Groundwater Availability Modeling (GAM) for the Queen City and Sparta Aquifers

Stakeholder Advisory Forum No. 4

City Commission Room, City Hall
Nacogdoches, Texas

April 29, 2004

Outline of Presentation

- Introduction
- Review of conceptual model
- Overview of revised model scope
- Model development
  - Integration with the Carrizo-Wilcox GAMs
- Steady-State Model Results
  - South
  - Central
  - North
- Schedule and Milestones
- Expectations for the next SAF

Stakeholder Advisory Forums - SAFs

- Held on 4 month schedule
  - SAF- 3 was delayed awaiting approval of the revised GAM scope and budget – currently back on track
- Today's meeting and future meetings will:
  - provide updates on progress
  - provide an opportunity to offer feedback
- SAF presentations and questions & responses from meetings will be posted at http://www.twdb.state.tx.us/gam/qc_sp/qc_sp.htm

Why Groundwater Flow Models?

- In contrast to surface water, groundwater flow is difficult to observe
- Aquifers are typically complex in terms of spatial extent and hydrogeological characteristics
- A groundwater model provides the best means for integrating available data for the <u>prediction</u> of groundwater flow at the scale of interest (measured data cannot tell the future).

Definition of a Model

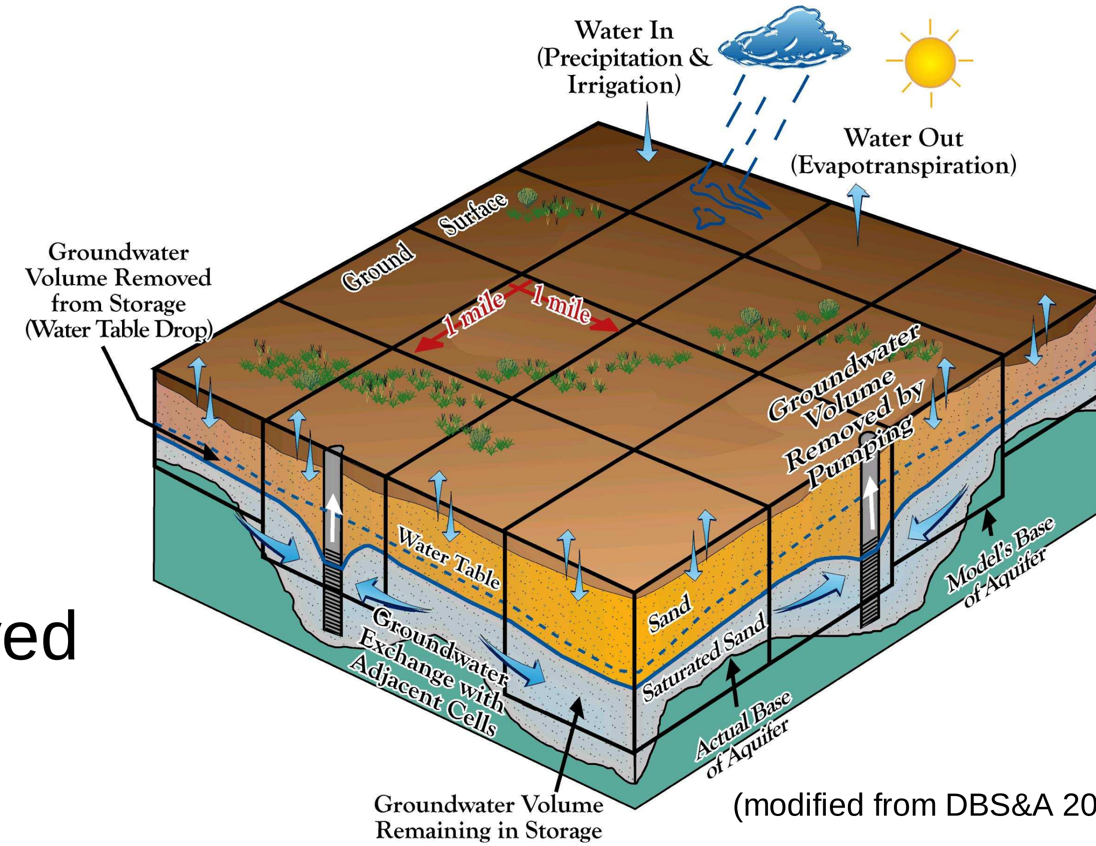
Merriam-Webster Online Dictionary: a description or analogy used to help visualize something (as an atom) that cannot be directly observed

Domenico (1972) defined a model as a representation of reality that attempts to explain the behavior of some aspect of reality and is always less complex than the real system it represents

Wang & Anderson (1982) defined a model as a tool designed to represent a simplified version of reality

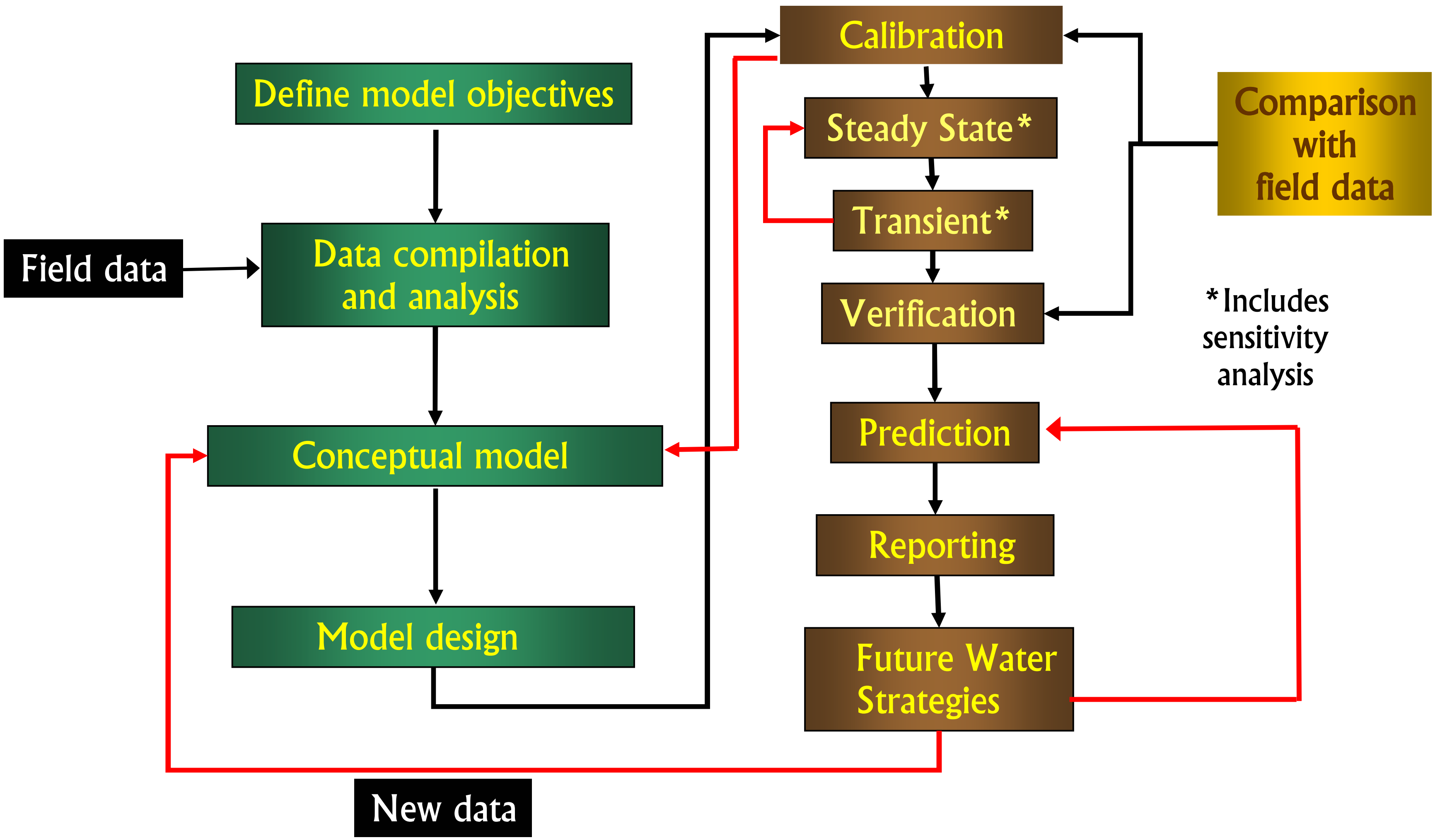
A Model is a Tool

- Model heads are calculated based upon:
  - Recharge
  - Aquifer properties
  - Pumping
  - Natural Discharge
- Model heads are compared to observed water levels
- The tool is used to predict future water levels



(modified from DBS&A 2001)

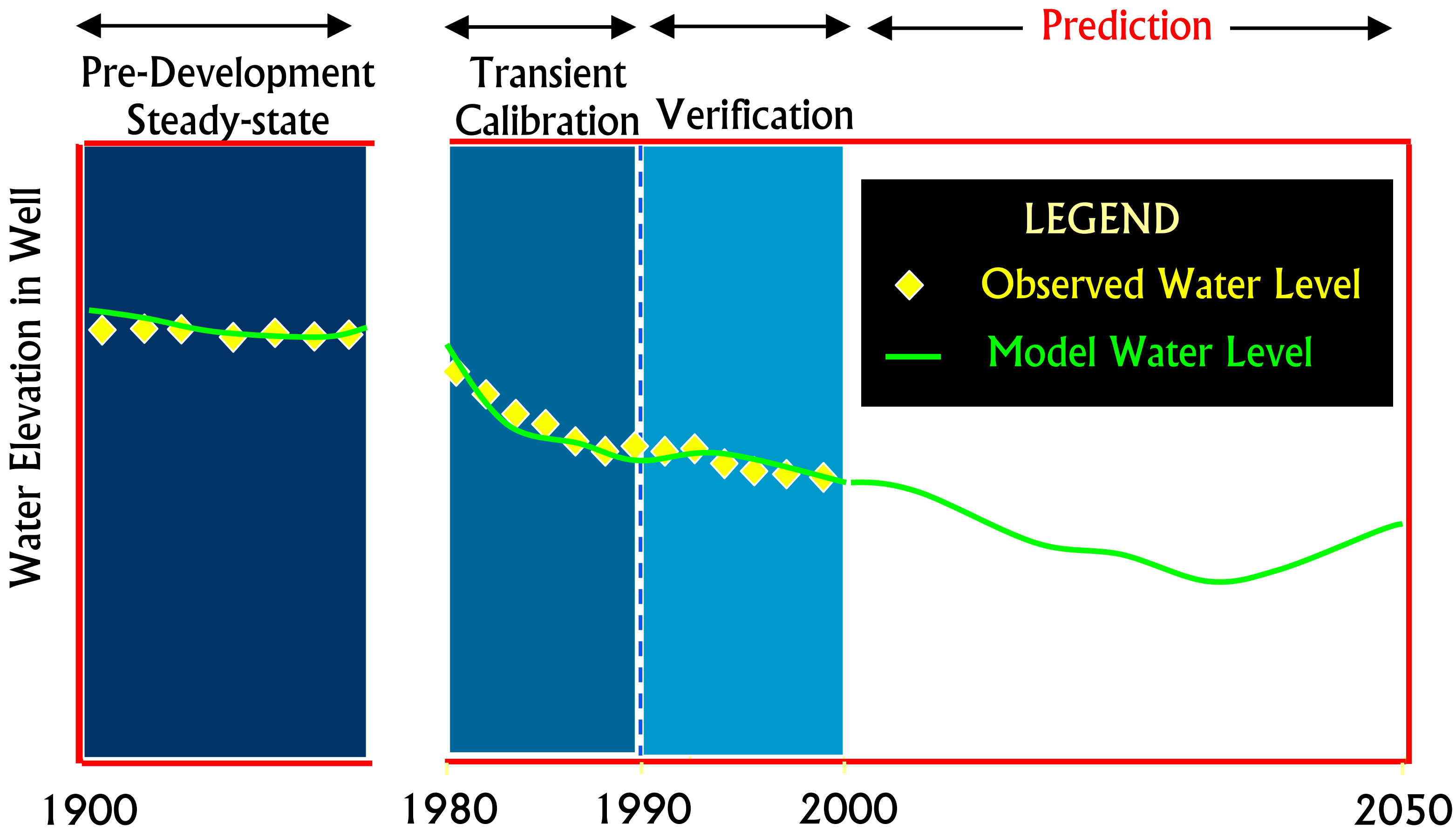
Modeling Protocol



GAM Model Specifications

- Three dimensional (MODFLOW-96)
- Regional scale (1000's of square miles)
- Grid spacing of 1 square mile
- Implement
  - recharge
  - groundwater/surface water interaction
  - pumping
- Calibration to observed water levels

GAM Model Periods

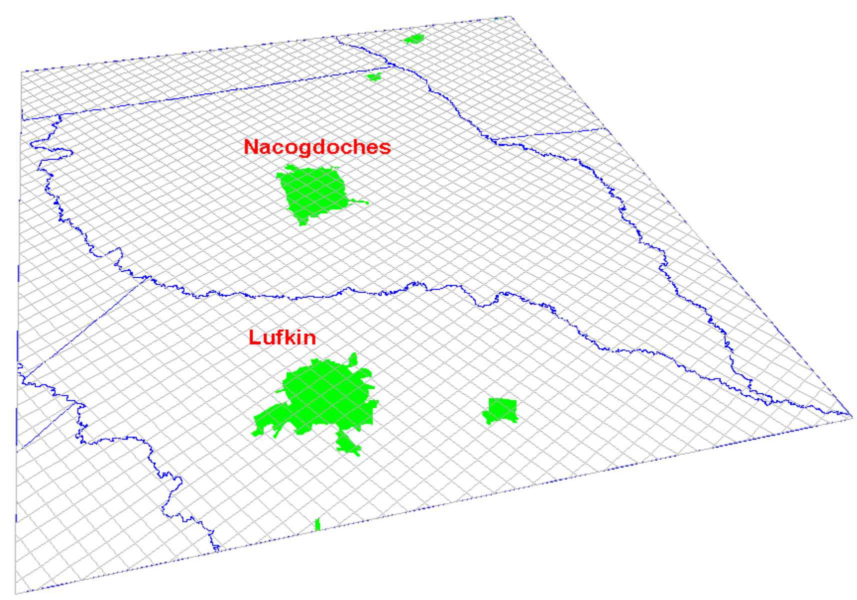


Pre-development and transient calibration periods represent different hydrologic conditions

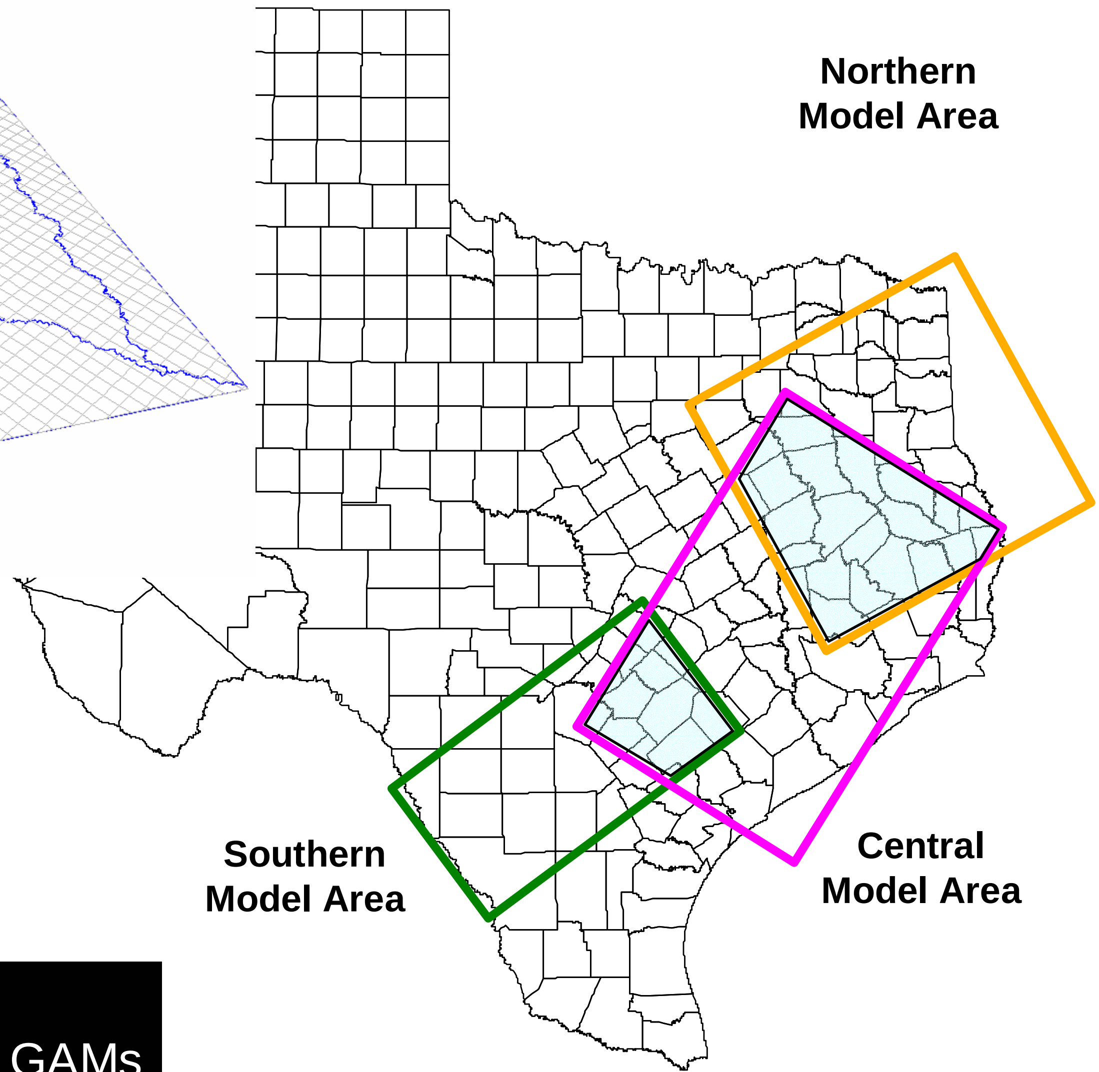
Queen City-Sparta GAM Specifications

- In addition to the generic GAM specifications, the Queen City and Sparta GAMs have additional specifications:
  - The Queen City and Sparta aquifer GAMs will be incorporated into the current Carrizo-Wilcox GAMs
  - The product will be delivered as three models (southern, central, and northern regions)
  - One modeling report will be produced

Model Domains – Same as C/W GAMs



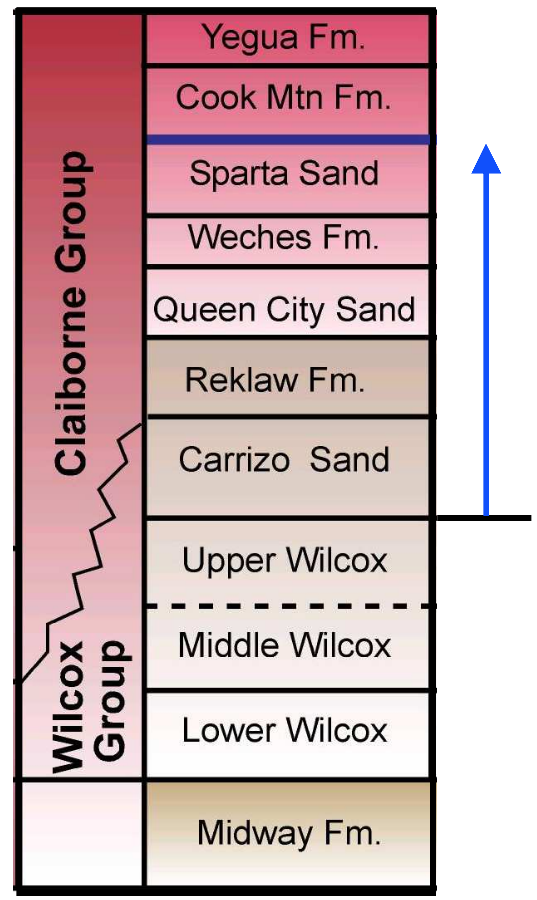
20,000 acres represents
Approximately 5 grid blocks



Grid - 1 square mile each
Same Grid as Carrizo-Wilcox GAMs

Queen City-Sparta GAM Specifications

- Original scope: Carrizo-Wilcox GAMs will be modified only as needed to properly add the Queen City and Sparta aquifers and recalibrate the entire model
- Revised scope: The Carrizo-Wilcox GAMs will be modified to be consistent in the overlap zones from the base of the Carrizo through the Sparta aquifer

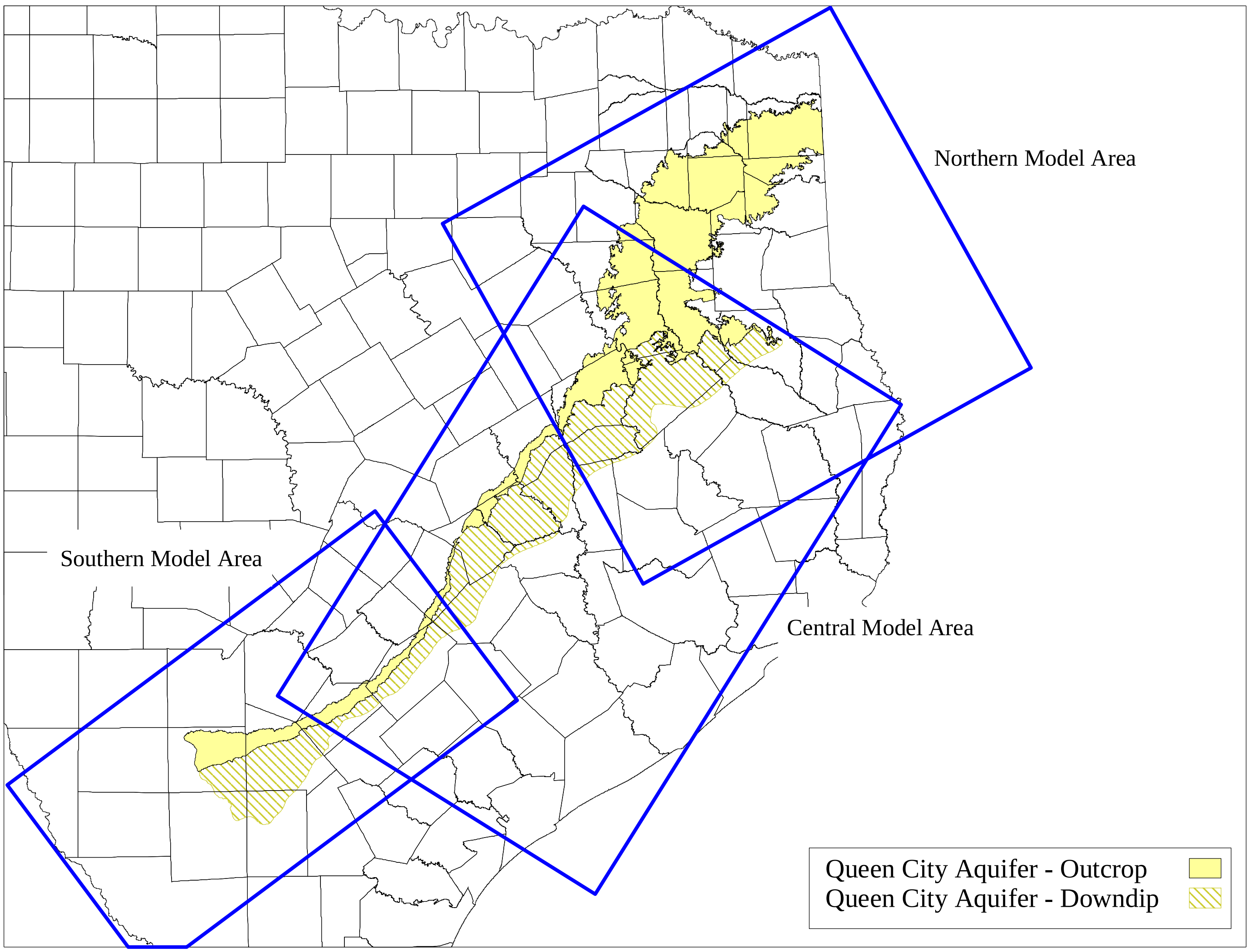


Conceptual Model Review

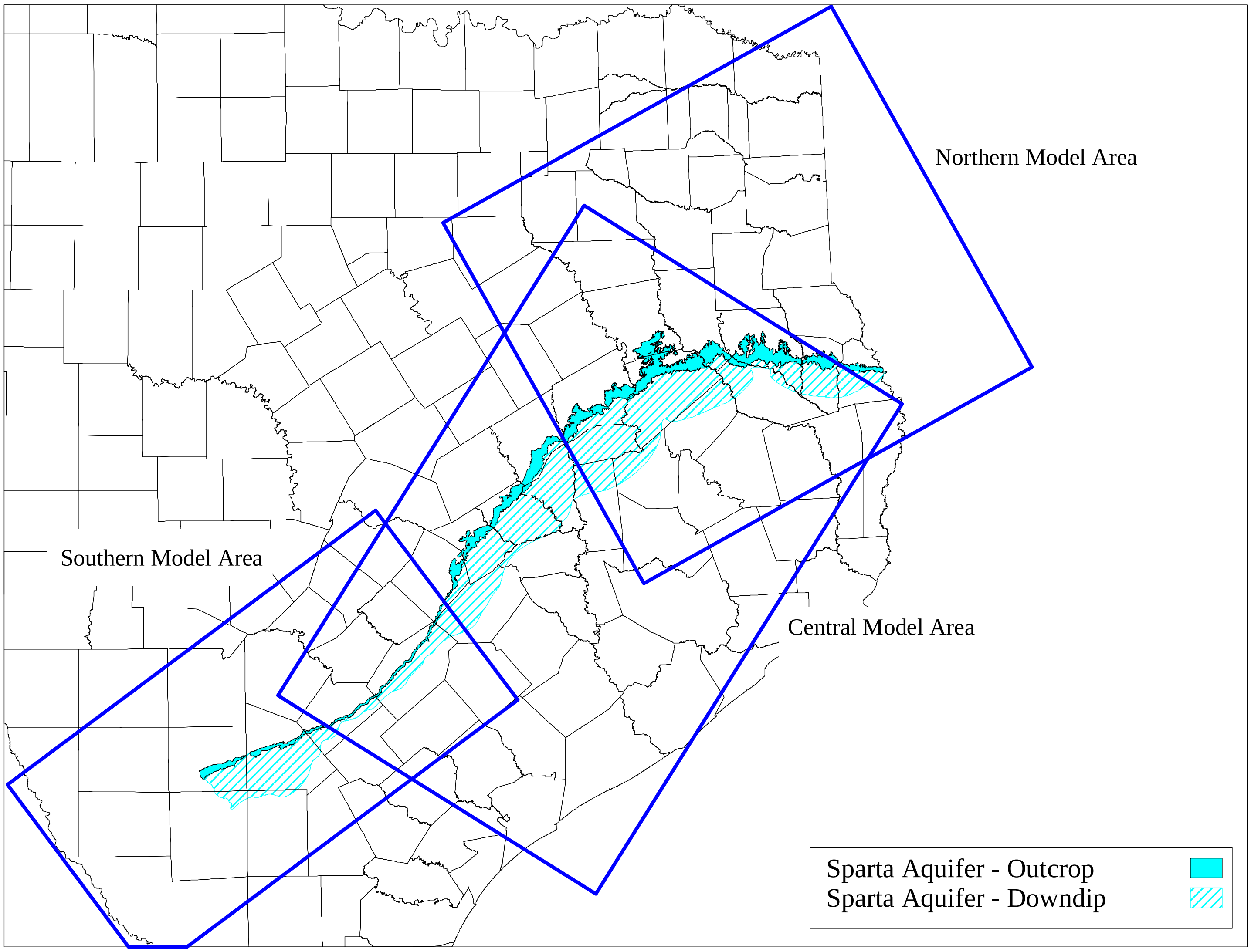
Queen City & Sparta Aquifers

- The Queen City and Sparta Aquifers extend from South Texas northeastward through East Texas into Ark. & La.
  - Sediments of the Tertiary Claiborne Group
  - Queen City aquifer consists of sand, loosely-cemented sands, and interbedded clays
  - Sparta Aquifer consists of sand and interbedded clays with massive basal sands which gently dip toward the Gulf Coast
  - Aquifers are separated by the Weches Formation which is a marine confining unit

