Groundwater Availability Modeling: Gulf Coast Aquifer, Lower Rio Grande Valley

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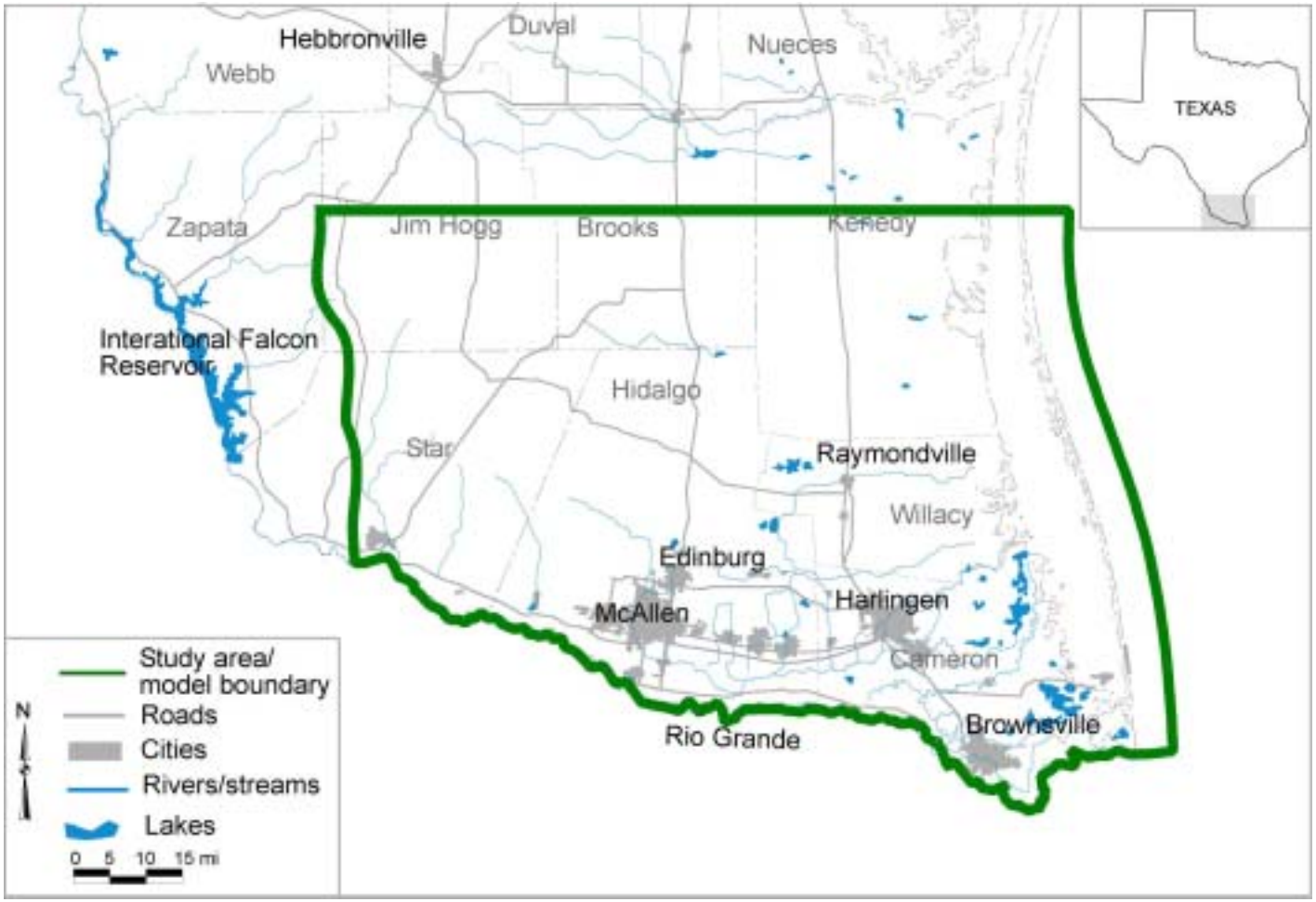
Texas Water Development Board

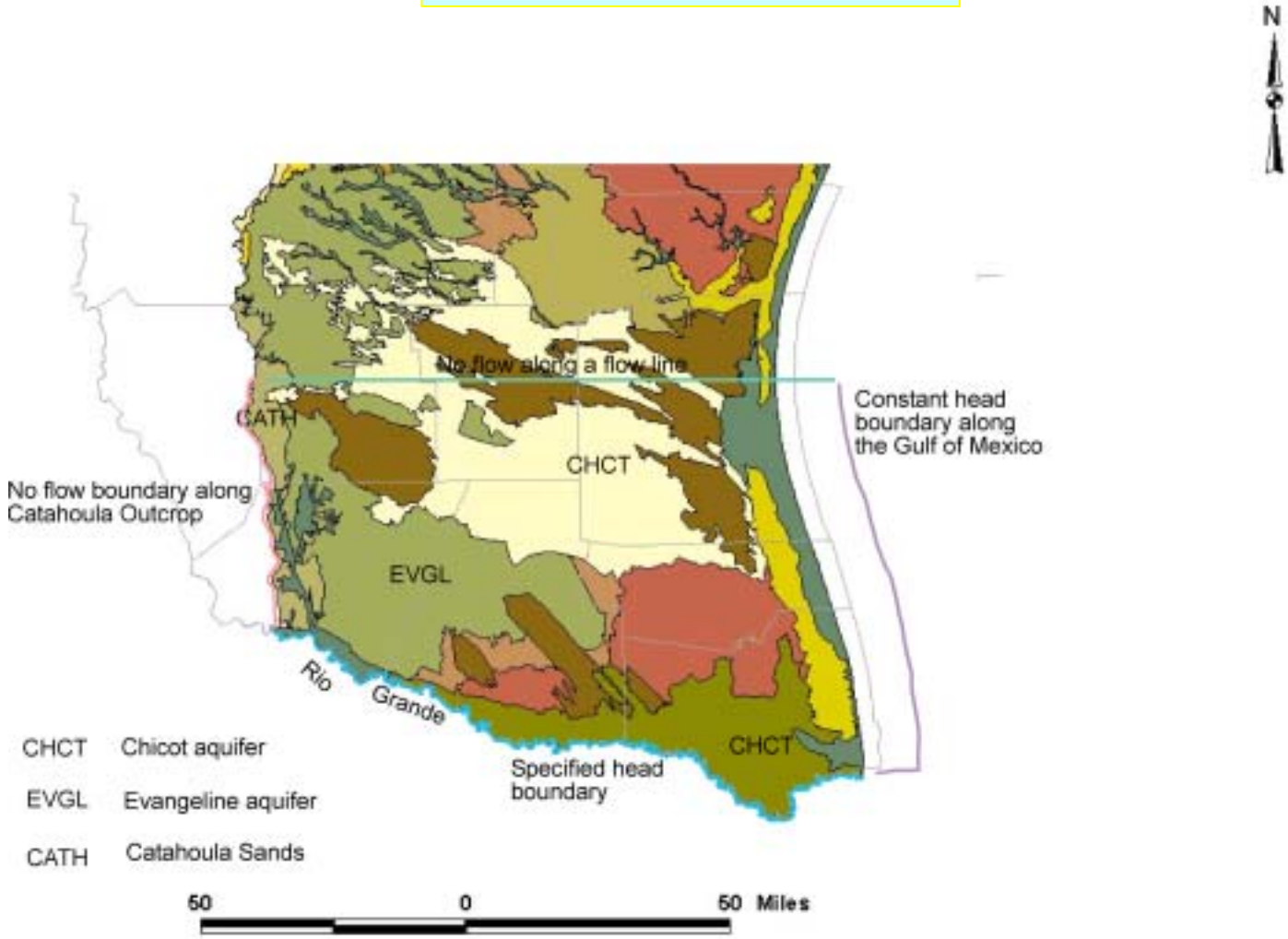
Outline

- summary model results
- Steady-State Model (1980)
- Transient Model (1981-1999)
- Predictive Model (2000-2050)
- Groundwater Availability

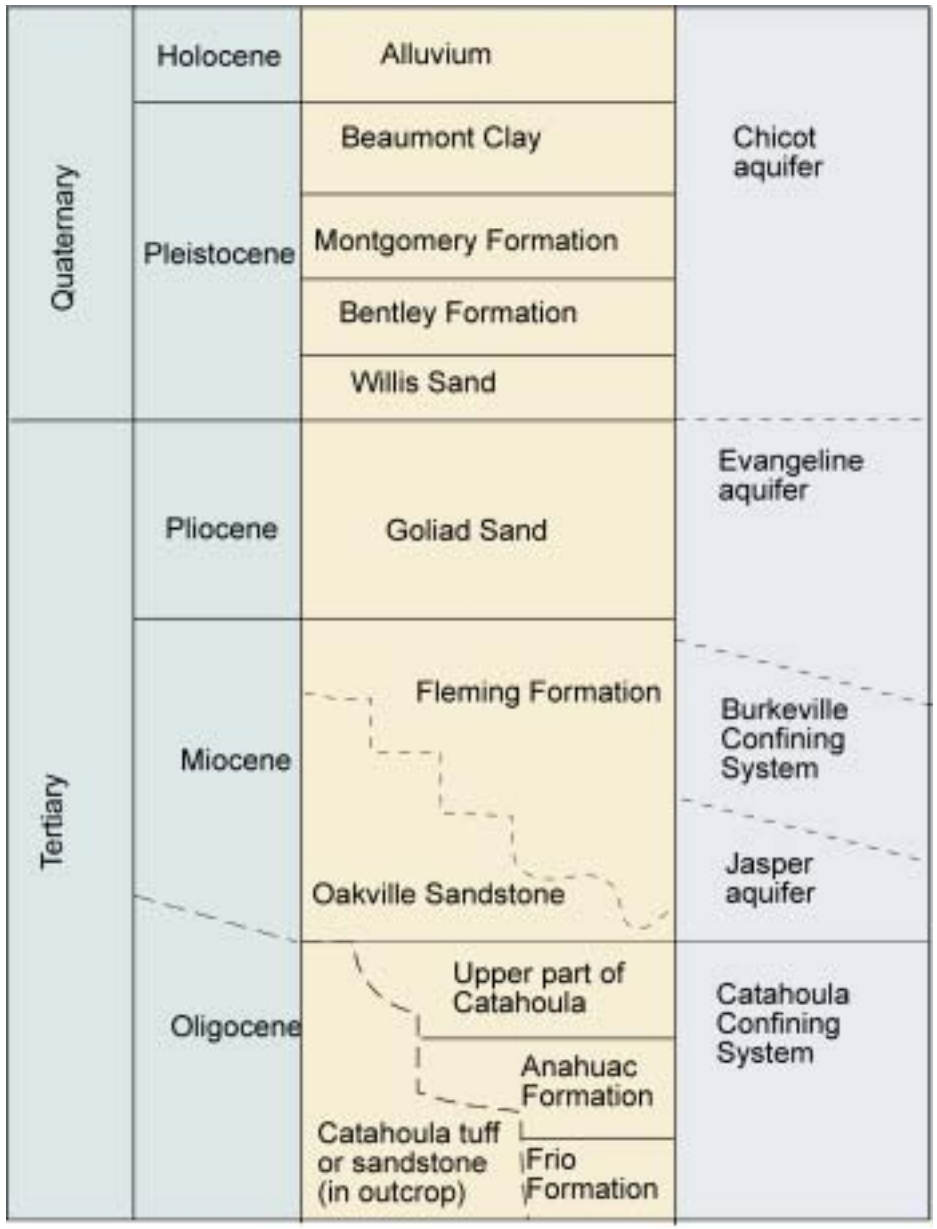
MODEL AREA


Hebbronville
Duval
Nueces
Webb
TEXAS
Zapata
Jim Hogg
Brooks
Kenedy
International Falcon Reservoir
Hidalgo
Starr
Raymondville
Willacy
Edinburg
McAllen
Harlingen
Cameron
Rio Grande
Brownsville
Study area/ model boundary
Roads
Cities
Rivers/streams
Lakes
N
0 5 10 15 mi

