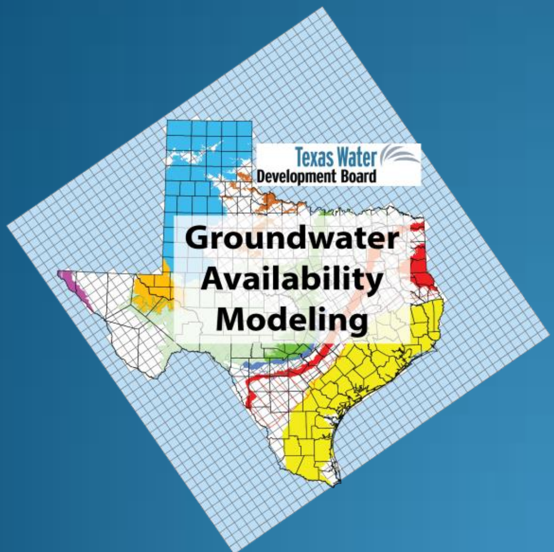
Llano Uplift Minor Aquifers GAM Stakeholder Advisory Forum Number 3



Groundwater Availability Modeling
Texas Water Development Board

Hill Country University Center
Fredericksburg, Texas

March 16, 2016

Disclaimer

The following presentation is based upon professional research and analysis within the scope of the Texas Water Development Board's statutory responsibilities and priorities but, unless specifically noted, does not necessarily reflect official Board positions or decisions.

Introduction of Groundwater Availability Modeling (GAM) Program in Texas Water Development Board (TWDB)

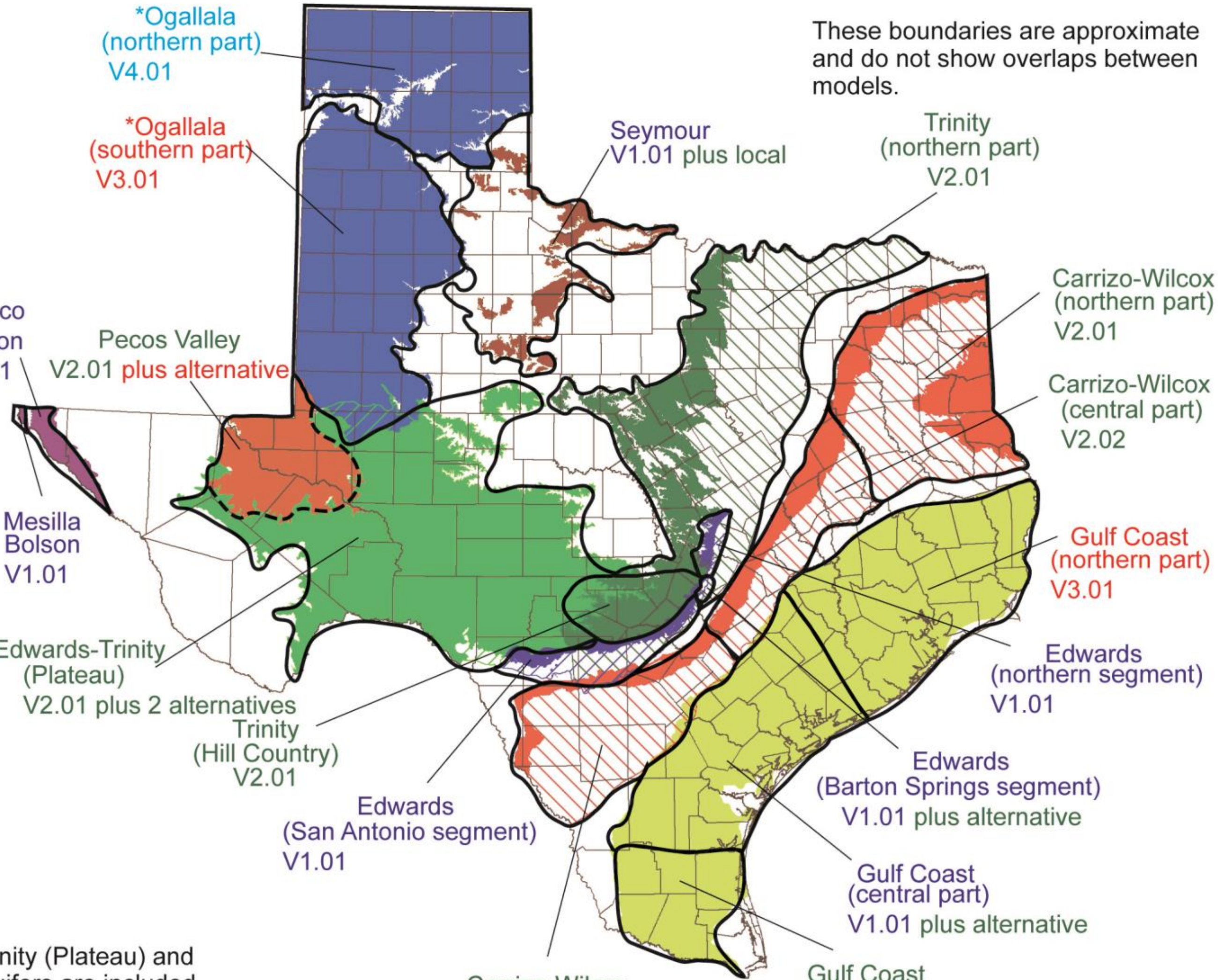
Jerry Shi, Ph.D., P.G.
Groundwater Availability Modeling
Texas Water Development Board

Hill Country University Center
Fredericksburg, Texas
March 16, 2016

Groundwater Availability Modeling Program

- **Aim**: Develop groundwater flow models for the major and minor aquifers of Texas.
- **Purpose**: Tools that can be used to aid in groundwater resources management by stakeholders.
- **Public process**: Stakeholder involvement during model development process.
- **Models**: Freely available, standardized, thoroughly documented. Reports available over the internet.
- **Living tools**: Periodically updated.

Major Aquifers

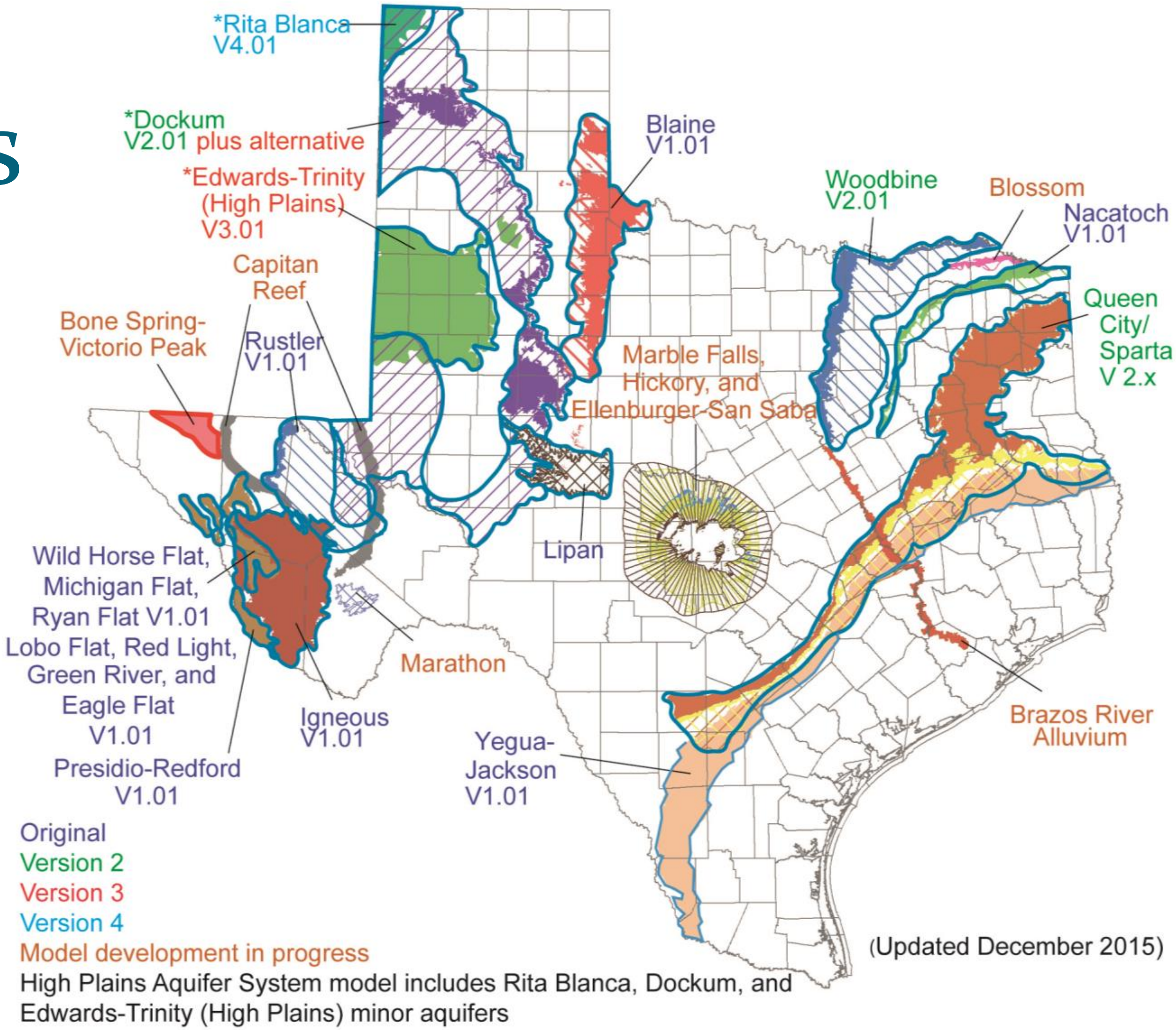


Original
Version 2
Version 3
Version 4

Note:
The Edwards-Trinity (Plateau) and Pecos Valley aquifers are included in the same model.
*Ogallala now combined in High Plains Aquifer System model

Updated December 2015

Minor Aquifers



How we use Groundwater Models?

- Provide groundwater conservation districts with water budget data for their management plans.
- Groundwater management areas can use to assist in determining desired future conditions.
- Calculating estimated Modeled Available Groundwater.
- Calculating Total Estimated Recoverable Storage.

Stakeholder Advisory Forums

- Keep stakeholders updated about progress of the model
- Inform how the groundwater model can, should, and should not be used
- Provide stakeholders with the opportunity to provide input and data to assist with model development

Contact Information

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Llano Uplift Minor Aquifers Numerical Flow Model

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Texas Water Development Board

And

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Independent Groundwater Consultant

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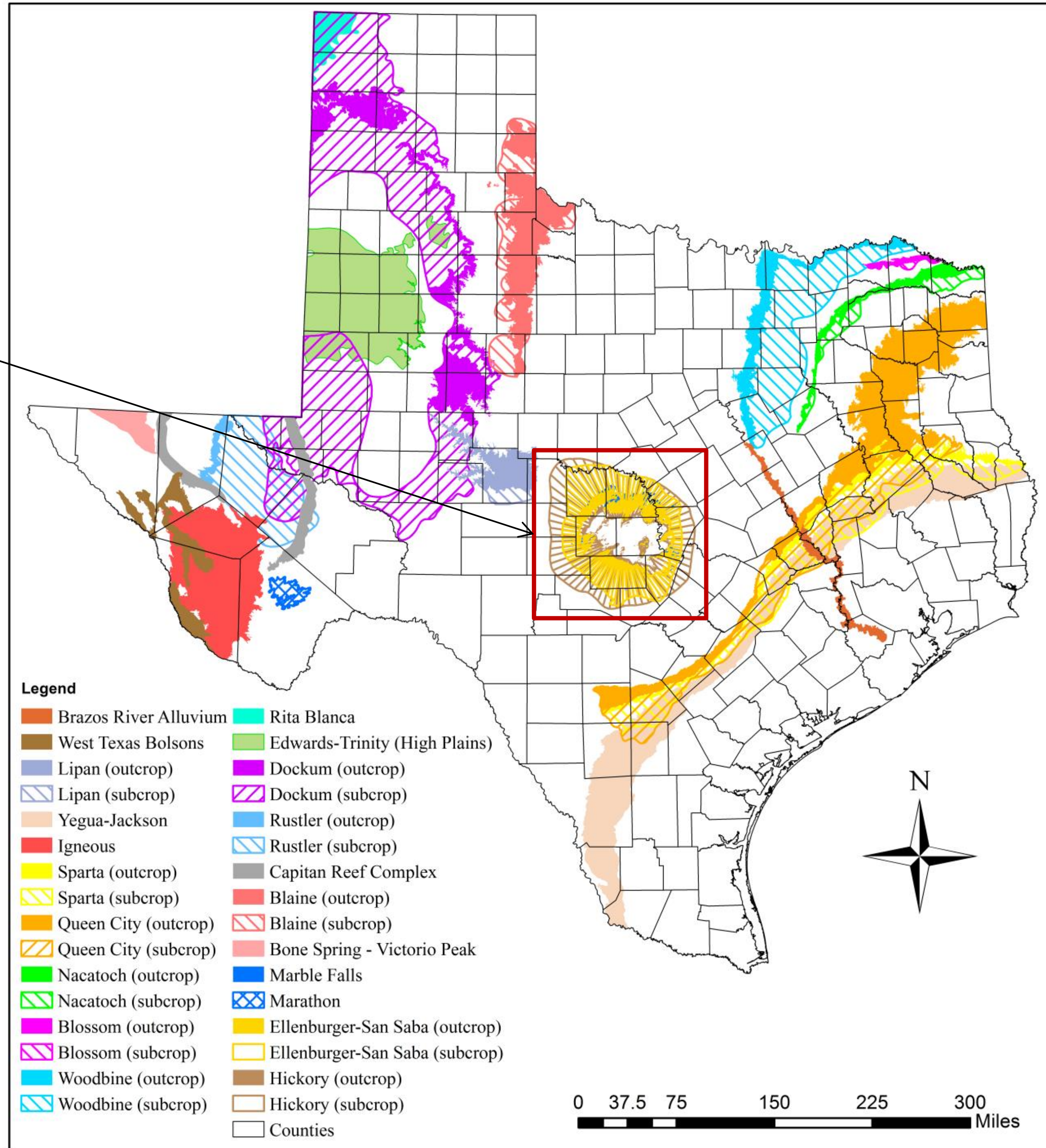
Fredericksburg, Texas
March 16, 2016

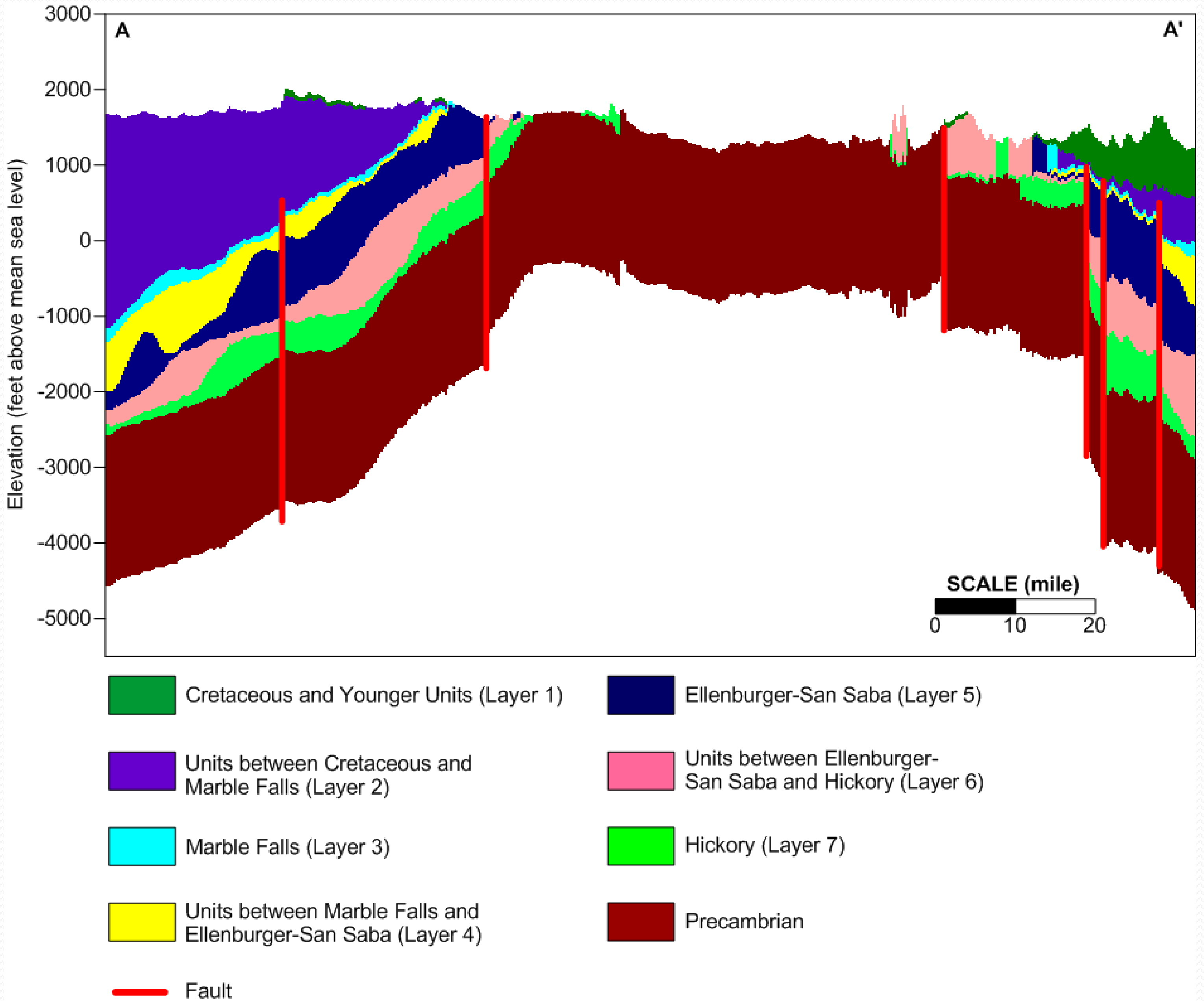
Outline

- Overview of Llano Uplift Minor Aquifers
- Numerical model
- Project schedule

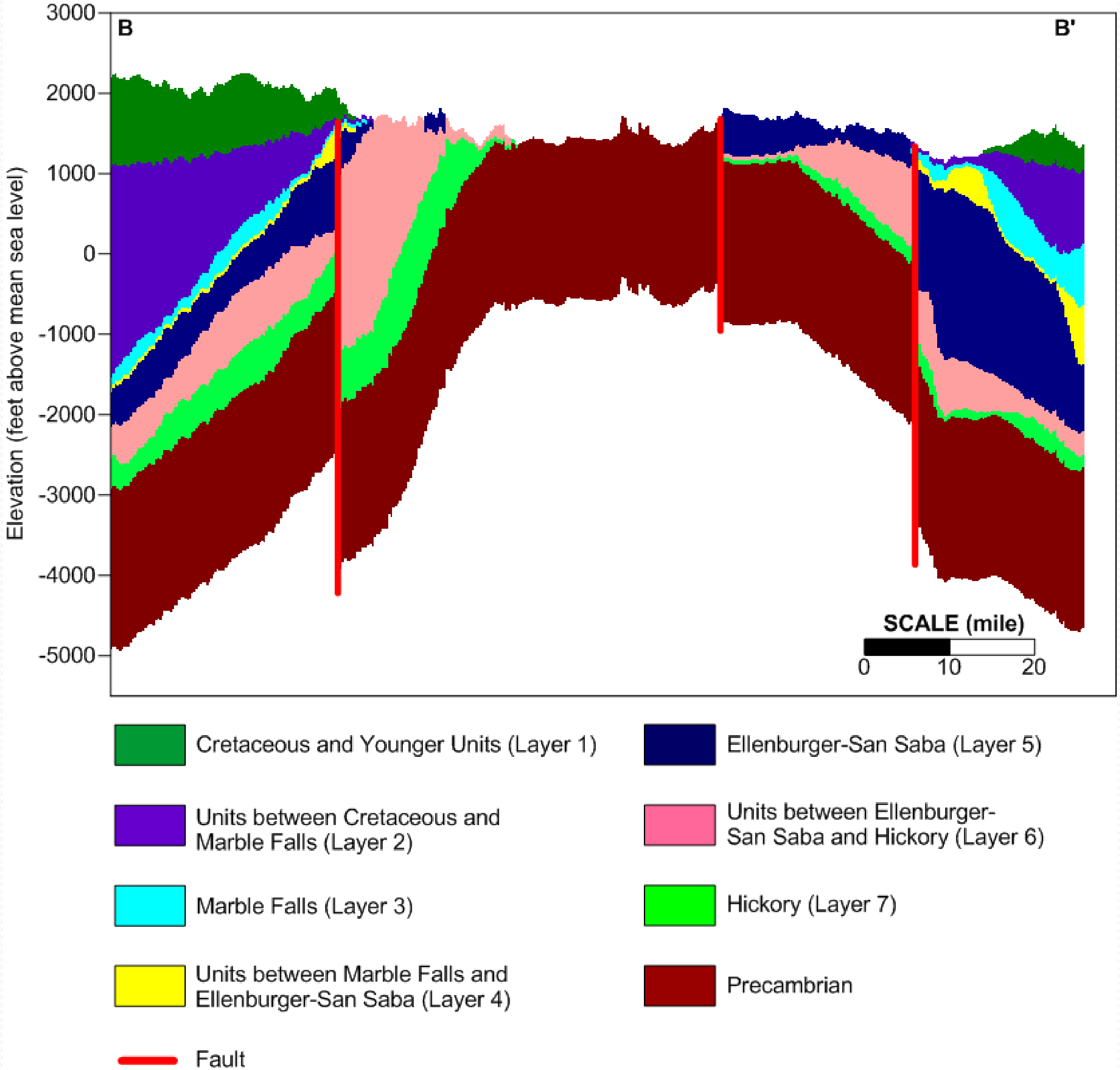
Study Area


Legend
Brazos River Alluvium
West Texas Bolsons
Lipan (outcrop)
Lipan (subcrop)
Yegua-Jackson
Igneous
Sparta (outcrop)
Sparta (subcrop)
Queen City (outcrop)
Queen City (subcrop)
Nacatoch (outcrop)
Nacatoch (subcrop)
Blossom (outcrop)
Blossom (subcrop)
Woodbine (outcrop)
Woodbine (subcrop)
Rita Blanca
Edwards-Trinity (High Plains)
Dockum (outcrop)
Dockum (subcrop)
Rustler (outcrop)
Rustler (subcrop)
Capitan Reef Complex
Blaine (outcrop)
Blaine (subcrop)
Bone Spring - Victorio Peak
Marble Falls
Marathon
Ellenburger-San Saba (outcrop)
Ellenburger-San Saba (subcrop)
Hickory (outcrop)
Hickory (subcrop)
Counties
N
0 37.5 75 150 225 300
Miles