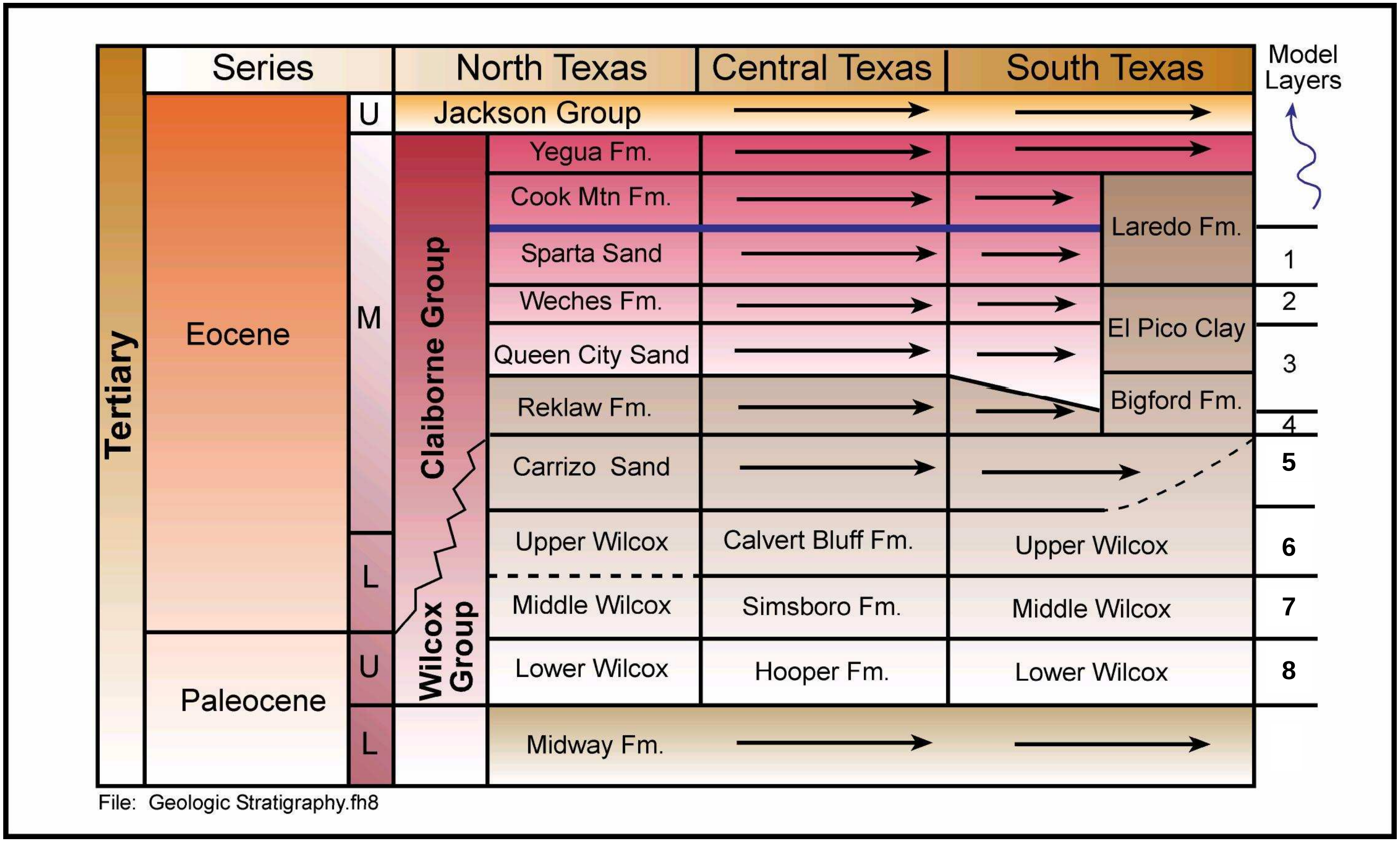
Queen City Aquifer



Sparta Aquifer

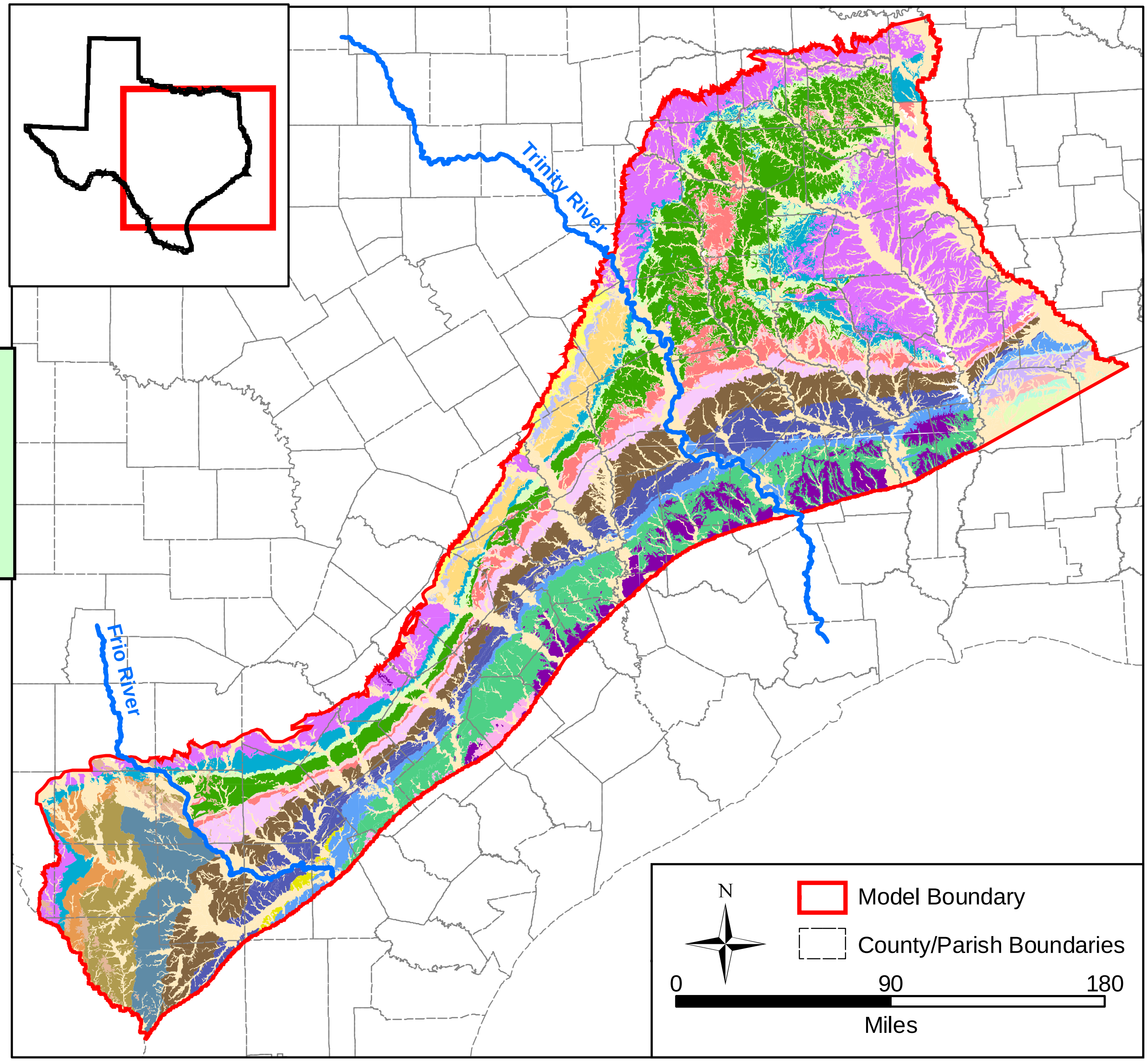


Model Stratigraphy



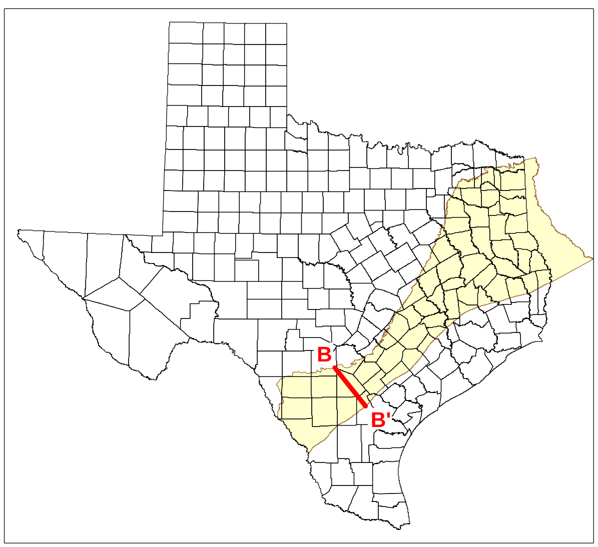
Geology

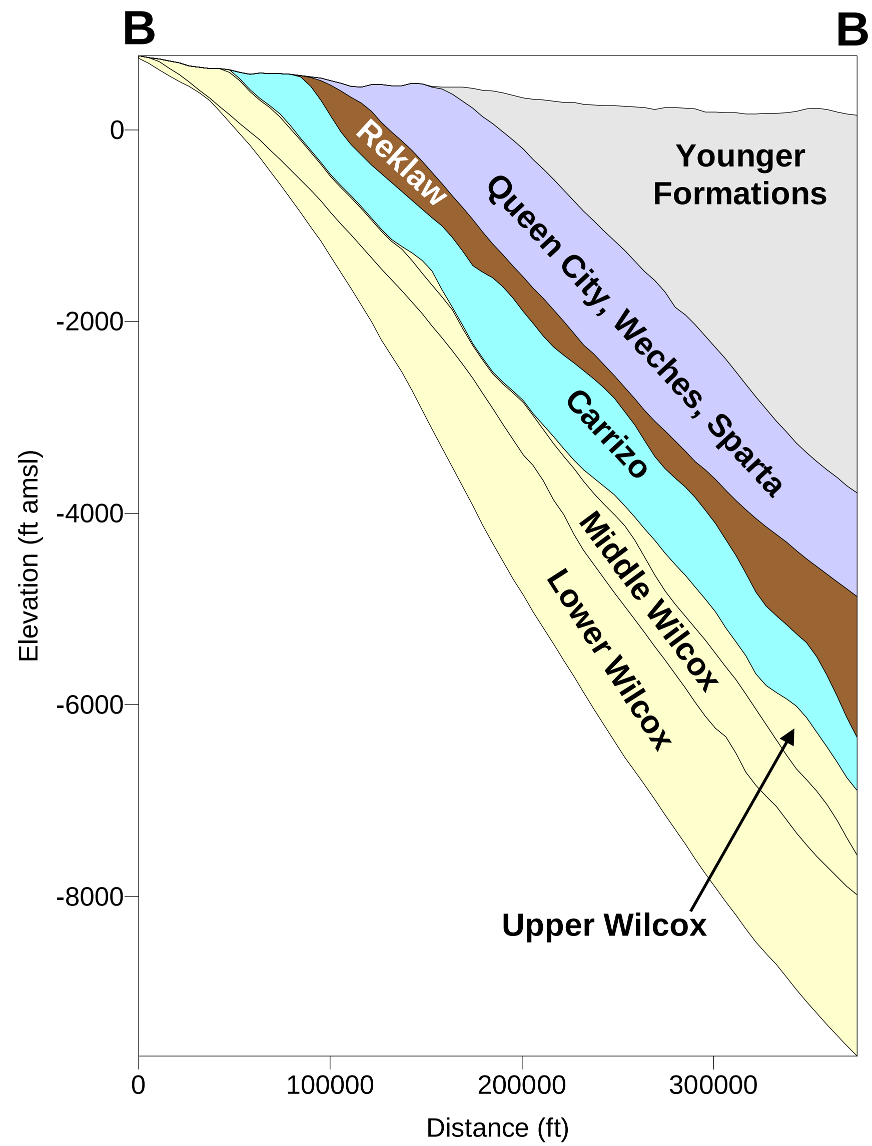
Outcrop for the active model domain



Hydrogeologic Cross section

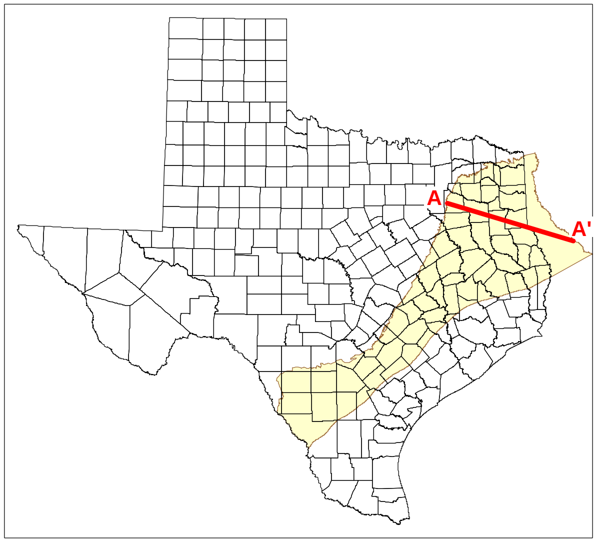
- Central and Southern Models
  - Outcrops are very narrow
  - Dips are very steep averaging 100 ft/mile or >

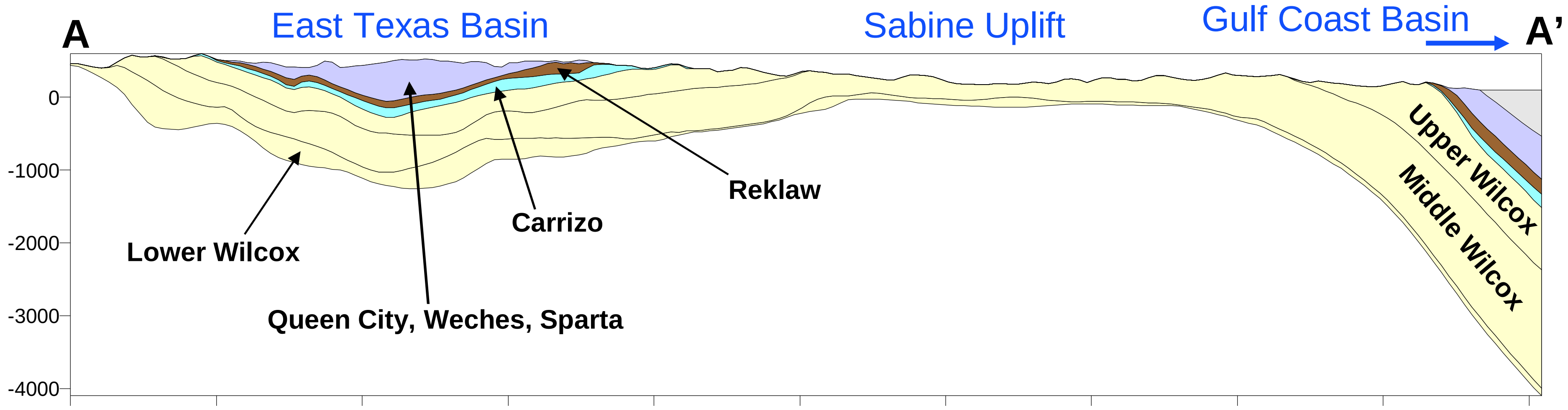




Hydrogeologic Cross Section

- Northern Model Region
  - Queen City outcrops over the majority of the East Texas Basin
  - Queen City and Sparta eroded across the Sabine Uplift
  - South of Sabine Uplift aquifers dip into the Gulf Coast Basin





Conceptual Model - Predevelopment

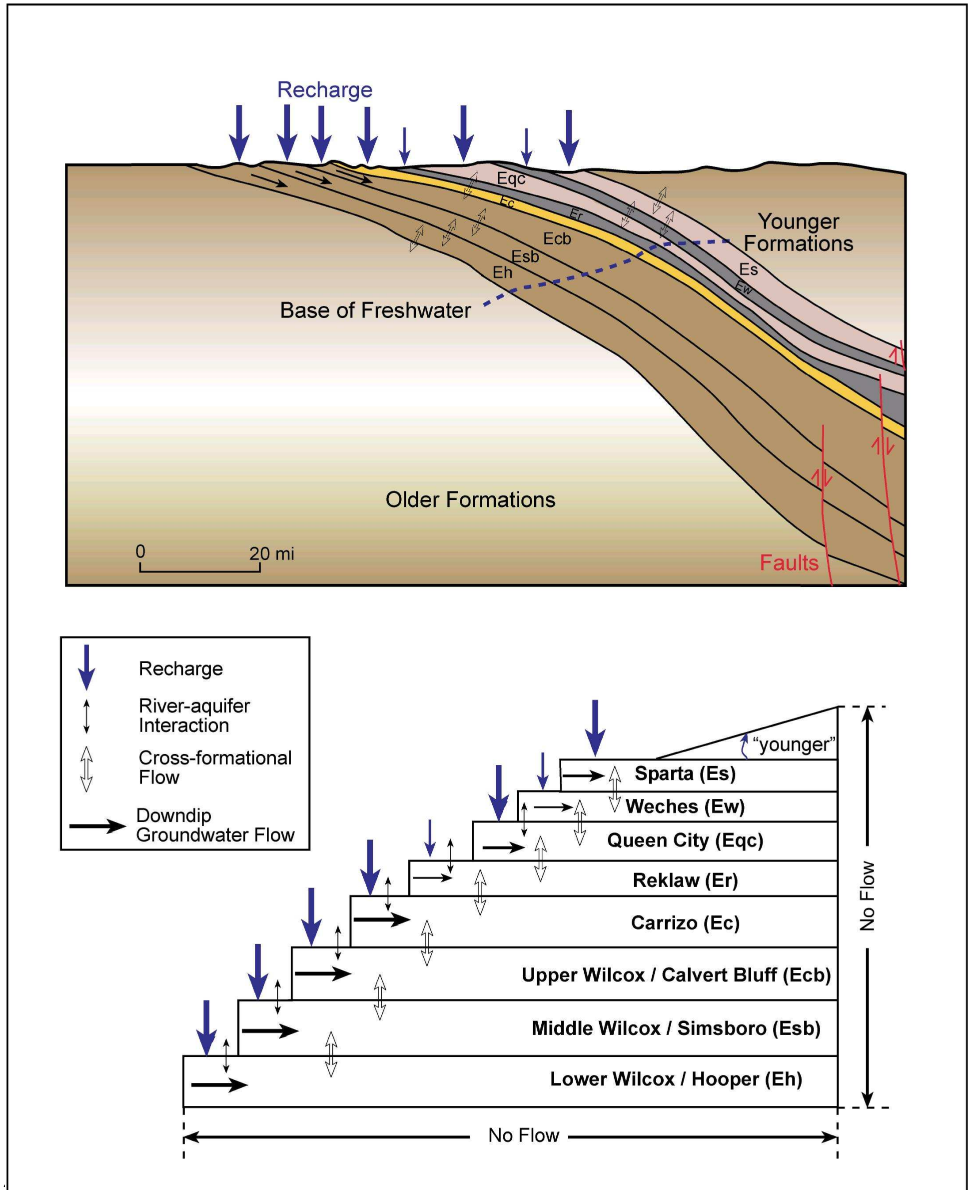
- Steady State Model
- $Q_{in}=Q_{out}$
- Recharge =

  ET groundwater

  spring flow

  stream gains

  cross formational flow



Cross-section-QCS.fh8

Groundwater Flow Conceptual Model

North-Central

- Groundwater flows locally in the Queen City aquifer rather than regionally due to topographic controls (Fogg and Kreitler, 1982)
- Streams are gaining
- Vertical gradients can be controlled by topography (up in river basins and down on topo highs).
- Shallow water table with greater groundwater ET
- Less percentage of recharge to the confined aquifer sections

South-Central

- Groundwater flows regionally in the Queen City and Sparta aquifers from topographic highs in the outcrop areas to topographic lows down dip of the outcrop
- Streams are gaining to losing in west
- Vertical gradients are upward in confined section
- Groundwater ET becomes less in the south
- Greater percentage of recharge to the confined aquifer sections

Recharge Conceptual Model

- Based upon the work of Scanlon (2003), Meyboom (1966) and Toth (1966), we expect recharge to be a function of:
  - Precipitation,
  - Topography, and
  - Underlying geology
- Topographic control:
  - North and Central - Recharge would be enhanced in the higher elevations relative to the low elevations
  - We expect that this trend would be more subdued to reversed in the arid southwest
- In steady-state, recharge is also fixed by the aquifers (also models) ability to discharge

Model Implementation Integration with C/W GAMs

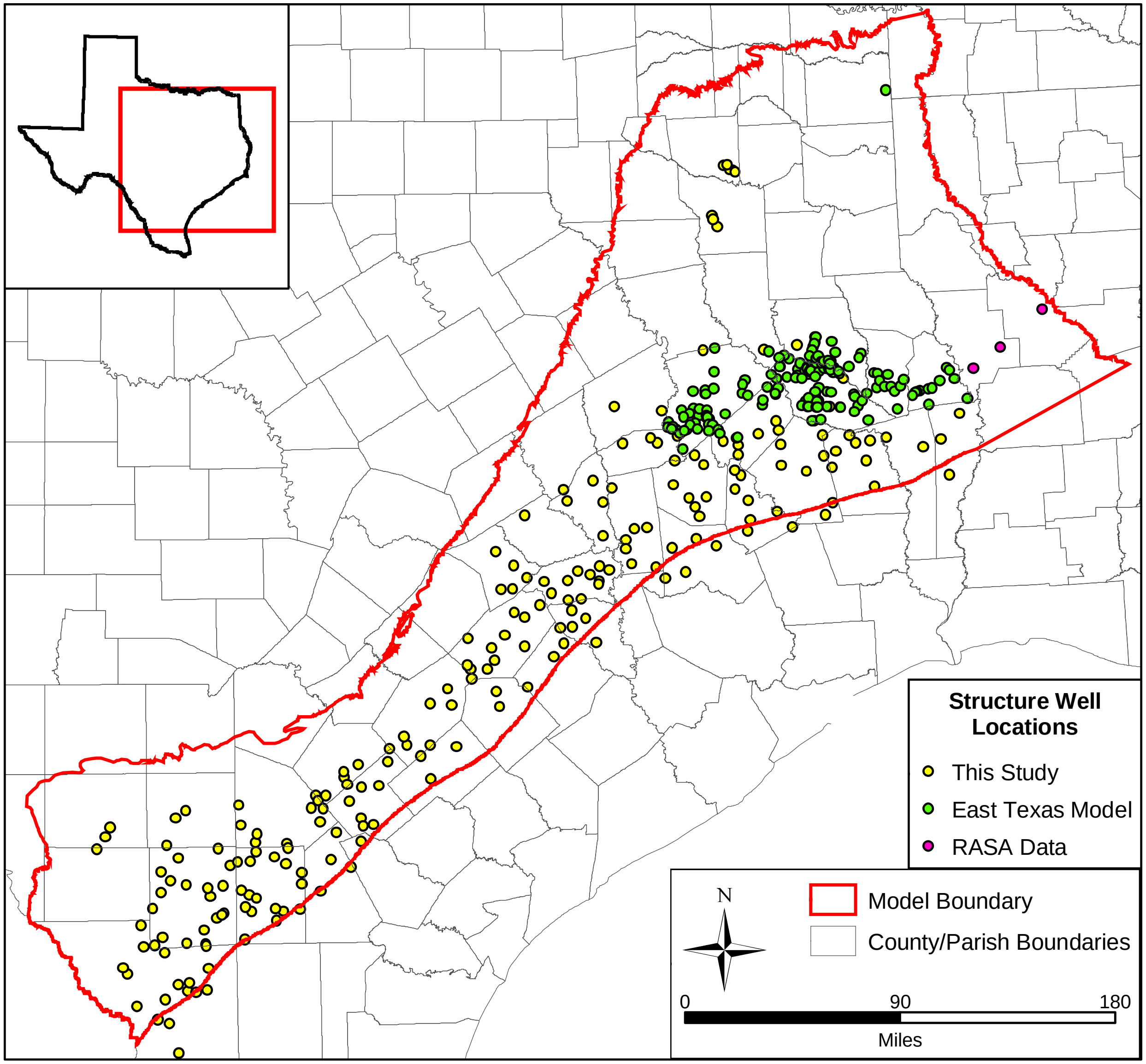
Model Implementation

- We begin with the same values in overlap areas for the Carrizo through the Sparta
  - Structure
  - Hydraulic Conductivity
  - Hydraulic Heads
  - Recharge
  - Boundaries
  - Storage
  - Pumping
- We will monitor parameter changes between models during calibration to insure consistency between models at the end of calibration

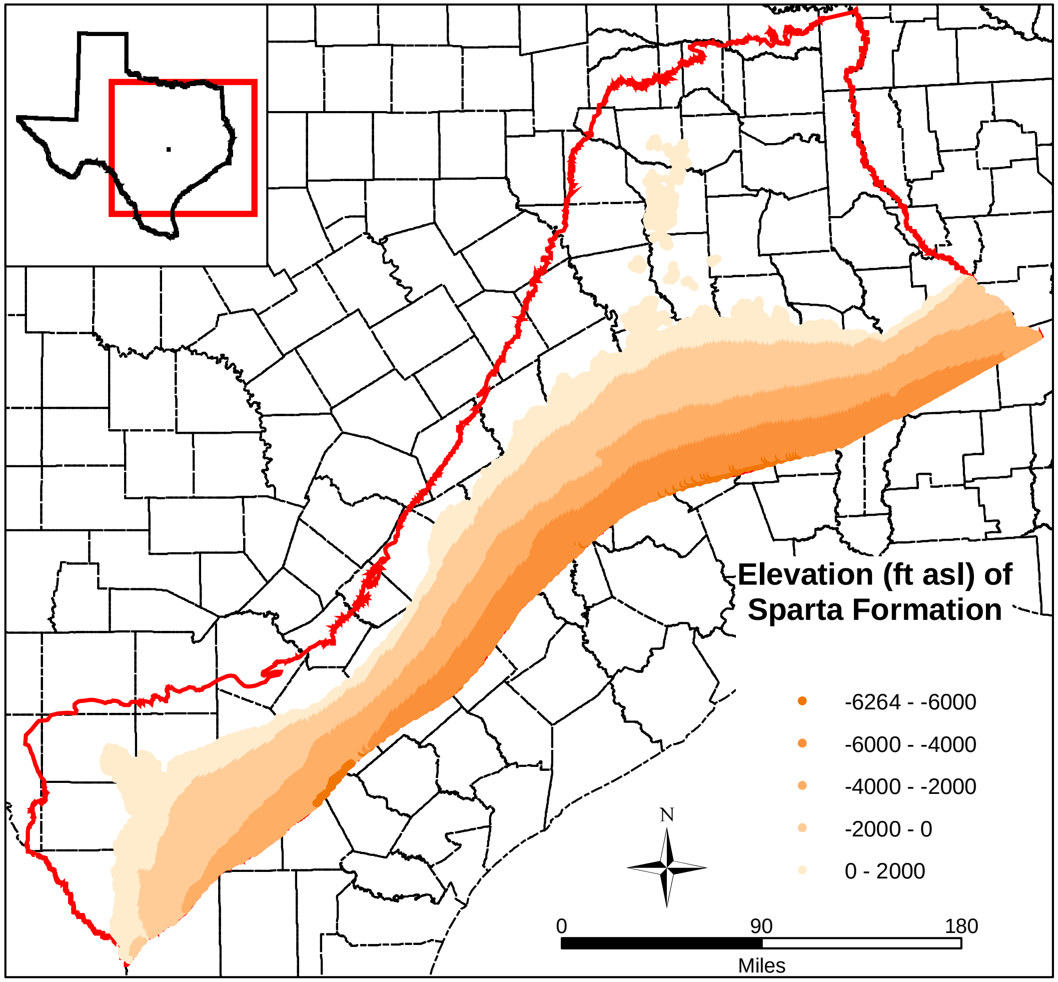
Geologic Structure Data Sources

- Structure – Refers to the elevation of the tops of the Queen City, the Weches, and the Sparta formations
- MS Thesis – TCEQ well log database
  - Guevara (1972) & Garcia (1972) – Queen City
  - Ricoy (1976) - Sparta
    - Approximately 250 logs used across the 3 model areas
  - Payne (1968)
  - East Texas Model
- Sand thickness maps:
  - Guevara (1972) & Garcia (1972) – Queen City
  - Ricoy (1976) and Payne (1968) – Sparta
  - GUWCD – Carrizo, Gonzales County

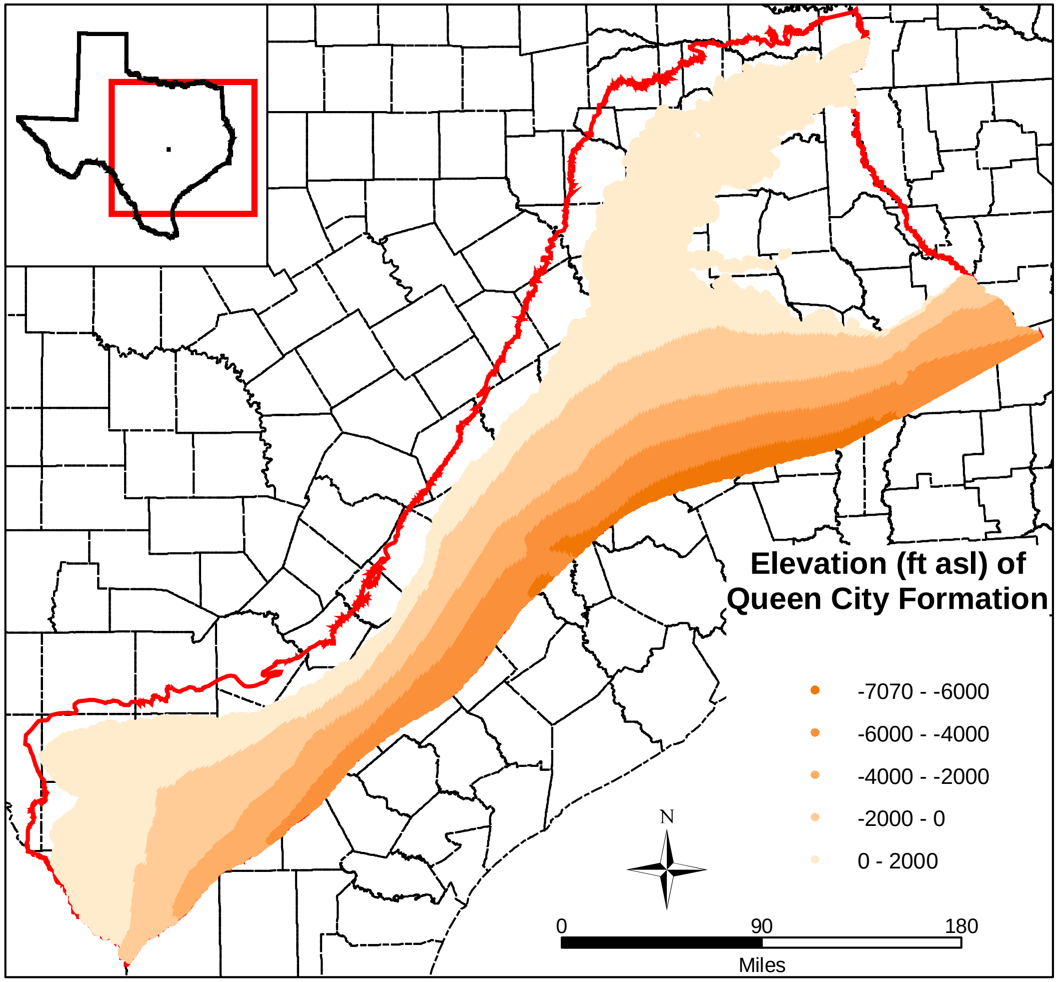
Queen City Aquifer – Structure Control



Structure Contour – Sparta Formation



Structure Contour – Queen City Formation



Hydraulic Properties

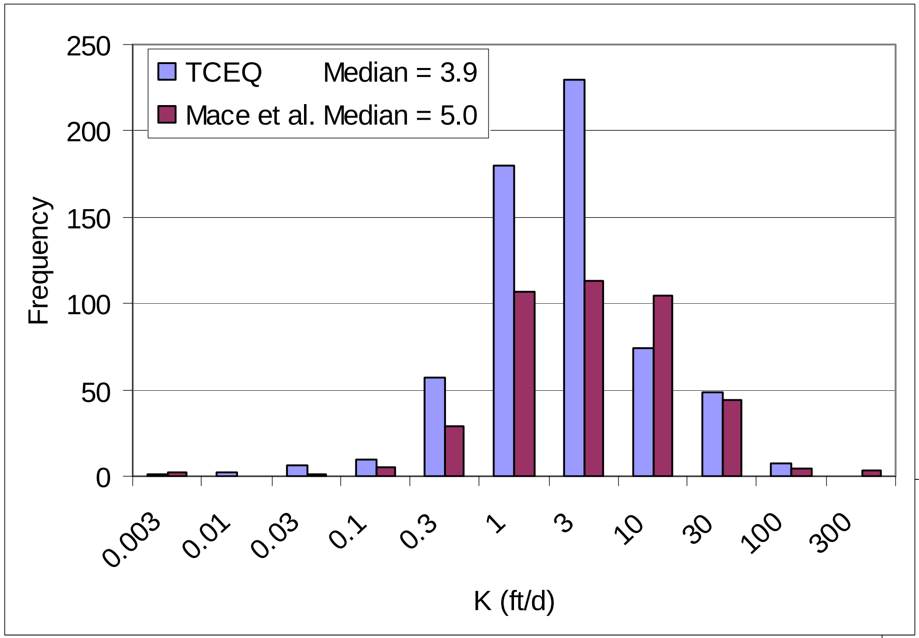
Soft Data:

- USGS
  - Payne (1968)
  - McWreath et al (1991)
  - RASA – Prudic (1991)
- BEG
  - Guevara & Garcia (1972)
  - Ricoy (1977)
- TWDB
  - Myers (1969)
  - County Reports

Hard Data:

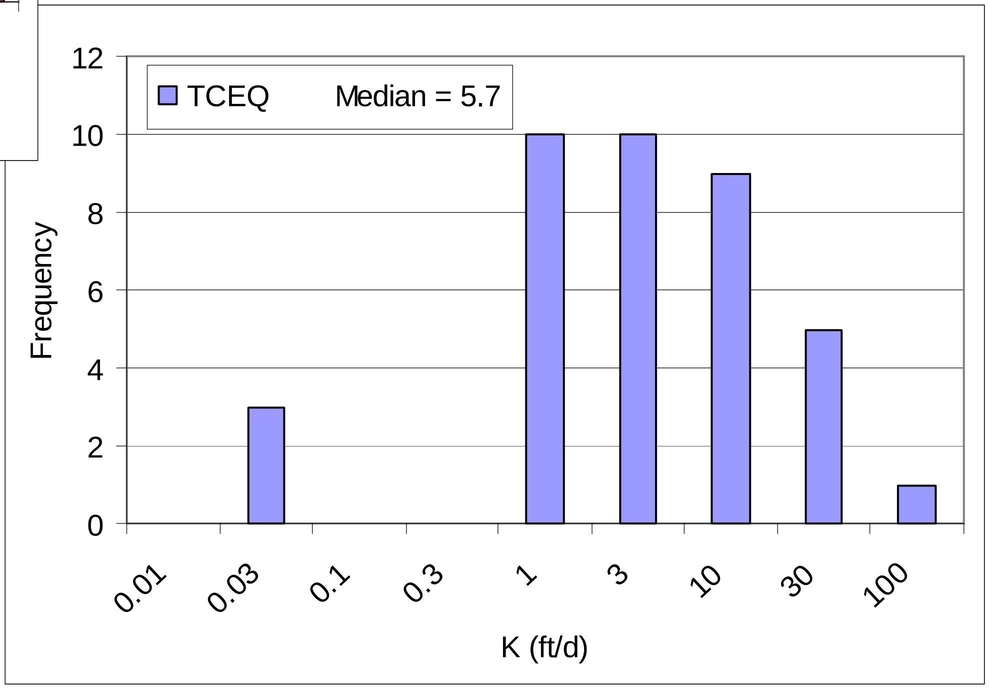
- TCEQ file search of the drillers logs
  - Queen City - 444 estimates
  - Sparta - 33 estimates
- Mace et al. (2000) database

Hydraulic Conductivity Distributions



Queen City

Sparta

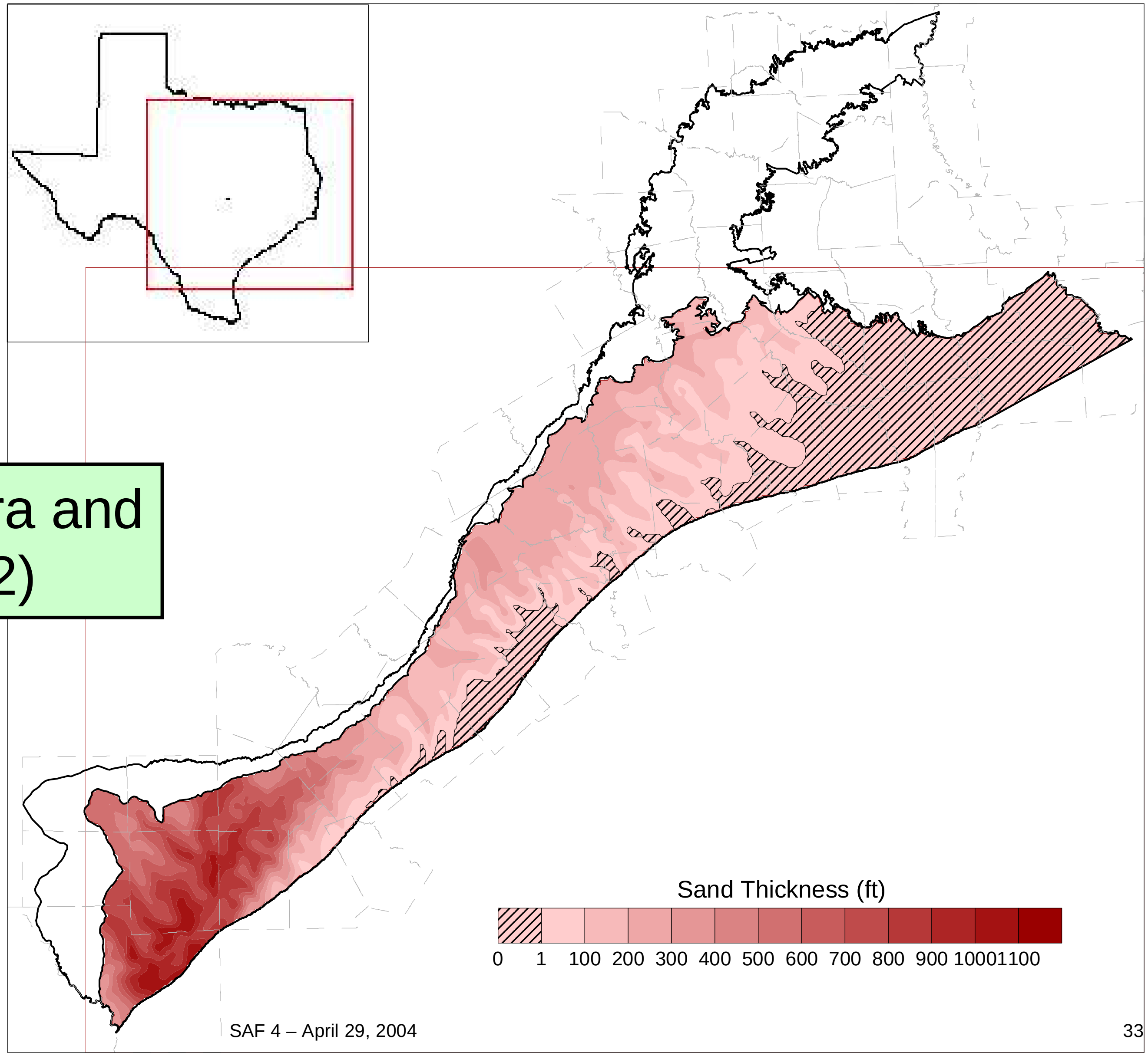


Hydraulic Conductivity Analysis Approach

- Krige available conductivity measurements
- Impose a depth trend based on Prudic (1991)
- Multiply by net sand fraction to convert to effective conductivity for import to MODFLOW

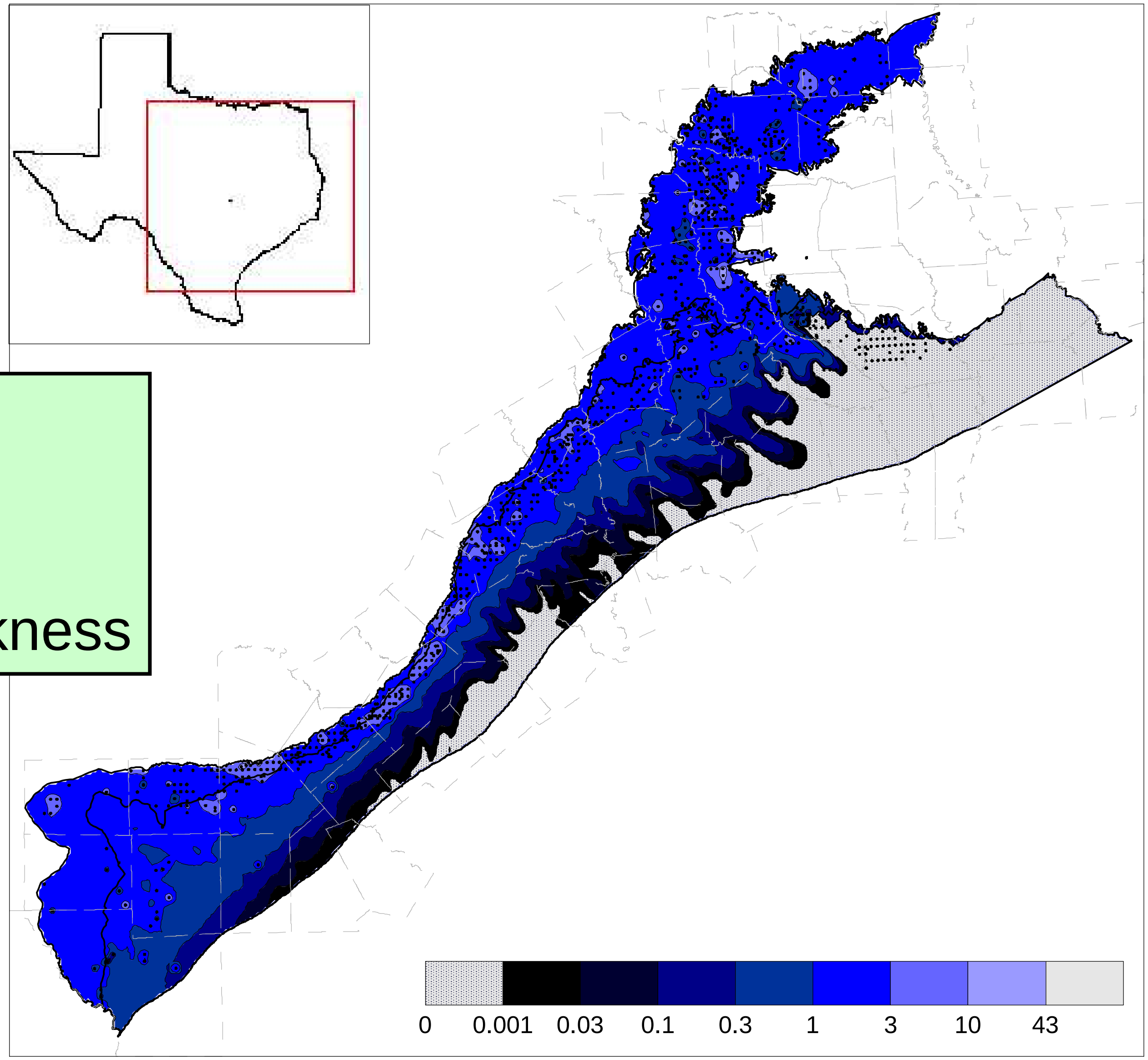
Queen City Net Sand Thickness (ft)

after Guevara and Garcia (1972)

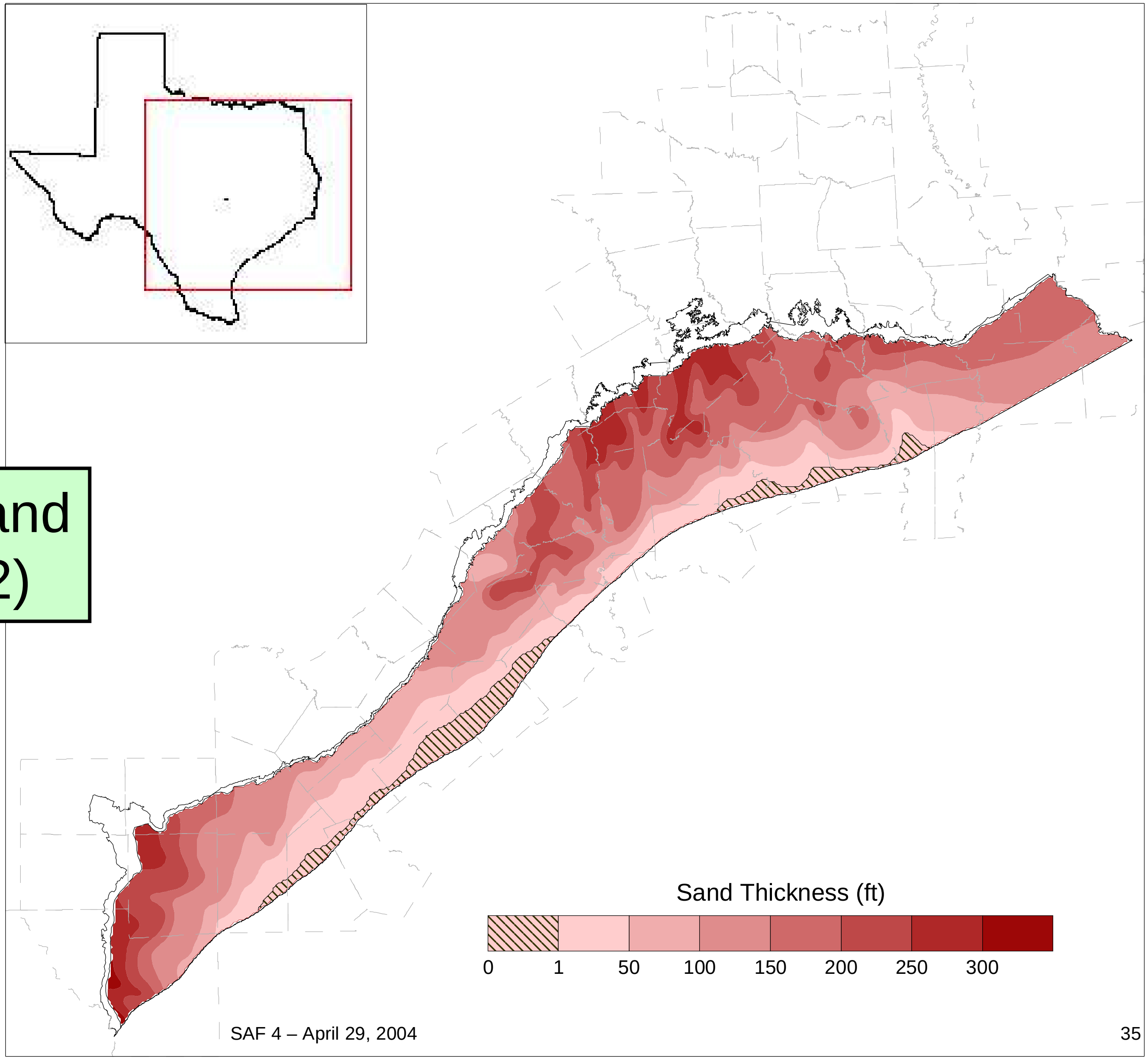


Queen City Effective Hyd. Conductivity

Combines:
* Test data
* Depth trend
* Net sand thickness

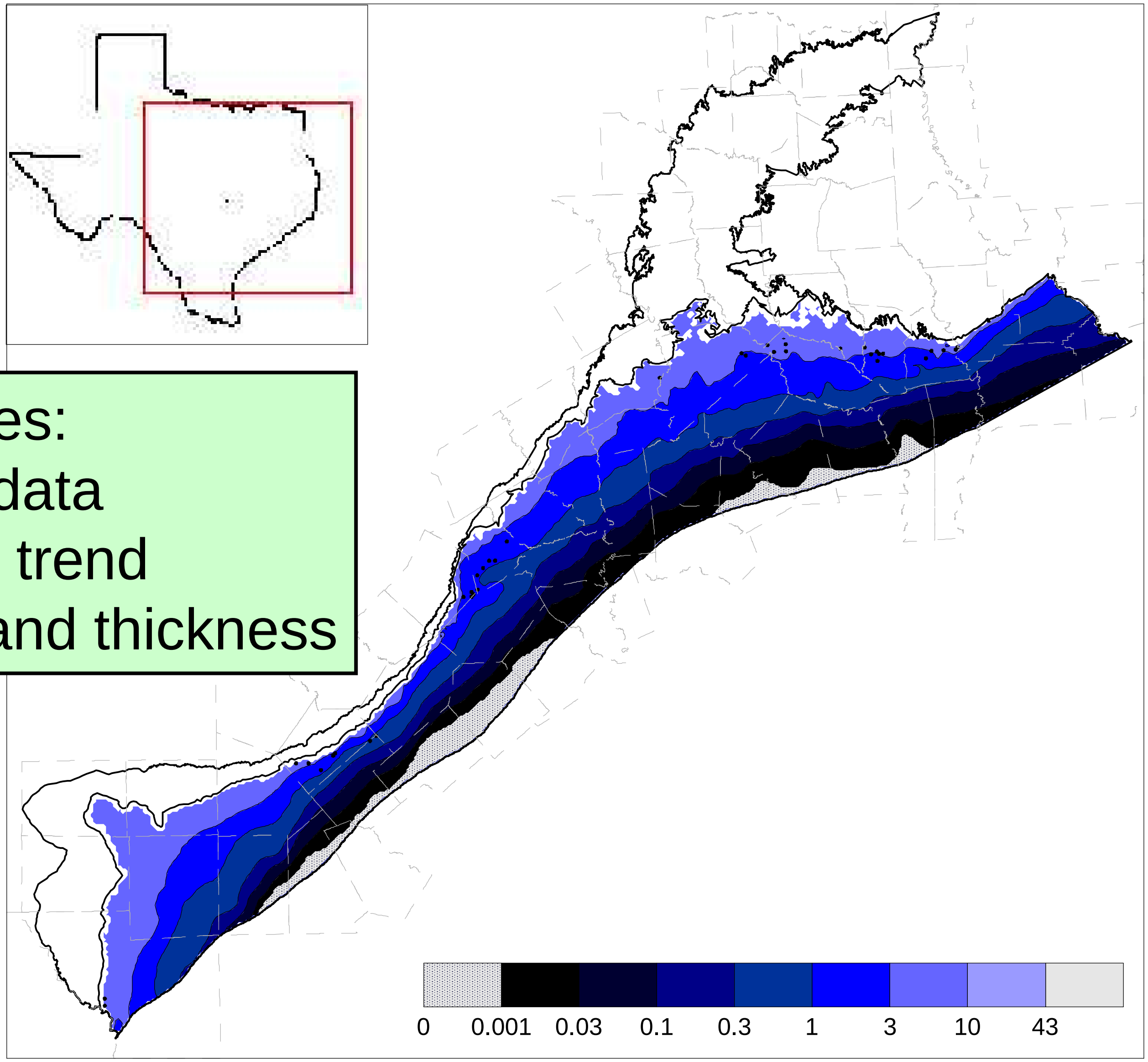


Sparta Net Sand Thickness (ft)



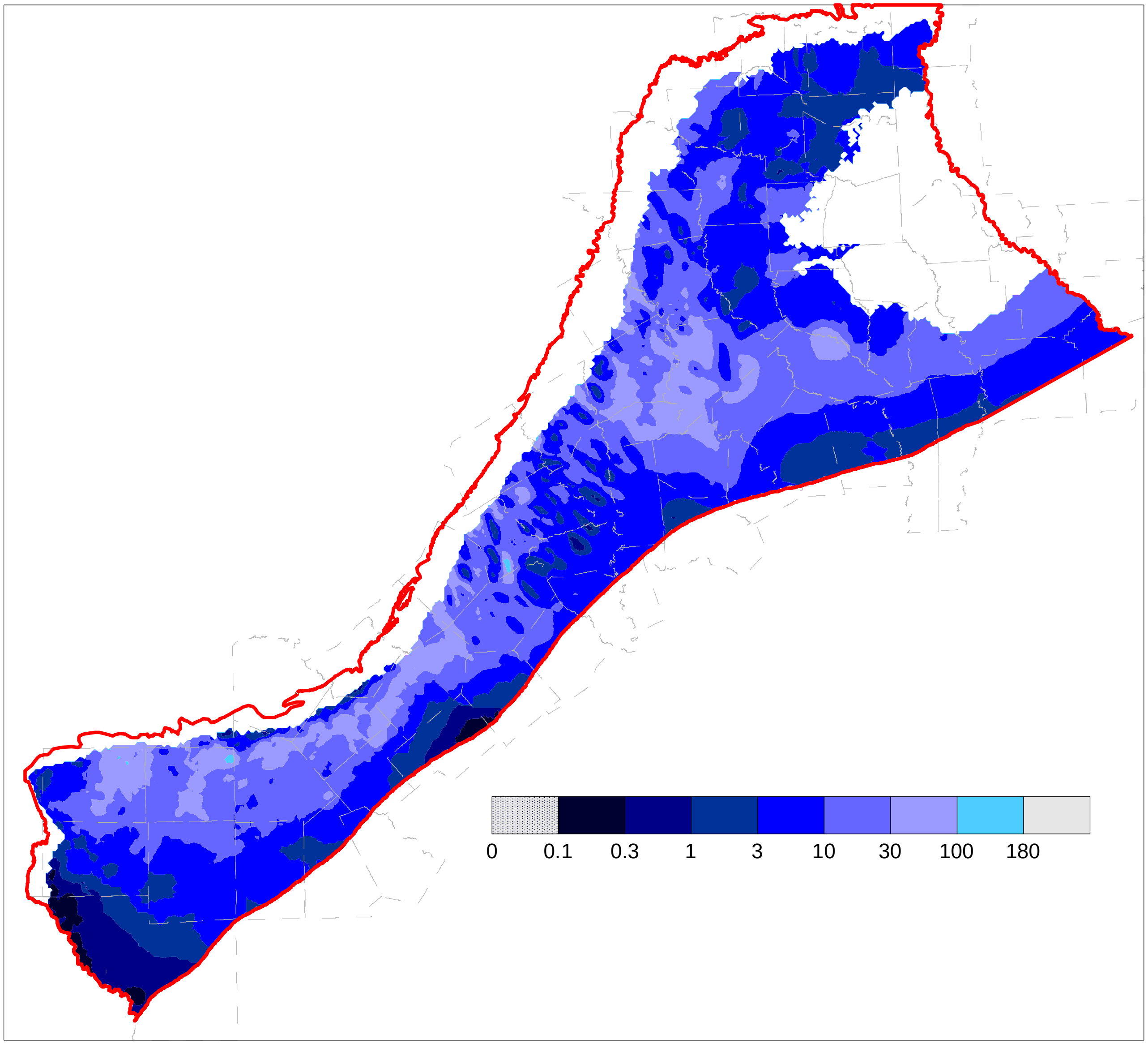
after Ricoy and Brown (1972)

Sparta Effective Hyd. Conductivity



Combines:
* Test data
* Depth trend
* Net sand thickness

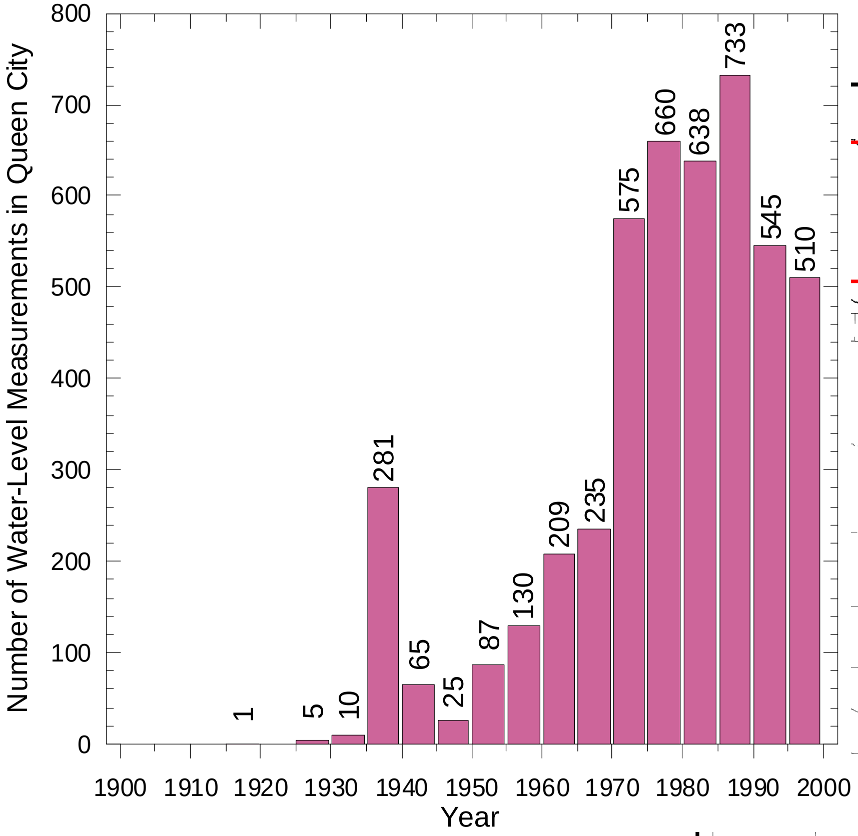
Effective K – Carrizo

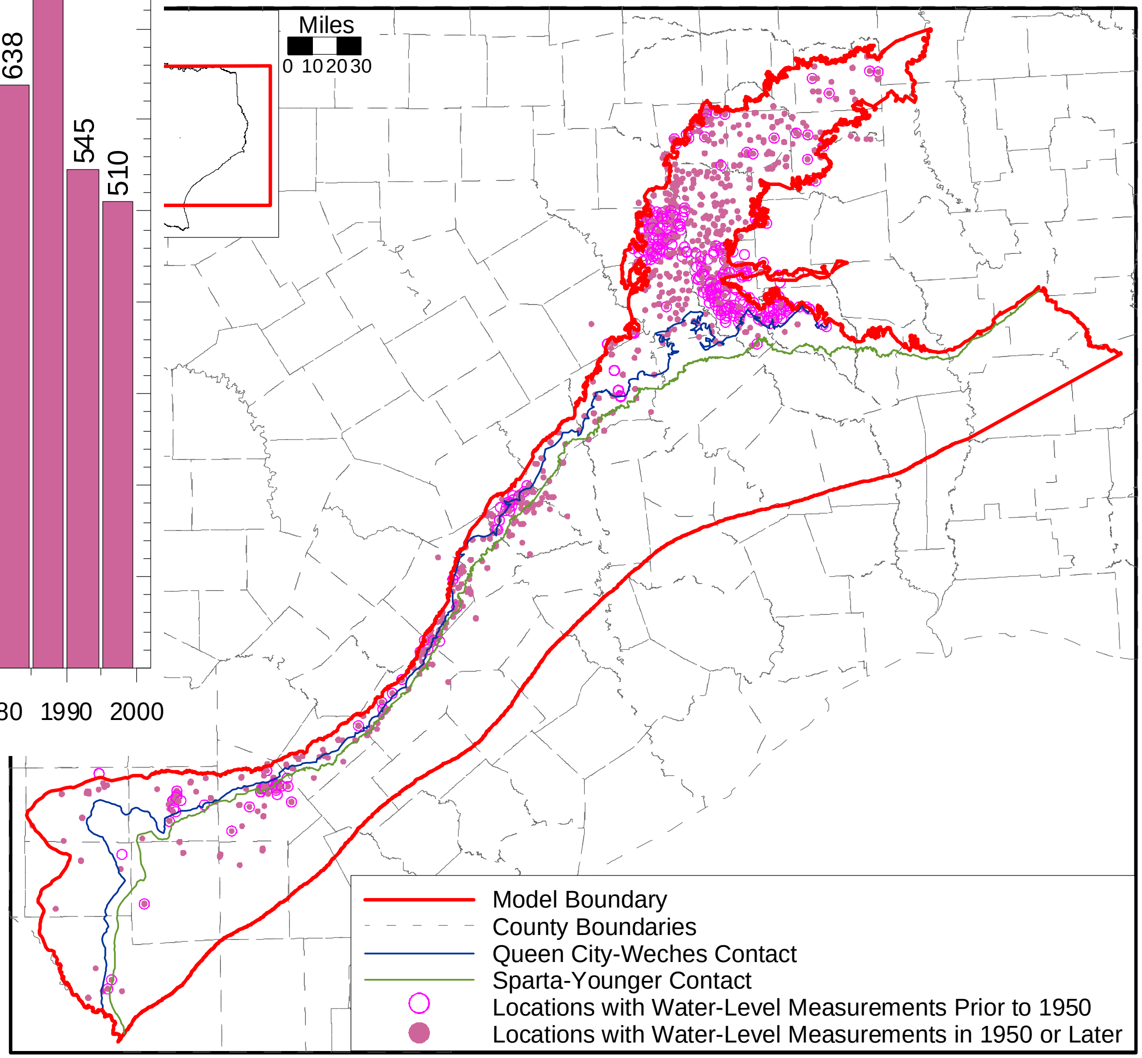


Kv – Implementation

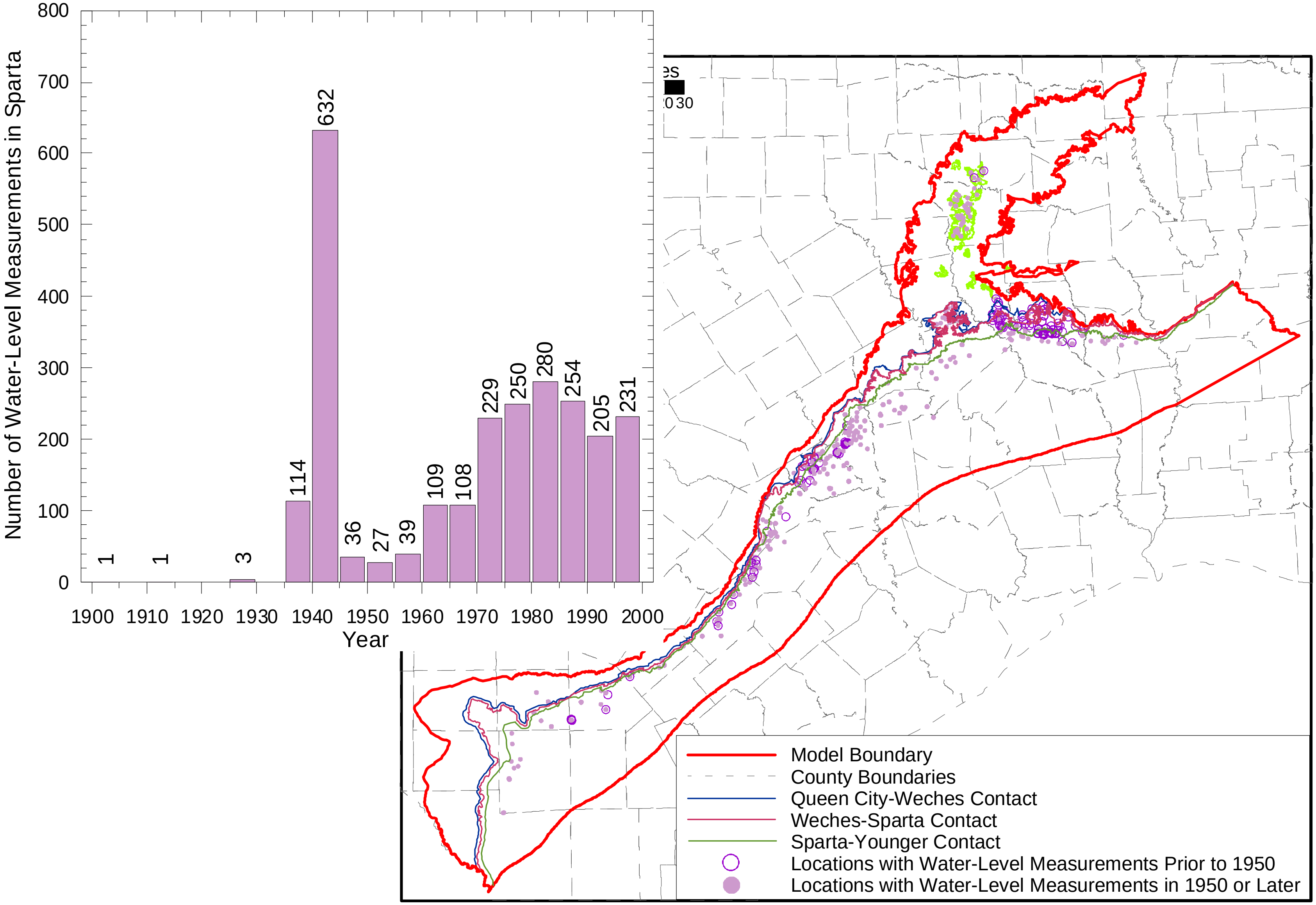
- Aquifers
  - Used clay fraction and an assumed clay conductivity to calculate geometric mean conductivity
- Aquitards
  - Used estimated clay fraction and an assumed clay conductivity to calculate harmonic mean conductivity
- Clay conductivity now set at
  - 1×10^{-4} ft/day, (0.0001)
  - Calibration parameter