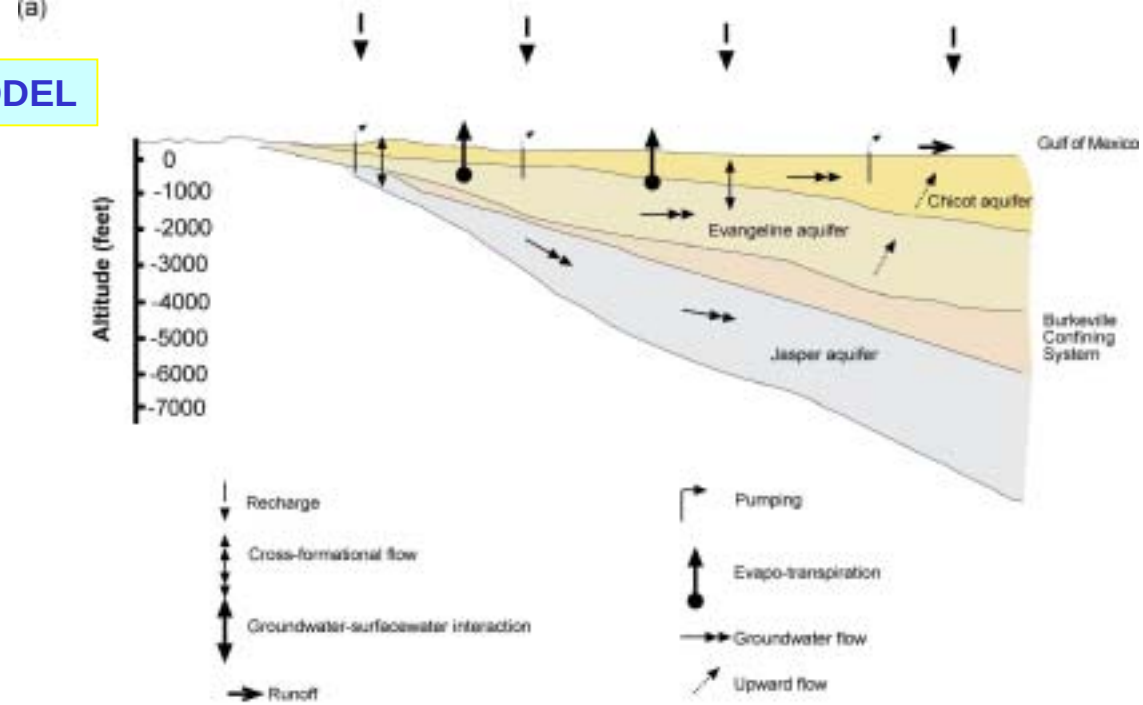
SURFACE GEOLOGY



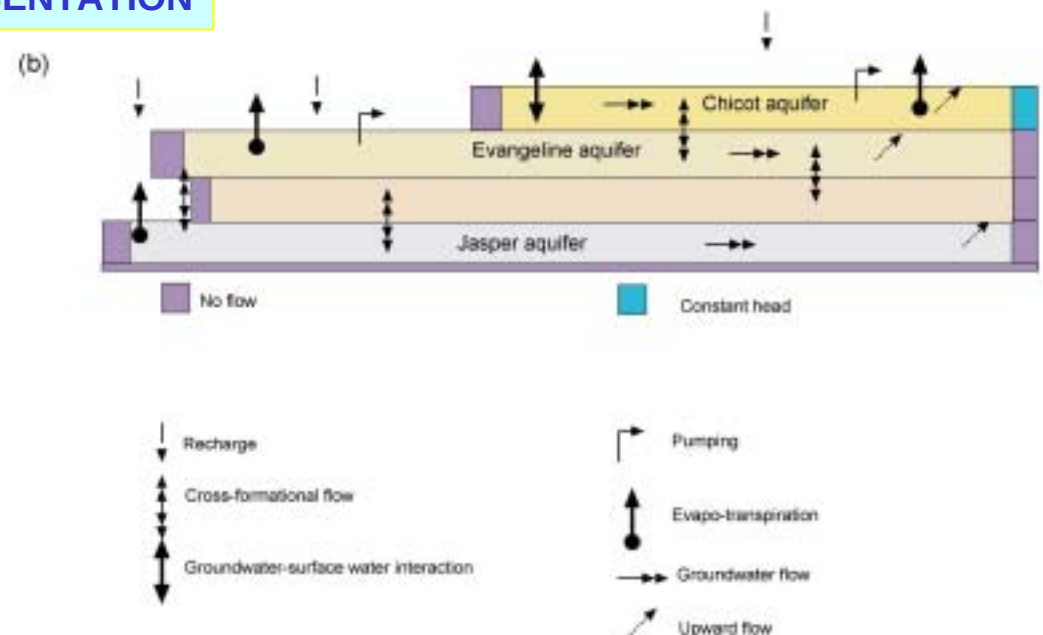
Stratigraphic Column for the Gulf Coast Aquifer



