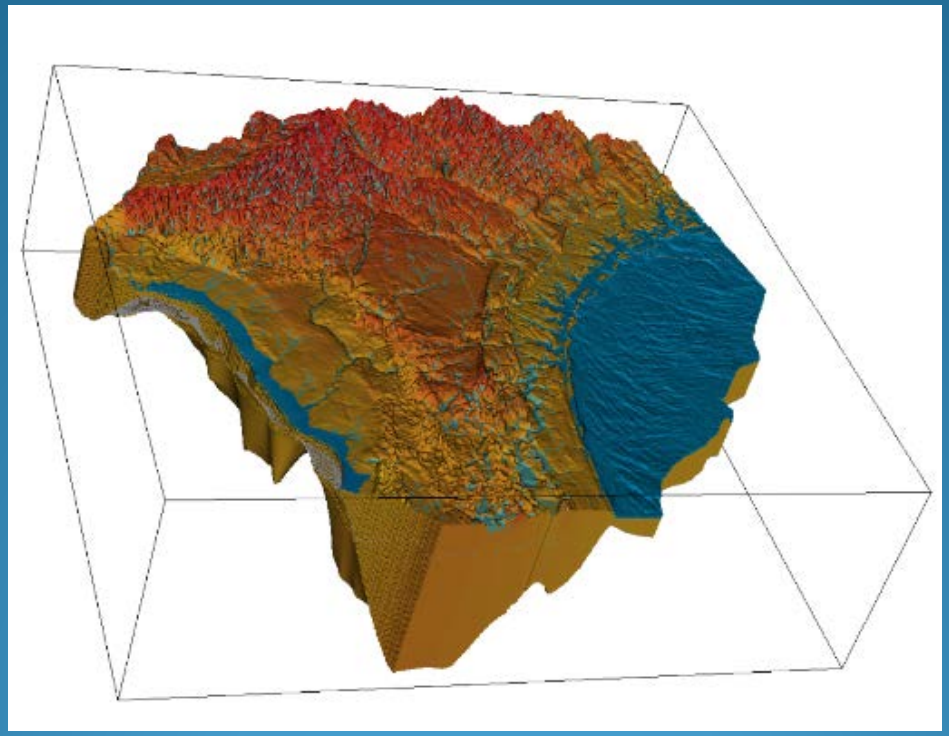
NFSEG Peer Review
Phase 1 Results Meeting



June 21, 2017

Outline

- Introduction/Meeting Objectives
- Overview of Phase 1 Results
  - HSPF
  - MODFLOW
- Peer Review Panel Discussions
- Technical Stakeholder Input
- Next Steps
- Public Comments
- Schedule/Meeting Recap

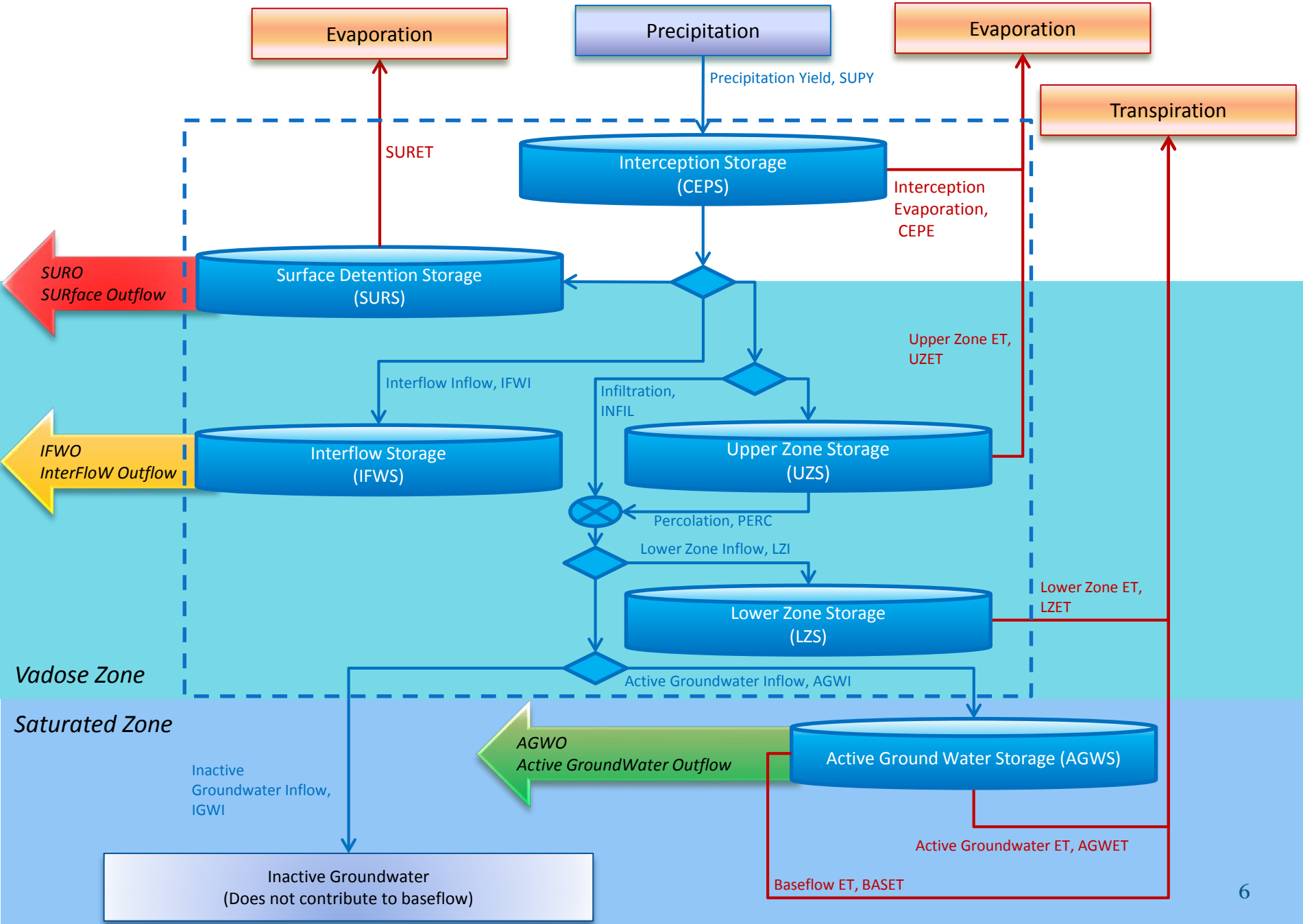
Introduction / Meeting Objective

- Task B Phase 1 Draft NFSEG v1.1 Model
  - Review model changes made to date
  - Discuss key findings as well as specific suggestions on outstanding tasks to be completed for final V1.1
  - Review and discuss preliminary consideration of Task D2 (Items A-F) and Task D3 (A-D, G, and H)
- Next Steps
  - Begin discussion of no-pumping / predevelopment simulations

Overview Of Phase 1 Results - HSPF

HSPF Updates

- New equation to calculate gross recharge
- Representation of more springs plus diffuse groundwater discharge to a reach
- Recalibrate
  - Adjustments of weights to emphasize frequency distribution curve, total actual evapotranspiration, and period of record volume.
  - Two additional flow observation stations.


Evaporation
Precipitation
Evaporation
Precipitation Yield, SUPY
Transpiration
SURET
Interception Storage (CEPS)
Interception Evaporation, CEPE
SURO SURface Outflow
Surface Detention Storage (SURS)
Upper Zone ET, UZET
Interflow Inflow, IFWI
Infiltration, INFIL
IFWO InterFloW Outflow
Interflow Storage (IFWS)
Upper Zone Storage (UZS)
Percolation, PERC
Lower Zone Inflow, LZI
Lower Zone ET, LZET
Lower Zone Storage (LZS)
Vadose Zone
Active Groundwater Inflow, AGWI
Saturated Zone
AGWO Active GroundWater Outflow
Active Ground Water Storage (AGWS)
Inactive Groundwater Inflow, IGWI
Active Groundwater ET, AGWET
Baseflow ET, BASET
Inactive Groundwater (Does not contribute to baseflow)

Mass Balance

- Mass balance within control volume (dashed blue box)

In = Out + (Change in storage)

where (Change in storage) = 0

In = Out

Precipitation = SURO + IFWO + LZET + UZET + AGWI + IGWI + SURET + CEPE

MODFLOW Recharge Equation

Recharge = precipitation - interception_et -
direct_runoff - unsaturated_et

where: interception_et = CEPE

direct_runoff = SURO + IFWO

unsaturated_et = LZET + UZET

Replace with HSPF Variables

Recharge = precipitation – CEPE – SURO – IFWO – LZET – UZET

Combine

HSPF Control Volume

Precipitation = SURO + IFWO + LZET + UZET +
AGWI + IGWI + SURET + CEPE

Precipitation - CEPE - SURO - IFWO - LZET - UZET = **AGWI + IGWI + SURET**

MODFLOW

Recharge = Precipitation - CEPE - SURO - IFWO - LZET - UZET

Recharge = **AGWI + IGWI + SURET**

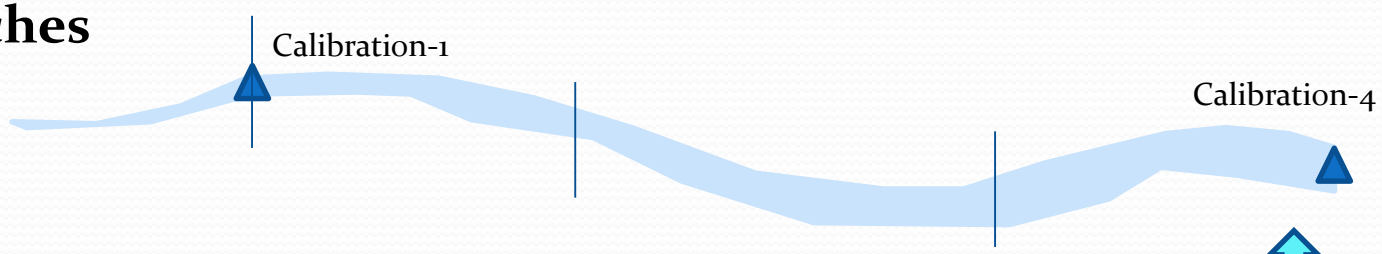
HSPF Surface ET (SURET)

- Zero except for water and wetlands
- For water and wetlands can be close to potential

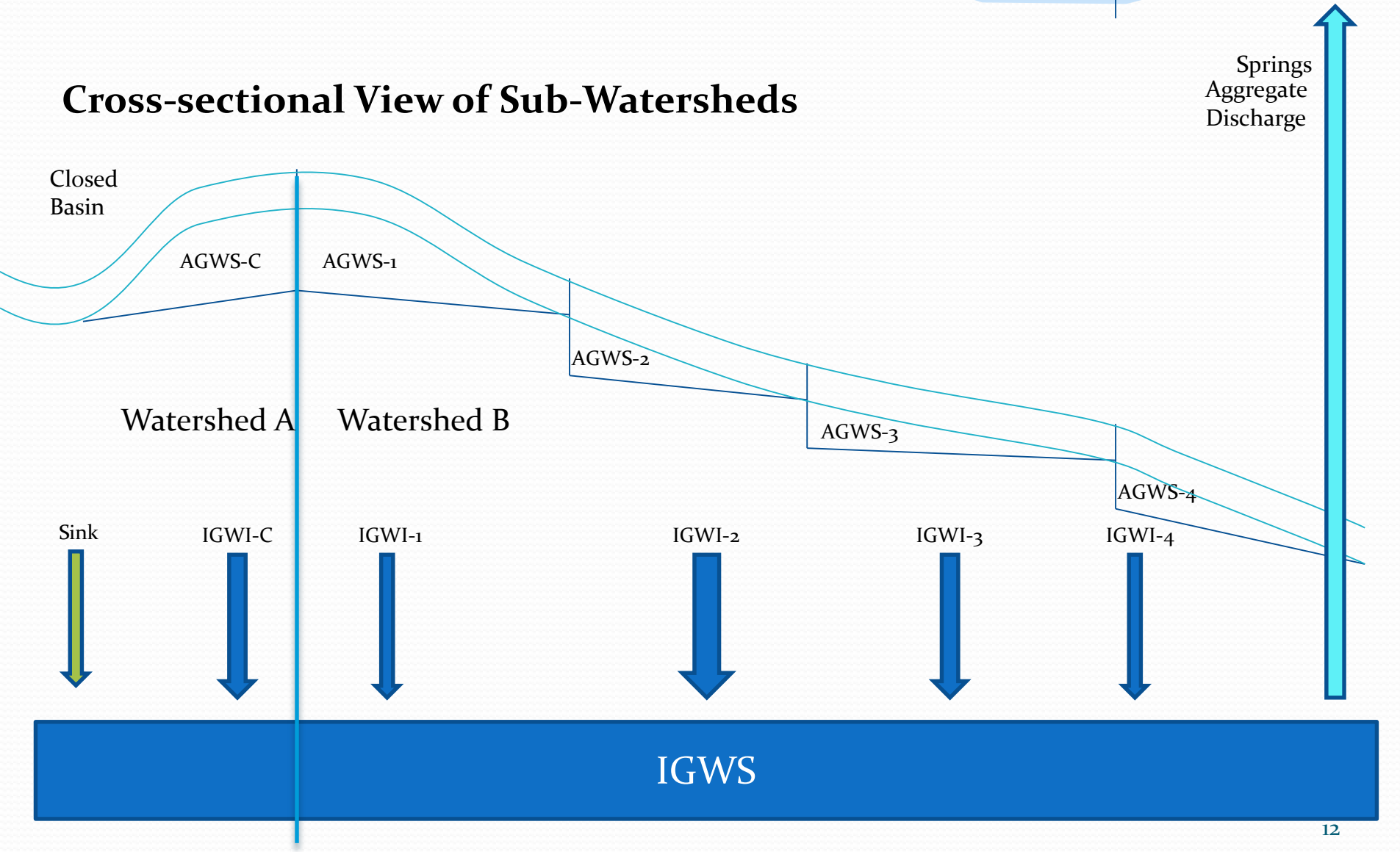
Springs Plus Diffuse Groundwater Discharge to a Reach (Aggregate Discharge)

- Inactive Groundwater Storage Approach
  - Expanded to include
    - Wakulla Springs
    - St. Marks Rise
    - Wacissa Springs
    - Rainbow Springs
    - Silver Springs

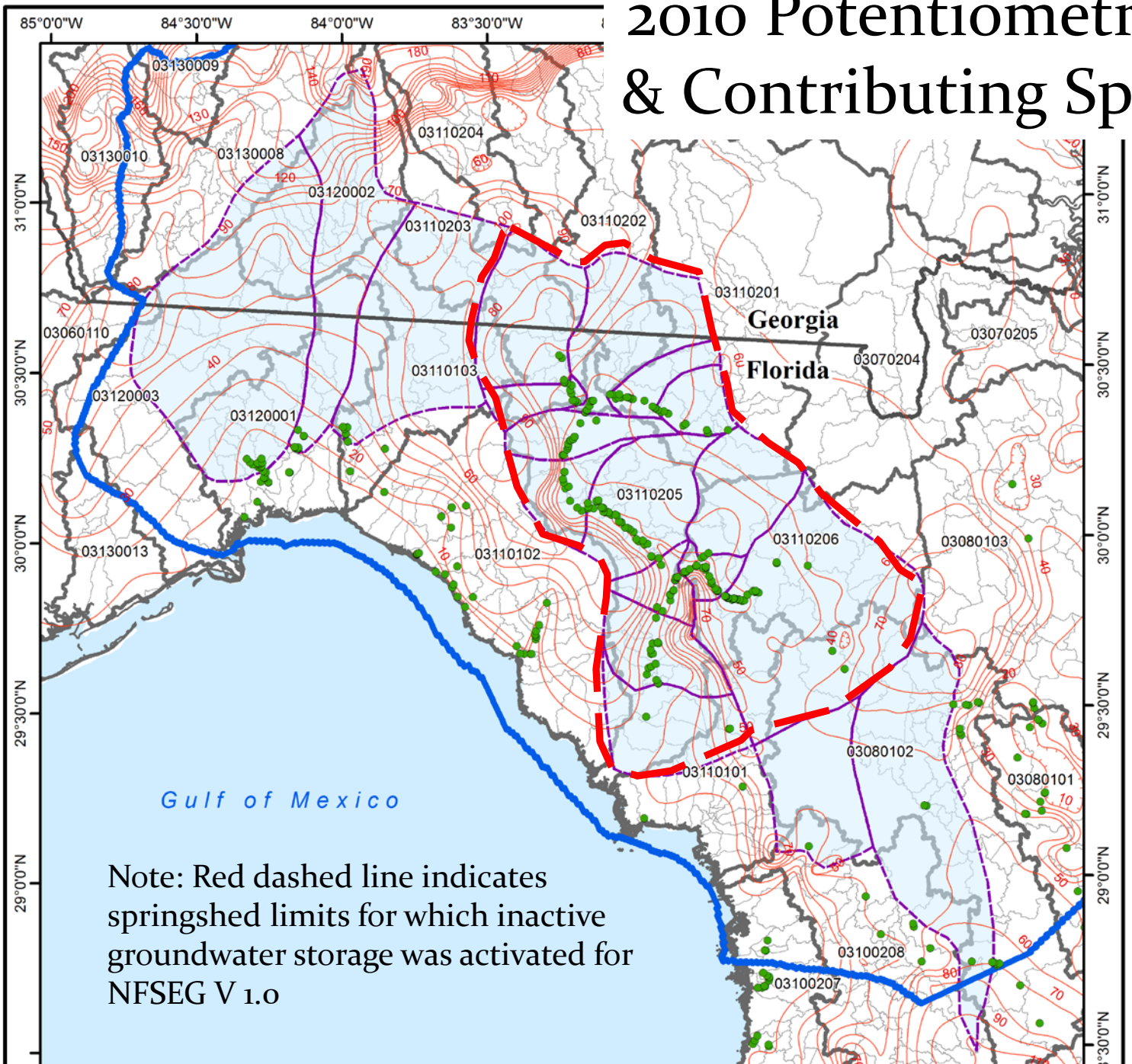
Plan View of Reaches



Cross-sectional View of Sub-Watersheds

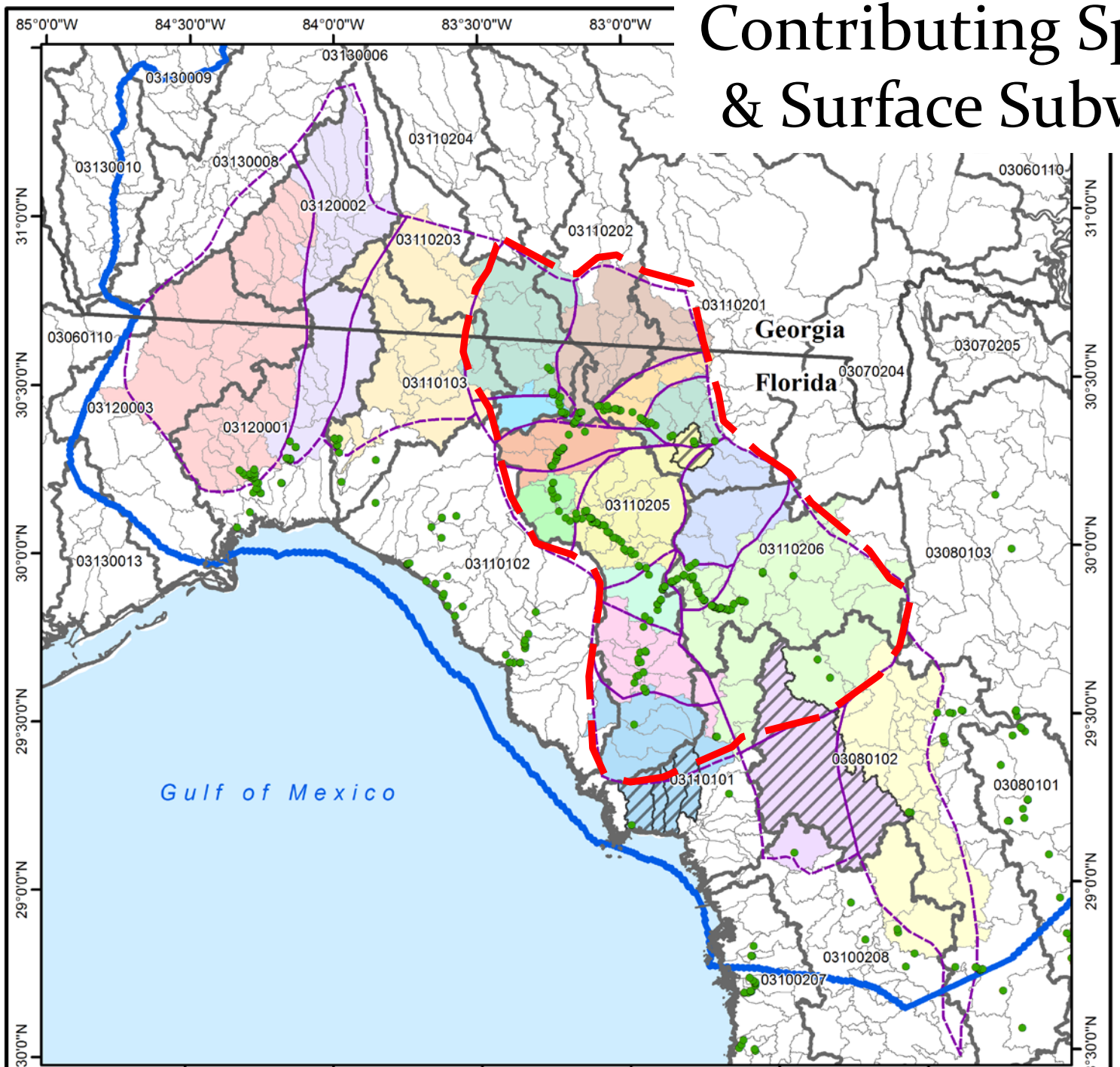


2010 Potentiometric Surface & Contributing Springsheds



Note: Red dashed line indicates springshed limits for which inactive groundwater storage was activated for NFSEG V 1.0

Contributing Springsheds & Surface Subwatersheds



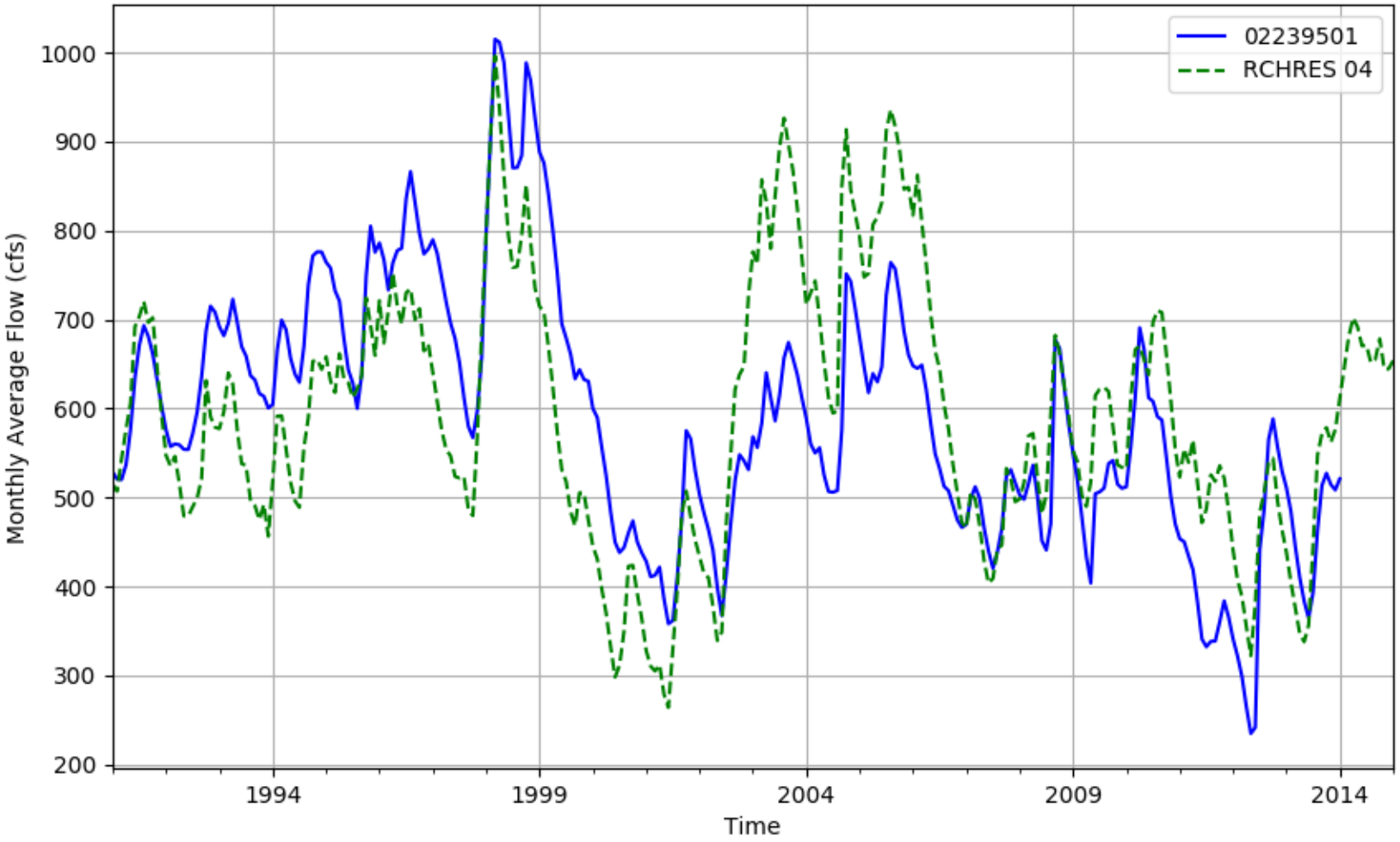
HSPF Function Table

- Table of stage, area, volume, and outflow
- Linear interpolation between records
- Used primarily in HSPF to route flow in channels and reservoirs (RCHRES) downstream
- Inactive Ground Water Storage (IGWS) implemented as a simple RCHRES that receives no precipitation, nor does it evaporate

IGWS Function Table
Silver Springs

Stage (ft)	Area, approx. area of springshed (acres)	Volume (acre ft)	Flow (cfs)
39.5	779574	0	0
46.5	779574	986973	1525