Northwest-Southeast Cross Section



Southwest-Northeast Cross Section

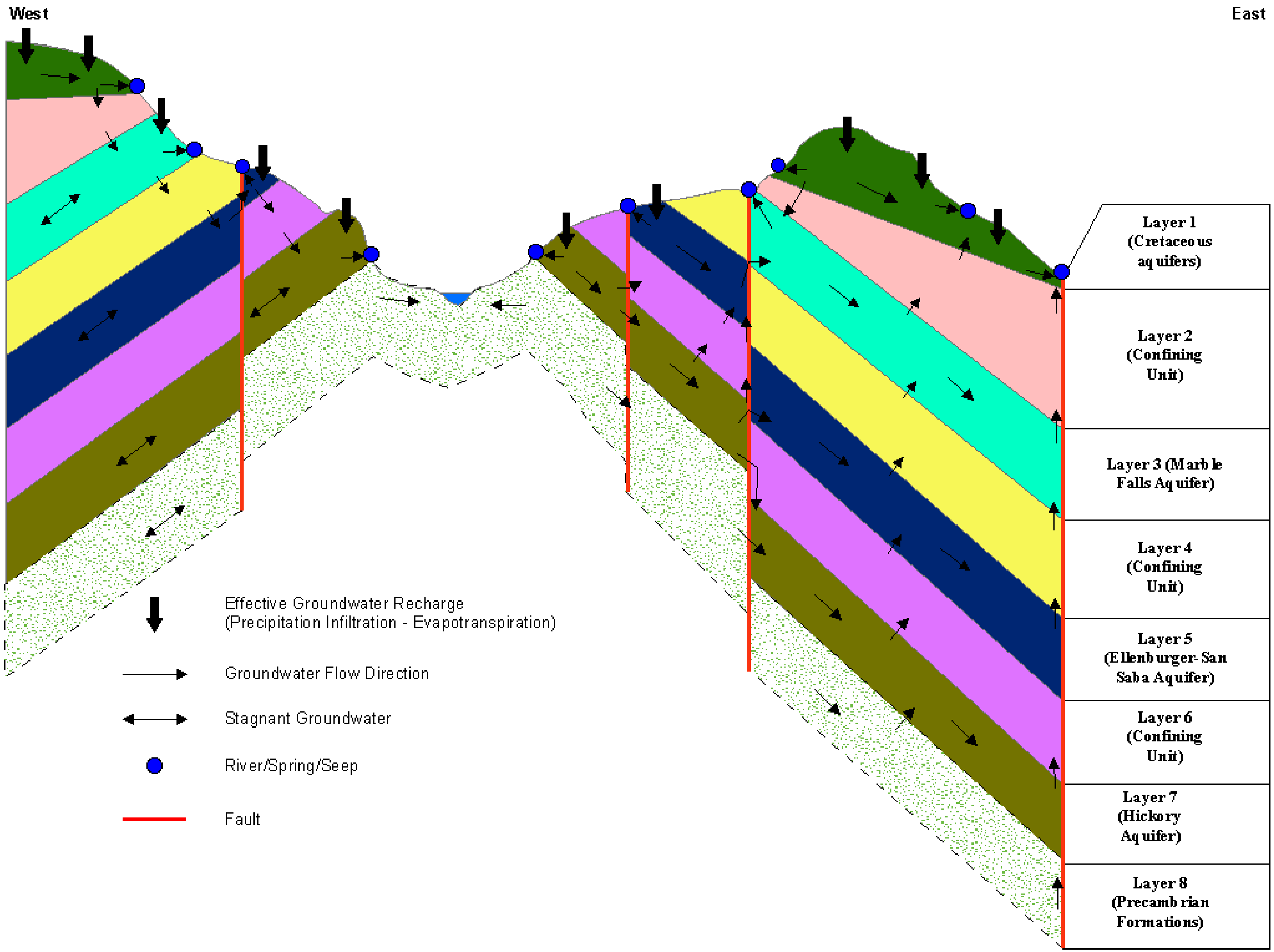


Geologic Units							Hydrogeologic Units
Era	System	North and East Study Area			South and West Study Area		
		Group	Formation	Member	Formation	Member	
Cenozoic	Quaternary	Loose sediments at river valley bottoms					Cretaceous Aquifer
Mesozoic	Cretaceous	Washita	Buda, Del Rio				
			Georgetown		Segovia (Edwards Group)		
			Kiamichi				
		Fredericksburg	Edwards		Fort Terrett (Edwards Group)		
			Comanche Peak				
			Walnut				
		Trinity	Antlers – Paluxy		Paluxy		
			Antlers – Glen Rose		Glen Rose		
			Antlers – Travis Peak – Hensell		Travis Peak – Hensell		
			Antlers – Travis Peak – Cow Creek/Hammett		Travis Peak – Cow Creek/ Hammett		
			Antlers – Travis Peak – Sycamore/Hosston		Travis Peak – Sycamore/ Hosston		
	Jurassic	Absent					
	Triassic	Absent					
Paleozoic	Permian	Wichita Albany	Undivided		Absent		
		Cisco	Undivided		Absent		
					Undivided		Confining Layer
	Pennsylvanian	Canyon	Undivided		Undivided		
		Strawn	Undivided		Undivided		
		Bend	Smithwick	Undivided	Smithwick	Undivided	
			Marble Falls	Undivided	Marble Falls	Undivided	Marble Falls Aquifer
	Mississippian		Barnett		Barnett		Confining Layer
			Chappel		Chappel		
	Devonian	Exists in collapses only					
	Silurian	Absent					
	Ordovician	Burnam	Exists in collapses only				
		Ellenburger	Honeycut	Undivided	Honeycut	Undivided	Ellenburger-San Saba Aquifer
			Gorman	Undivided	Gorman	Undivided	
			Tanyard	Staendebach	Tanyard	Staendebach	
				Threadgill		Threadgill	
	Cambrian	Moore Hollow	Wilberns	San Saba	Wilberns	San Saba	
				Point Peak		Point Peak	Confining Layer
				Morgan Creek		Morgan Creek	
				Welge		Welge	Welge-Lion Mountain Aquifer
			Riley	Lion Mountain	Riley	Lion Mountain	
				Cap Mountain		Cap Mountain	Confining Layer
				Hickory		Hickory	Hickory Aquifer

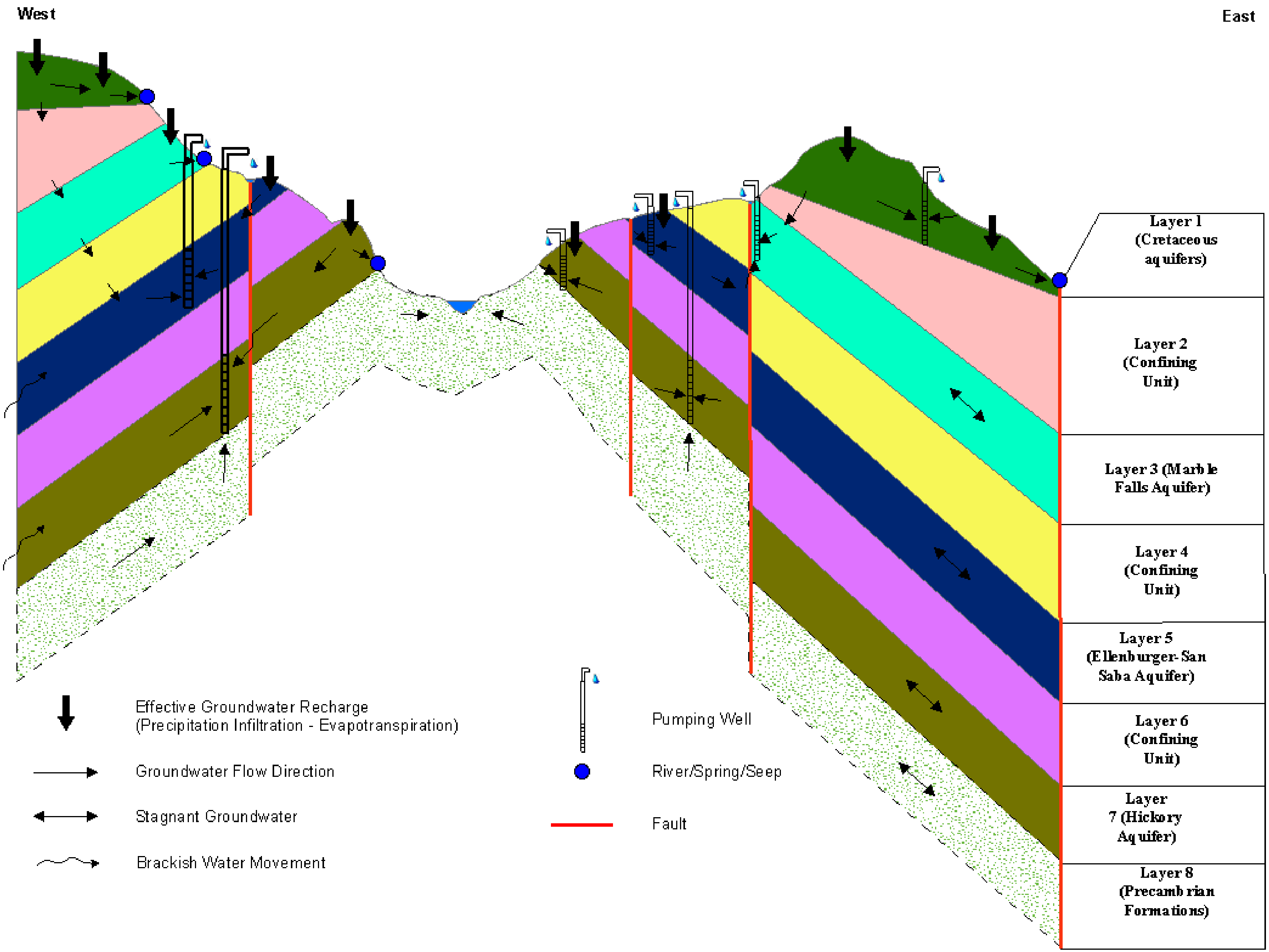
Model Stratigraphy and Layering

System	Group/Formation/Member	Aquifer/Confining Unit	Model Layer
Quaternary	Unclassified Alluvium	Alluvium Aquifer	1
Cretaceous	Edwards Group	Edwards – Trinity Aquifers	
	Trinity Group		
Permian and Pennsylvanian	Wichita Albany Group	Confining Units	2
	Cisco Group		
	Canyon Group		
	Strawn Group		
	Smithwick Formation		
	Marble Falls Formation	Marble Falls Aquifer	3
Mississippian	Barnett Formation	Confining Units	4
	Chappel Formation		
Ordovician	Ellenburger Group	Ellenburger-San Saba Aquifer	5
Cambrian	San Saba Member		
	Point Peak Member	Confining Units	6
	Morgan Creek Member		
	Welge Member		
	Lion Mountain		
	Cap Mountain		
	Hickory	Hickory Aquifer	7
Precambrian	Unclassified Rocks	Confining Units	8

Pre-development



Post-development



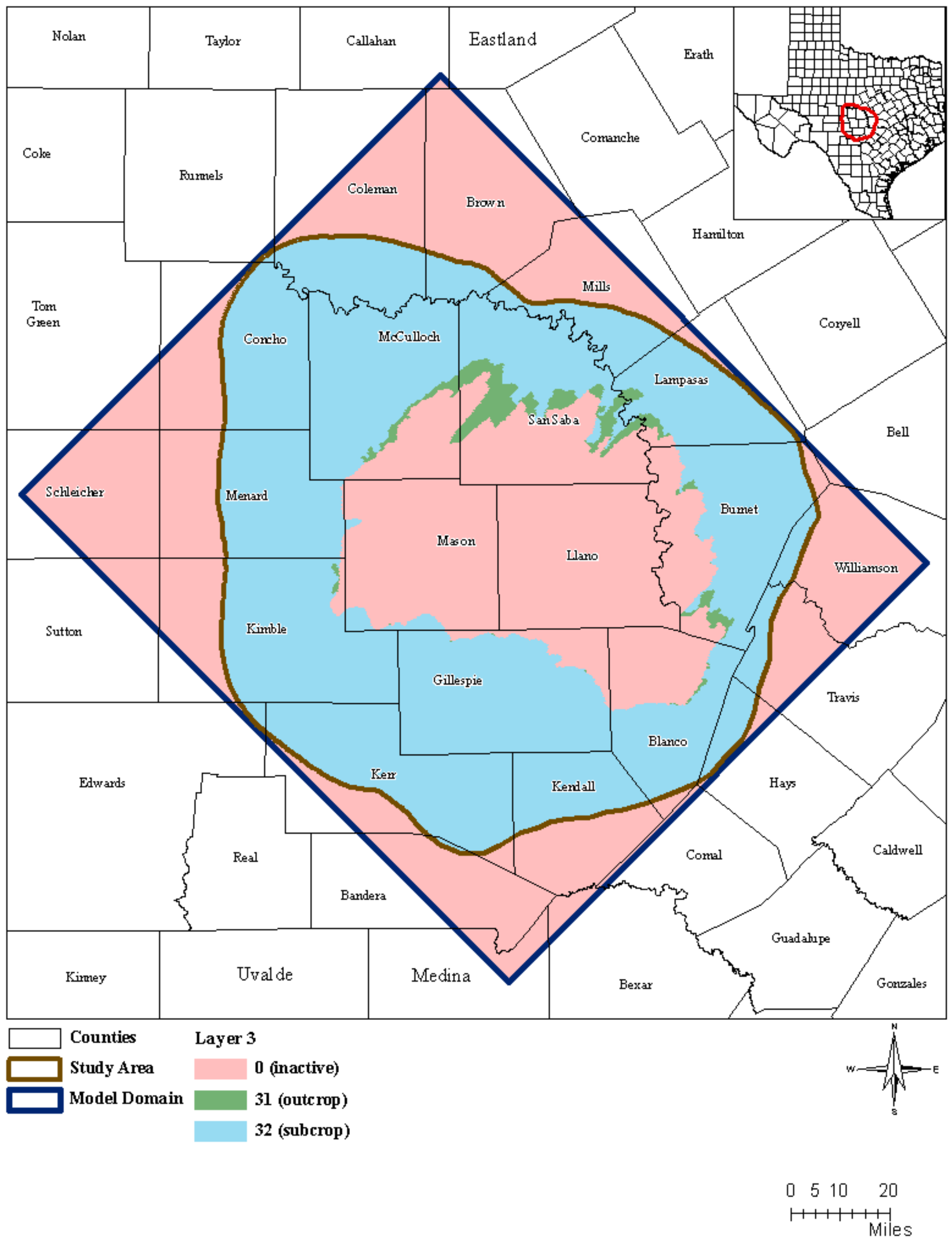
Model Inputs

Packages

File Type Abbreviation	File Type	Input File Name
BAS6	Basic Package	llano-uplift.bas
DISU	Unstructured Discretization File	llano-uplift.dis
DRN	Drain Package	llano-uplift.drn
GHB	General Head Package	llano-uplift.ghb
LPF	Layer-Property Flow Package	llano-uplift.lpf
OC	Output Control Option	llano-uplift.oc
RCH	Recharge Package	llano-uplift.rch
RIV	River Package	llano-uplift.riv
SMS	Sparse Matrix Solver Package	llano-uplift.sms
WEL	Well Package	llano-uplift.wel

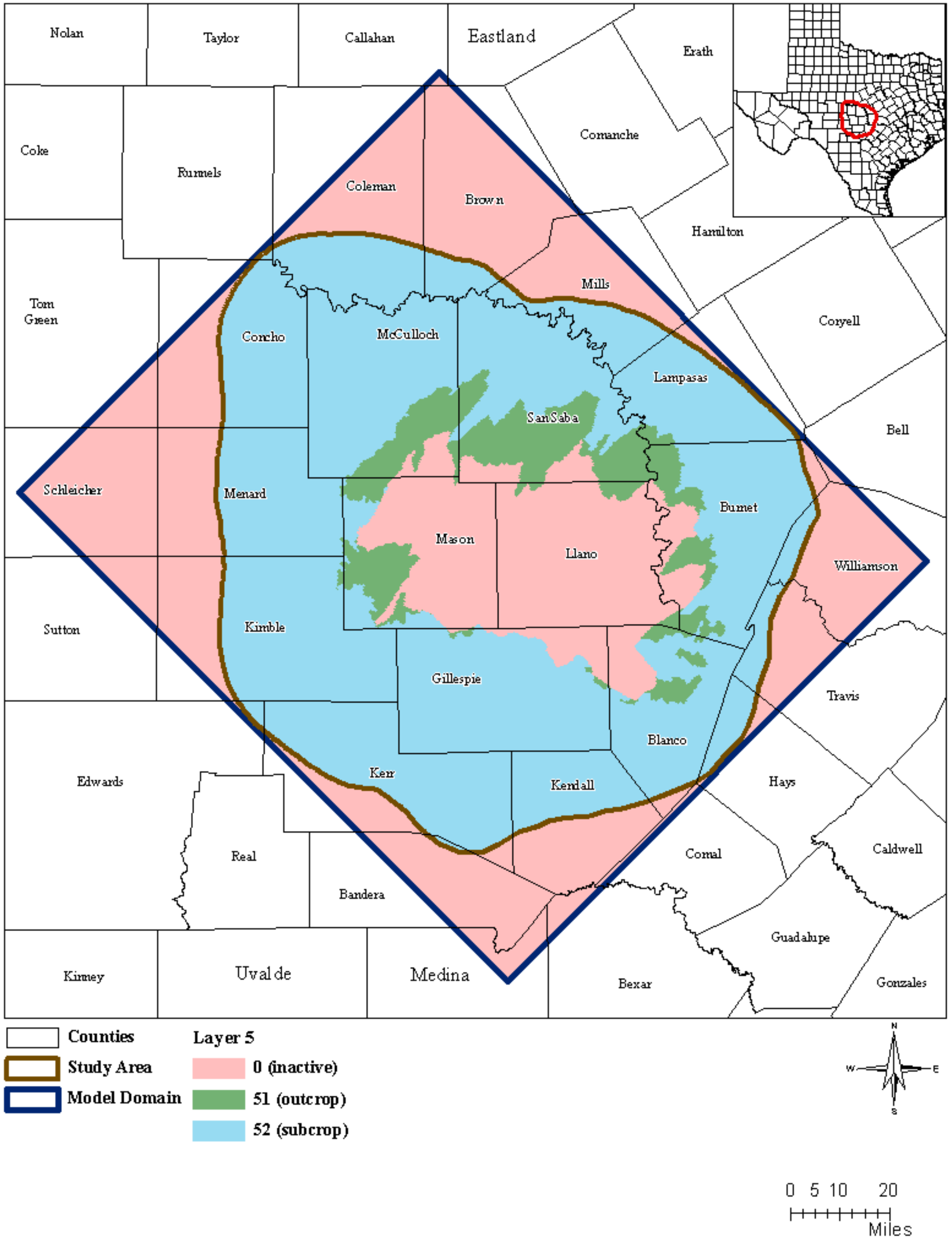
MODFLOW-USG Basic Package:

IBOUND (Marble Falls Aquifer/Unit)



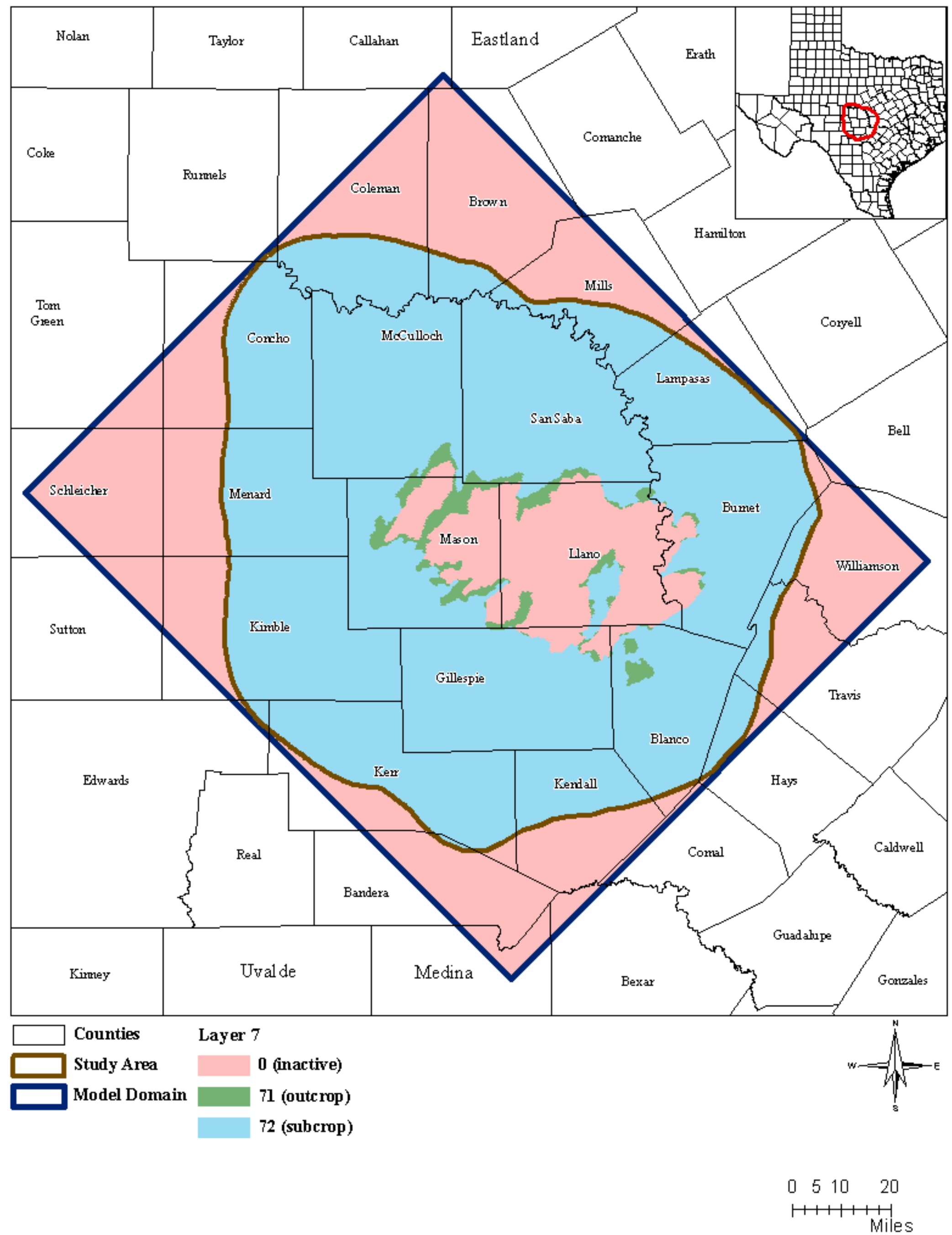
MODFLOW-USG Basic Package:

IBOUND (Ellenburger-San Saba Aquifer/Unit)



MODFLOW-USG Basic Package:

IBOUND (Hickory Aquifer/Uint)

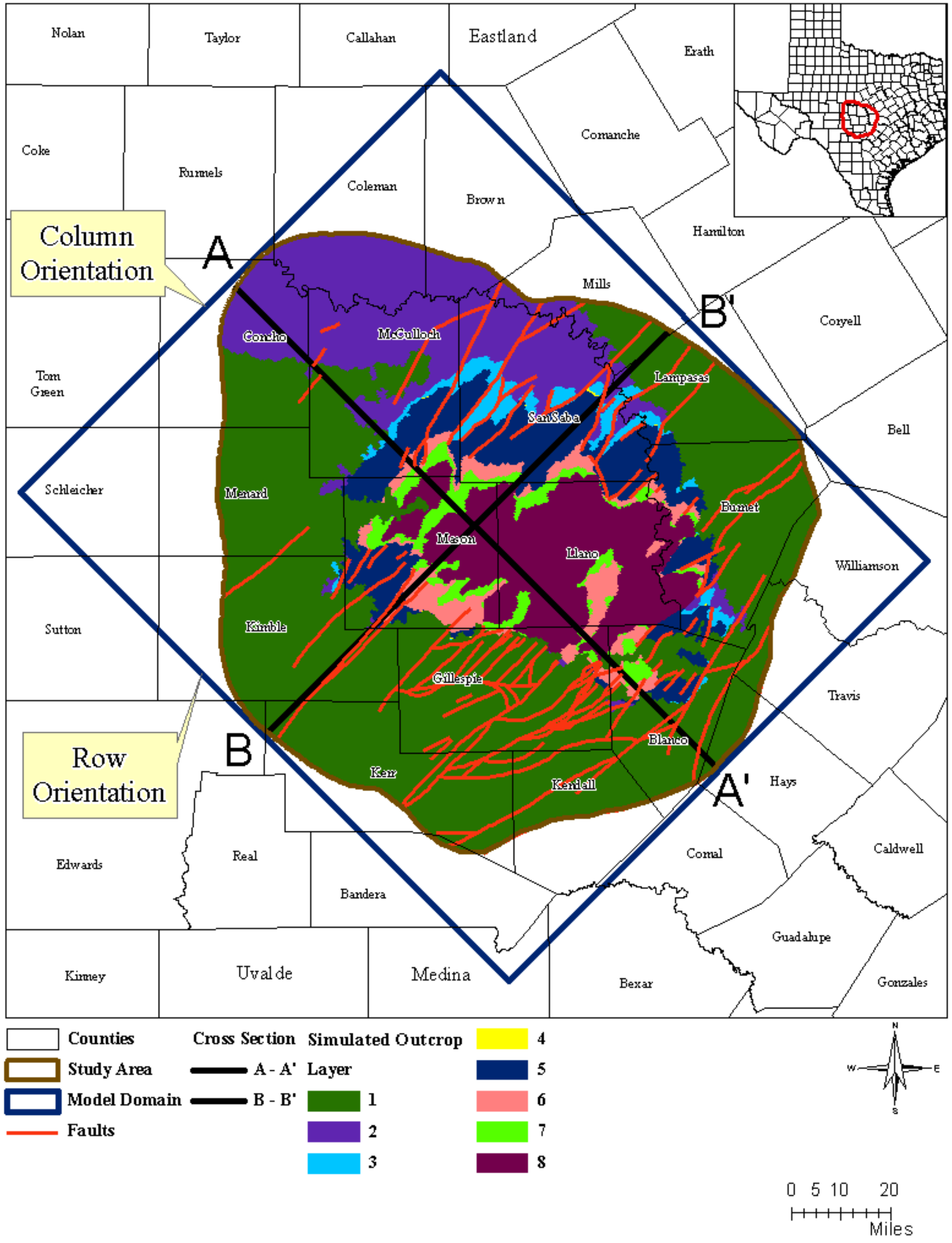


MODFLOW-USG Discretization Package

Simulation Period: 1980 through 2010

- 1980
  - steady state
  - stress period 1
- 1981 through 2010
  - Transient
  - stress periods 2 through 31