Queen City Water Level Control

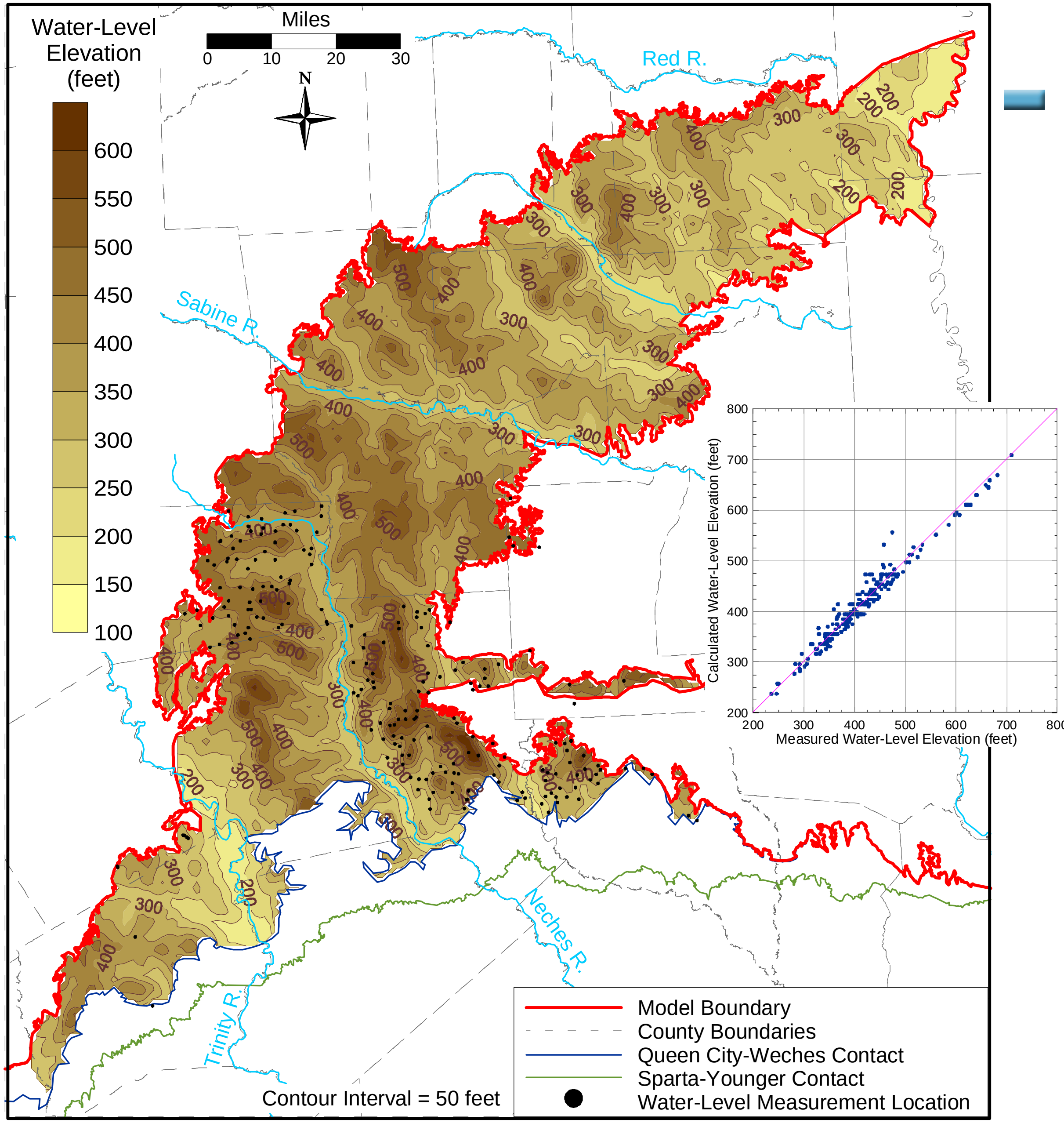




Water Level Control – Sparta aquifer

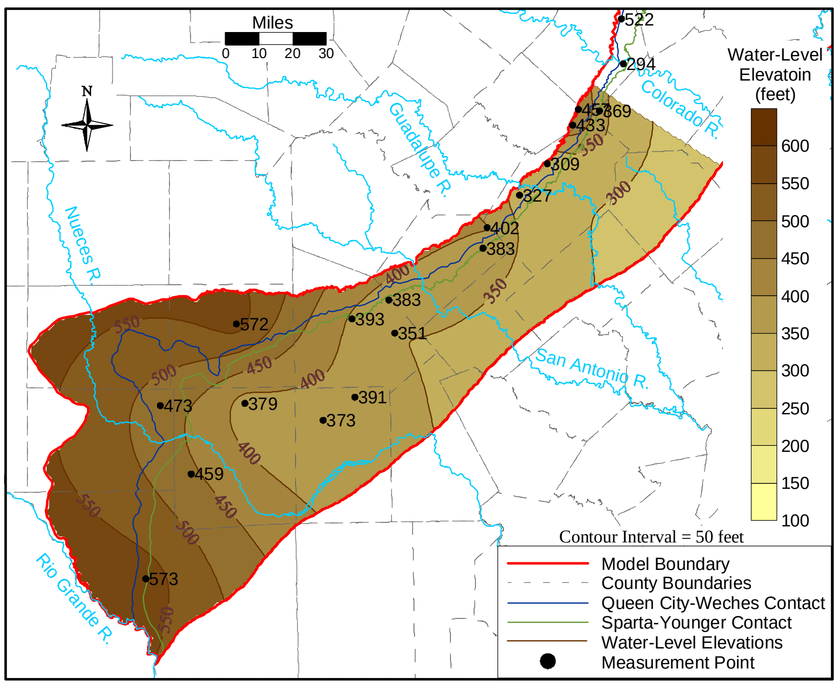


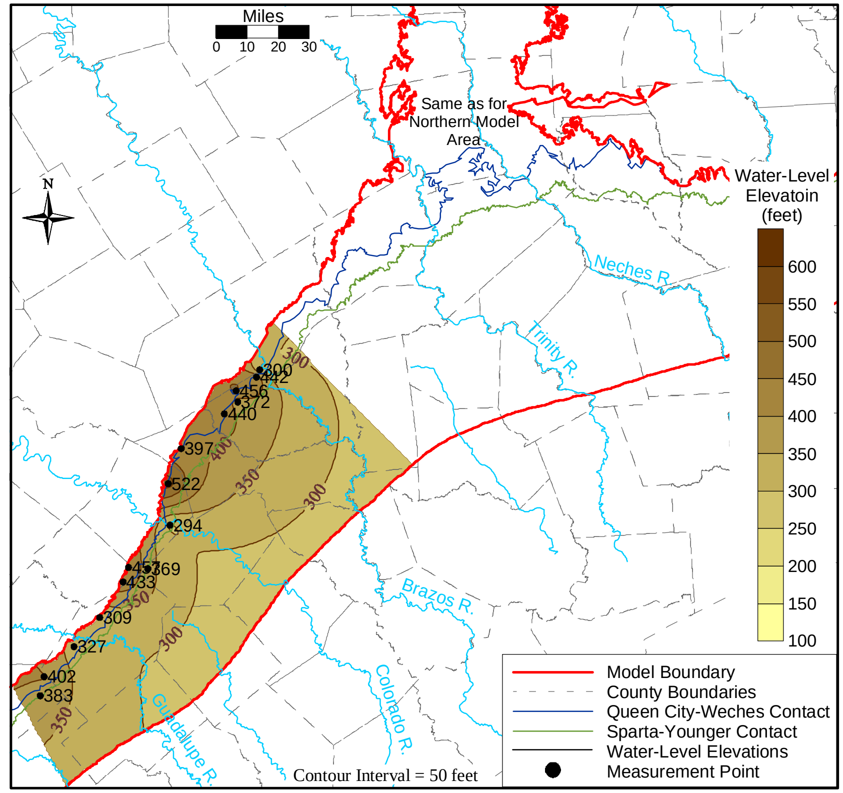
Queen City Predevelopment Water Levels Northern Area



Queen City Predevelopment

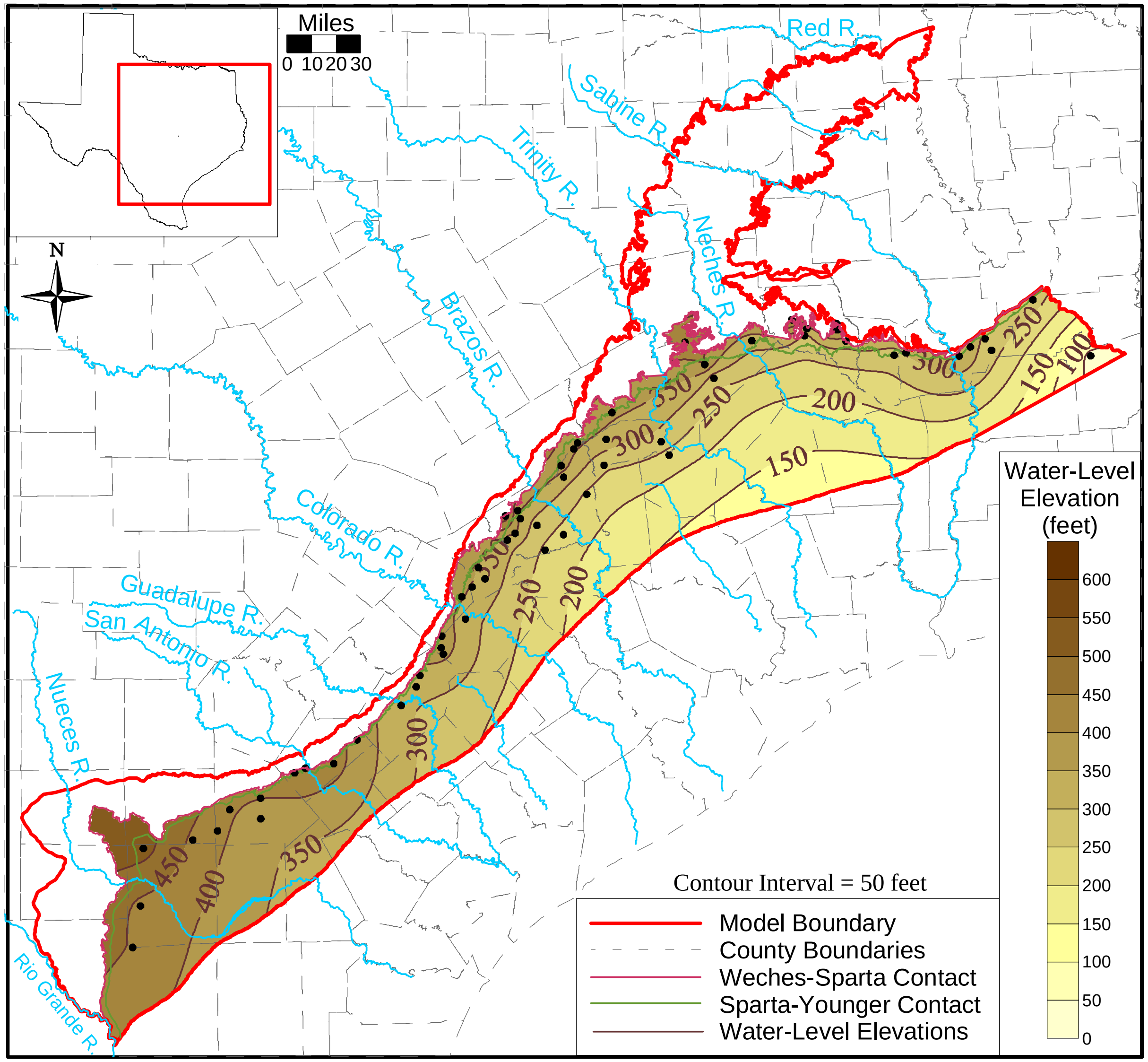
Southern Area





Central Area

Sparta Predevelopment



Number of Steady-State Head Targets

	GAM		
Aquifer	**Southern**	**Central**	**Northern**
Sparta	15	45	26
Queen City	16	203	191
Carrizo	36	42	35

Aquifer Sinks and Sources

Recharge, Springs

& Aquifer-Stream Interactions

Recharge Implementation

- We developed a method based upon
  - precipitation,
  - topographic relationships, and
  - underlying aquifer properties
- Method is based upon the recently published recharge report by Dr. Scanlon (BEG).
- The recharge estimates will be constrained based upon previous estimates
- Consistency in recharge implies some change within the Carrizo-Wilcox models
- Recharge will be calibrated in the SS models
- Transient climatic forcing function will be derived from precipitation variation (SPI)

Precipitation - Simulation Results
(after Scanlon et al., 2003)

Table 11: Simulation results for layered profiles with vegetation. *R/P* represents the ratio of recharge to precipitation expressed as percentage.

Units: mm/yr	*P*	*Dryland*					*Irrigated*			
Study Area		*R*	*R/P*	*RO*	*E*	*T*	*R*	*RO*	*E*	*T*
El Paso County	224	0.2	0.1	0	119	89				
Midland County	380	2	0.5	5	192	201	4	5	199	216
Cenozoic Pecos Alluvium	380	7	1.8	13	179	186				
Lubbock County	474	1	0.2	55	164	148	6	116	208	235
Carson County	497	0.5	0.0	244	148	125	0.5	367	158	148
Fisher/Jones Counties	619	7	1.1	179	262	197	7	180	262	199
Starr County	676	31	4.6	31	303	221				
Bastrop County	809	16	2.0	192	307	327				
Parker County	855	27	3.2	162	352	361				
Hopkins/Rains Counties	855	24	2.8	59	403	386				
Upshur/Gregg Counties	855	38	4.4	27	325	491				
Victoria County	932	21	2.3	401	310	227				
Liberty County	1184	114	9.6	325	318	432				

P: precipitation, *R*: recharge, *RO*: runoff, *E*: evaporation, *T*: transpiration

Precipitation - Simulation Results

(after Scanlon et al., 2003)

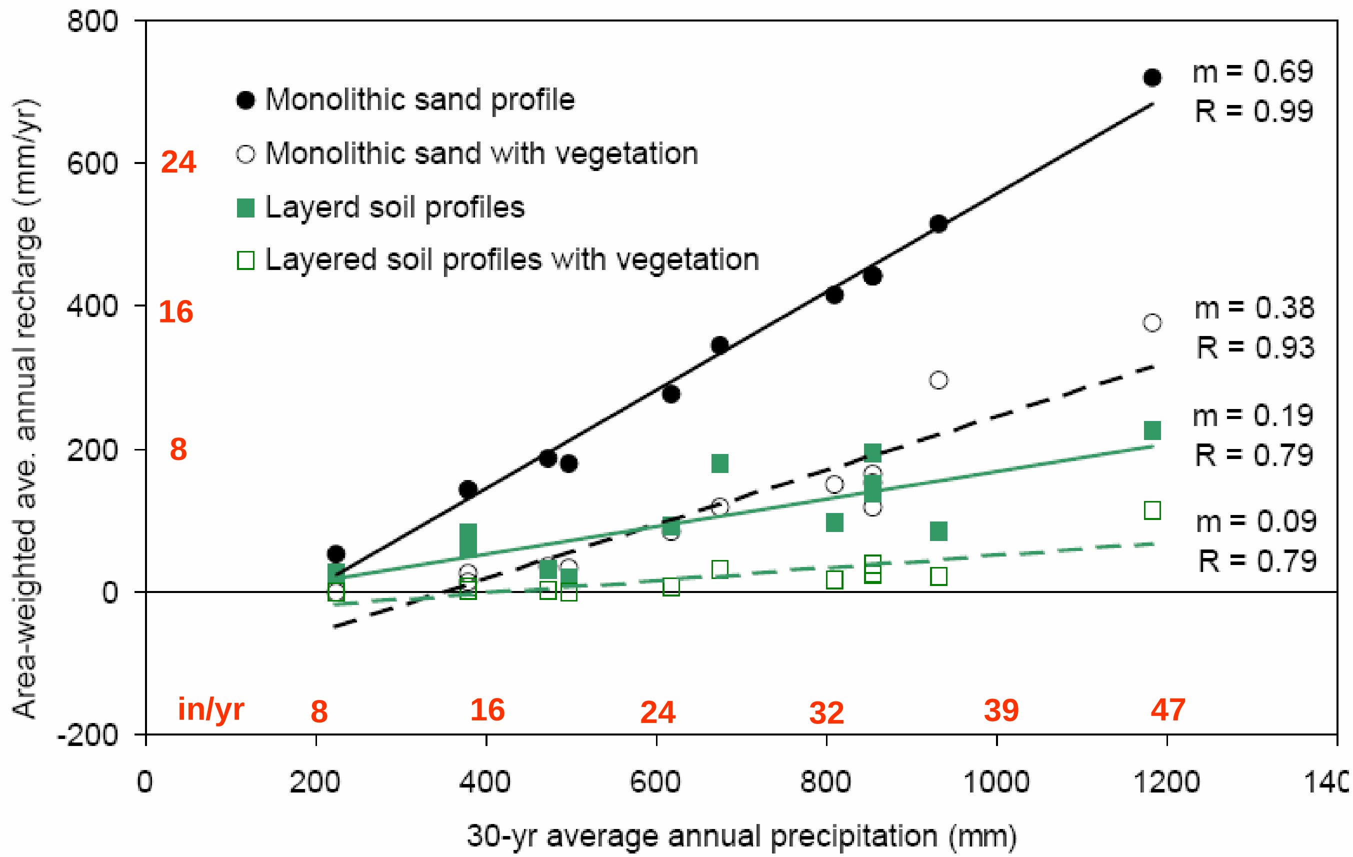
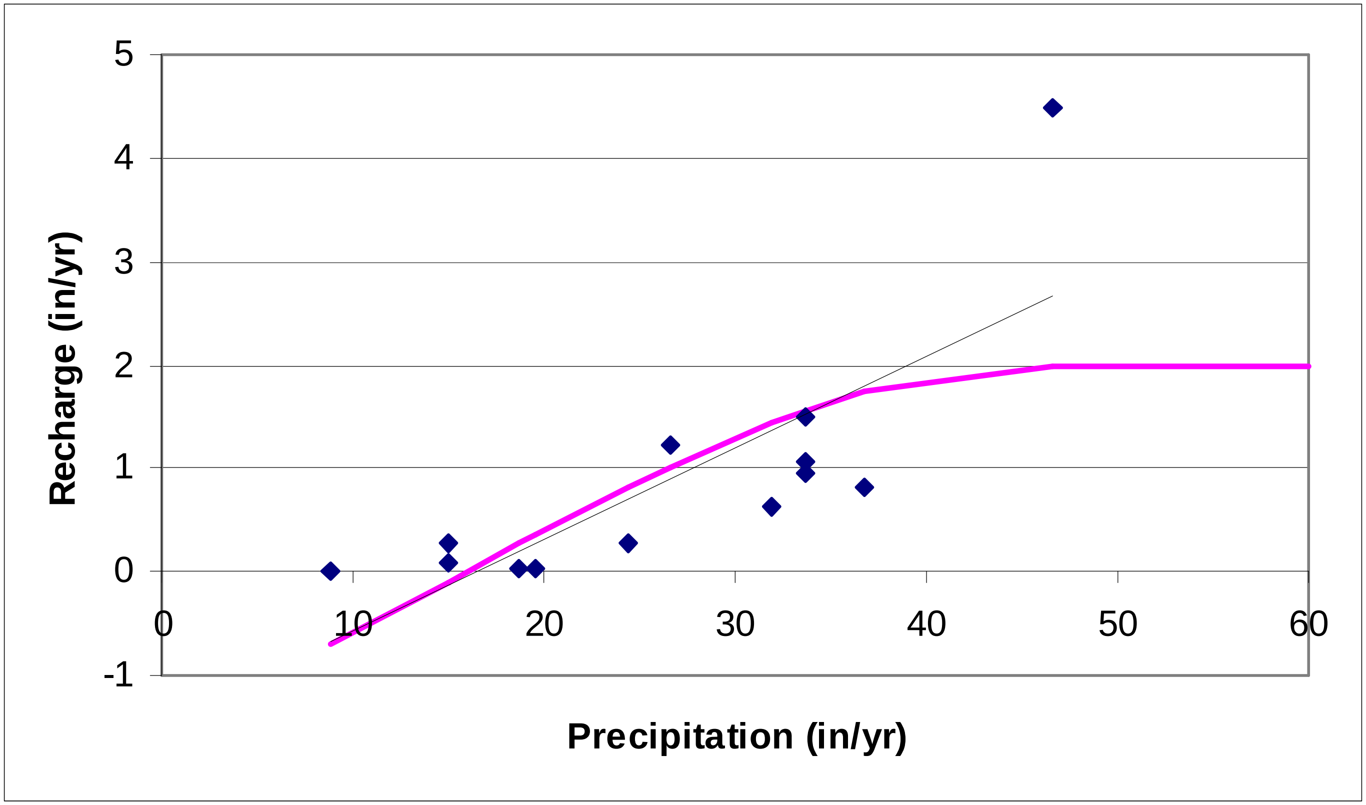


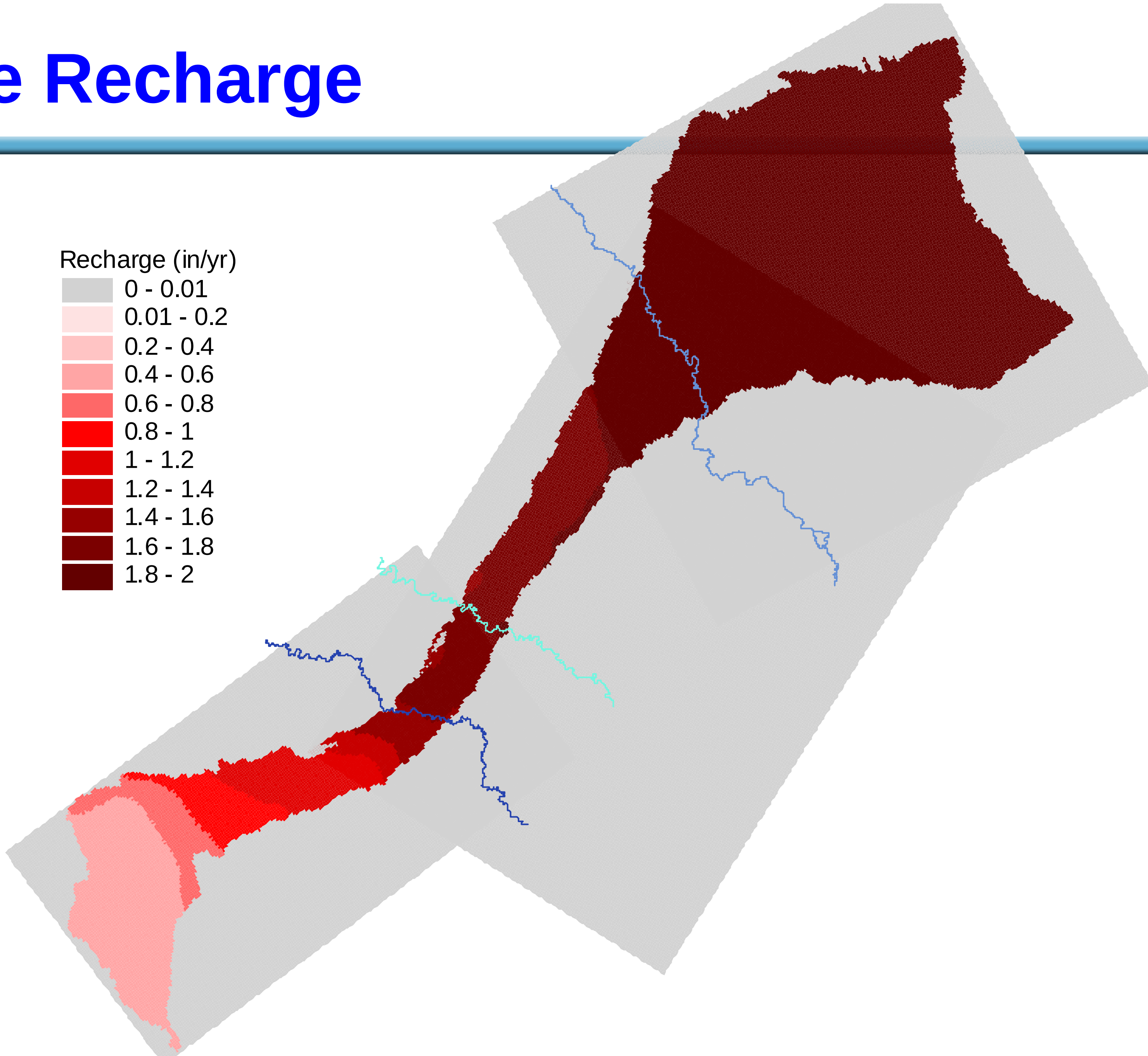
Figure 10: Relationships between precipitation and simulated area-weighted average annual recharge. (R = correlation coefficient, m = slope of regression line.)