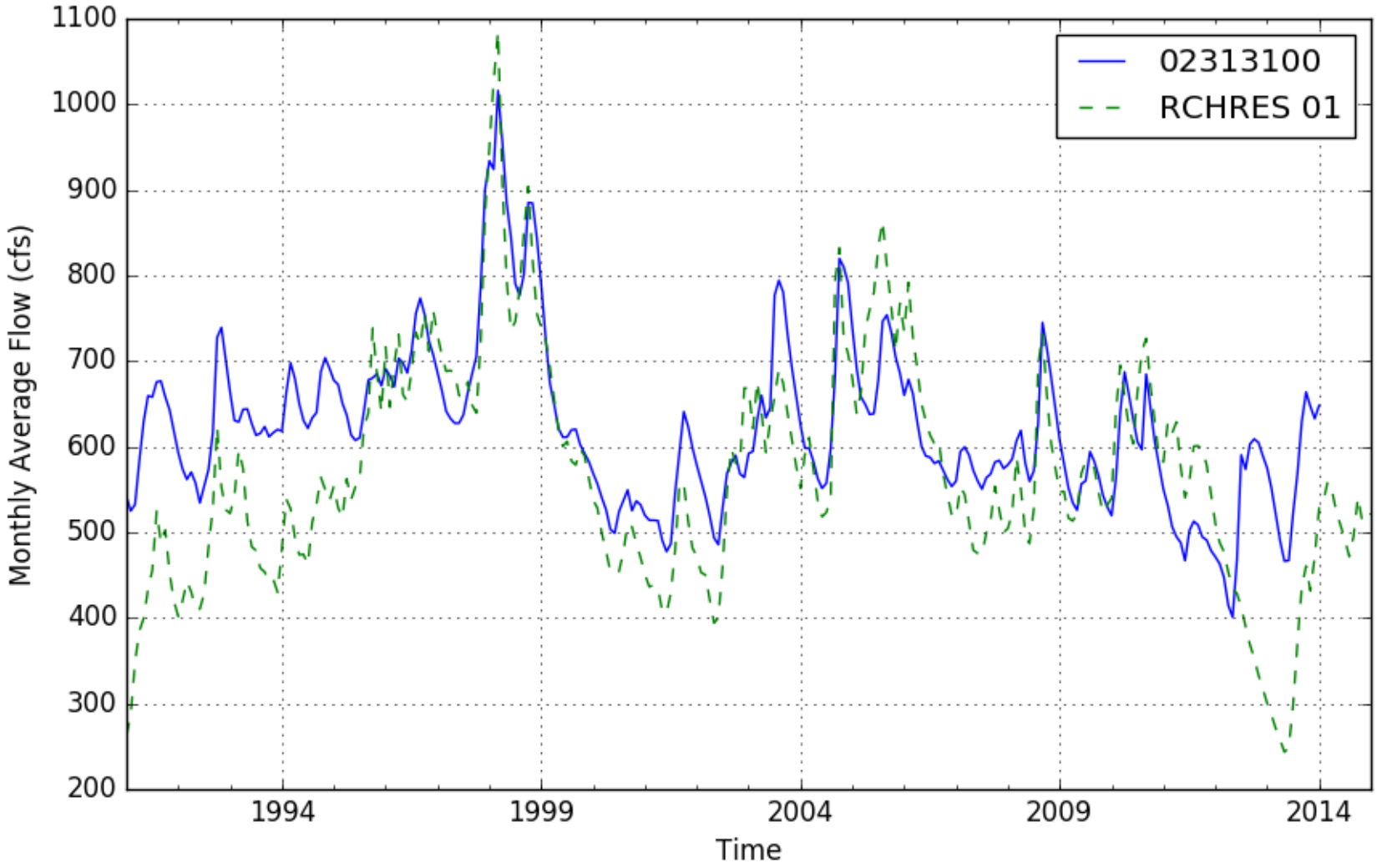
Silver Springs



IGWS Function Table Rainbow Springs

Stage (ft)	Area, approx. area of springshed (acres)	Volume (acre ft)	Flow (cfs)
0	370000	0	0
10	370000	1480000	1178

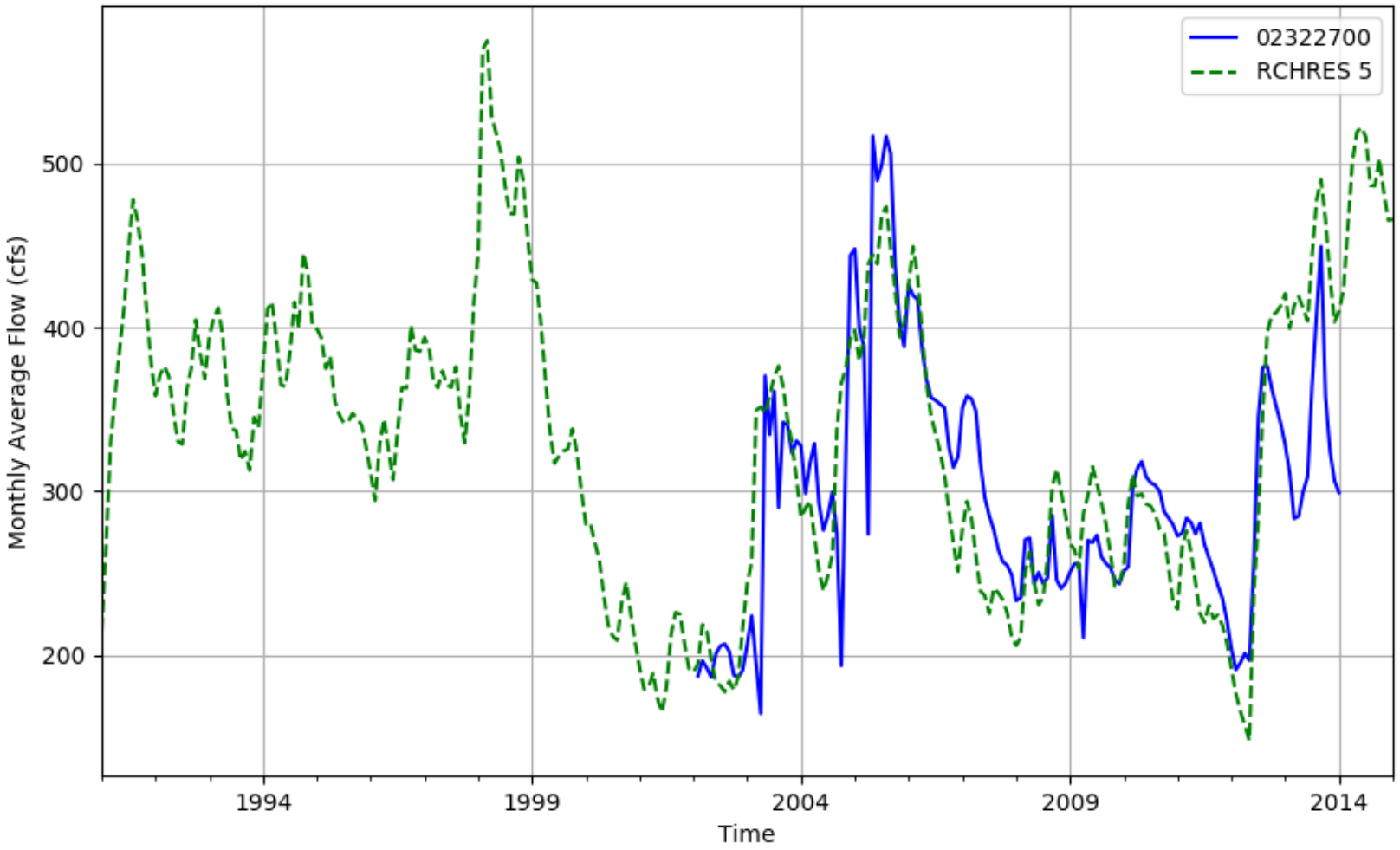
Rainbow Springs



IGWS Function Table Ichetucknee Springs

Stage (ft)	Area, approx. area of springshed (acres)	Volume (acre ft)	Flow (cfs)
0	239258	0	0
10	239258	600346	899

Ichetucknee Springs



Post-Processing

- Develop PERLND ID raster
  - National Land Cover Database (NLCD) 30x30 meter
  - Subwatershed raster
- Develop Look Up Table (LUT)
  - hspfbintoolbox to develop PERLND ID to model output (LUT)
- ViRTual (VRT) spatial dataset
  - http://www.gdal.org/drv_vrt.html
  - Allows for efficient transformation of PERLND ID raster to model output raster using LUT
- QGIS is used for visualization of VRTs (http://qgis.org)
- Zonal statistics to get average across MODFLOW cell

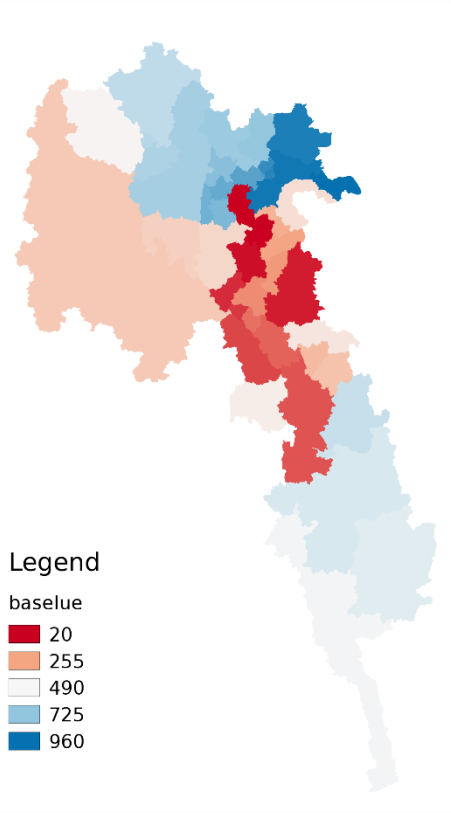
Create Raster of PERLND Labels

- HSPF PERLND labels 1-999
- PERLND label = RCHRES * 20 + HSPF Land Cover

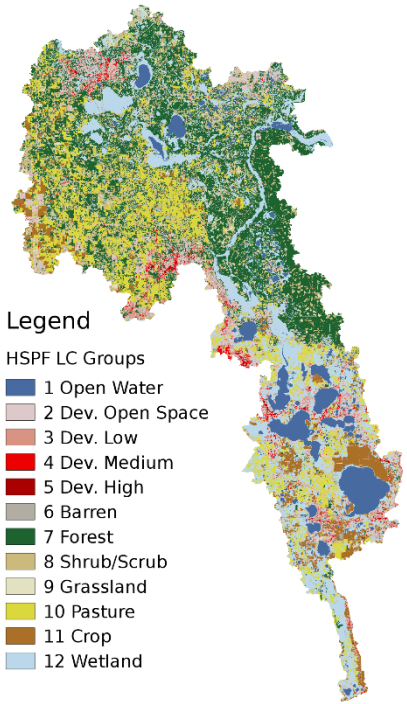
NLCD Land Use	HSPF Land Cover Group Assignment	Approximate Percentage of NFSEG Domain
Water-Open	1: Water	3.3
Developed-Open Space	2: Developed Open Space	5.8
Developed-Low Intensity	3: Developed Low Intensity	2.3
Developed-Medium Intensity	4: Developed Medium Intensity	0.6
Developed-High Intensity	5: Developed High Intensity	0.2
Barren Land	6: Open and barren land	0.4
Forest-Deciduous	7: Forest	8.9
Forest-Evergreen	7: Forest	24.9
Forest-Mixed	7: Forest	2.6
Scrub-Scrub	8: Shrub	5.9
Grassland	9: Rangeland	5.6
Agriculture-Pasture	10: Pasture	8.1
Agriculture-Cultivated Crops	11: Agricultural general	8.4
Wetlands-Woody	12: Wetlands	18.9
Wetlands-Emergent Herbaceous	12: Wetlands	4.0

VRT Raster Look Up Table (LUT)

baselue.vrt



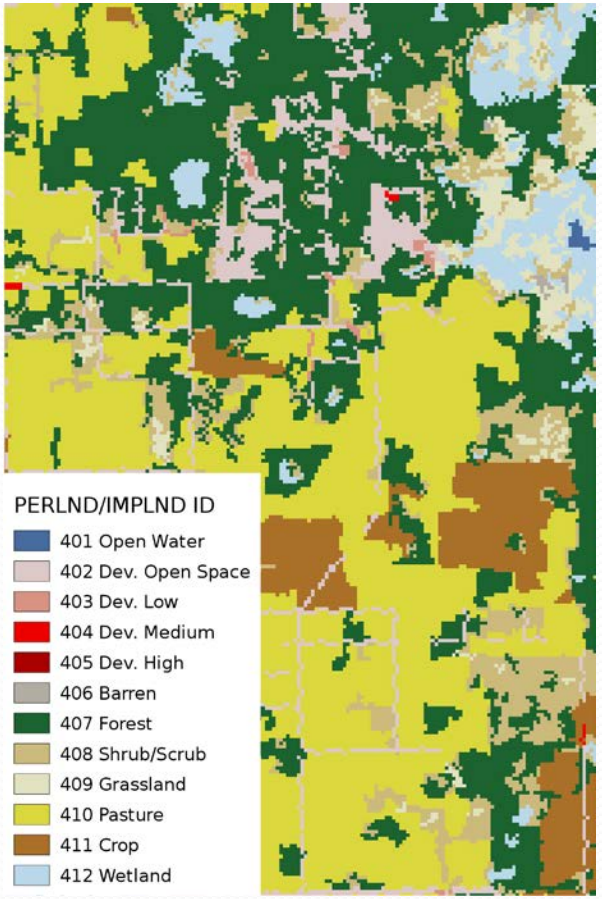
hspflue.vrt



PERLND Raster

```
gdal_calc.py
      -A baselue.vrt
      -B hspf_lc.vrt
      --calc=A+B
      --outfile=lue.tif
      --NoDataValue=-9999
      --type=Int16
      --co COMPRESS=DEFLATE
      --co PREDICTOR=2
      --co TILED=YES
      --overwrite
```

=



hspfbintoolbox

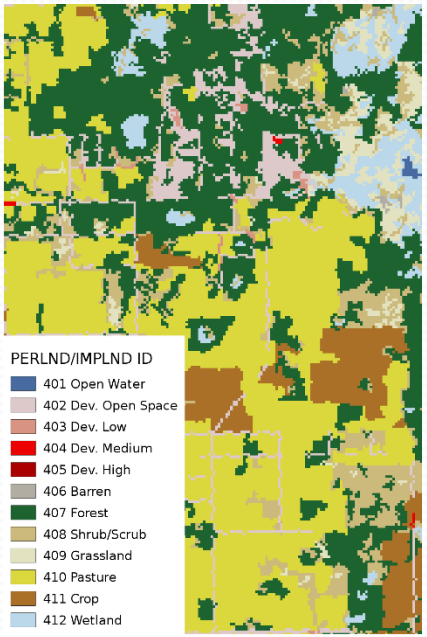
- hspfbintoolbox extracts results from HSPF binary files
- Python, cross-platform tool
- Command line and Python library
- Installation (typical):

```
pip install hspfbintoolbox
```

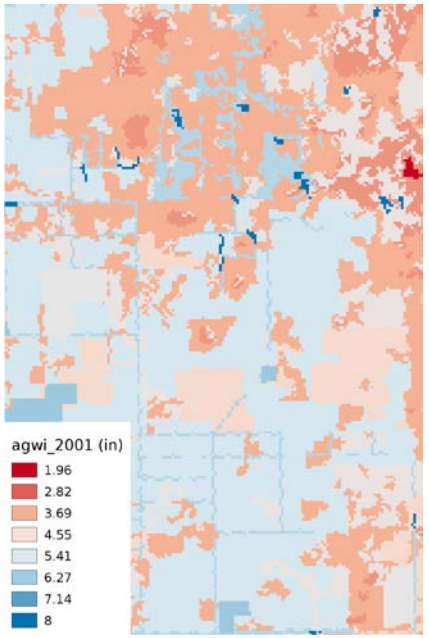
- Used to create Look Up Tables for nearly all HSPF variables, yearly, and monthly

VRT Raster Look Up Table (LUT)

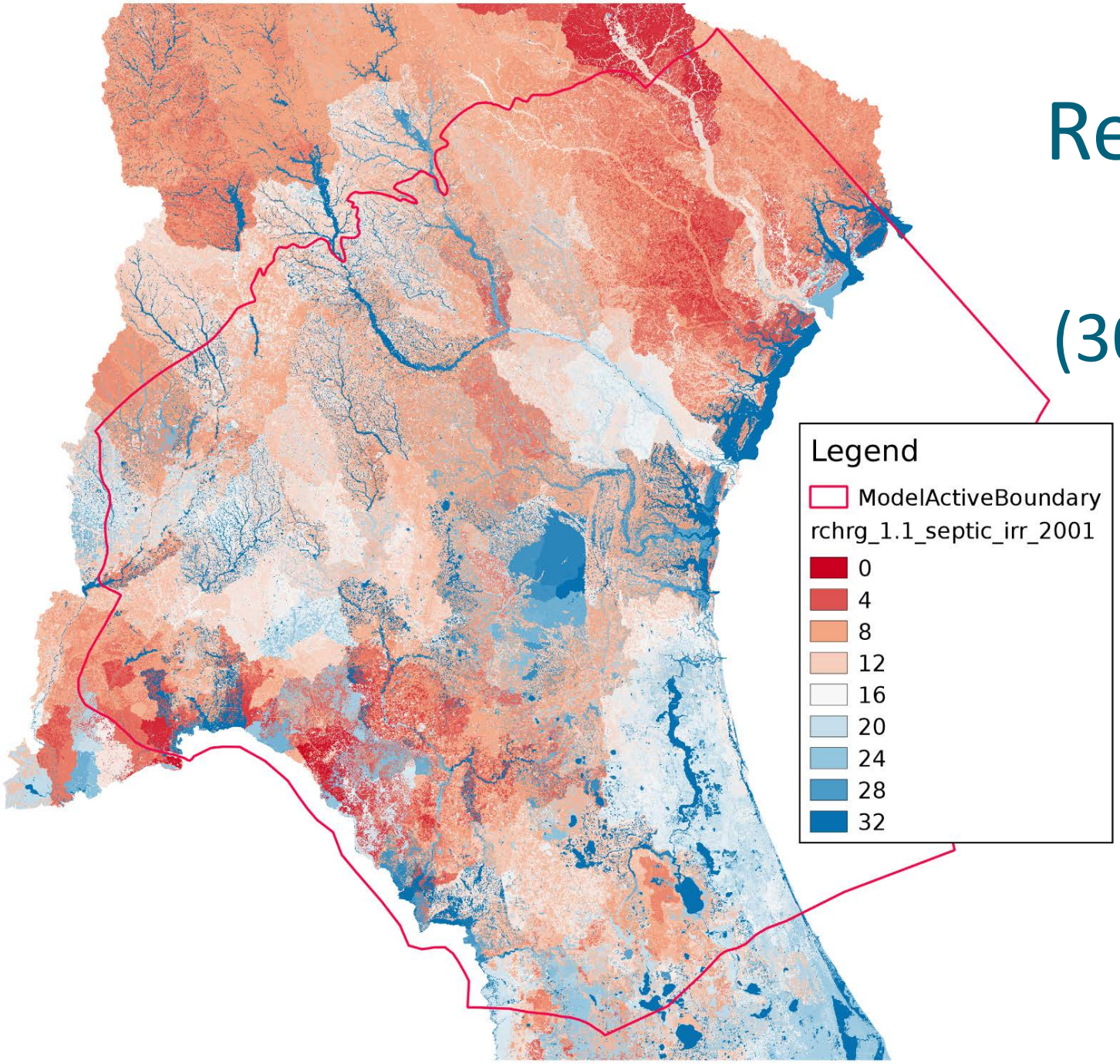
PERLND ID → **agwi_septic_irr_2001.vrt**



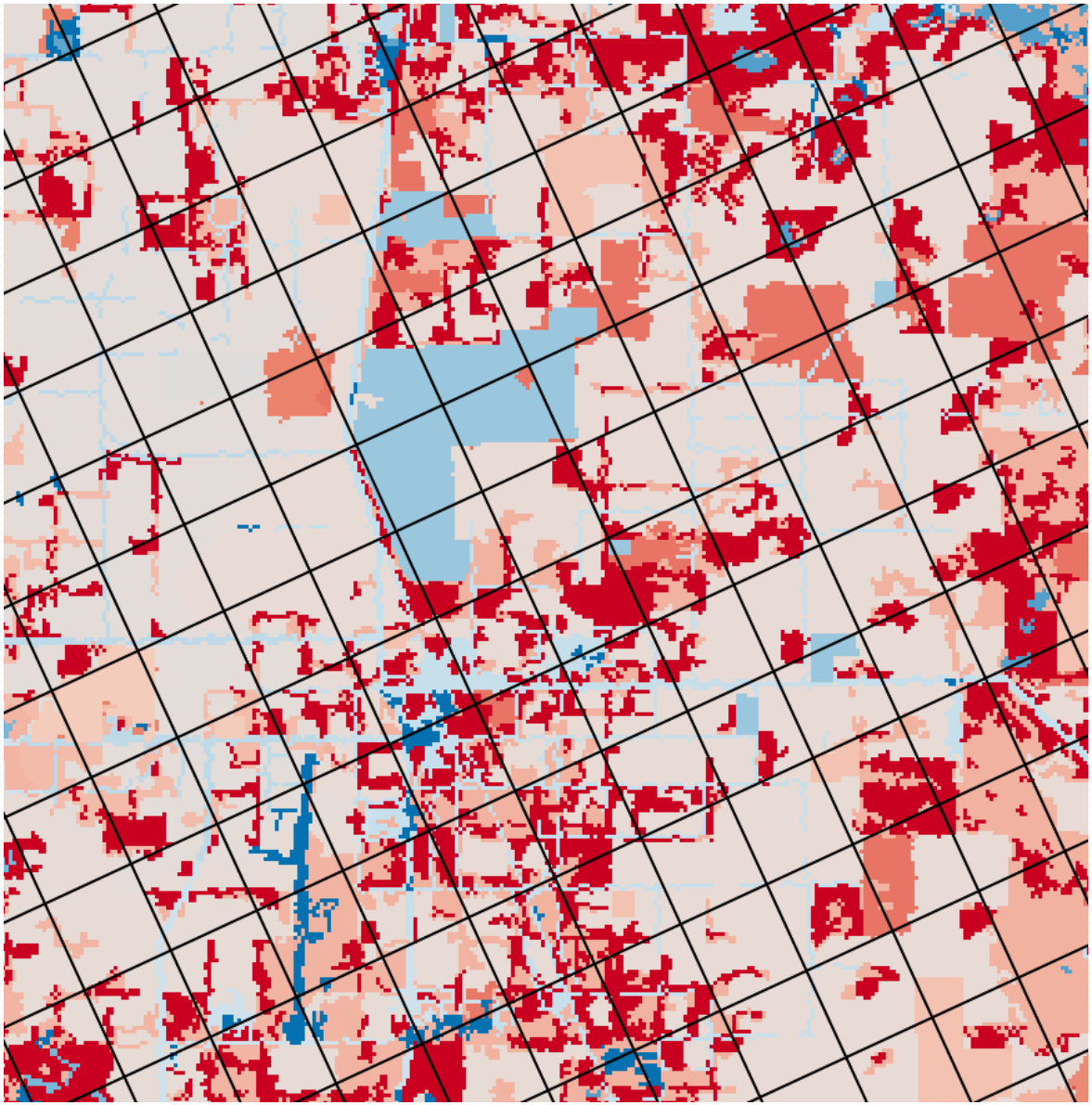

```
<VRTDataset rasterXSize="3554" rasterYSize="
 <SRS>PROJCS["NAD83(HARN) / Florida GDI
 <GeoTransform>  5.3594982359709428e+05,
 <VRTRasterBand
      dataType="Float32" band="1">
  <NoDataValue>-9999</NoDataValue>
  <ComplexSource>
   <SourceFilename relativeToVRT="1">
     ../gis/lue_irr.tif</SourceFilename>
   <SourceBand>1</SourceBand>
   <SourceProperties RasterXSize="3554" Rast
   <SrcRect xOff="0" yOff="0" xSize="3554" yS
   <DstRect xOff="0" yOff="0" xSize="3554" yS
   <NODATA>0</NODATA>
   <LUT>401:1.9615,402:5.9667,403:40.548,404
  </ComplexSource>
 </VRTRasterBand>
</VRTDataset>
```



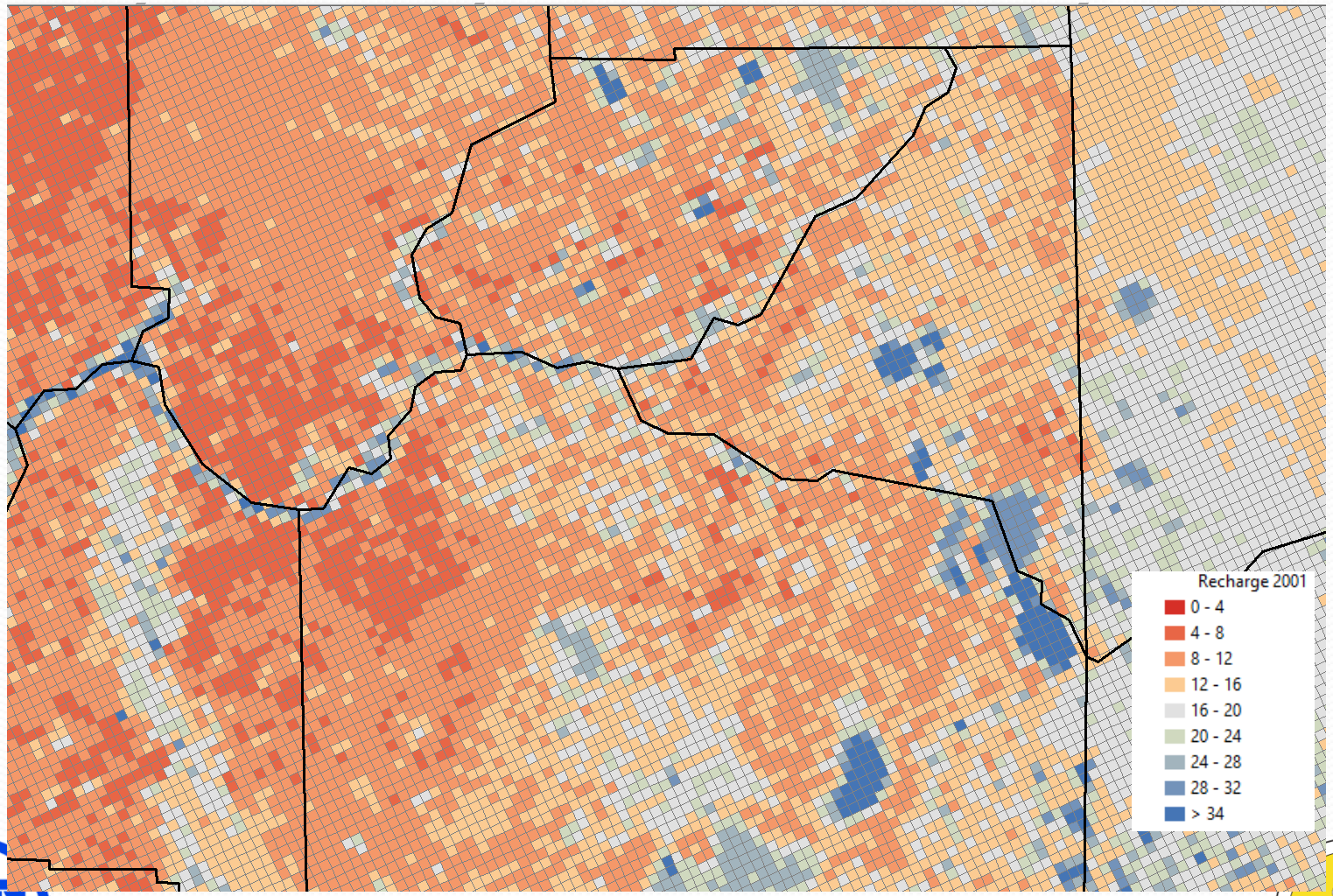
Recharge 2001 (30m Grid)