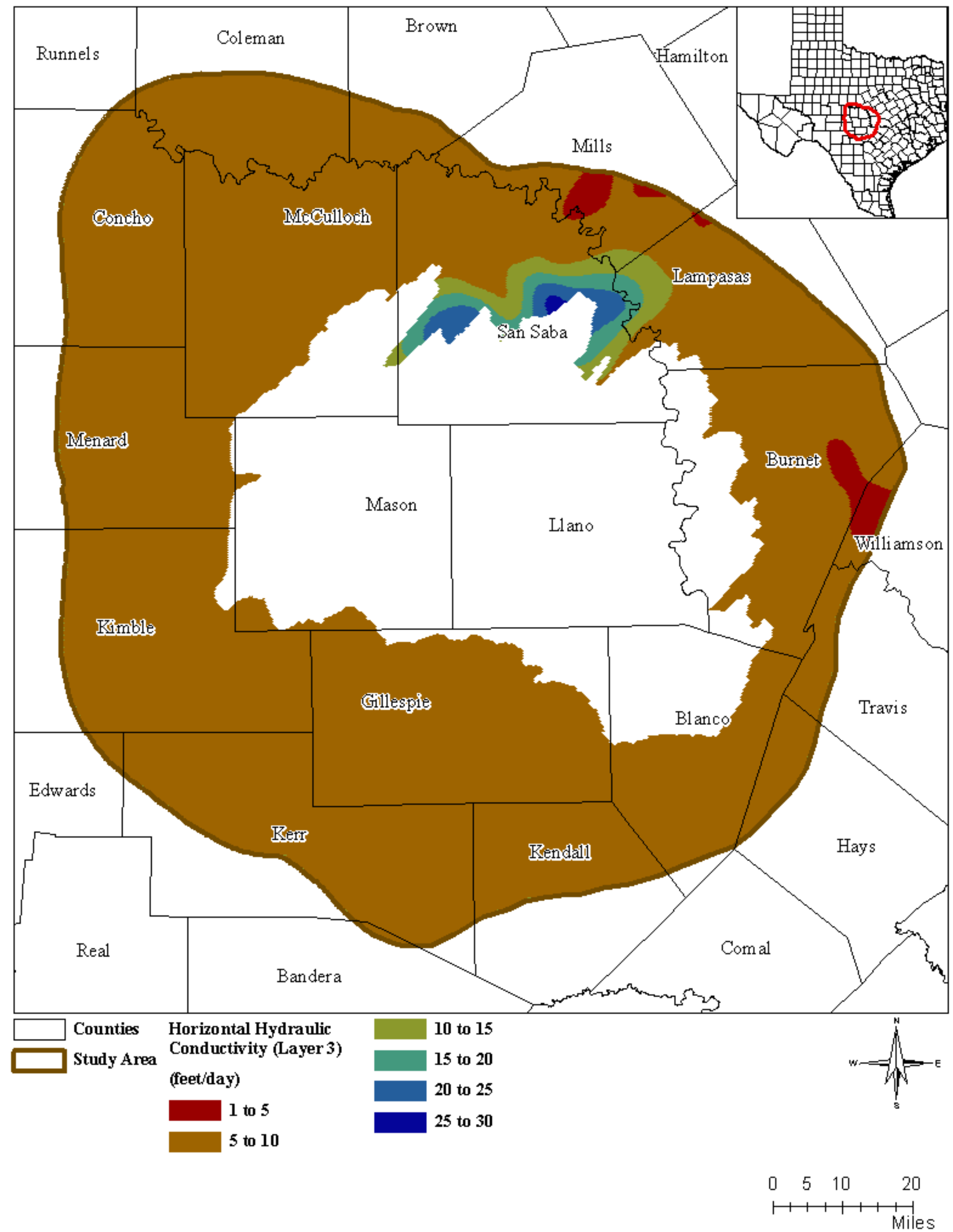
8 layers
478 rows
556 columns



MODFLOW-USG LPF Package:

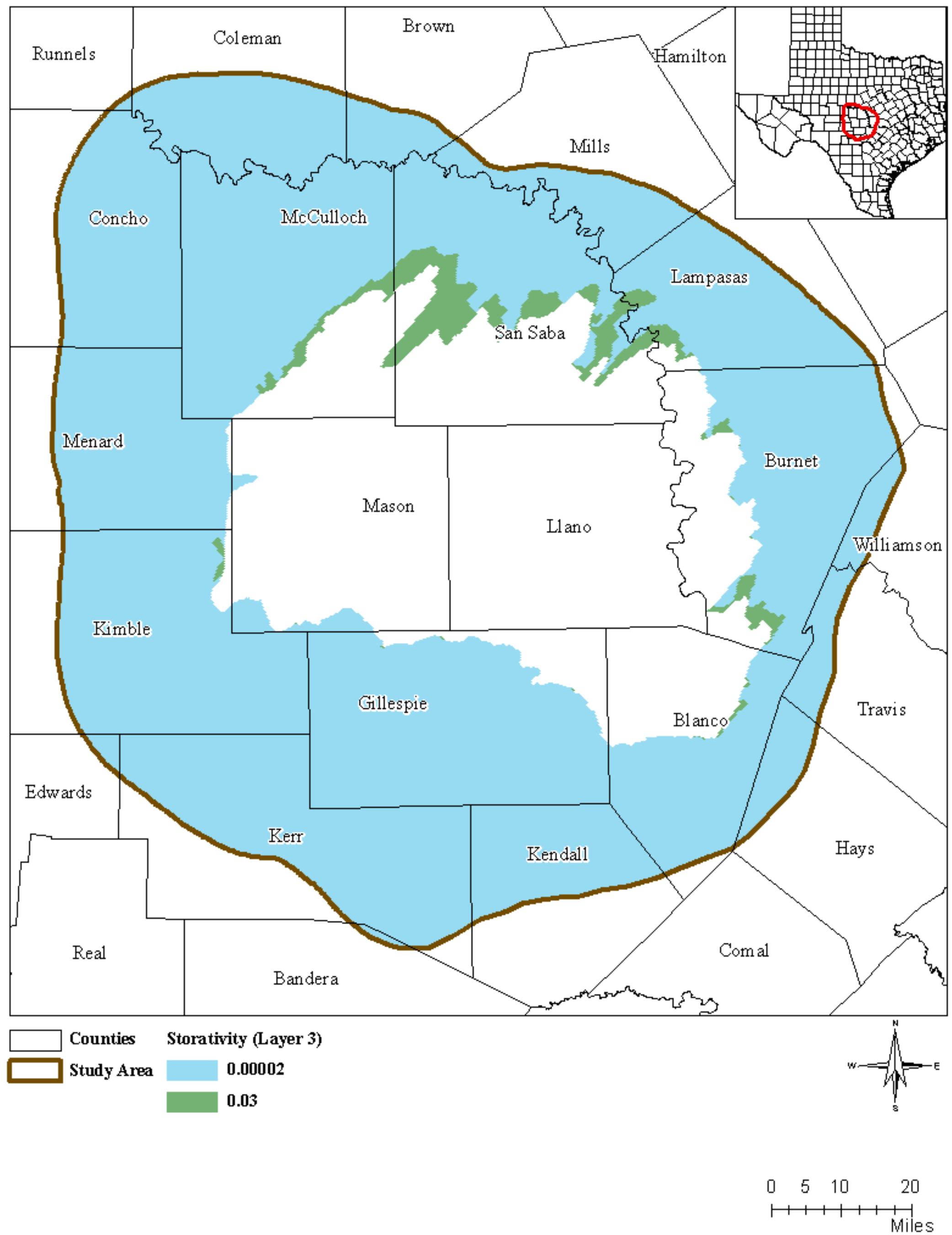
Horizontal Hydraulic Conductivity (Marble Falls Aquifer/Unit)

Vertical Anisotropy = 12.9



MODFLOW-USG LPF Package:

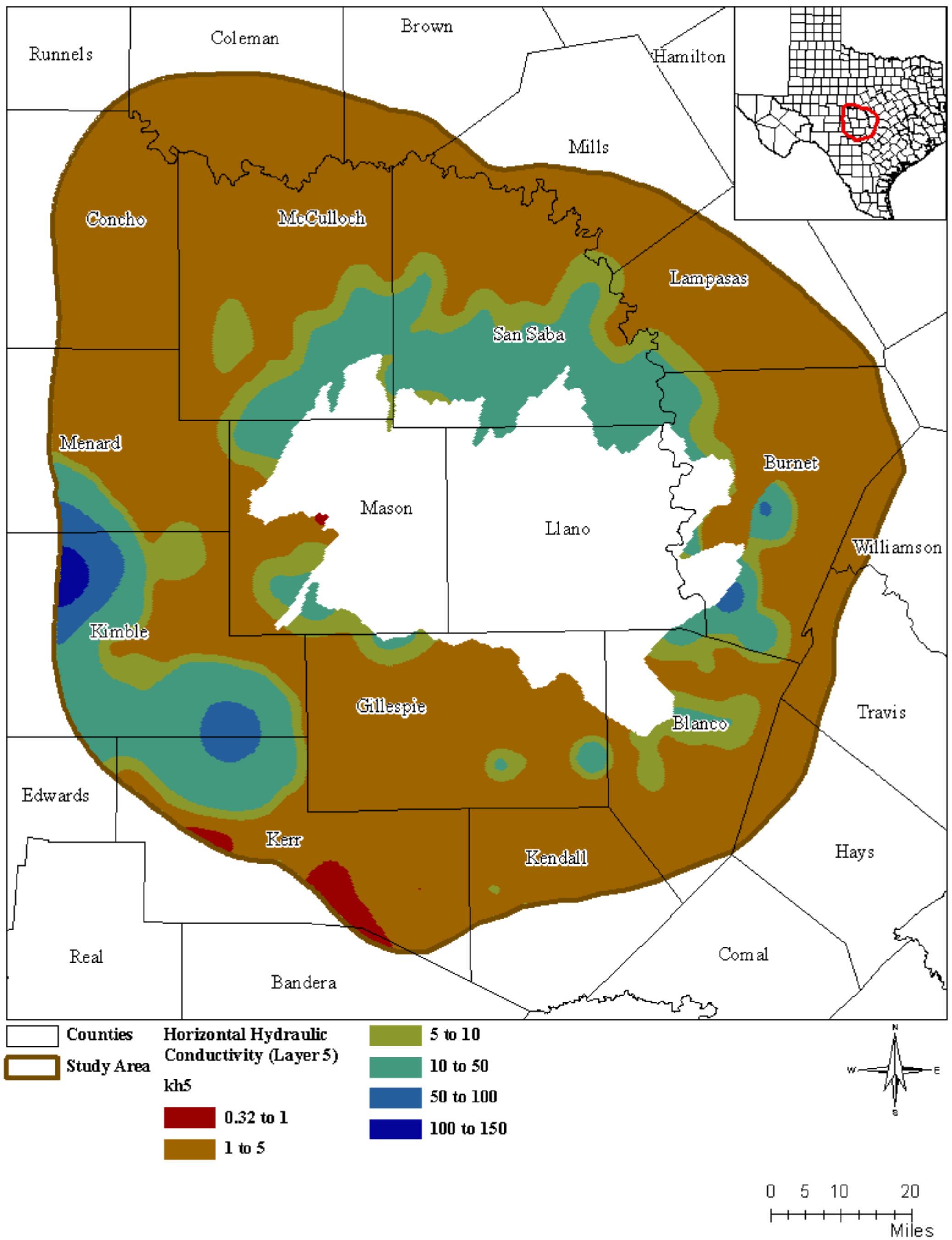
Storativity (Marble Falls Aquifer/Unit)



MODFLOW-USG LPF Package:

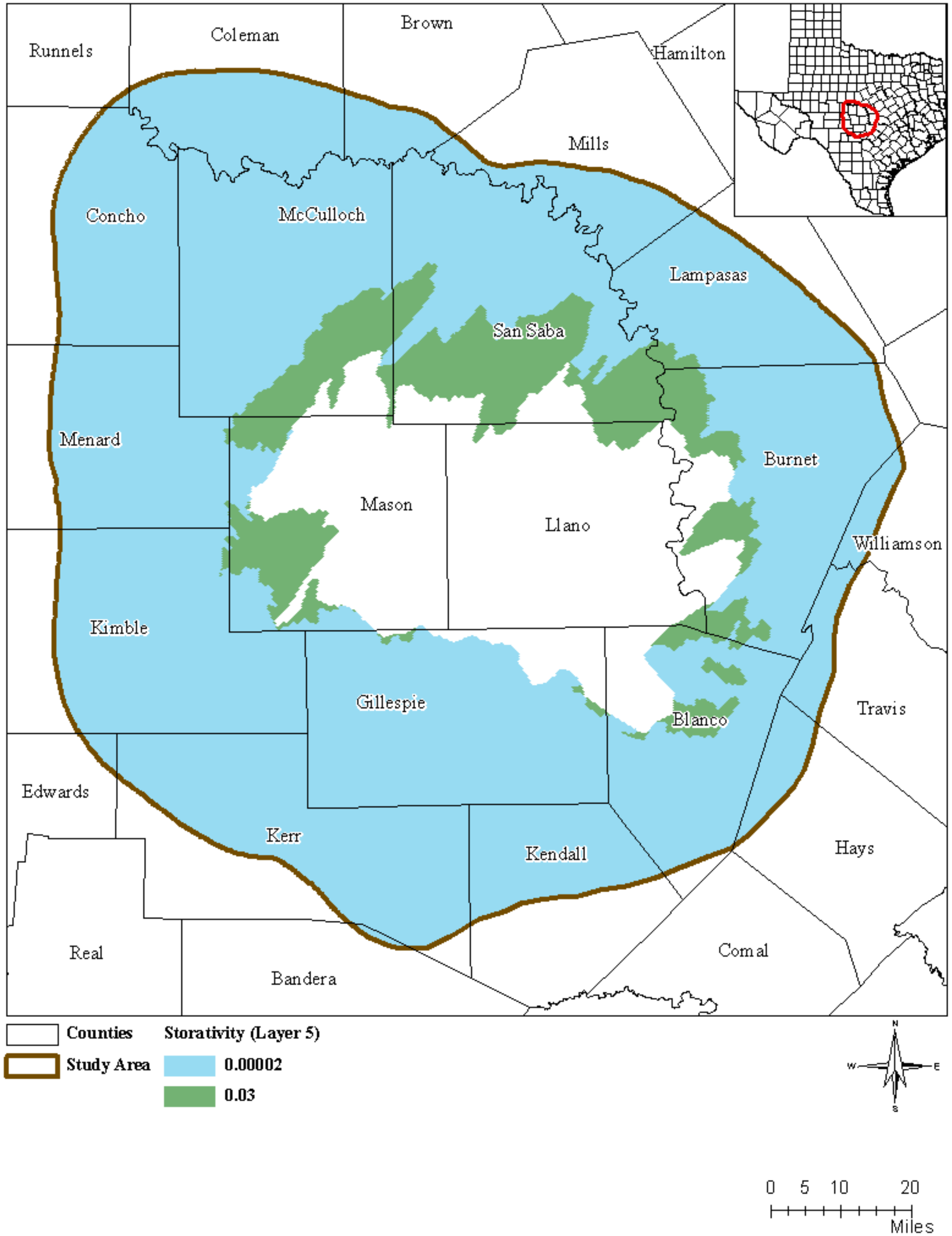
Horizontal Hydraulic Conductivity (Ellenburger-San Saba Aquifer/Unit)

Vertical Anisotropy = 7.6



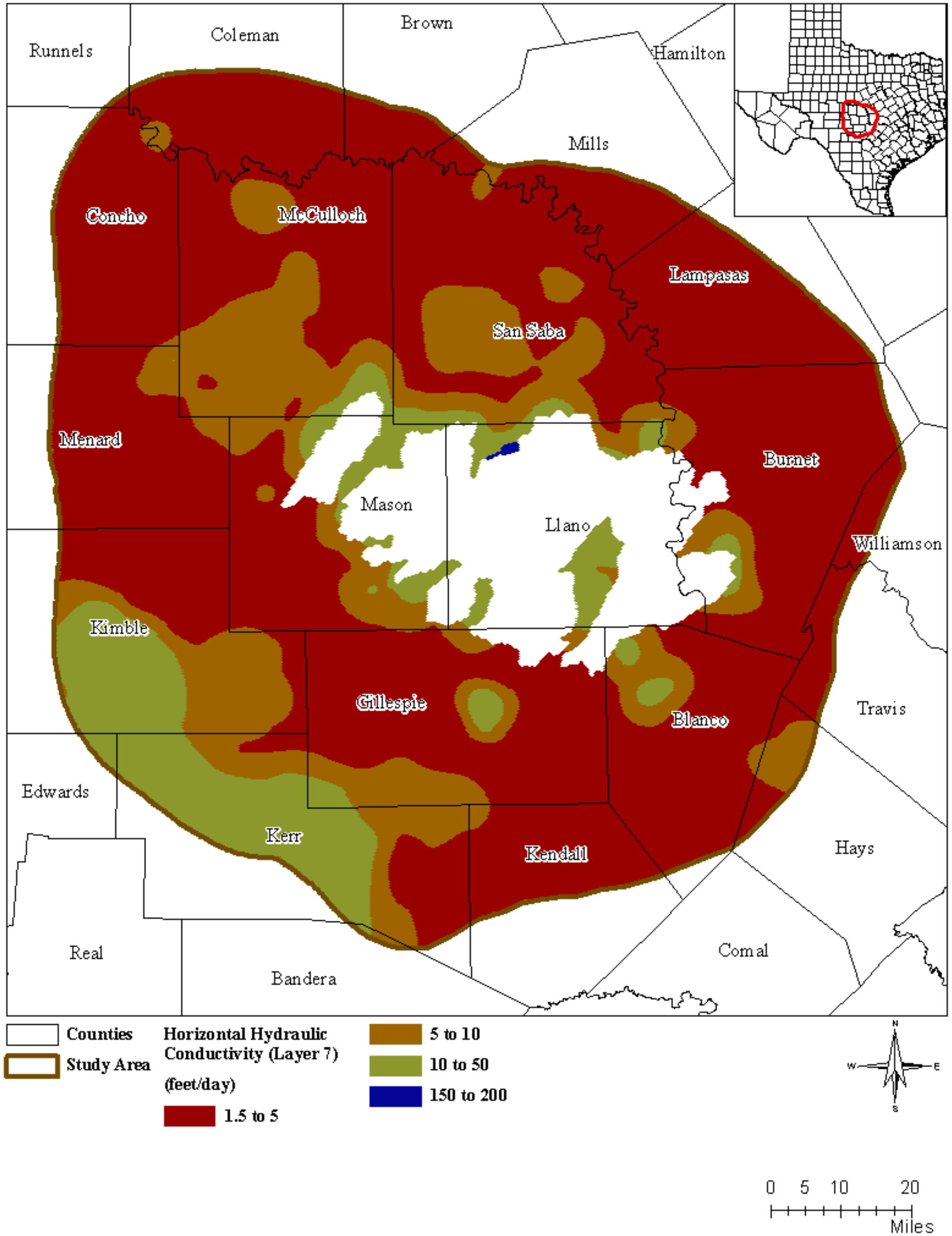
MODFLOW-USG LPF Package:

Storativity (Ellenburger-San Saba Aquifer/Unit)



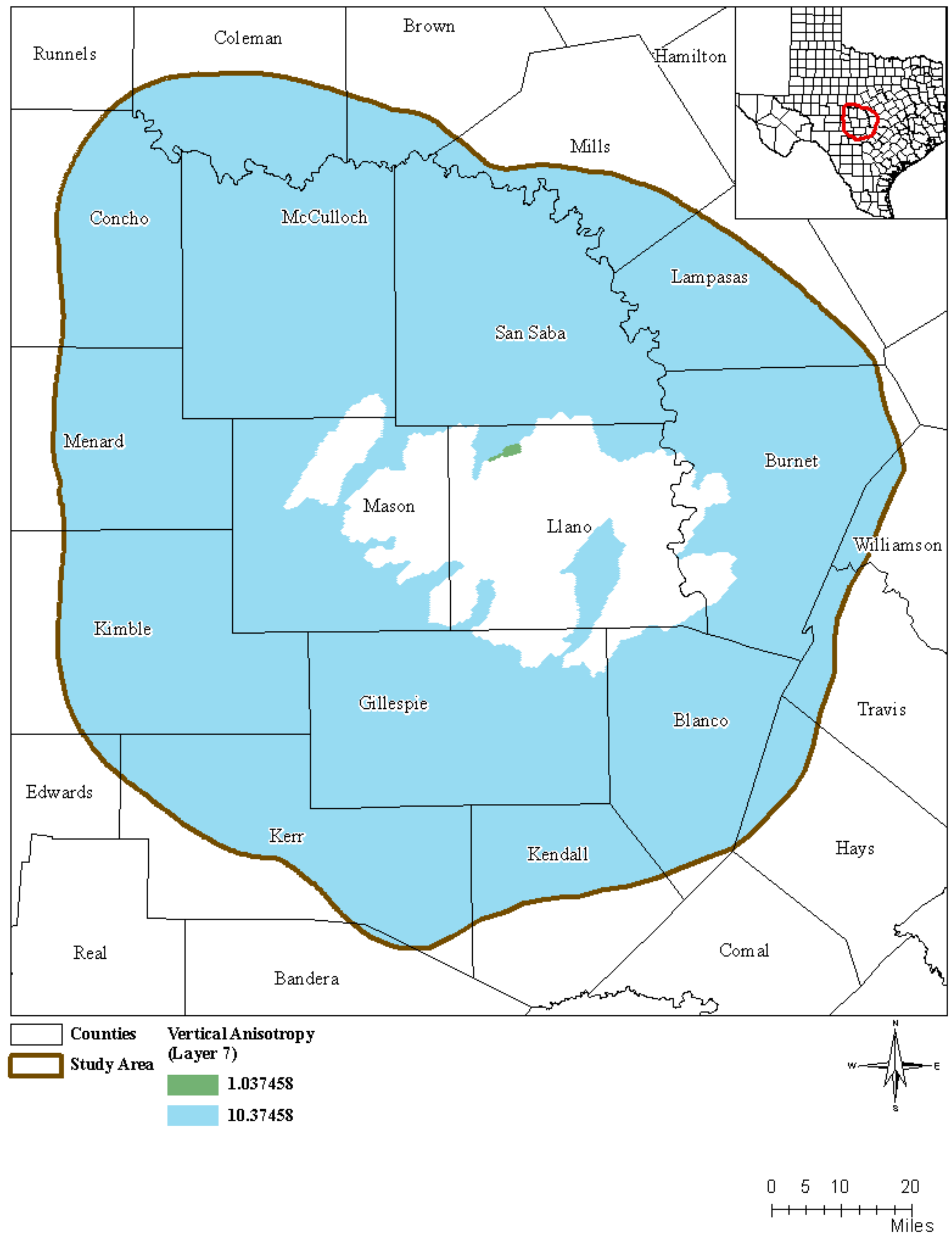
MODFLOW-USG LPF Package:

Horizontal Hydraulic Conductivity (Hickory Aquifer/Unit)



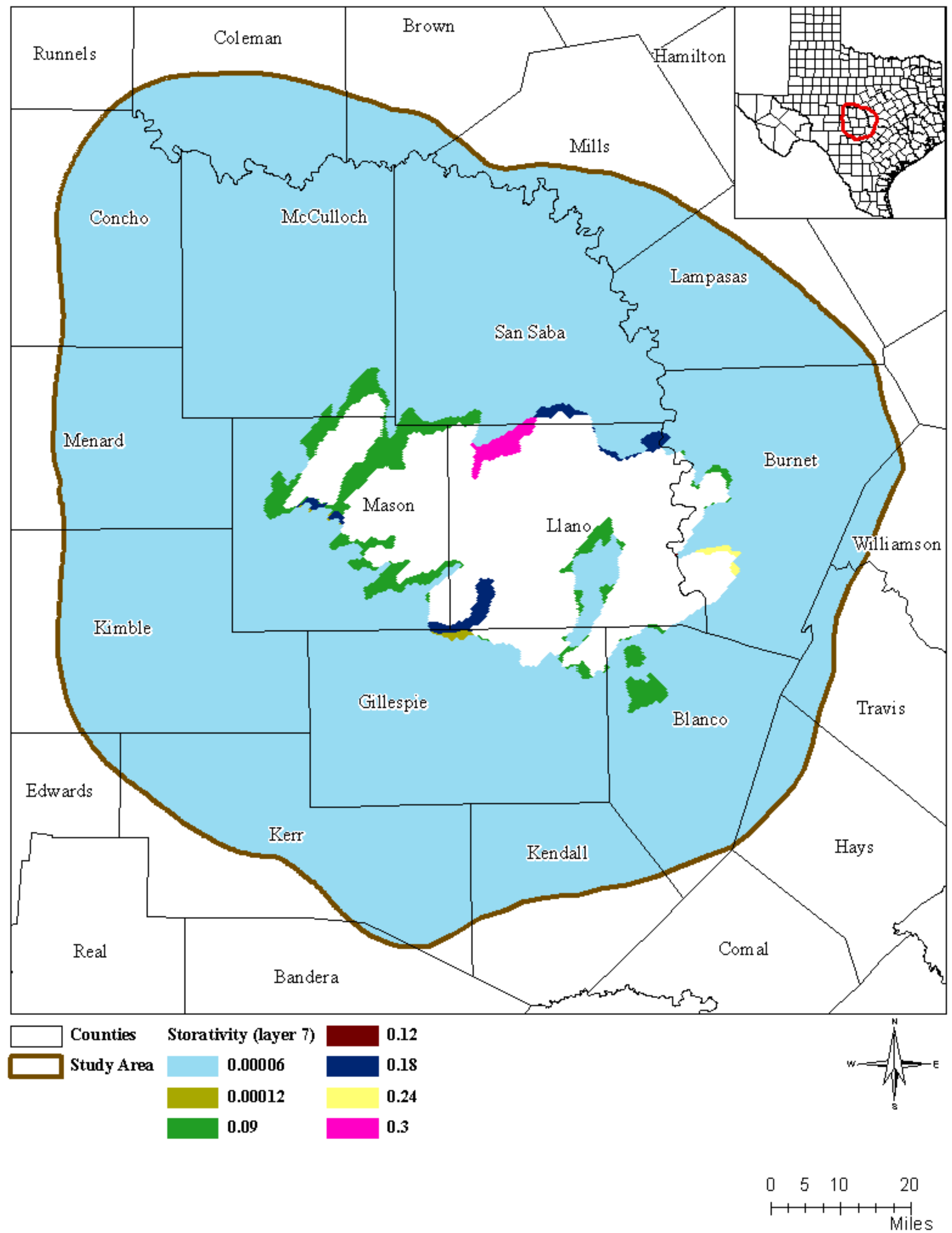
MODFLOW-USG LPF Package:

Vertical Anisotropy (Hickory Aquifer/Unit)



MODFLOW-USG LPF Package:

Storativity (Hickory Aquifer/Unit)

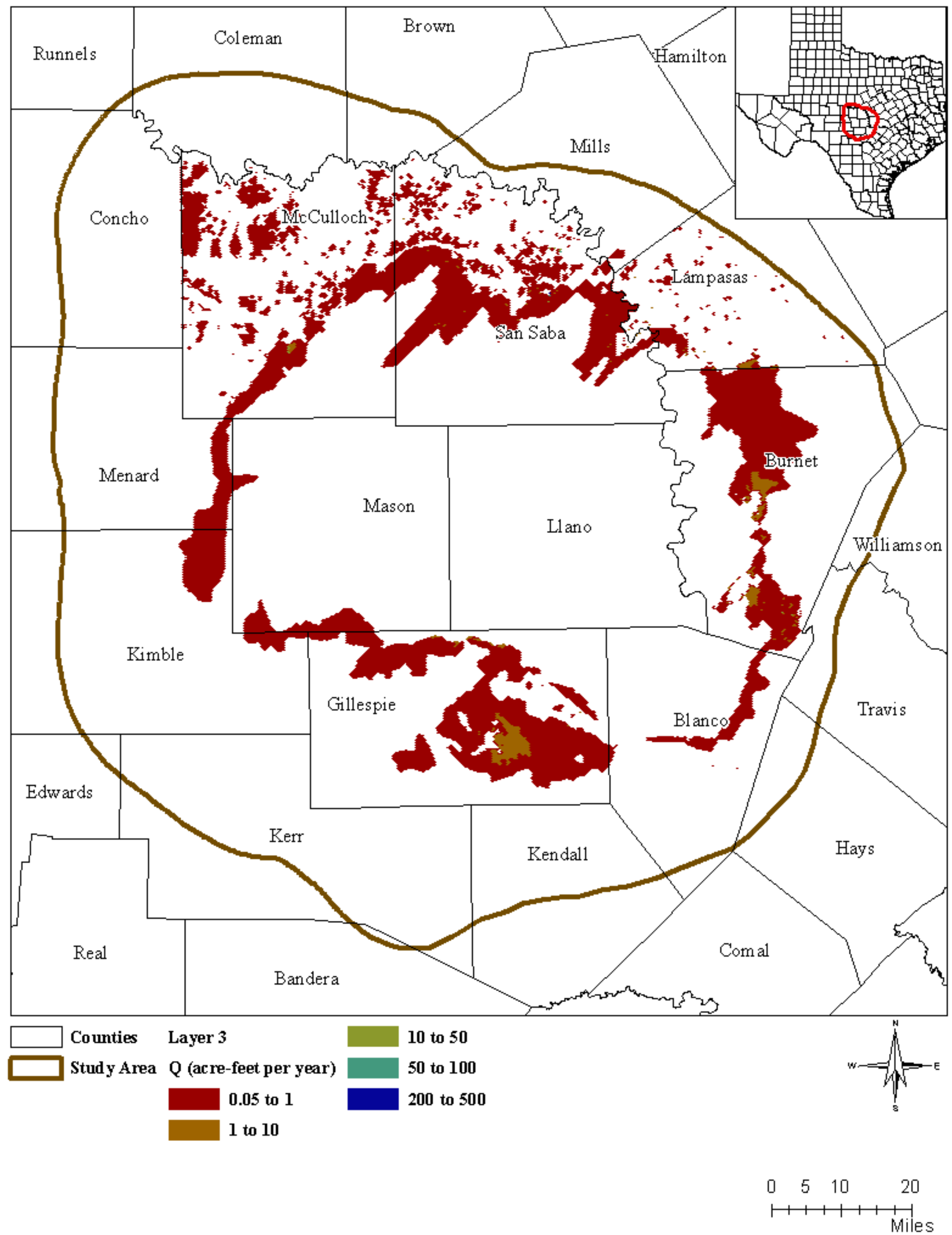


Comparison between Conceptual Model and Numerical Model in Hydraulic Conductivity

Layer	Field Hydraulic Conductivity (feet per day)		Hydraulic Conductivity in Model (feet per day)	
	Range	Geometric Mean	Range	Geometric Mean
1 (Cretaceous)	0.02 to 885	1.7	0.02 to 902	1.03
2	NA	NA	0.01 to 0.03	0.08
3 (Marble Falls)	6.29 to 197.2	35.2	4.3 to 26.3	6.2
4	NA	NA	0.25	
5 (Ellenburger-San Saba)	0.01 to 224.64	2.8	0.3 to 132.6	4.9
6	NA	NA	0.3	
7 (Hickory)	0.03 to 155.5	3.1	1.7 to 192	5.6
8 (Precambrian)	NA	NA	0.1	

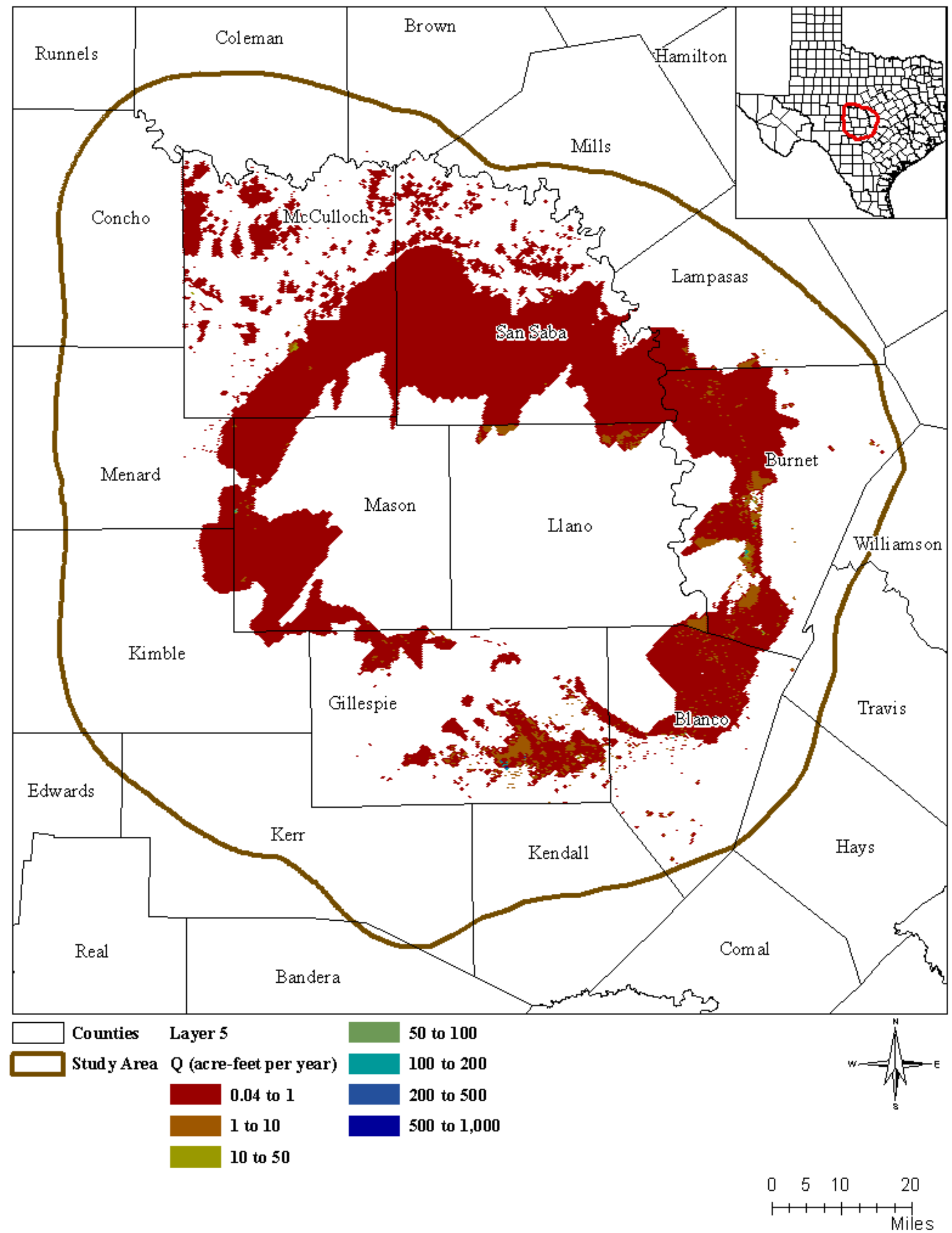
Groundwater Pumping:

Marble Falls Aquifer/Unit (average 1981 – 2010)



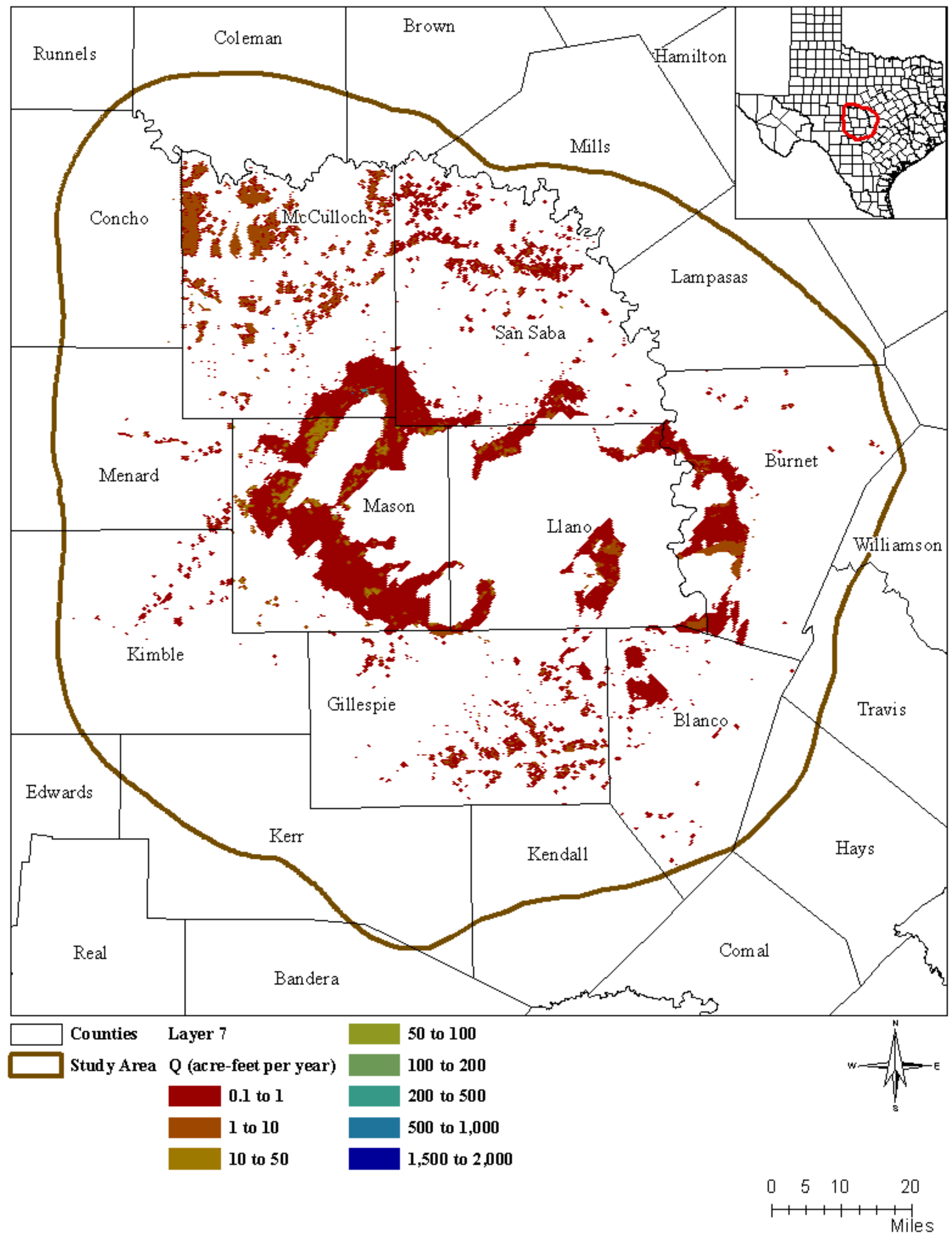
Groundwater Pumping:

Ellenburger-San Saba Aquifer/Unit (average 1981 – 2010)

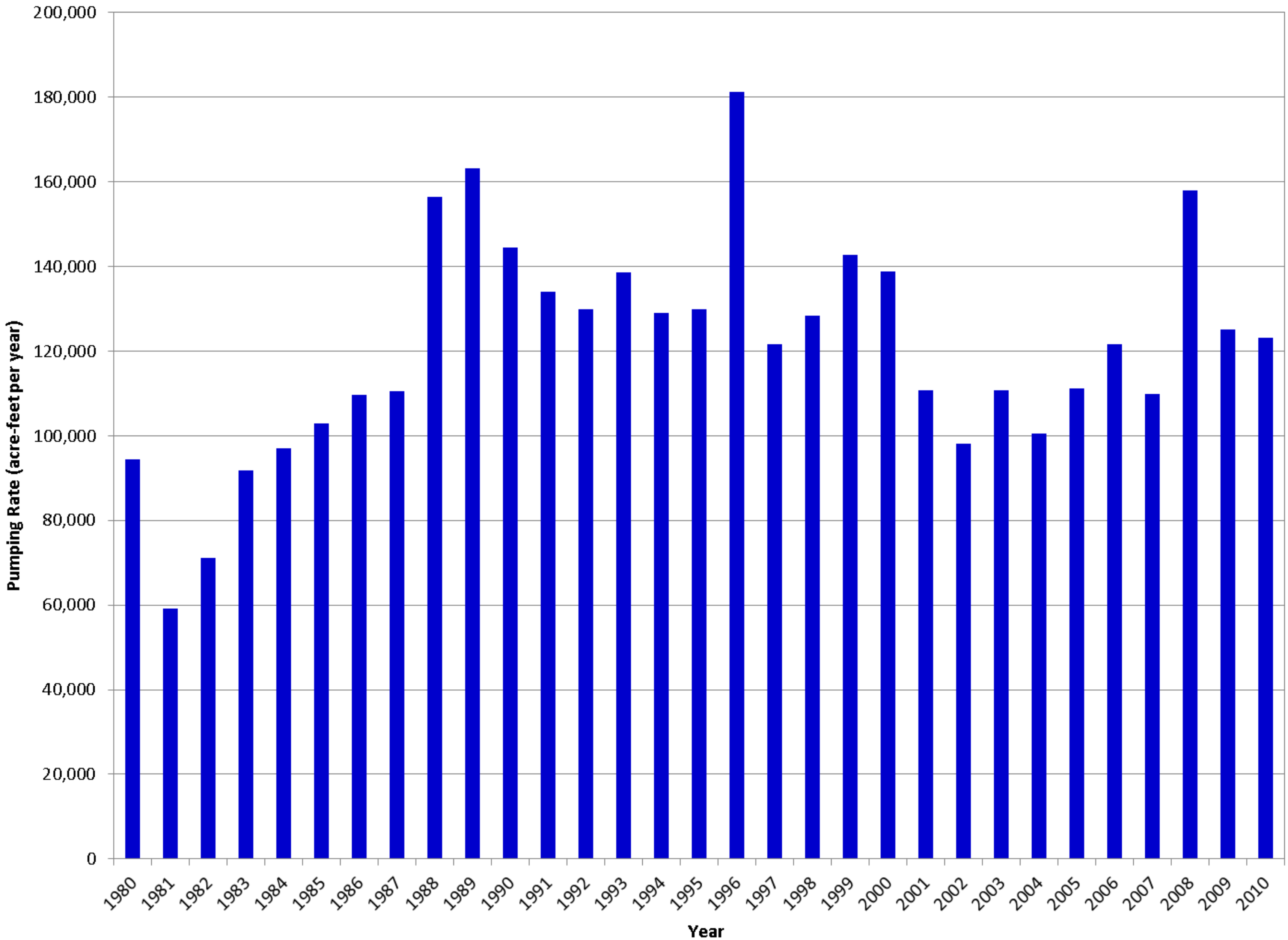


Groundwater Pumping:

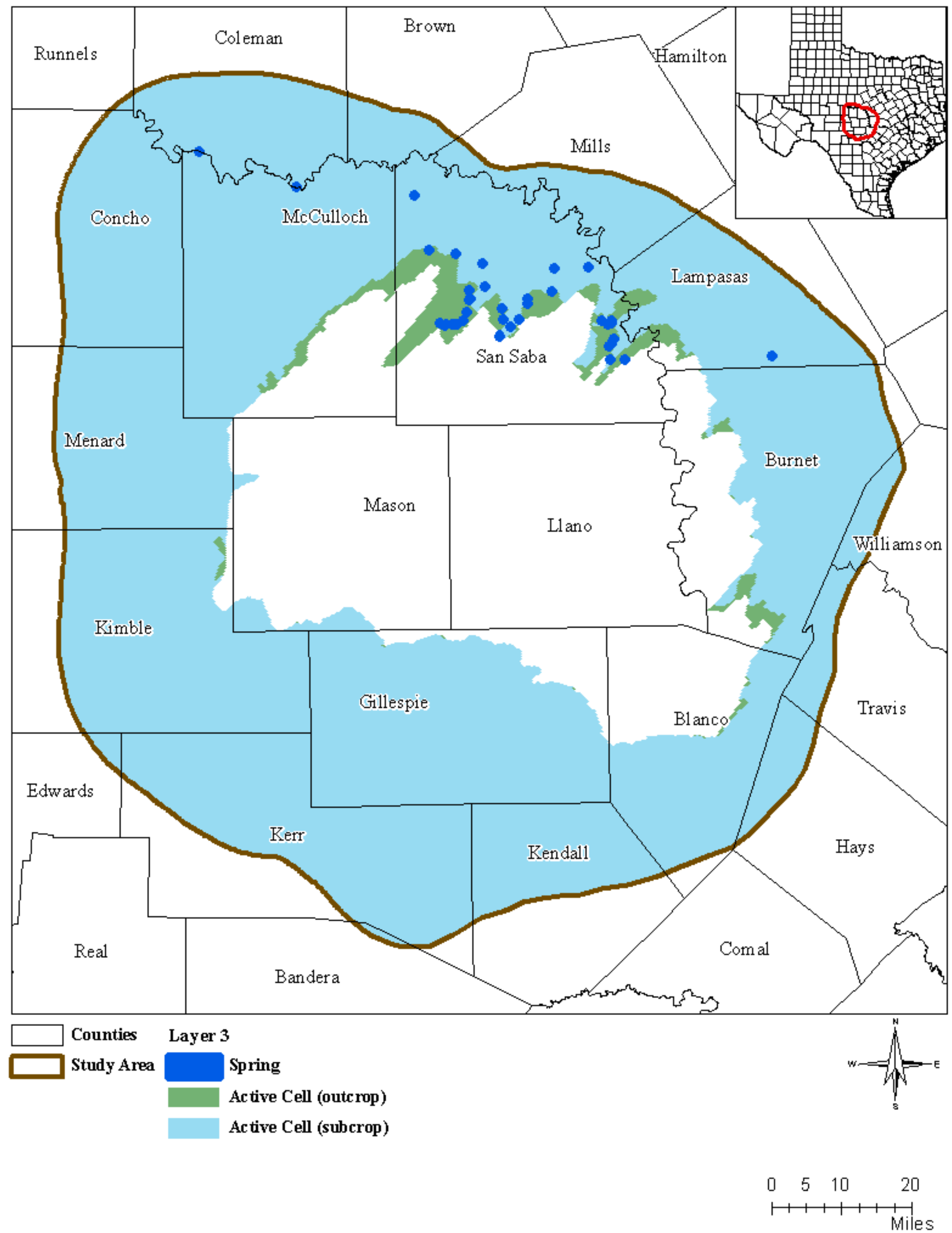
Hickory Aquifer/Unit (average 1981 – 2010)



