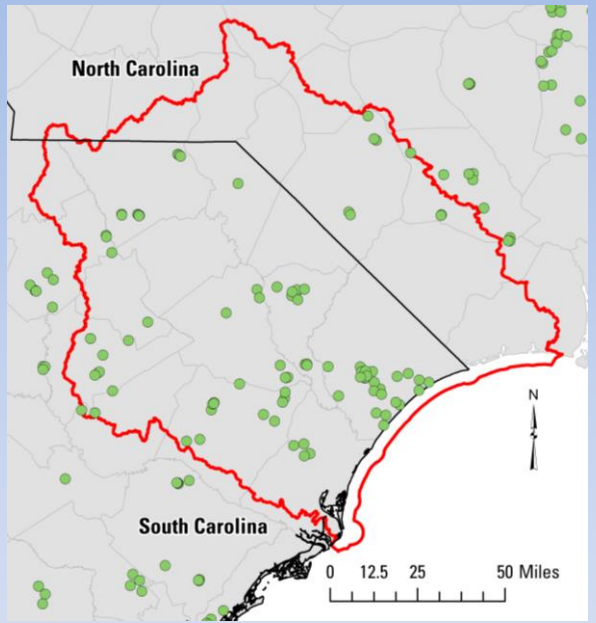
Wells Reporting Groundwater Withdrawal



Wells in Crouch Branch Aquifer



Wells in McQueen Branch Aquifer



Wells in Charleston Aquifer

South Carolina wells through 2020, SC Department of Health and Environmental Control
North Carolina wells through 2015, NC Department of Environmental Quality

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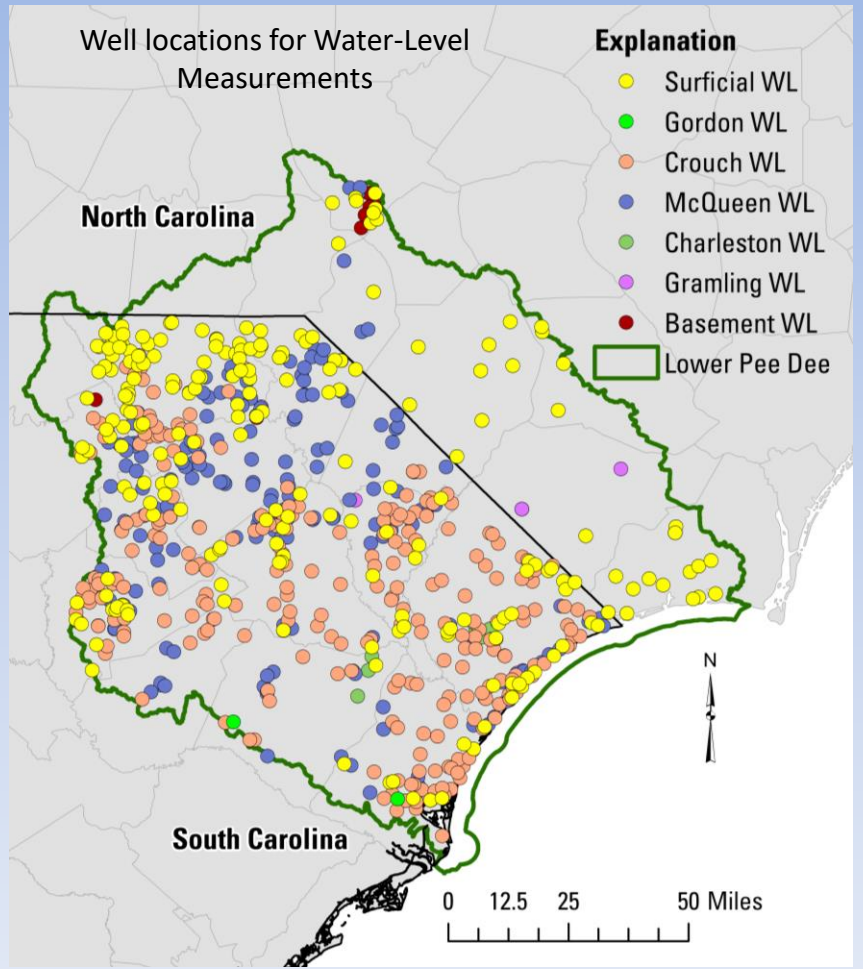
Water-Level Measurements by Aquifer