Zonal Statistics



RECHARGE 2001 - MODFLOW GRID



Next Steps - HSPF

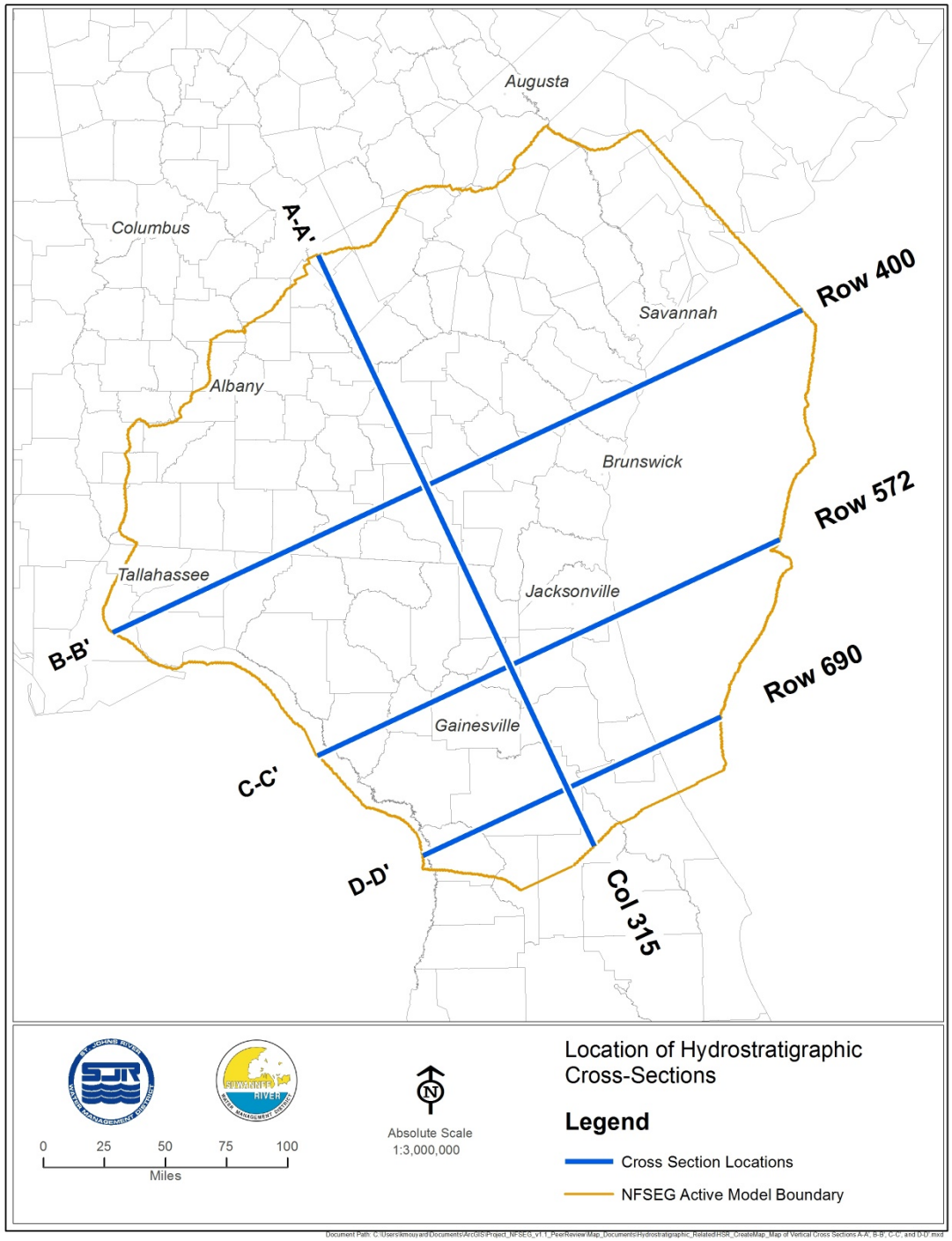
- Implement areal recharge for select closed basins
- Currently simulated as sinks with direct injection to Layer 3
- Other feedback from peer review panel

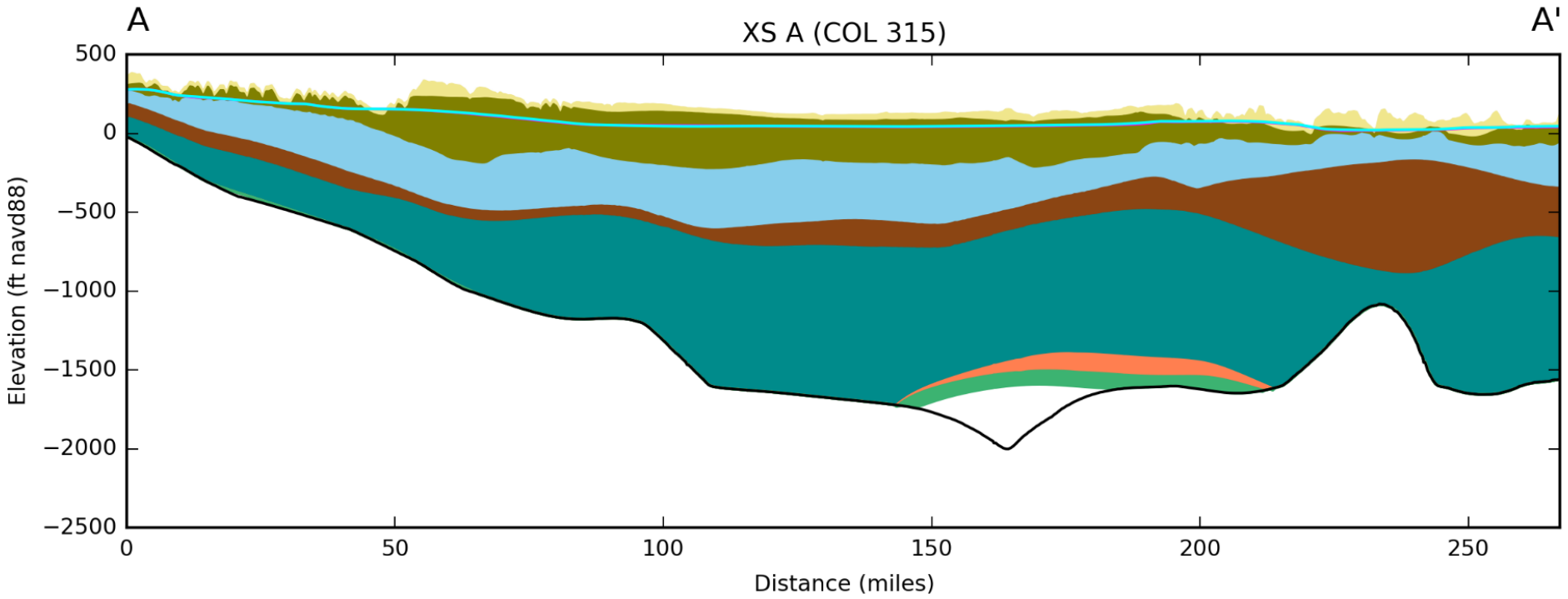
Overview Of Phase 1 Interim Results – MODFLOW Case 004b

Improvements/Status

- Merged multiple river and drain boundaries used to represent flowlines within individual grid cells into single river and drain boundaries
- Updated methodology for calibration of river and drain conductances
- Updated Recharge and MSET arrays
- Created synthetic SAS water-level targets in areas where simulated SAS water levels were deemed too high or low but available SAS observations were unavailable or sparse
- Improved spring flow estimates
- Added additional flowlines to areas of simulated flooding
- Removed MNW2 wells with flux rates of 0 cfs
- **<u>Effects of listed changes include</u>**:
  - improved representation of groundwater levels and flows
  - increased model stability and decreased model runtimes.

Cross Section Locations

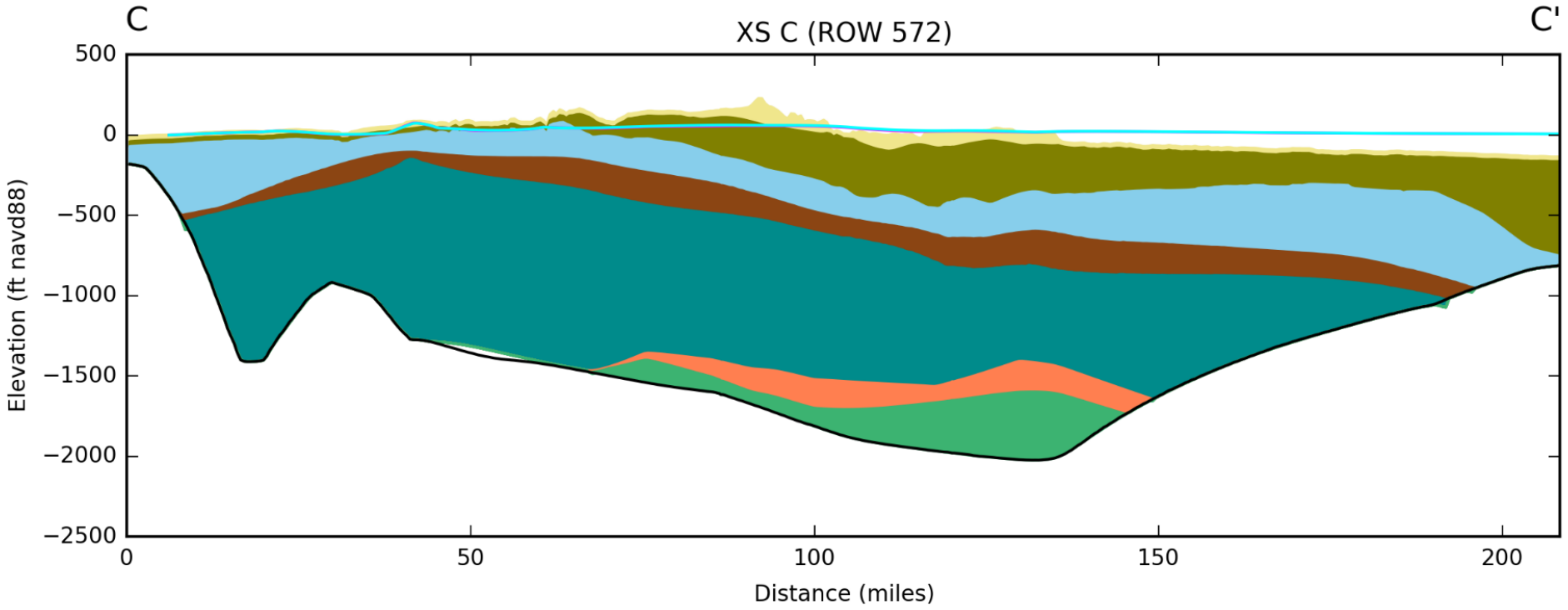


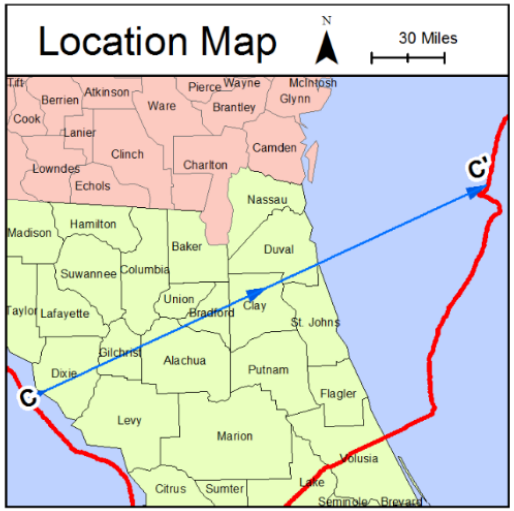


LEGEND

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5
- Layer 6
- Layer 7
- 2001 UFA Potentiometric Surface
- 2009 UFA Potentiometric Surface
- Elevation of 10,000 mg/L TDS

Figure # Cross Sections
XS A (COL 315)





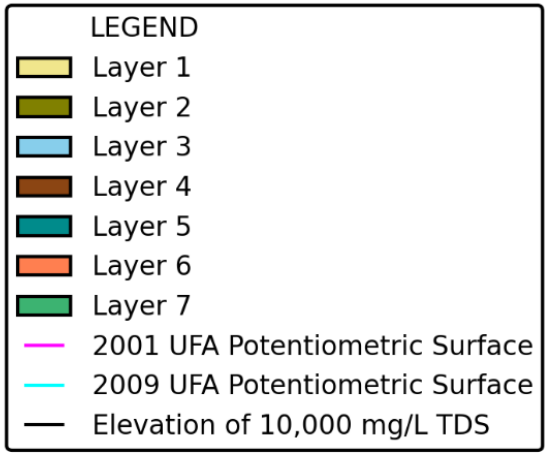
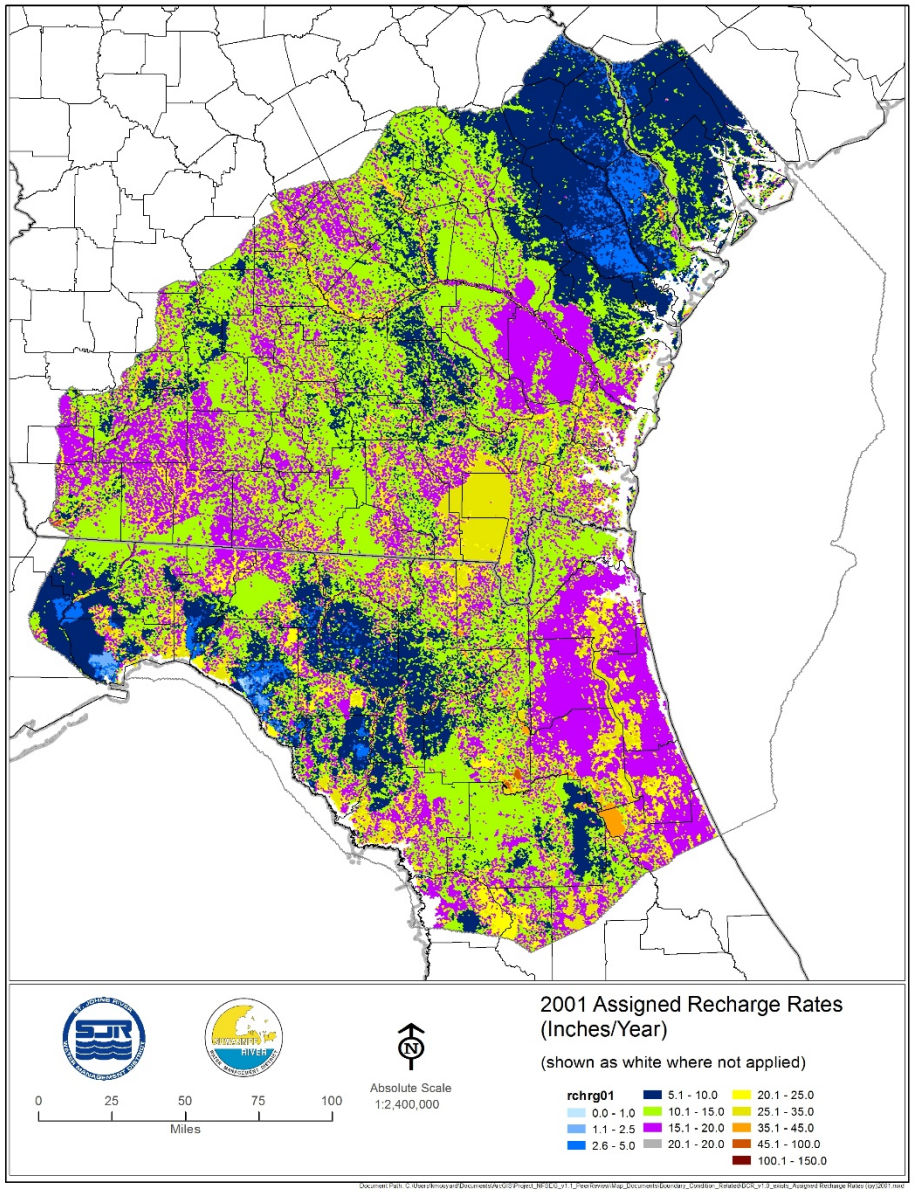
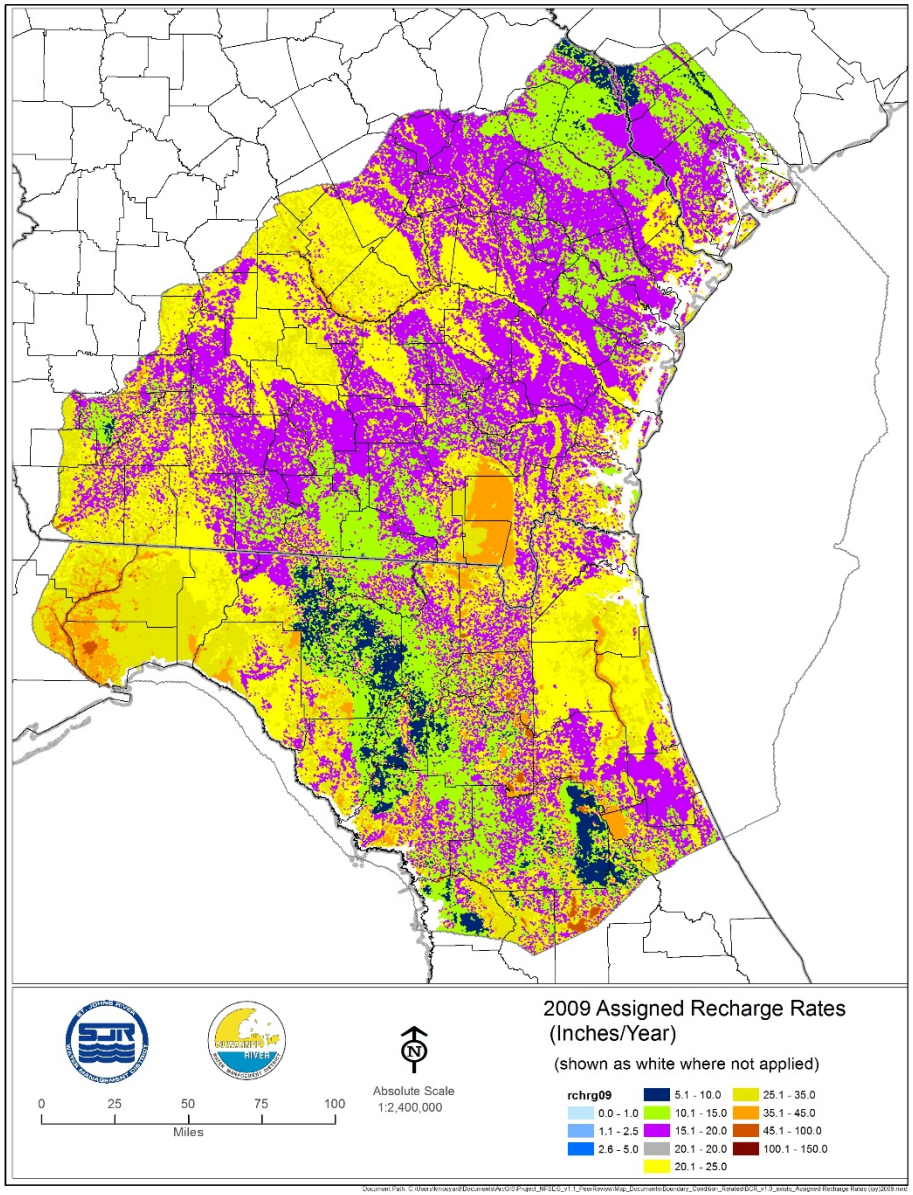
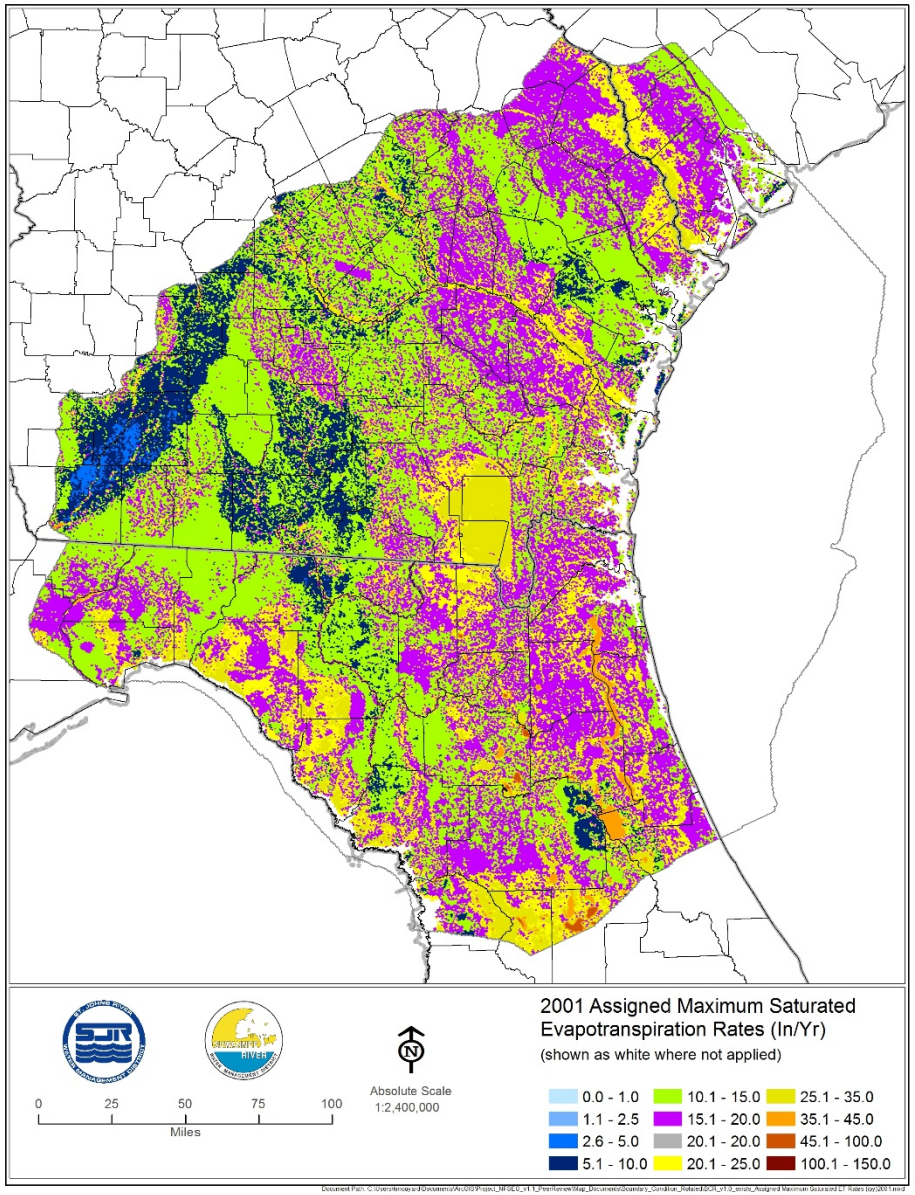


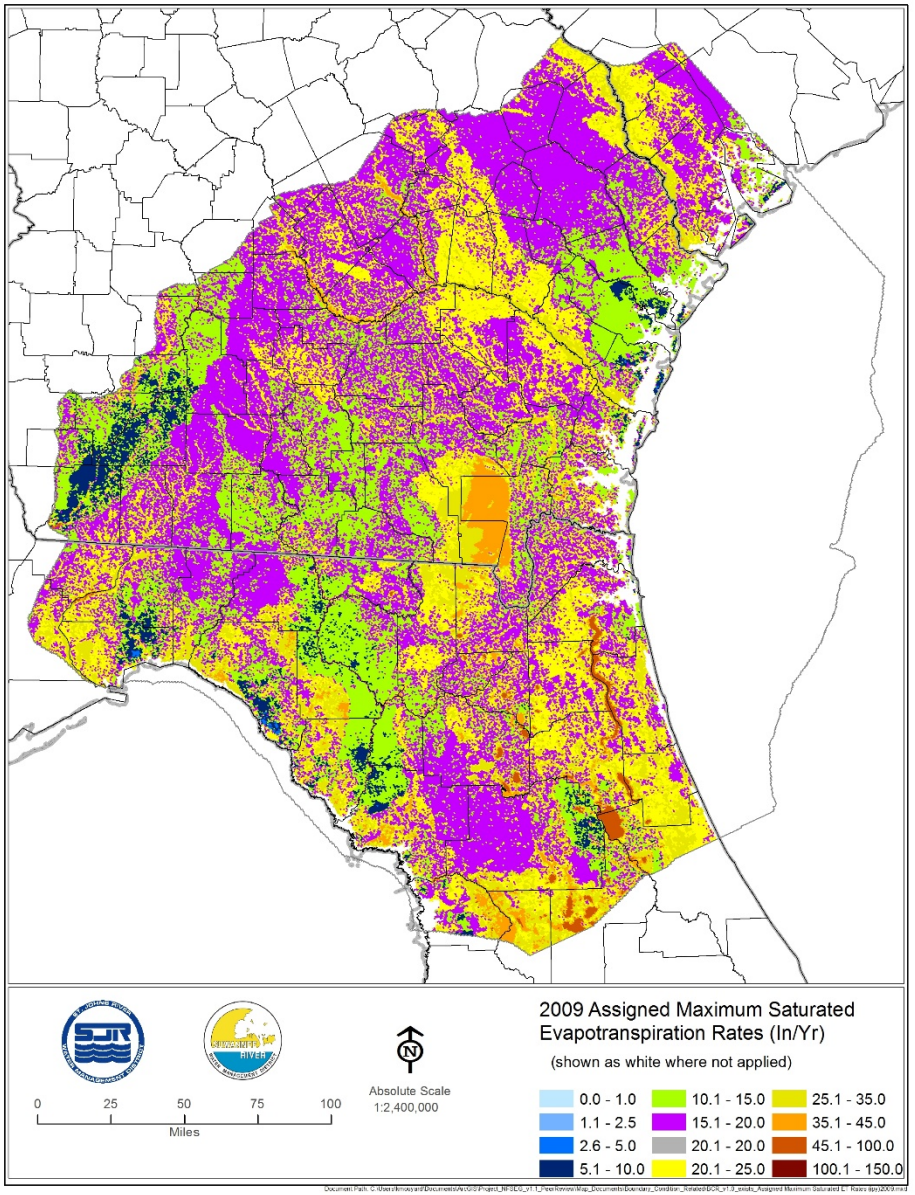
Figure # Cross Sections
XS C (ROW 572)