Fit to Scanlon et al. 2003 simulations

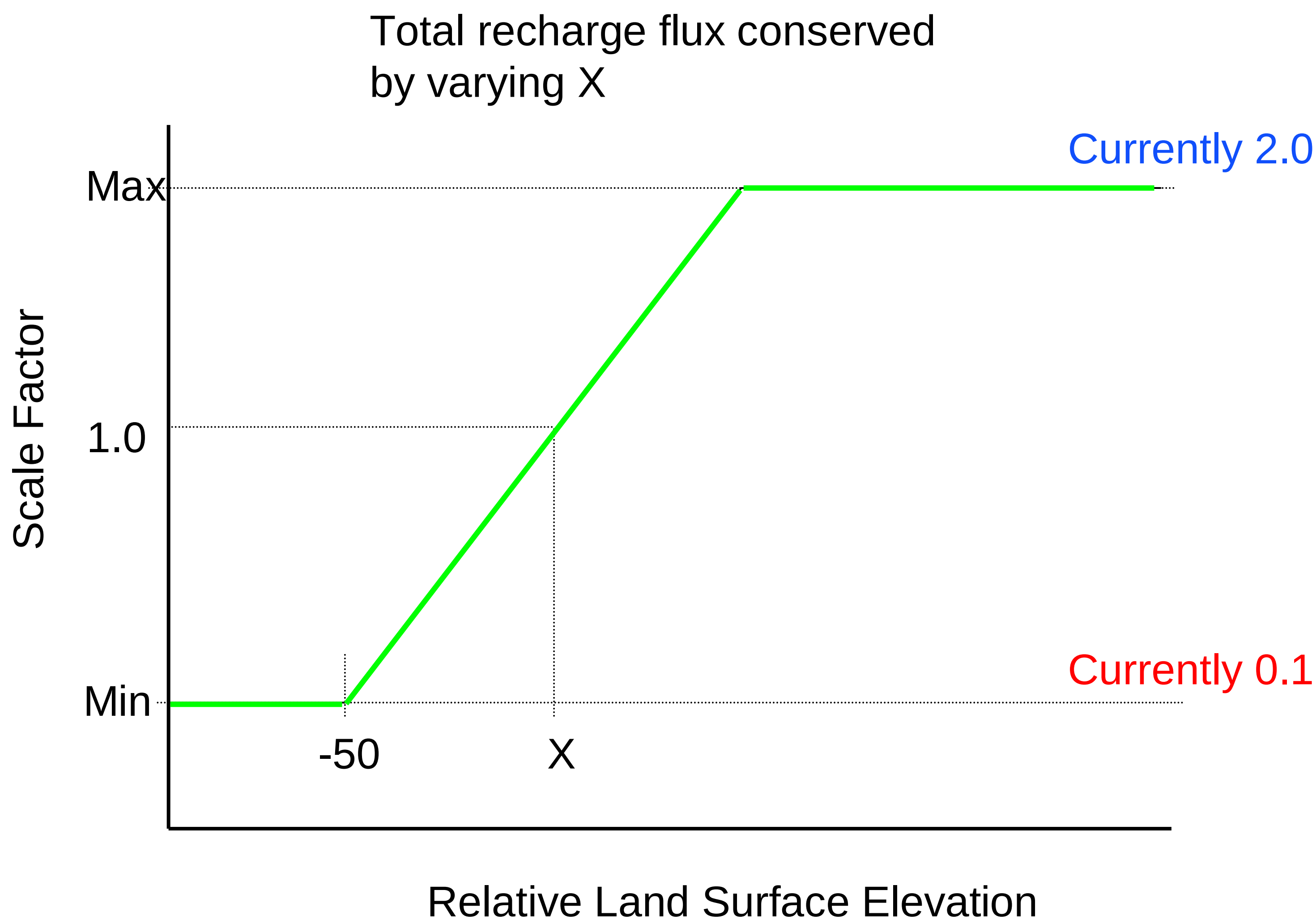
$$R(P) = \begin{cases} C_1\left(1.5\frac{P-O}{A} - 0.5\left(\frac{P-O}{A}\right)^3\right) & (P-O) < A \\ C_1 & (P-O) \geq A \end{cases}$$



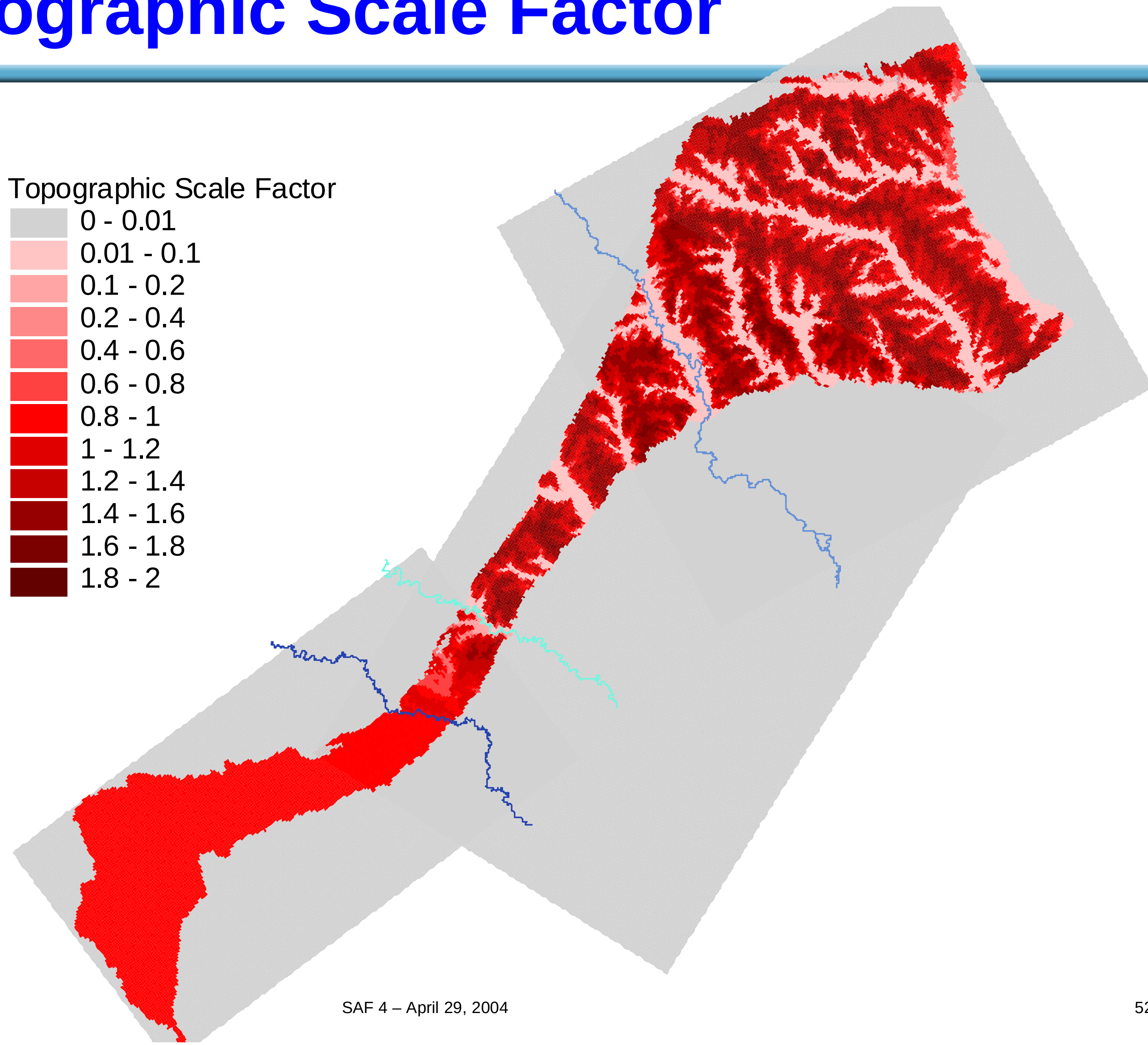
Base Recharge



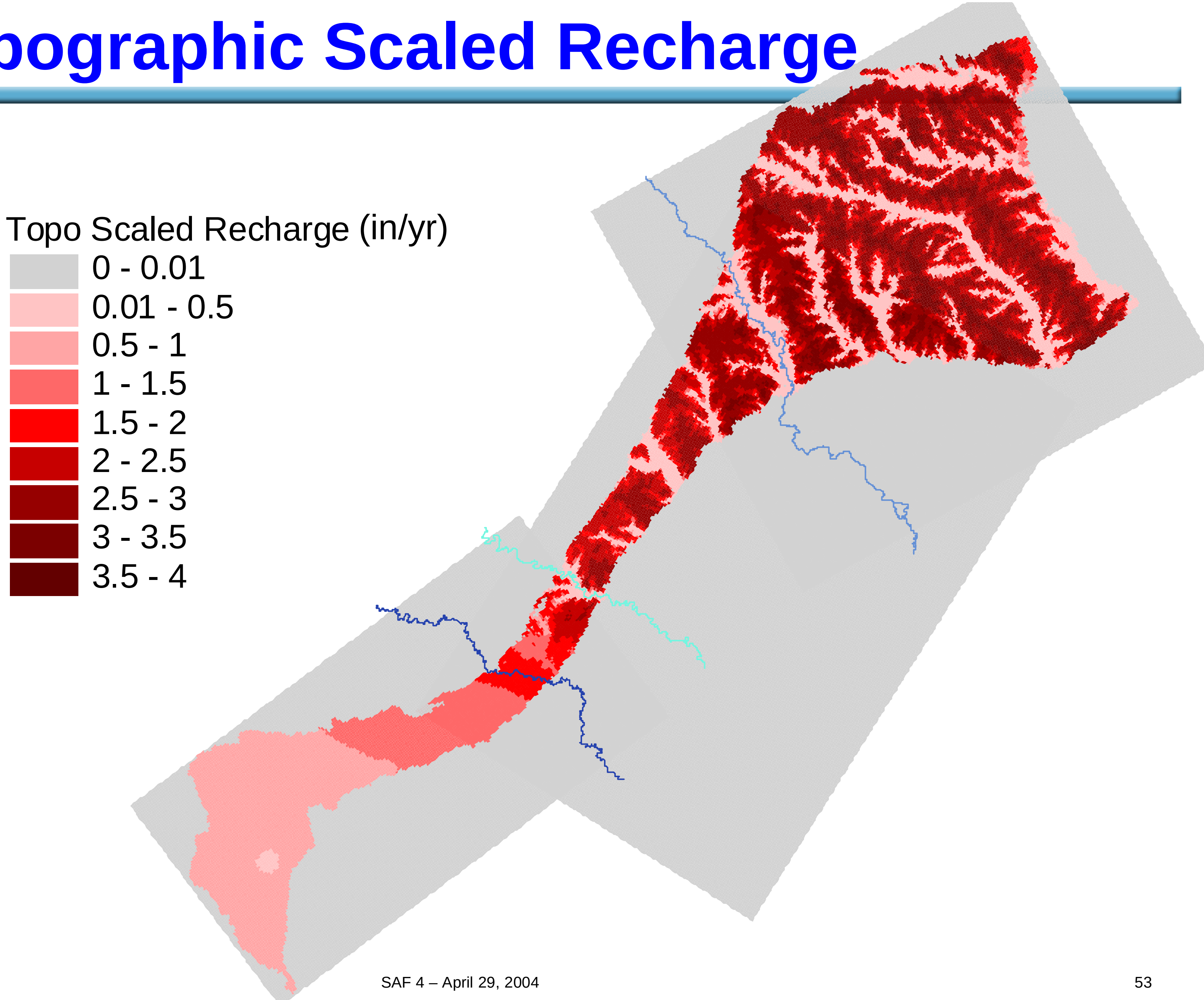
Topographic Scale Factor



Topographic Scale Factor



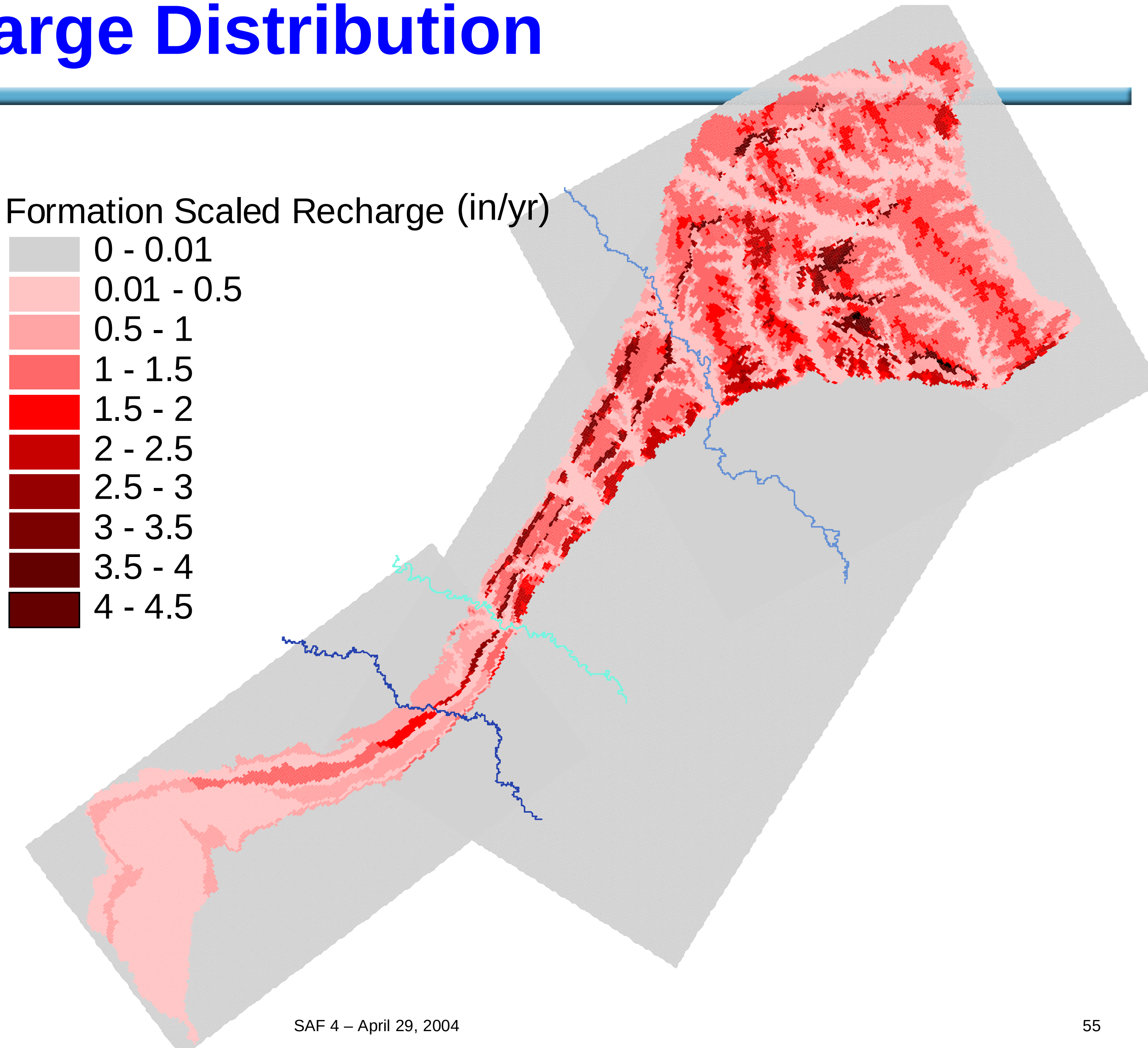
Topographic Scaled Recharge



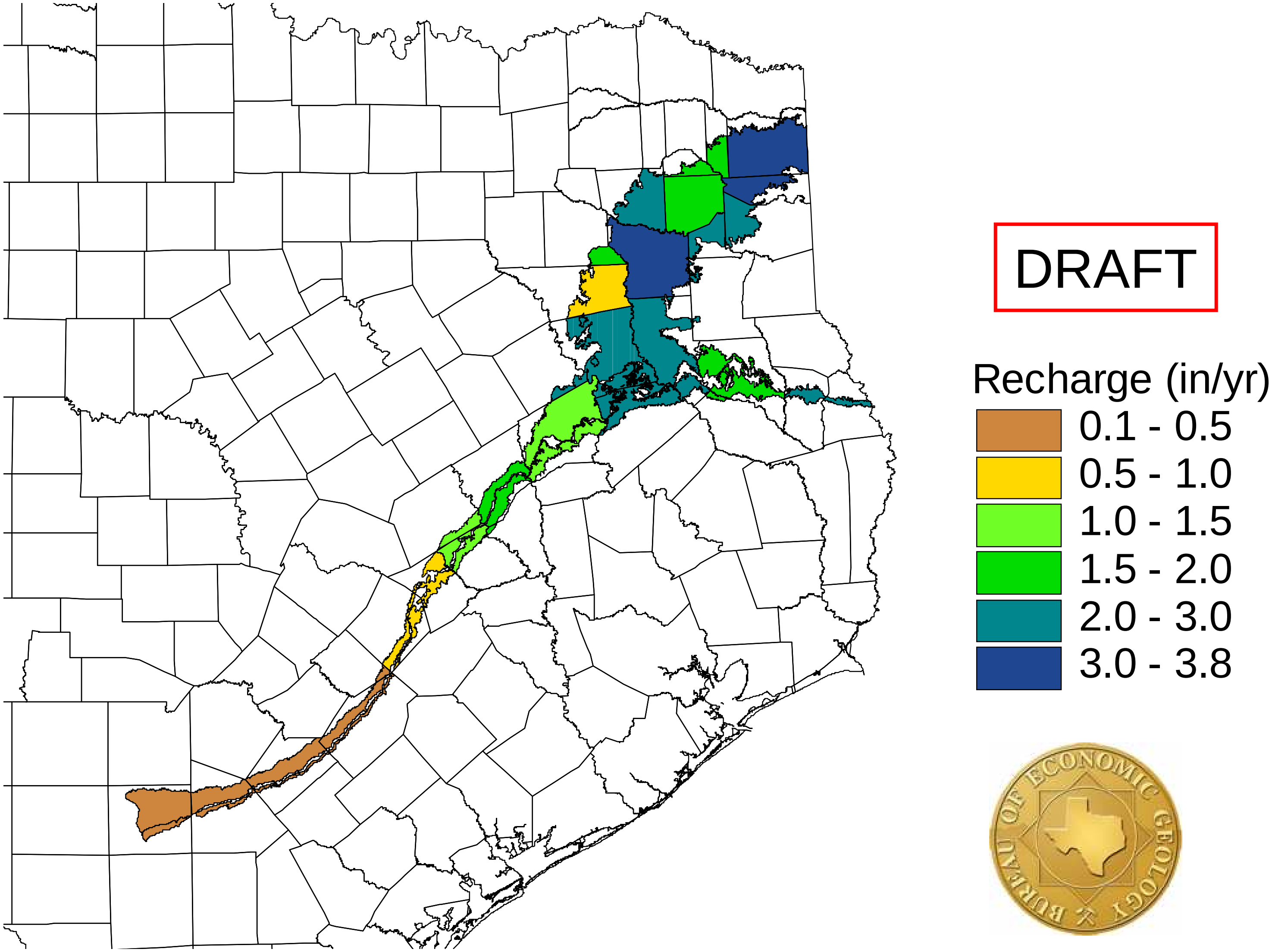
Formation Scale Factor

Formation	Layer	All	Model Region S	Model Region C	Model Region N
Sparta	1	0.8			
Weches	2	0.2			
Queen City	3	0.5			
Reklaw	4	0.2			
Carrizo	5	1.2			
Upper Wilcox/Calvert Bluff/Upper Wilcox	6		0.4	0.5	0.5
Upper Wilcox/Simsboro/Upper Wilcox	7		0.4	1.2	0.5
Upper Wilcox/Hooper/Upper Wilcox	8		0.5	0.4	0.4

Recharge Distribution



Chloride Method (Scanlon & Reedy)



Current Recharge Model

Aquifer	North M&P 79	North Model	Central M&P 79	Central Model	South M&P 79	South Model
Sparta	96,800	104,381	136,400	101,932	60,000	24,458
Queen City	655,600	318,039	294,300	168,938	23,800	67,229
Carrizo/Wilcox	327,460	400,763	479,700	249,900	186,340	112,621
Total	1,079,860	823,182	910,400	520,770	270,140	204,308

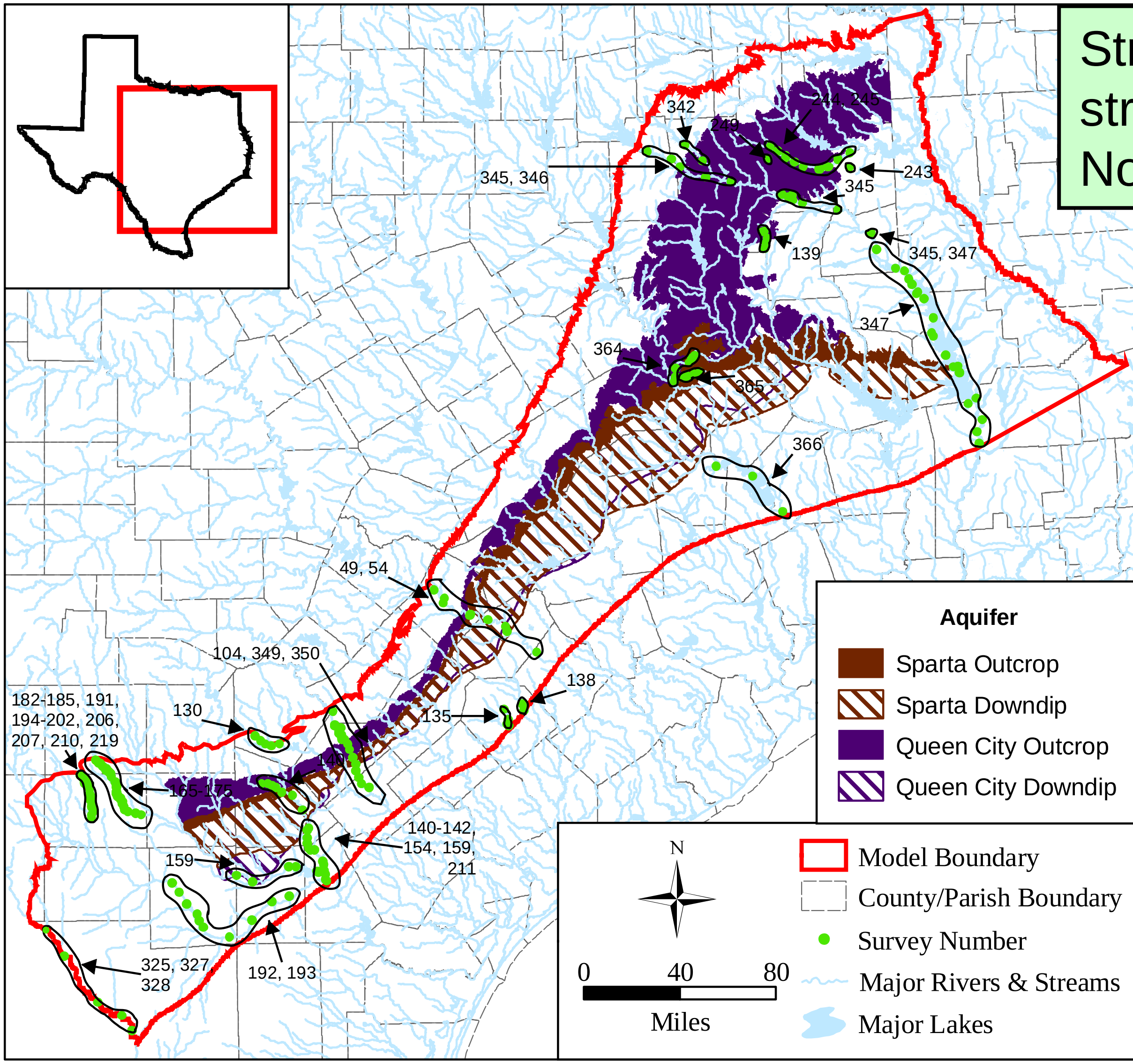
QCS recharge (in/year)

Region	Sparta	Weches	QC
Northern	1.7	0.5	1.0
Central	1.7	0.4	0.9
Southern	0.5	0.1	0.3

C/W recharge (in/yr)

Region	Reklaw	Carrizo	U. Wilcox	M. Wilcox	L. Wilcox
Northern	0.3	2.5	0.9	1.1	0.7
Central	0.3	2.3	0.9	1.8	0.7
Southern	0.1	0.8		0.3	0.3

Gain-Loss Studies (Slade et al. 2002)

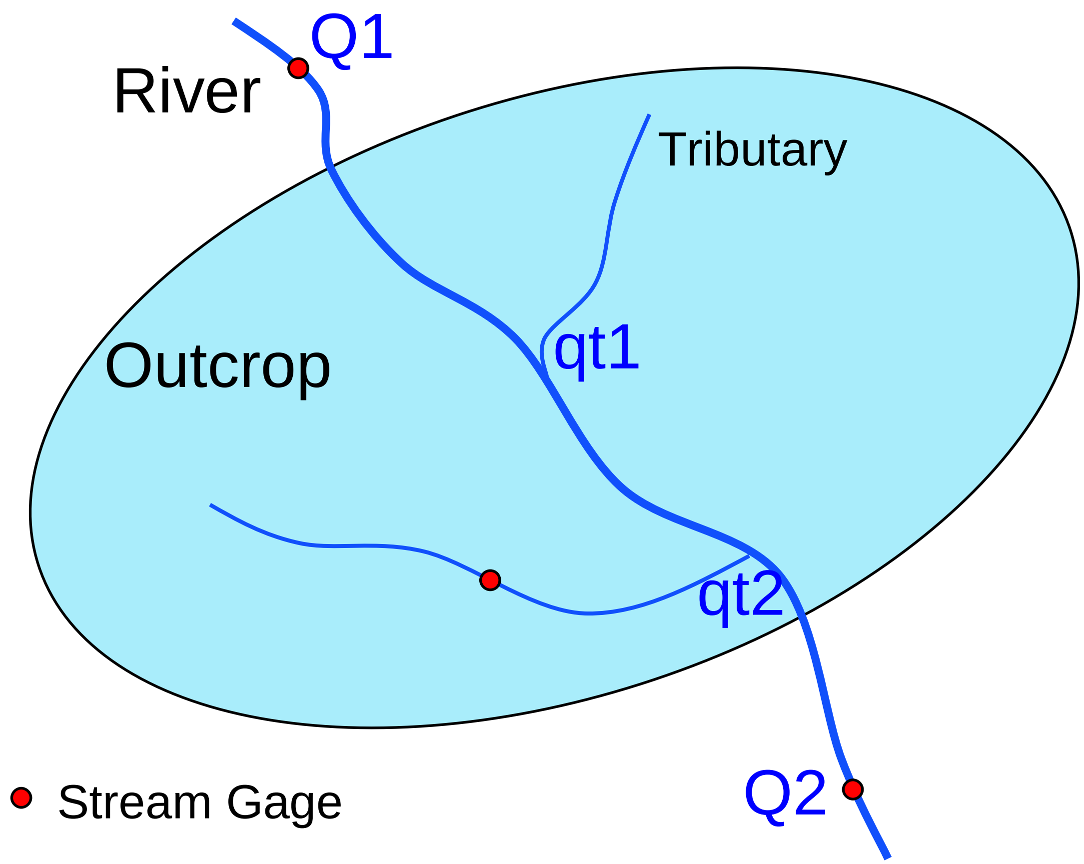


Streams tend to be more strongly gaining in the North than in the South

We also have:

- Brandes Study
- HDR Study
- Guyton-HDR Study

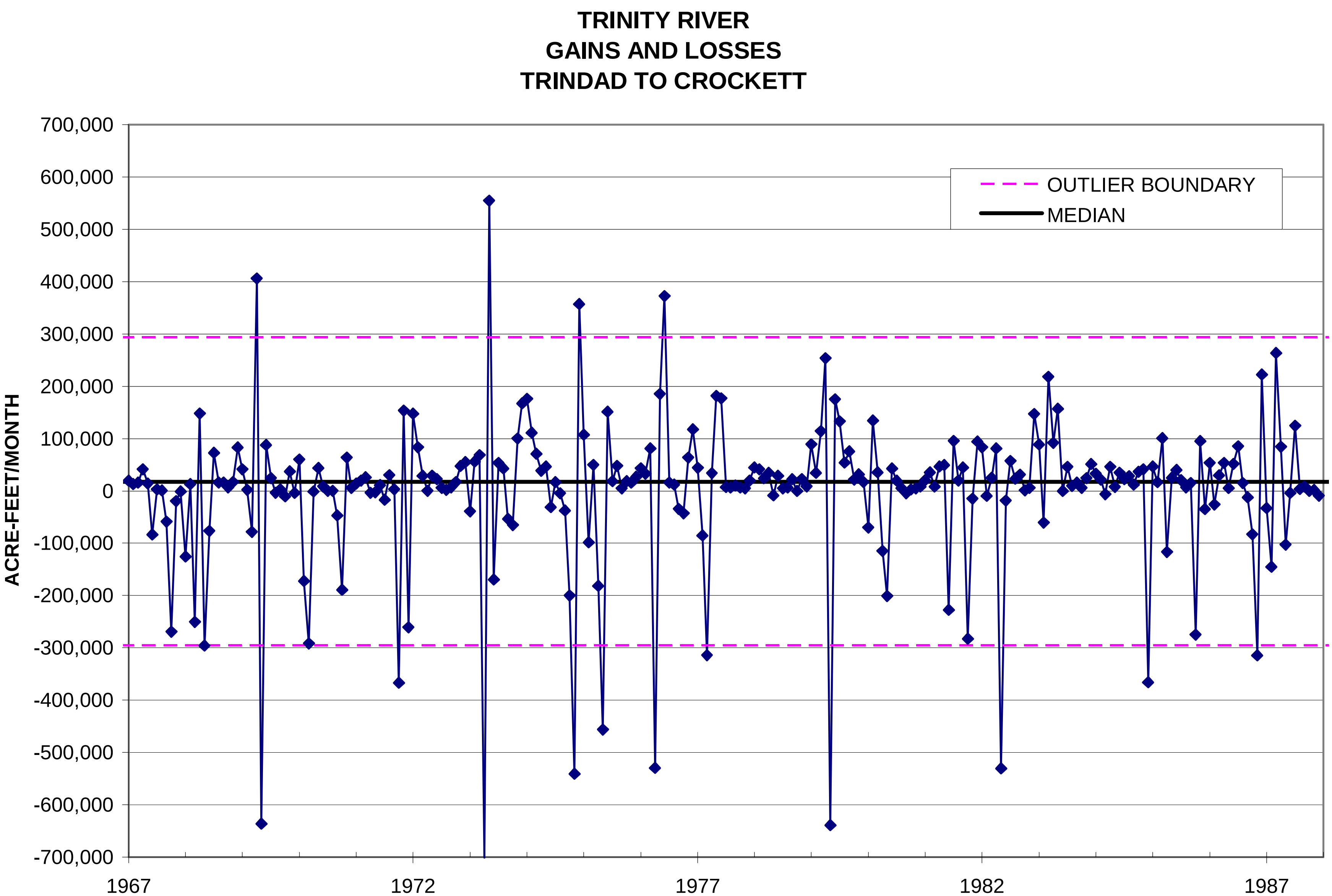
Gain/Loss Method



Gain/loss = Q1 – Sum qt – Q2

- WAM Naturalized stream flows
- Removes anthropological effects
  - diversions,
  - return flow,
  - dams and impoundments

Trinity Gain/Loss (AF/month)