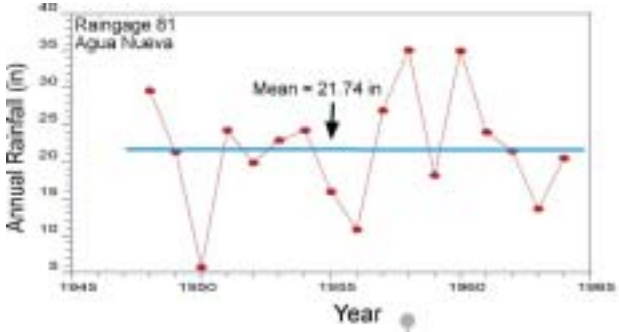
CONCEPTUAL MODEL

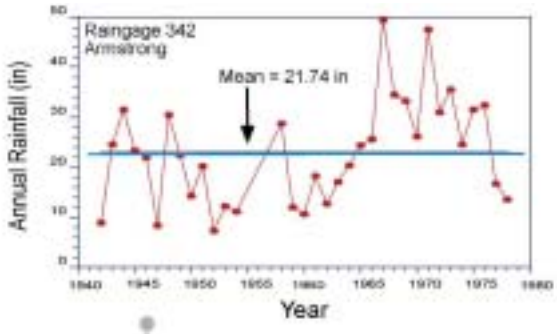


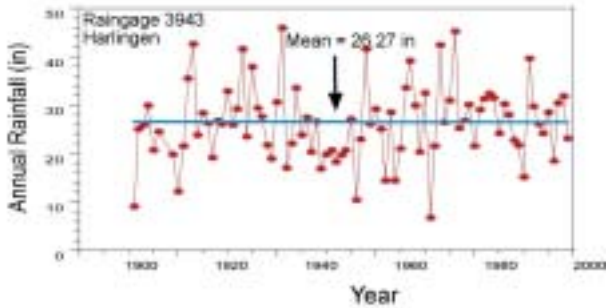
NUMERICAL REPRESENTATION

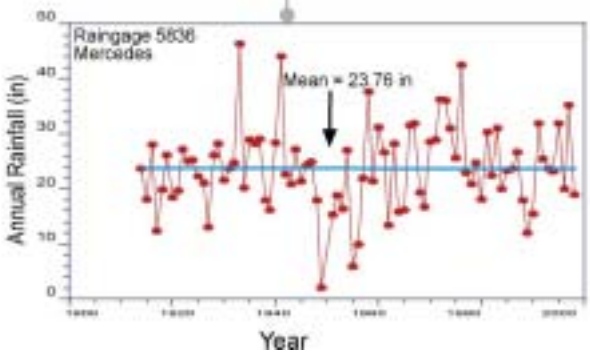


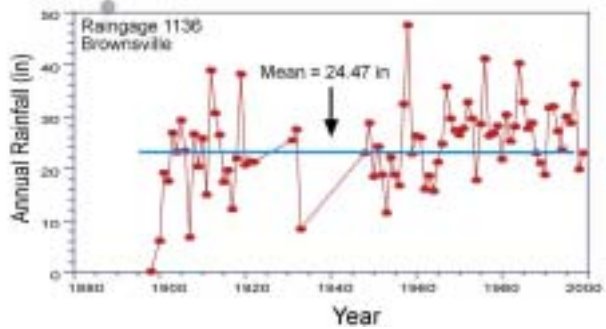
HISTORICAL RAINFALL HYDROGRAPHS



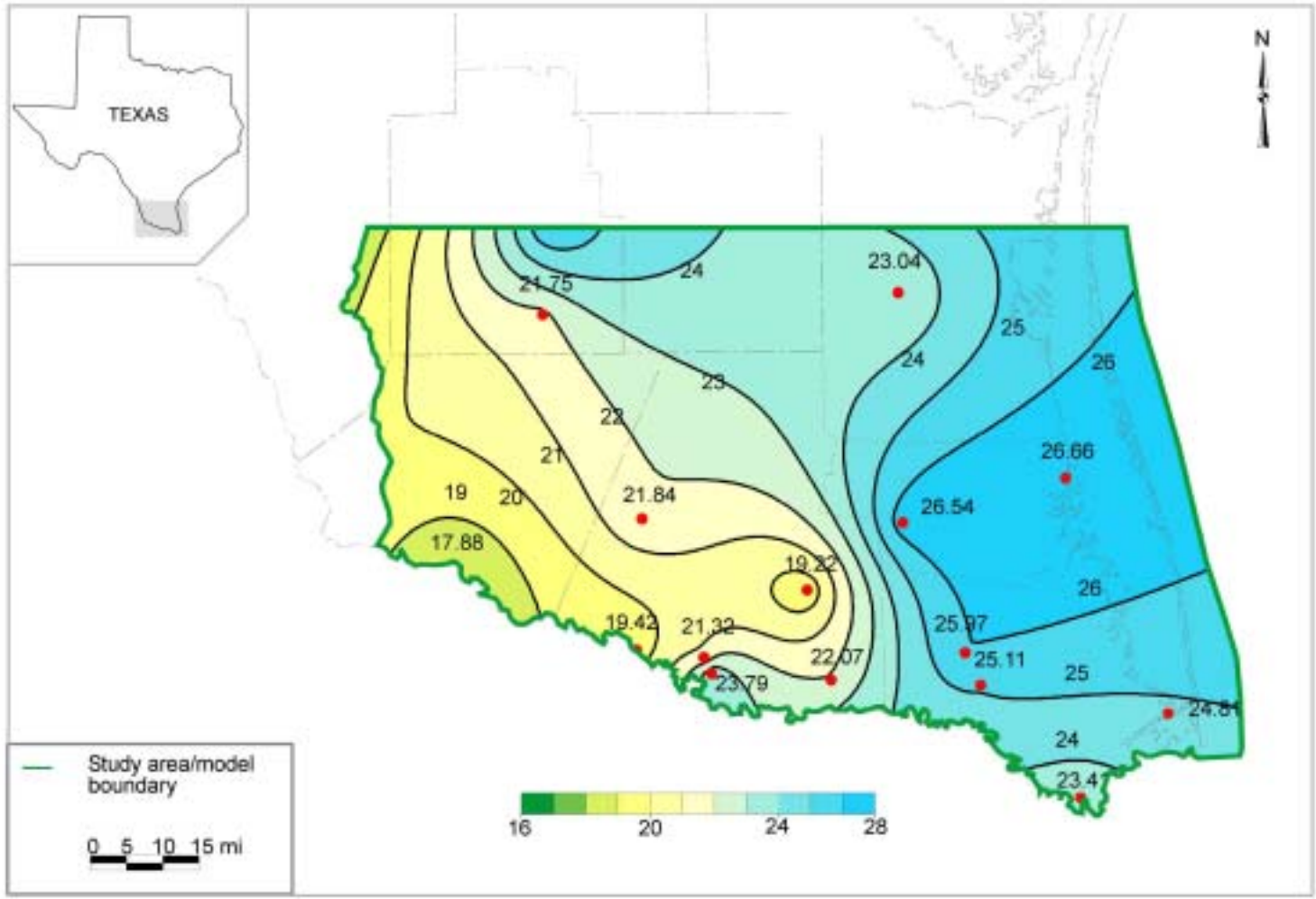






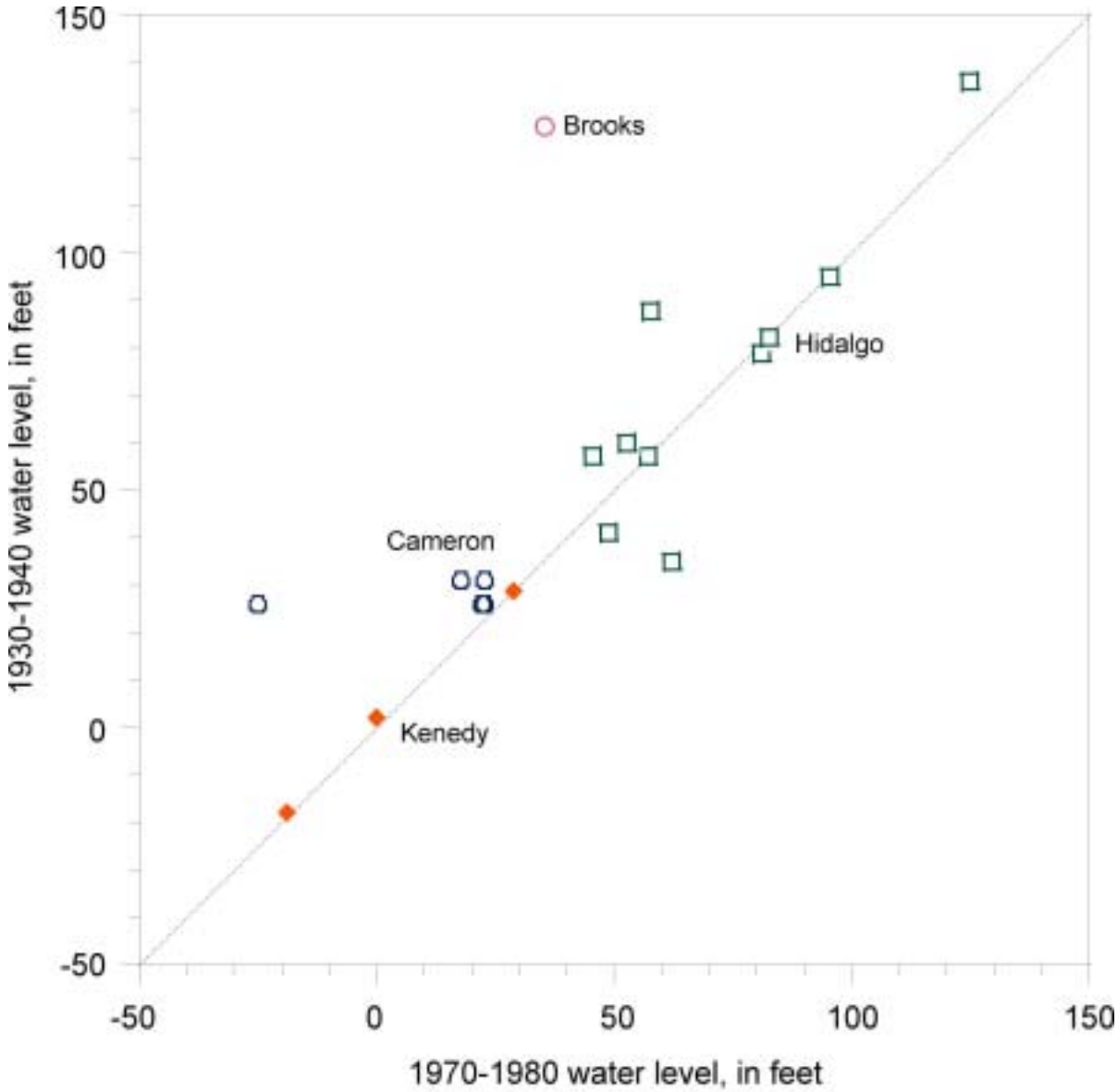


RAINFALL DISTRIBUTION FOR 1930-1980 (INCHES/YEAR)



Recharge for the Gulf Coast Aquifer

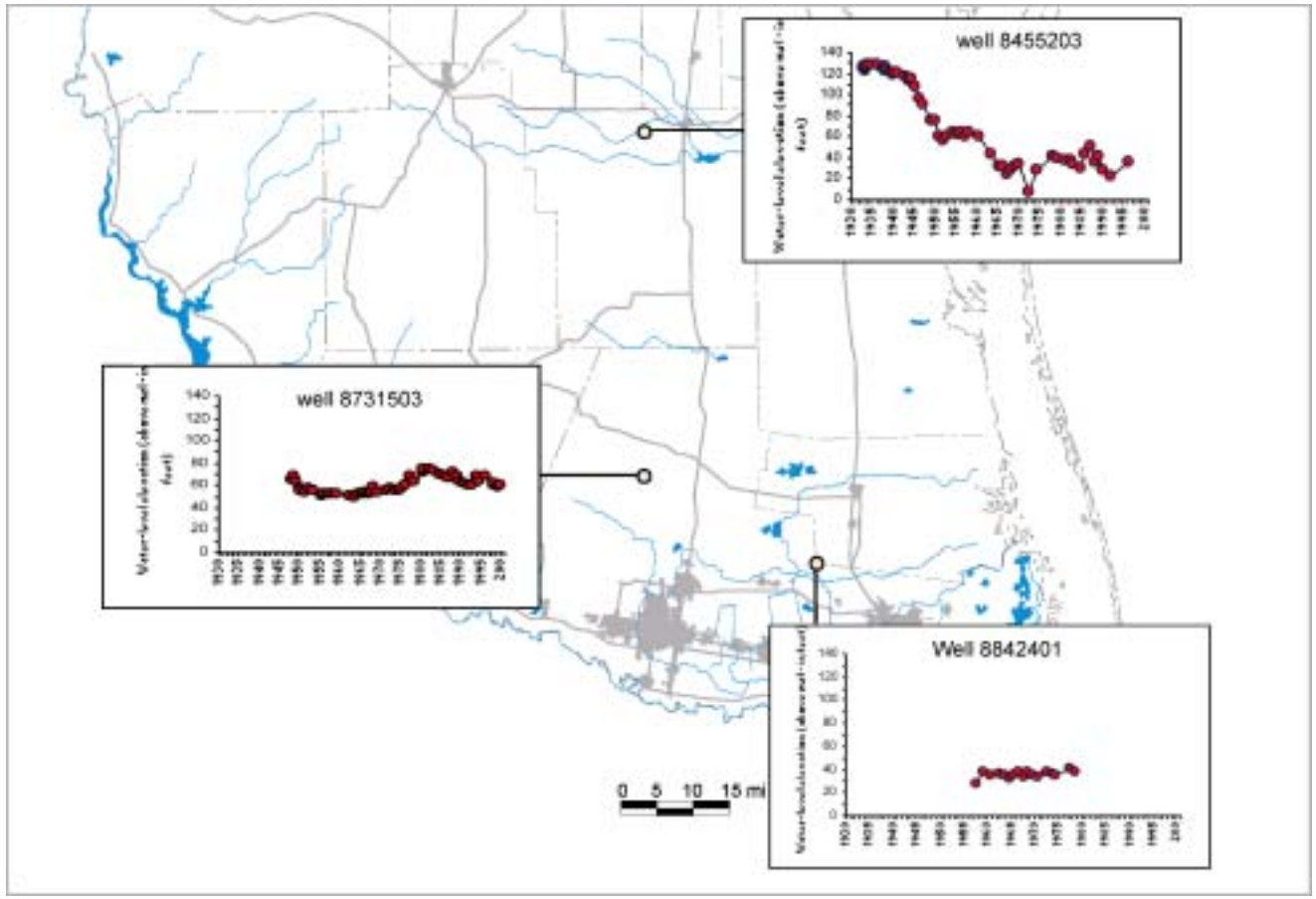
Source	Recharge (in/yr)
Groschen (1985)	0.06
Ryder (1988)	0 to 6
Dutton and Richter (1990)	0.1 to 0.4
Noble and others (1996)	6
Hay (1999)	.00004 to .04
Harden and Associates (2001)	3
This study **TWDB (2003)**	**0.08 to 0.14**