Recharge 2001/2009





Max. Sat. ET 2001/2009

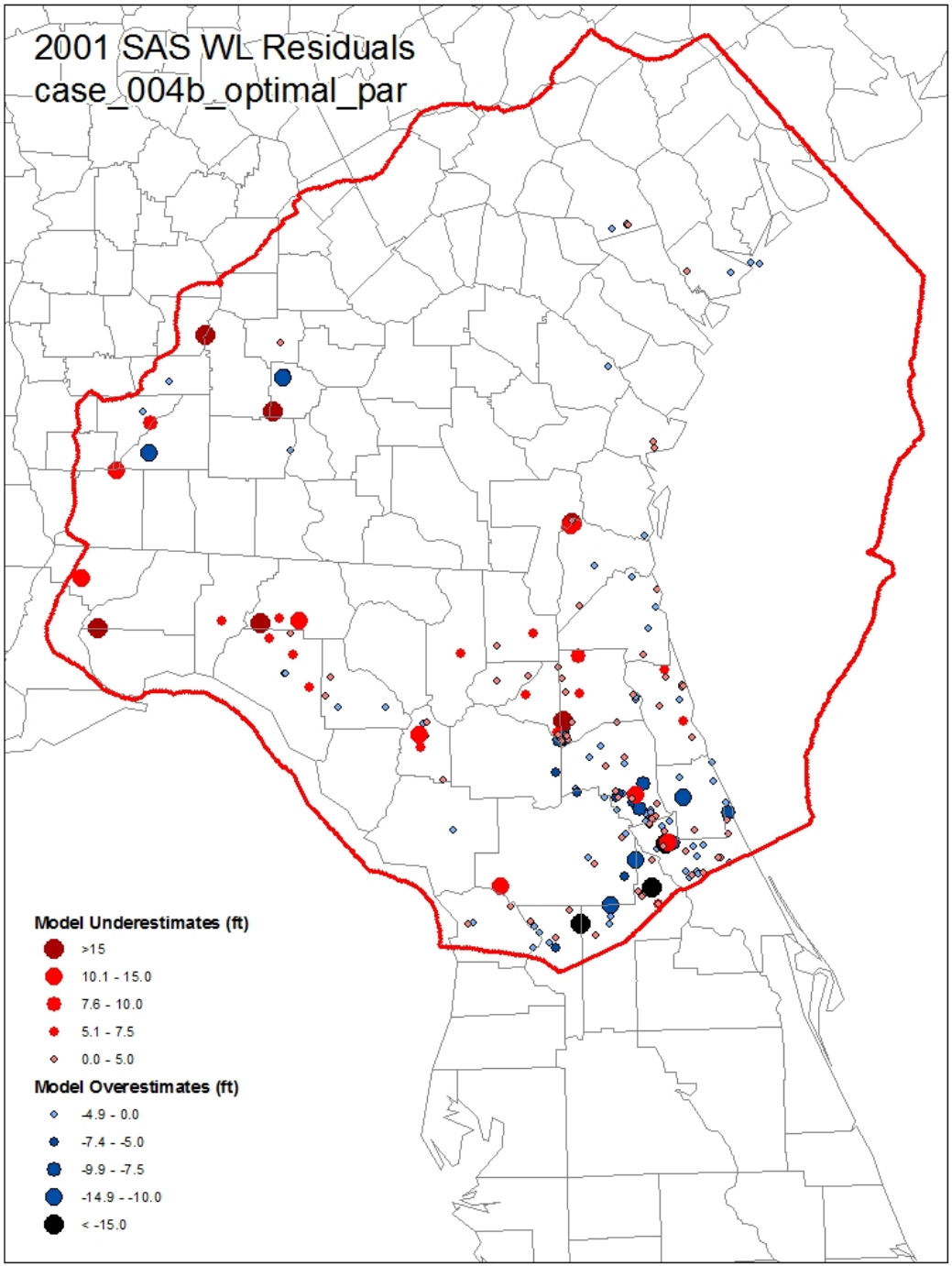
Calibration/History Match Objectives

- Fundamental objective:
  - Develop improved tool to support water-supply decision making
- Guiding principles:
  - Make efficient use of available data
  - Employ observations that inform predictions of interest
  - Utilize a wide variety of observation types
  - Uncertainty analysis of model parameters and key predictions
  - Provide a framework for continued improvement in the model and its use to support decision making
- Objectives:
  - Aspire to parameter and prediction estimates that are, ideally, unbiased and of minimum error variance
  - Avoid overfitting (can increase predictive uncertainty)
  - Reasonable estimates of parameter values

Calibration Statistics – Case 004b

Statistical Criterion	Proposed Target	All Target Wells		Model Layer 1		Model Layer 3		Model Layer 5	
		2001	2009	2001	2009	2001	2009	2001	2009
-5 feet < Residual < 5 feet	80%	69	71	69	76	73	72	59	61
-2.5 feet < Residual < 2.5 feet	50%	40	46	41	52	43	46	31	46
Mean Error		-0.04	0.06	0.65	0.84	-0.73	-0.79	0.57	0.92
Root Mean Square of Error		7.12	8.82	7.53	11.87	5.05	4.94	5.28	5.41
Mean Absolute Error		4.59	4.72	4.95	5.41	3.81	3.71	4.40	4.17
Number of Targets		1357	1721	228	567	979	990	39	41

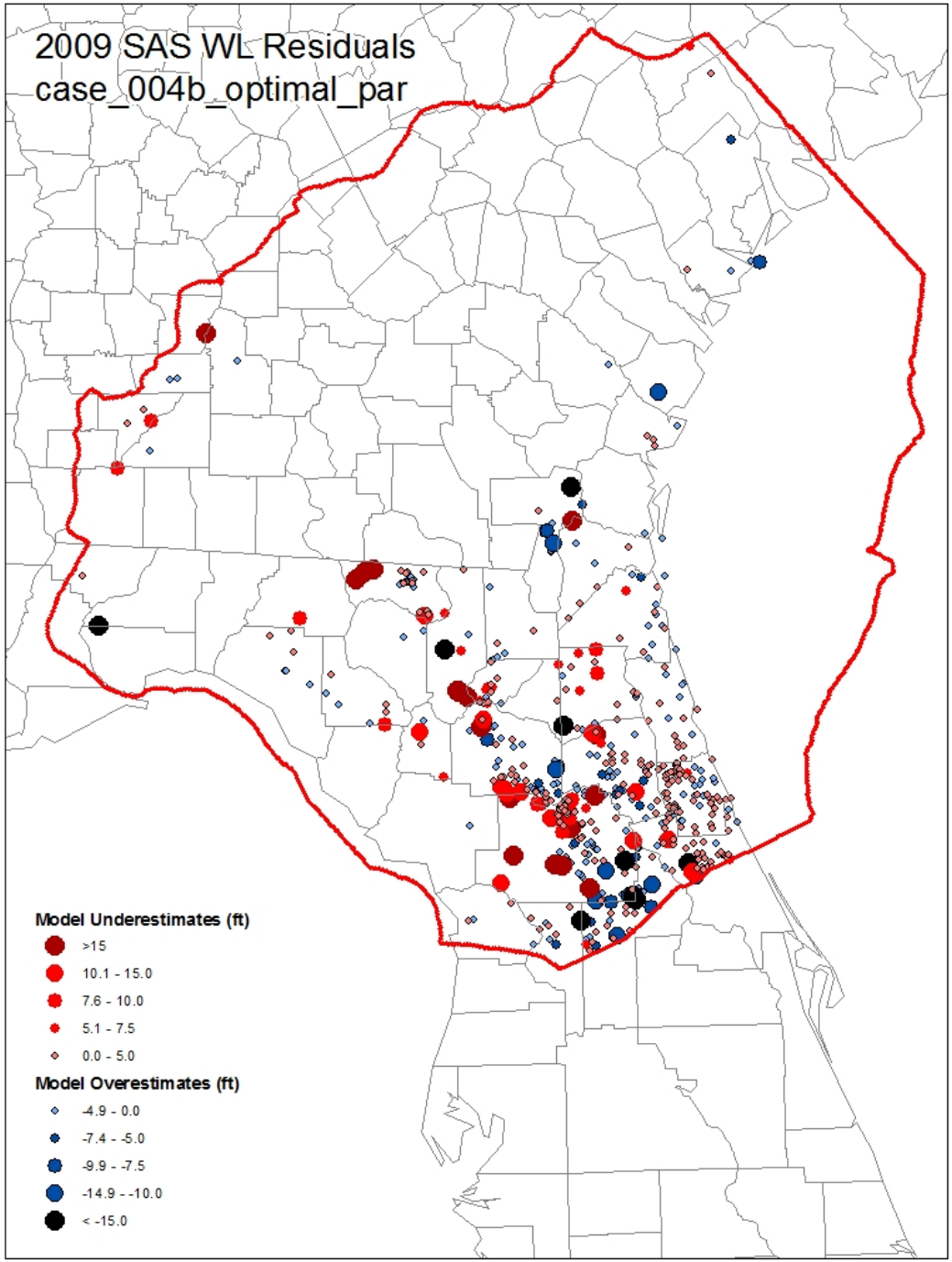
Note: The proposed target statistical criterion are aspirational, not absolute.