WAM Gain/Loss Results

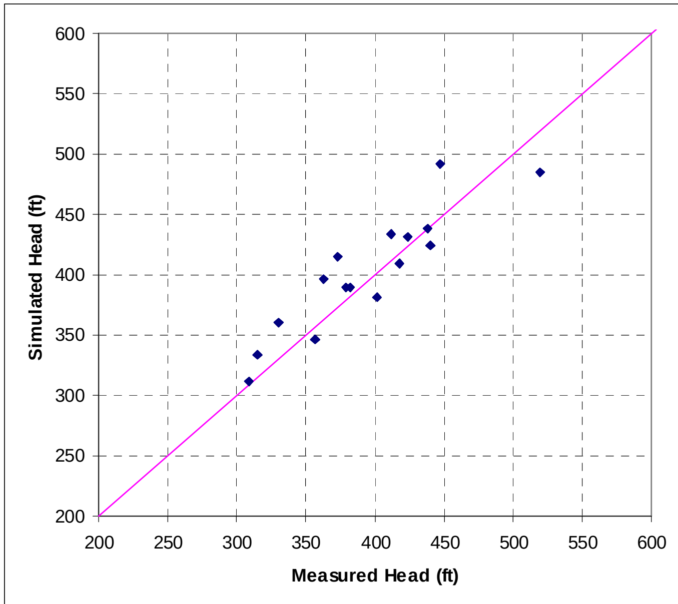
River	Group	Period of Analysis	Distance Between Gages (miles)	Mainstem Incremental Drainage Area (square miles)	Number of Tributary Gages	Tributary Drainage Area (square miles)	Gain/Loss (AF/day/mile)	Gain/Loss (ft^3/day/mile)
TRINITY R	A-1	1967-1987	125.8	5,373	5	2,261	4.6	202,366
GUADALUPE R	A-2	1964-1989	180.5	2,874	3	1,435	0.6	28,038
BRAZOS R	A-3	1965-1994	152.8	13,444	4	9,723	3.7	159,763
NUECES R	A-4	1964-1996	263.4	13,566	3	5,383	-0.4	-18,924
NECHES R	B-1	1959-1979	219.8	6,429	3	2,192	-0.9	-40,038
RIO GRANDE	B-2	1940-2000	139.3	5,266	NA	NA	-0.2	-8,344
NAVASOTA R	B-3	1978-1997	93	1,214	1	97	0.1	5,223
SAN ANTONIO R	B-4	1962-1986	57.5	370	1	827	0.6	25,690
COLORADO R	B-5	1960-1998	105.1	1,664	1	901	-1.1	-47,598
FRIO R	C-1	1964-1996	79.4	2,798	4	1,341	0.3	12,926
ATASCOSA R	C-2	1964-1996	65.8	1,171	1	783	0.4	18,064
ANGELINA R	C-3	1962-1981	43	1,278	2	534	-0.7	-32,639
SABINE R	C-4	1974-1996	321.4	6,125	4	1,112	-0.3	-12,776
SULPHUR R	D-1	1953-1996	114.7	2,916	2	770	0.0	-557
SAN MARCOS R	D-2	1957-1989	37.9	426	1	309	-0.8	-33,111
LEONA R	D-3	-----	-----	-----	-----	-----	-----	-----
CIBOLO CR	D-4	1946-1989	69.2	553	1	549	0.1	4,895
BLACK CYPRESS BAYOU	D-5	-----	-----	-----	-----	-----	-----	-----
BIG CYPRESS CREEK	D-6	1968-1998	48.5	365	1	383	1.5	64,198

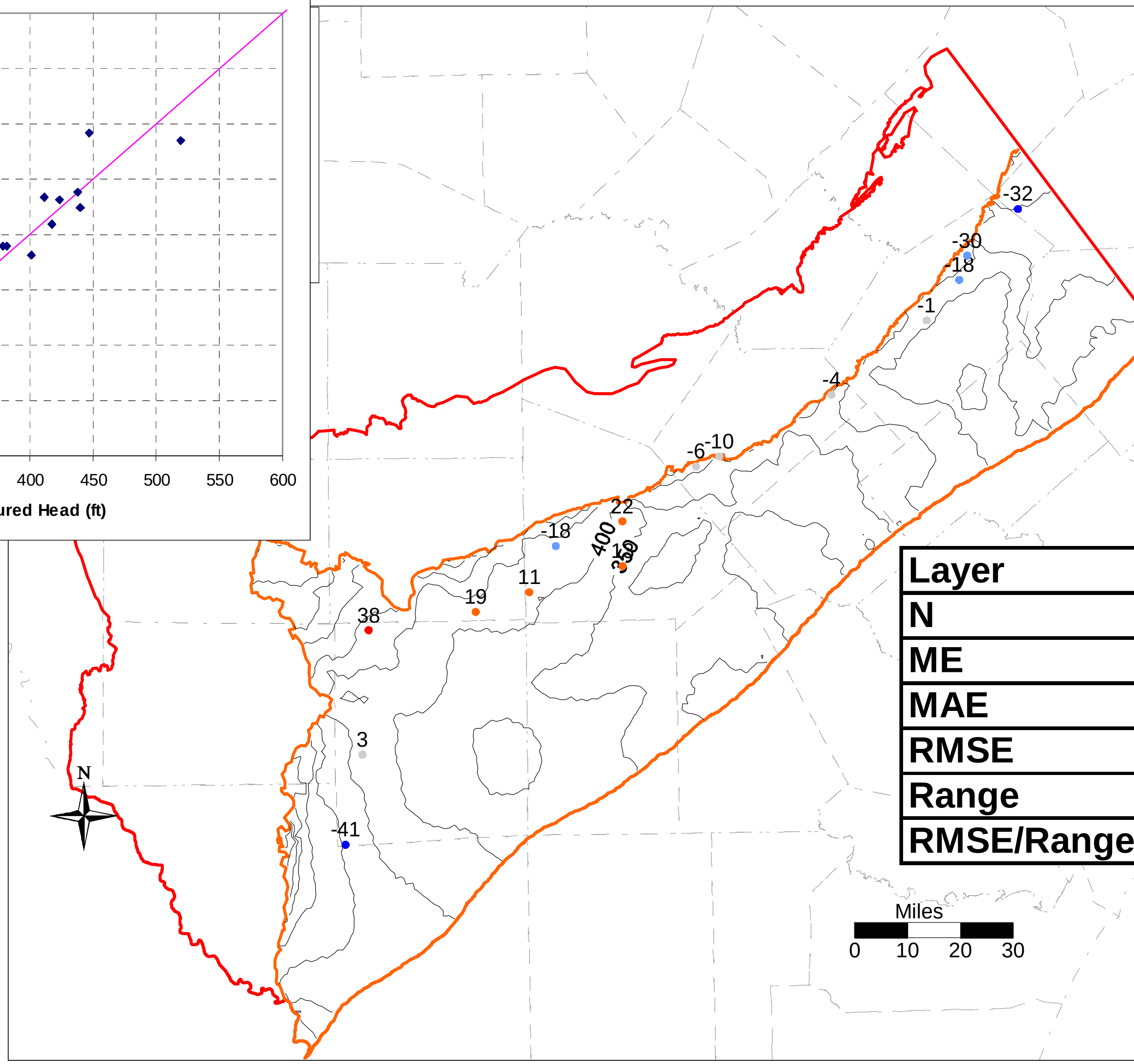
Results under review

R.J. Brandes & Co. will provide a
Qualitative indication of
Method accuracy for analyzed streams

