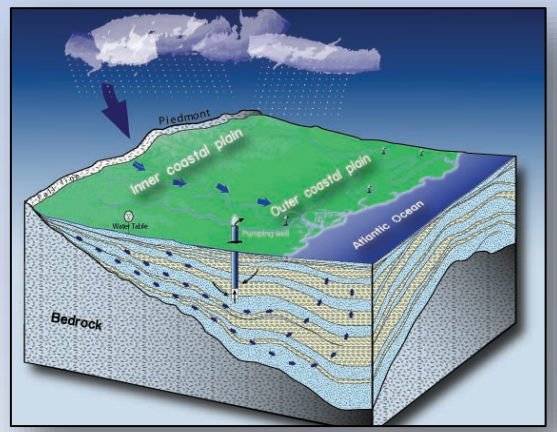
South Carolina Atlantic Coastal Plain Groundwater Availability Model

Bruce Campbell, Greg Cherry, Jason Fine

US Geological Survey – South Atlantic Water Science Center

Alex Butler - South Carolina Department of Health and Environmental Control

Joe Gellici - South Carolina Department of Natural Resources



U.S. Department of the Interior
U.S. Geological Survey

Focus Area Study / SCDNR Model Update

Combines funding sources:

- Internal USGS Water Census Program / Focus Area Study
- Cooperative funding from South Carolina Department of Natural Resources/USACOE
- Cooperative funding from South Carolina Department of Health and Environmental Control

1) Water Census Program / Focus Area Study:

- Internal USGS funding from the SECURE Water Act
- Southeastern Atlantic Coastal Basins of the Carolinas

2) SCDNR/US ACOE Project

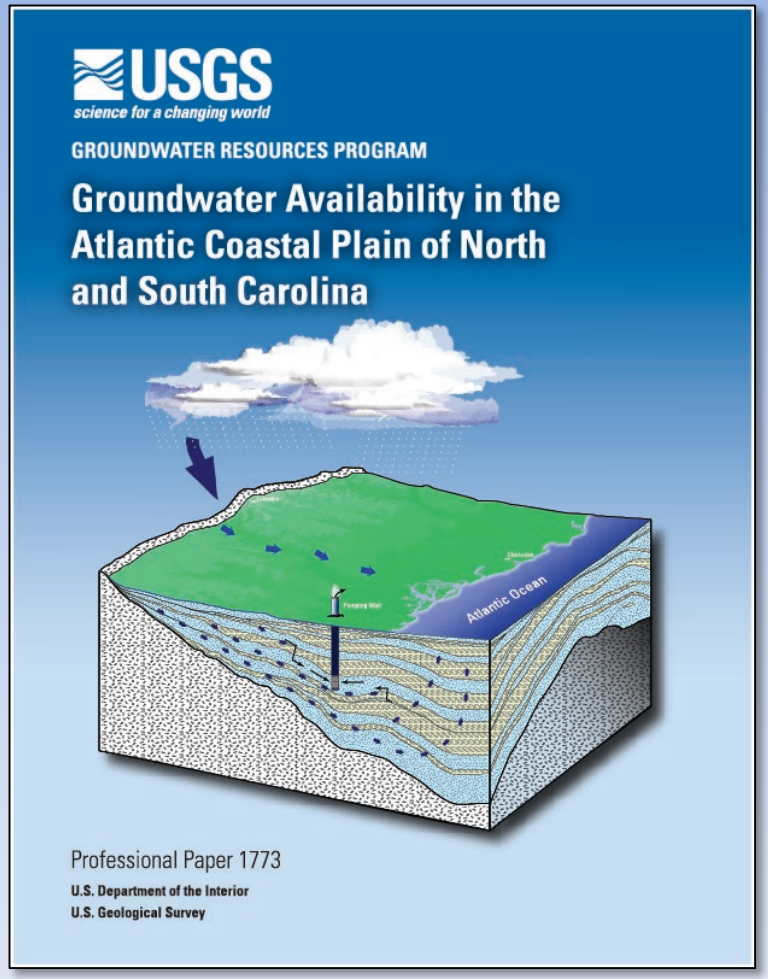
Funding to expand groundwater model area to include all of the SC Coastal Plain

USGS

USGS Groundwater Resources Program

Groundwater Flow Model of the Atlantic Coastal Plain of NC, SC, eastern GA, southern VA

- Calibrated to 2004 conditions
- Revised hydrogeologic framework
- Analysis of GW monitoring networks
- Climate change predictions



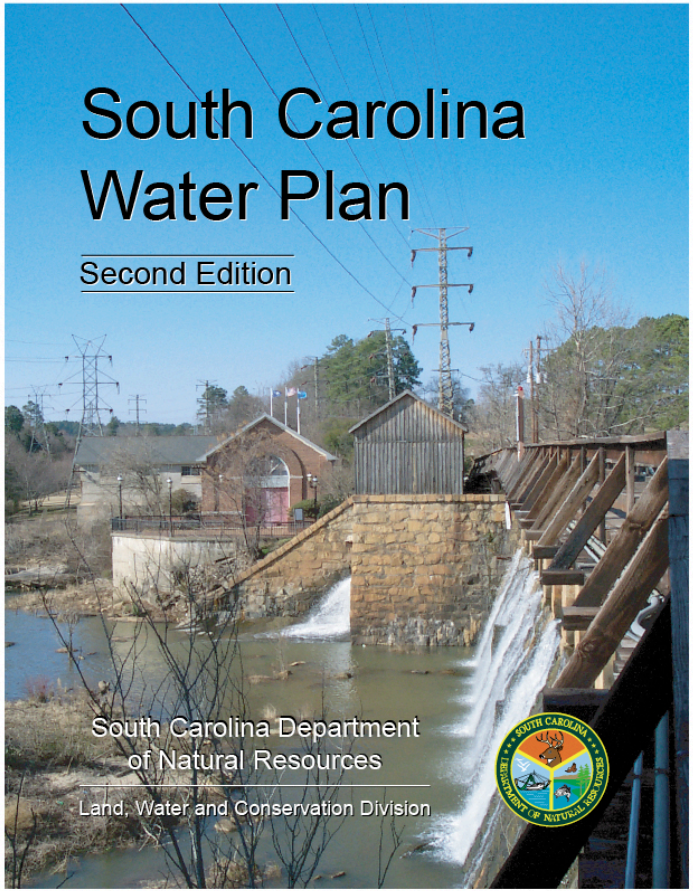
USGS

South Carolina Water Plan

South Carolina Department of Natural Resources

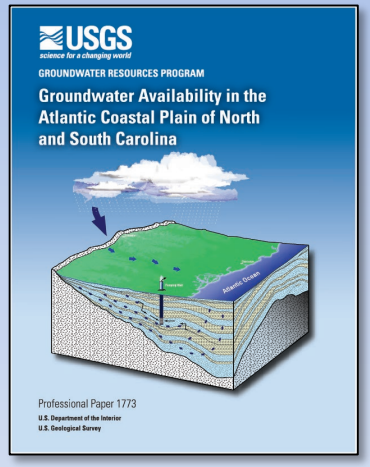
Recommendation:

"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 spacing's."



USGS

Groundwater Model Area



USGS

Model Area

EXPLANATION

GW Model Area Boundary

Grid Outline

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Coastal Plain Issues

- Increase in Atlantic Coastal Plain population
- Increased demand on groundwater resources
- Groundwater quality issues
- Increased agricultural withdrawals
- Impact of increased groundwater withdrawals on surface water flows

USGS

Objectives

- Overall update the 2010 groundwater flow model
- Activating the entire surficial aquifer model layer
- Recharge from SWB Model
- Adding recent groundwater-related data (2005-2015)
- Refine the model grid from 2 x 2 miles to 2,000 x 2,000 ft
- Incorporate a more detailed representation of the Fall Line area
- Incorporate newer MODFLOW packages – Newton Formulation, Multi-Node Well Package
- Re-calibration, and apply the model to a series of scenarios

USGS

New Data

USGS

Model Framework

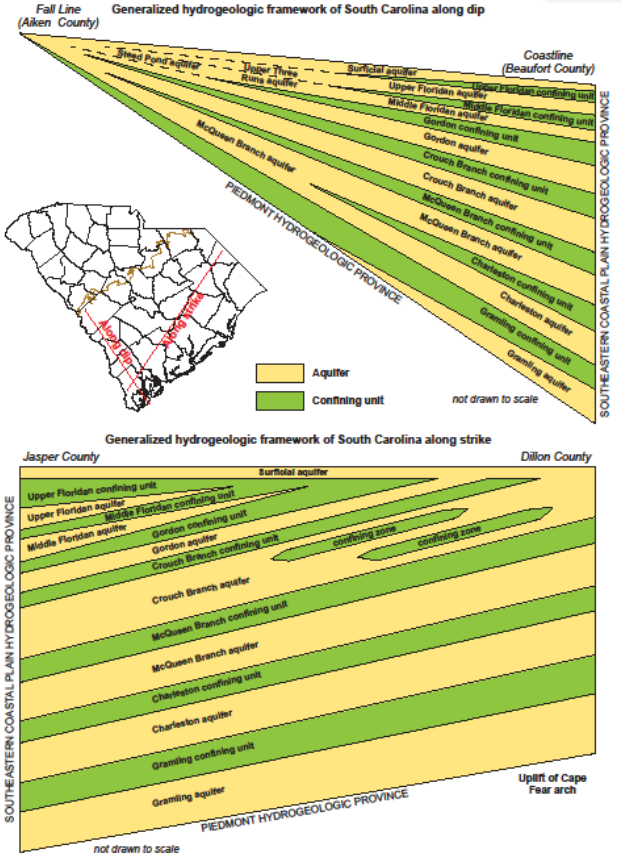


Figure 1. Generalized hydrogeologic framework of the South Carolina Coastal Plain (Gellici and Lautier, 2010).

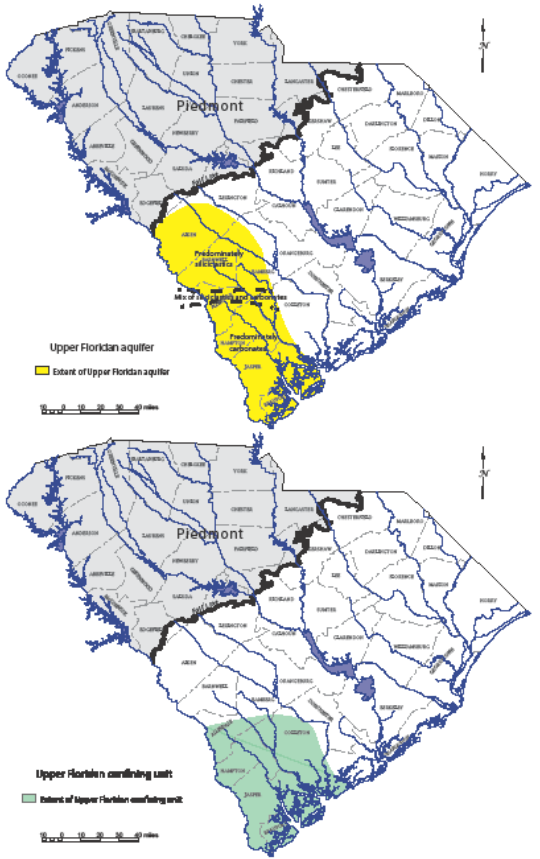
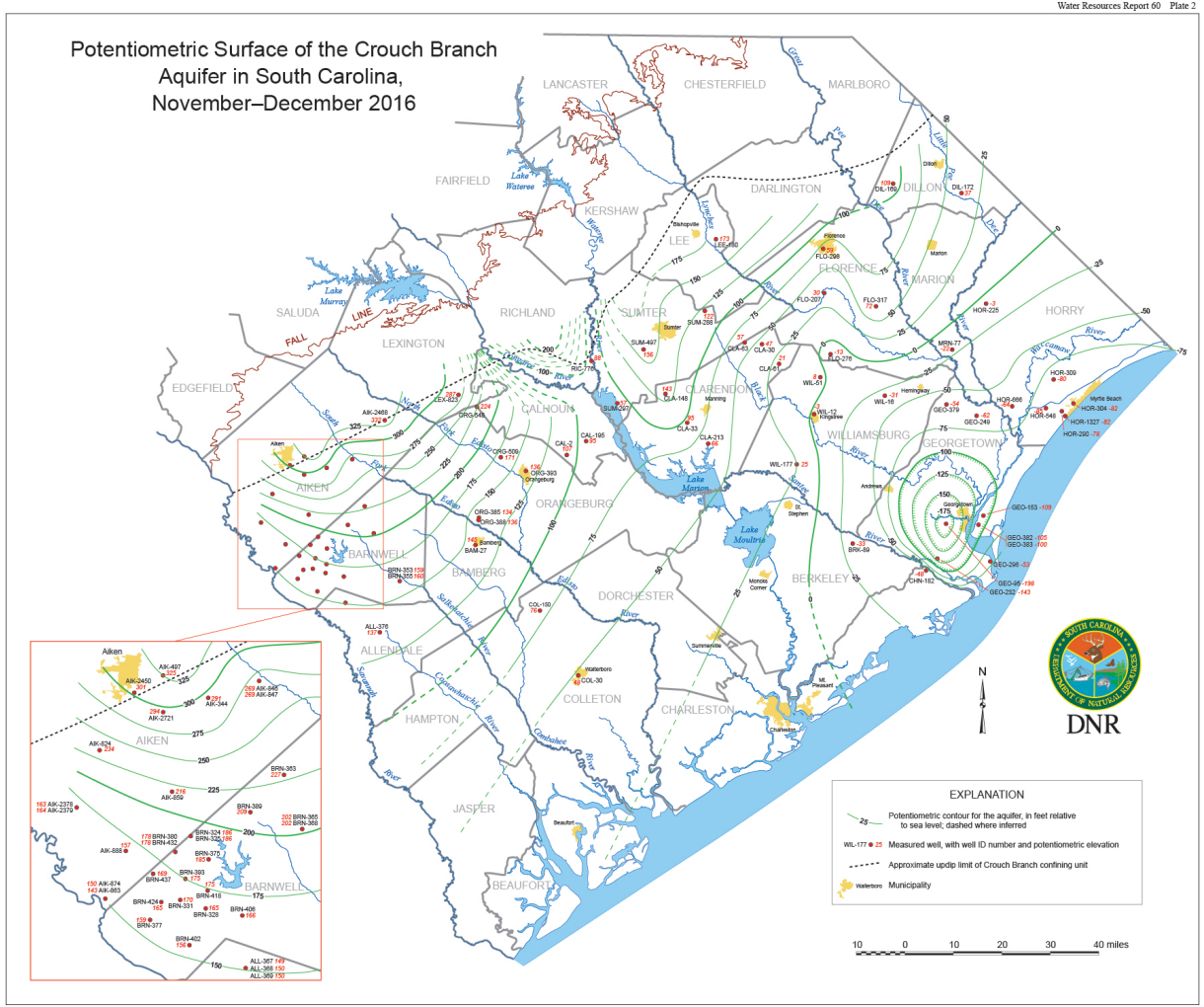