GW Level Residuals

Layer 1

2001

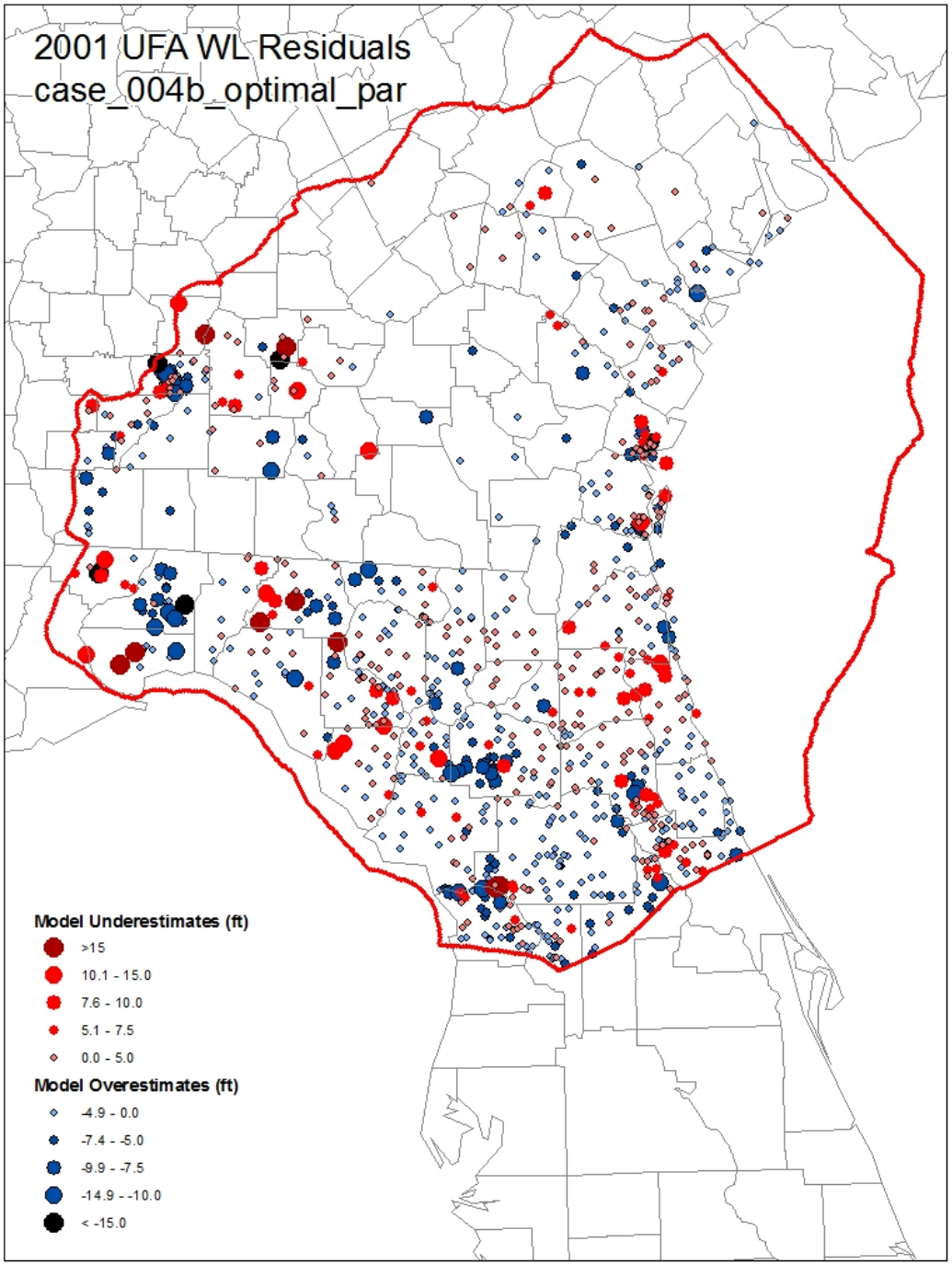


GW Level Residuals

Layer 1

2009

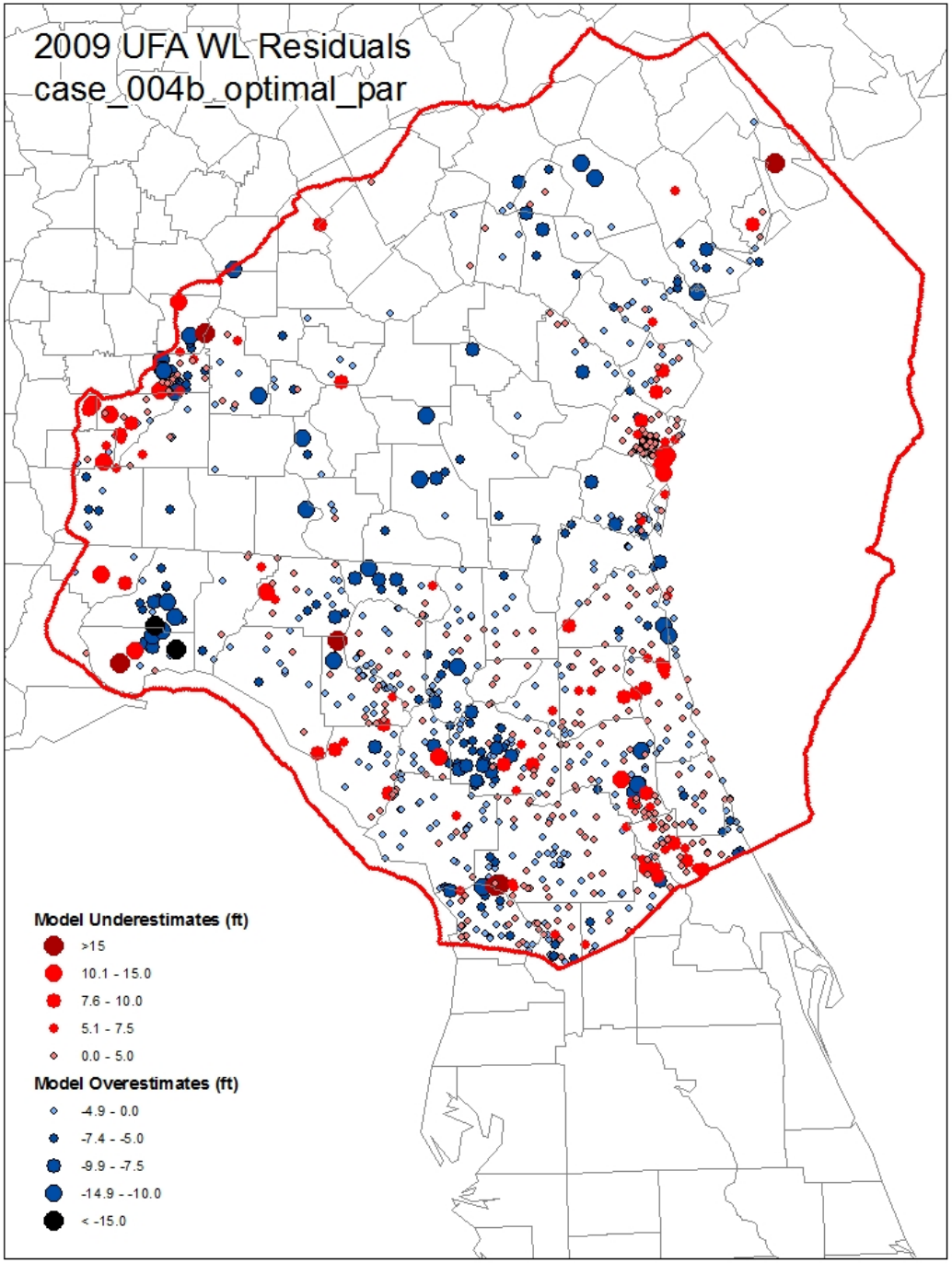
Note: includes synthetic targets



GW Level Residuals

Layer 3

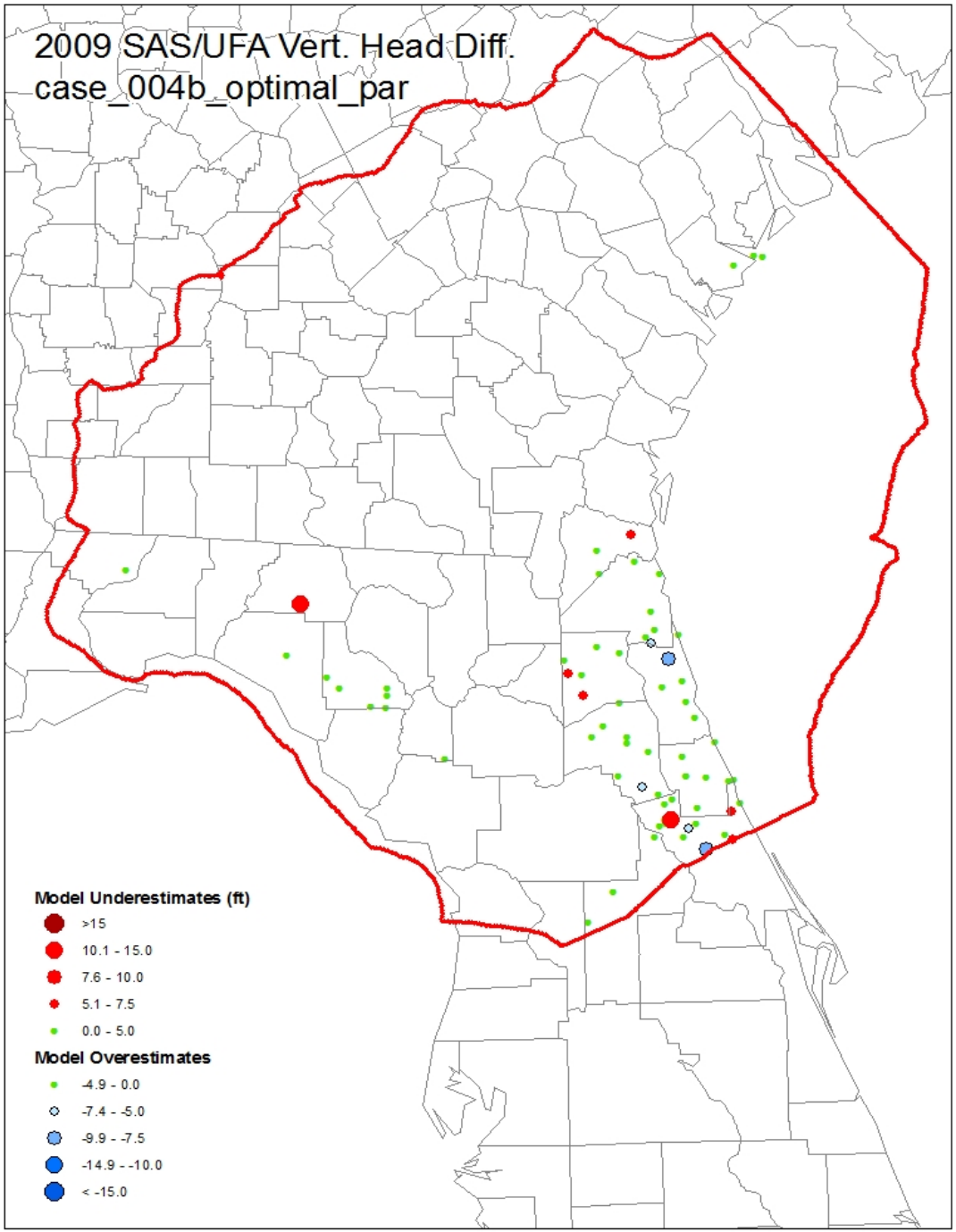
2001



GW Level Residuals

Model Layer 3

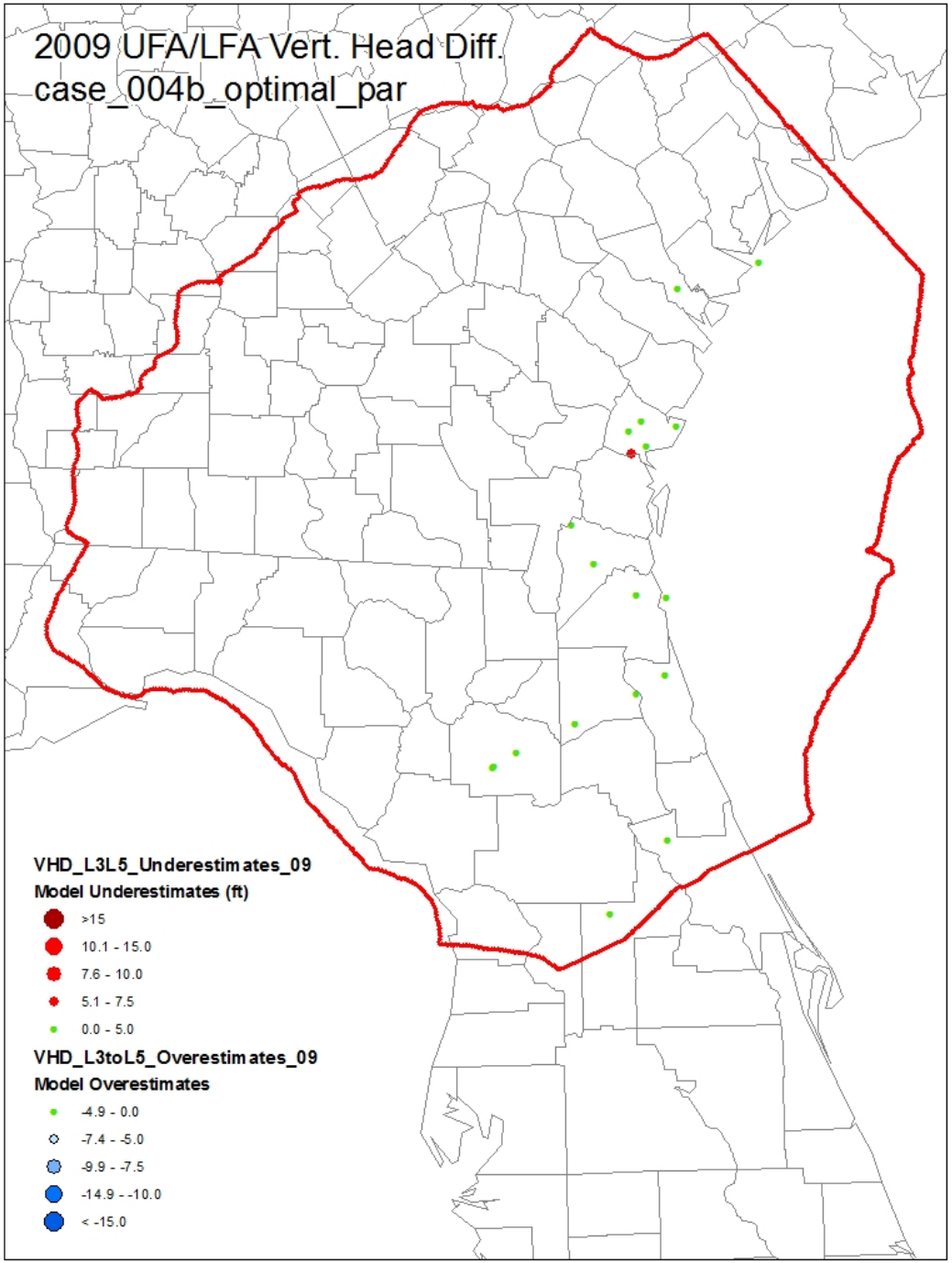
2009



Vertical Head Difference Residuals

Differences between model Layers 1 and 3

2009



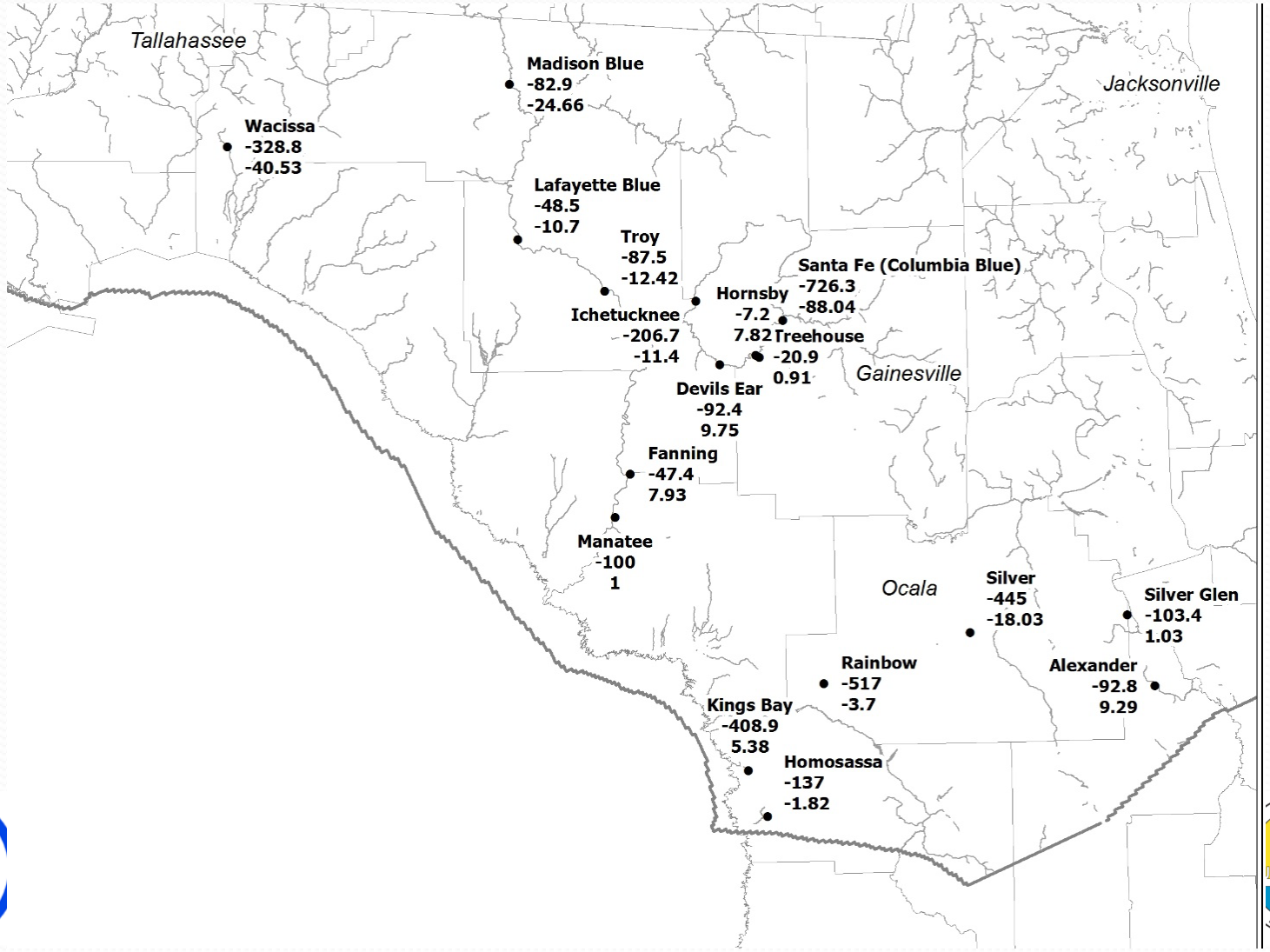
Vertical Head Difference Residuals

Differences between model Layers 3 and 5

2009

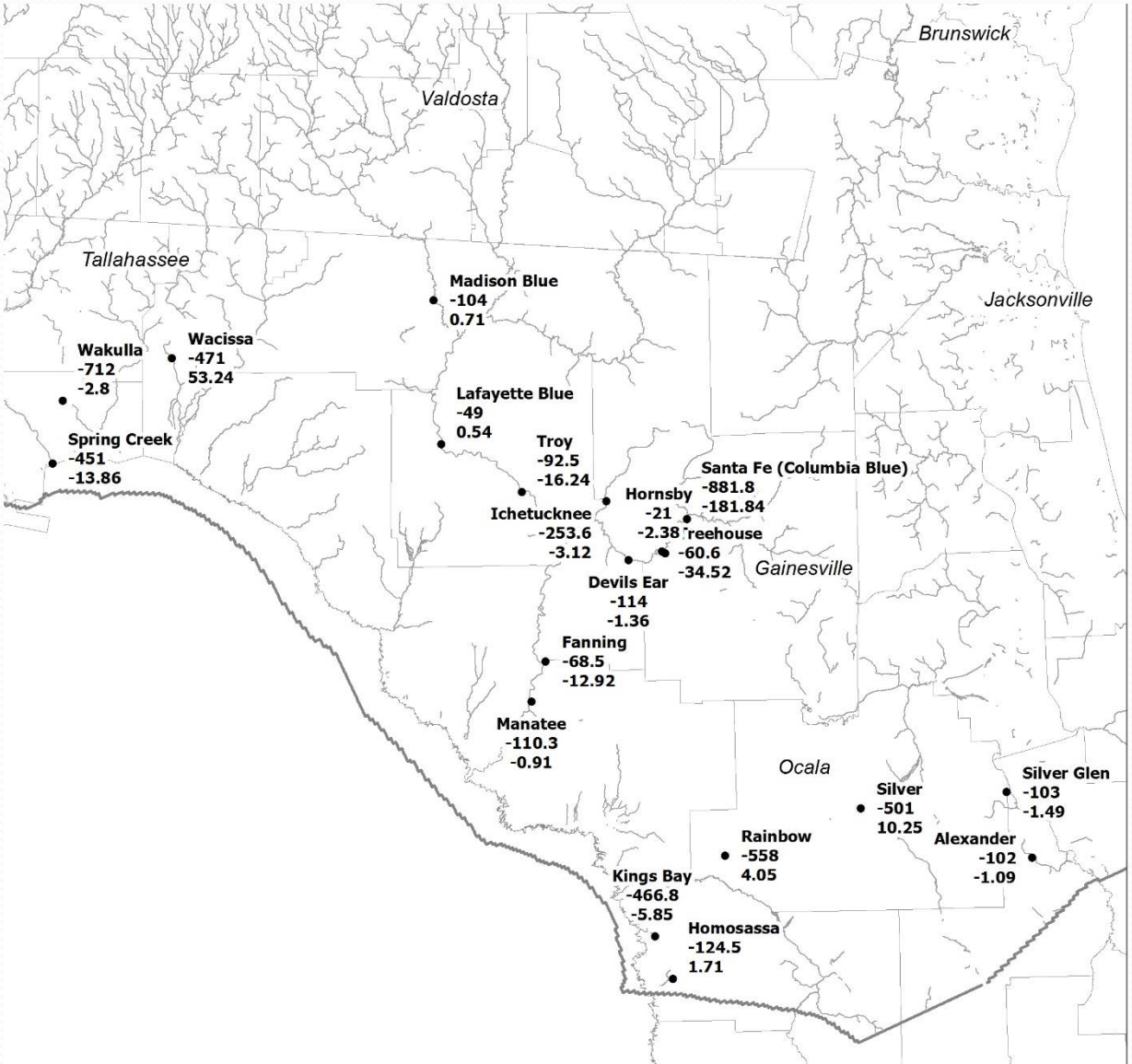
Magnitude 1 Springs & Spring Groups

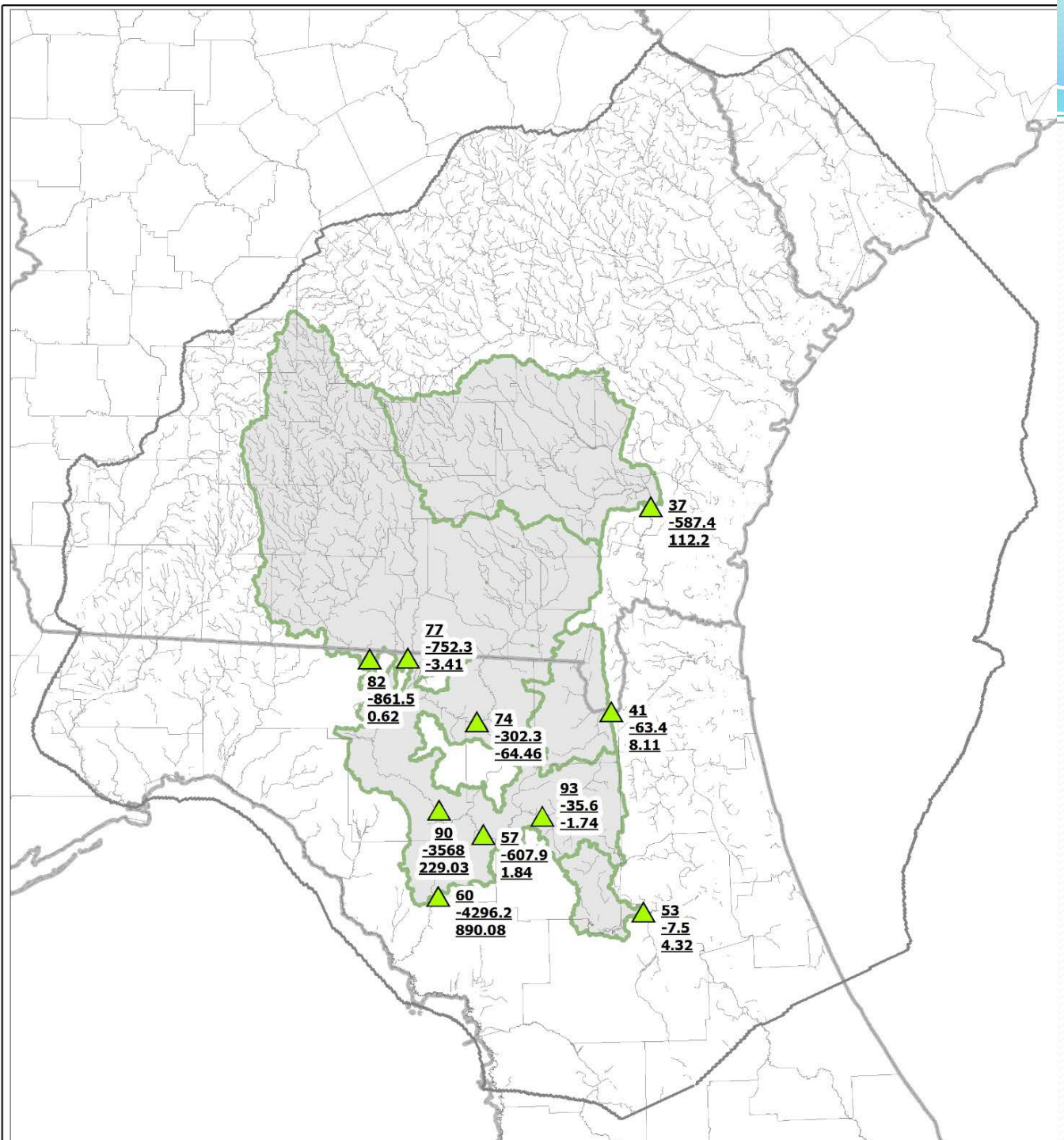
2001 Observed Flows and Residuals (cfs)



Magnitude 1 Springs & Spring Groups

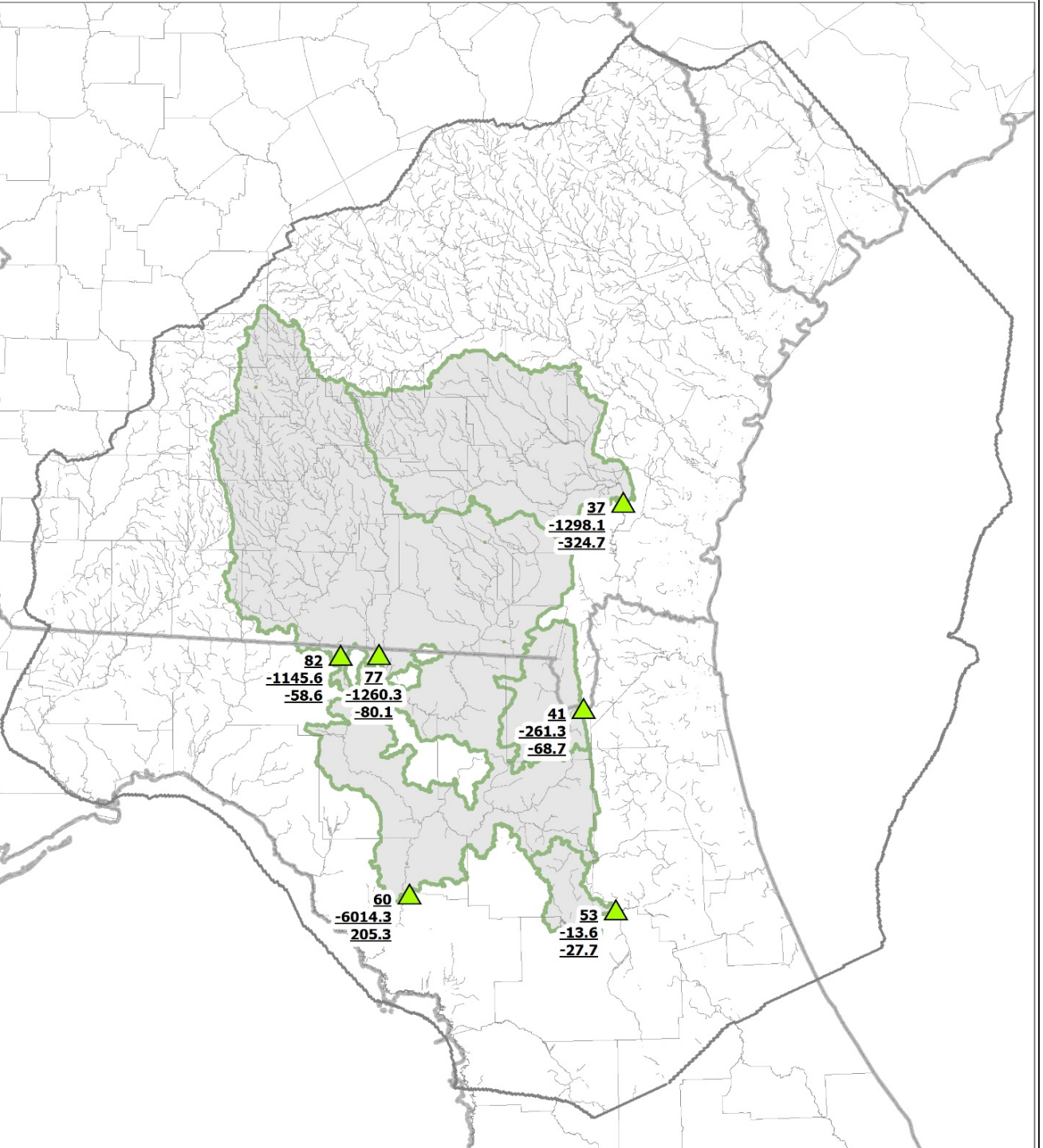
2009 Observed Flows and Residuals (cfs)





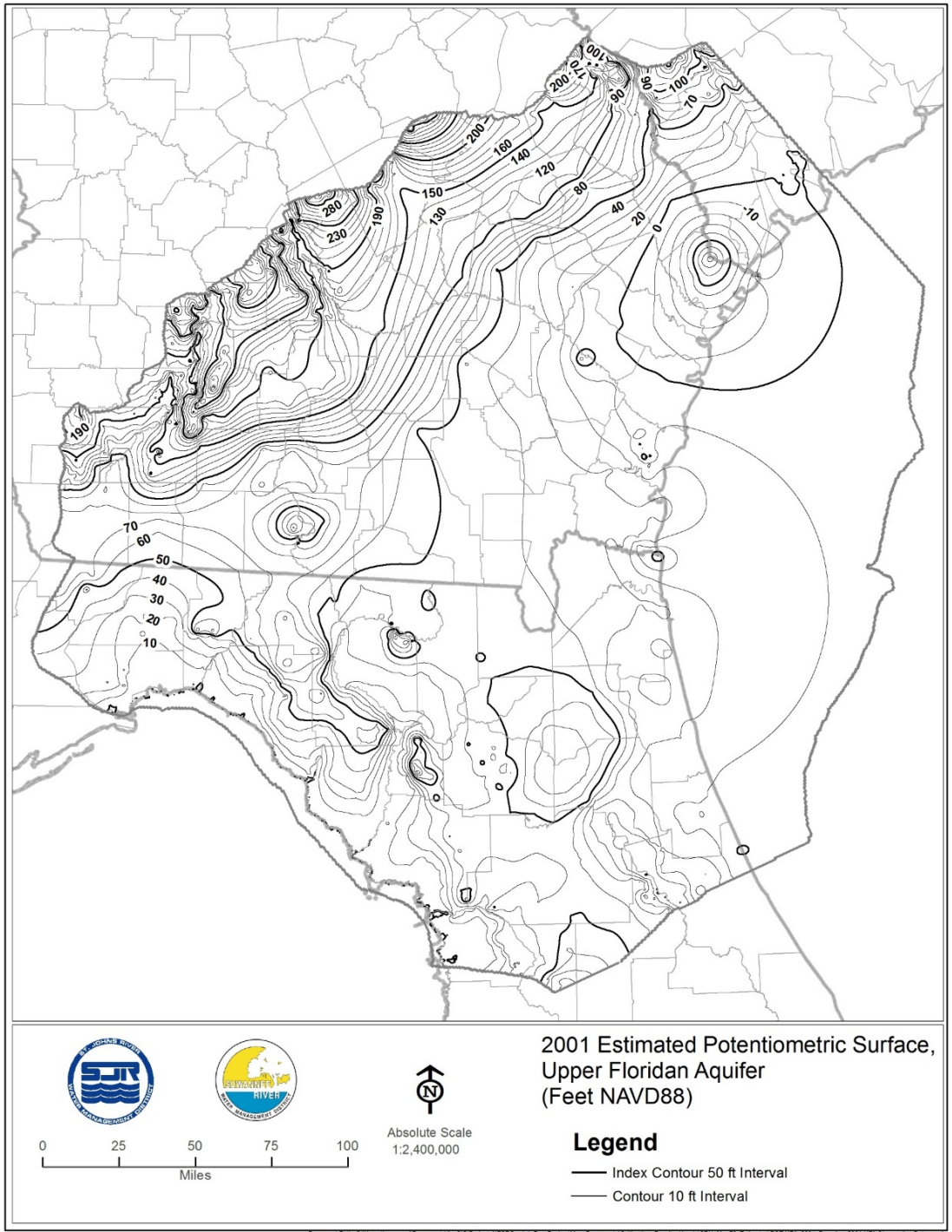
Estimated Cumulative Baseflows and Residuals

2001



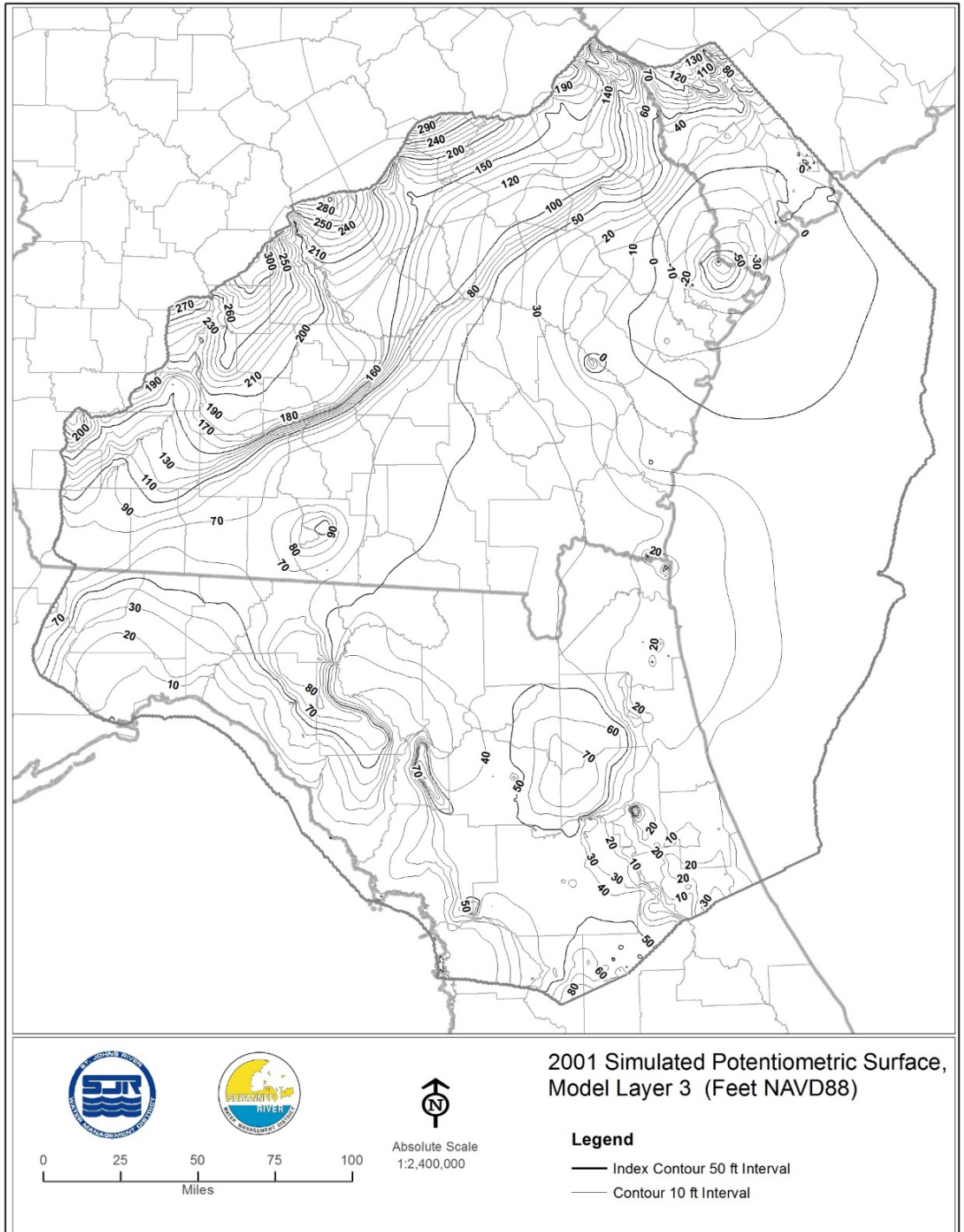
Estimated Cumulative Baseflows and Residuals

2009



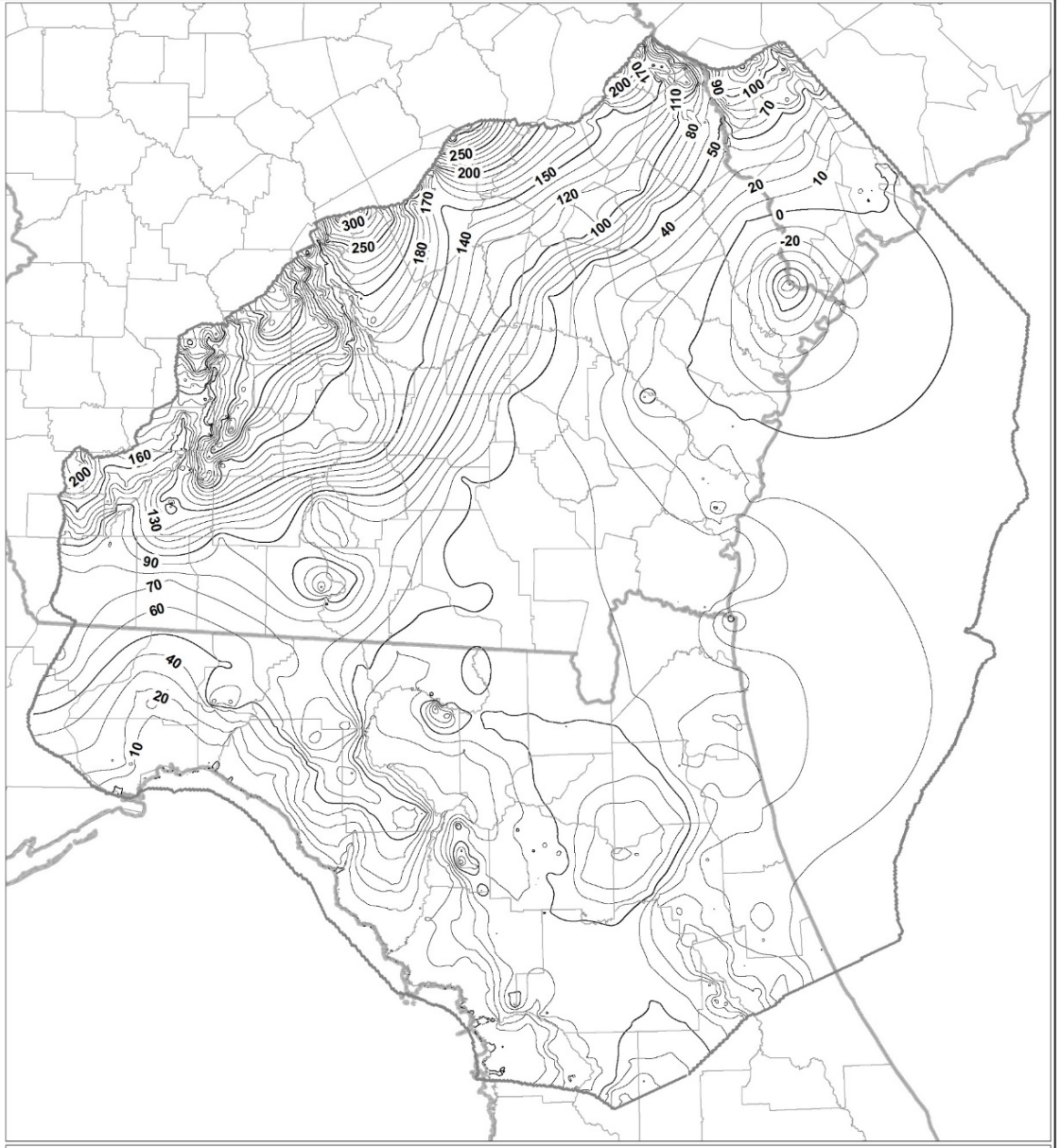
Upper Floridan Aquifer Estimated Potentiometric Surface