Steady-State Results

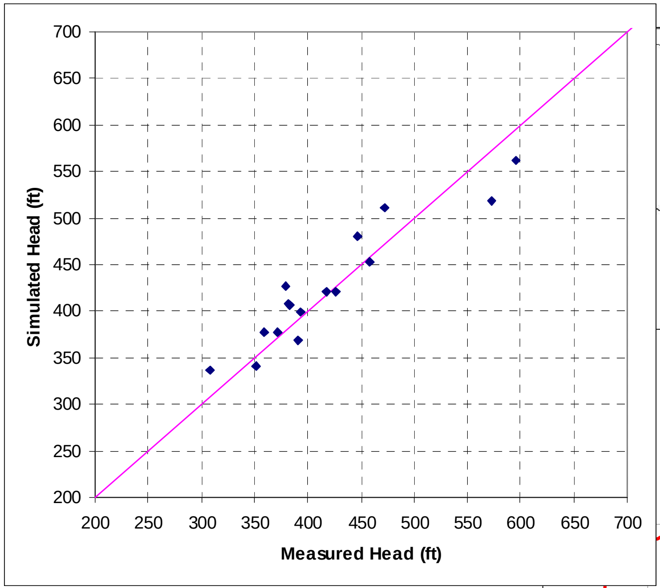
Southern QCSP Heads – Sparta

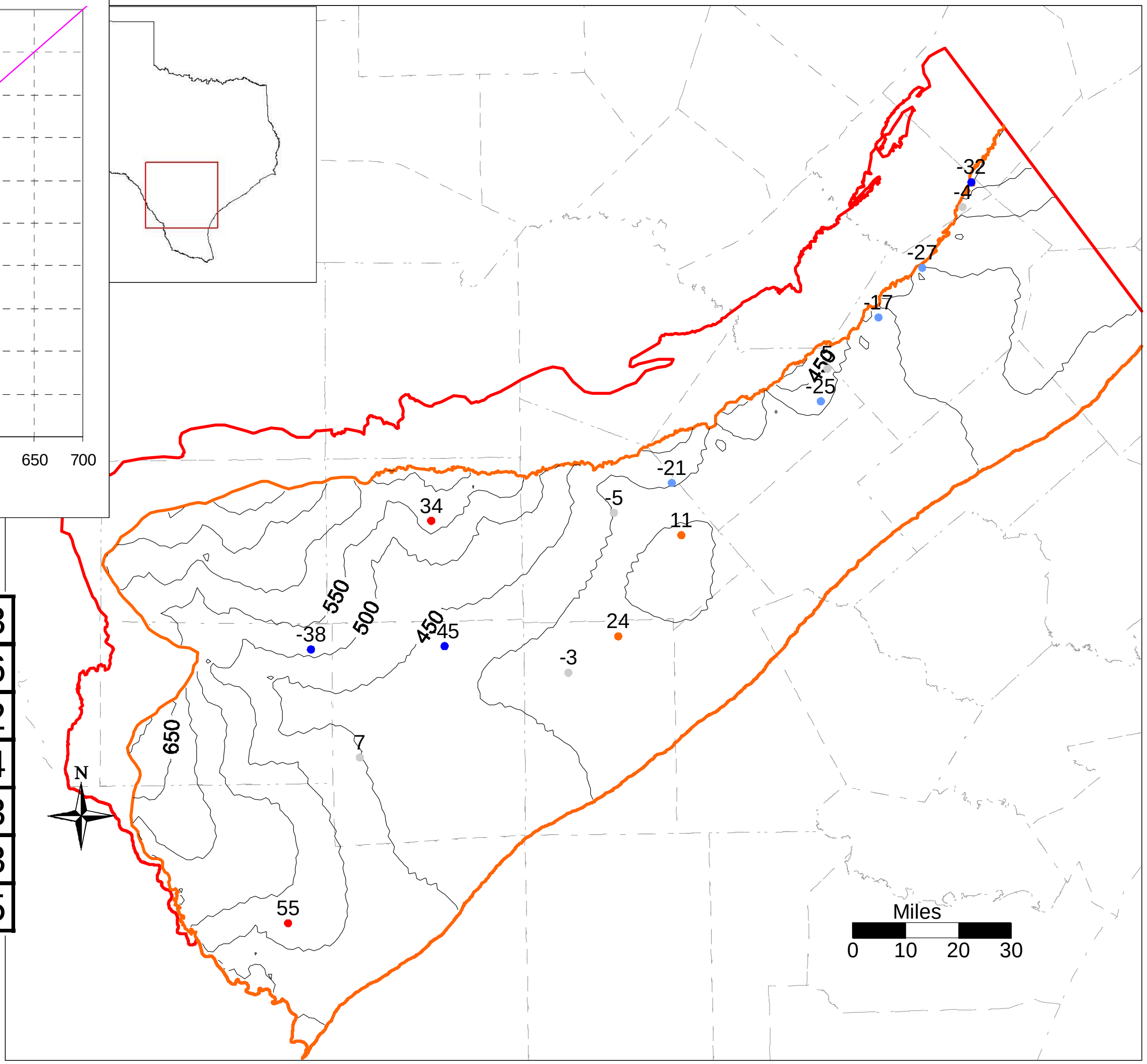




Layer	1
N	15
ME	-3.8
MAE	18.4
RMSE	22.1
Range	210.6
RMSE/Range	0.10

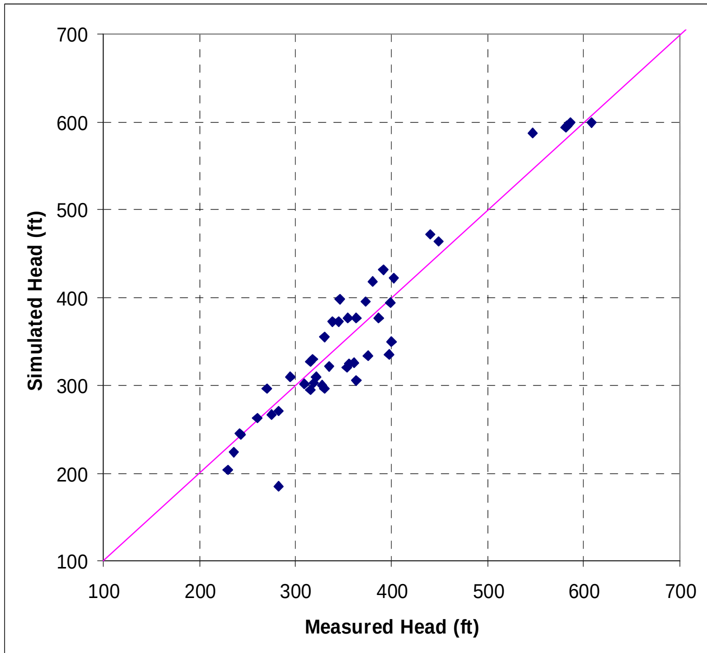
Southern QCSP Heads – Queen City

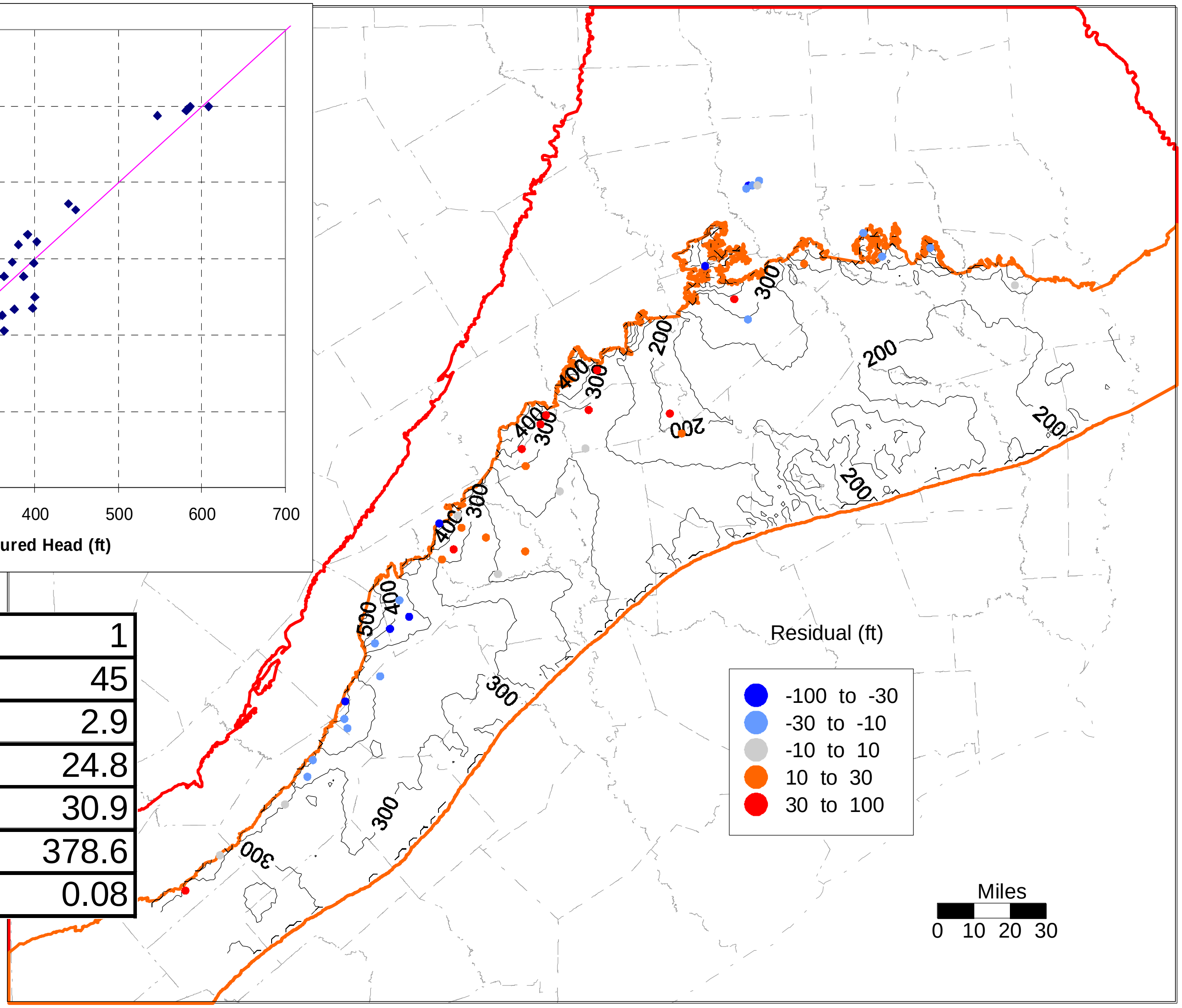




Layer	3
N	16
ME	-5.2
MAE	22.4
RMSE	27.3
Range	288.3
RMSE/Range	0.095

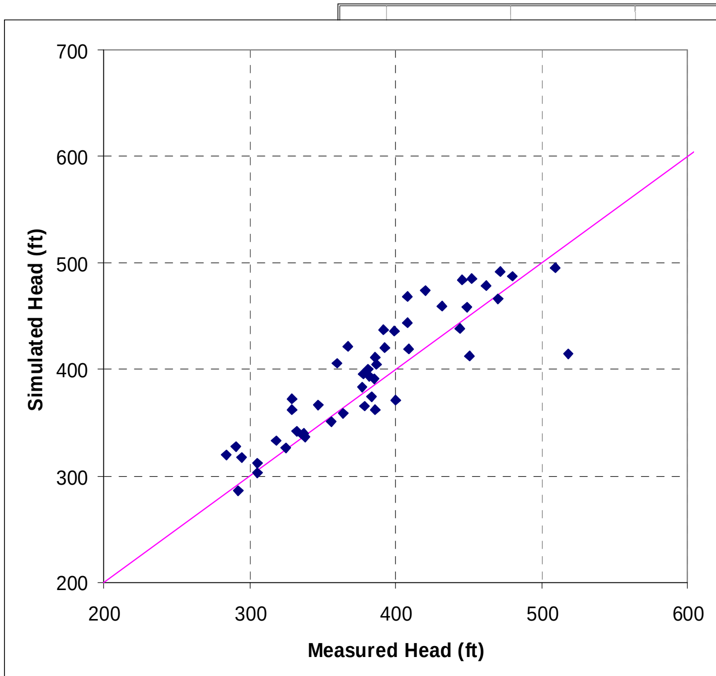
Central QCSP Heads – Sparta

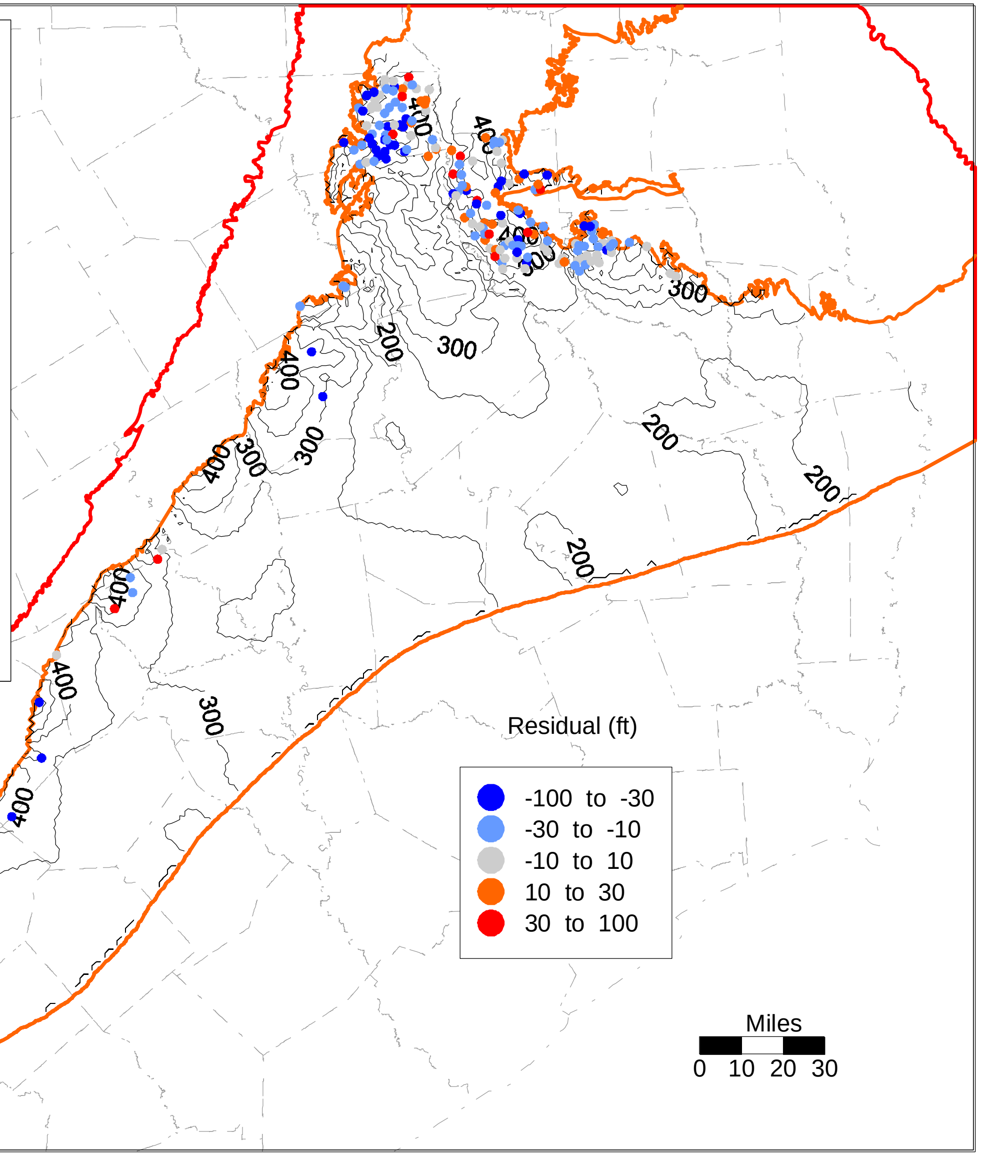




Layer	1
N	45
ME	2.9
MAE	24.8
RMSE	30.9
Range	378.6
RMSE/Range	0.08

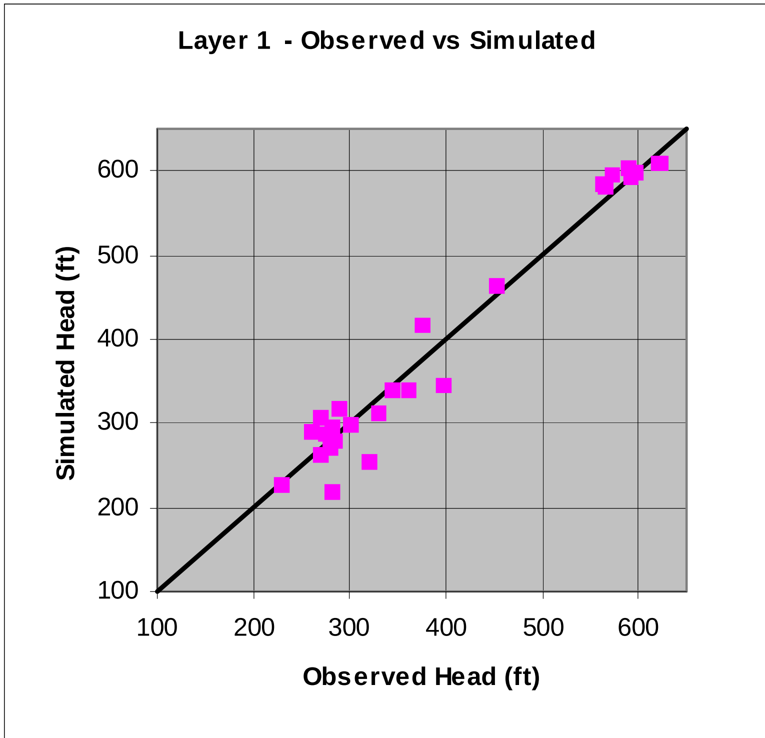
Central QCSP Heads – Queen City

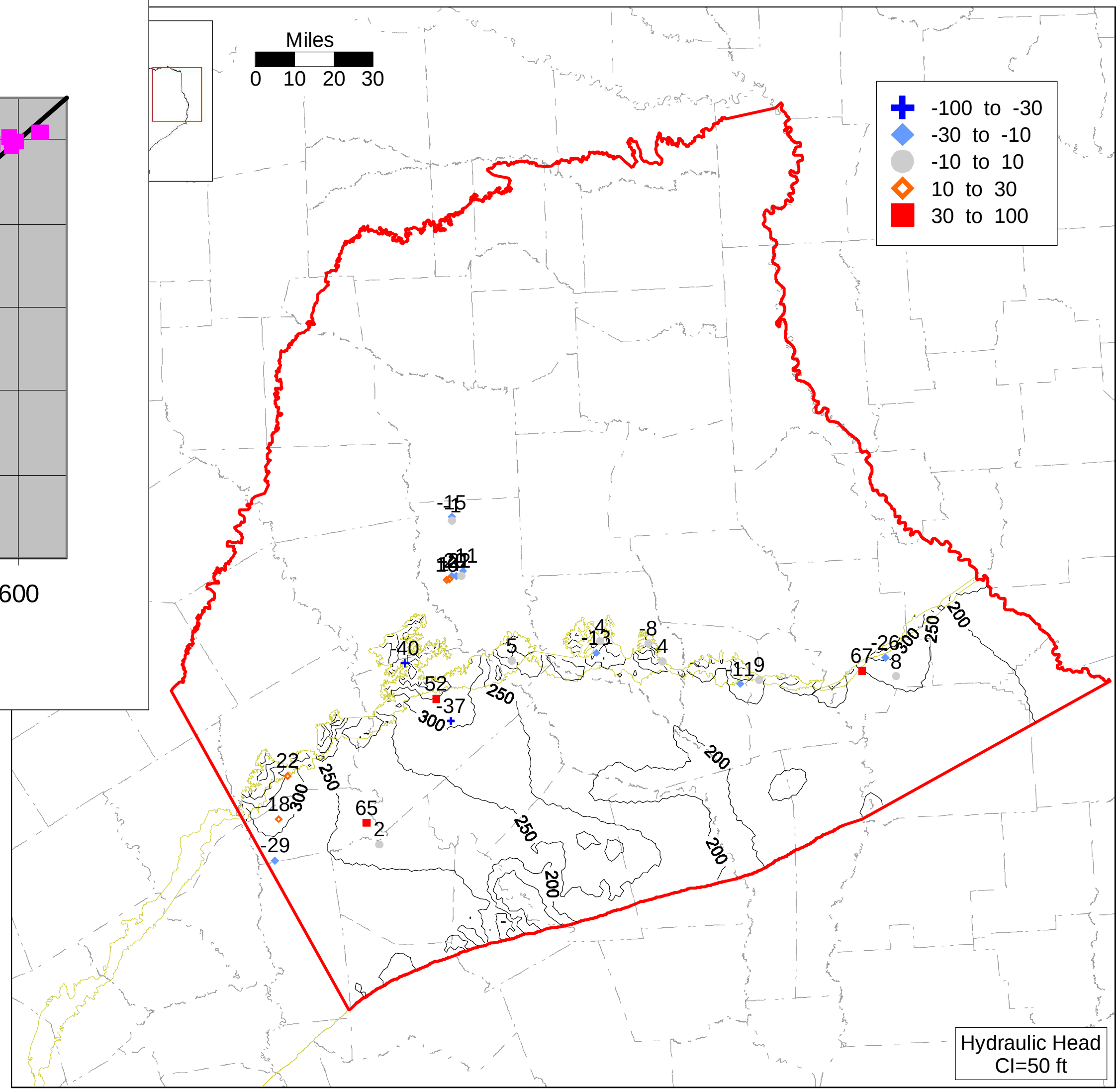




Layer	3
N	203
ME	-8.1
MAE	25.1
RMSE	34.8
Range	429.0
RMSE/Range	0.08

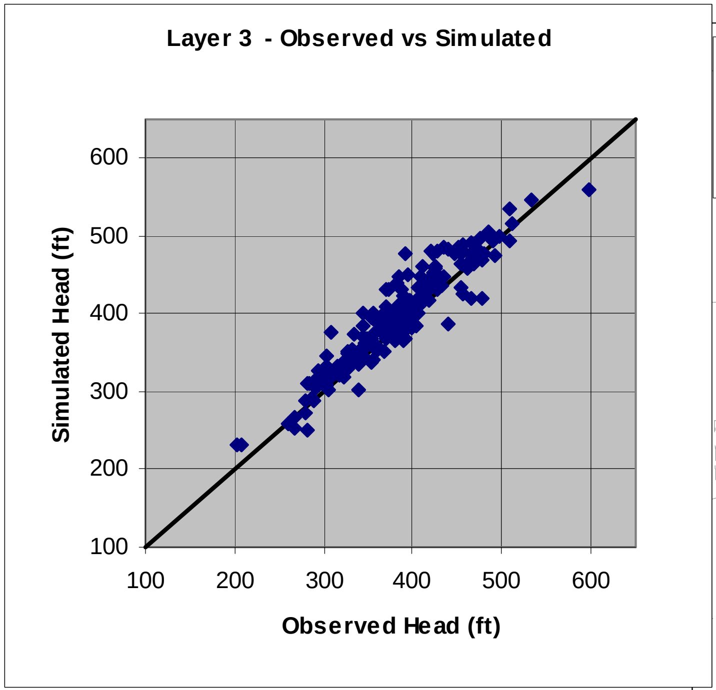
Northern QCSP Heads – Sparta



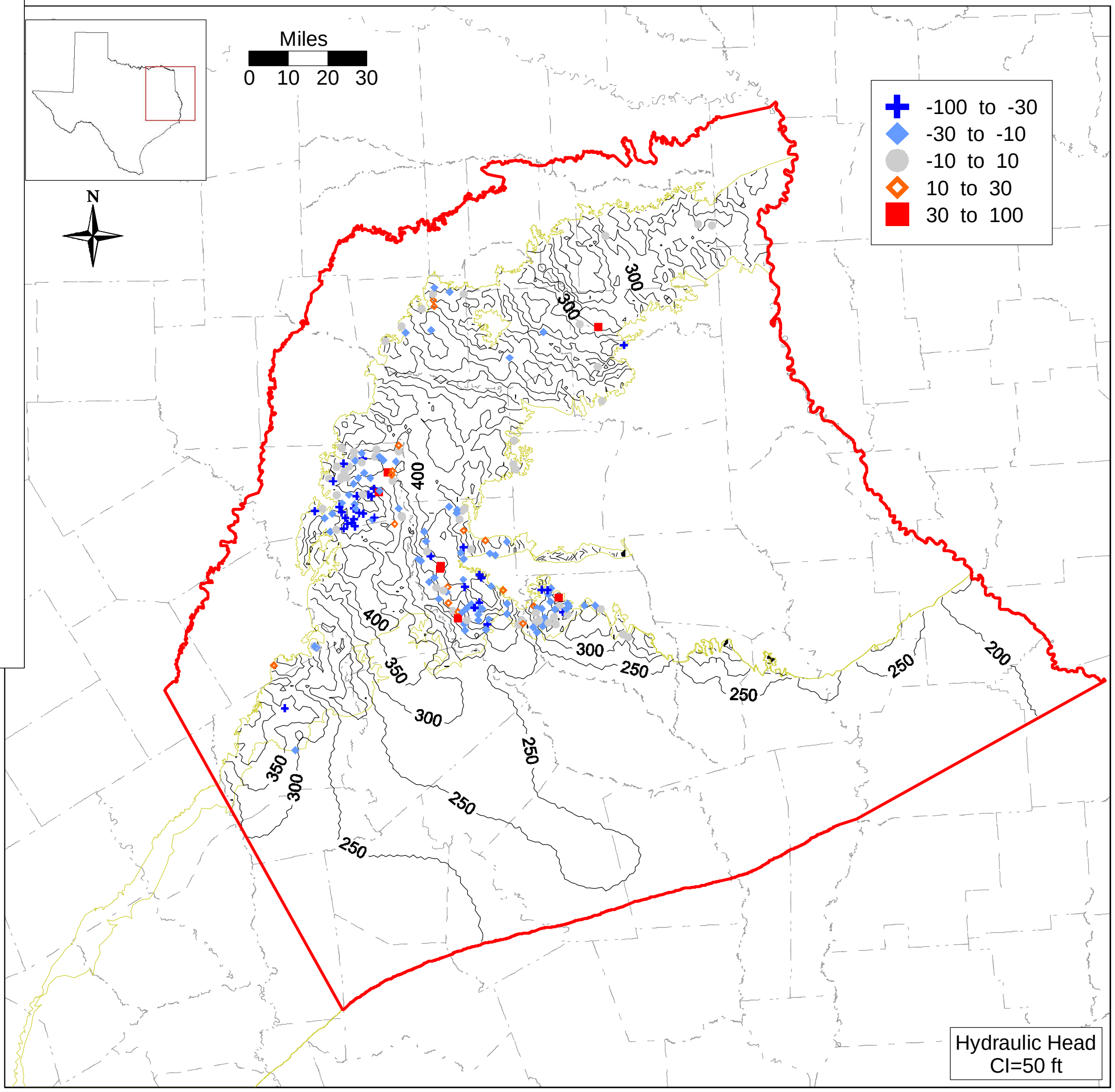


Layer	1
N	26
ME	2.1
MAE	20.4
RMSE	27.3
Range	393.7
RMSE/Ran	0.069

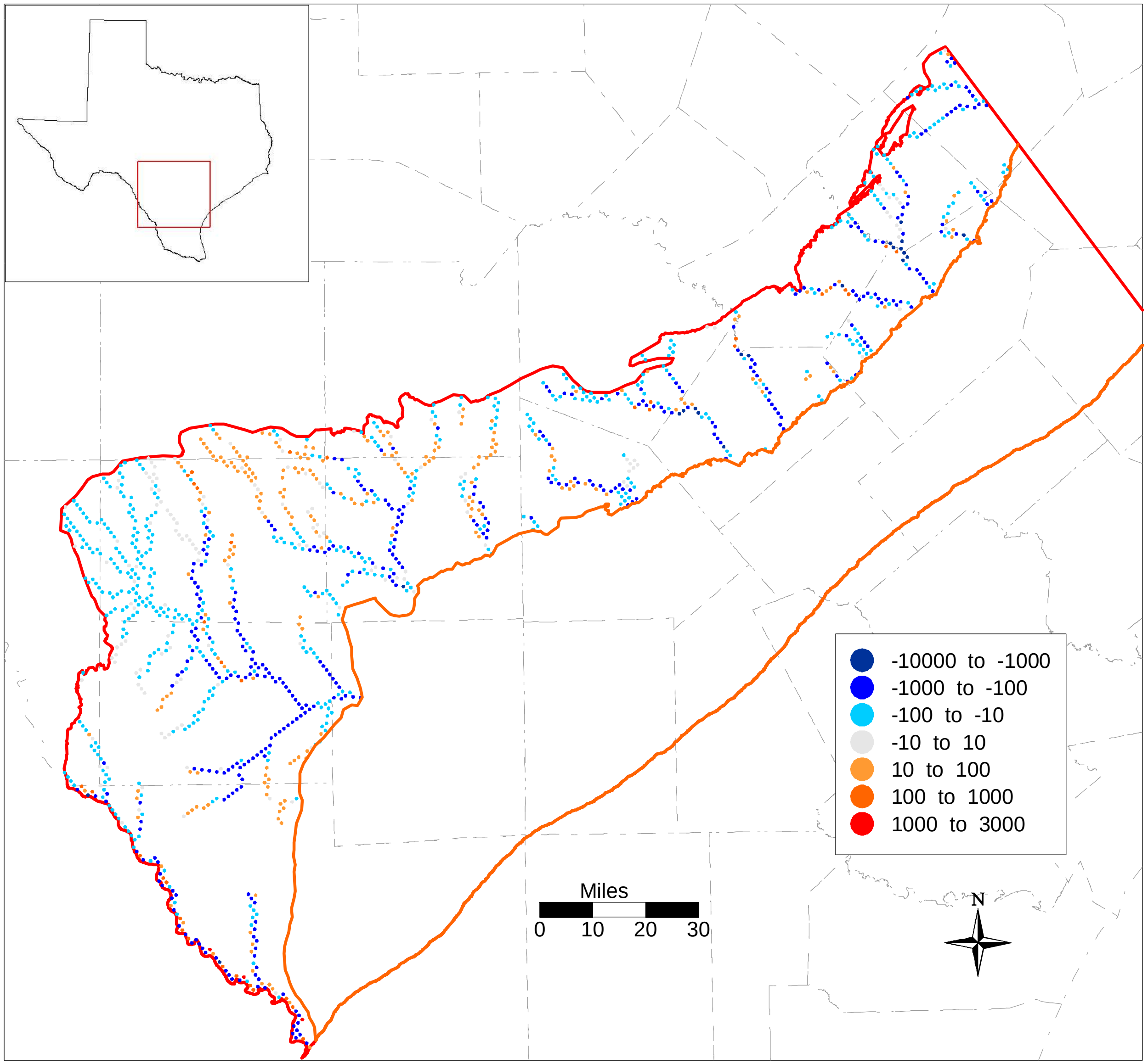
Northern QCSP Heads – Queen City



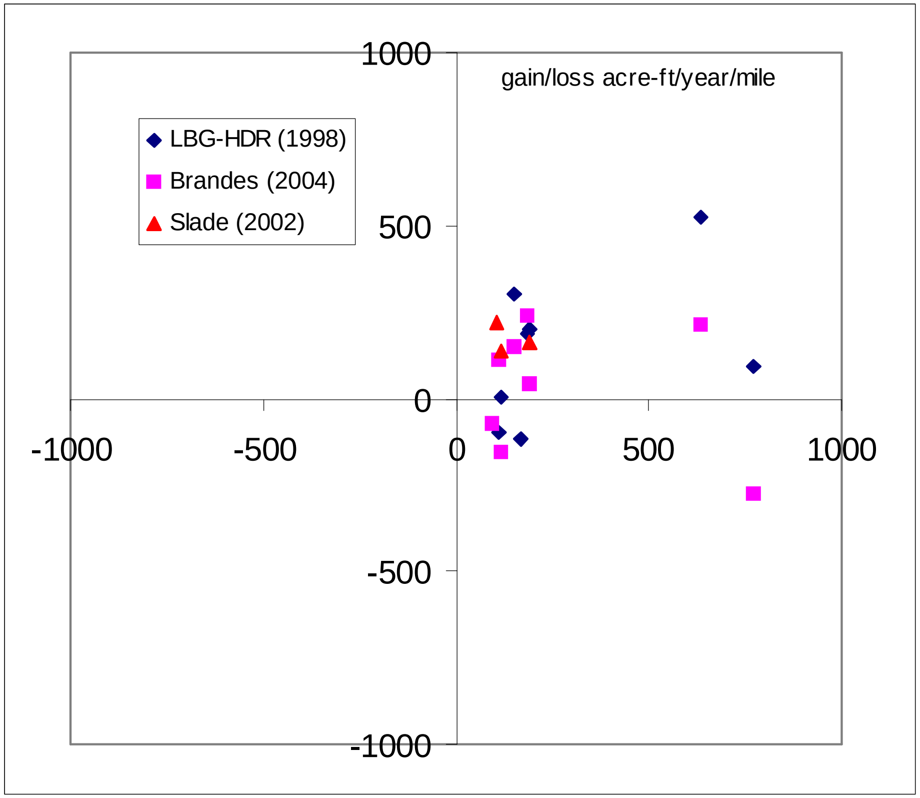
Layer	3
N	191
ME	-13.5
MAE	20.1
RMSE	25.9
Range	394.5
RMSE/Rar	0.066

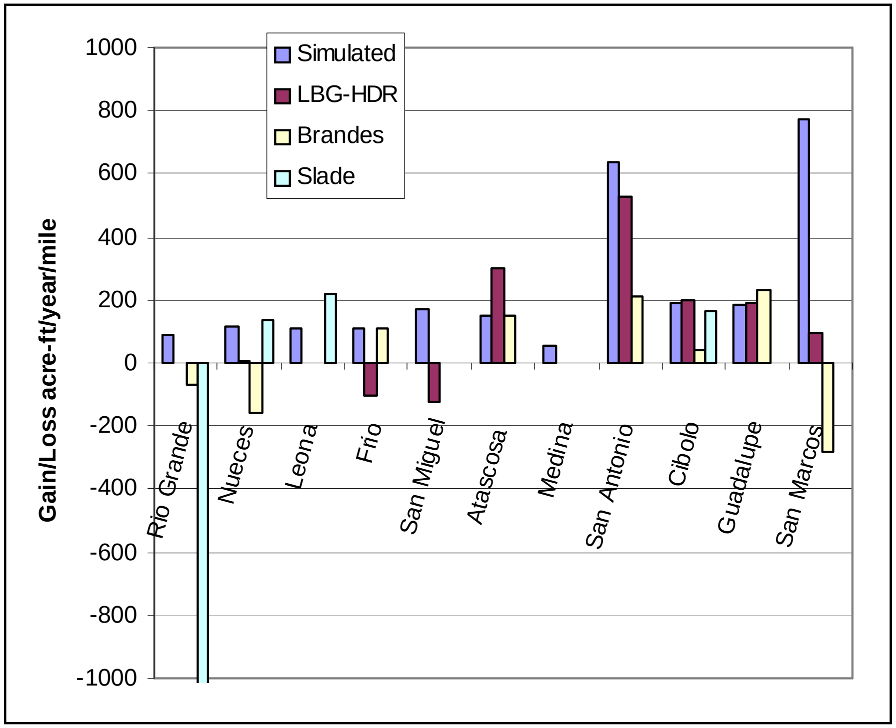


Southern QCSP Stream Gain/Loss

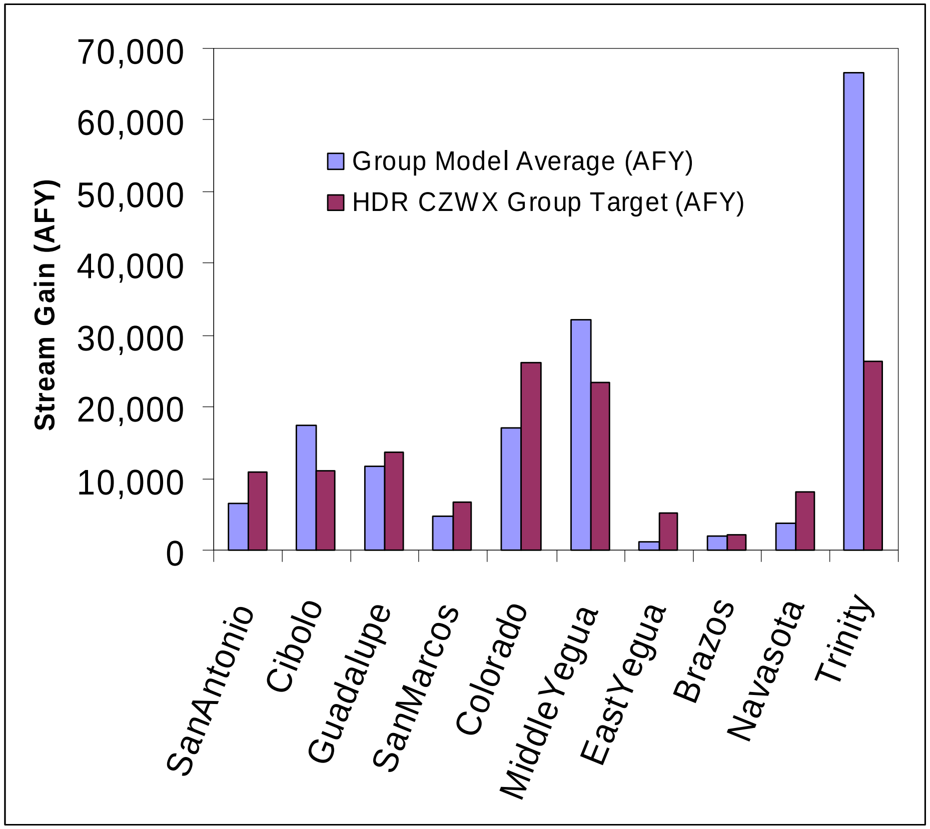


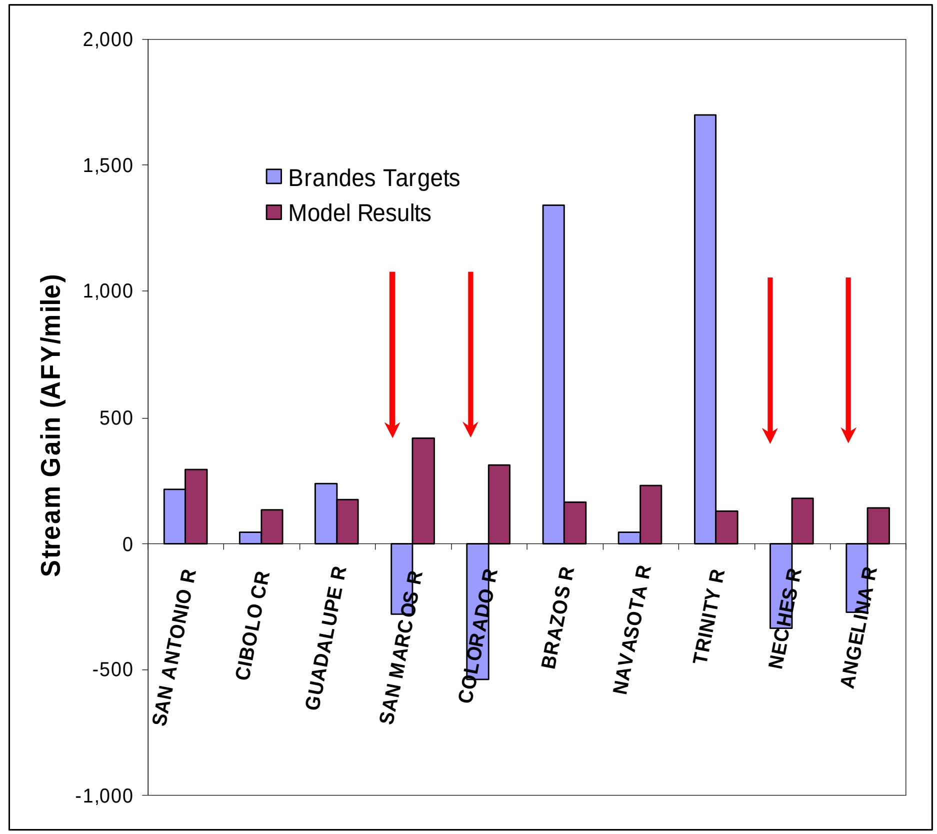
Southern QCSP Stream Gain/Loss



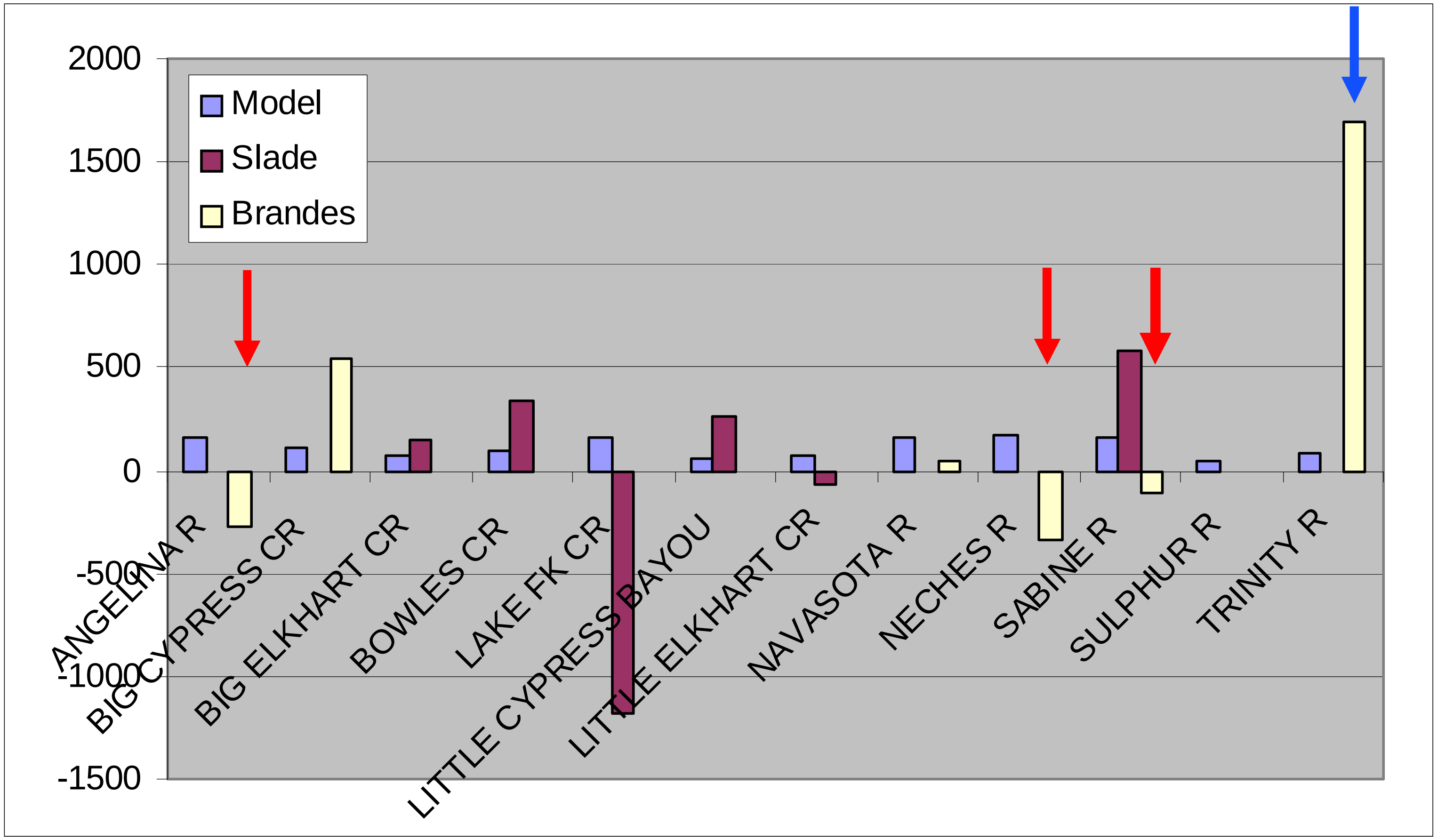


Central QCSP Stream Calibration



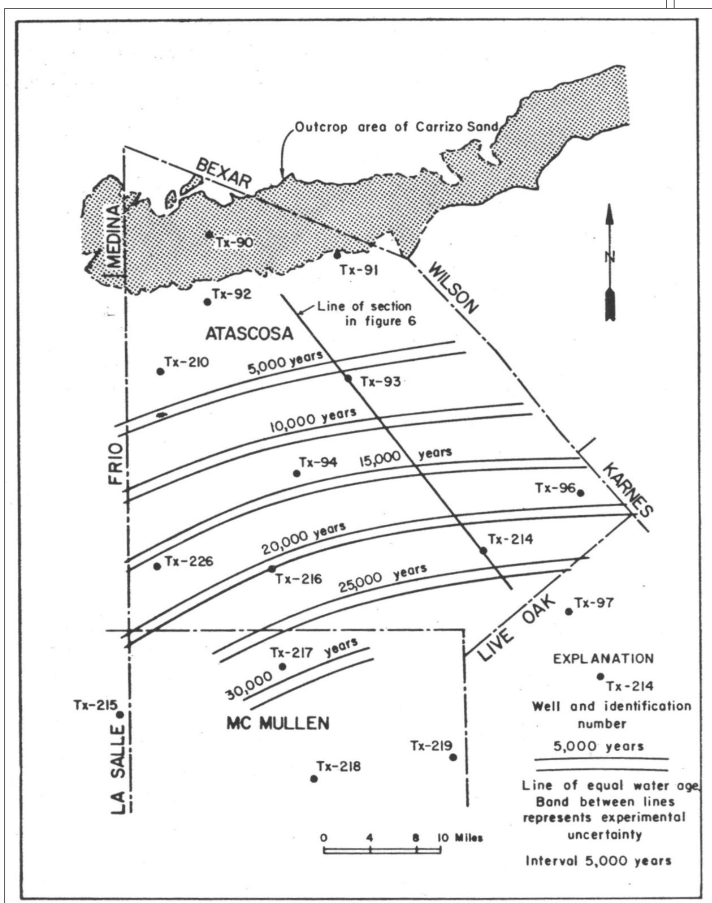


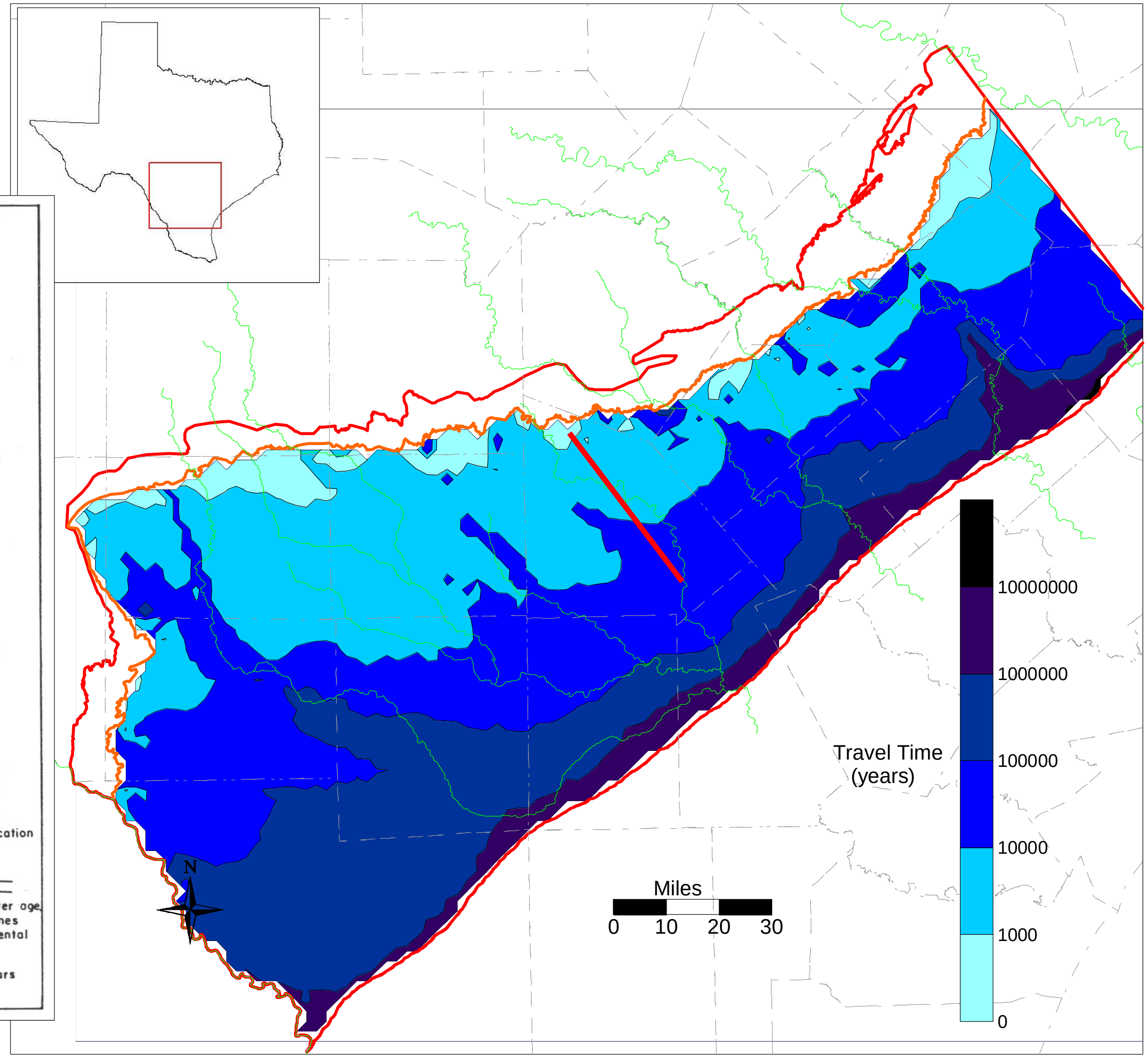
Northern QCSP Stream Gain/Loss



Southern QCSP, Carrizo Travel Time

Pearson and White





Southern QCSP Mass Balance (AFY)

IN	Layer	GHBs	Recharge	Streams	Top	Bottom
	1	9,504	25,206	2,479	0	48,802
	2	0	3,027	374	11,116	48,774
	3	0	69,988	7,873	12,042	47,390
	4	0	5,807	3,638	6,324	45,923
	5	0	66,878	2,956	6,038	16,236
	6	0	487	0	8,916	10,878
	7	0	23,382	4,589	2,956	15,395
	8	0	23,661	815	5,450	0
	Sum	9,504	218,436	22,723	52,841	233,399
OUT	**Layer**	**GHBs**	**ET**	**Streams**	**Top**	**Bottom**
	1	60,511	1,805	12,542	0	11,116
	2	0	371	2,056	48,802	12,042
	3	0	7,050	75,226	48,774	6,324
	4	0	870	7,490	47,390	6,038
	5	0	4,006	34,209	45,923	8,916
	6	0	158	1,152	16,236	2,956
	7	0	2,167	27,793	10,878	5,450
	8	0	3,571	11,085	15,395	0
	Sum	60,511	19,998	171,554	233,399	52,841

Southern QCSP Mass Balance (%)

IN	Layer	GHBs	Recharge	Streams
	1	3.8	10.1	1.0
	2	0.0	1.2	0.1
	3	0.0	27.9	3.1
	4	0.0	2.3	1.5
	5	0.0	26.7	1.2
	6	0.0	0.2	0.0
	7	0.0	9.3	1.8
	8	0.0	9.4	0.3
	Sum	3.8	87.1	9.1
OUT	Layer	GHBs	ET	Streams
	1	24.0	0.7	5.0
	2	0.0	0.1	0.8
	3	0.0	2.8	29.8
	4	0.0	0.3	3.0
	5	0.0	1.6	13.6
	6	0.0	0.1	0.5
	7	0.0	0.9	11.0
	8	0.0	1.4	4.4
	Sum	24.0	7.9	68.1

Central QCSP Mass Balance (AFY)

IN	Layer	GHBs	Recharge	Streams	Top	Bottom
	1	16,096	127,567	690	0	55,969
	2	0	12,180	35	31,781	53,609
	3	0	179,546	3,423	34,333	50,768
	4	0	16,890	674	37,647	49,291
	5	0	83,490	6,593	36,342	15,741
	6	0	57,449	5,385	8,202	21,489
	7	0	53,550	6,078	13,753	8,159
	8	0	26,406	2,706	3,027	0
	Sum	16,096	557,077	25,584	165,084	255,025
OUT	**Layer**	**GHBs**	**ET**	**Streams**	**Top**	**Bottom**
	1	75,223	52,886	42,729	0	31,781
	2	0	2,809	4,833	55,969	34,333
	3	0	84,221	95,629	53,609	37,647
	4	0	6,119	11,758	50,768	36,342
	5	0	27,492	50,431	49,291	8,202
	6	0	16,949	44,177	15,741	13,753
	7	0	16,901	40,963	21,489	3,027
	8	0	8,708	15,678	8,159	0
	Sum	75,223	216,083	306,197	255,025	165,084