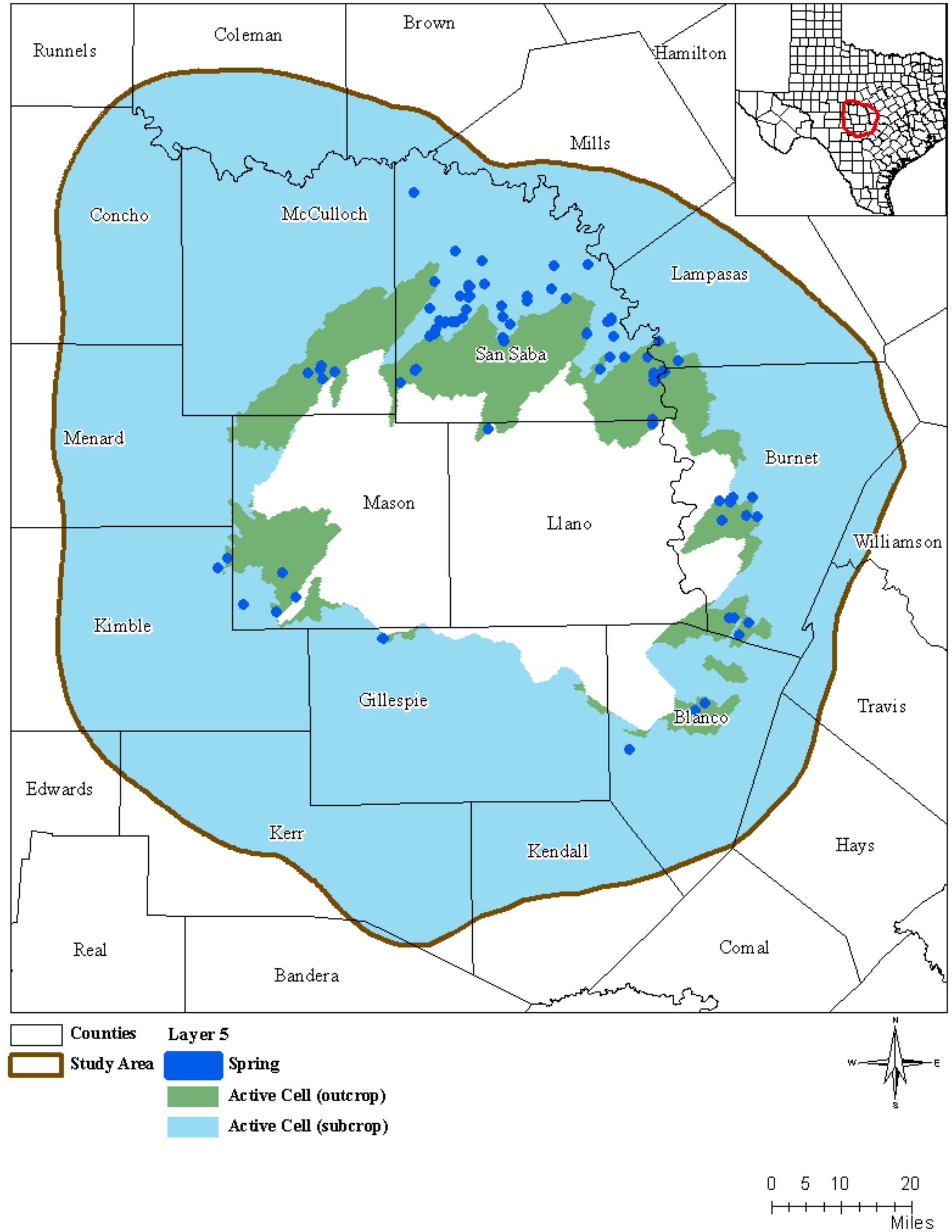
Simulated Total Pumping in Study Area (1980 to 2010)



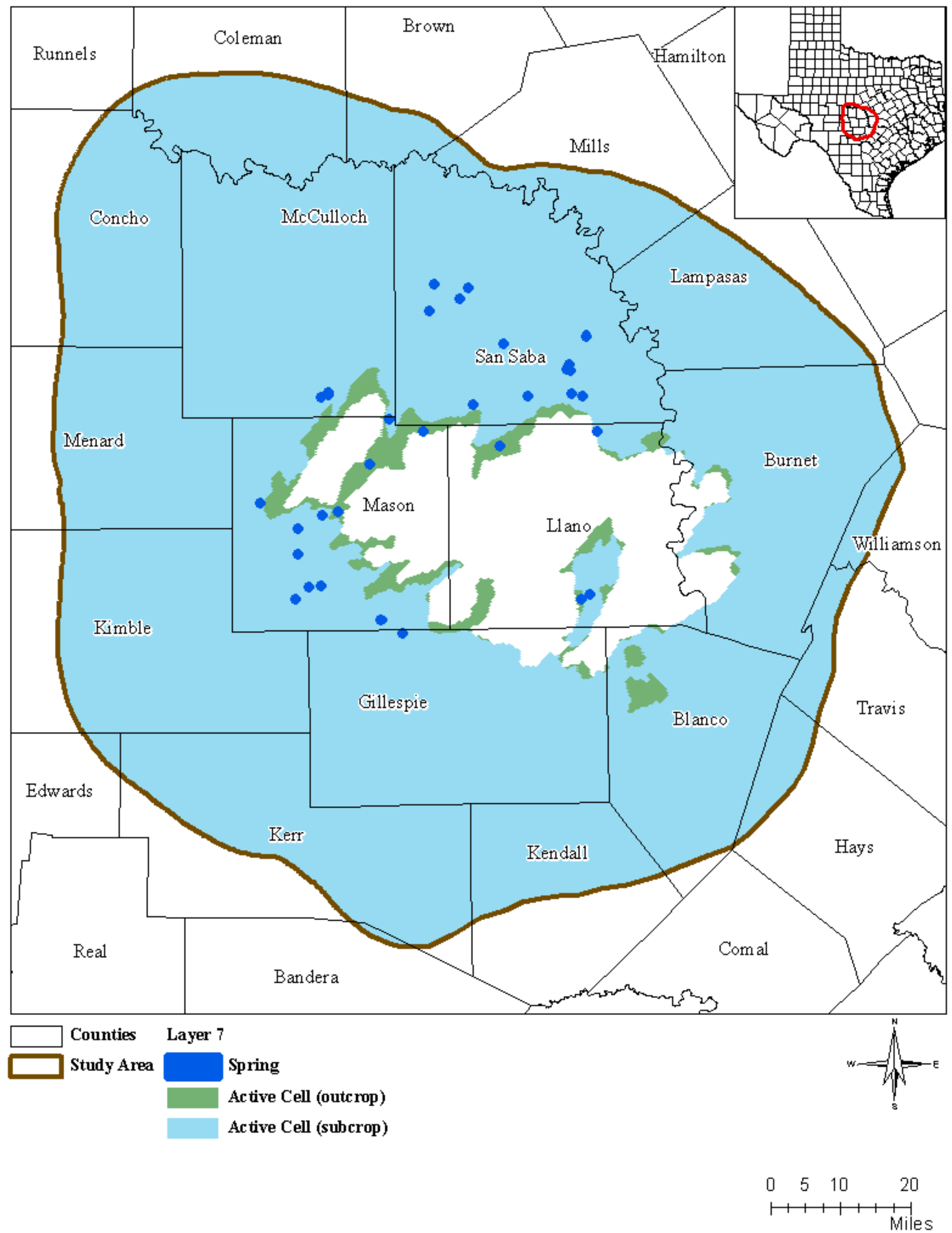
Simulated Springs in Marble Falls Aquifer/Unit



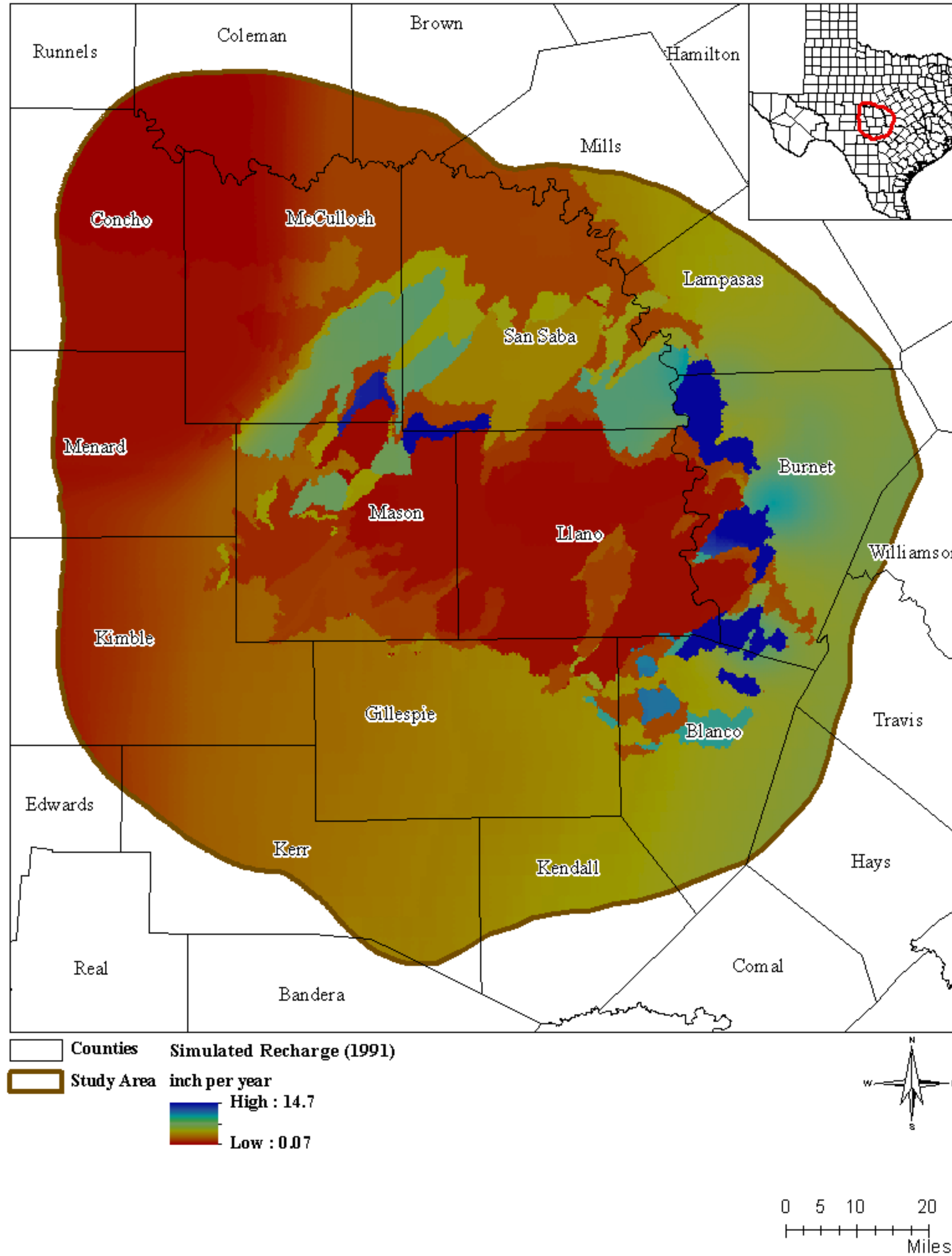
Simulated Springs in Ellenburger-San Saba Aquifer/Unit



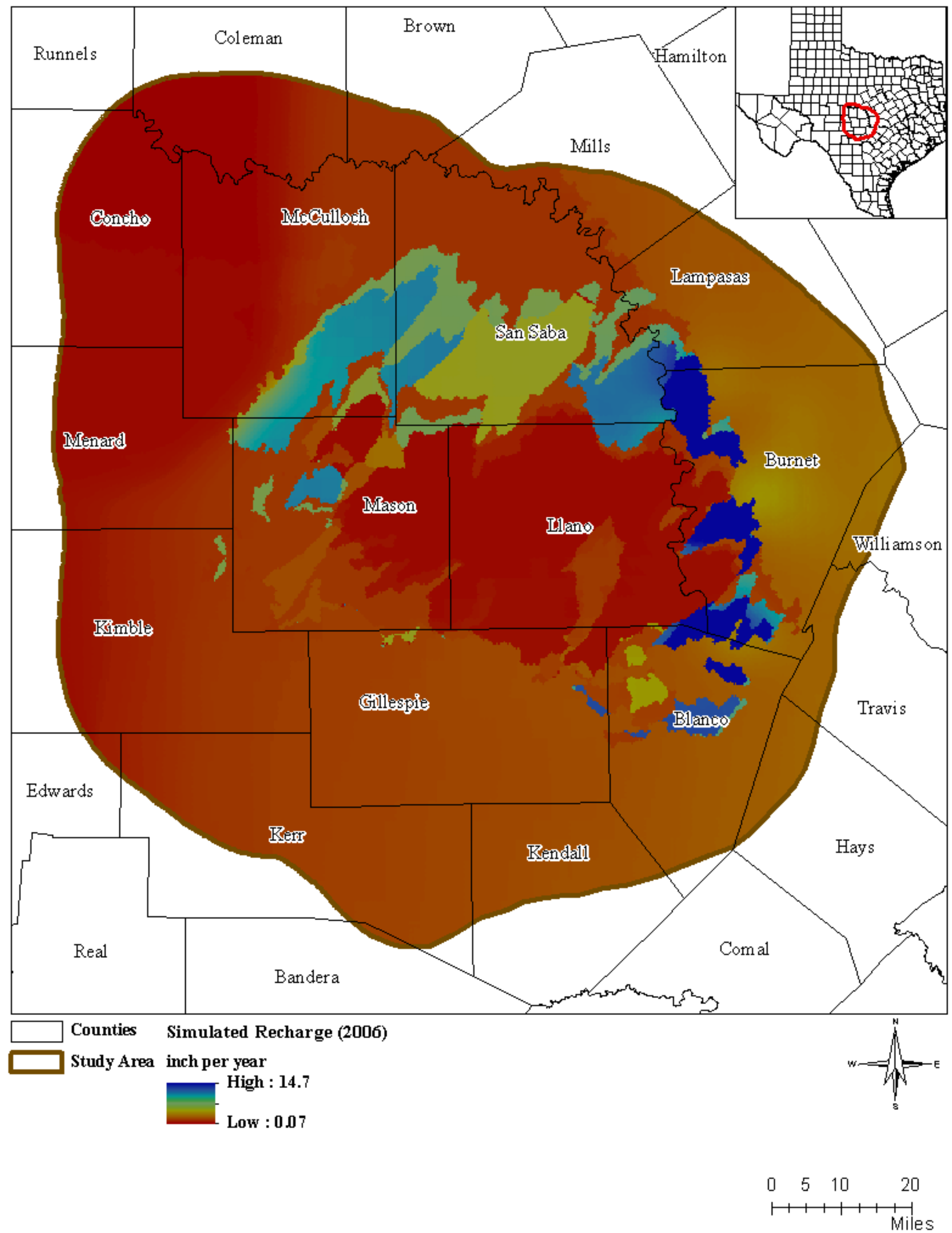
Simulated Springs in Hickory Aquifer/Unit



Simulated Effective Groundwater Recharge (1991)



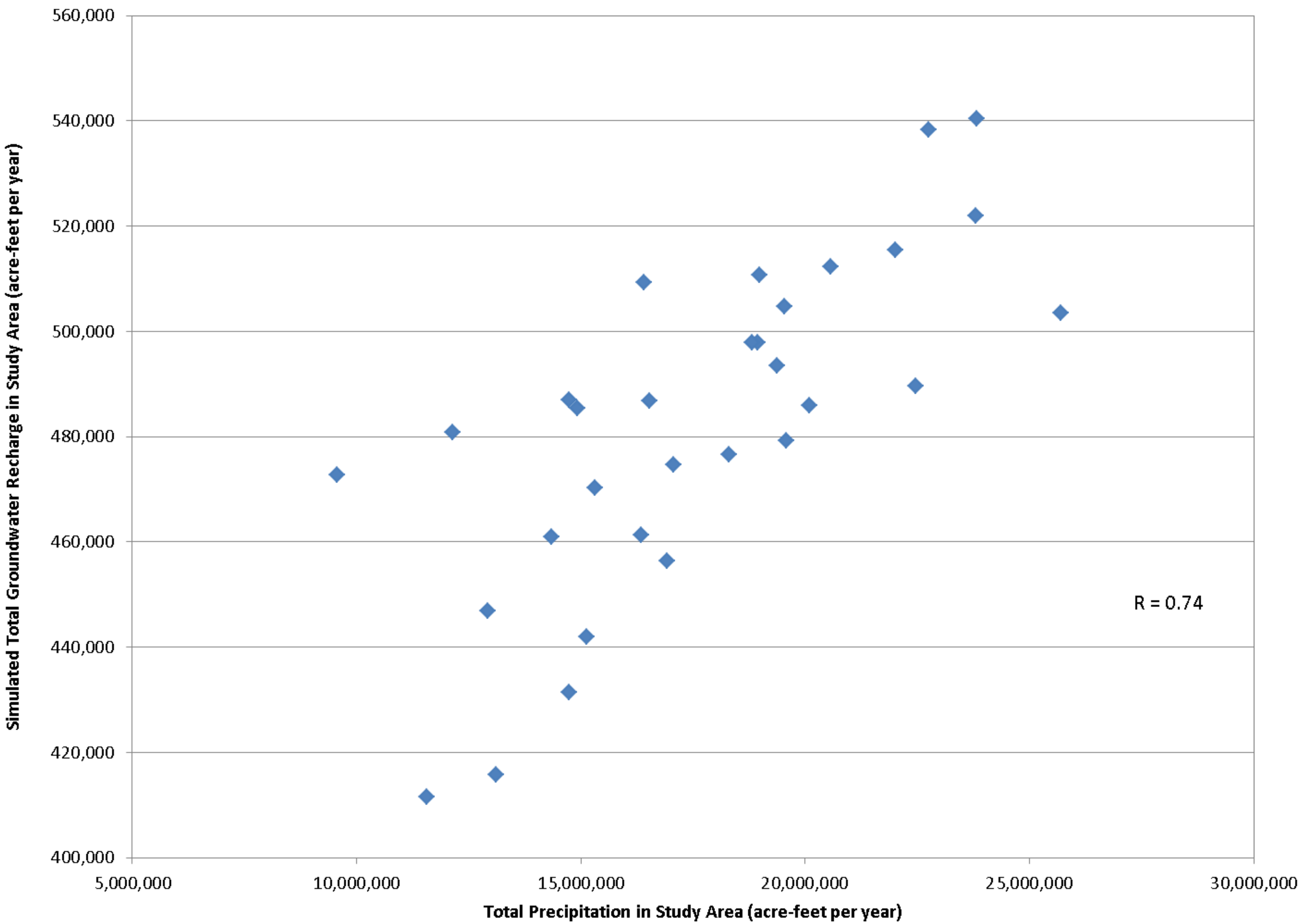
Simulated Effective Groundwater Recharge (2006)



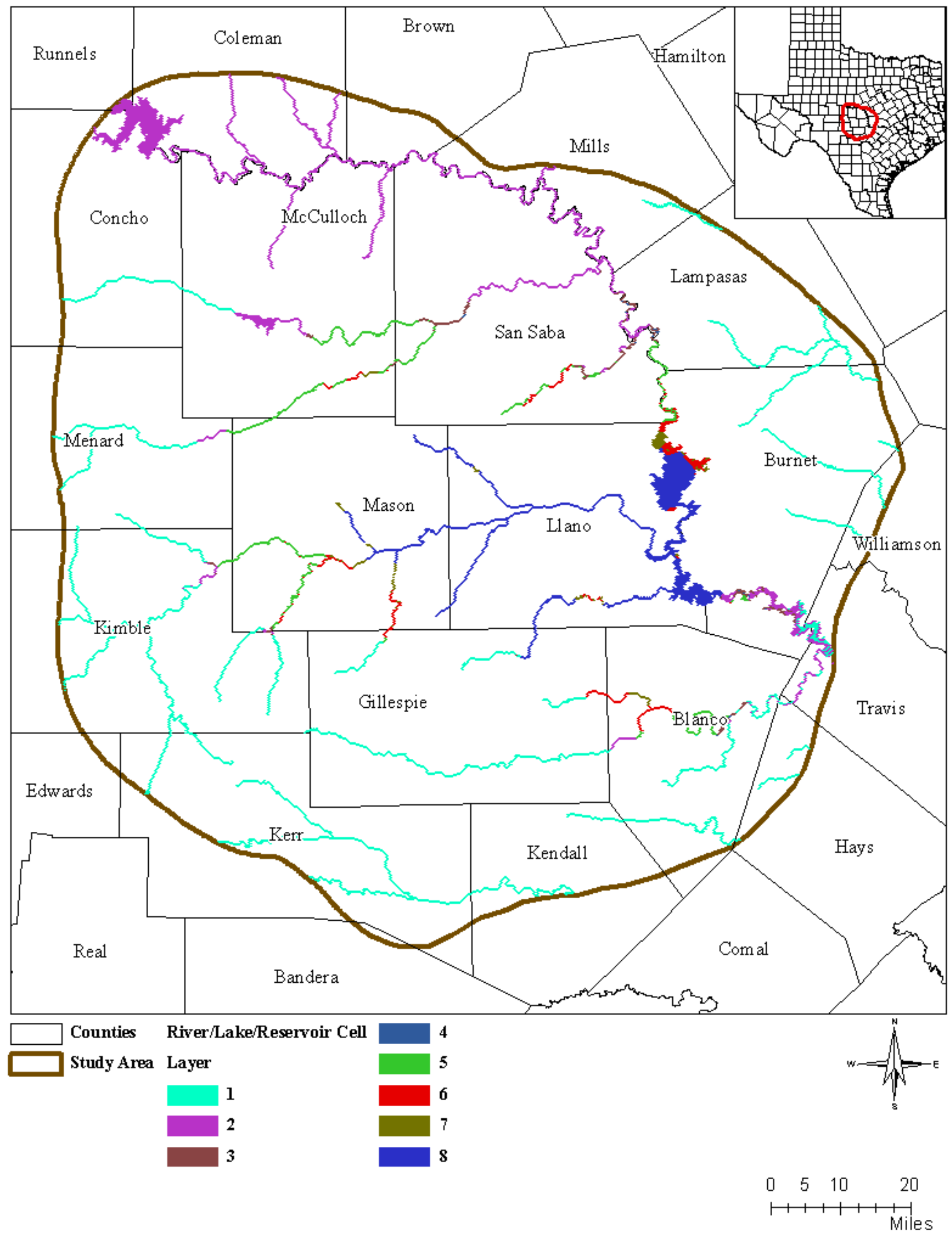
Simulated Effective Groundwater Recharge (1980 – 2010)