Figure 4. **Approximate extent of the Upper Floridan aquifer and confining unit, as used in this report.**

Synoptic Potentiometric Surface Mapping



USGS

SCDNR Groundwater Level Monitoring Network

USGS

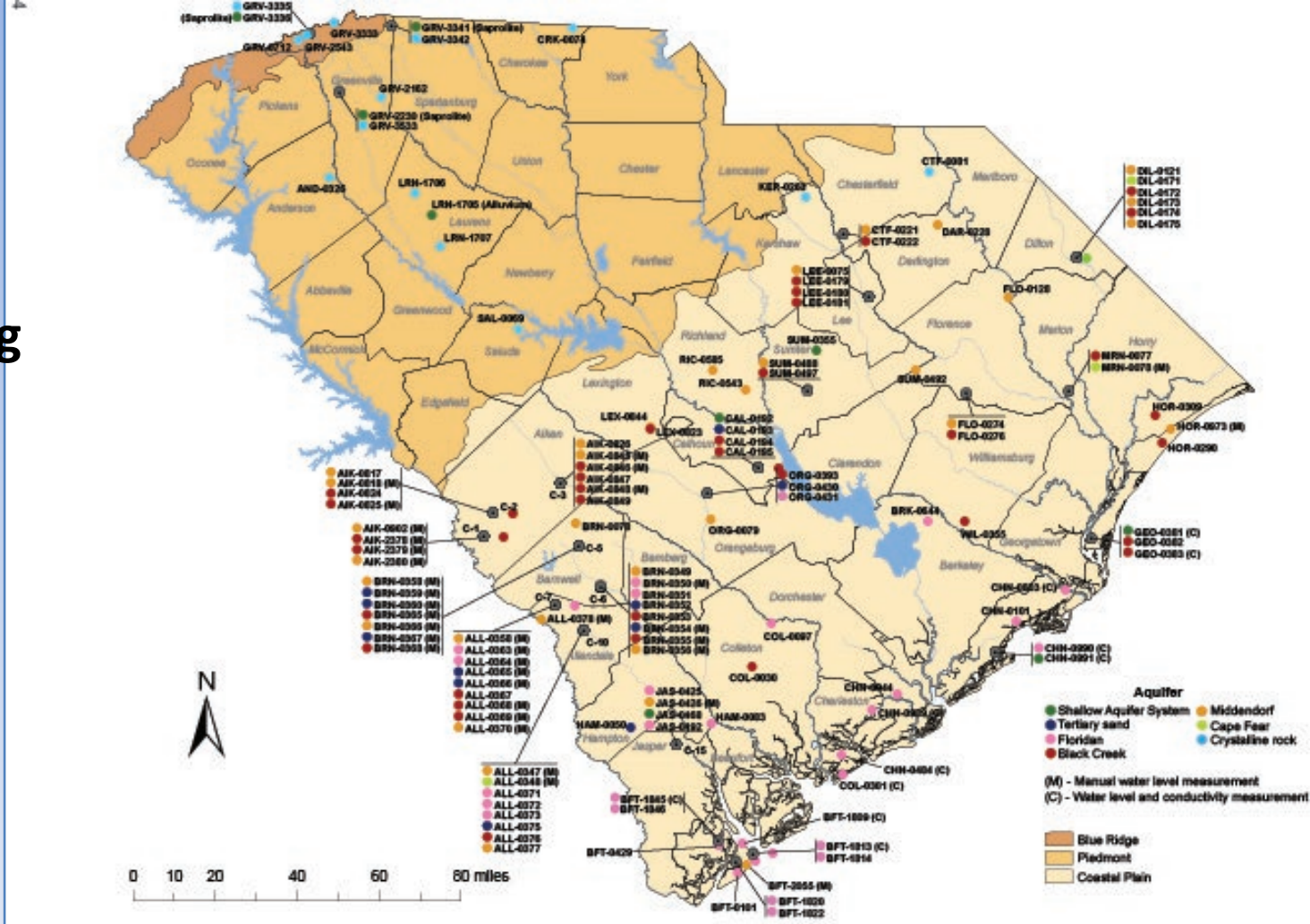
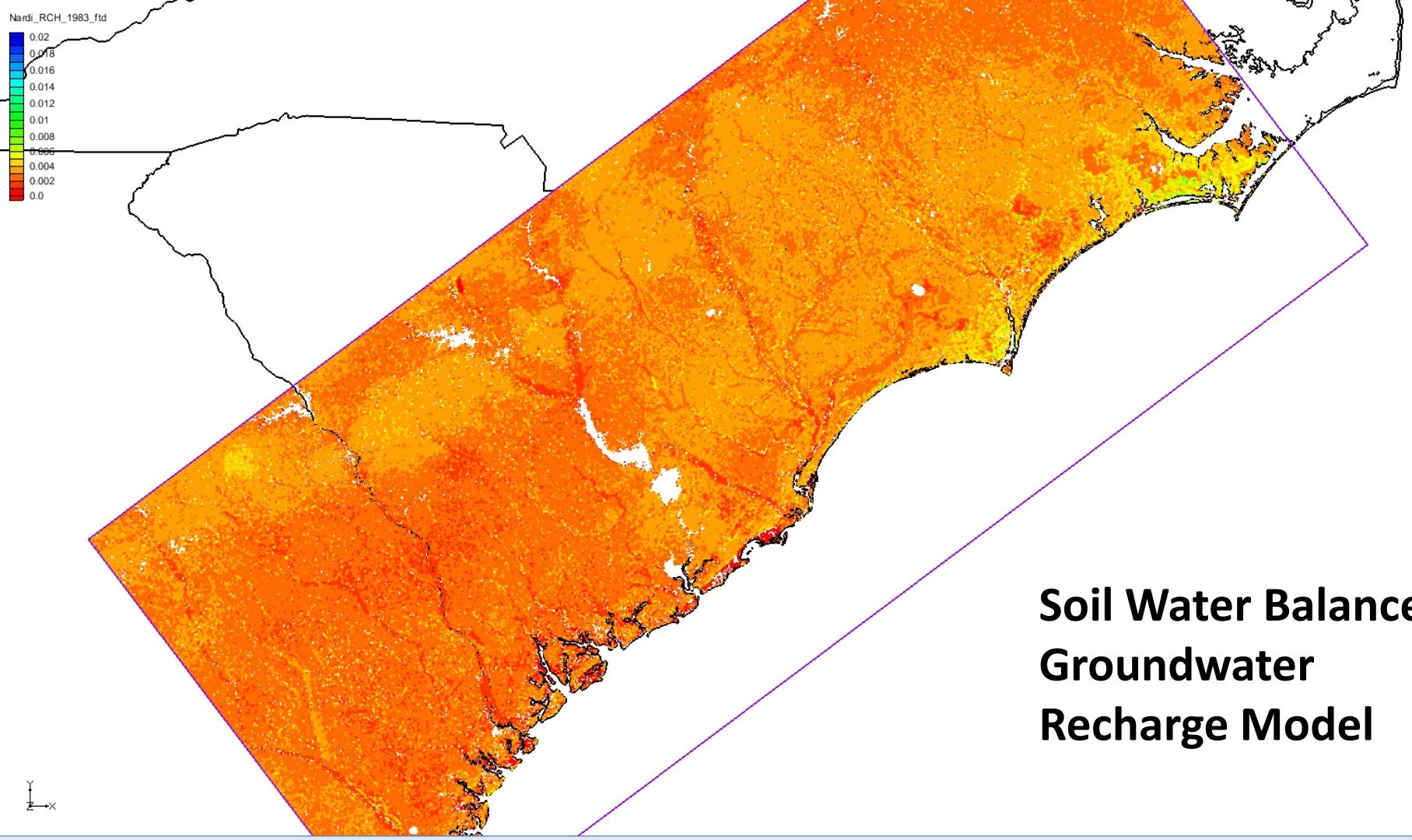
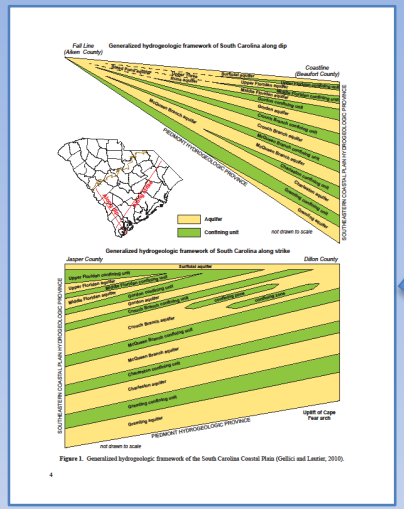


Figure 3. South Carolina DNR groundwater monitoring network (June 2014).

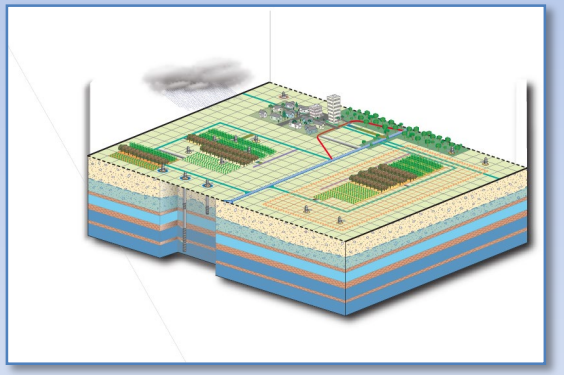


Soil Water Balance Groundwater Recharge Model

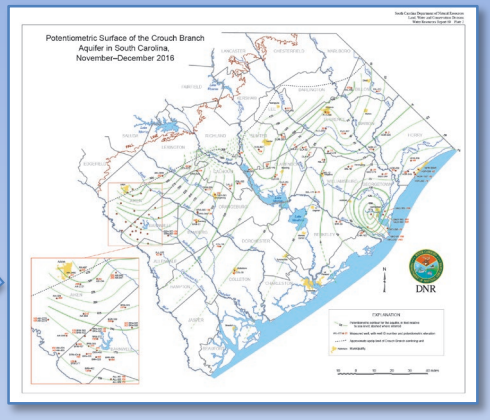


Framework

New GW Water-Use Data



Groundwater Model



Potentiometric Maps

Groundwater Levels

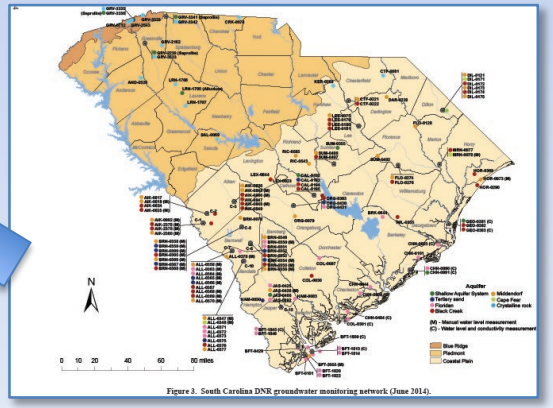
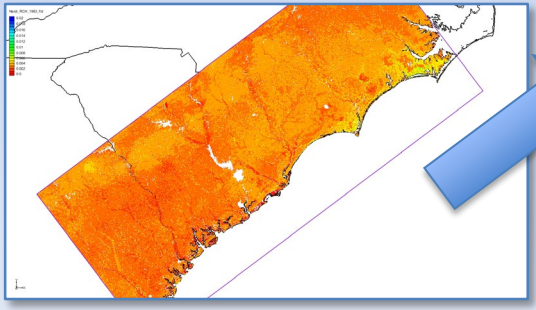


Figure 3. South Carolina DNR groundwater monitoring network (June 2014).