Sources: SC Department of Natural Resources, USGS National Water Information System

Well Counts	
Surficial	217
Gordon	3
Crouch	281
McQueen	203
Charleston	9
Gramling CU	1
Gramling	13
Basement	8



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USGS Streamgage Locations

Stream Baseflow is the part of stream discharge that is supplied by groundwater.

Stream Baseflow is calculated from stream discharge using the USGS Hydrologic Toolbox Software.

Streamflow data from the USGS National Water Information System (NWIS)

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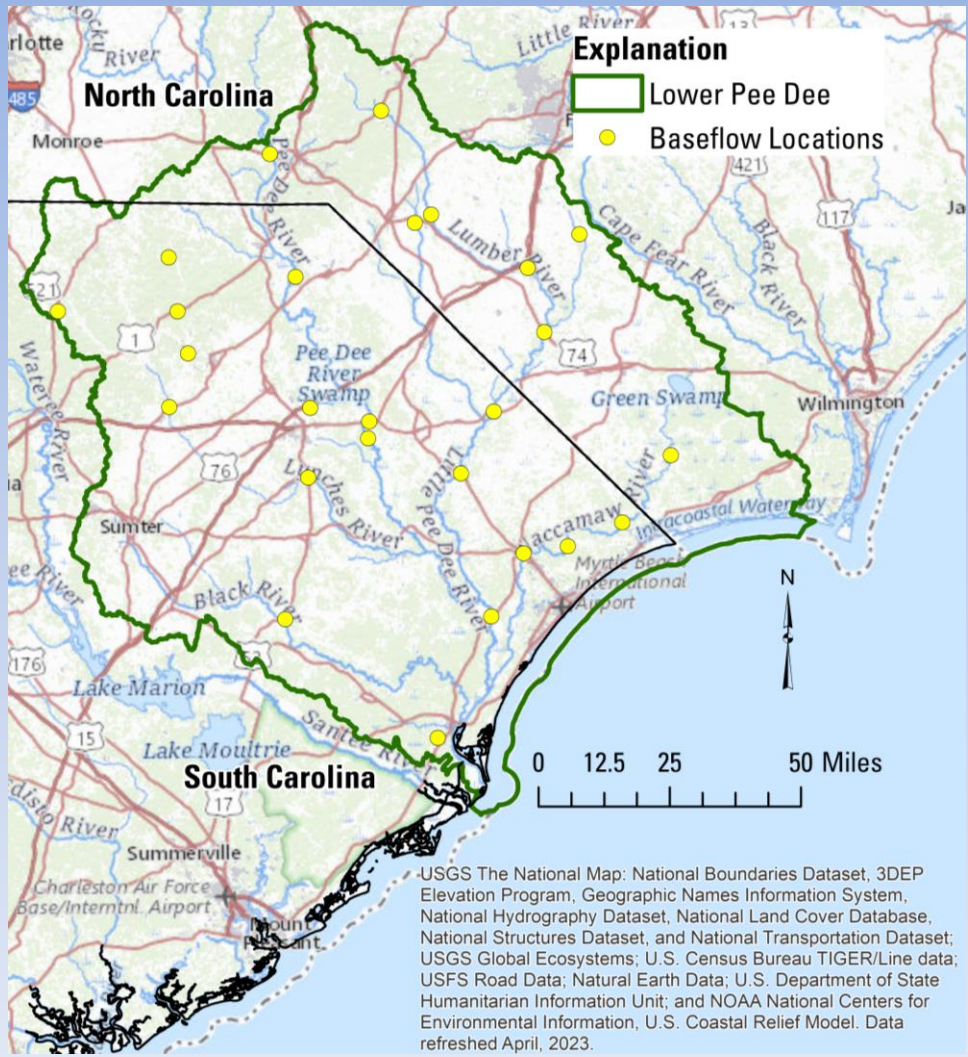