WATER-LEVELS FROM 1930'S AND 1970'S

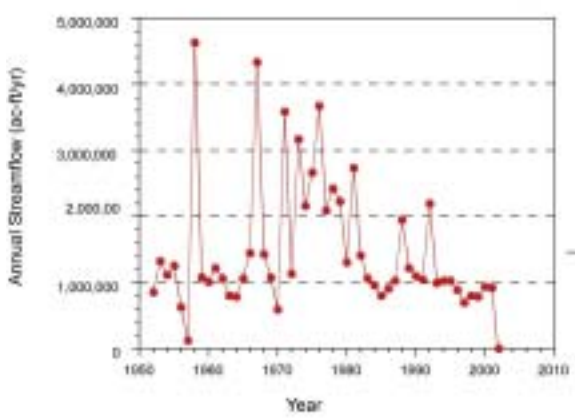
Distance between wells < 1,000 m

Hydrographs

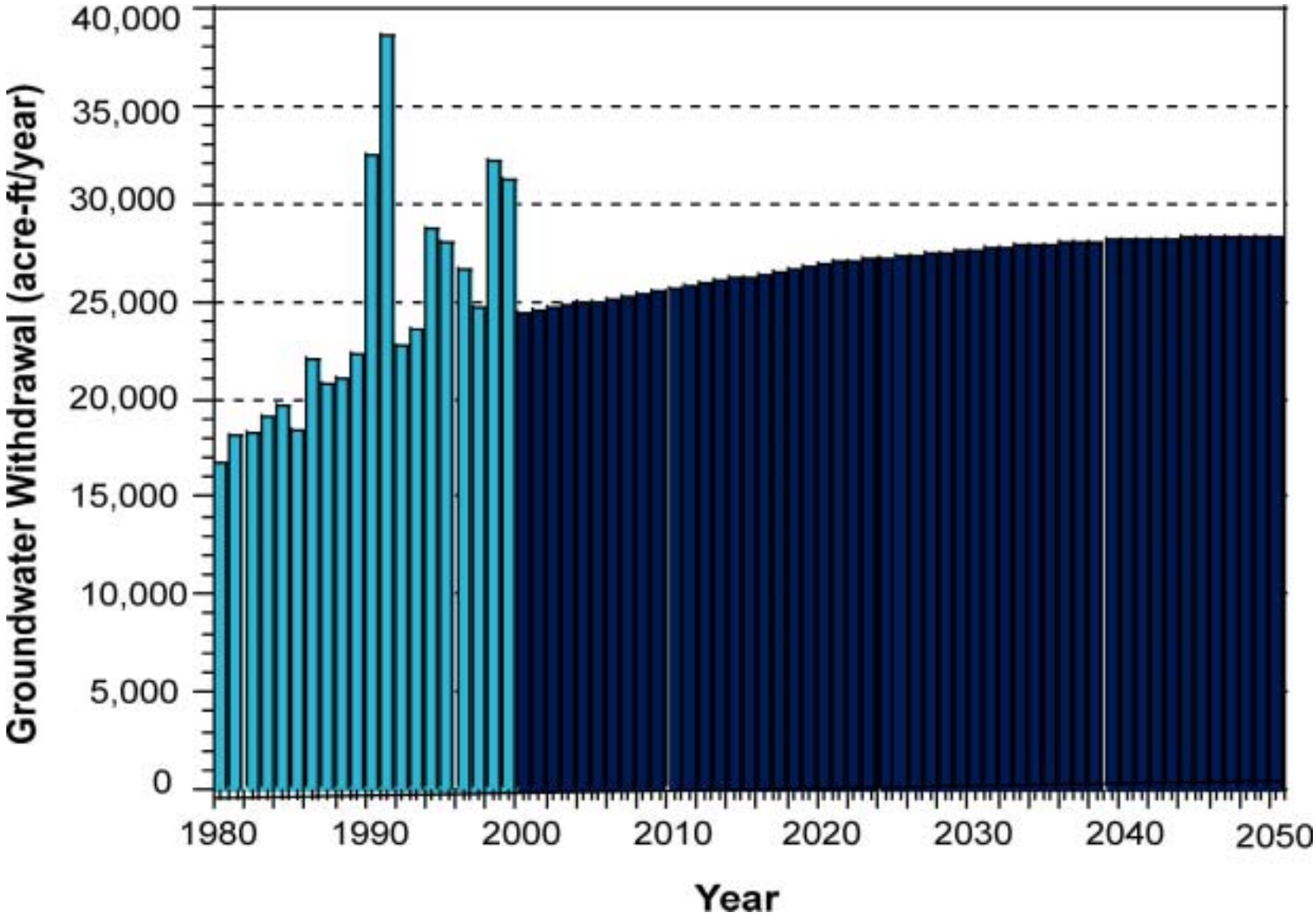


USGS Streamgaging Station #8461300
Rio Grande below Falcon Dam near Falcon, Texas

USGS Streamgaging Station #8459200
Rio Grande below Anzalduas Dam near Mission, Texas

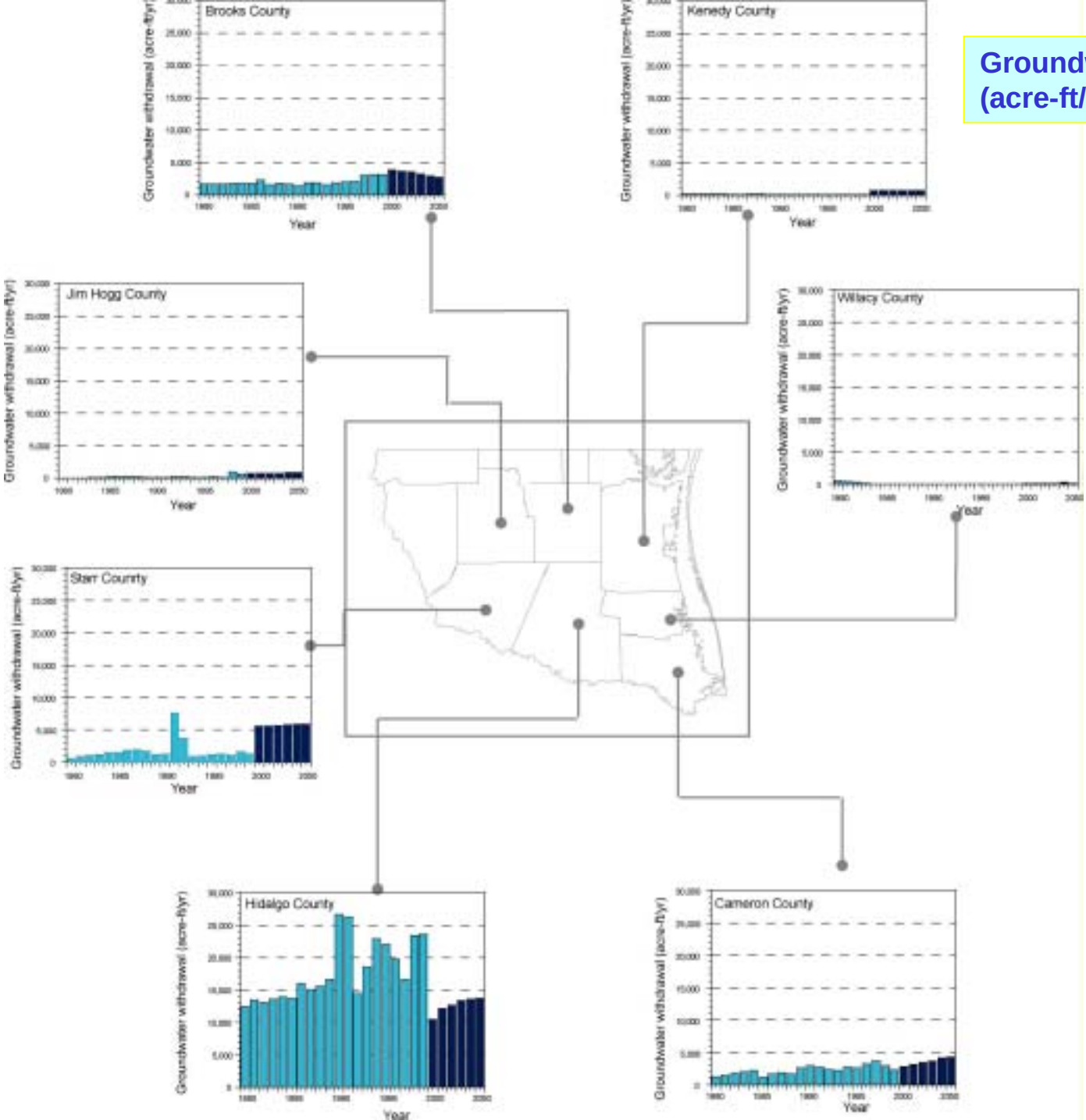


USGS Streamgaging Station #8475000
Rio Grande below Anzalduas Dam near Brownsville, Texas

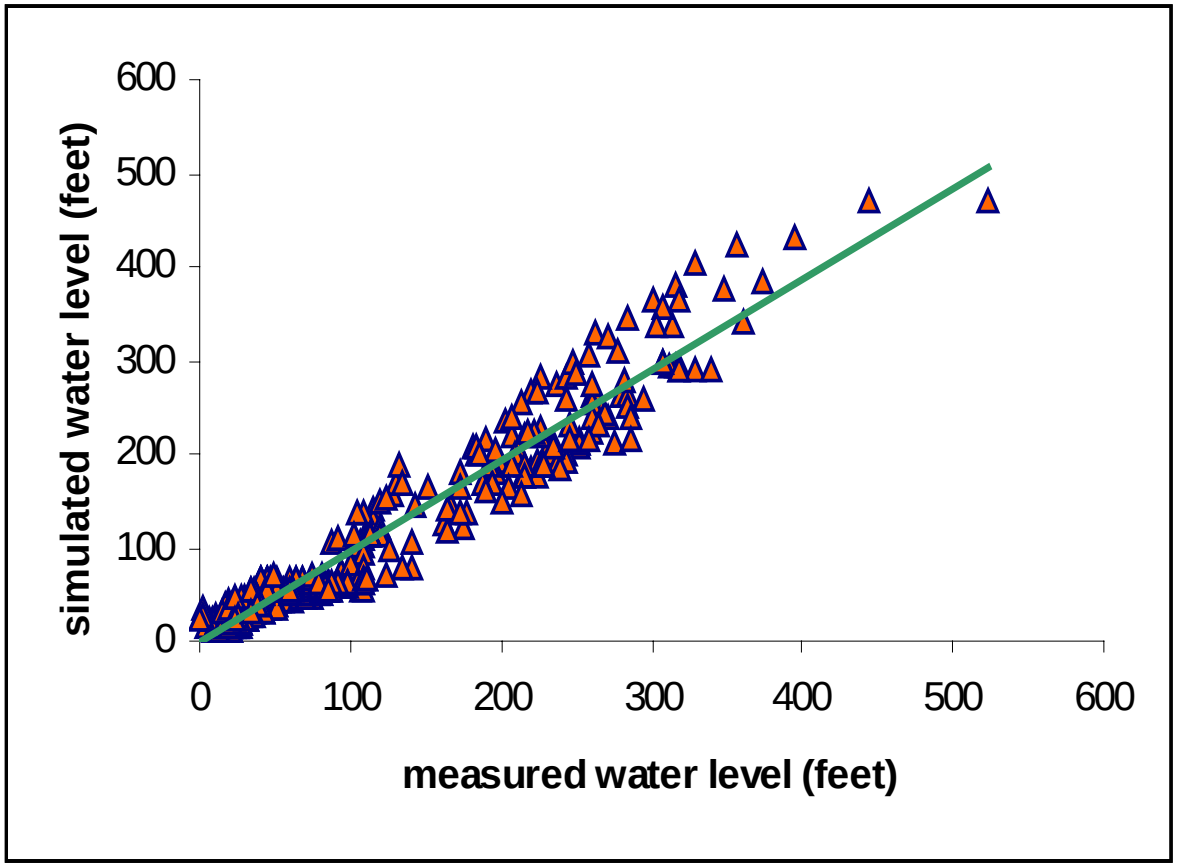


Historical and predictive total groundwater withdrawal (acre-feet/year)