2001



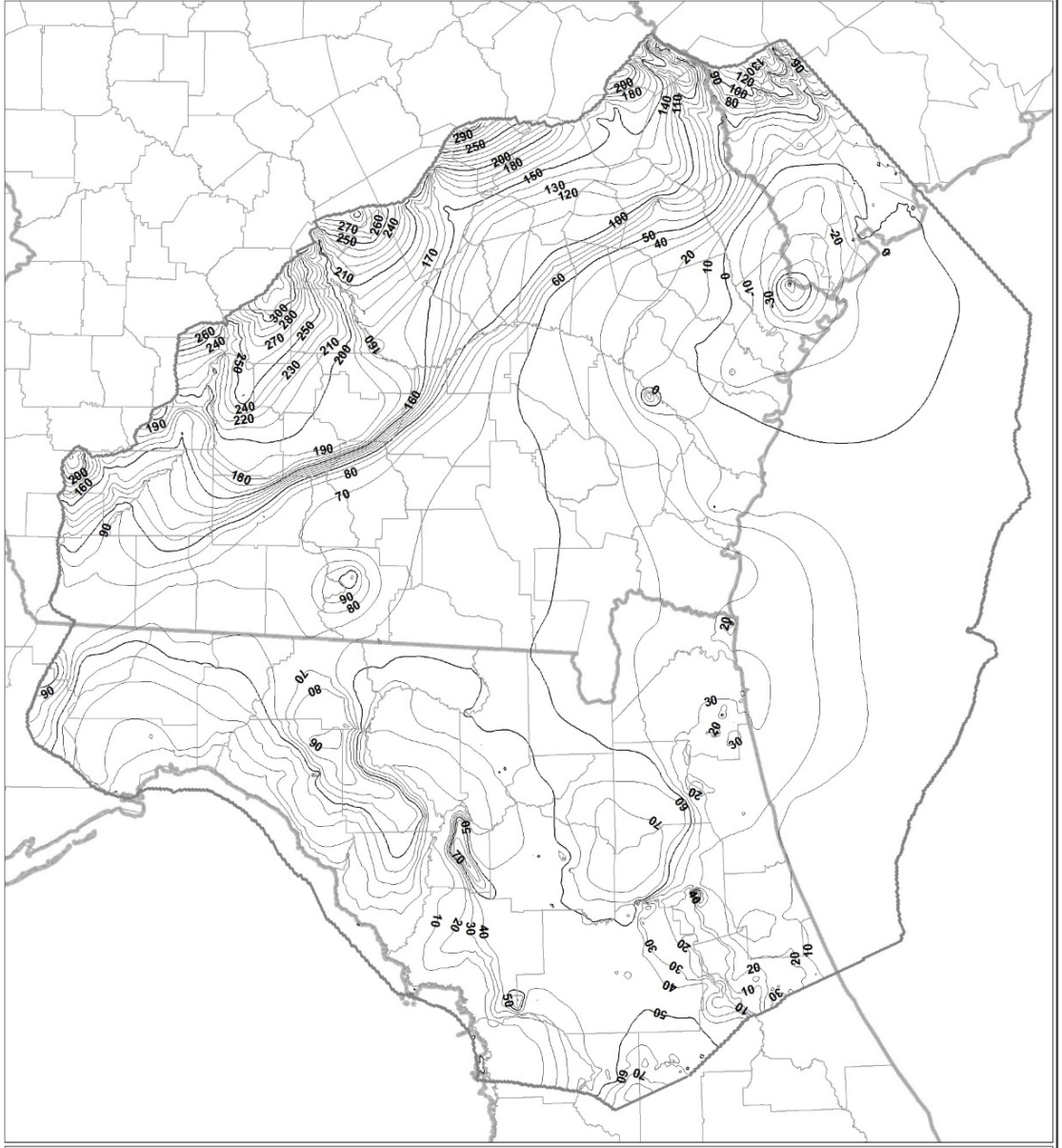
Model Layer 3 Simulated Potentiometric Surface

2001



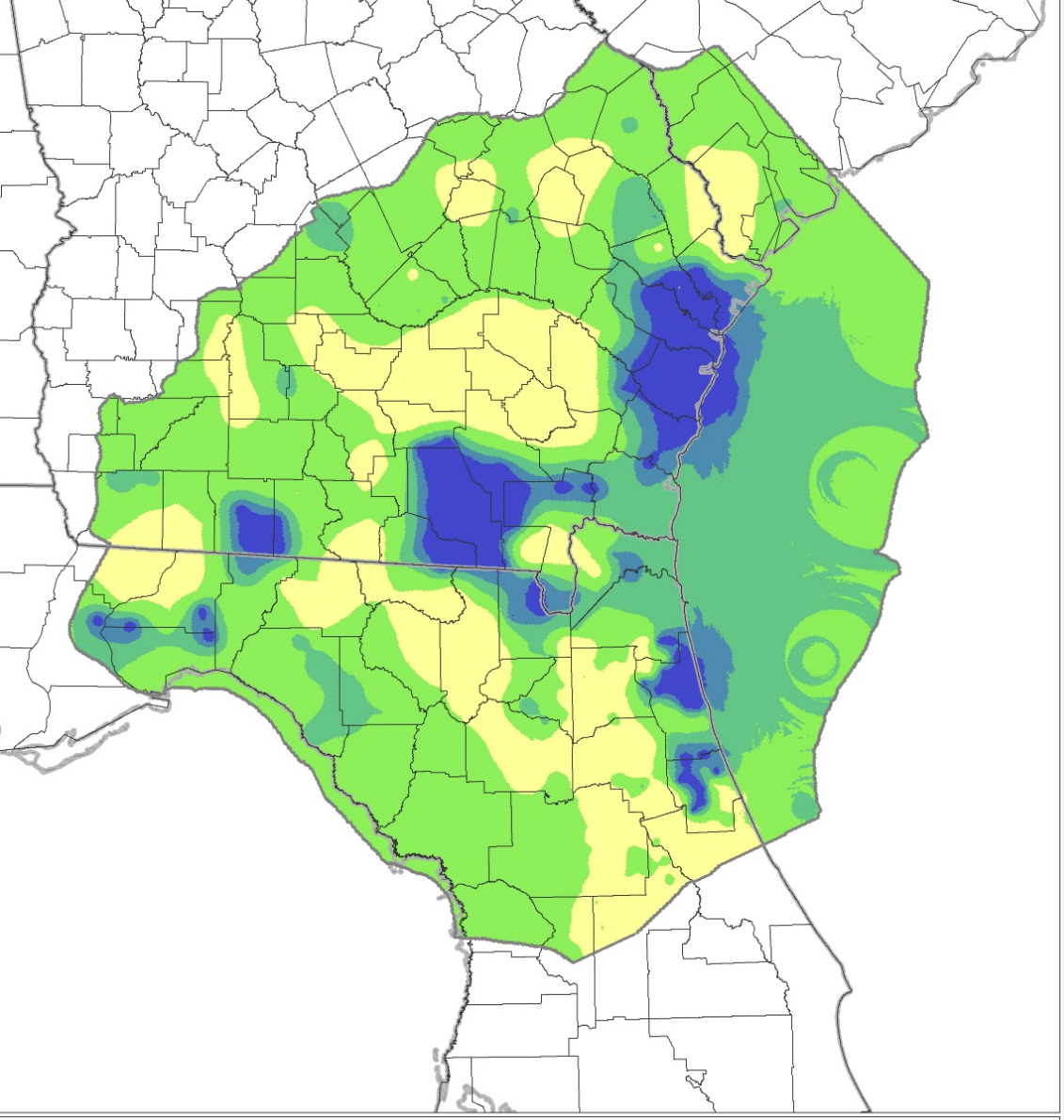
Upper Floridan Aquifer Estimated Potentiometric Surface

2009

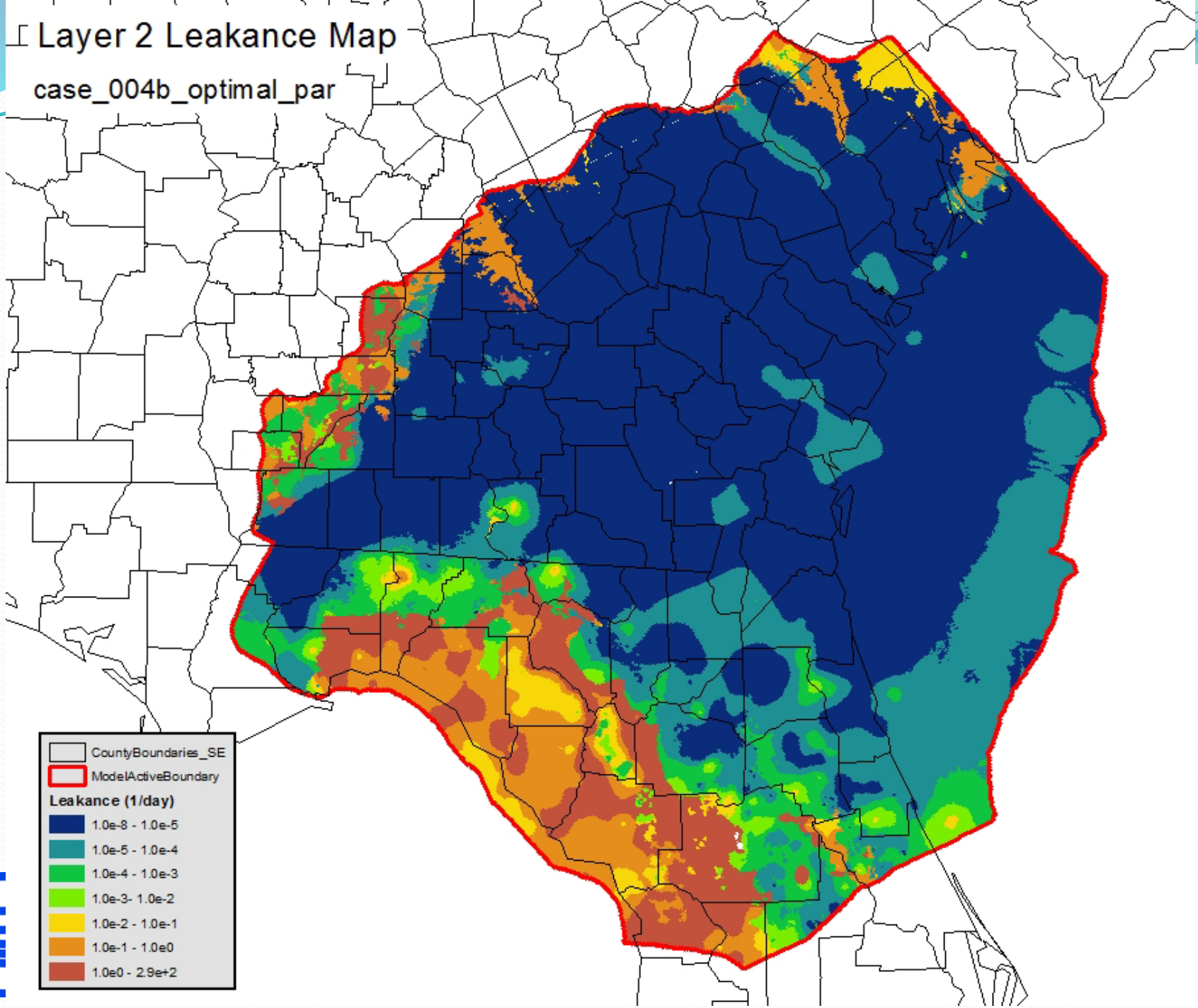


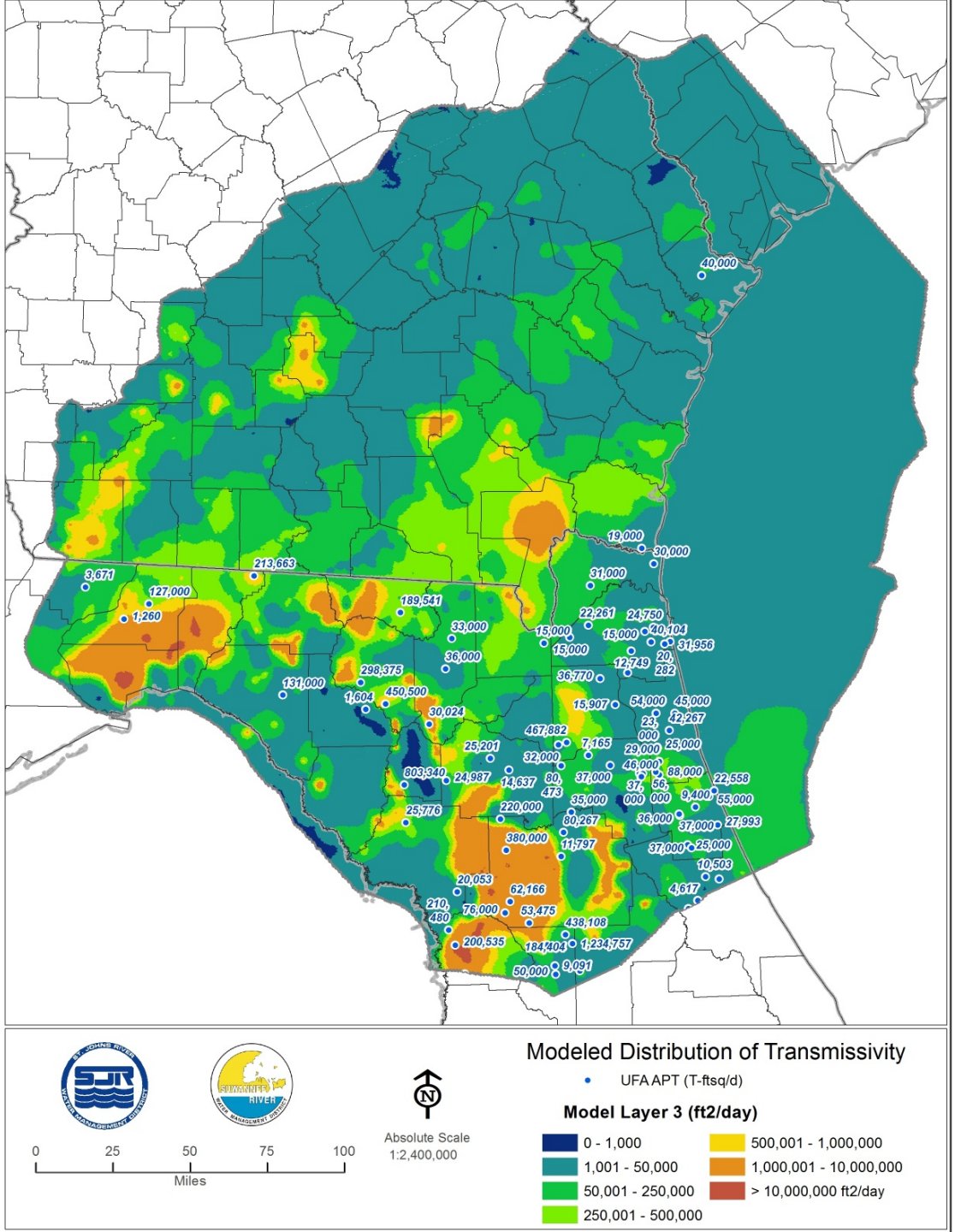
Model Layer 3 Simulated Potentiometric Surface

2009



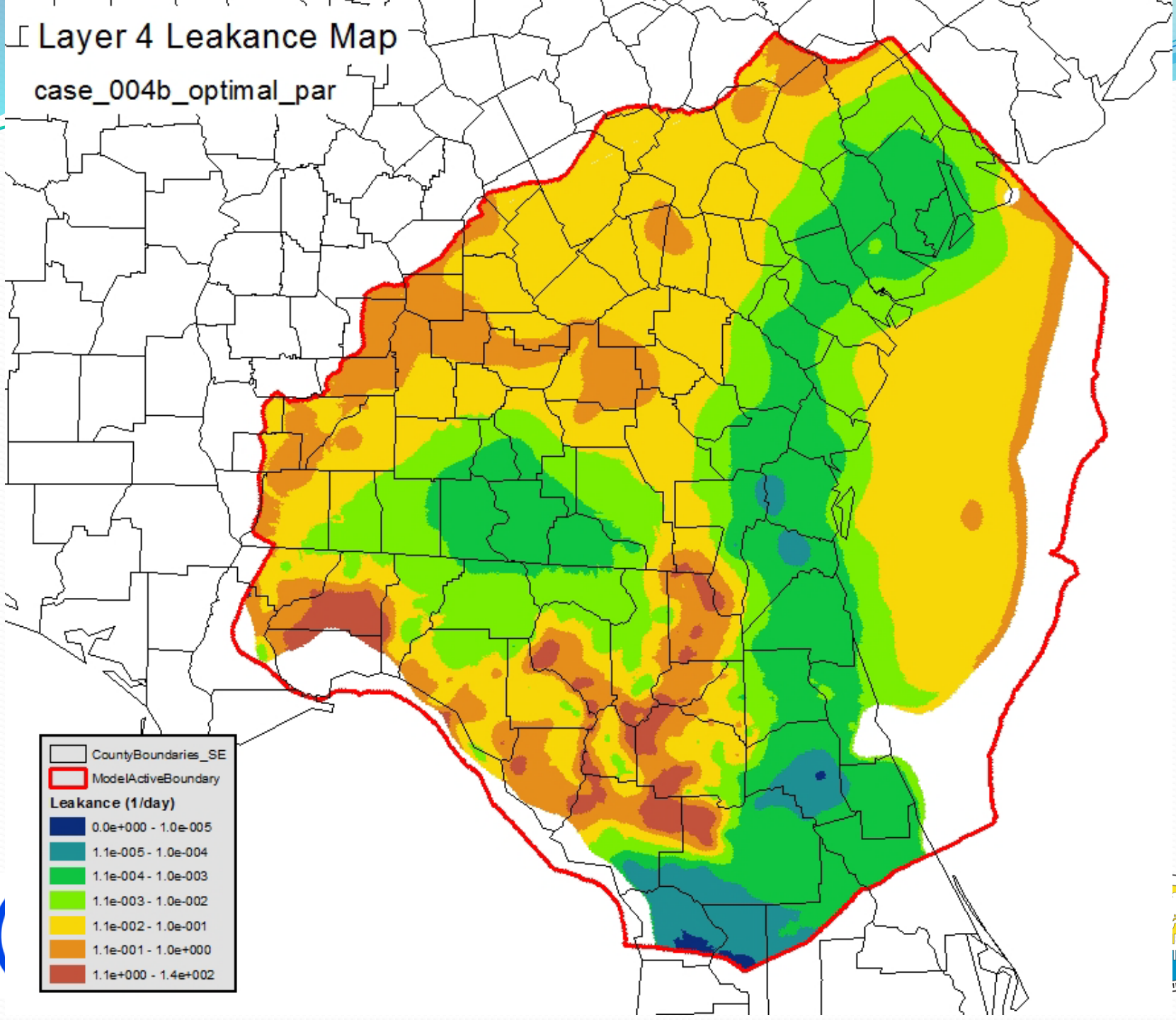
Layer 1 Horizontal Hydraulic Conductivity

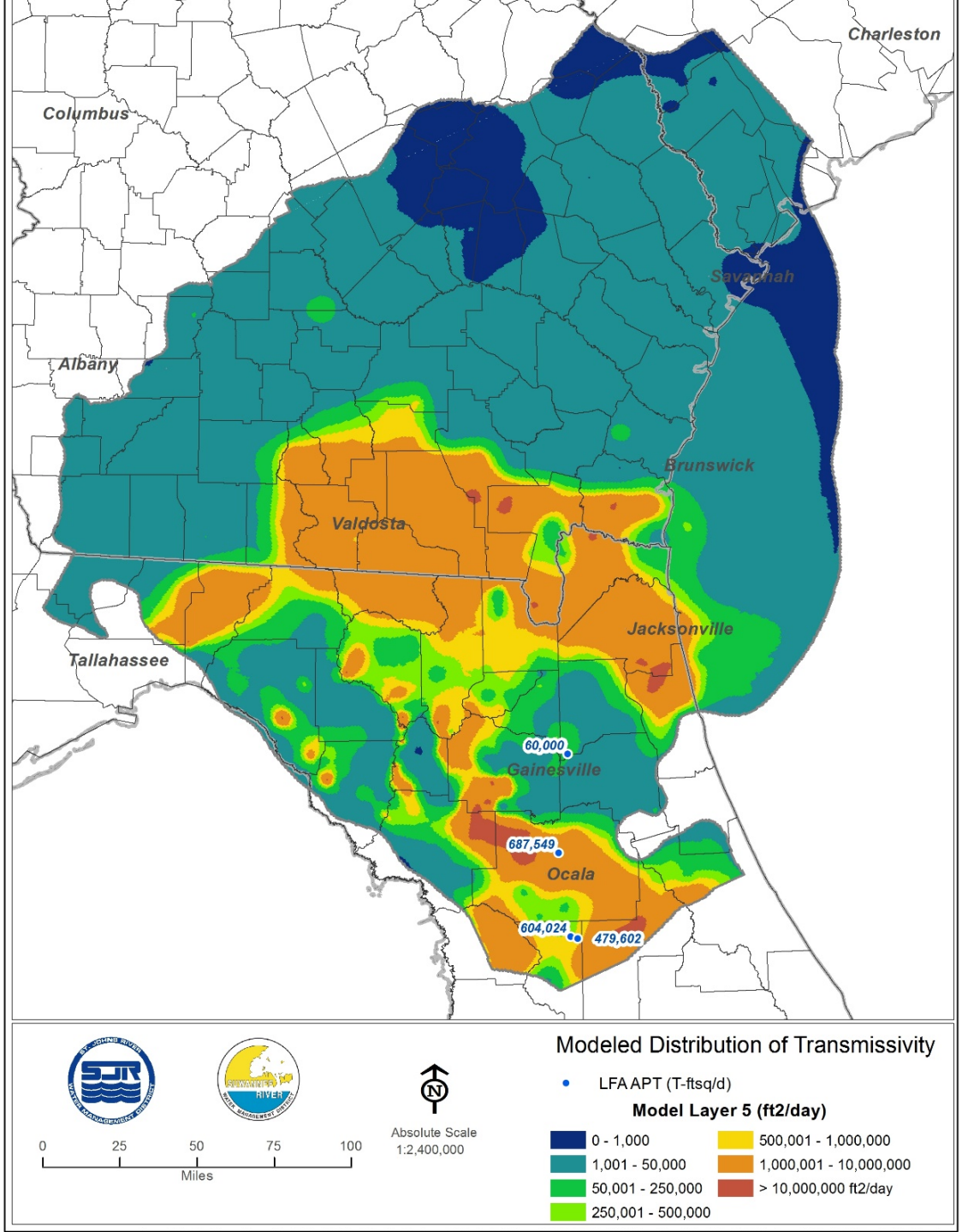

Layer 2 Leakance Map
case_004b_optimal_par
CountyBoundaries_SE
ModelActiveBoundary
Leakance (1/day)
1.0e-8 - 1.0e-5
1.0e-5 - 1.0e-4
1.0e-4 - 1.0e-3
1.0e-3- 1.0e-2
1.0e-2 - 1.0e-1
1.0e-1 - 1.0e0
1.0e0 - 2.9e+2



Estimated Transmissivity Layer 3

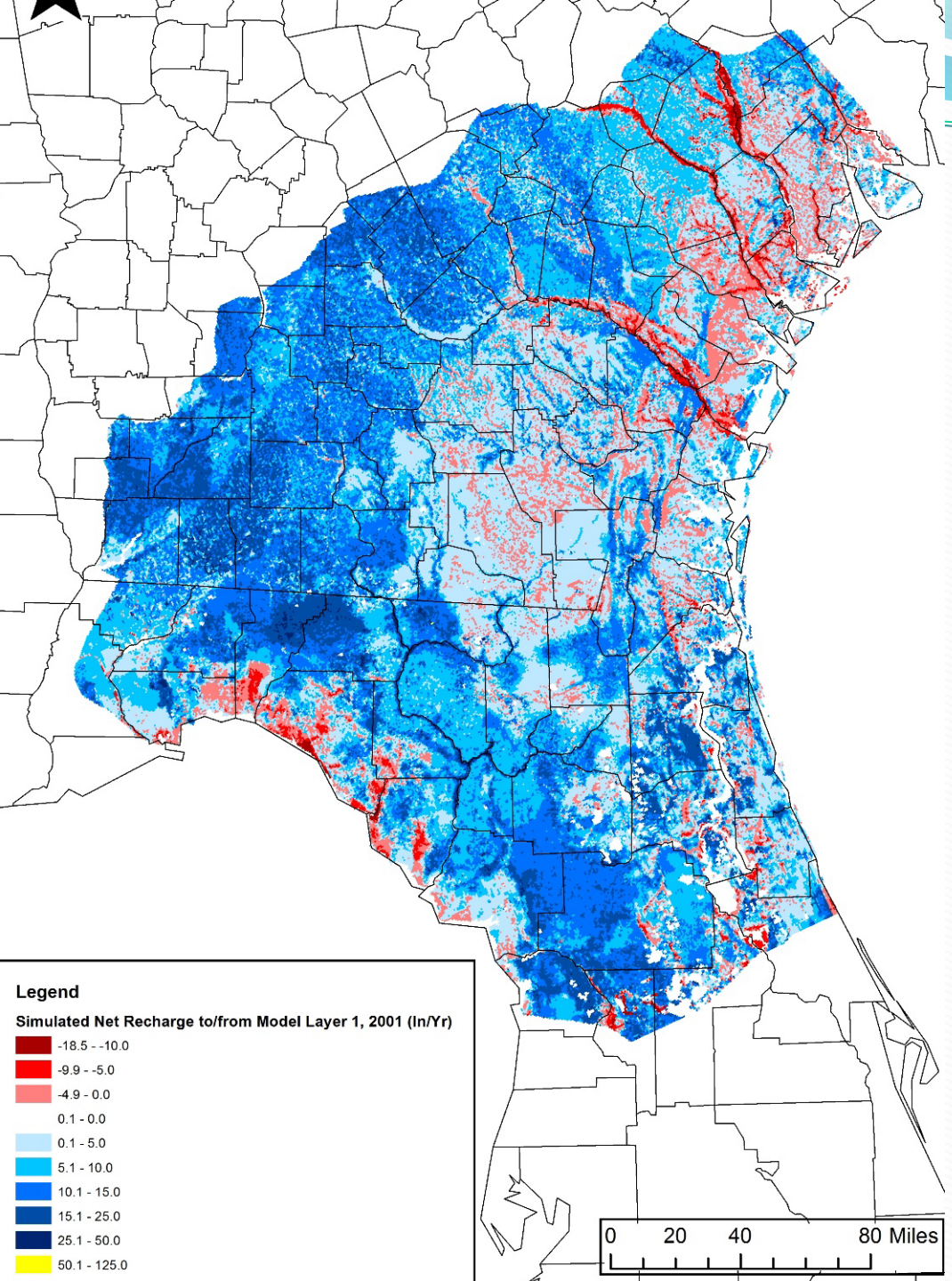
(with superimposed point estimates from APT results)


Layer 4 Leakance Map
case_004b_optimal_par
CountyBoundaries_SE
ModelActiveBoundary
Leakance (1/day)
0.0e+000 - 1.0e-005
1.1e-005 - 1.0e-004
1.1e-004 - 1.0e-003
1.1e-003 - 1.0e-002
1.1e-002 - 1.0e-001
1.1e-001 - 1.0e+000
1.1e+000 - 1.4e+002