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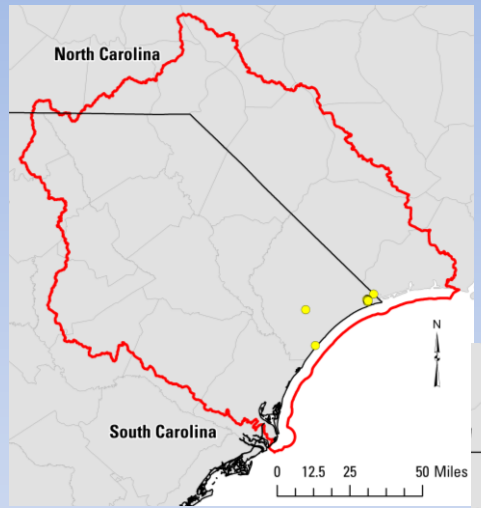
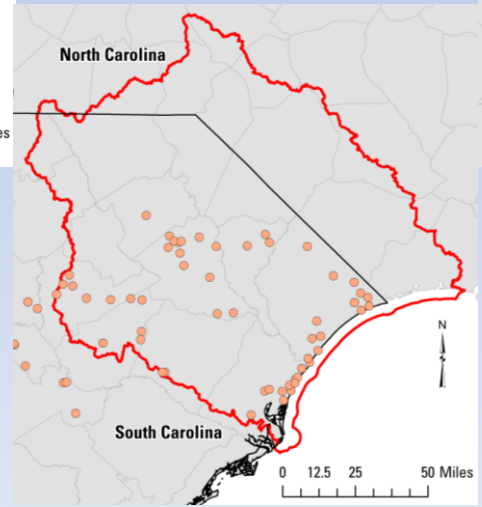
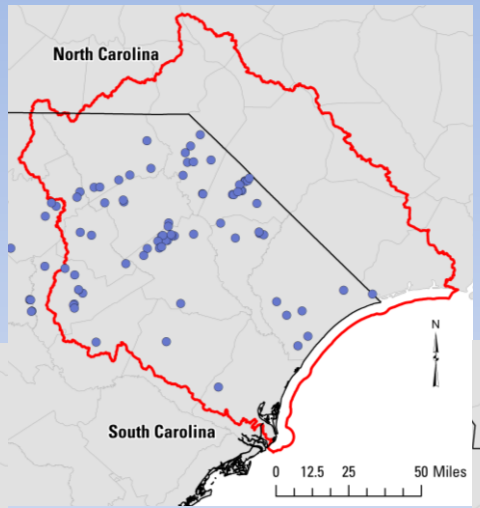
Aquifer Tests – Hydraulic Conductivity



Surficial Aquifer Test
Well Locations

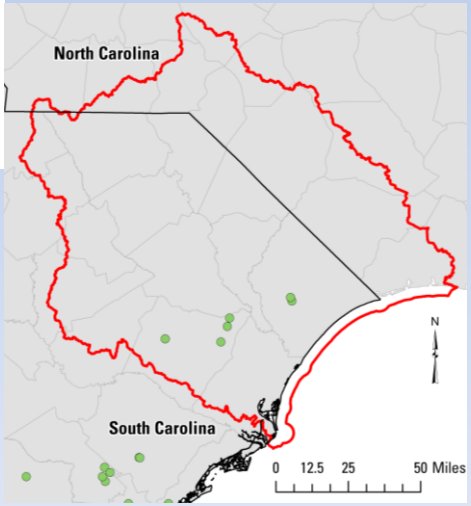
Crouch Branch Aquifer Test
Well Locations