Recharge Model

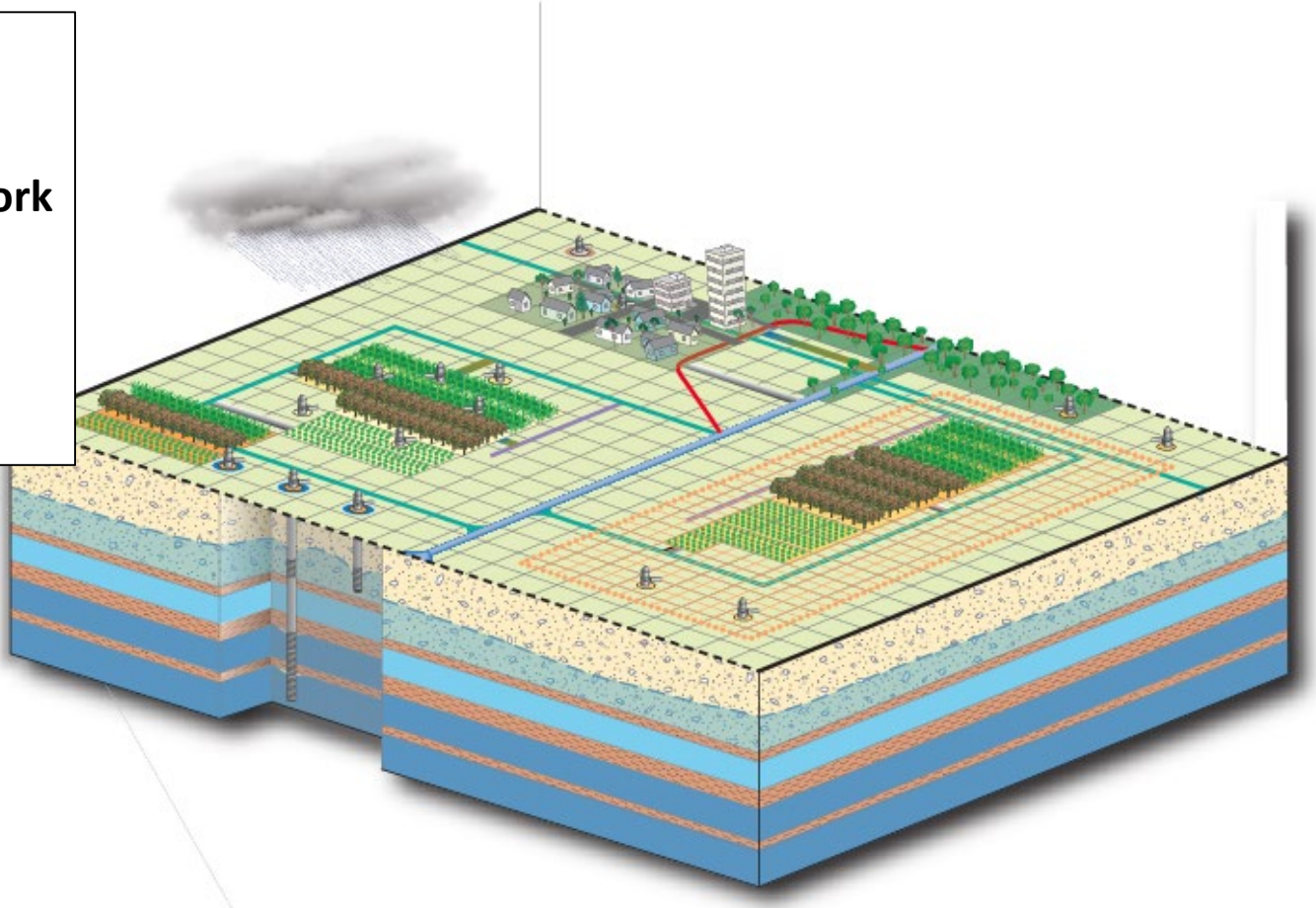


Primary inputs:

- Model Grid
- Hydrogeologic Framework
- Aquifer Properties
- Observation Data
- Boundaries
- Wells – Water Use Data

Primary Outputs:

- Groundwater Levels
- Budgets

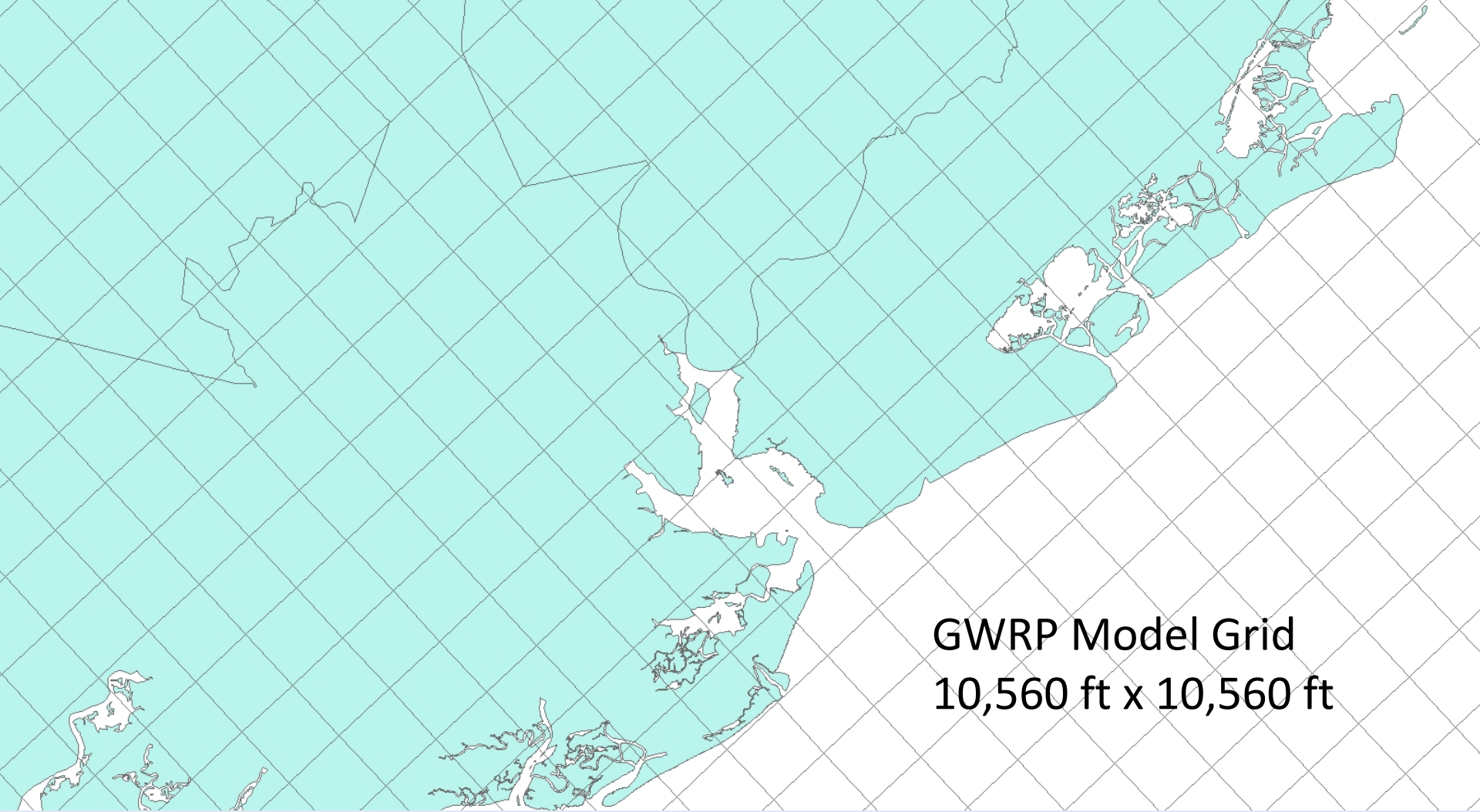


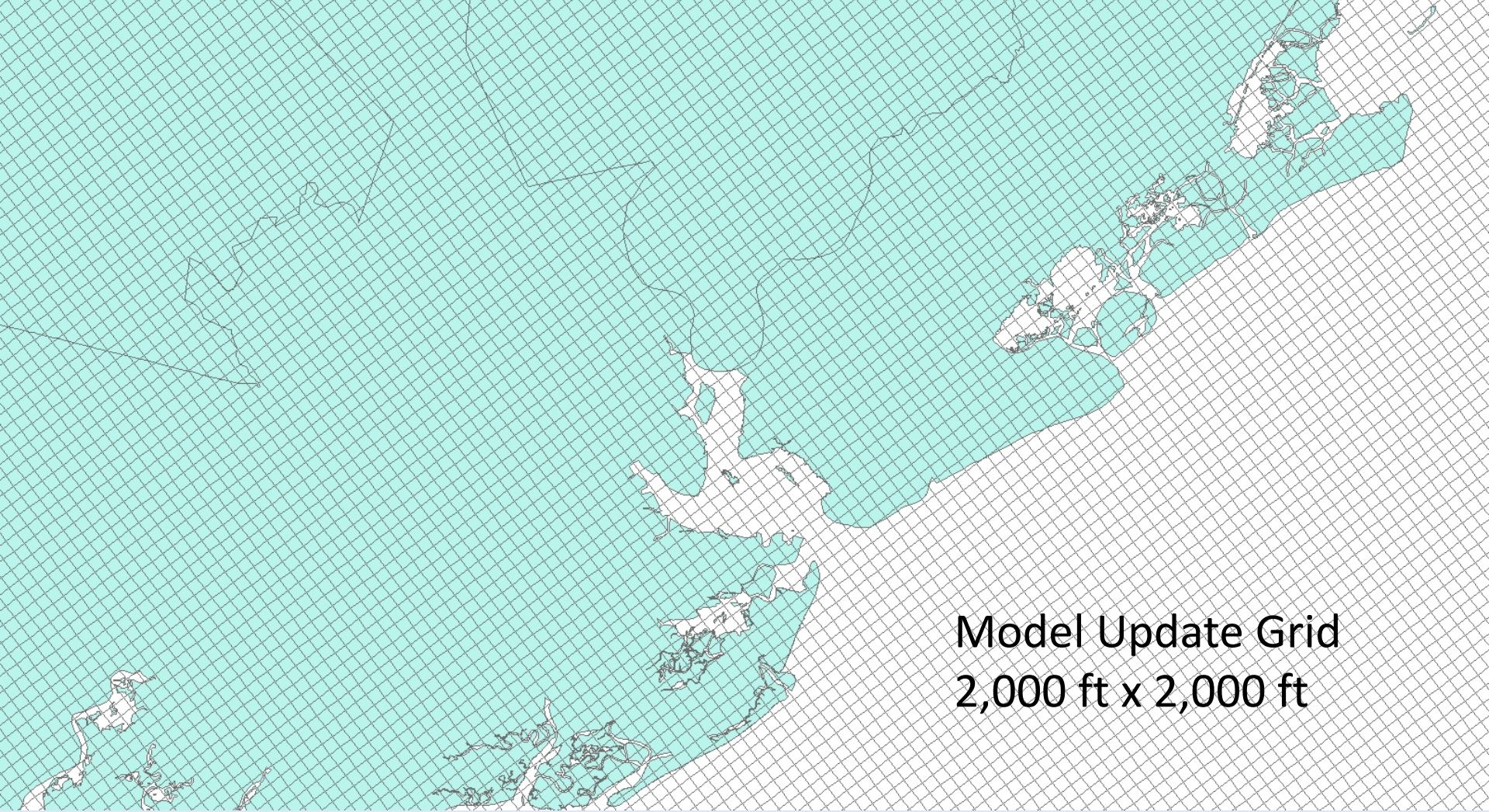
USGS

Representative GW Flow Model

Model Grid Update to the 2004 Groundwater Model

USGS


GWRP Model Grid
10,560 ft x 10,560 ft

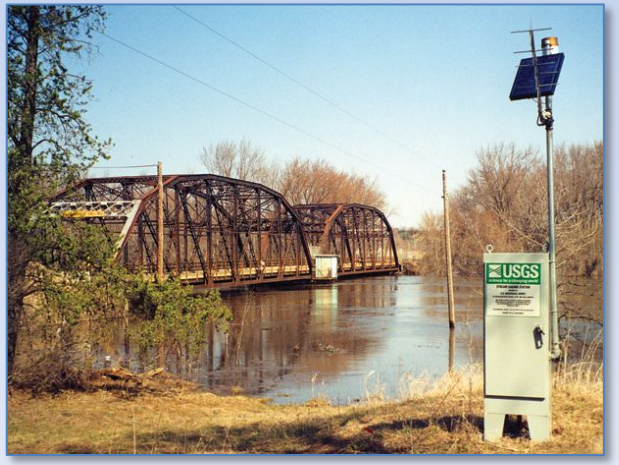

Model Update Grid
2,000 ft x 2,000 ft

Model Calibration

USGS

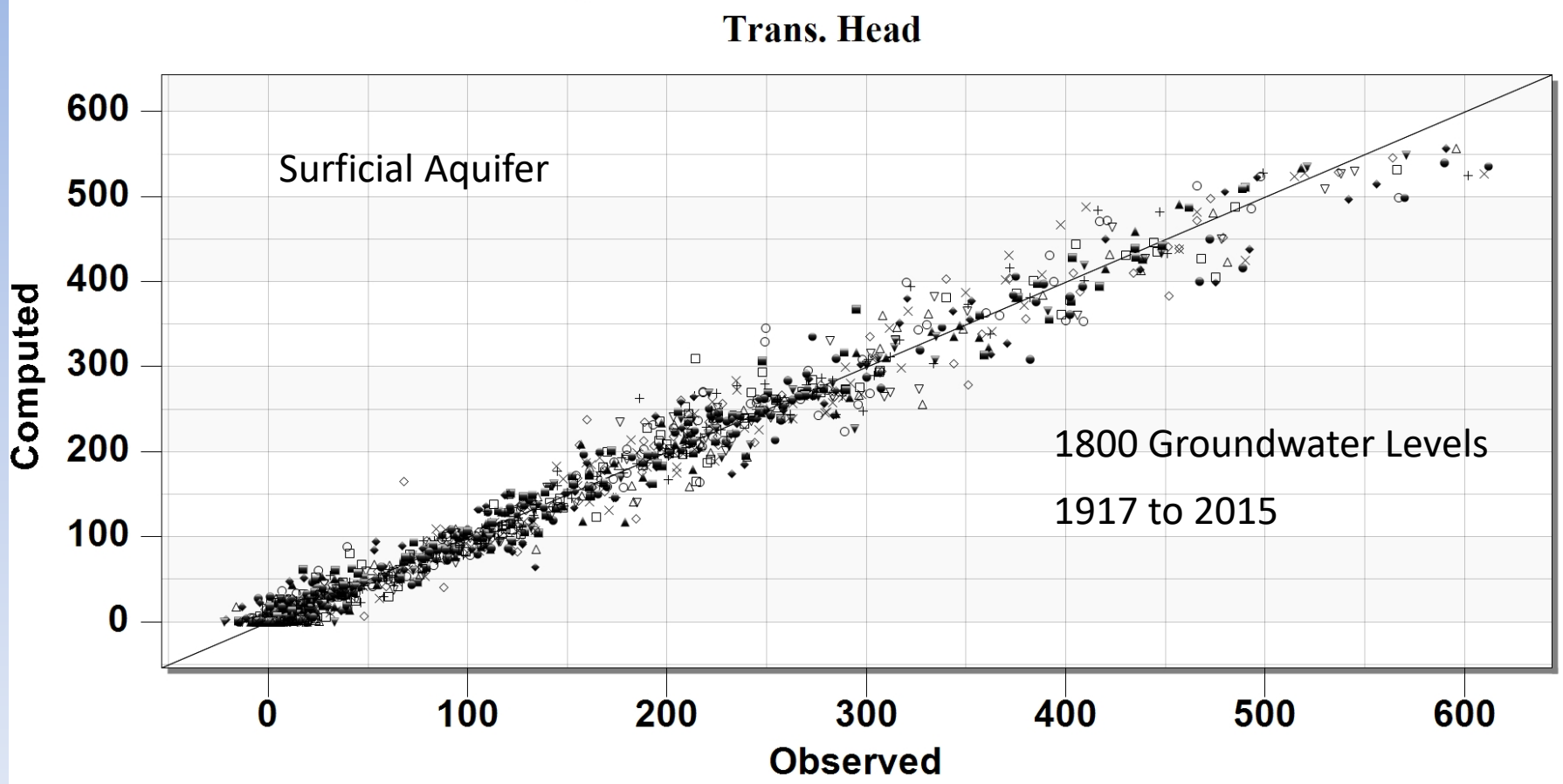
Model Calibration

- Parameter Estimation (Inverse Modeling)
- About 37,000 Groundwater Levels from 1904-2015
- 1685 Annual Base-Flow Calculations from 46 Stream Gages
  - Period of Gaging: 1930's - 2015
- 16 Model Layers – Aquifers and Confining Units