Groundwater withdrawal (acre-ft/yr) by county



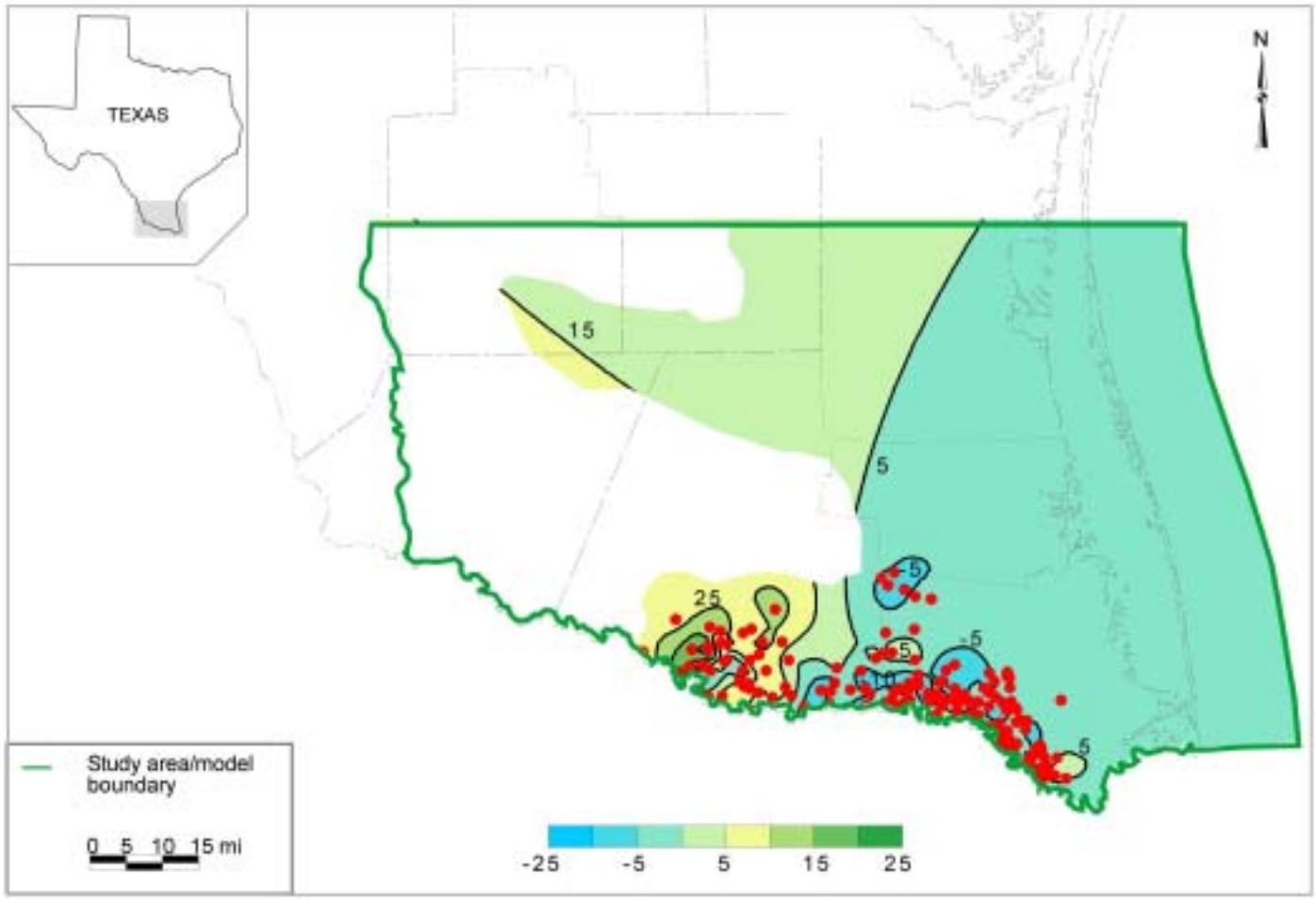
Simulated Versus Measured Water Levels, Steady-State



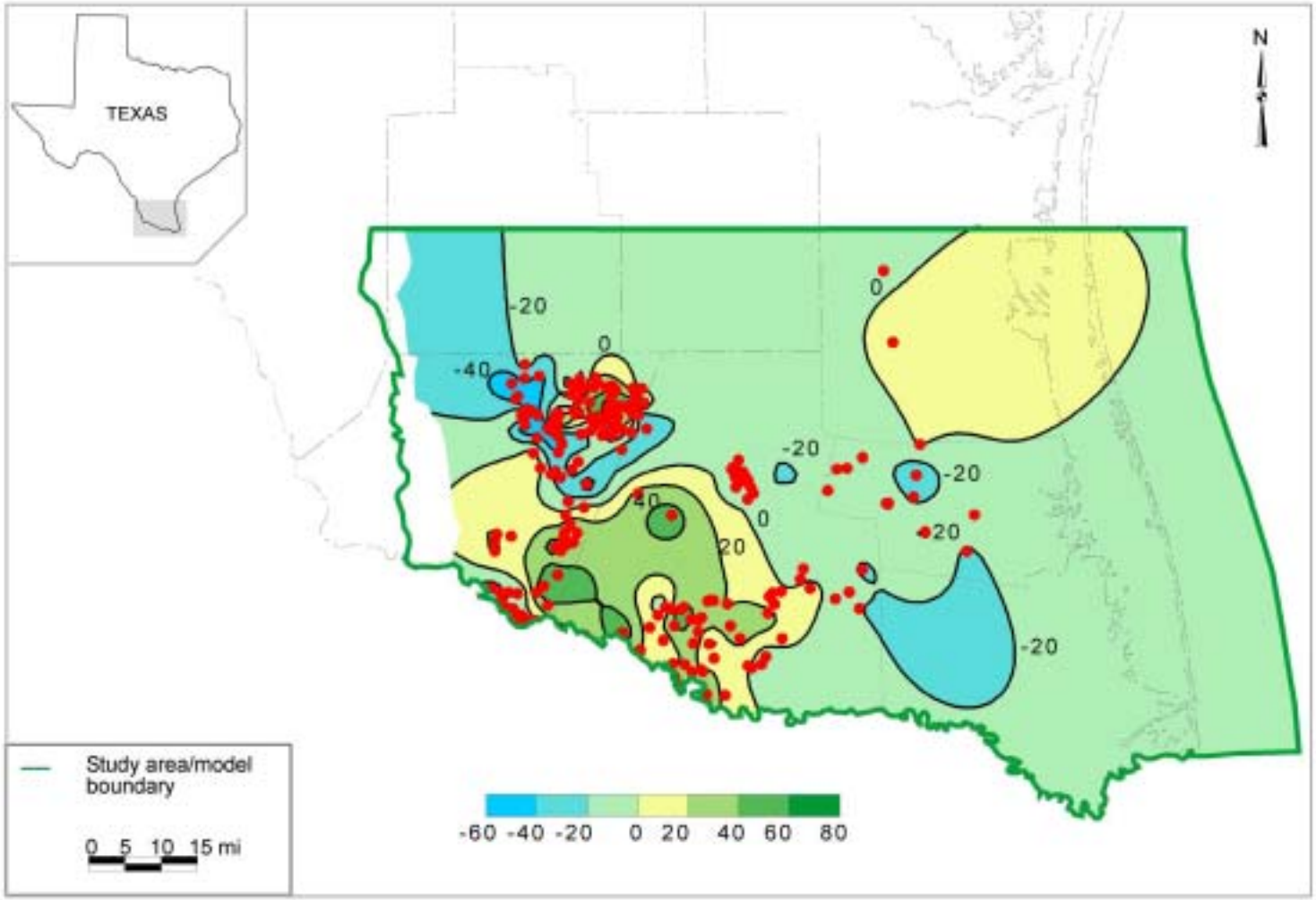
Root Mean Squared Error (RMSE) = 23.44 feet

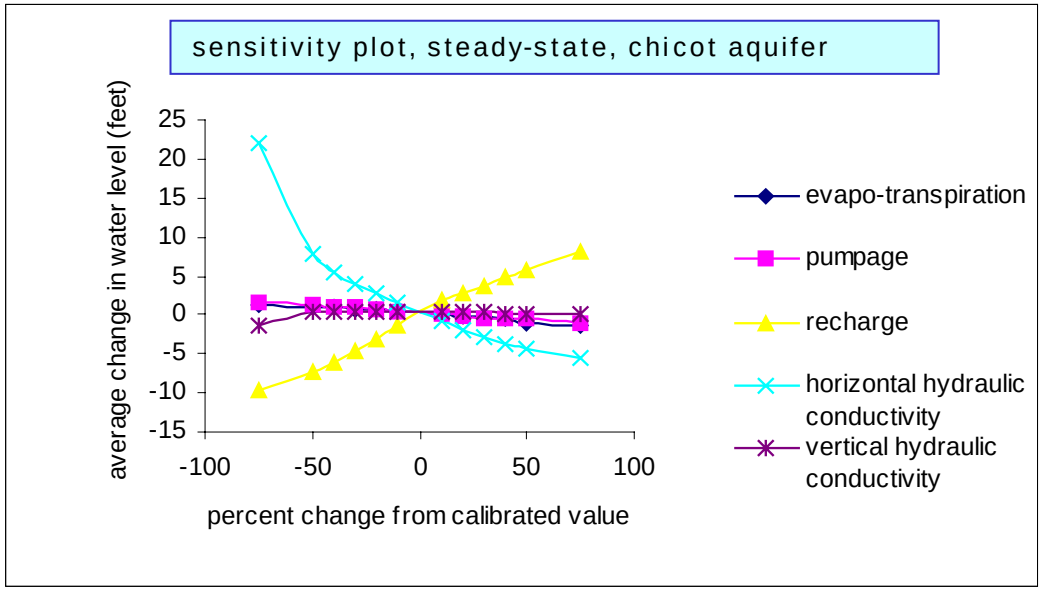
RMSE is 4.4% of the total head drop across model

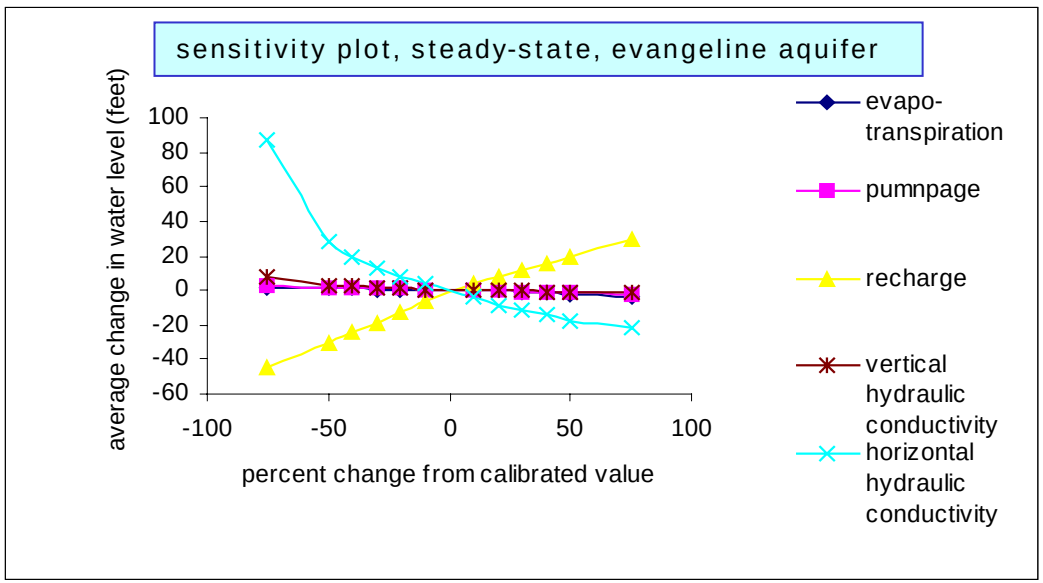
Water level residuals in the chicot aquifer (1980)