Estimated Transmissivity Layer 5

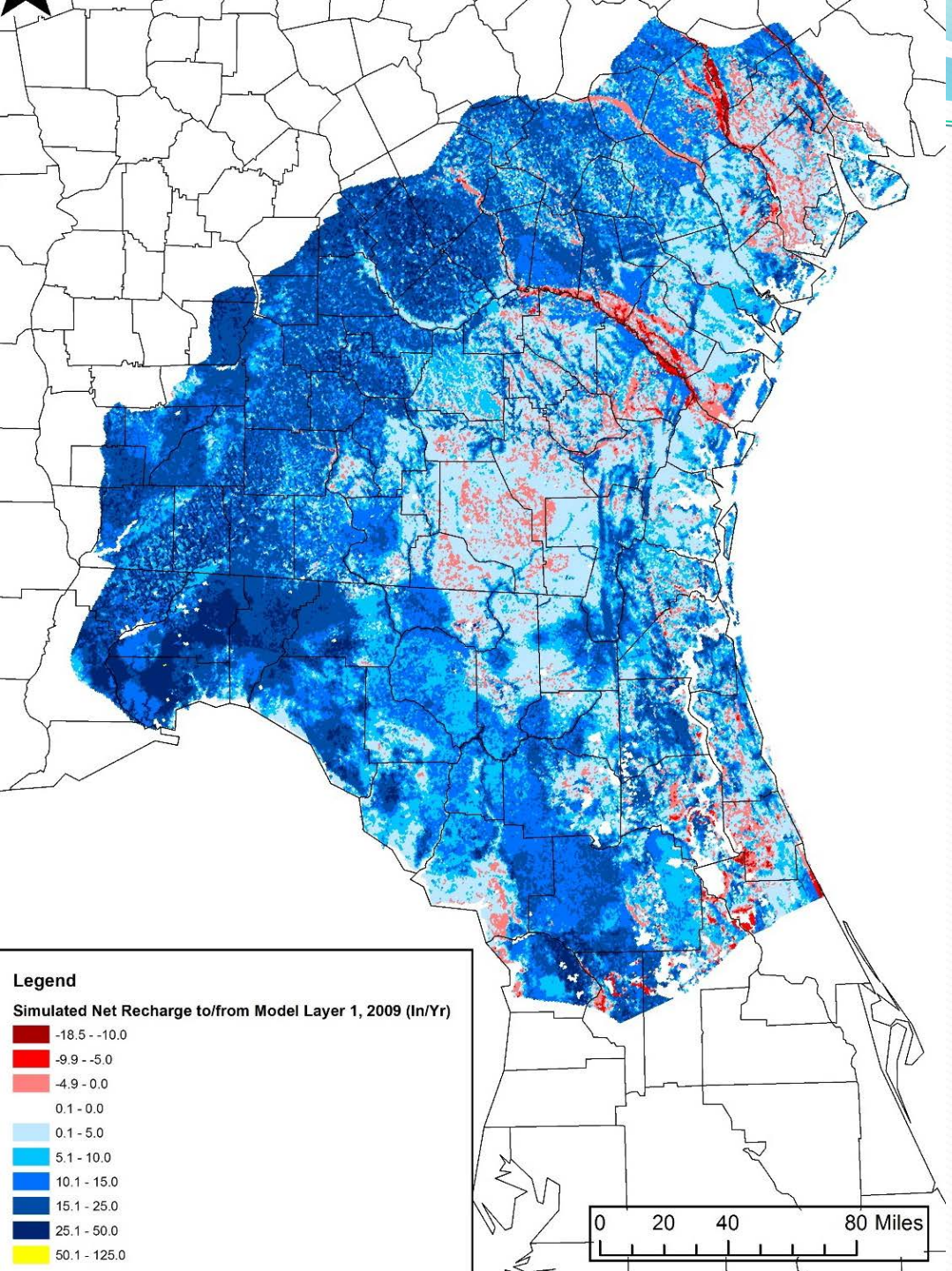
(with superimposed point estimates from APT results)



Simulated Net Recharge

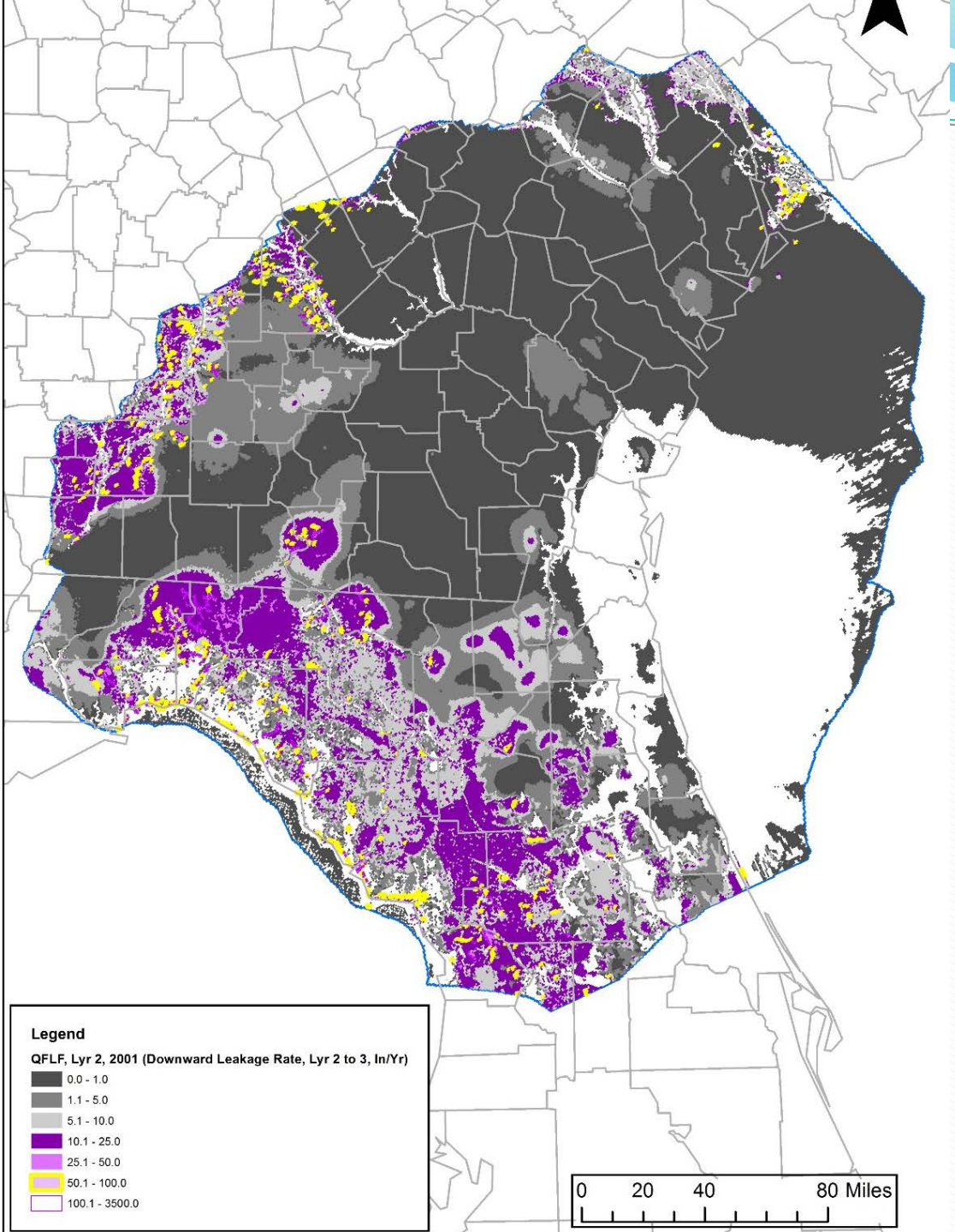
(Inches/Year)

2001



Simulated Net Recharge (Inches/Year)

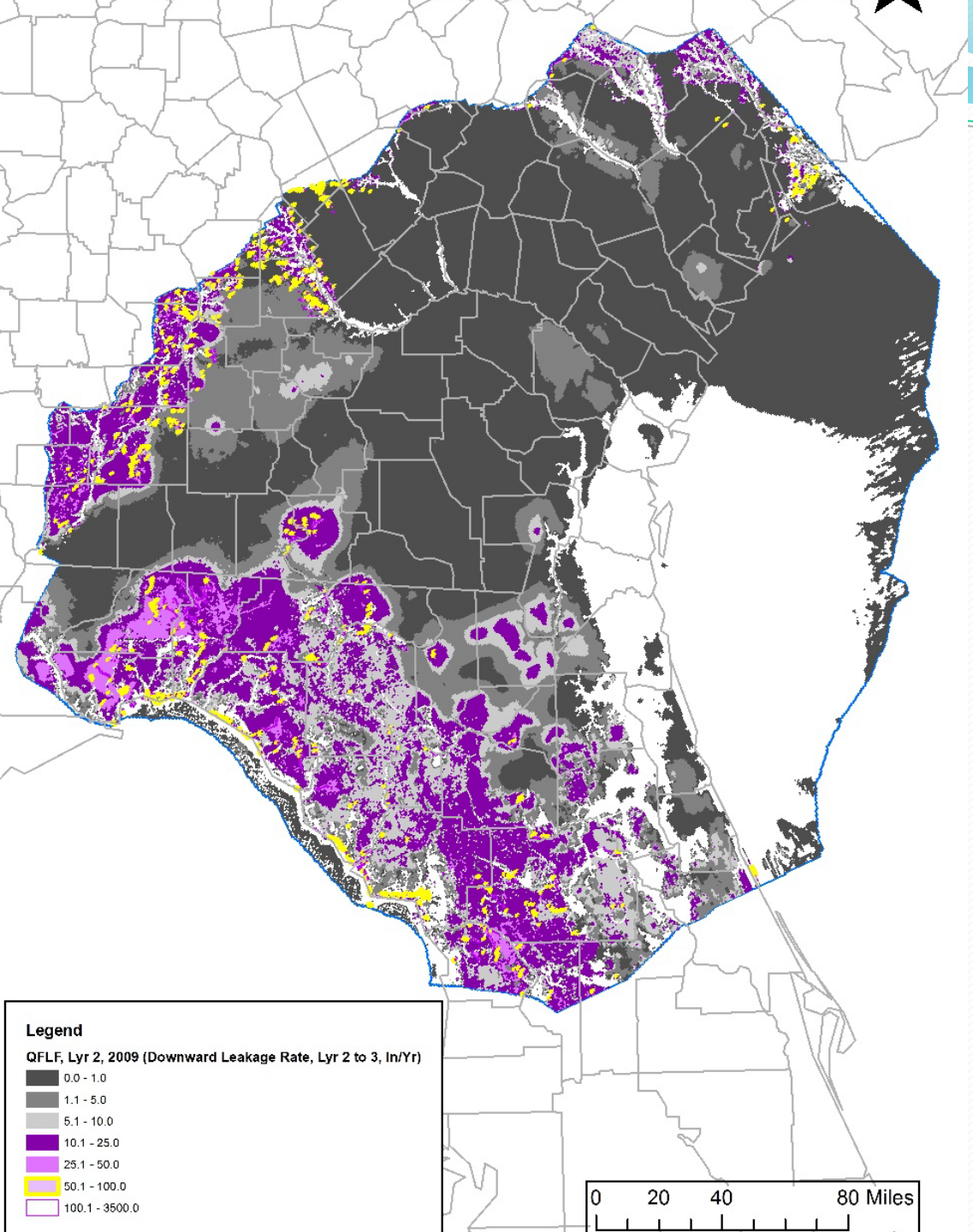
2009



Downward Leakage Rate (Inches/Year)

Layer 2 to 3

2001



Downward Leakage Rate (Inches/Year)

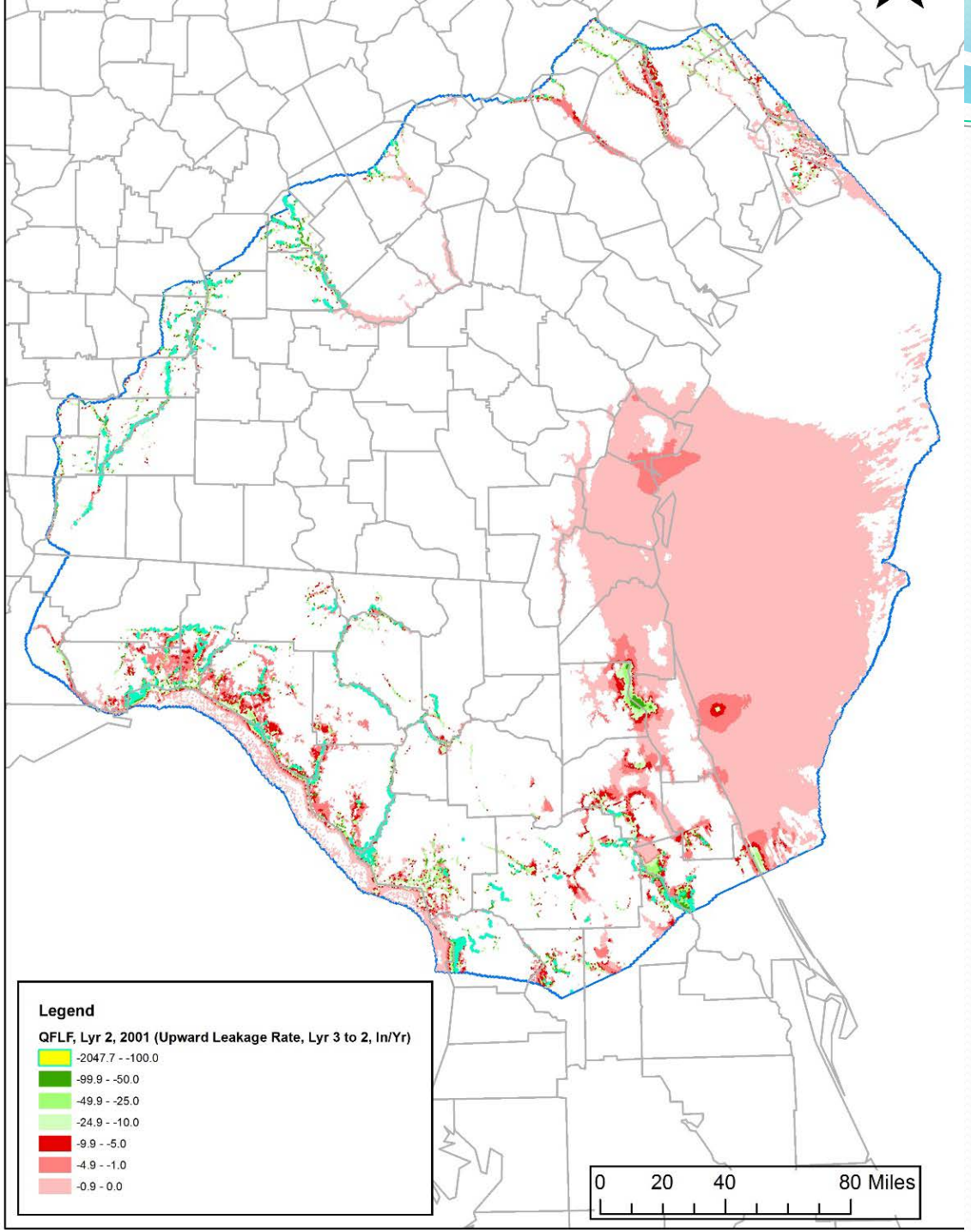
Layer 2 to 3

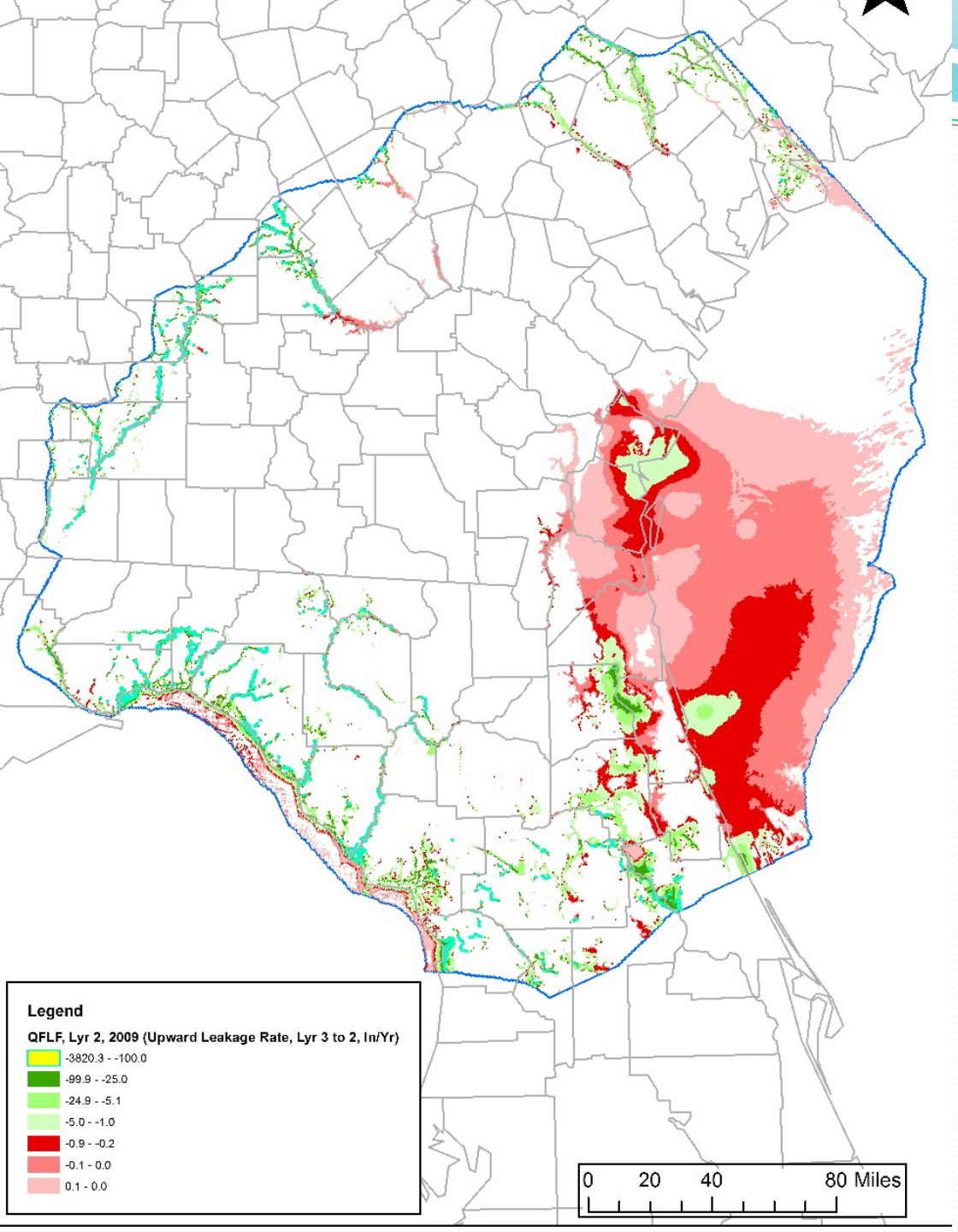
2009

Upward Leakage Rate (Inches/Year)

Layer 3 to 2

2001

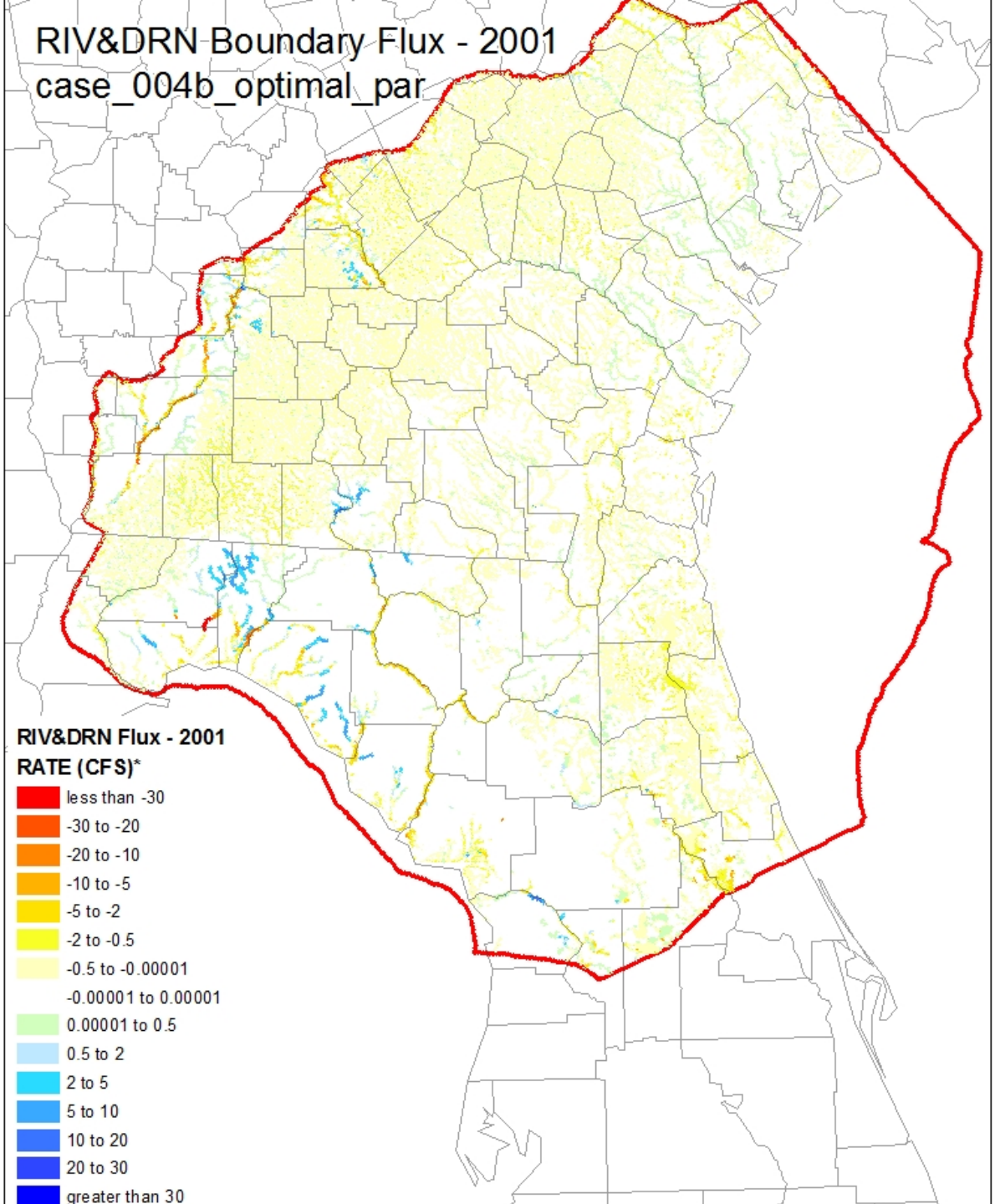




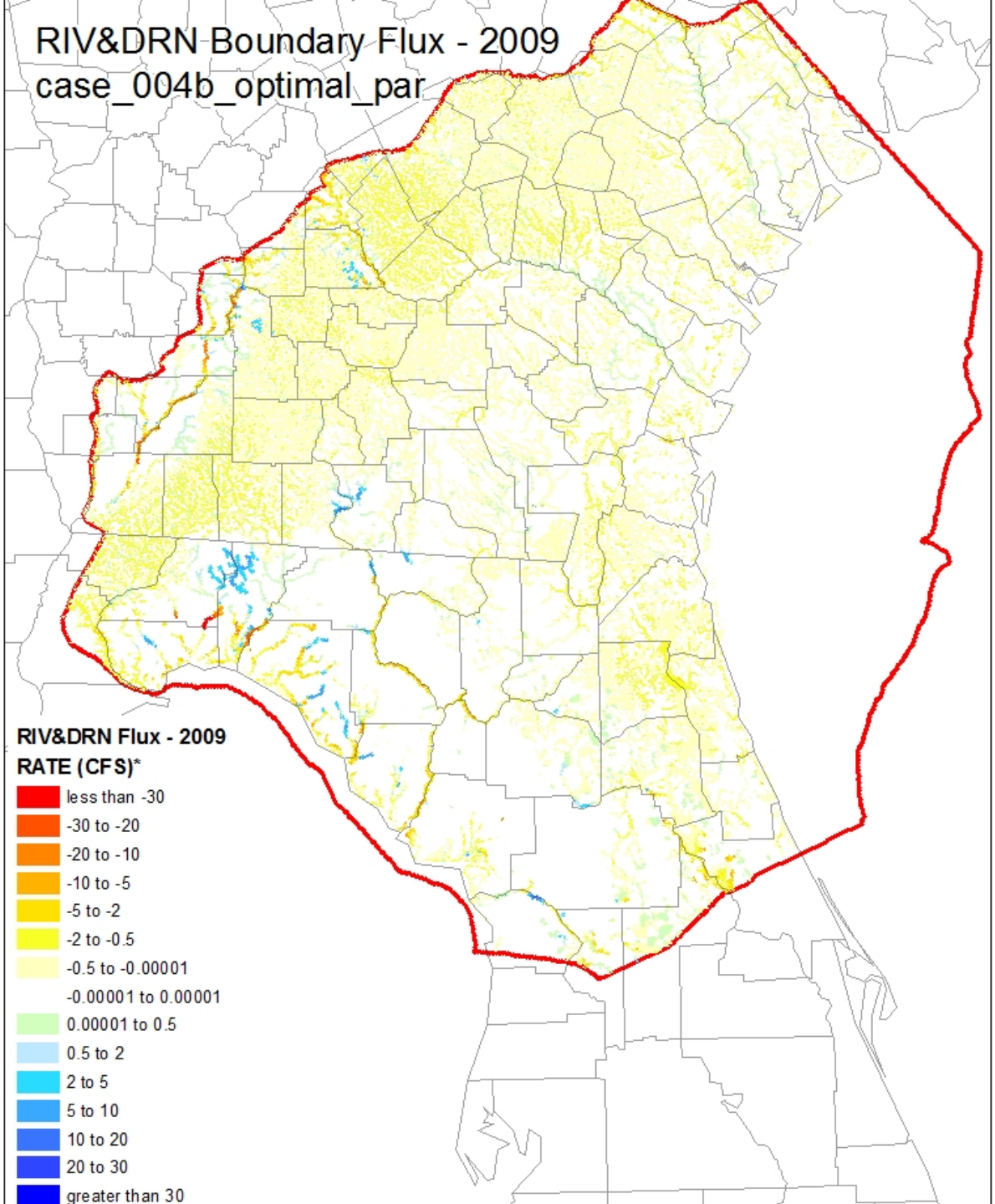
Upward Leakage Rate (Inches/Year)