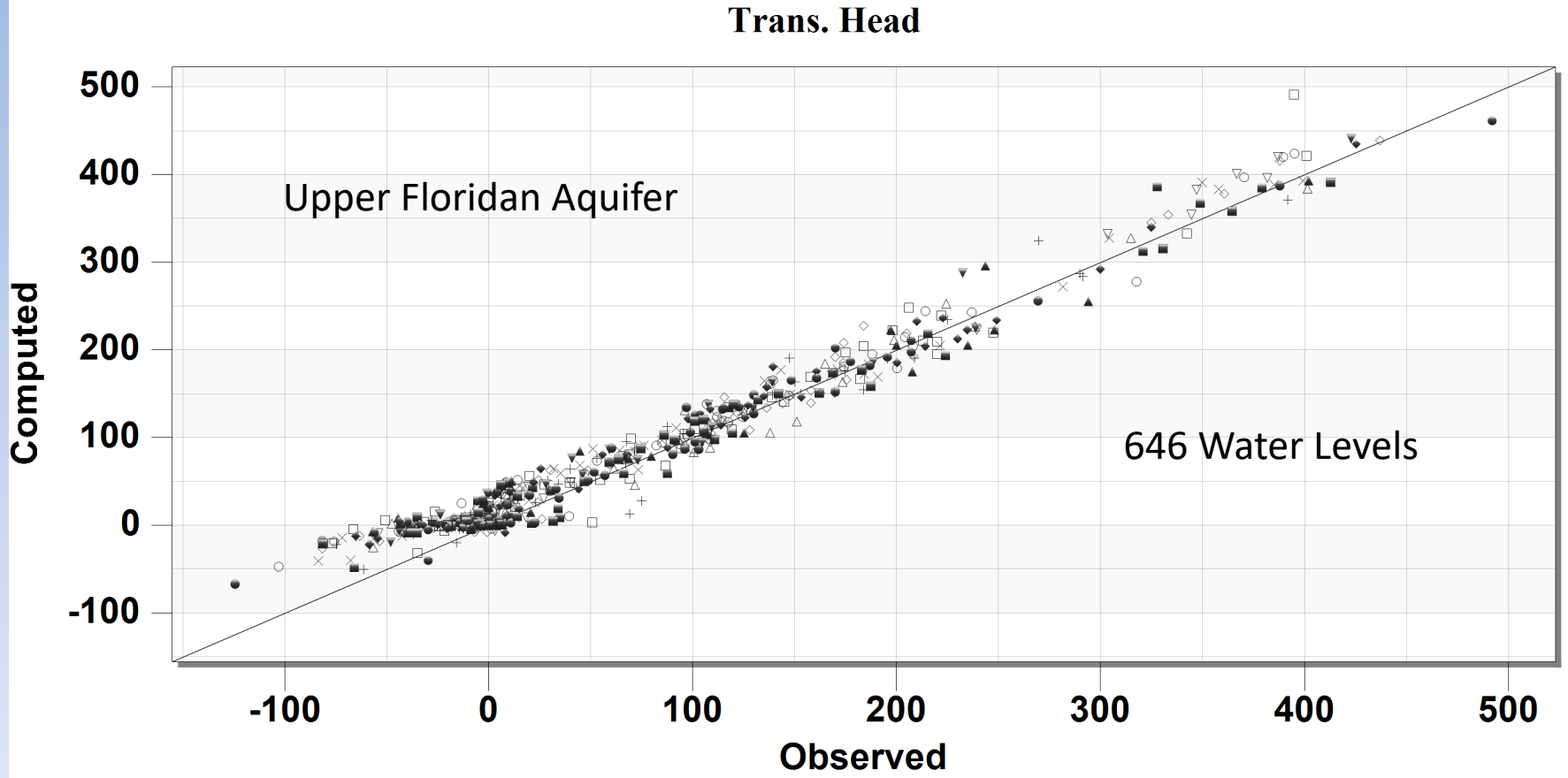


USGS

Computed vs. Observed Values

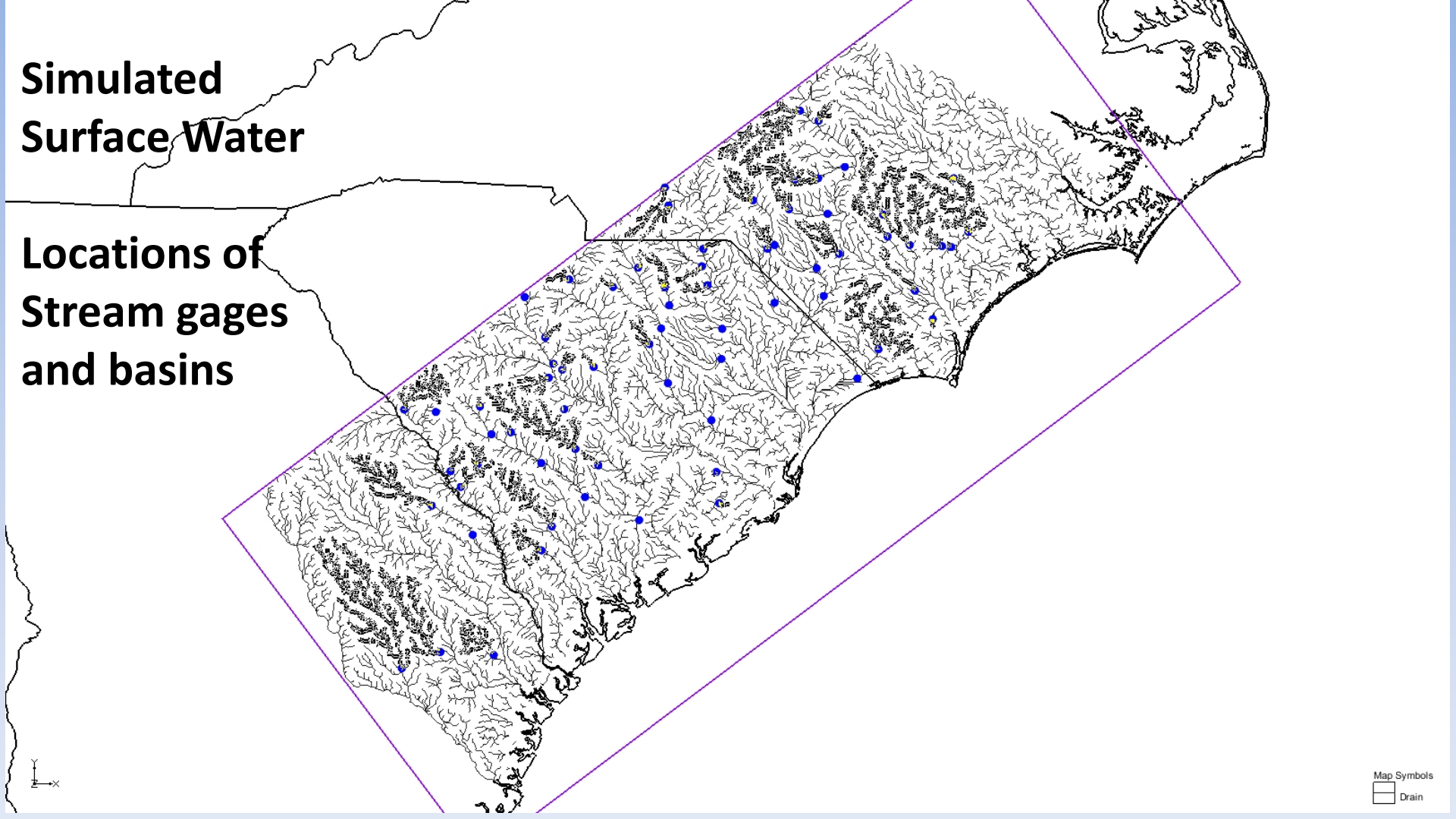


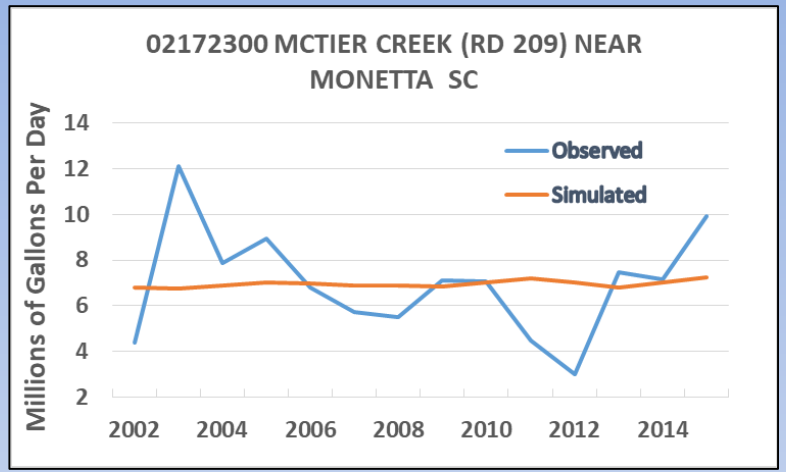
Computed vs. Observed Values

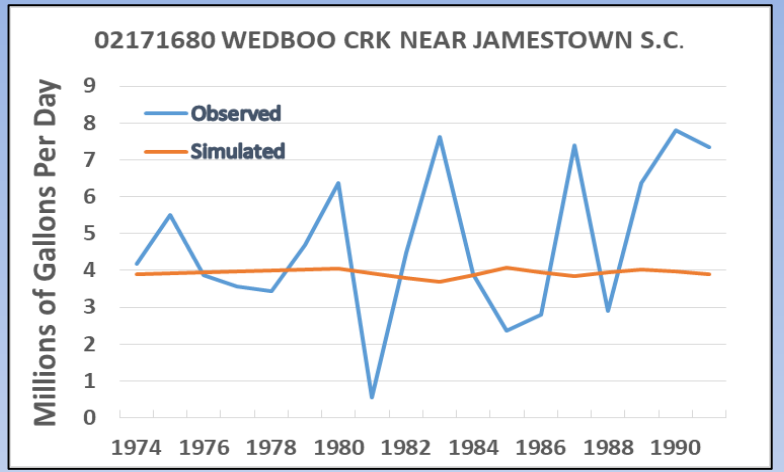


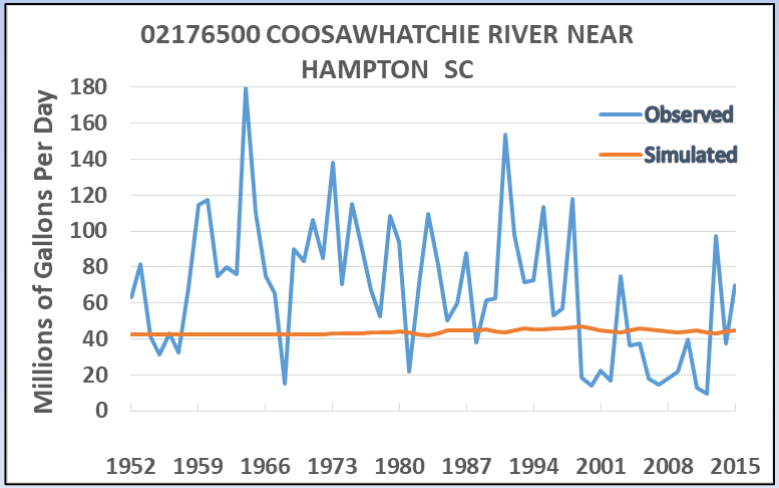
Simulated Surface Water

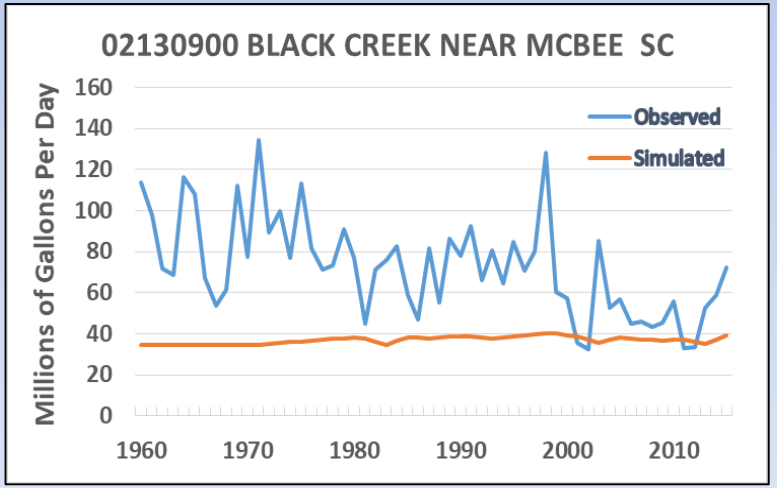
Locations of Stream gages and basins









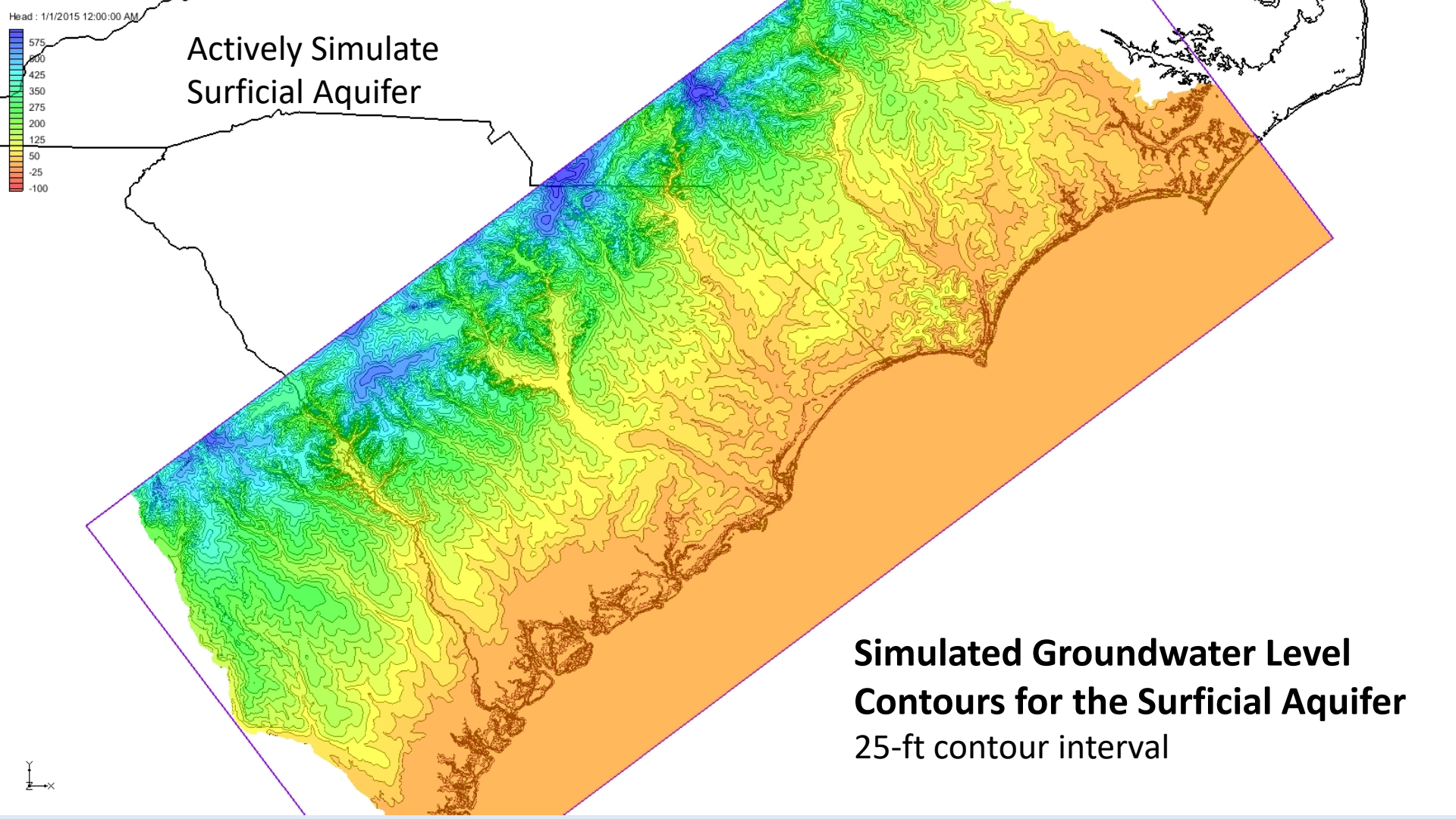


USGS

Groundwater Base-Flow Calibration Examples

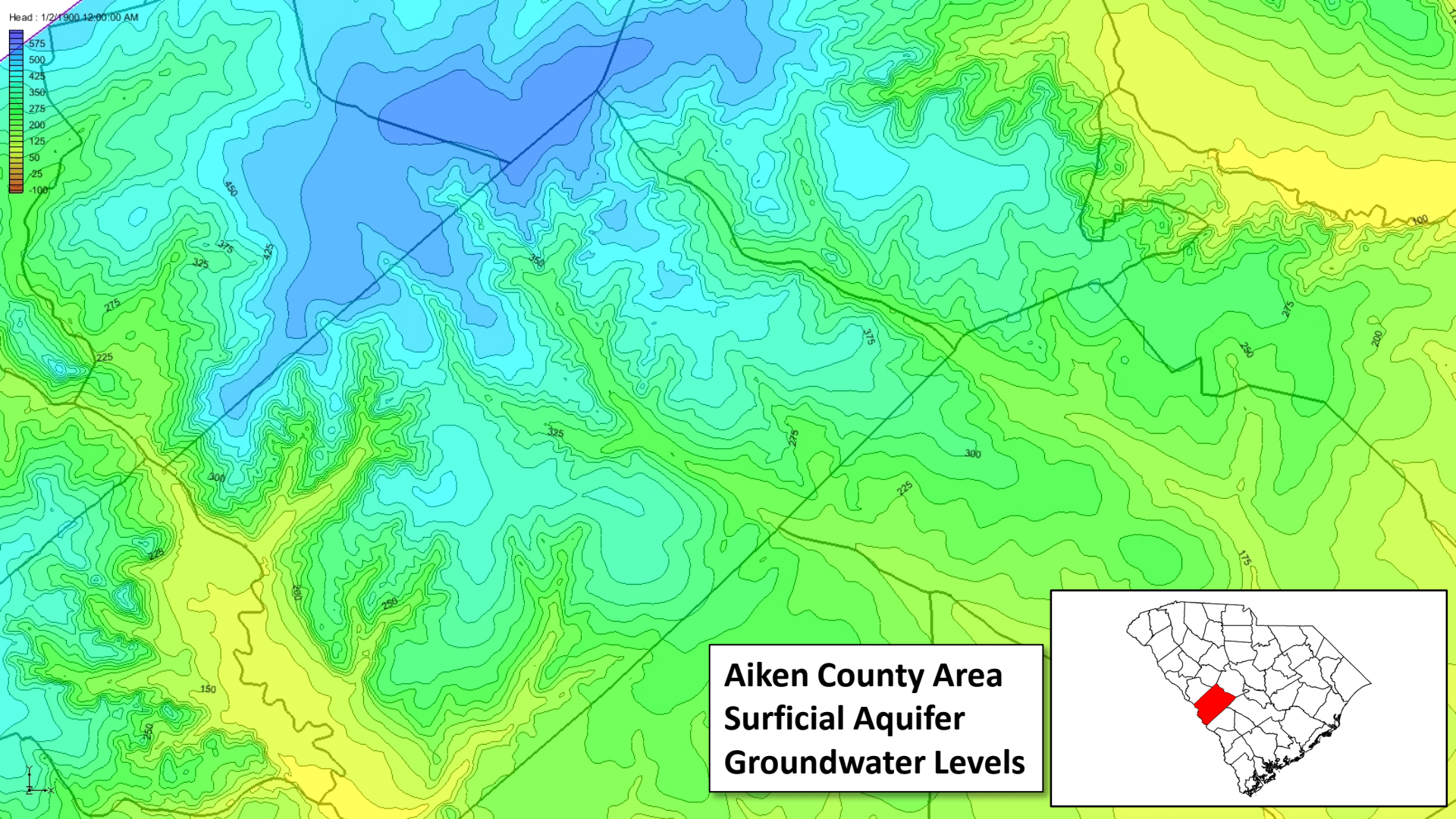
Model Results:
Simulated Water Levels

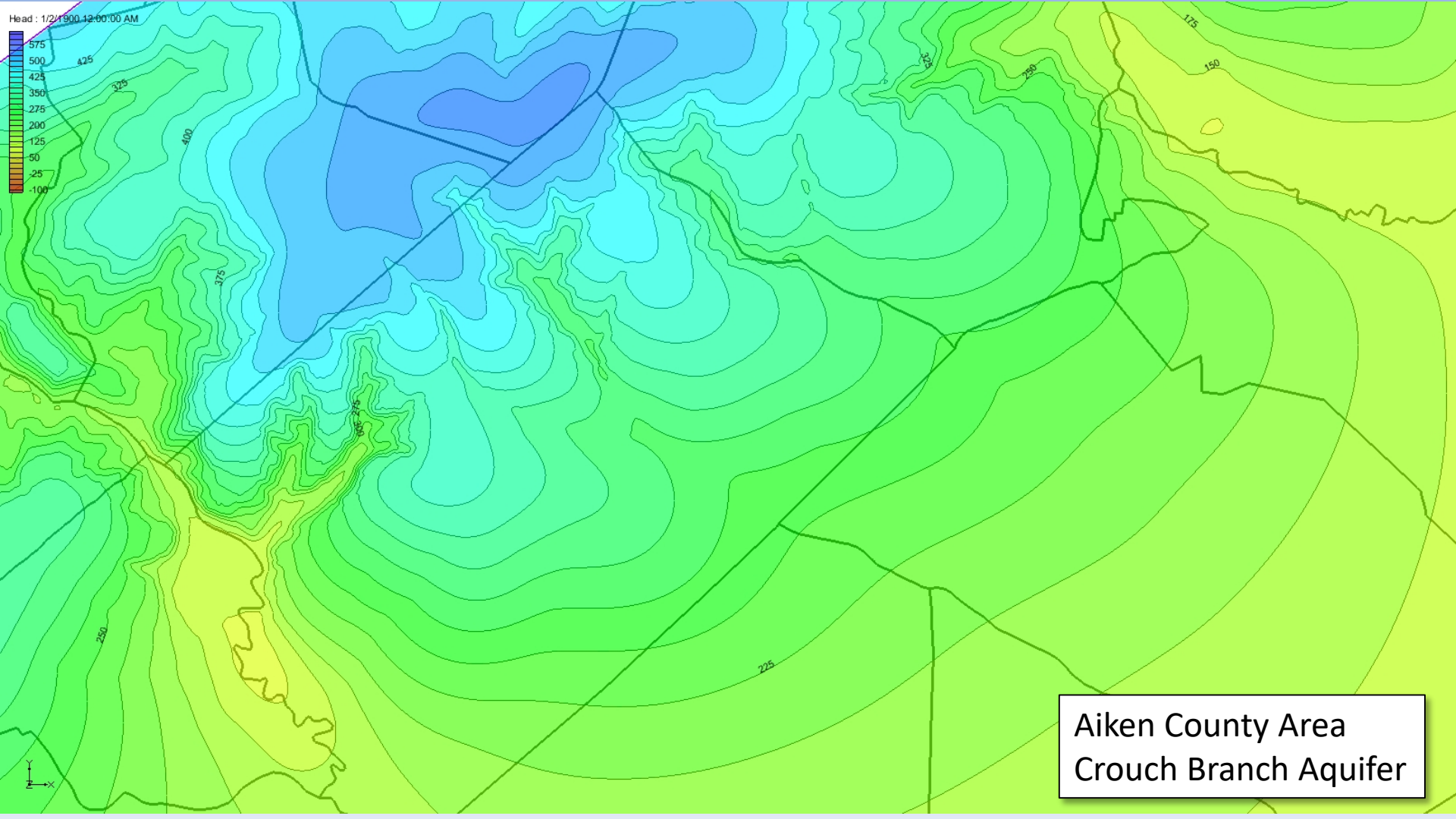
USGS



Simulated Groundwater Level Contours for the Surficial Aquifer

25-ft contour interval


Head : 1/2/1900 12:00:00 AM
575
500
425
350
275
200
125
50
-25
-100
Aiken County Area
Surficial Aquifer
Groundwater Levels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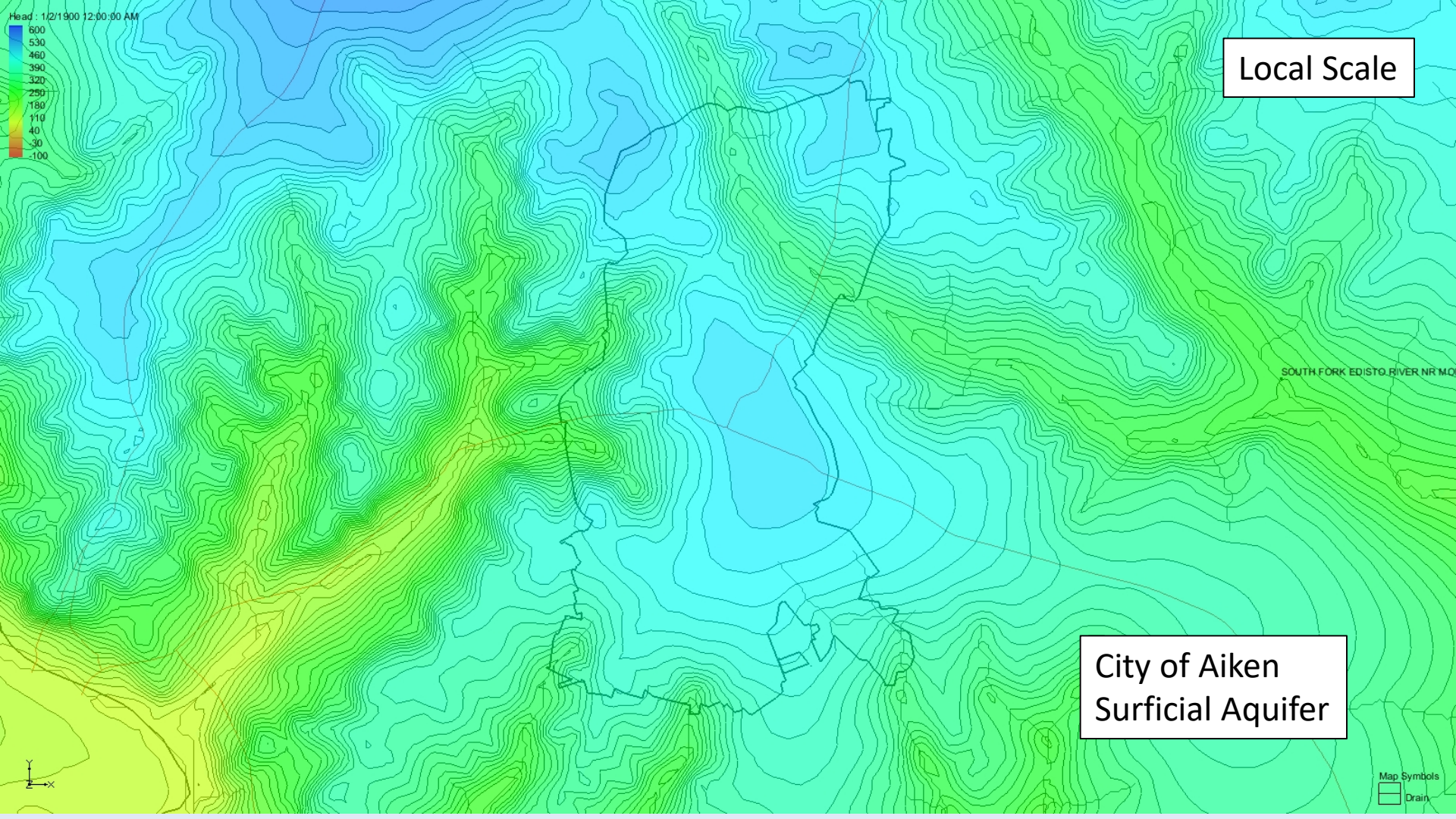