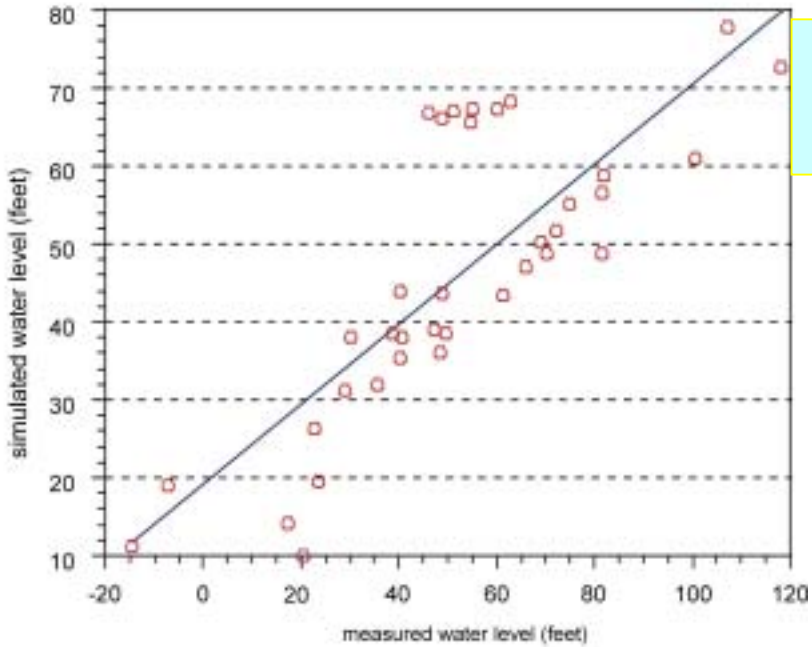
Water-level residuals in the Evangeline aquifer (1980)




sensitivity plot, steady-state, chicot aquifer
average change in water level (feet)
25
20
15
10
5
0
-5
-10
-15
-100
-50
0
50
100
percent change from calibrated value
evapo-transpiration
pumpage
recharge
horizontal hydraulic conductivity
vertical hydraulic conductivity

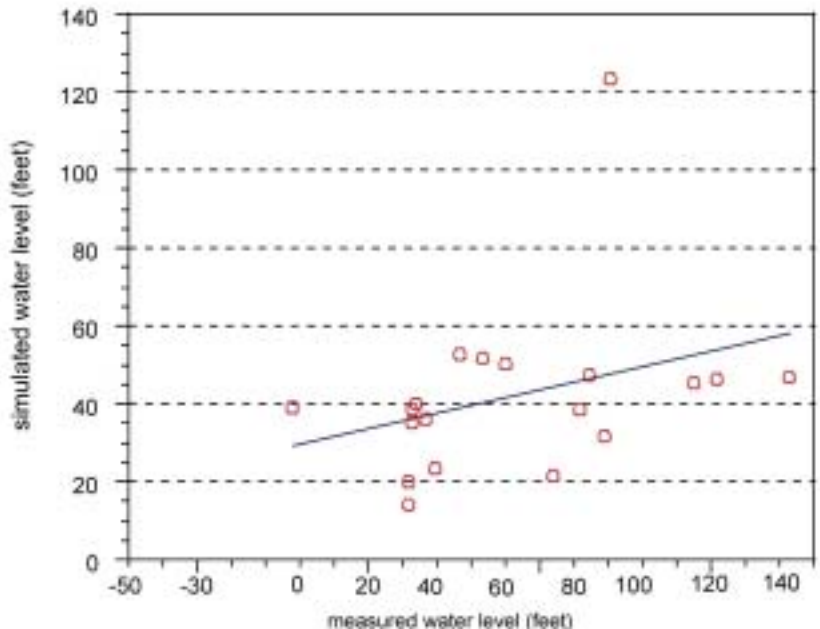

sensitivity plot, steady-state, evangeline aquifer
average change in water level (feet)
100
80
60
40
20
0
-20
-40
-60
-100
-50
0
50
100
percent change from calibrated value
evapo-transpiration
pumnpage
recharge
vertical hydraulic conductivity
horizontal hydraulic conductivity

(a)

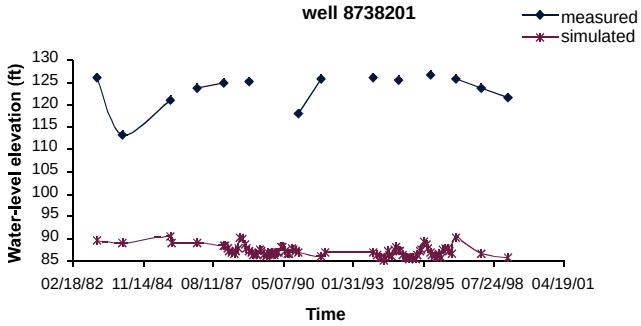


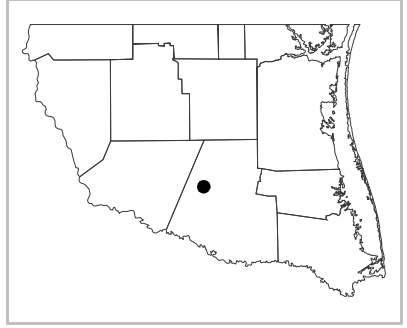
Simulated vs. measured water level
1990 transient calibration
RMS error ± 17 feet

(b)

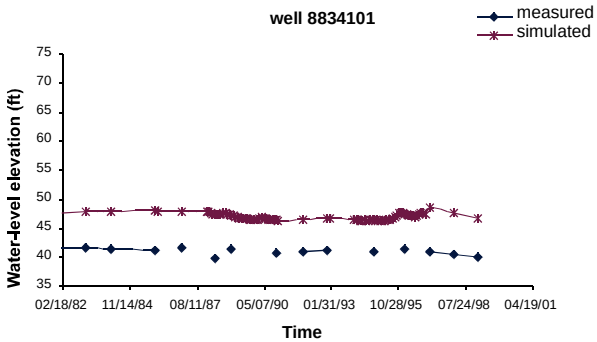


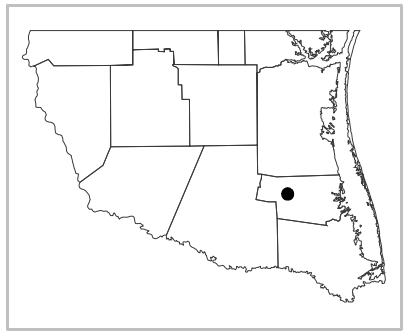
Simulated vs. measured water level
1999 transient verification
RMS error ± 18 feet

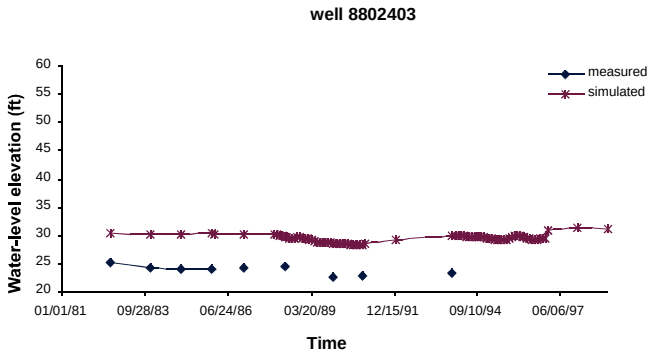


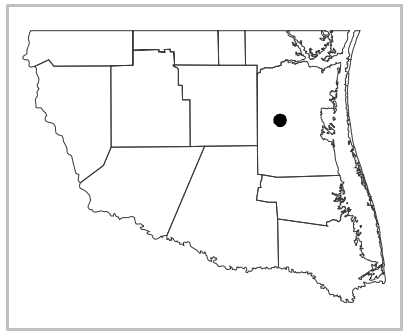


Transient Calibration (1981-1999)



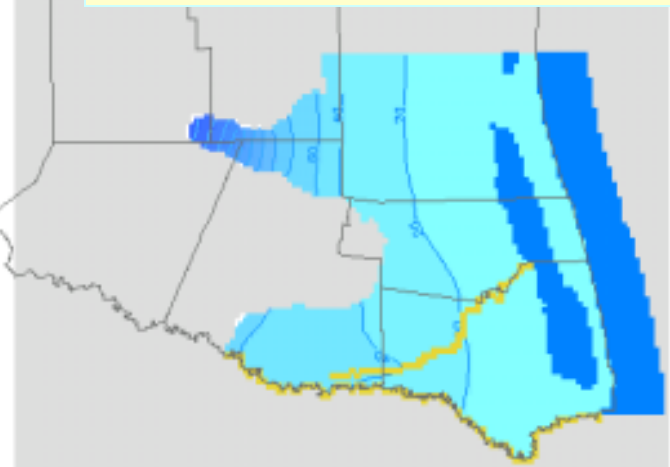




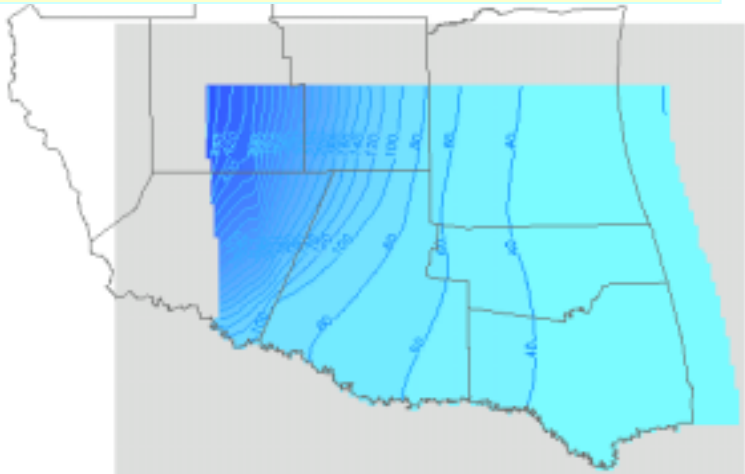


Comparison of simulated water levels in 1980 to water levels in 2050

1980

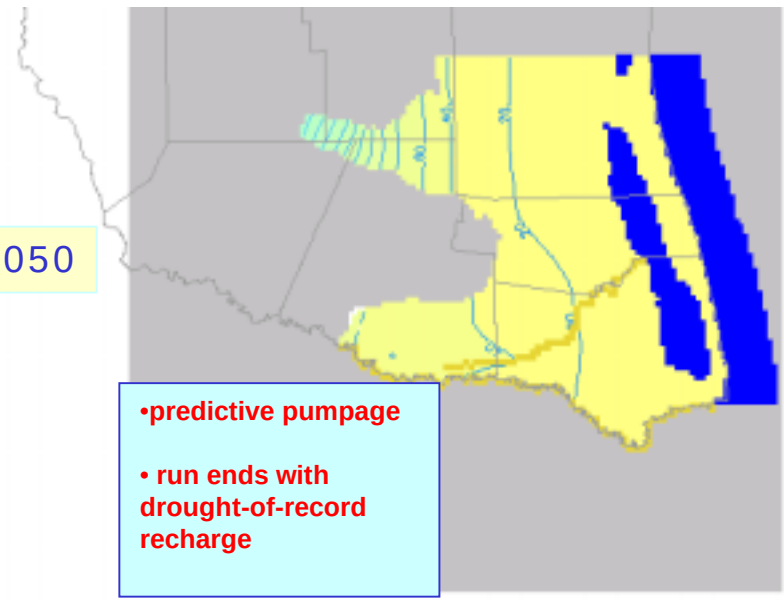


Chicot aquifer



Evangeline aquifer

2050



- predictive pumpage
- run ends with drought-of-record recharge

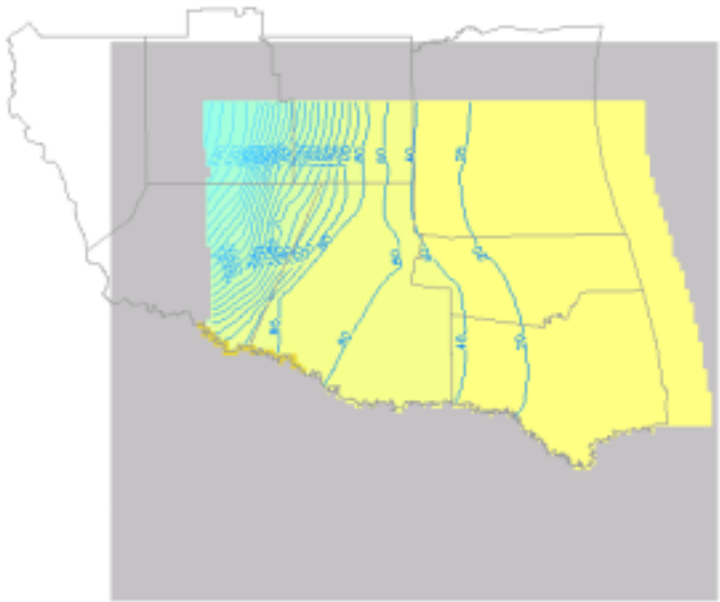


Table : Water budget for the calibrated steady-state (1980), calibrated transient (1980-1999) and predictive runs (2010-2050). All values are in acre-feet/year.