Year	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8	Entire Study Area
1980	0.71	0.35	2.63	0.13	2.33	1.59	1.29	0.17	0.84
1981	0.61	0.21	2.13	0.25	3.18	0.89	1.00	0.20	0.80
1982	0.64	0.21	2.33	0.19	2.90	0.96	1.02	0.20	0.80
1983	0.67	0.21	2.34	0.19	2.59	0.71	2.01	0.20	0.80
1984	0.54	0.15	1.32	0.14	3.30	0.88	0.80	0.52	0.77
1985	0.60	0.15	0.94	0.13	3.30	0.45	0.69	0.53	0.78
1986	0.72	0.32	2.32	0.17	2.75	0.49	1.86	0.19	0.85
1987	0.76	0.23	0.93	0.19	3.01	0.44	0.90	0.13	0.81
1988	0.70	0.30	1.15	0.34	2.45	1.11	1.67	0.14	0.79
1989	0.53	0.24	0.94	0.13	3.47	0.87	1.26	0.13	0.76
1990	0.81	0.26	1.82	0.34	2.26	0.96	1.06	0.23	0.83
1991	0.90	0.29	1.28	0.14	2.37	0.46	1.30	0.15	0.86
1992	0.61	0.26	1.24	0.14	3.57	0.46	0.77	0.24	0.81
1993	0.54	0.29	0.25	0.07	3.35	0.07	1.27	0.21	0.73
1994	0.70	0.36	2.00	0.11	3.08	0.13	1.58	0.14	0.84
1995	0.53	0.27	1.48	0.45	3.26	1.04	0.69	0.12	0.75
1996	0.56	0.31	0.99	0.48	3.11	1.17	1.00	0.11	0.76
1997	0.76	0.40	1.44	0.32	2.95	1.32	1.04	0.14	0.89
1998	0.65	0.26	1.80	0.10	2.83	1.13	0.89	0.13	0.79
1999	0.36	0.24	2.50	0.11	3.42	0.65	0.73	0.13	0.68
2000	0.60	0.26	2.63	0.12	3.17	1.11	0.96	0.16	0.82
2001	0.64	0.28	1.60	0.10	2.84	1.16	1.05	0.12	0.78
2002	0.64	0.32	1.72	0.10	3.21	1.27	1.30	0.13	0.84
2003	0.44	0.24	1.32	0.09	3.56	0.81	0.74	0.11	0.71
2004	0.67	0.43	1.91	0.11	3.29	1.52	0.87	0.14	0.89
2005	0.41	0.24	1.04	0.35	3.60	0.66	0.63	0.10	0.68
2006	0.50	0.24	2.09	0.16	3.35	0.48	0.70	0.17	0.74
2007	0.59	0.29	2.55	0.38	3.56	0.50	0.74	0.20	0.83
2008	0.53	0.32	1.06	0.14	3.35	1.17	1.30	0.14	0.78
2009	0.70	0.30	0.99	0.14	2.91	1.12	1.18	0.14	0.82
2010	0.71	0.21	1.42	0.17	2.59	1.04	1.53	0.18	0.80
Minimum	0.36	0.15	0.25	0.07	2.26	0.07	0.63	0.10	0.68
Maximum	0.90	0.43	2.63	0.48	3.60	1.59	2.01	0.53	0.89
Average	0.62	0.27	1.62	0.19	3.06	0.86	1.09	0.18	0.79

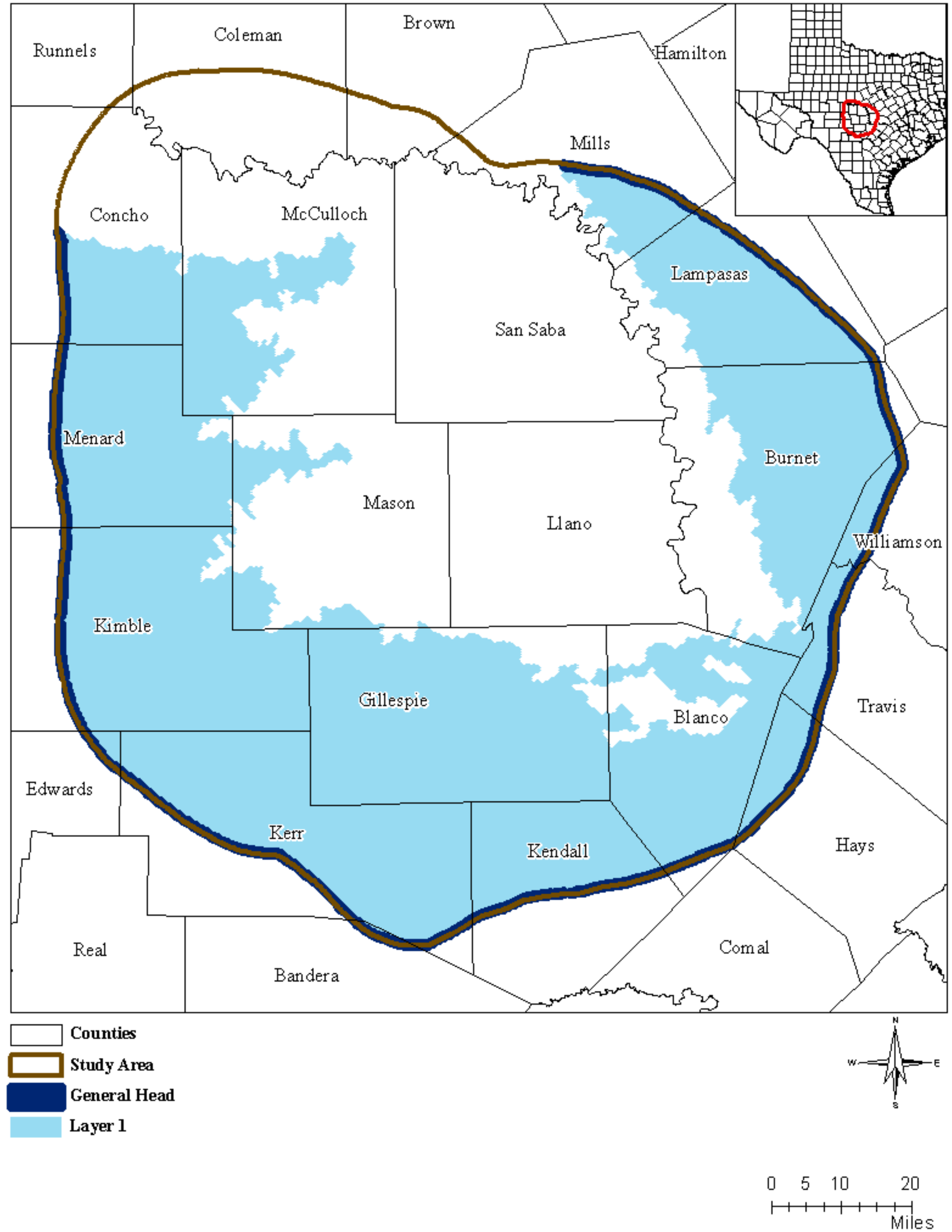
Correlation between Recharge and Precipitation



Simulated Rivers, Lakes, and Reservoirs



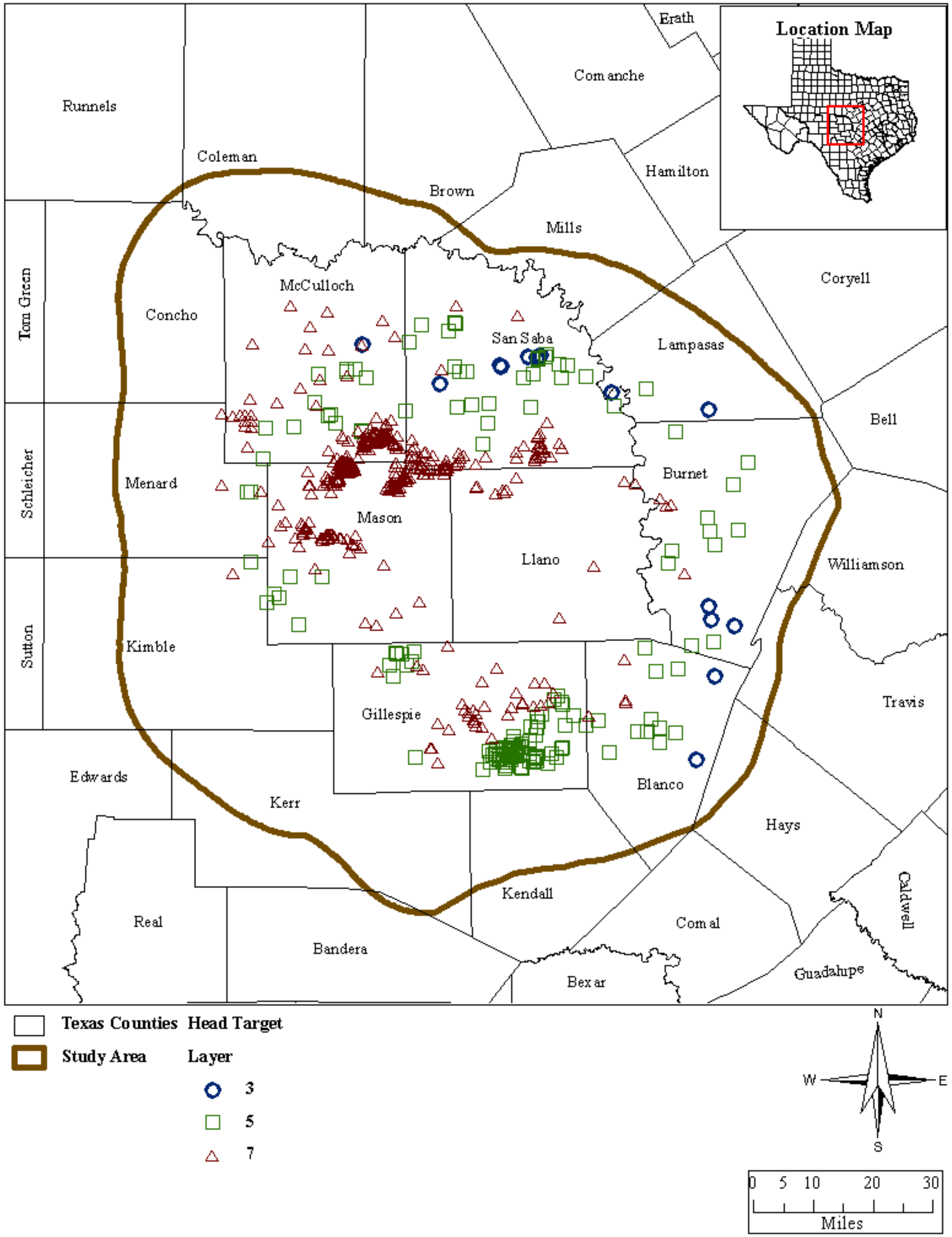
General Head Used to Simulate Lateral Flow in Cretaceous across Study Area Boundary



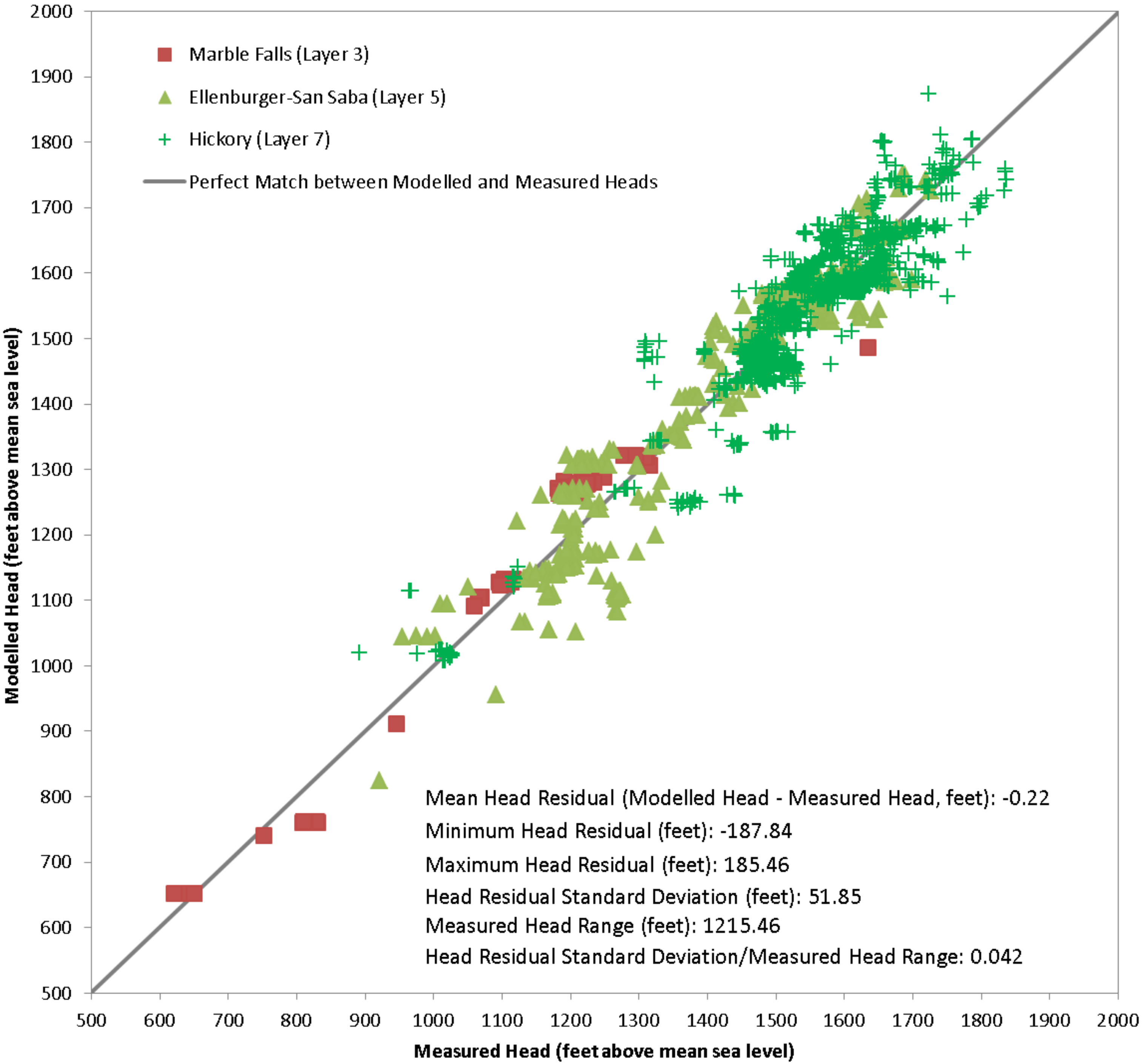
Model Calibration Result

Modified from Standen and others (2009)

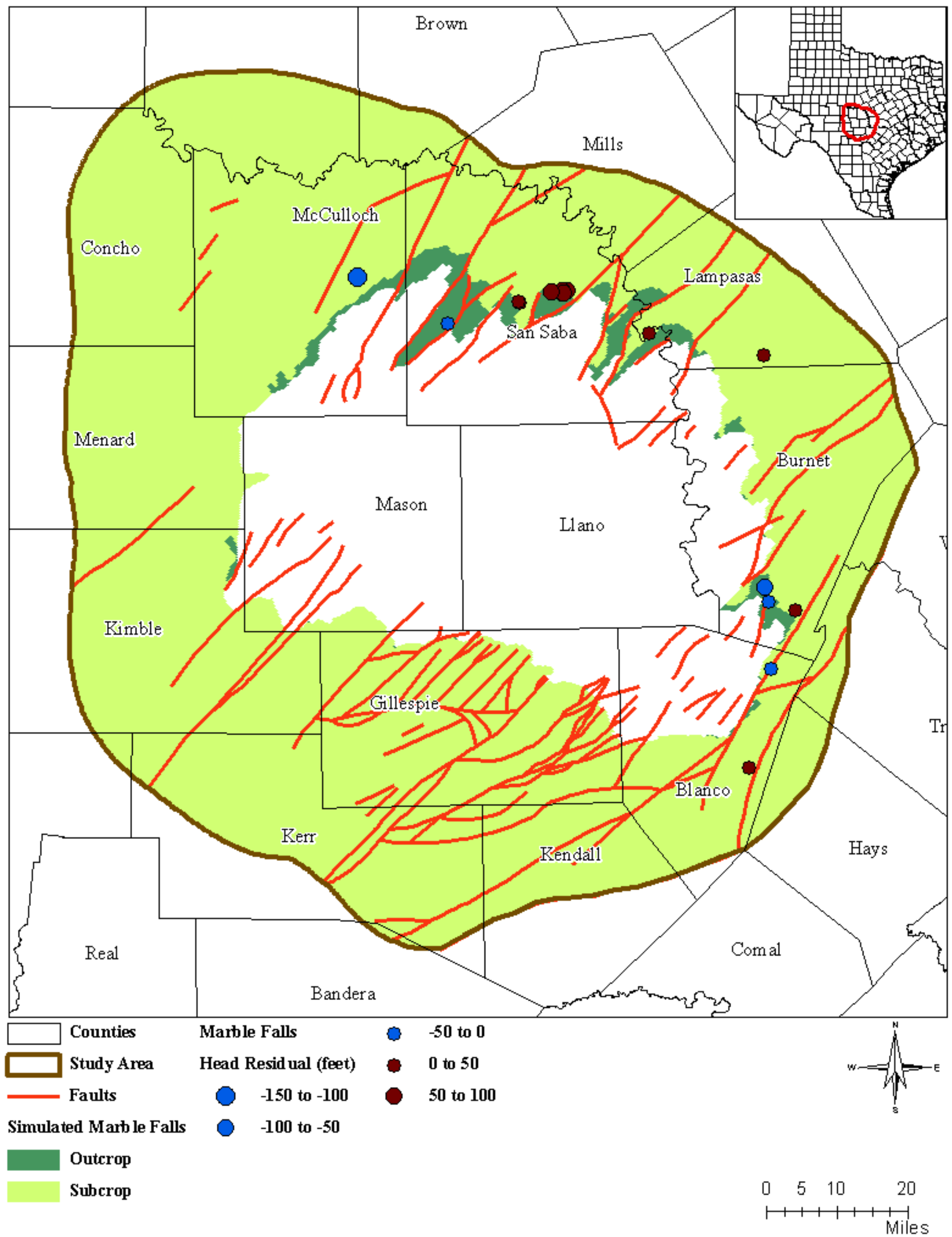
Water Level Targets



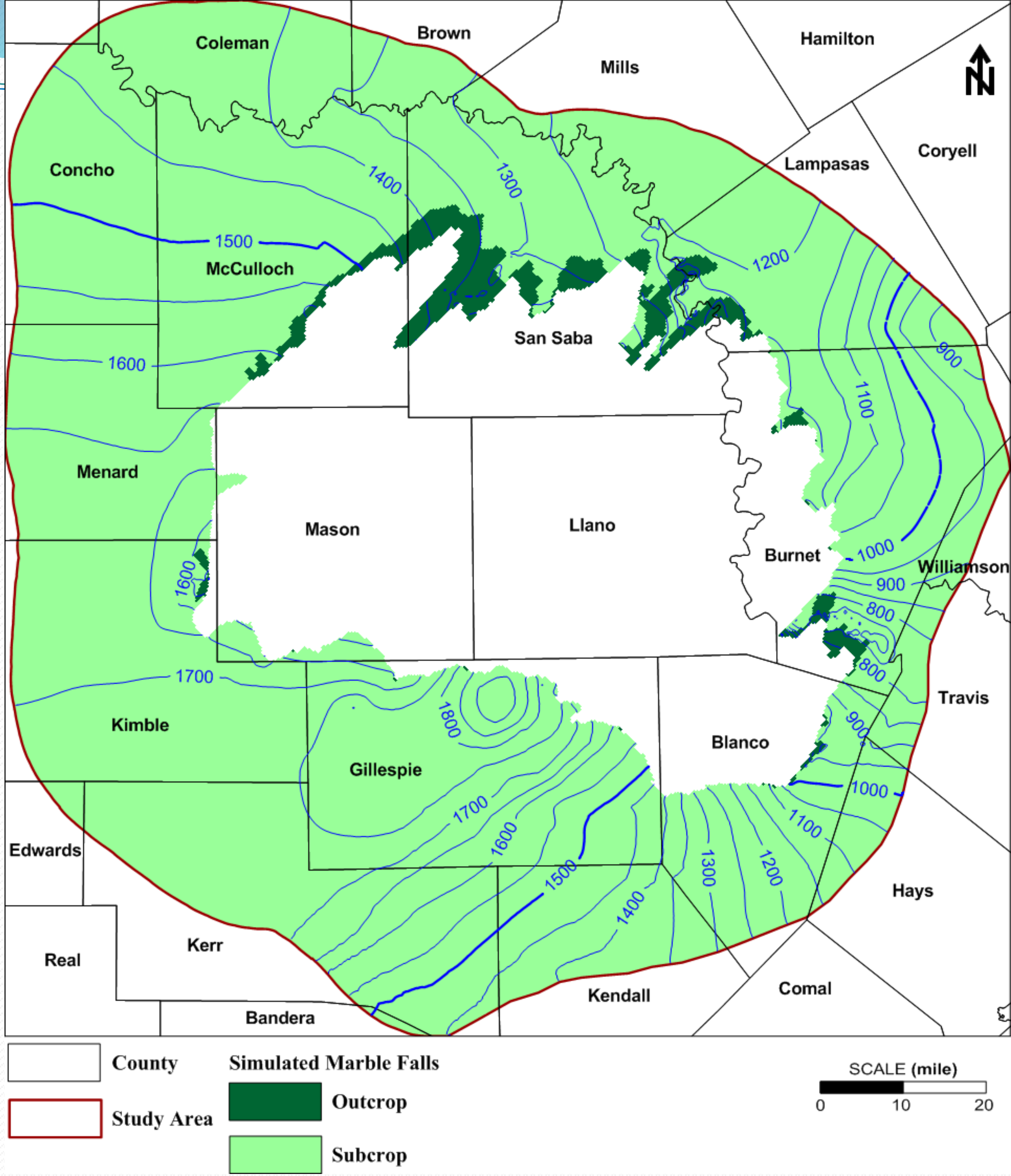
Water Level Calibration



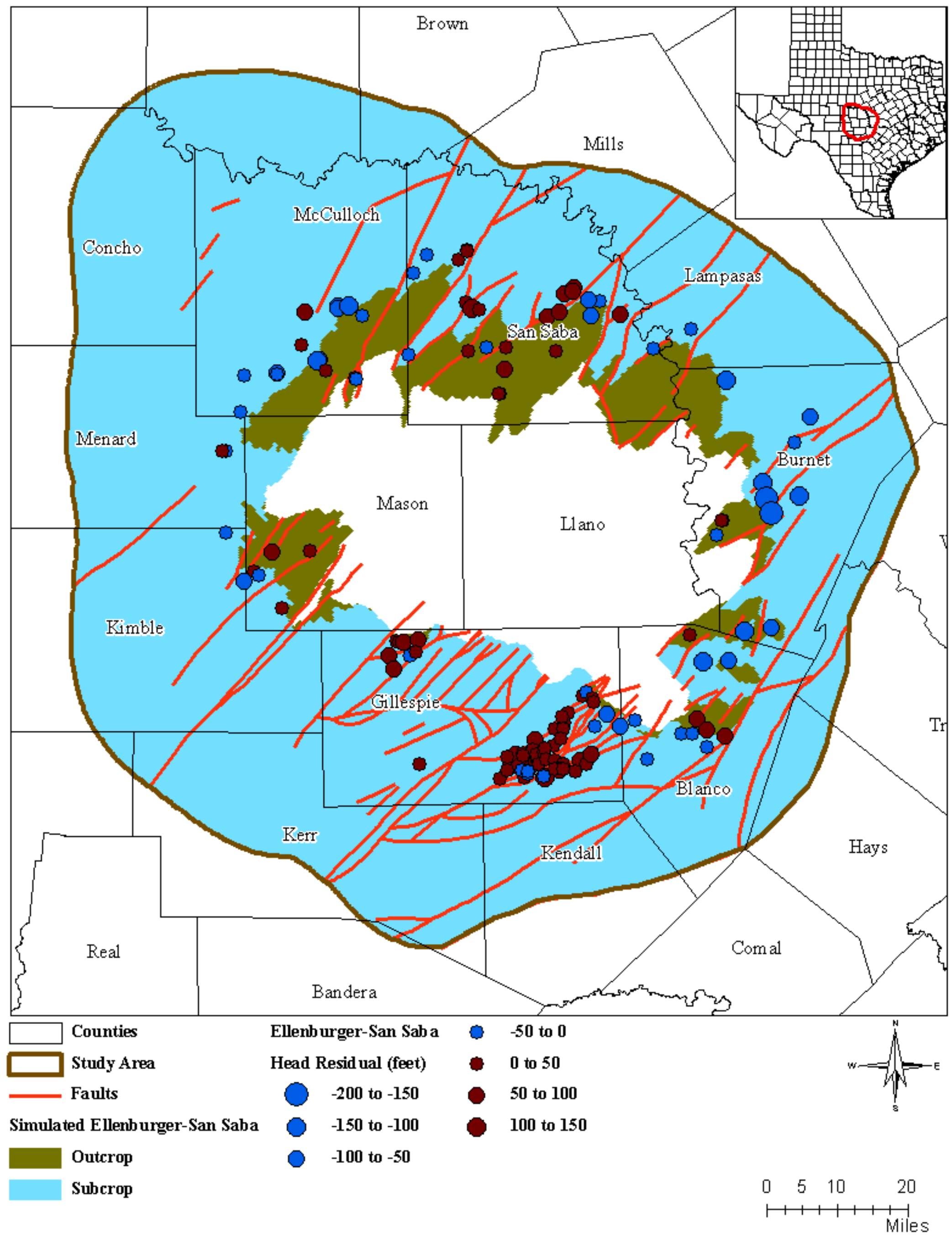
Head Residuals in Marble Falls Aquifer/Unit