225
250
225
175
150
Aiken County Area
Crouch Branch Aquifer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530
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390
320
250
180
110
40
-30
-100
Local Scale
SOUTH FORK EDISTO RIVER NR MO
City of Aiken
Surficial Aquifer
Map Symbols
Drain

Model Results:

Simulated Water Budgets

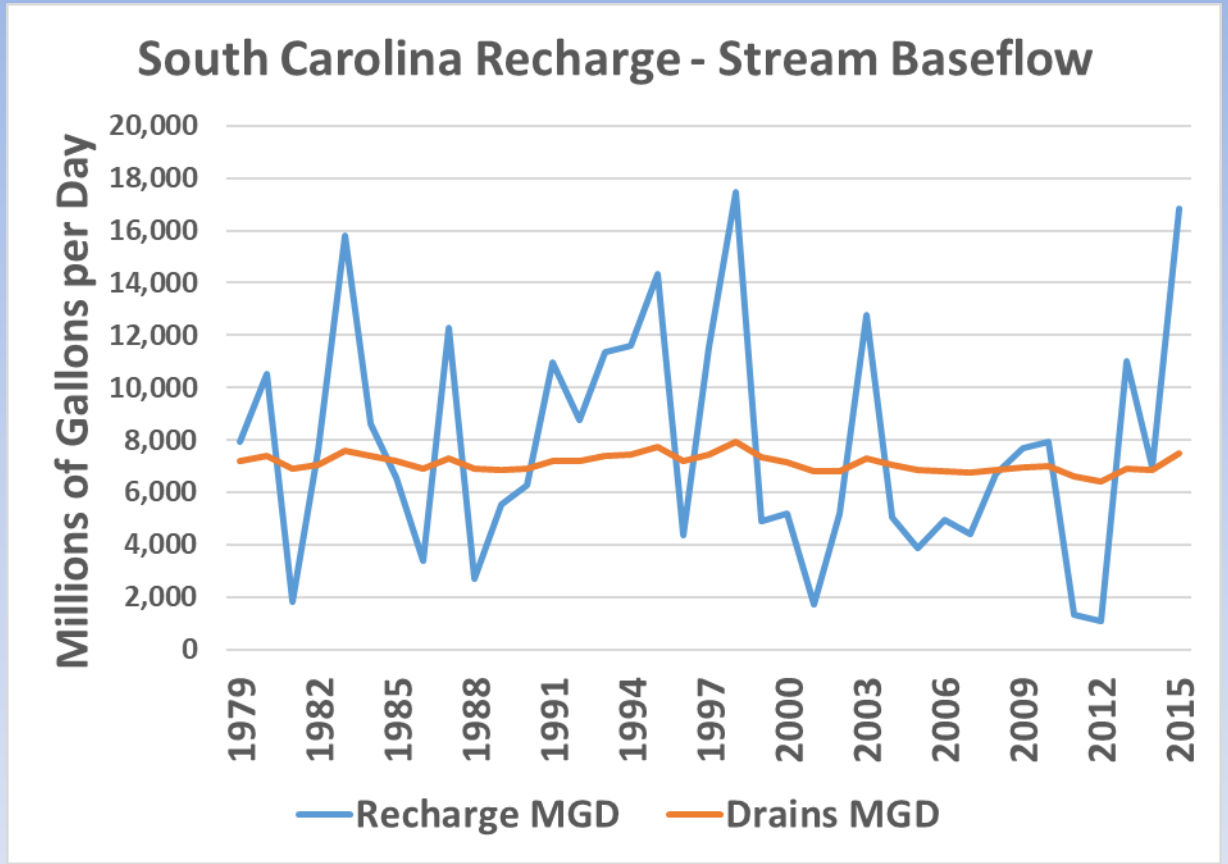
USGS

Coastal Plain

GW Recharge SWB Model

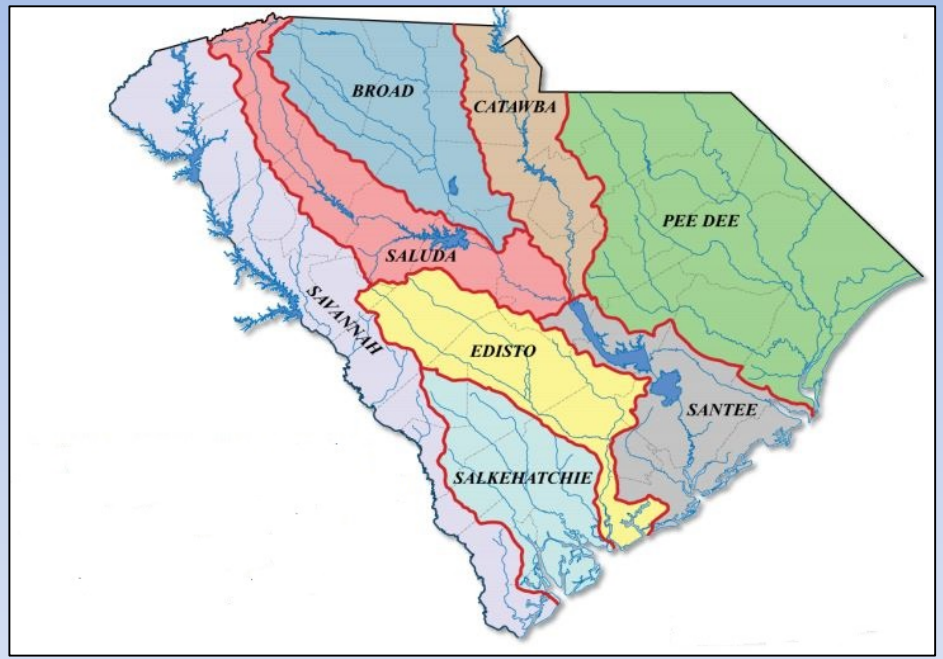
Stream Baseflow:

Stream flow minus Overland Flow

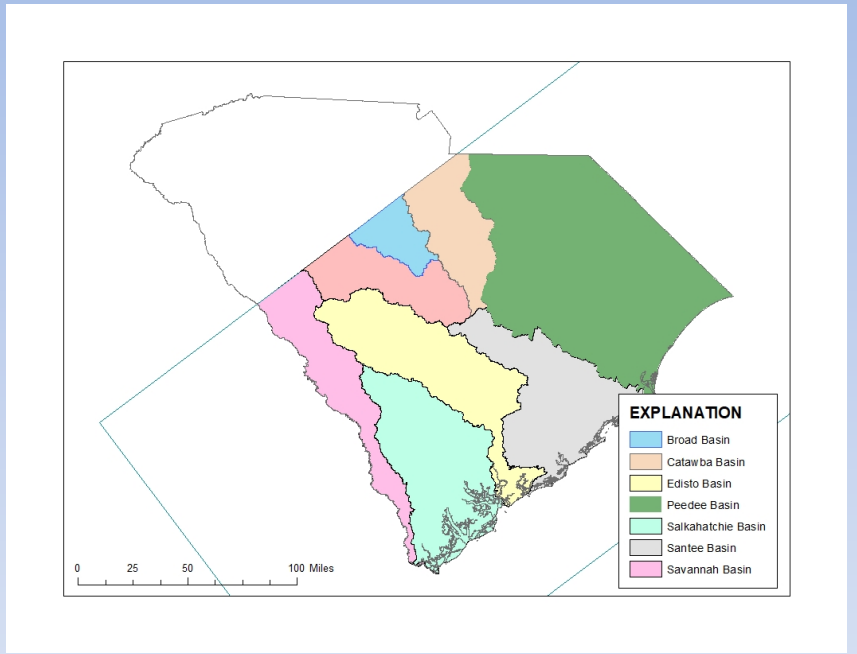


USGS

SC River Basins



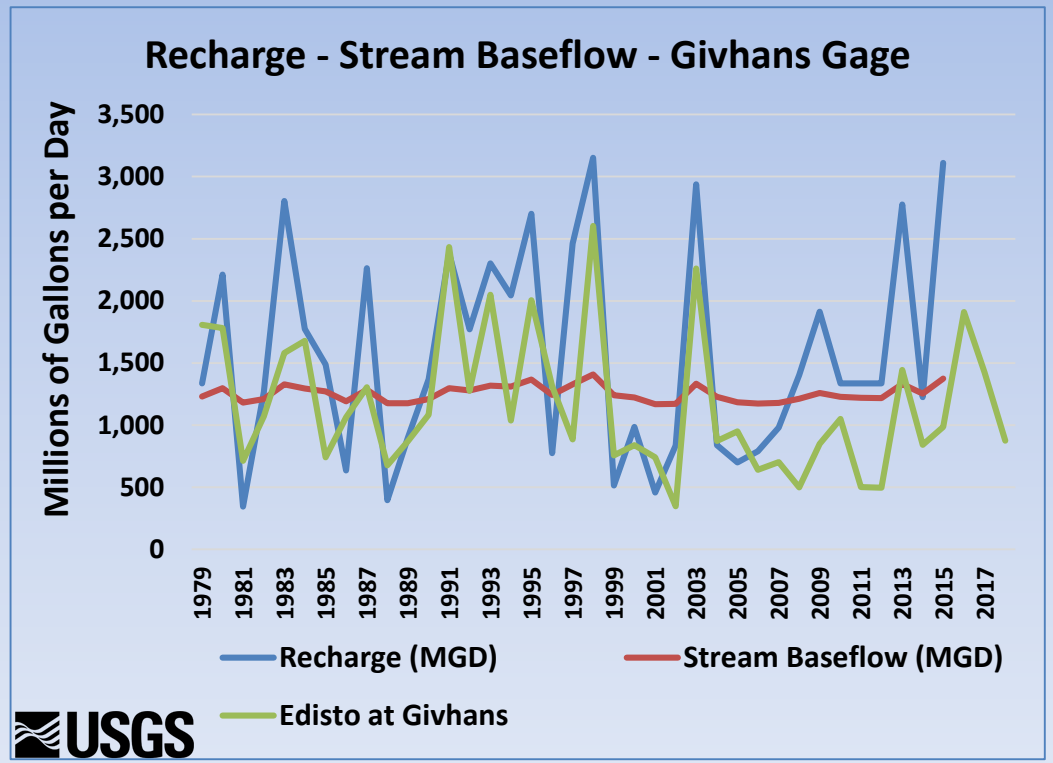
Truncated River Basins

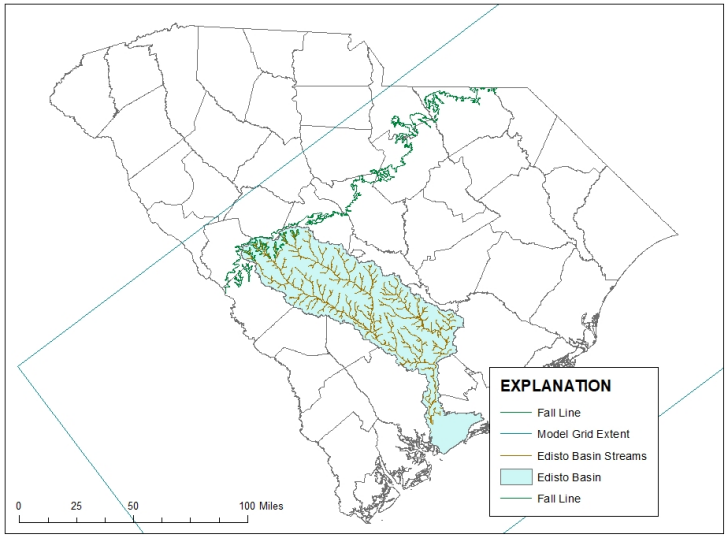


USGS

Edisto Basin

All Simulated
3,143 Square miles
2,011,352 Acres





Recharge (MGD)
Mean – 1,221
Max – 3,151 (1998)
Min – 344 (1981)