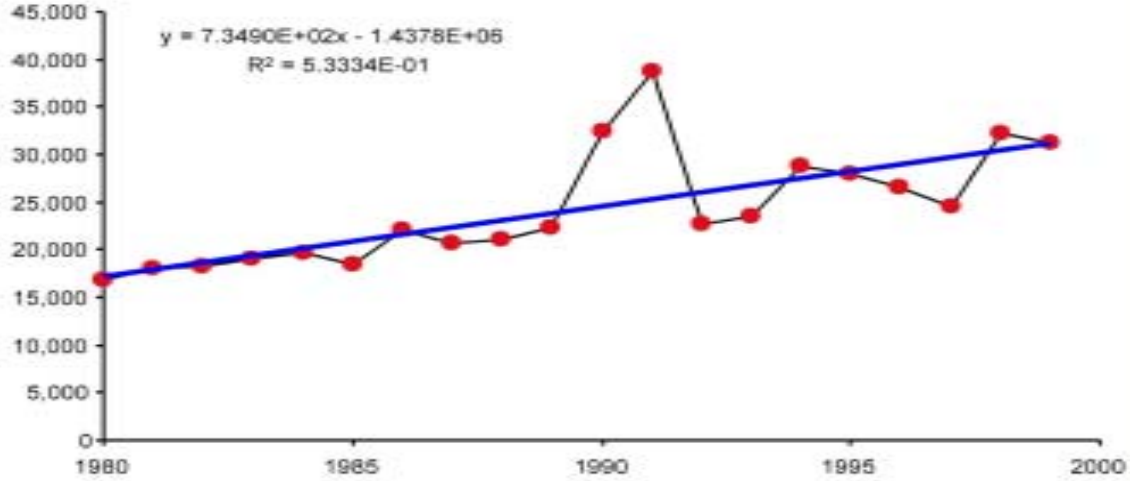
Year	Layer	Recharge	River leakage	Groundwater discharge	ET	Wells	X-flow upper (in)	X-flow Upper (out)	net x-flow (upper)	x-flow lower (in)	x-flow lower(out)	net x-flow (lower)	Constant head	Storage
1980	1	26108	43236	-27454	-2101	-11470	0	0	0	15965	-1128	14837	-43156	0
	2	13945	2381	-874	-414	-1942	1128	-15965	-14837	2256	-513	1742	0	0
	3	204			0		513	-2256	-1742	2221	-682	1538	0	0
	4	1611			-73		682	-2221	-1538	0	0	0	0	0
	All	41868	45617	-28329	-2587	-13413	2323	-20441	-18118	20441	-2323	18118	-43156	0
1991	1	30622	49196	-26323	-2276	-23658	0	0		17229	-1293	15937	-43585	-87
	2	14774	2504	-1019	-462	-2864	1293	-17229	-15937	3164	-244	2920	0	-82
	3	206	0	0	0	0	244	-3164	-2920	2254	-444	1810	0	-904
	4	1721	0	0	-134	0	444	-2254	-1810	0	0	0	0	-223
	All	47324	51700	-27342	-2872	-26522	1981	-22648	-20667	22648	-1981	0	-43585	-1297
1999	1	22273	48932	-25657	-2106	-19092				17973	-1393	16579	-41951	-1022
	2	13472	2973	-949	-514	-3575	1393	-17973	-16579	3159	-193	2966	0	-2207
	3	160	0	0	0	0	193	-3165	-2972	2299	-435	1864	0	-949
	4	1348	0	0	-80	0	435	-2299	-1864	0	0	0	0	-596
	All	37253	51904	-26607	-2701	-22668	2021	-23436	-21415	23430	-2021	21409	-41951	-4775
2010	1	15583	46987	-25752	-1226	-12501	0	0	0	15340	-1143	14197	-39096	-1807
	2	7531	2973	-644	-227	-3635	1143	-15340	-14197	4814	-43	4771	0	-3428
	3	104	0	0	0	0	43	-4814	-4771	3098	-201	2898	0	-1769
	4	865	0	0	-44	0	201	-3098	-2898	0	0	0	0	-2077
	All	24082	49960	-26396	-1497	-16136	1387	-23253	-21866	23253	-1387	21866	-39096	-9082
2020	1	15583	47907	-25517	-1219	-13648	0	0	0	15230	-1171	14059	-38933	-1767
	2	7531	3102	-603	-216	-3789	1171	-15230	-14059	4746	-42	4787	0	-3331
	3	104	0	0	0	0	42	-4746	-4704	3080	-194	2886	0	-1714
	4	865	0	0	-44	0	194	-3080	-2886	0	0	0	0	-2065
	All	24082	51008	-26119	-1479	-17437	1407	-23056	-21649	23056	-1407	21733	-38933	-8877

Year	Layer	Recharge	River leakage	Groundwater discharge	ET	Wells	X-flow upper (in)	X-flow Upper (out)	net x-flow (upper)	x-flow lower (in)	x-flow lower(out)	net x-flow (lower)	Constant head	Storage
	1	15583	48672	-25355	-1216	-14537	0	0	0	15158	-1188	13971	-38867	-1749
	2	7531	3157	-577	-209	-3860	1188	-15158	-13971	4686	-41	4645	0	-3284
	3	104	0	0	0	0	41	-4686	-4645	3063	-189	2874	0	-1667
	4	865	0	0	0	0	189	-3063	-2874	0	0	0	0	-2010
	All	24082	51829	-25932	-1424	-18397	1417	-22907	-21490	22907	-1417	21490	-38867	-8710
2040	1	15583	49078	-25205	-1214	-15106	0	0	0	15106	-1196	13910	-38783	-1737
	2	7531	3226	-555	-202	-3985	1196	-15093	-13897	4639	-40	4679	0	-3283
	3	104	0	0	0	0	40	-4639	-4599	3050	-185	2865	0	-1630
	4	865	0	0	0	0	185	-3050	-2865	0	0	0		-2001
	All	24082	52304	-25761	-1416	-19091	1421	-22782	-21361	22795	-1340	21455	-38783	-8651
2050	1	15583	49283	-25143	-1212	-15350				15038	-1201	13837	-38740	-1742
	2	7531	3258	-538	-196	-4019	1201	-15038	-13837	4581	-40	4541	0	-3260
	3	104	0	0	0	0	40	-4581	-4541	3031	-182	2849	0	-1589
	4	865	0	0	-42	0	182	-3031	-2849	0	0	0	0	-2026
	All	24082	52541	-25681	-1450	-19369	1423	-22651	-21228	22651	-1423	21228	-38740	-8617
*2050	1	25564	46296	-26483	-2013	-15350	0	0	0	15198	-1279	13920	-41950	-16
	2	13451	2682	-811	-417	-4019	1279	-15198	-13920	3364	-143	3221	0	187
	3	200	0	0	0	0	180	-3123	-2943	2288	-383	1905	0	-838
	4	1628	0	0	-80	0	300	-2423	-2123	0	0	0	0	-575
	All	40843	48978	-27294	-2510	-19369	1759	-20744	-18985	20851	-1805	19046	-41950	-1242

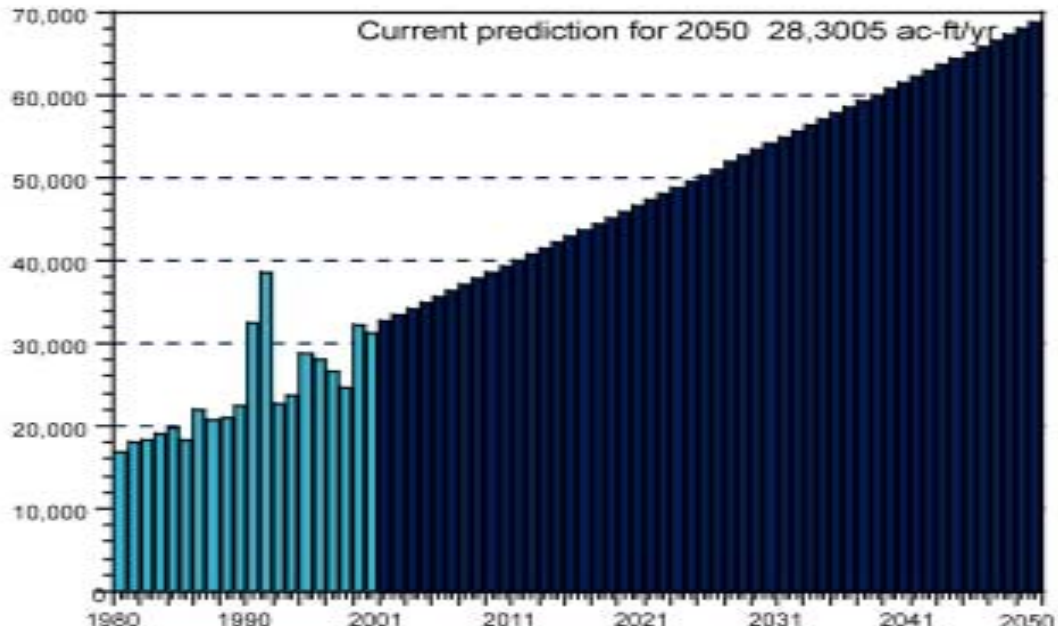
*2050 predictive run with average recharge