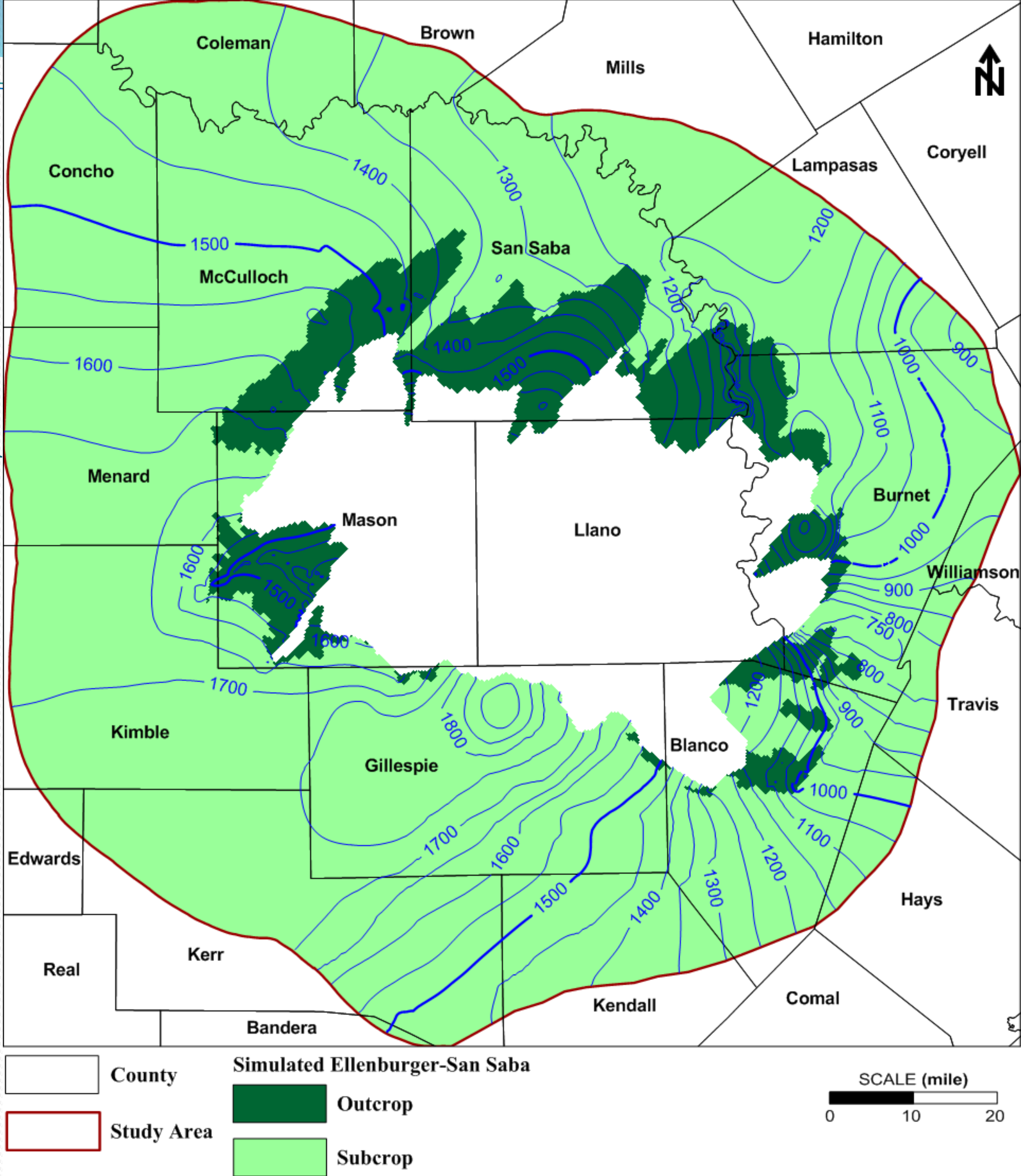
Head Distribution in Marble Falls Aquifer/Unit



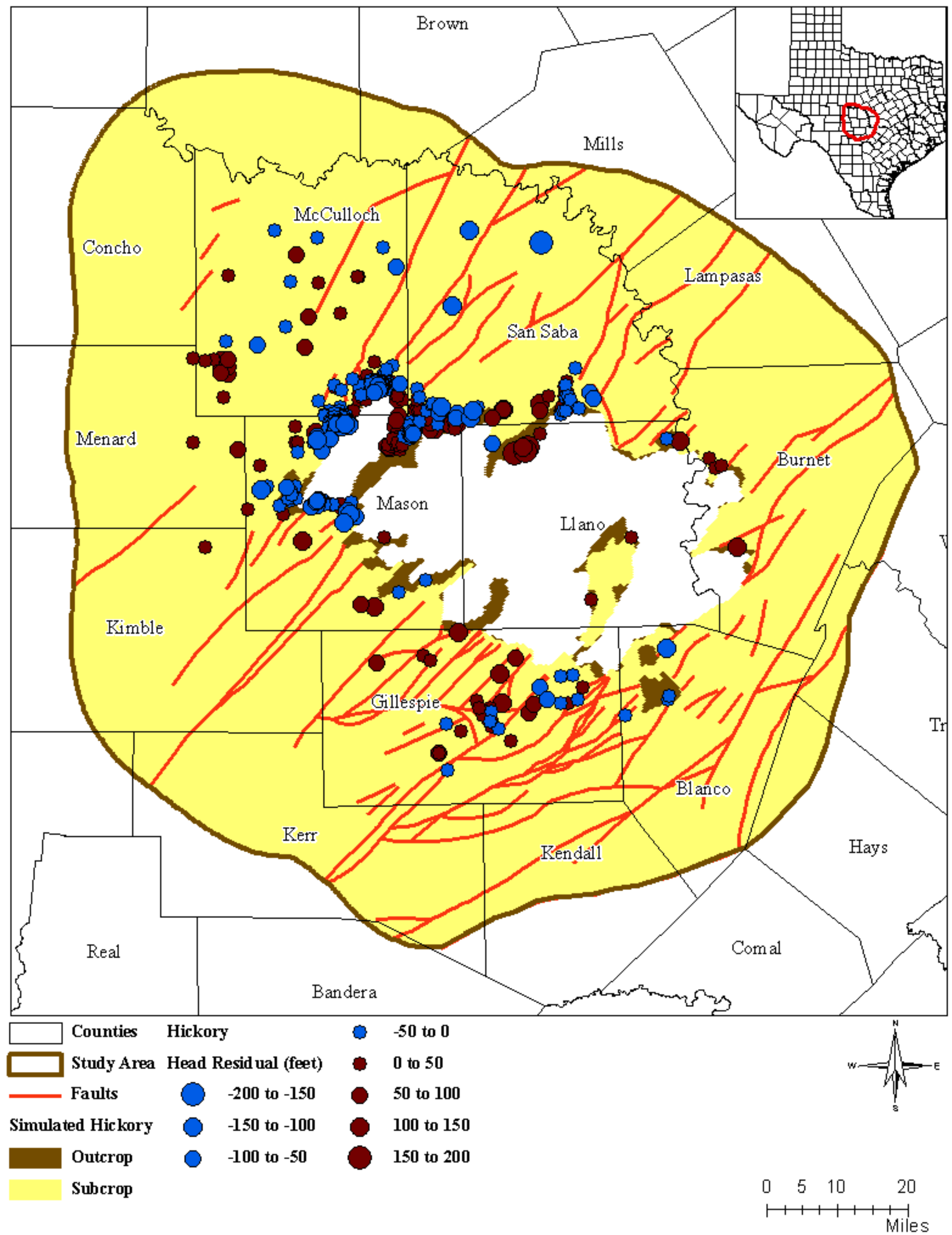
Head Residuals in Ellenburger-San Saba Aquifer/Unit



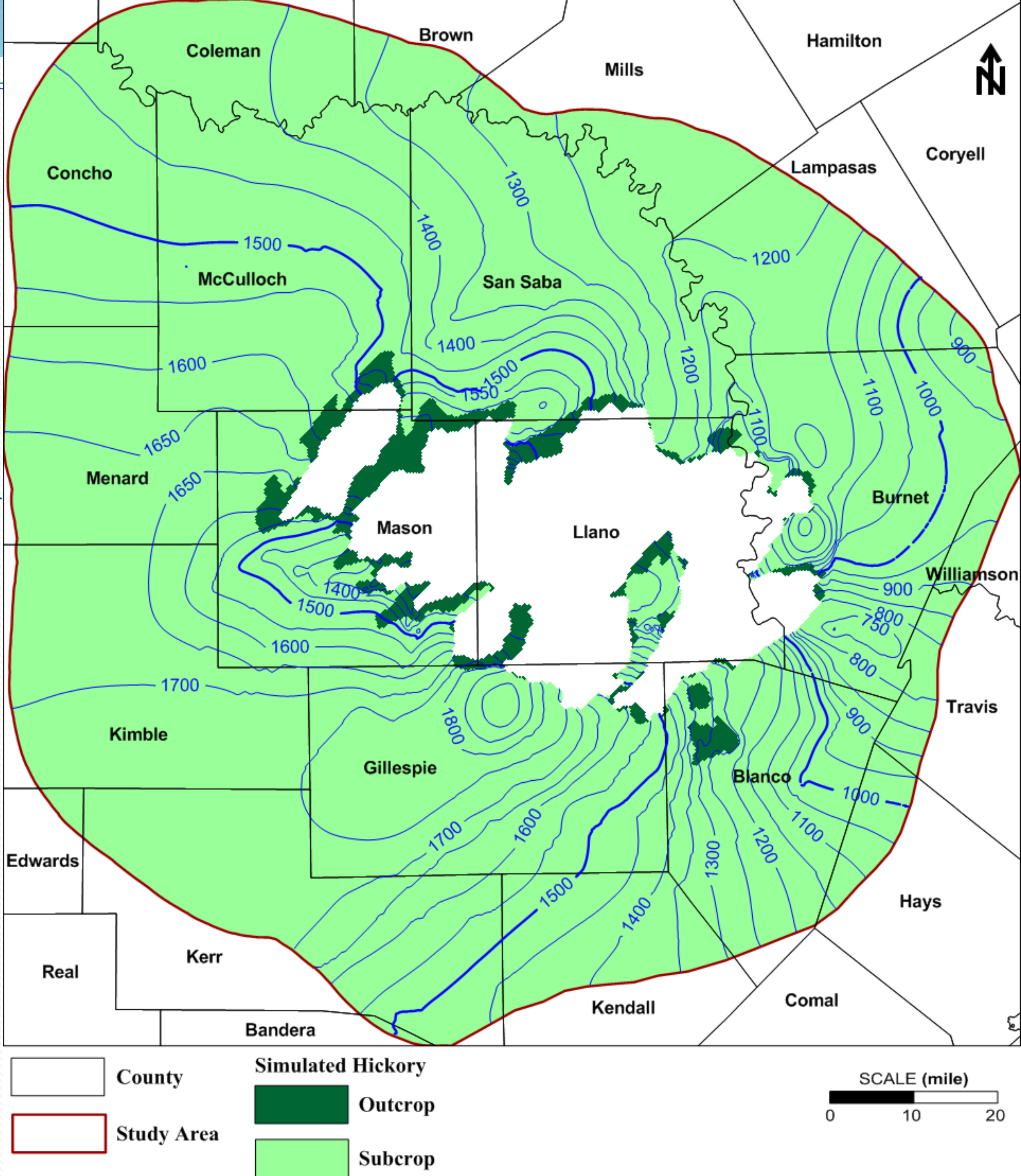
Head Distribution in Ellenburger-San Saba Aquifer/Unit



Head Residuals in Hickory Aquifer/Unit

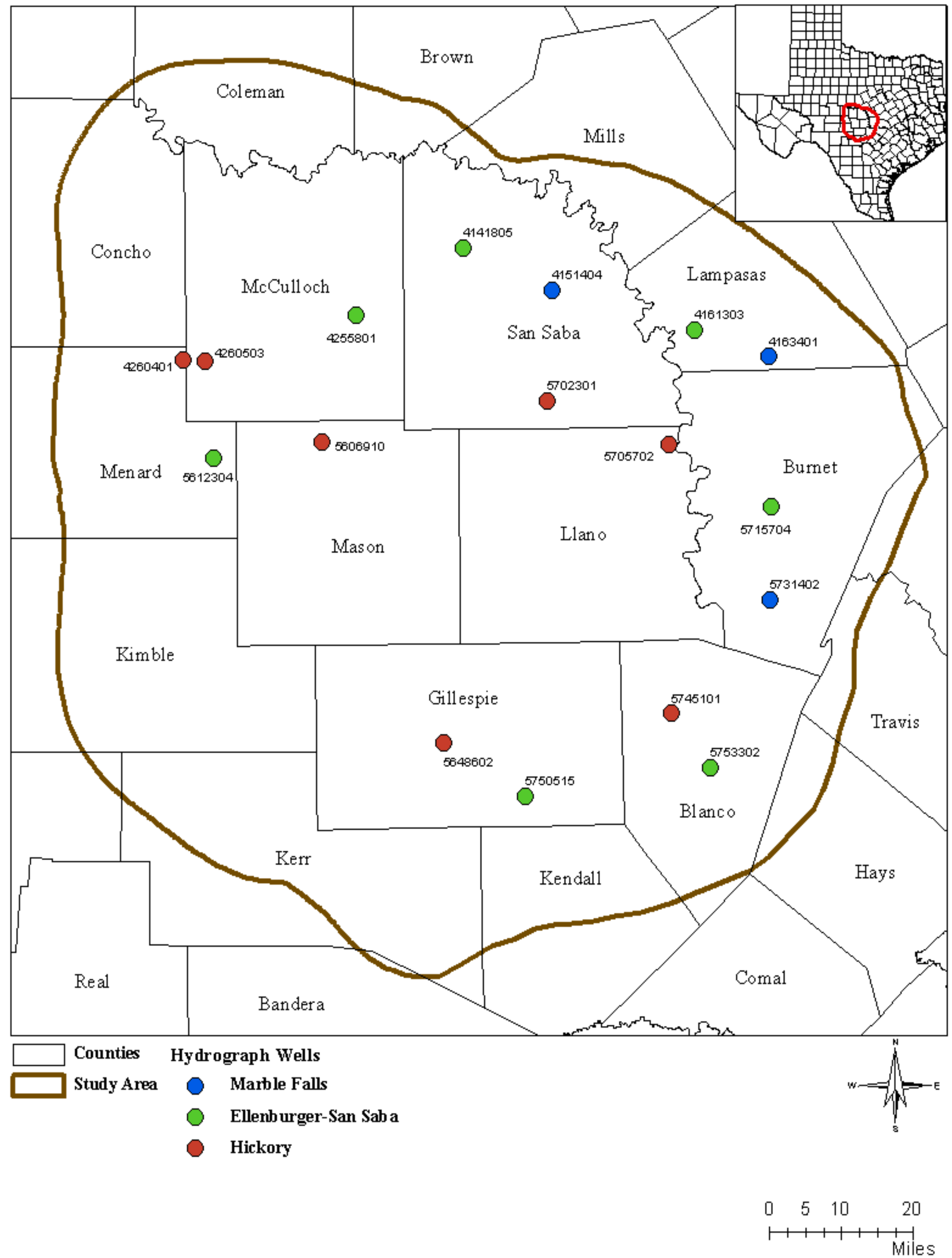


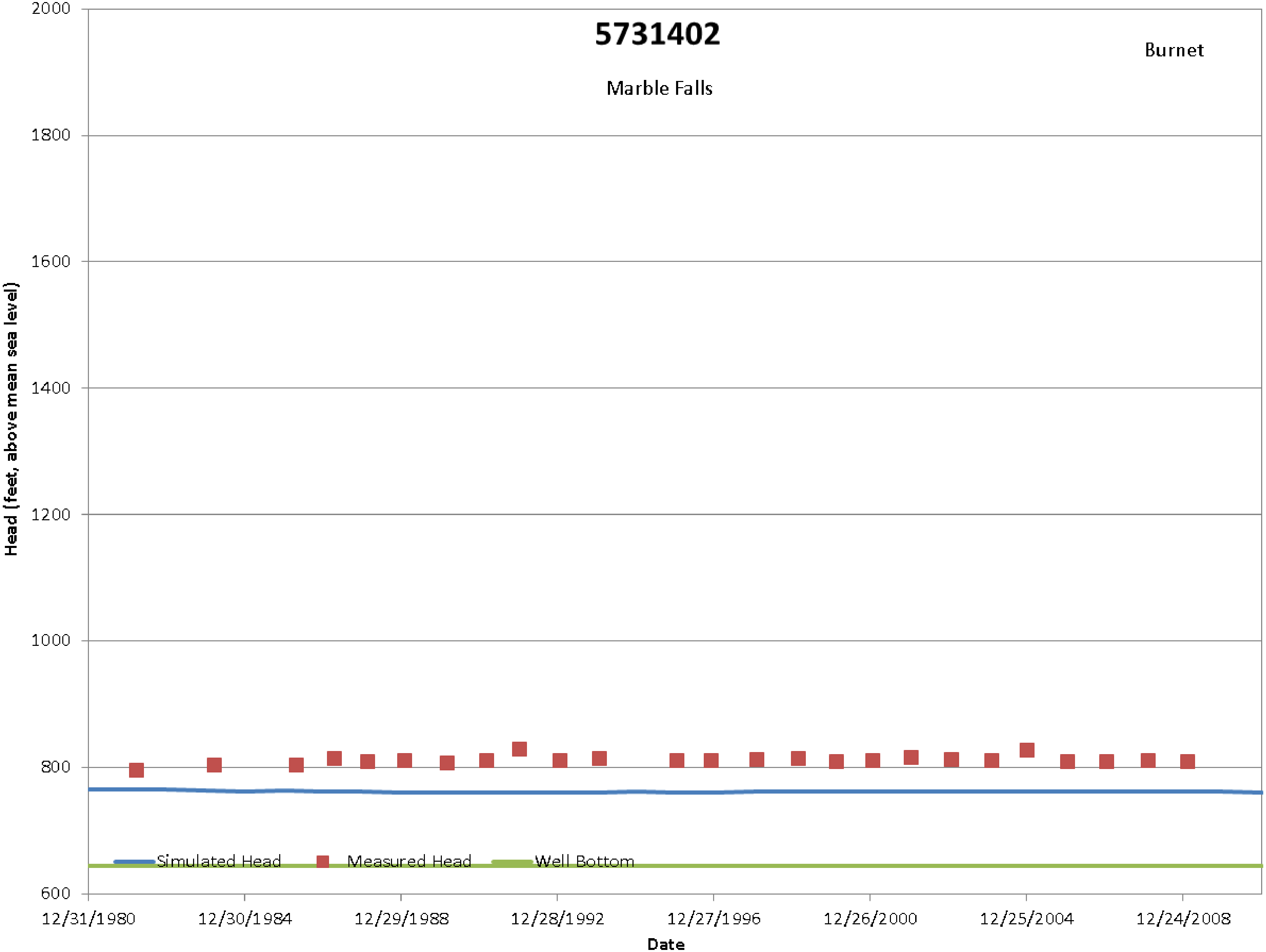
Head Distribution in Hickory Aquifer/Unit