Stream Baseflow (MGD)
Mean – 1,254
Max – 1,407 (1998)
Min – 1,169 (2001)

Model Limitations

USGS

Groundwater Flow Model Limitations

- Based on limited data
- Simplification of the actual groundwater flow system
- Can limit the ability of the model to predict actual hydraulic conditions over time
- Accuracy and prediction capabilities of this model are affected by the finite-difference discretization, boundary conditions, hydraulic properties, and observations used in the model calibration
- Groundwater withdrawals simulated in the model underrepresent actual historical water use because pumping rates less than 3 million gallons per month are not required to be reported to the State agencies and, therefore, are unknown.

USGS

Aiken County Groundwater Model

USGS

Development and Application of a Groundwater-Flow Model of the Atlantic Coastal Plain aquifers, Aiken County, South Carolina to Support Water Resource Decisions

Bruce Campbell and Jim Landmeyer

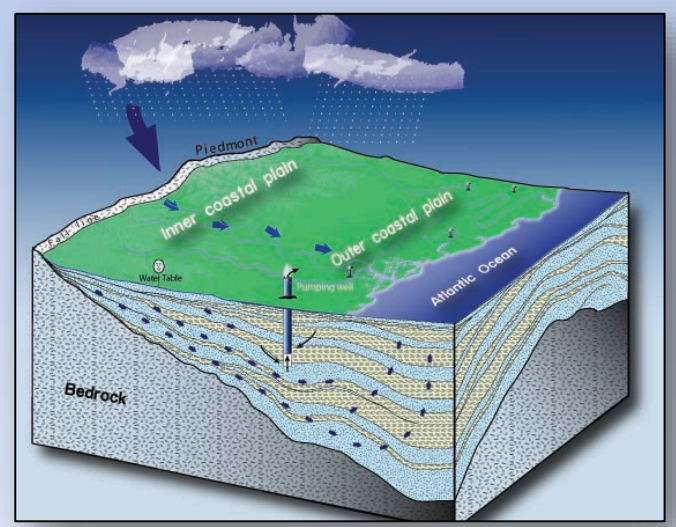
US Geological Survey – South Atlantic Water Science Center

Joe Gellici

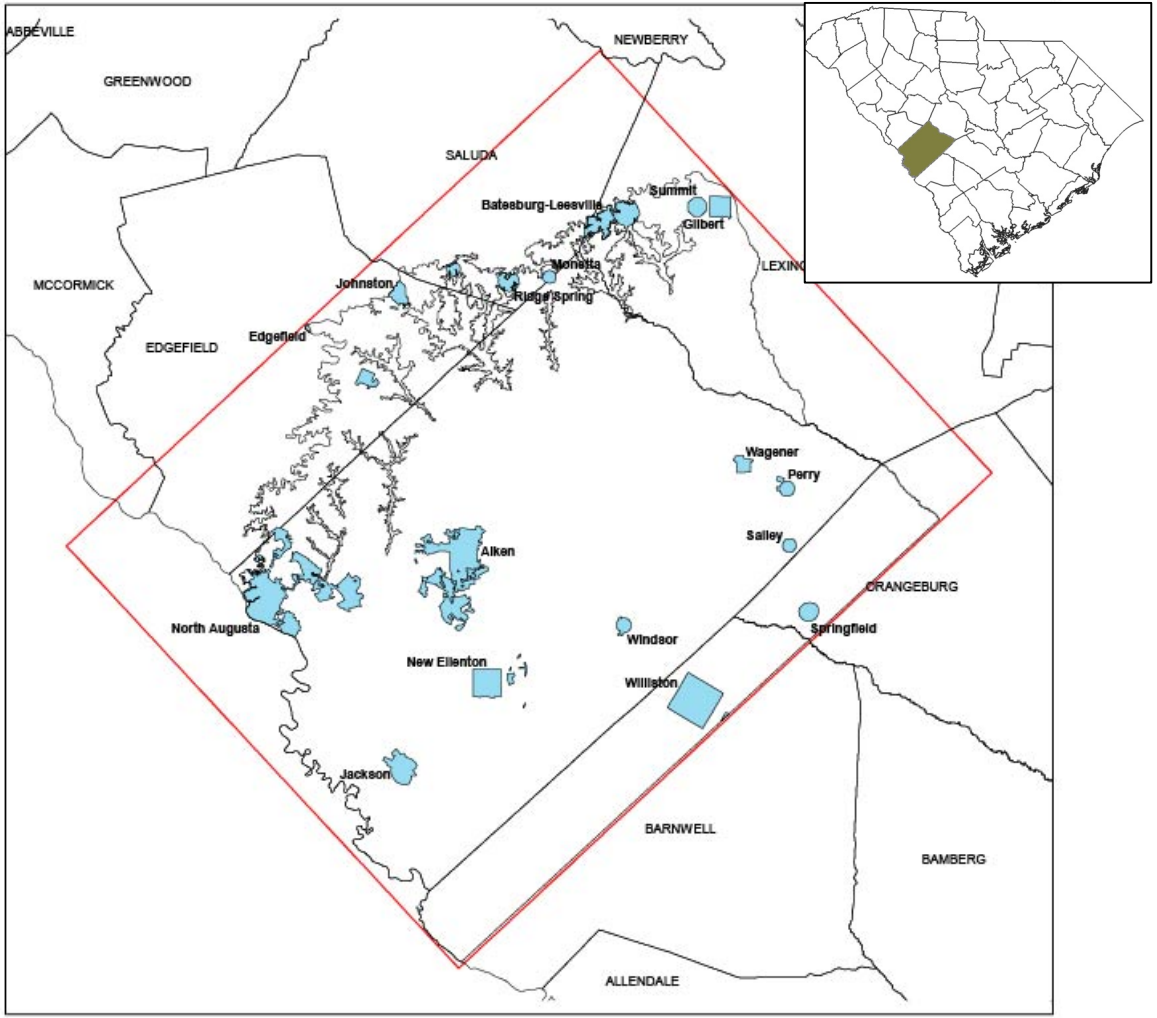
South Carolina Department of Natural Resources

Alex Butler

South Carolina Department of Health and Environmental Control

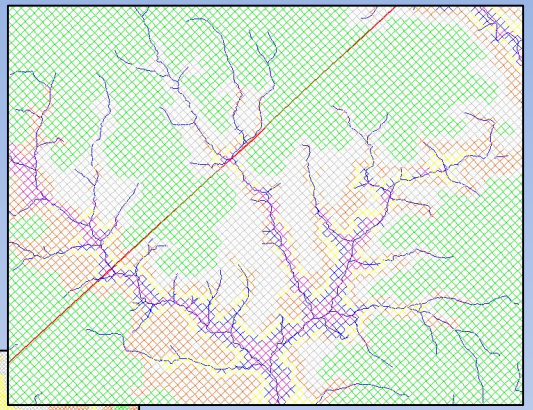


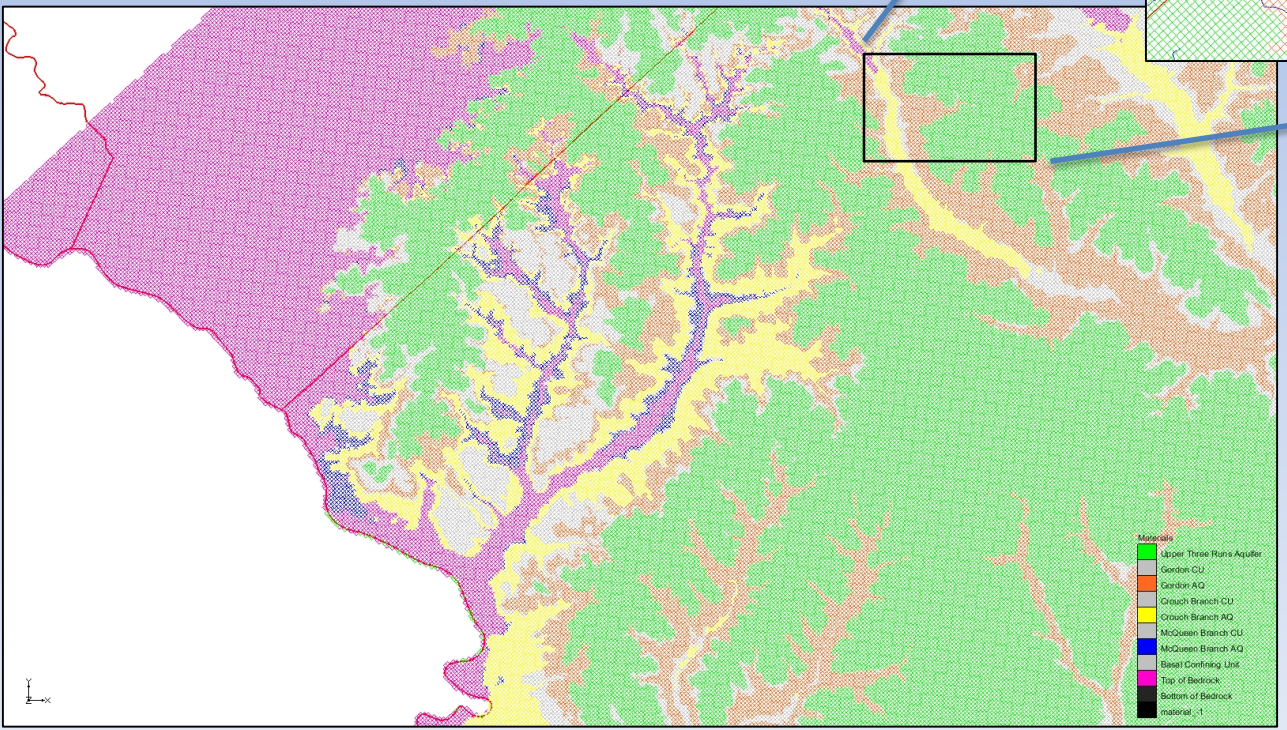
Aiken County Groundwater Availability Study



USGS

Model Cells – 400 ft x 400 ft





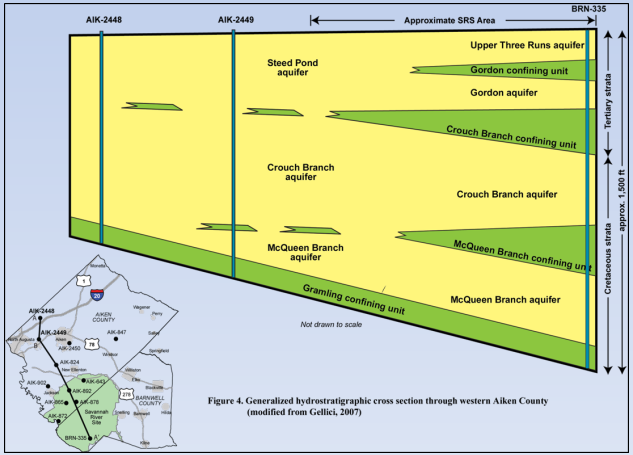
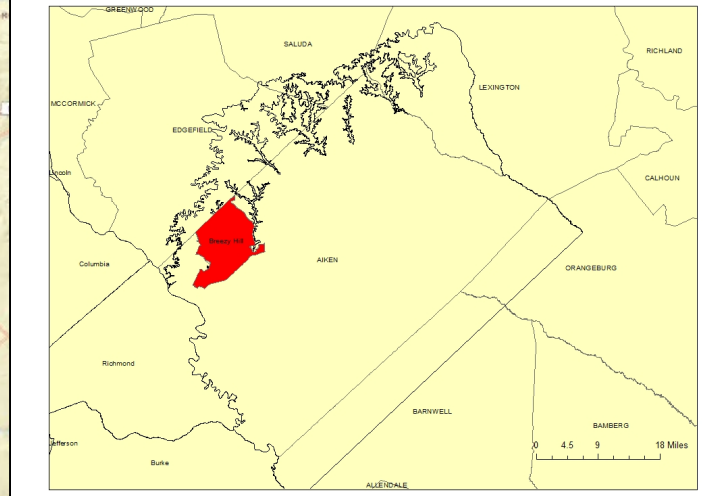