Layer 3 to 2

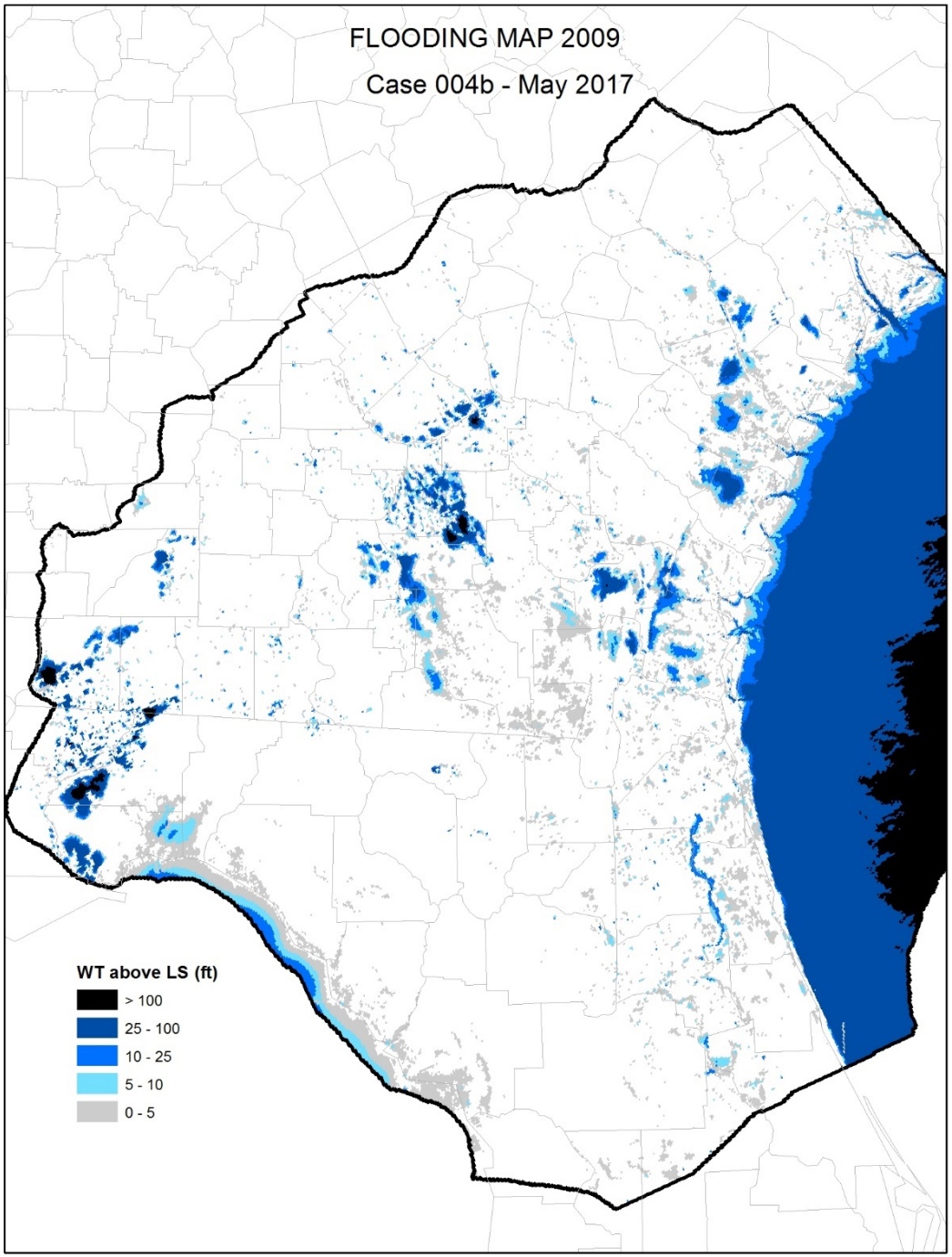
2009



River and Drain Fluxes 2001

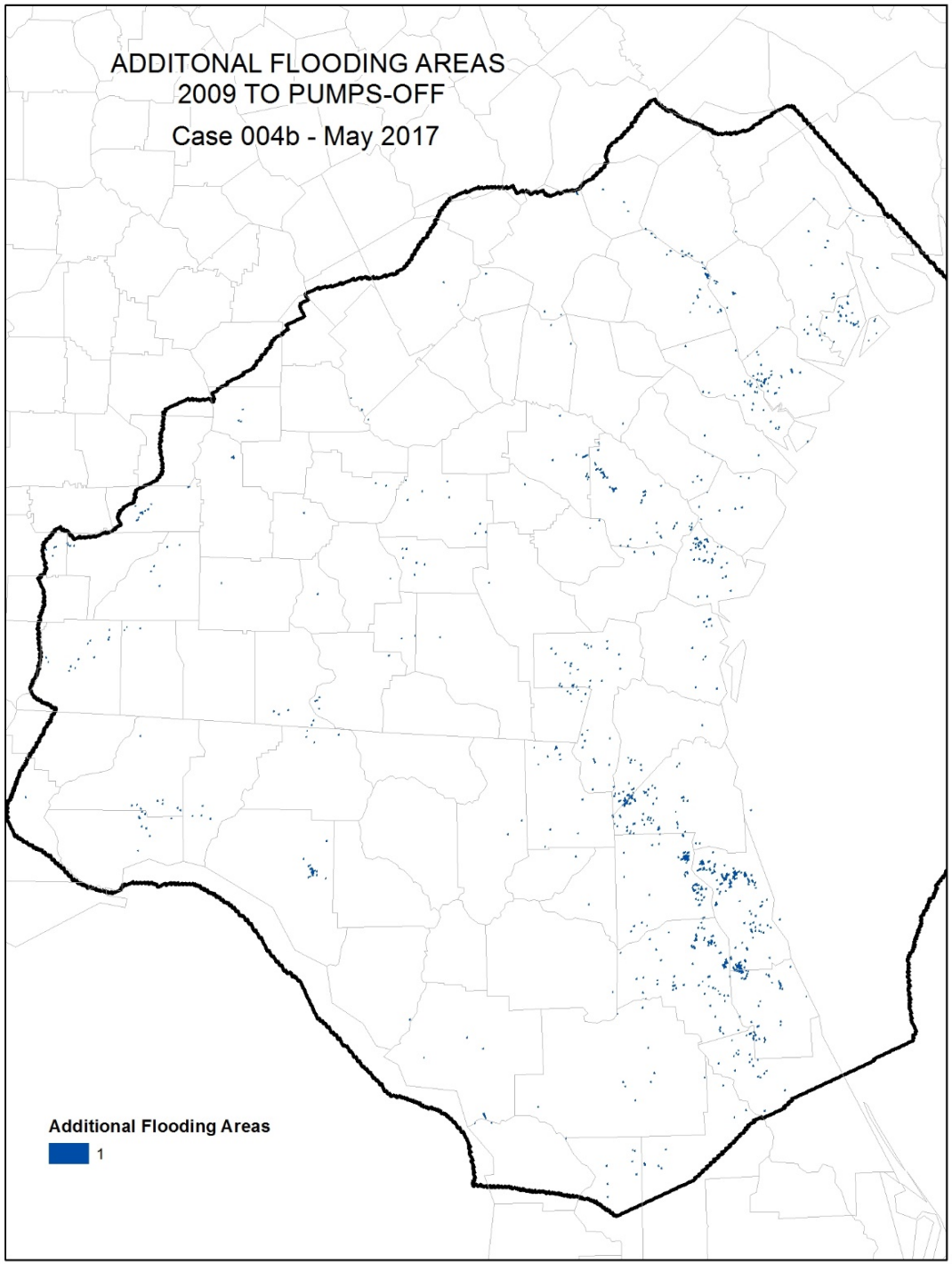


River and Drain Fluxes 2009



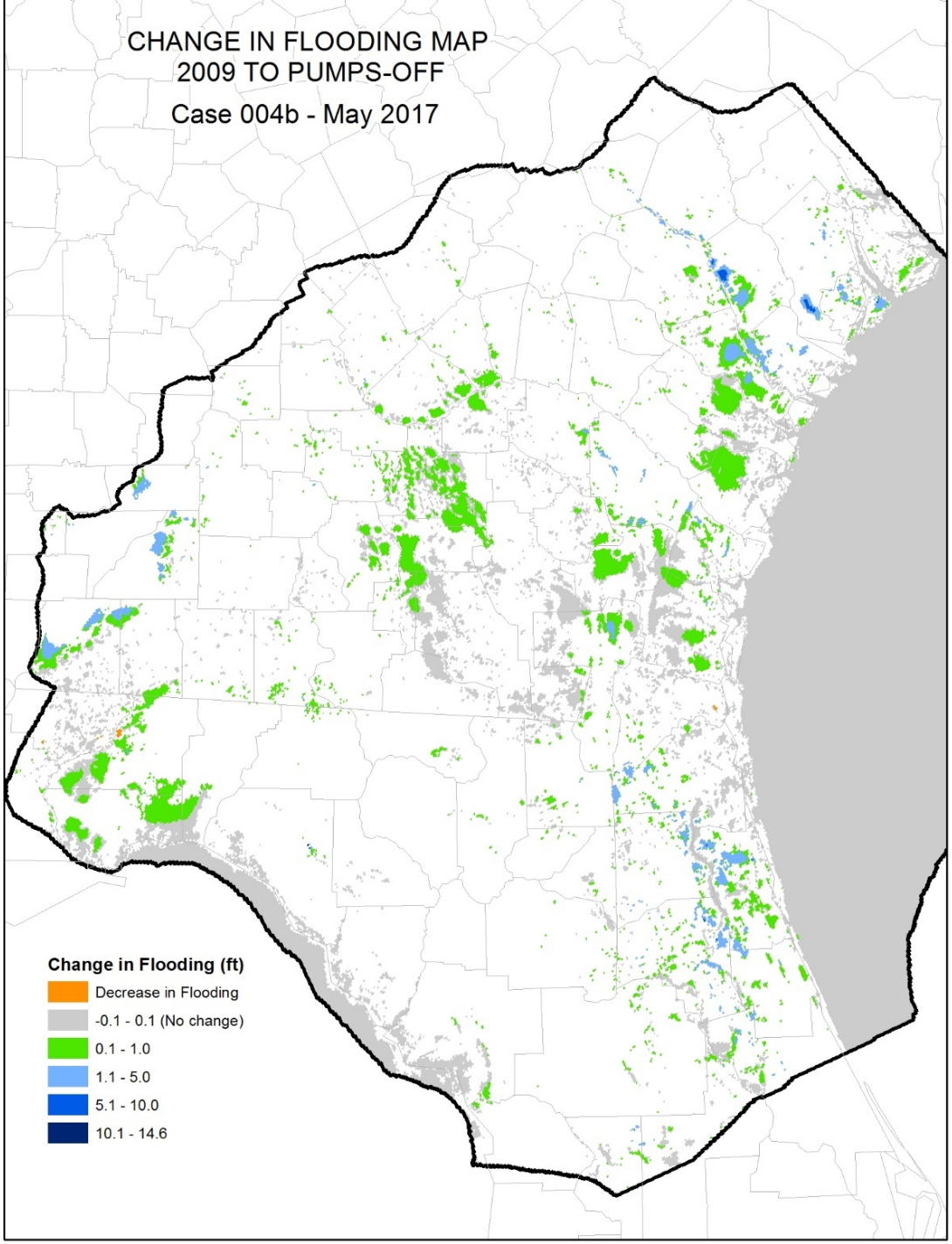
Height of Simulated Water Table Above Land Surface

2009



Additional Flooding Areas

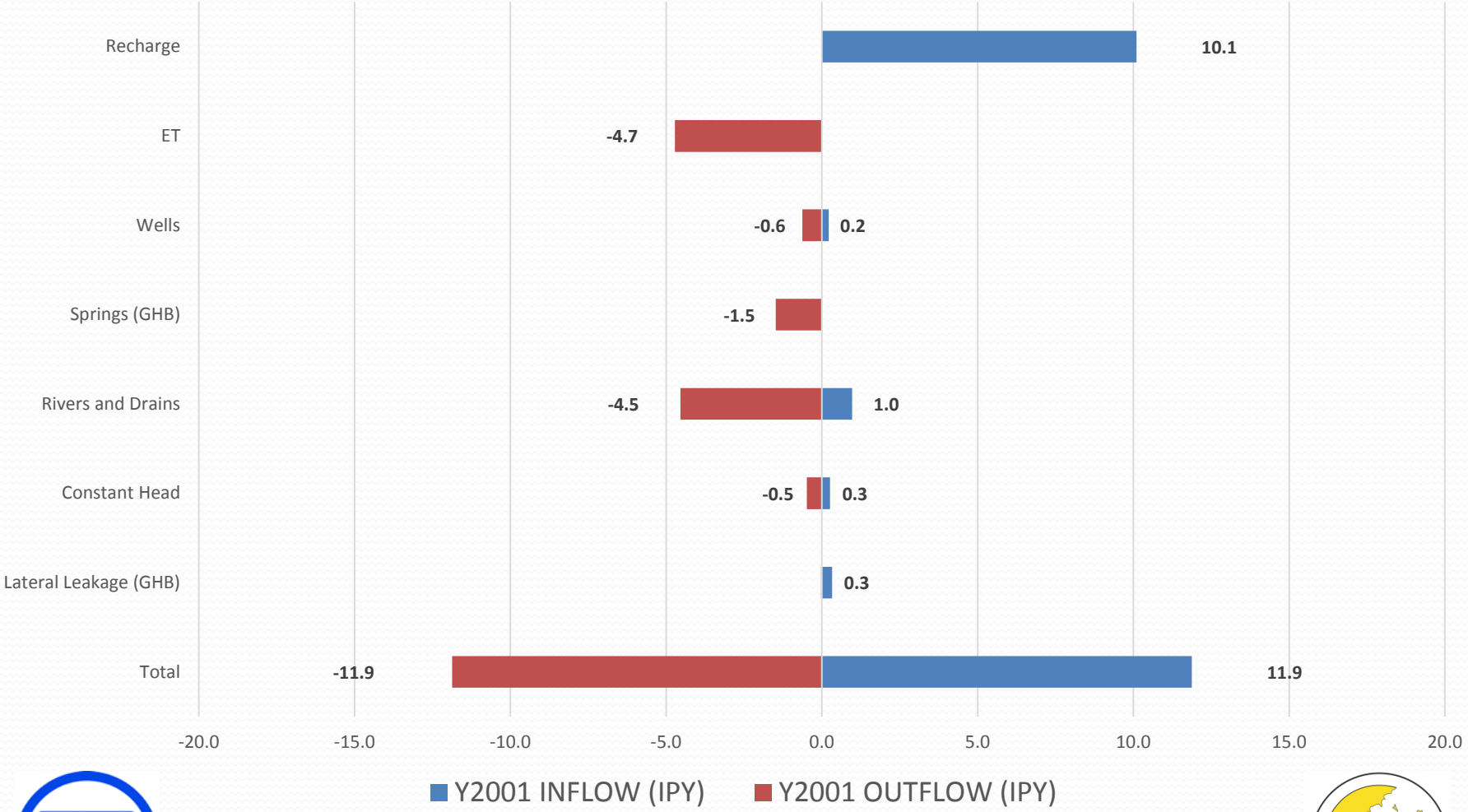
Pumps Off to 2009



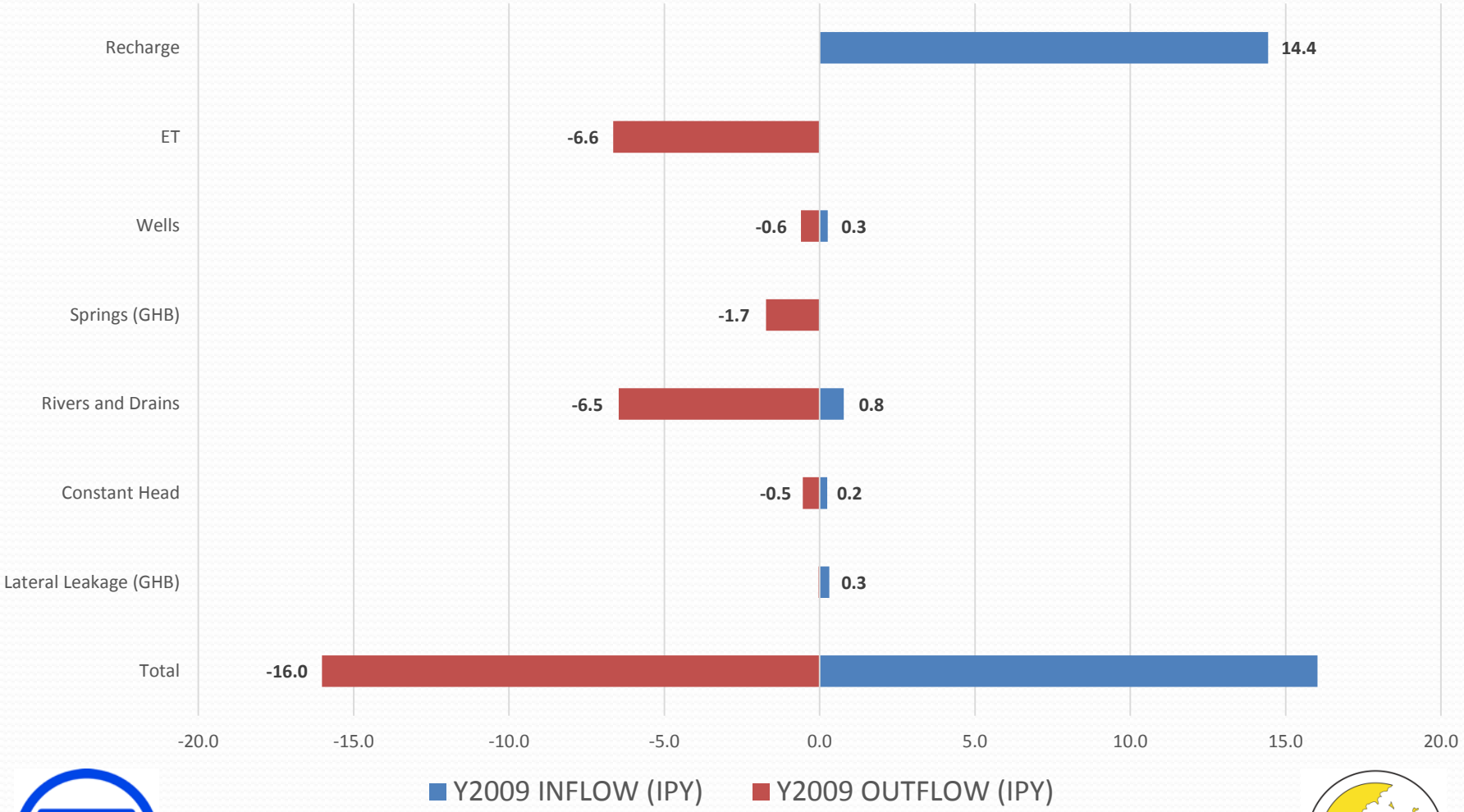
Difference of Height of Simulated Water Table Above Land Surface

Pumps Off to 2009

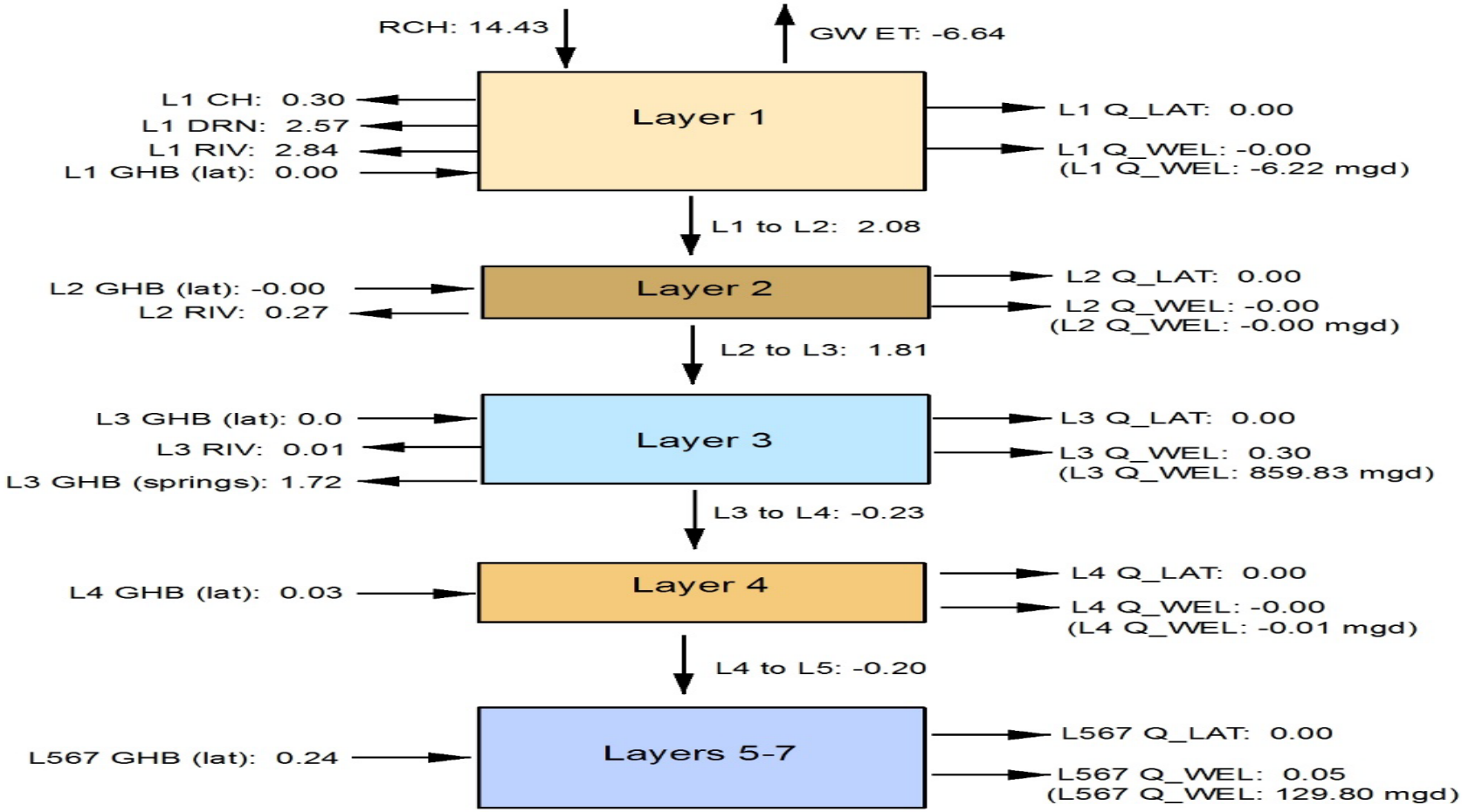
NFSEG V1.1 PEST RUN 4B: 2001 WATER BUDGET



NFSEG V1.1 PEST RUN 4B: 2009 WATER BUDGET



Model Wide Mass Balance Summary - 2009



ZB_NAME: Modelwide Active L1 Number of Cells: 266895 Area Per Cell: 6,250,500 SF
All units expressed as Inches Per Year over the selected cells (except where noted)
Values reflect the net water balance for all cells in zone corresponding to the direction indicated.

D:\00Temp\NFSEGv1_1\case_004b\pest_dir\nfseg_pest_postproc\case_004b_optimal_par__massbal_Modelwide Active L1_2009.mxd 6/9/2017 tdesmara

Next Steps

- Task B.2. – Peer Review Memorandum
  - Clear and specific suggestions to improve model calibration
  - Preliminary consideration of Task D2 (Items A-F) and Task D3 (A-D, G, and H)
- Task C. Phase 2
  - Review spring observations (e.g. updates using new data)
  - Observation group reweighting
  - Regularization updates
  - Incorporate peer review suggestions
- Uncertainty Analysis
- Verification Run
- No-pumping / predevelopment simulations
  - Historical Review

Peer Review Panel Discussion

Technical Stakeholder Input

Uncertainty Analysis

- Need to define confidence intervals for model predictions (as well as model calibration, refinements/data gaps, etc.)
- Linear analysis
  - Ability to estimate parameters
  - Parameter and prediction uncertainty estimates
- Nonlinear analysis
  - Parameter and prediction uncertainty estimates (no linearity assumption)

Verification Simulation

- 2010 Water Use and Recharge/Max Sat ET (only)
- Preliminary Run in August, Present 8/24 Meeting
- Previous analyses have been generally qualitative in nature

No Pumping/Predevelopment Simulations

Historical Review

Need for No Pumping Simulation

- Use In Minimum Flows and Levels Programs
  - Estimation of Groundwater Withdrawals Impacts on:
    - Flowing Systems
    - Lakes
  - Apportionment/Individual Users Pro-Rata Share of Impacts

UFA No Pumping Evaluations

- Phase 1 - Estimation of UFA Predevelopment (PD) Potentiometric Surface
  - 1980
    - USGS – OFR 80-406 – Johnston et al.

- Phase 2 – Models Created to Simulate PD Surface
  - 1981-1982
    - USGS – OFR 81-681 (East Central FLA - Tibbals)
    - USGS – WRI 82-173 (SE GA, NE FLA, and S SC - Krause)
    - USGS – WRI 82-905 (SE US – Bush)

UFA No Pumping Evaluations

- Phase 3 – Model Based Comparisons of PD to Historic Water Use and/or Projected Water Use
  - 1988 – 1989
    - USGS – PP 1403-C – (SE US – Bush and Johnston)
      - Modeled - PD Compared to 1980
    - USGS – PP 1403-D (SE GA – Krause and Randolph)
    - USGS – PP 1403-E (East Central FL – Tibbals)
  - 1991-2006
    - Georgia GS - Bulletin 116 – Coastal Georgia (1991)
    - SJRWMD – Tech. Pub. SJ 91-4 - Northeast Florida (1991)

UFA No Pumping Evaluations

- 1991-2006 (cont'd)
  - SWFWMD - Northern Tampa Bay (1993)
  - SJRWMD – Special Pub. SJ94-6 – Seminole Cty. (1994)
  - SJRWMD – Special Pub. SJ95-SP7 – North Central Fla (1995)
  - SJRWMD – Technical Pub. SJ95-5 – Titusville (1995)
  - SWFWMD/USGS – WRI 94-4254 – Lake Wales Ridge (1996)
  - SJRWMD – Technical Pub. SJ97-2 – North East Fla (1997)
  - SJRWMD – Technical Pub. SJ2002-3 – East Central Fla (2002)
  - USGS – SIR 2005-5089 – Coastal Georgia (2005)
  - SJRWMD – Technical Pub. SJ2006-4 – Volusia (2006)

UFA No Pumping Evaluations

- 2010 - Present
  - SWFWMD/TBW – Integrated Northern Tampa Bay (2013)
  - SWFWMD/SJRWMD – Northern District Model V5 (2016)

Schedule

June 30:	Phase 1 Review Memo Due
July 26:	Phase 2 Prelim. Results Meeting – Tele.
August 4:	Phase 2 Prelim. Results Memo Due
August 24:	Phase 2 Results Meeting - *Palatka*
September 1:	Phase 2 Results Memo Due
October 19:	Review Draft NFSEG v1.1 - *Palatka*
November 9:	Draft Peer Review Report
December 21:	Final Peer Review Report

Public Comments