Central QCSP Mass Balance (%)

IN	Layer	GHBs	Recharge	Streams
	1	2.7	21.3	0.1
	2	0.0	2.0	0.0
	3	0.0	30.0	0.6
	4	0.0	2.8	0.1
	5	0.0	13.9	1.1
	6	0.0	9.6	0.9
	7	0.0	8.9	1.0
	8	0.0	4.4	0.5
	Sum	2.7	93.0	4.3

OUT	Layer	GHBs	ET	Streams
	1	12.6	8.8	7.1
	2	0.0	0.5	0.8
	3	0.0	14.1	16.0
	4	0.0	1.0	2.0
	5	0.0	4.6	8.4
	6	0.0	2.8	7.4
	7	0.0	2.8	6.8
	8	0.0	1.5	2.6
	Sum	12.6	36.1	51.1

Northern QCSP Mass Balance (AFY)

IN	Layer	GHBs	Recharge	Streams	Drains	Top	Bottom
	1	26,399	139,984	1,403	0	0	24,737
	2	0	10,683	1,099	0	36,456	23,390
	3	0	337,822	13,478	0	38,029	48,028
	4	0	33,322	11,562	0	62,050	50,537
	5	0	131,965	3,327	0	57,526	16,137
	6	0	169,967	4,694	0	30,398	13,869
	7	0	274,133	8,542	0	19,442	12,481
	8	0	23,374	461	0	14,354	0
	Sum	26,399	1,121,251	44,566	0		
OUT	Layer	GHBs	ET	Streams	Drains	Top	Bottom
	1	36,161	74,882	40,910	4,144	0	36,456
	2	0	6,023	2,824	20	24,737	38,029
	3	0	204,251	142,741	4,924	23,390	62,050
	4	0	35,258	16,094	568	48,028	57,526
	5	0	96,555	29,226	2,385	50,537	30,398
	6	0	83,396	95,410	4,664	16,137	19,442
	7	0	124,673	157,552	4,870	13,869	14,354
	8	0	16,297	9,331	127	12,481	0
	Sum	36,161	641,335	494,086	21,702		

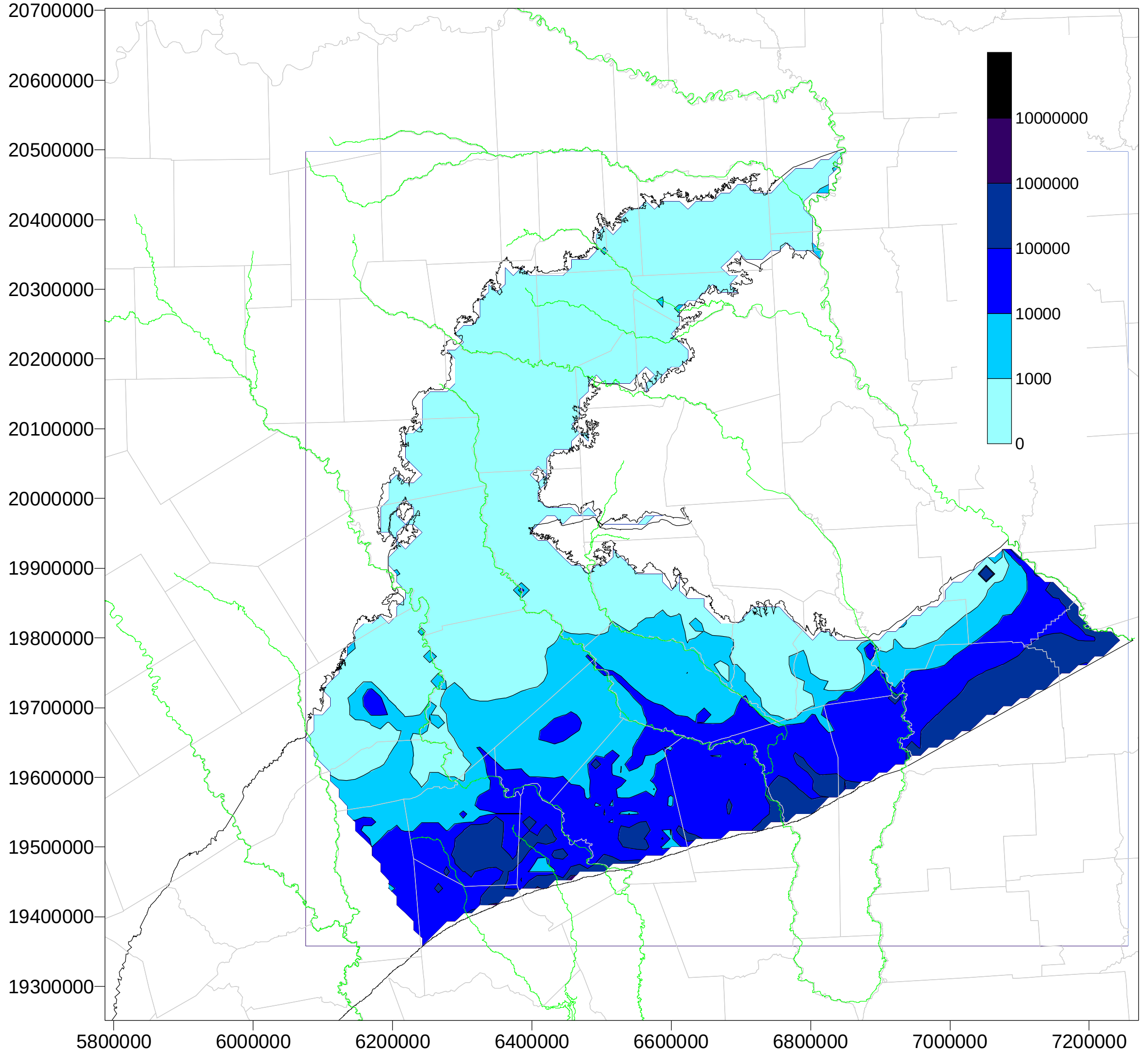
Northern QCSP Mass Balance (%)

IN	Layer	GHBs	Recharge	Streams	Drains
	1	2.2	11.7	0.1	0.0
	2	0.0	0.9	0.1	0.0
	3	0.0	28.3	1.1	0.0
	4	0.0	2.8	1.0	0.0
	5	0.0	11.1	0.3	0.0
	6	0.0	14.3	0.4	0.0
	7	0.0	23.0	0.7	0.0
	8	0.0	2.0	0.0	0.0
	Sum	2.2	94.0	3.7	0.0
OUT	**Layer**	**GHBs**	**ET**	**Streams**	**Drains**
	1	3.0	6.3	3.4	0.3
	2	0.0	0.5	0.2	0.0
	3	0.0	17.1	12.0	0.4
	4	0.0	3.0	1.3	0.0
	5	0.0	8.1	2.4	0.2
	6	0.0	7.0	8.0	0.4
	7	0.0	10.4	13.2	0.4
	8	0.0	1.4	0.8	0.0
	Sum	3.0	53.7	41.4	1.8

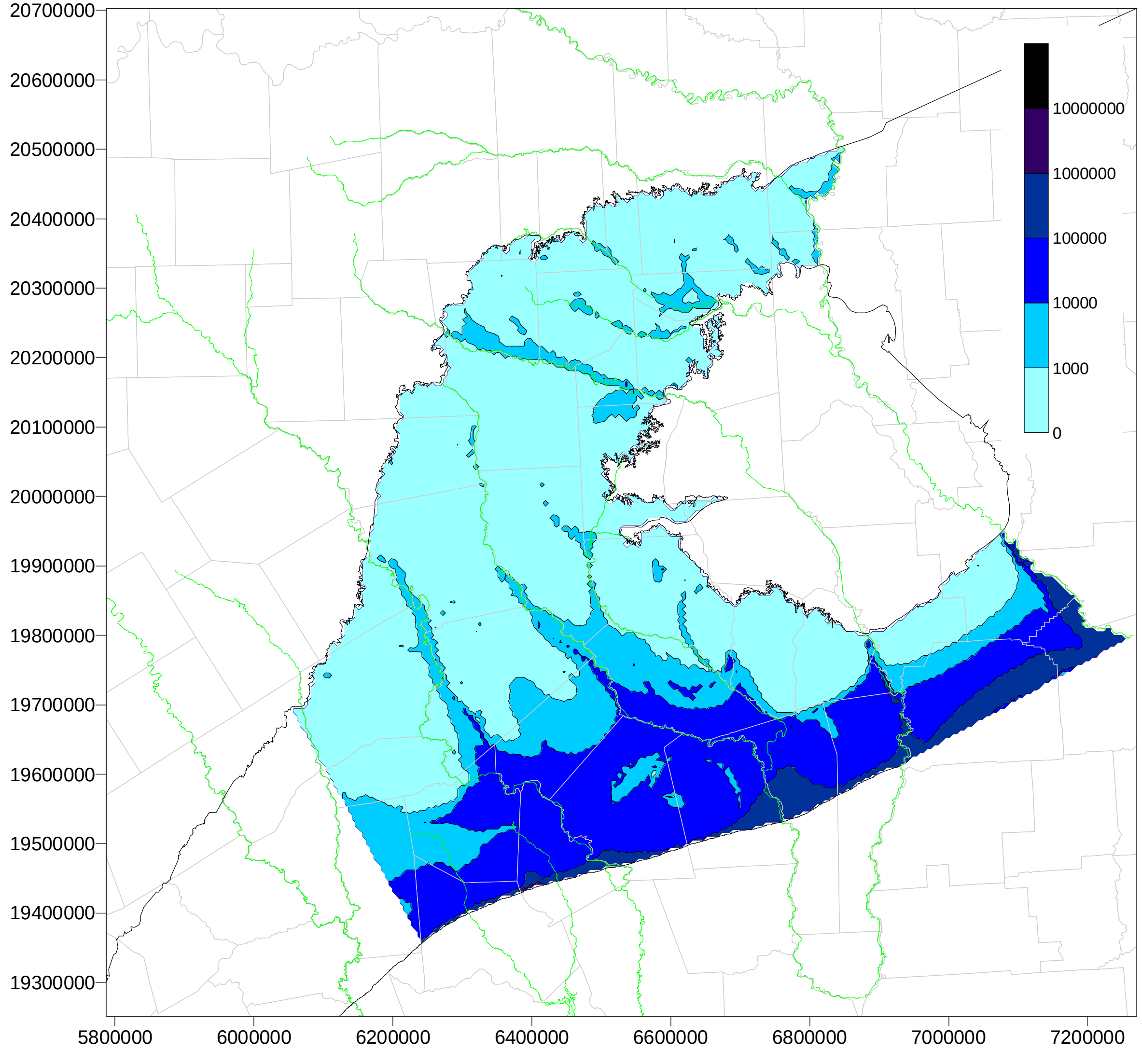
Fit to Conceptual Model

		Percent of Recharge		
QCSP GAM	Recharge (AFY)	GAM GW ET	Streams	Confined Flow
Southern	218,436	8	68	24
Central	557,077	36	51	13
Northern	641,335	53	44	3

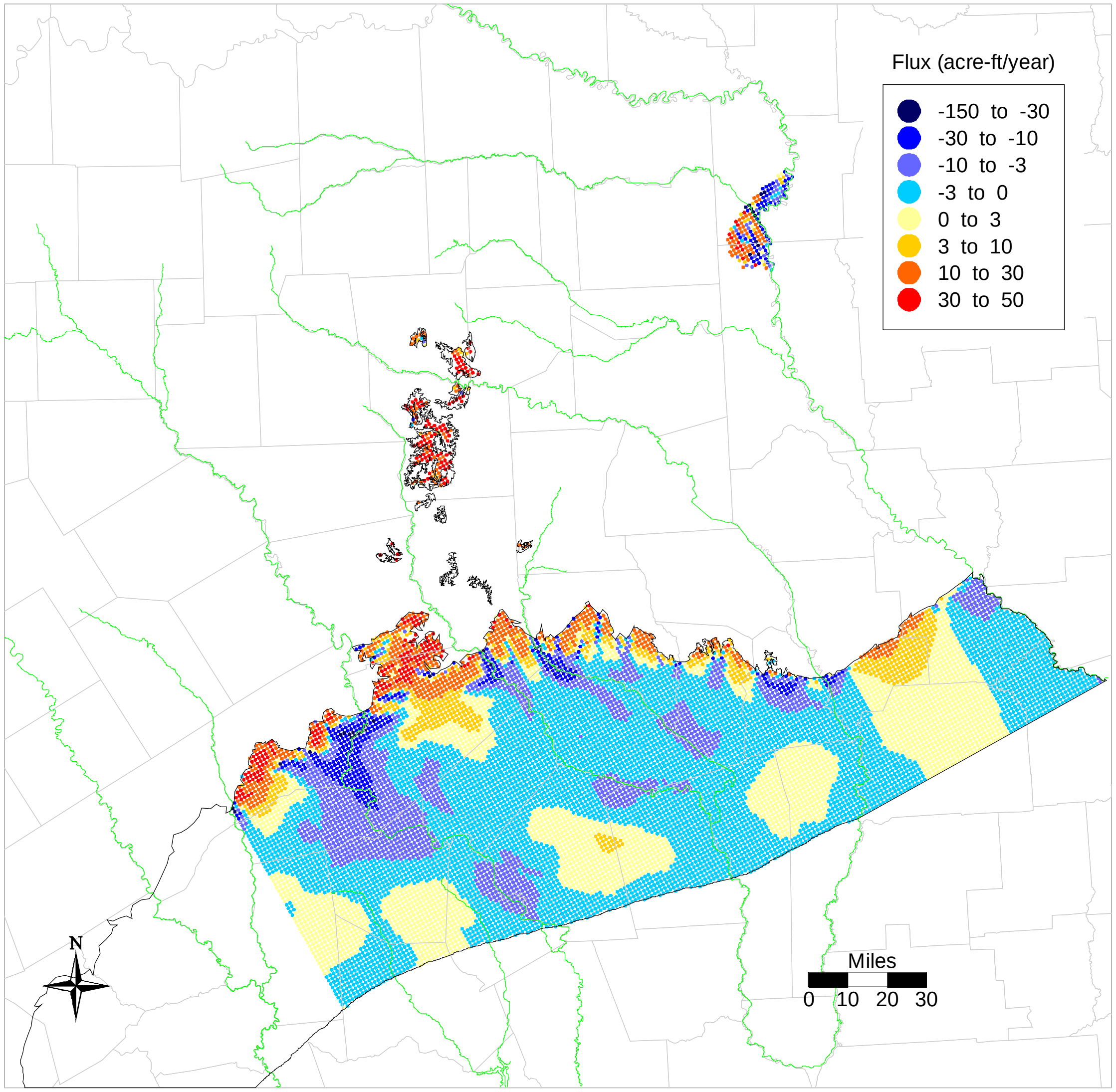
Northern QCSP QC Travel Time



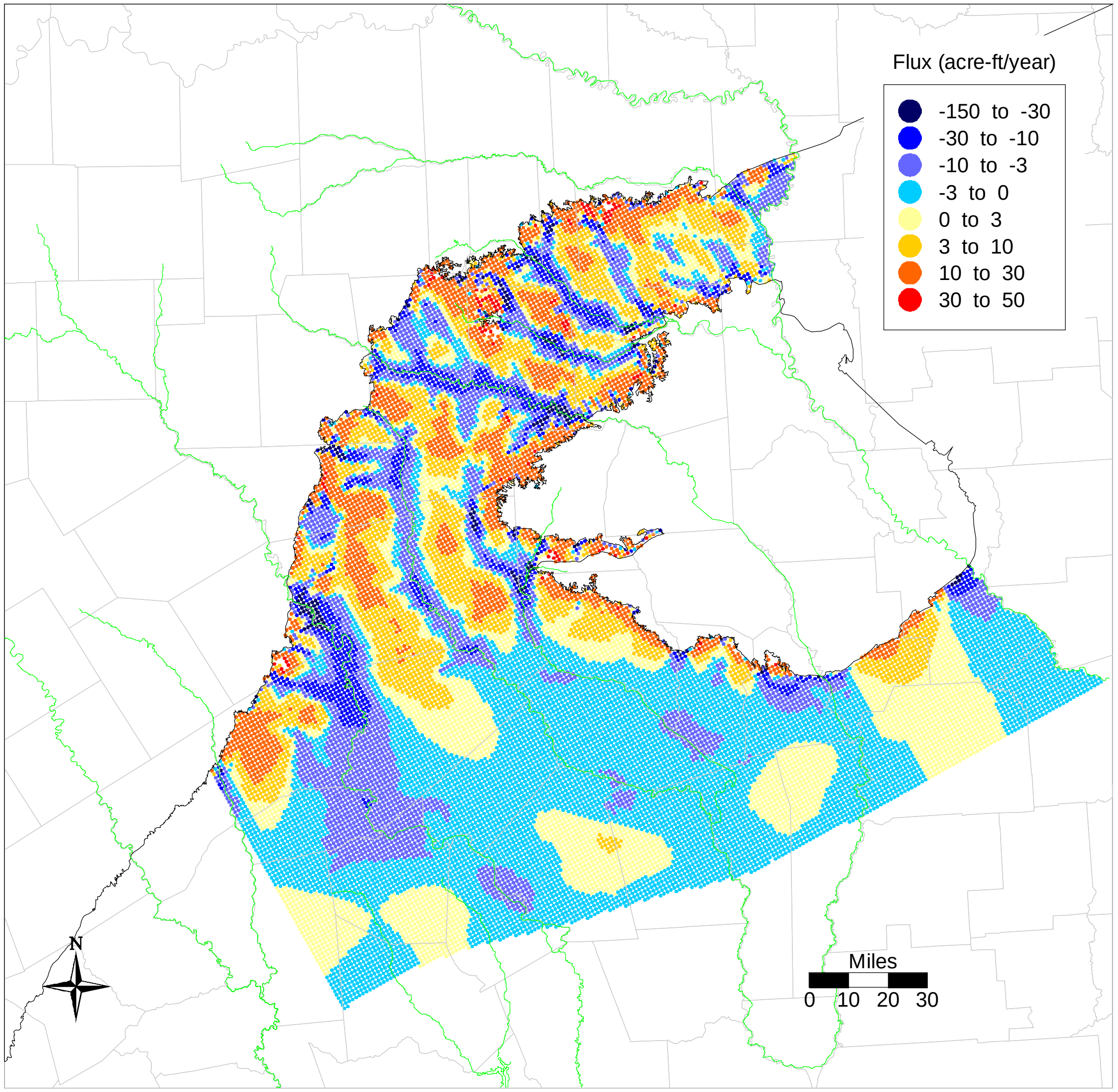
Northern QCSP Carrizo Travel Time



Northern QCSP Queen City Top Flux



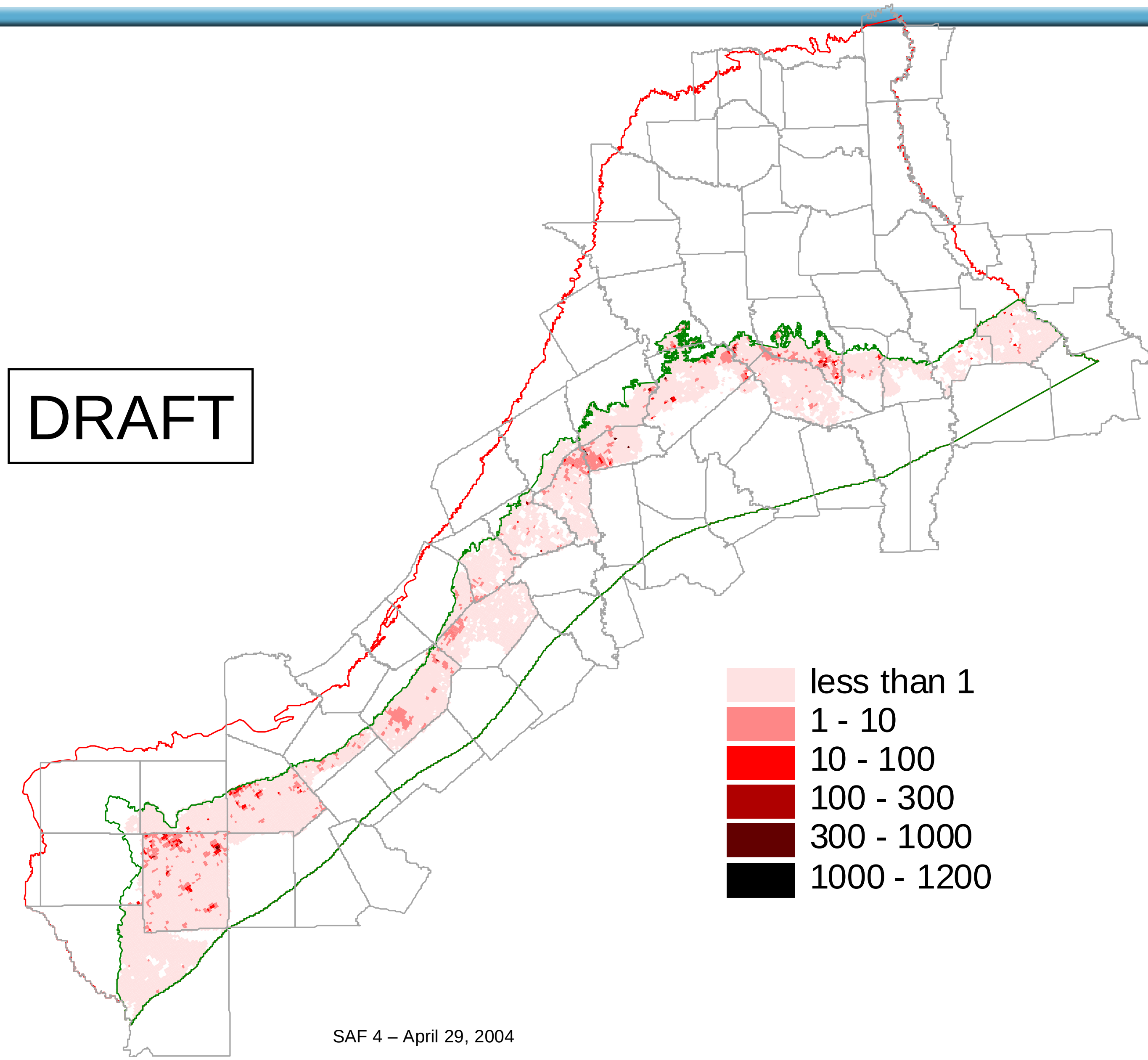
Northern QCSP Carrizo Top Flux



Transient Issues - Progress

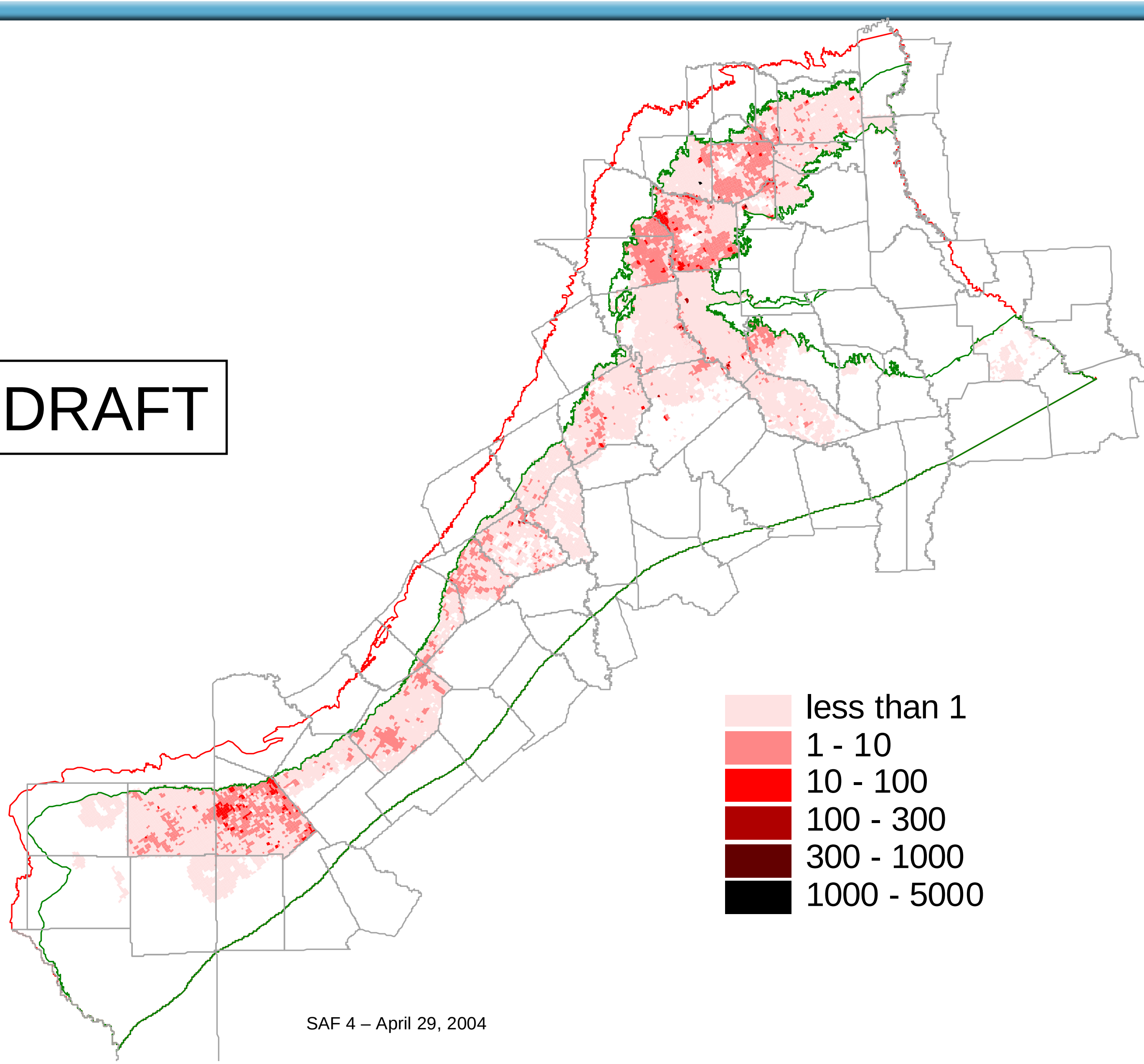
- We begin with the same values in overlap areas for the Carrizo through the Sparta
  - Structure
  - Hydraulic Conductivity
  - Hydraulic Heads
  - Recharge - Transient
  - Boundaries – GHB Coupled Between Models
  - Storage
  - Pumping
- We will monitor parameter changes between models during calibration to insure consistency

Sparta Pumping (AFY)



Queen City Pumping (AFY)

DRAFT



Revised Schedule – Milestones

2003

SAF 1 — Feb 28

Stakeholder Data - Apr 31

SAF 2 — June 12

- Jan 23 — Kickoff Meeting
  - Complete database
  - Evaluate data
  - Preliminary model design
- July 31 — Draft Conceptual Model Report

2004

SAF 3 — Jan 9

SAF 4 — April

SAF 5 — June

Stakeholder Comments

SAF 6 — Sep

- March — Steady-state model review
- May — Transient model review
- June — Predictions review
- July1 — Draft report review
- Oct 30 — Final Report & Model

Meeting Wrap-Up

- Next meeting – June/July
  - Draft transient model calibration
  - Draft model predictions
- Discussion / comments / questions

Who to Contact?

- Van Kelley

INTERA Inc.
9111A Research Blvd
Austin, TX 78758
(512) 425-2047
vkelley@intera.com

- Dr. Shirley Wade

Texas Water Development Board
P.O. Box 13231
Austin, TX 78711
(512) 936-0883
shirley.wade@twdb.state.tx.us

Thank You

Meeting Minutes for the

Forth Queen City/Sparta Groundwater Availability Model (GAM) Stakeholder Advisory Forum (SAF) Meeting

April 29, 2004

Nacogdoches City Hall

Nacogdoches, Texas

The forth Stakeholder Advisory Forum (SAF) Meeting for the Queen City/Sparta Groundwater Availability Model (GAM) was held on April 29th, 2004 from 9:00 AM until 10:30 AM in City Commission Room 119 of City Hall, 202 E. Pilar St, Nacogdoches, Texas. A list of meeting participants is shown at the end of these meeting notes.

The purpose of the forth SAF meeting was to provide an update on the progress for the Queen City/Sparta Aquifers GAM and provide an opportunity for feedback from stakeholders.

Meeting Introduction: Shirley Wade, TWDB

The meeting was initiated by Shirley Wade of the Texas Water Development Board (TWDB). She gave a brief introduction to the GAMs and discussed the current status of the GAM program. She then discussed groundwater availability and use of the GAMs, followed by a look at the future of the GAMs and opportunities for public involvement in GAM development.

SAF Presentation: Van Kelley, INTERA Inc

Van Kelley of INTERA presented a prepared presentation discussing updates and calibration status of Queen City/Sparta Groundwater Availability Model (GAM). The presentation was structured according to the following outline:

1. Review of Conceptual Model
2. Overview of Revised Model Scope
3. Model development (including integration with Carrizo-Wilcox GAMs)
4. Steady State Model Results
5. Schedule and Expectations for the next SAF Meeting

The presentation is available on the GAM website

http://www.twdb.state.tx.us/gam/qc_sp/qc_sp.htm)

Questions and Answers: Open Forum:

Q: How long has water being pumped from a well in the Carrizo aquifer in the Nacogdoches area been traveling to that point?

A: *Travel time plots from the steady-state model suggest travel times from the outcrop downdip to Nacogdoches County in the range of 1,000 with some isolated spots in the county having travels times greater than 1,000 years and less than 10,000 years..*

Queen City Sparta Stakeholder Advisory Forum 4, April 29, 2004

Attendance

Name	Affiliation
David B. Smith	City of Nacogdoches/Pineywoods Groundwater Conservation District
Van Kelley	INTERA Inc.
Shirley Wade	TWDB