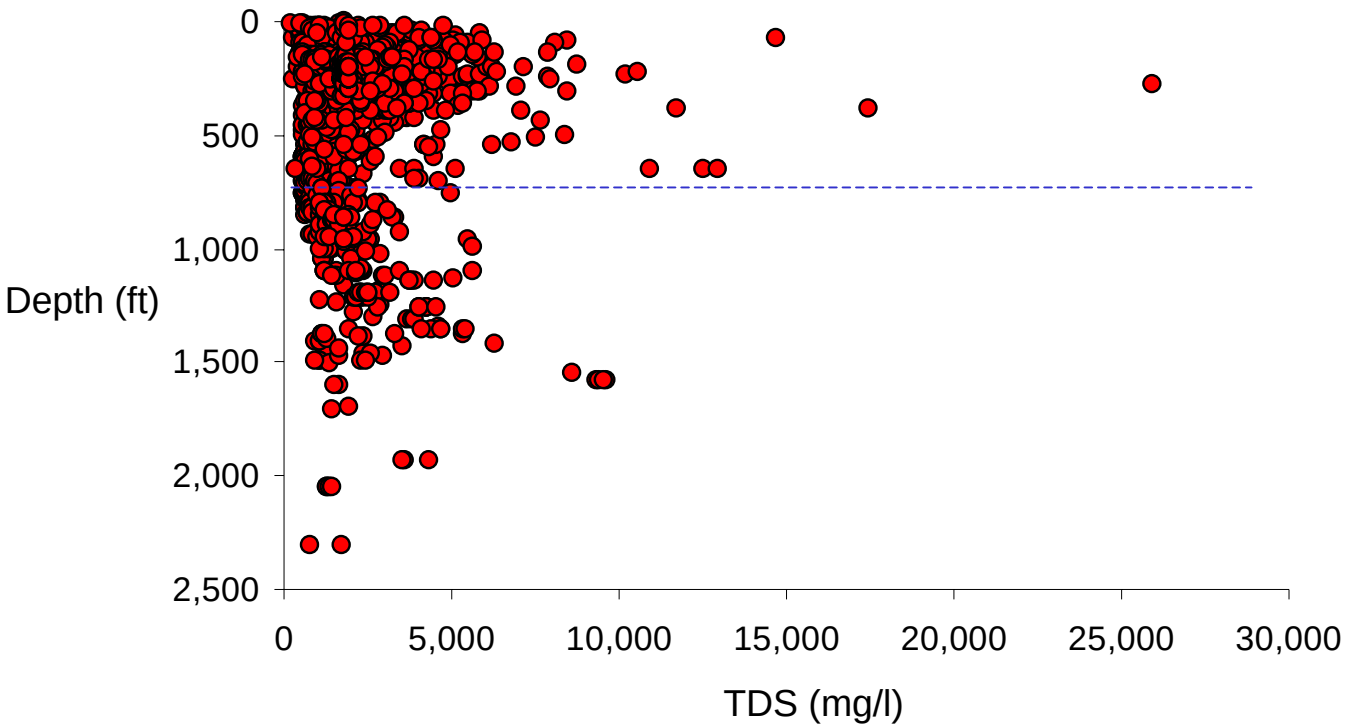
A positive sign indicates additions to the aquifer and negative sign indicates removal from it. Storage declines from 1999 to 2010 due to drought-of-record recharge. Storage slowly recovers throughout 2010-2050 due to steady pumping. Numbers presented represent fluxes for the specified year.

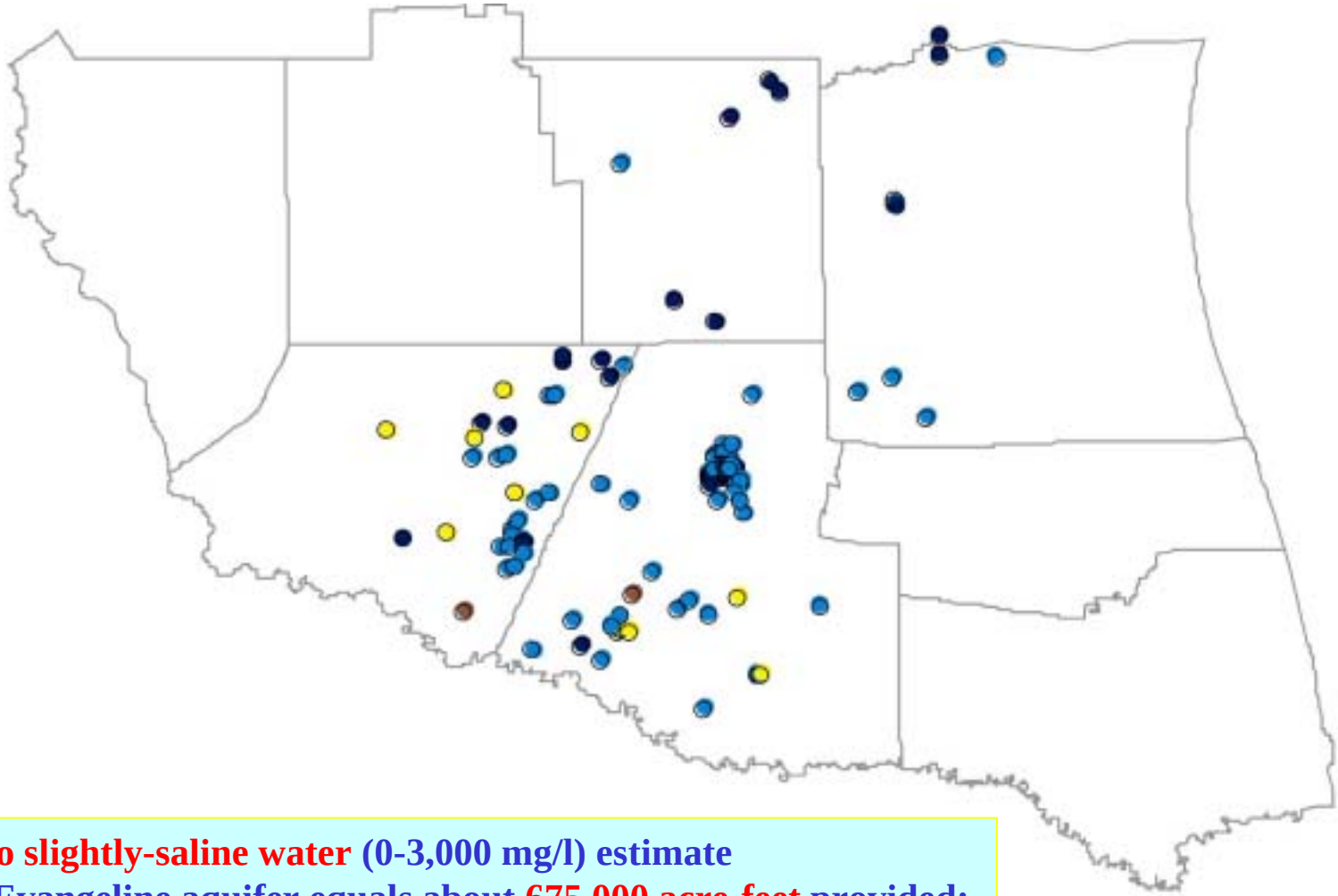
(a)


y = 7.3490E+02x - 1.4378E+06
R² = 5.3334E-01
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1980
1985
1990
1995
2000

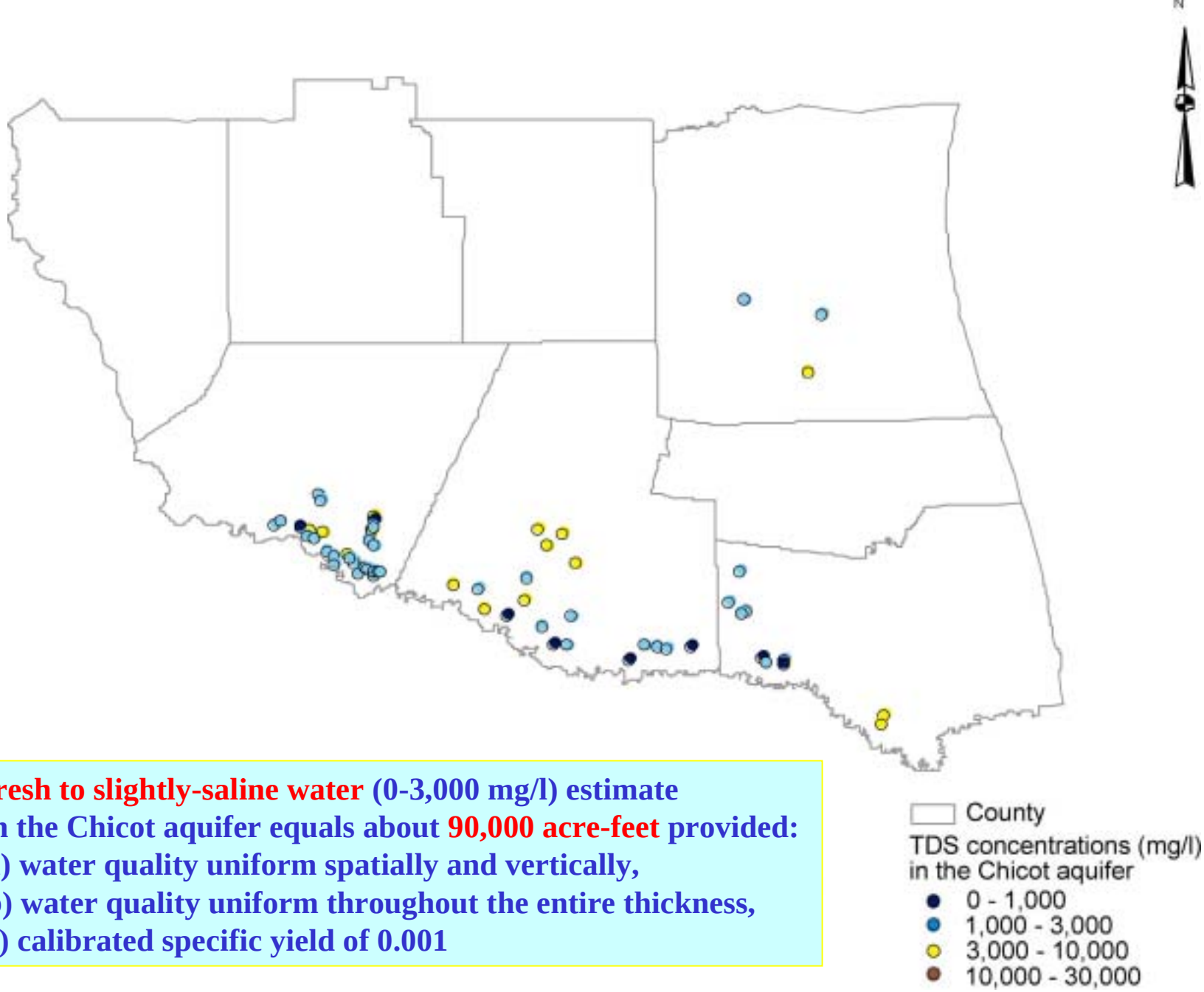
(b)


Current prediction for 2050 28,3005 ac-ft/yr
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1980
1990
2001
2011
2021
2031
2041
2050


0
500
1,000
1,500
2,000
2,500
Depth (ft)
0
5,000
10,000
15,000
20,000
25,000
30,000
TDS (mg/l)



Fresh to slightly-saline water (0-3,000 mg/l) estimate in the Evangeline aquifer equals about 675,000 acre-feet provided:
(a) water quality uniform spatially and vertically,
(b) water quality uniform throughout the entire thickness,
(c) calibrated specific yield of 0.001



Fresh to slightly-saline water (0-3,000 mg/l) estimate in the Chicot aquifer equals about 90,000 acre-feet provided:
(a) water quality uniform spatially and vertically,
(b) water quality uniform throughout the entire thickness,
(c) calibrated specific yield of 0.001

Conclusions

- Developed a groundwater availability model for the southern gulf coast aquifer

- RMSE error 23 feet (4.4% of head drop across the model area)

- Total volume of recharge from rainfall about 42,000 acre-ft/yr
  - Nearly 2/3rd enter through the Chicot outcrop

- Recharge from leakage of the Rio Grande and the Arroyo Colorado.
  - 45,000 acre-ft/yr
  - Supported by water quality and isotopic data

- Water in storage declines from –1297 acre-ft/yr in 1991 to –4774 acre-ft/yr in 1999.
  - Storage rebounds due to decreased pumpage by 2010
  - No significant changes in storage through 2050.

- Sensitivity analysis
  - Model sensitive to recharge and horizontal hydraulic conductivity of the Chicot and the Evangeline aquifers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