McQueen Branch Aquifer Test
Well Locations

Charleston Aquifer Test
Well Locations



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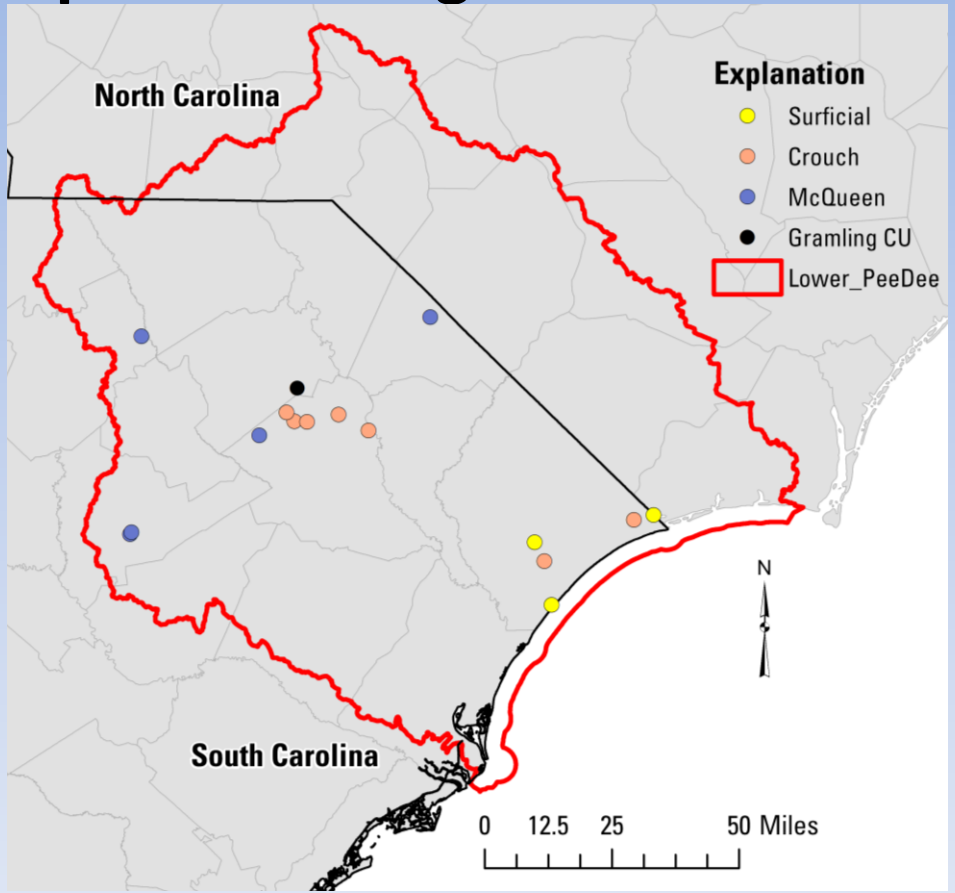
Roy Newcome, Jr., 1993, 2000, and 2005

Aquifer Tests – Specific Storage

Points on the map show the well locations for the historic Specific Storage Aquifer Tests.

The different colors represent the different aquifers in which the wells are located.



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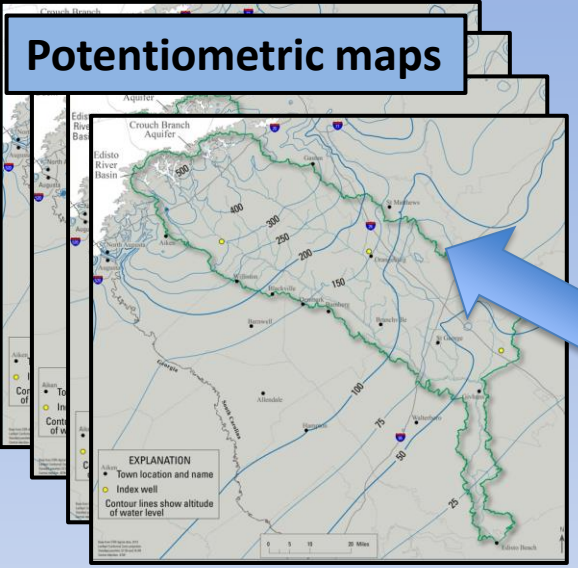
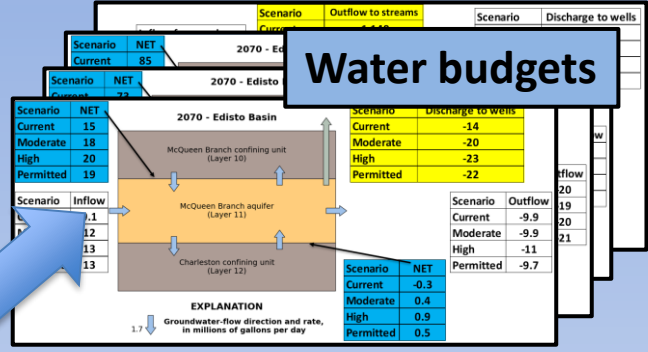
Roy Newcome, Jr., 2005