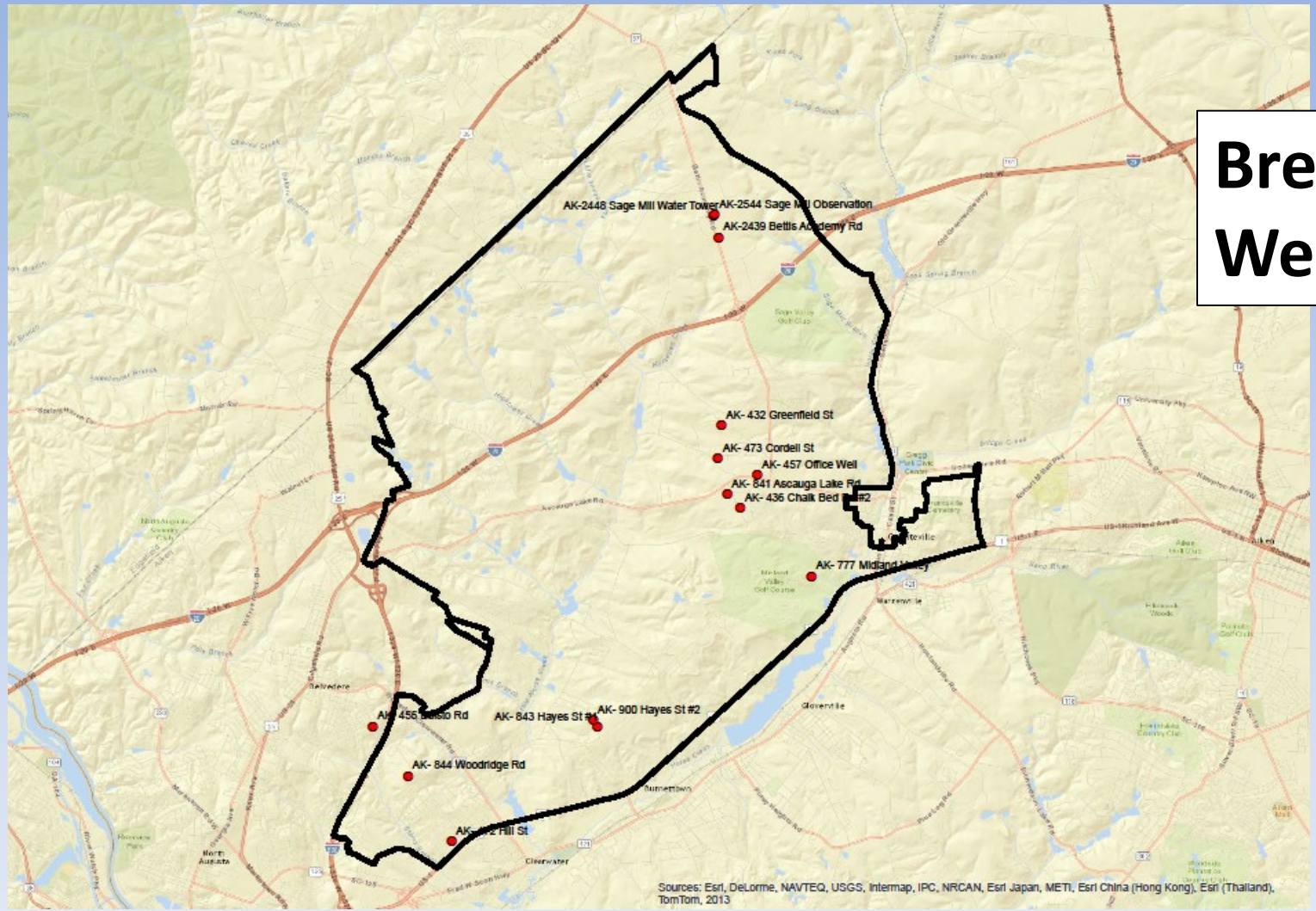
Figure 4. Generalized hydrostratigraphic cross section through western Aiken County (modified from Gellici, 2007)

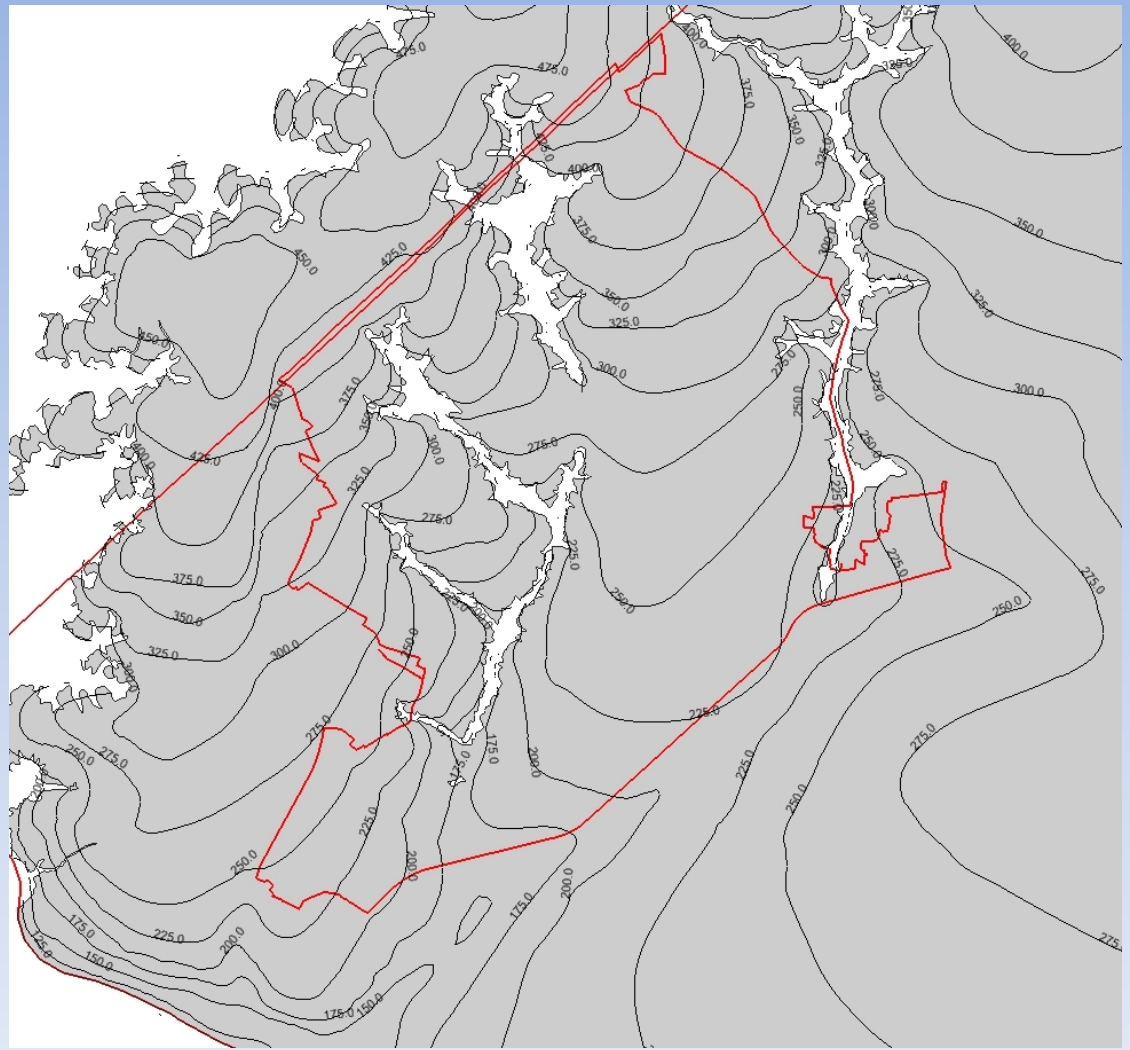
Breezy Hill Water and Sewer - Service Area



Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, IPC, NRCAN, Es
TomTom, 2013

Breezy Hill Wellfield





Breezy Hill – Simulated Groundwater Levels

Proposed Groundwater Modeling Scenarios by USGS

Jimmy Clark
Matt Petkewich
Greg Cherry

USGS

USGS
South Atlantic Water Science Center

Groundwater Scenarios

Predevelopment Groundwater Use
- Remove withdrawals and simulate levels prior to gw development
- Recharge rates from SWB model
- Focused on Edisto Basin

Current Groundwater Use
- Simulates current groundwater conditions from 2015-2065

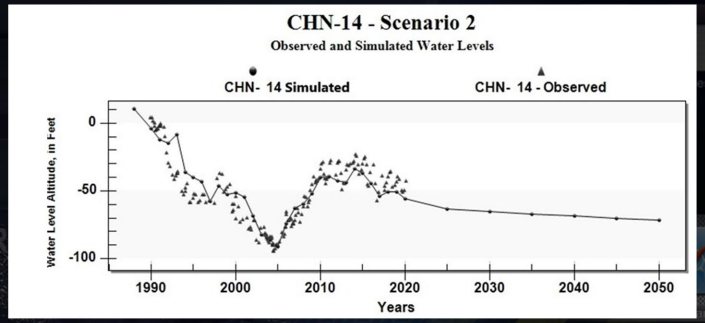
Permitted Groundwater Use
- 2015-2065 simulation
- Maximum permitted pumping rates (Coastal Plain)
- Average historical (1979-2015) recharge rates

Business-as-Usual Water-Demand
- 2015-2065 simulation
- Assumes normal climate and moderate population/economic growth
- Average historical recharge

High Water-Demand Projection
- 2015-2065 simulation
- Assumes hot/dry climate and high population/economic growth
- Average historical recharge

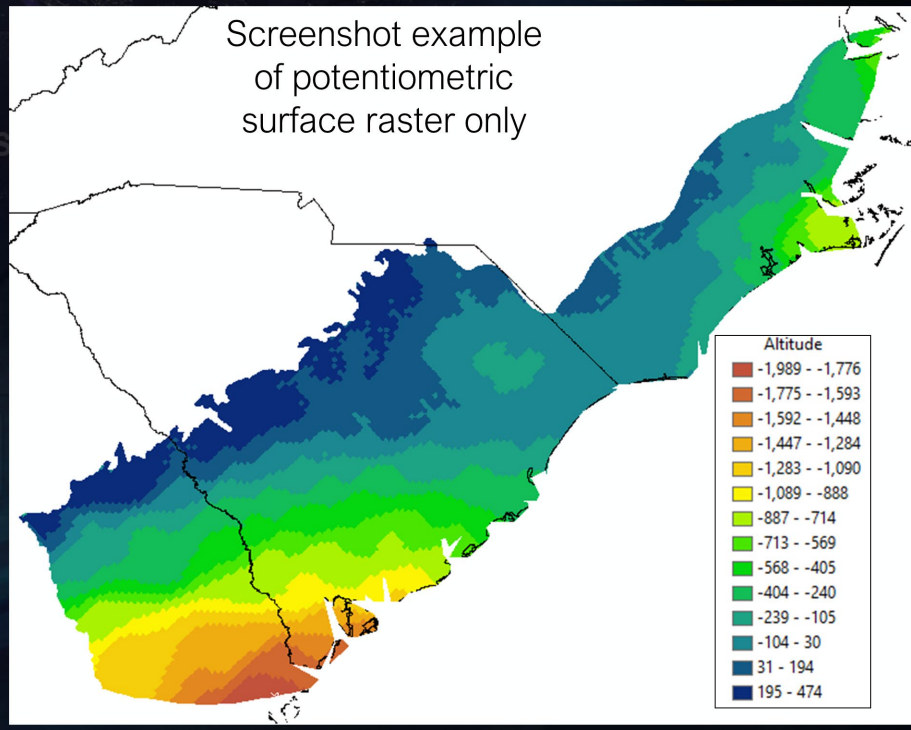
Potential Additional Scenarios
- Availability
- Management strategies

Deliverables



Meetings
- Presentations of scenario results
  - Plots
  - Potentiometric surface figures (raster)

Publications
- Data Release(s)
  - Model inputs, outputs, and metadata



Summary

- Revised and Updated SC Coastal Plain GW model
- Addition of new data
- Recharge model and data
- Surficial aquifer actively simulated
- Model limitations
- Aiken County model
- Planned scenarios

USGS

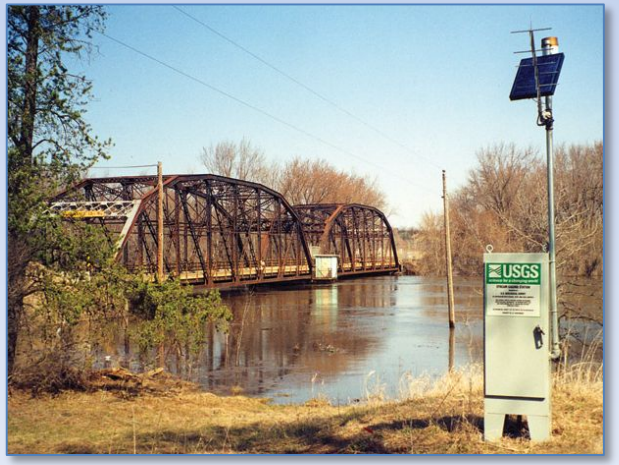
Questions?

Bruce Campbell
bcampbel@usgs.gov
803-727-9035

USGS

Model Calibration

- Parameter Estimation (Inverse Modeling)
- About 37,000 Groundwater Levels from 1904-2015
- 1685 Annual Base-Flow Calculations from 46 Stream Gages
  - Period of Gaging: 1930's - 2015
- 16 Model Layers – Aquifers and Confining Units



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