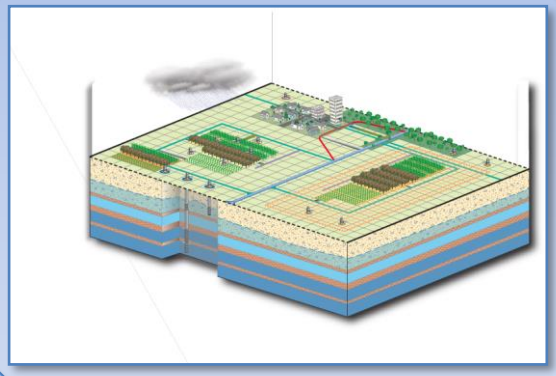
Examples of Model Products

Potentiometric maps



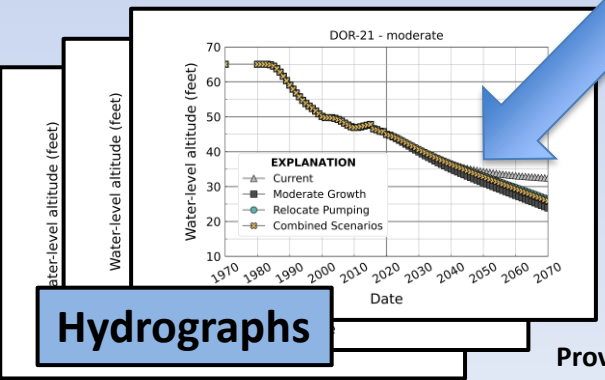
Water budgets



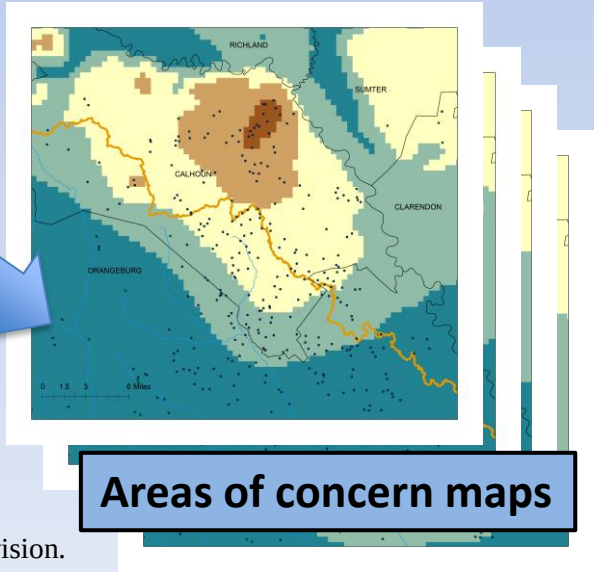


Groundwater Model

Hydrographs



Areas of concern maps



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Resources

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Tianjun Zhou, et al, 2020, The Sources of Uncertainty in the Projection of Global Land Monsoon Precipitation, GRL, v. 47, I 15. [Fig. 1b]

Campbell, Cherry, Fine, and Nardi, In Press, Simulation of Groundwater Flow in the Atlantic Coastal Plain and underlying crystalline bedrock, South Carolina, eastern Georgia, and southern North Carolina, Predevelopment to 2015, U.S. Department of the Interior, U.S. Geological Survey

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Questions?

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