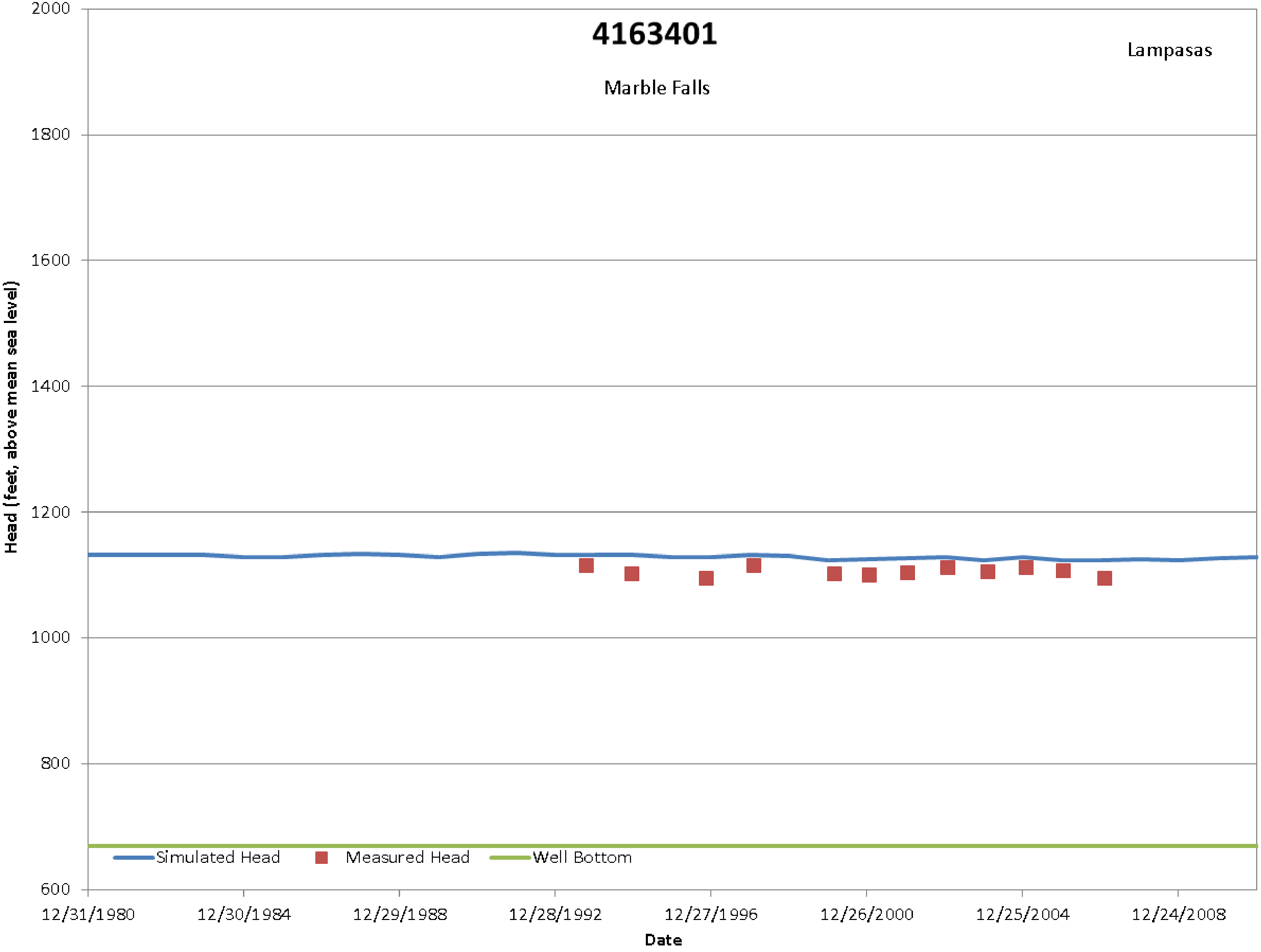


Water Level Hydrograph

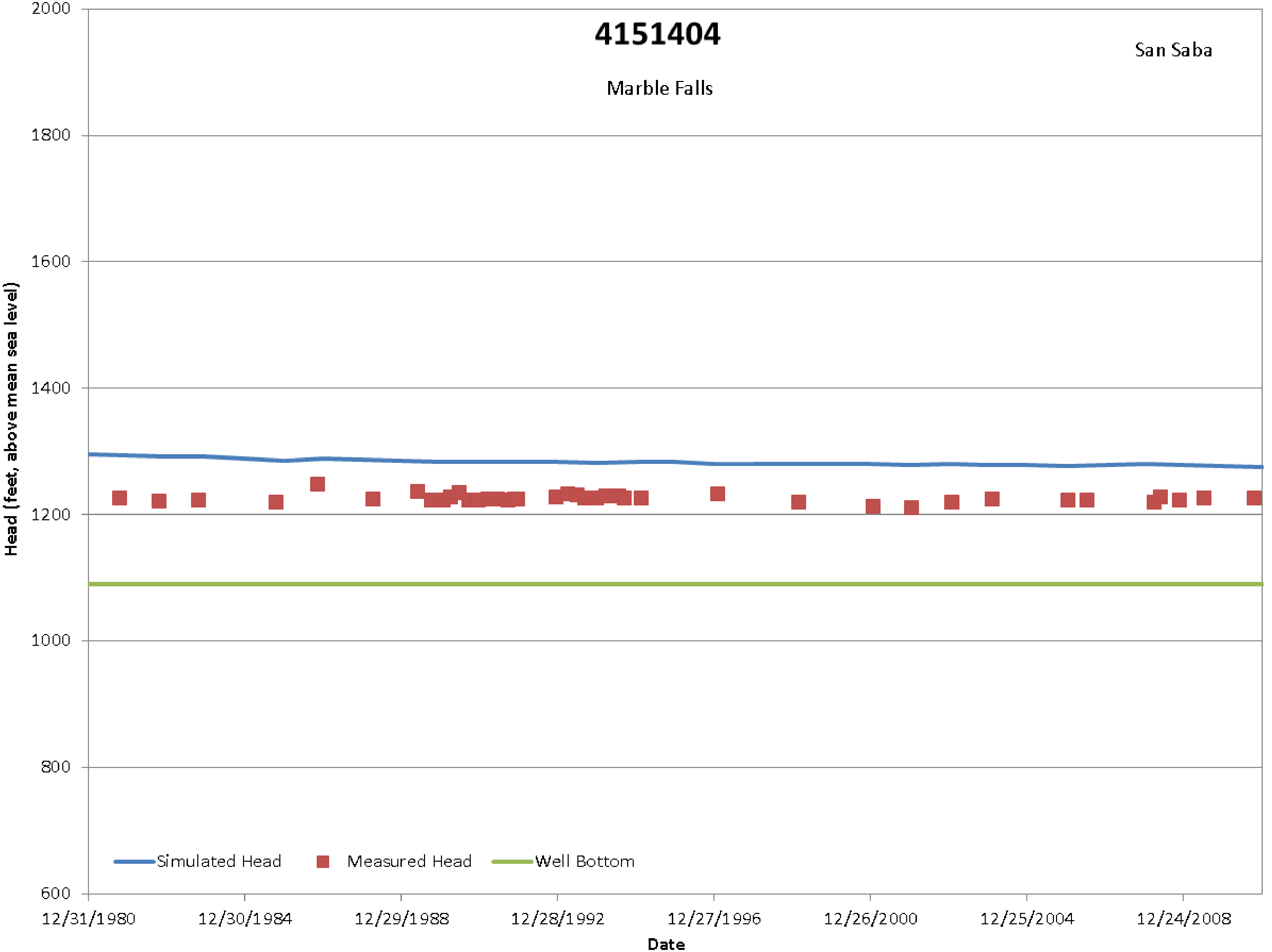
Wells with Water Level Hydrograph

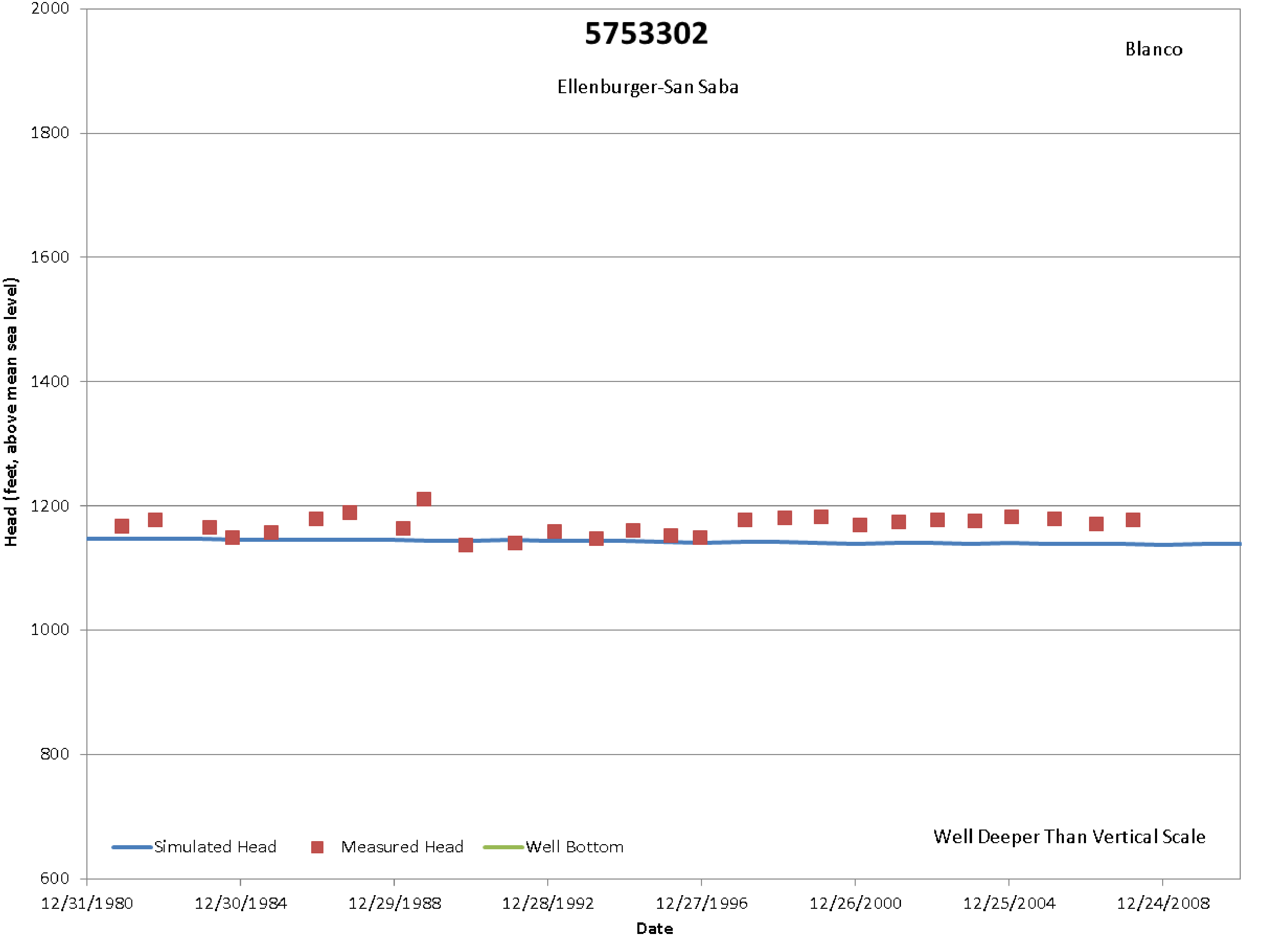



5731402
Burnet
Marble Falls
Head (feet, above mean sea level)
2000
1800
1600
1400
1200
1000
800
600
Simulated Head
Measured Head
Well Bottom
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date

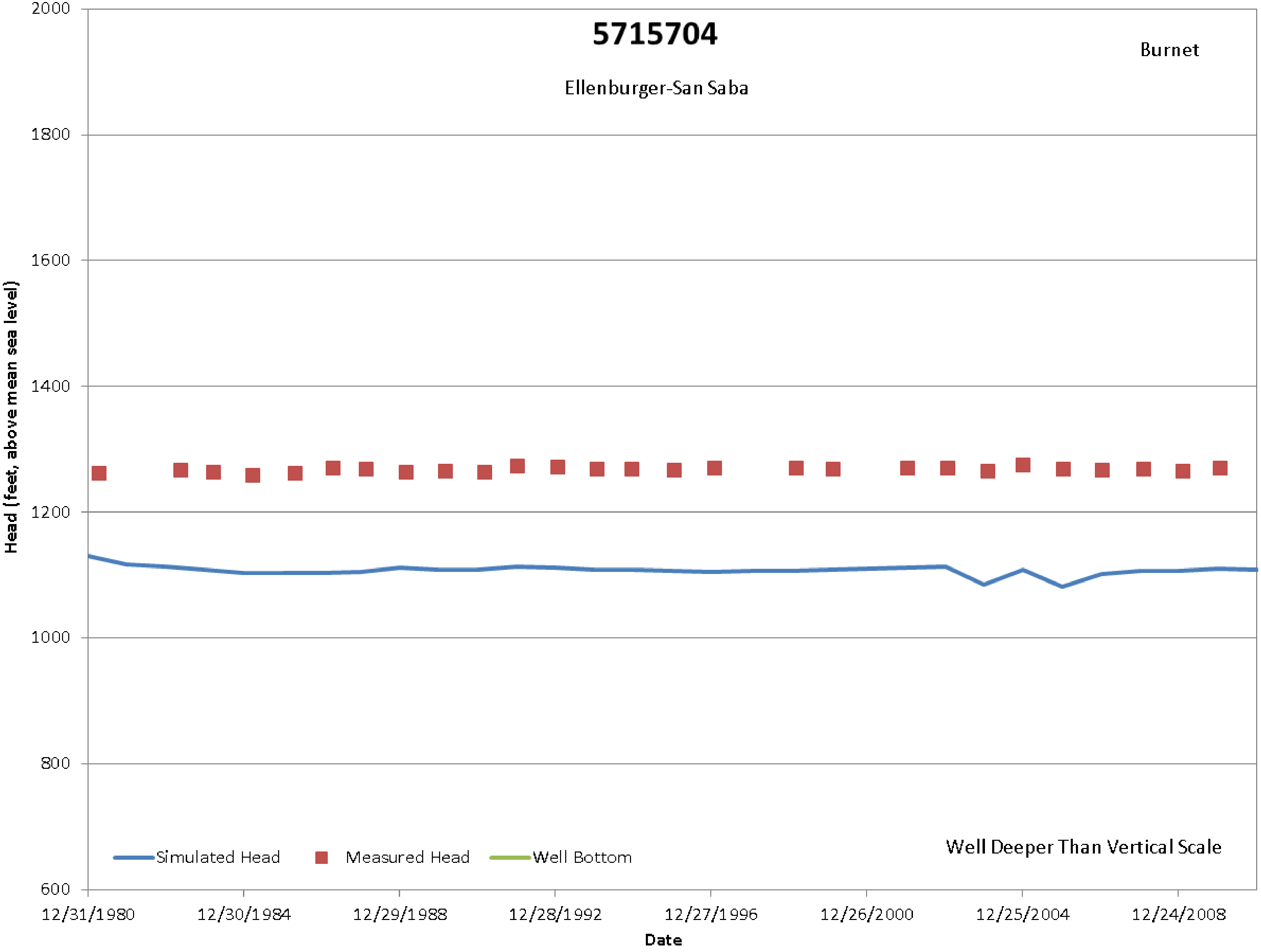


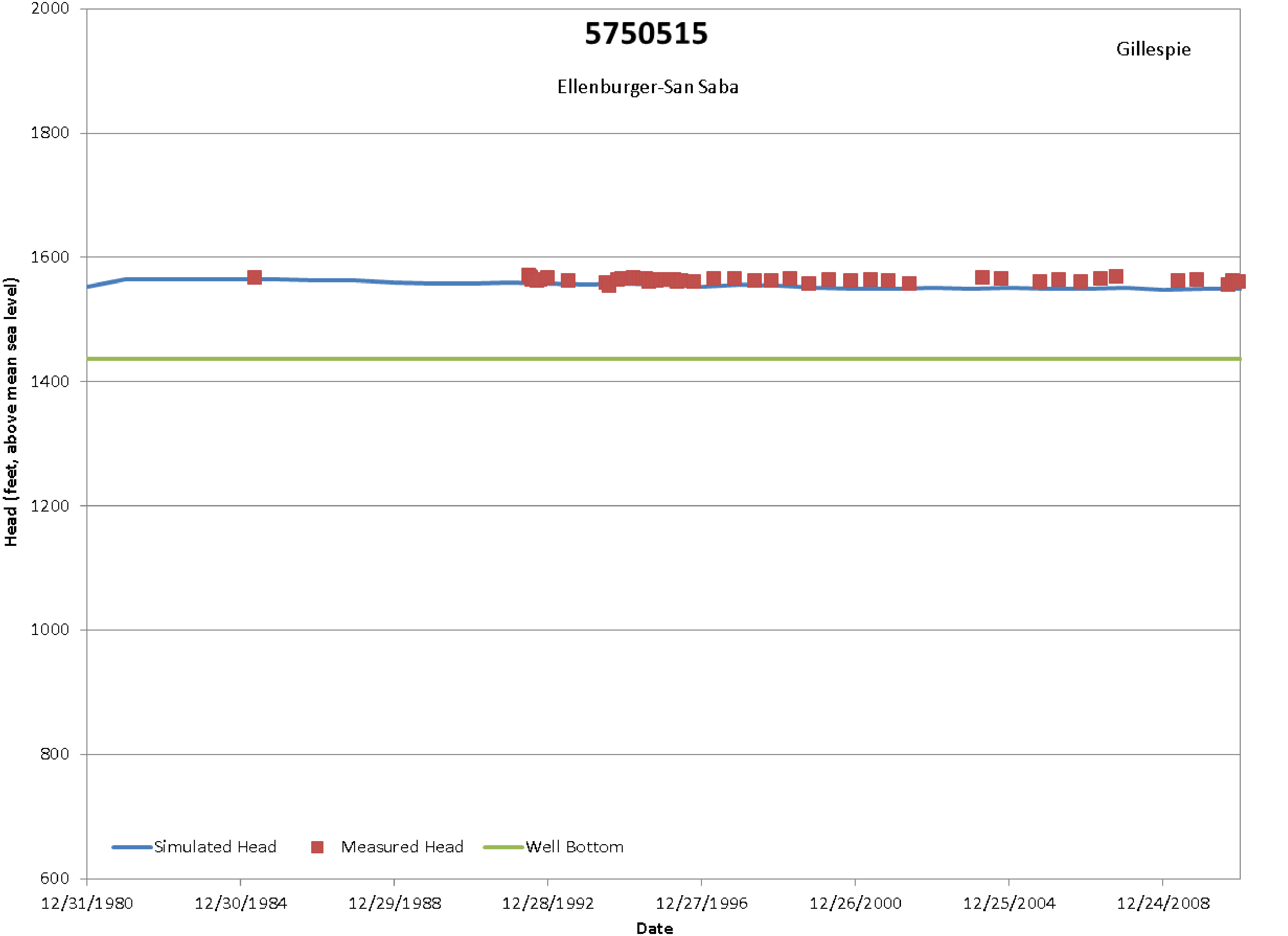
4163401
Lampasas
Marble Falls
Head (feet, above mean sea level)
2000
1800
1600
1400
1200
1000
800
600
Simulated Head
Measured Head
Well Bottom
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date


4151404
San Saba
Marble Falls
Head (feet, above mean sea level)
2000
1800
1600
1400
1200
1000
800
600
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date
Simulated Head
Measured Head
Well Bottom

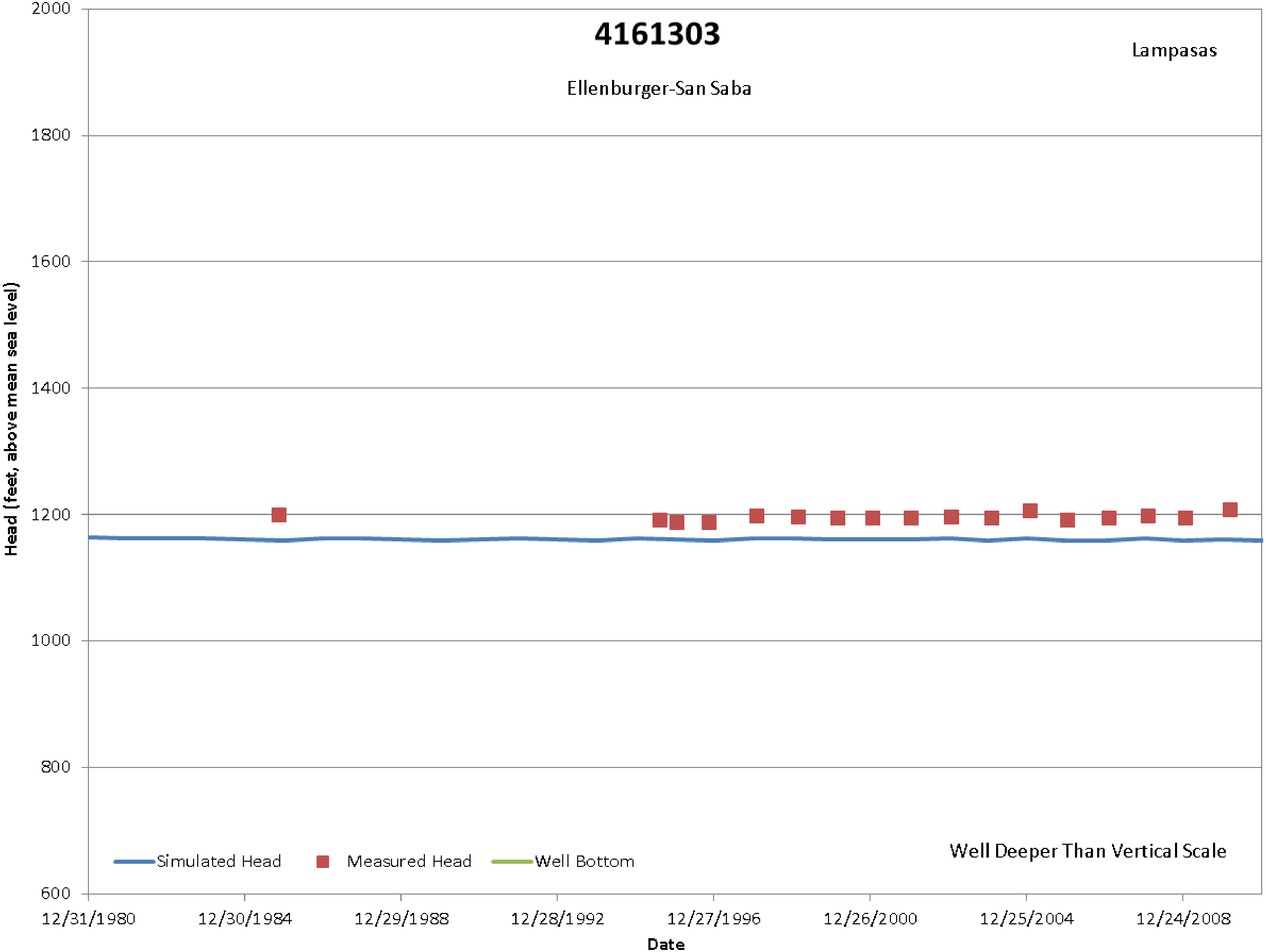


5753302
Blanco
Ellenburger-San Saba
Head (feet, above mean sea level)
2000
1800
1600
1400
1200
1000
800
600
Simulated Head
Measured Head
Well Bottom
Well Deeper Than Vertical Scale
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date

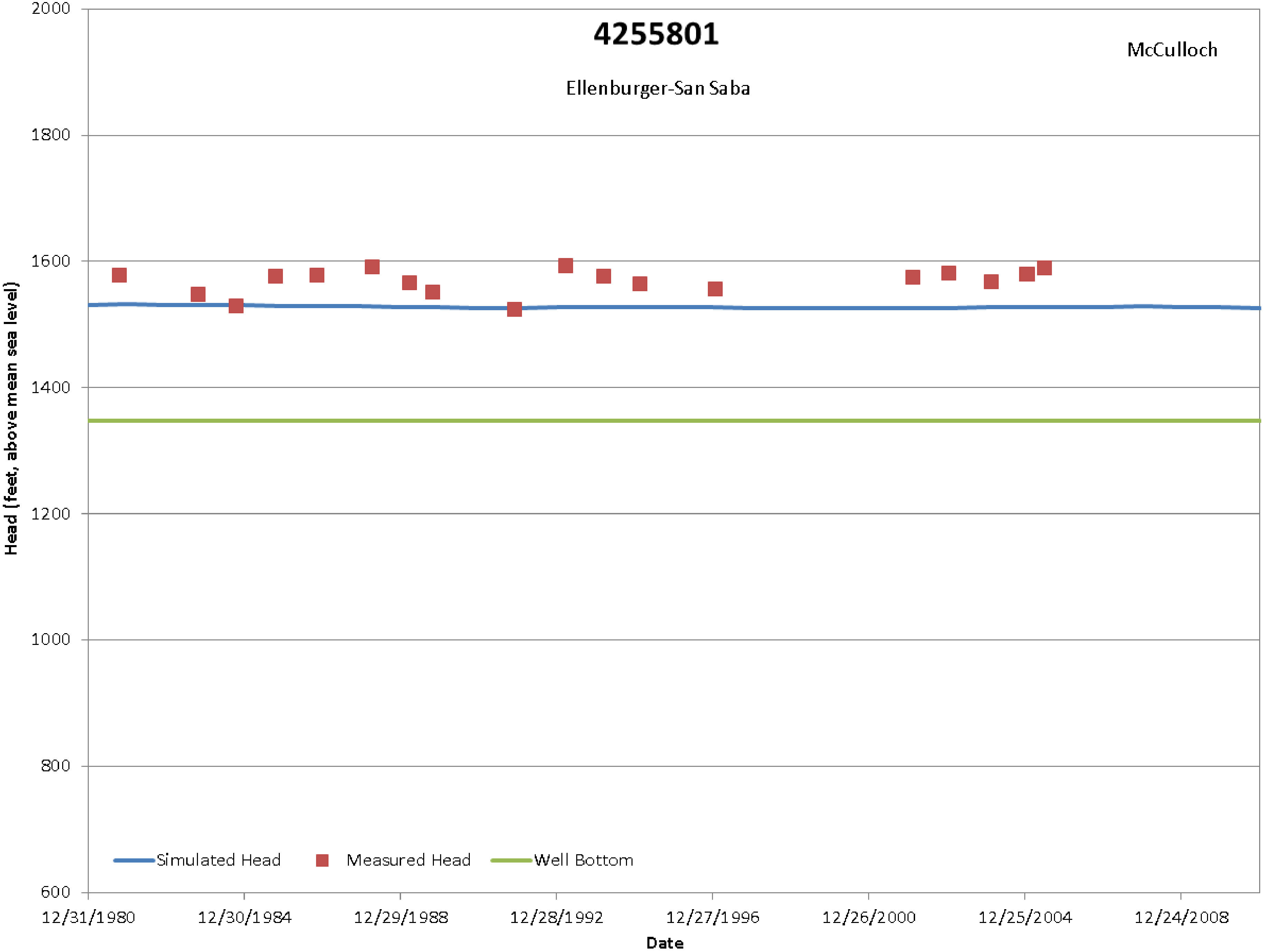

5715704
Burnet
Ellenburger-San Saba
Head (feet, above mean sea level)
2000
1800
1600
1400
1200
1000
800
600
Well Deeper Than Vertical Scale
Simulated Head
Measured Head
Well Bottom
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date



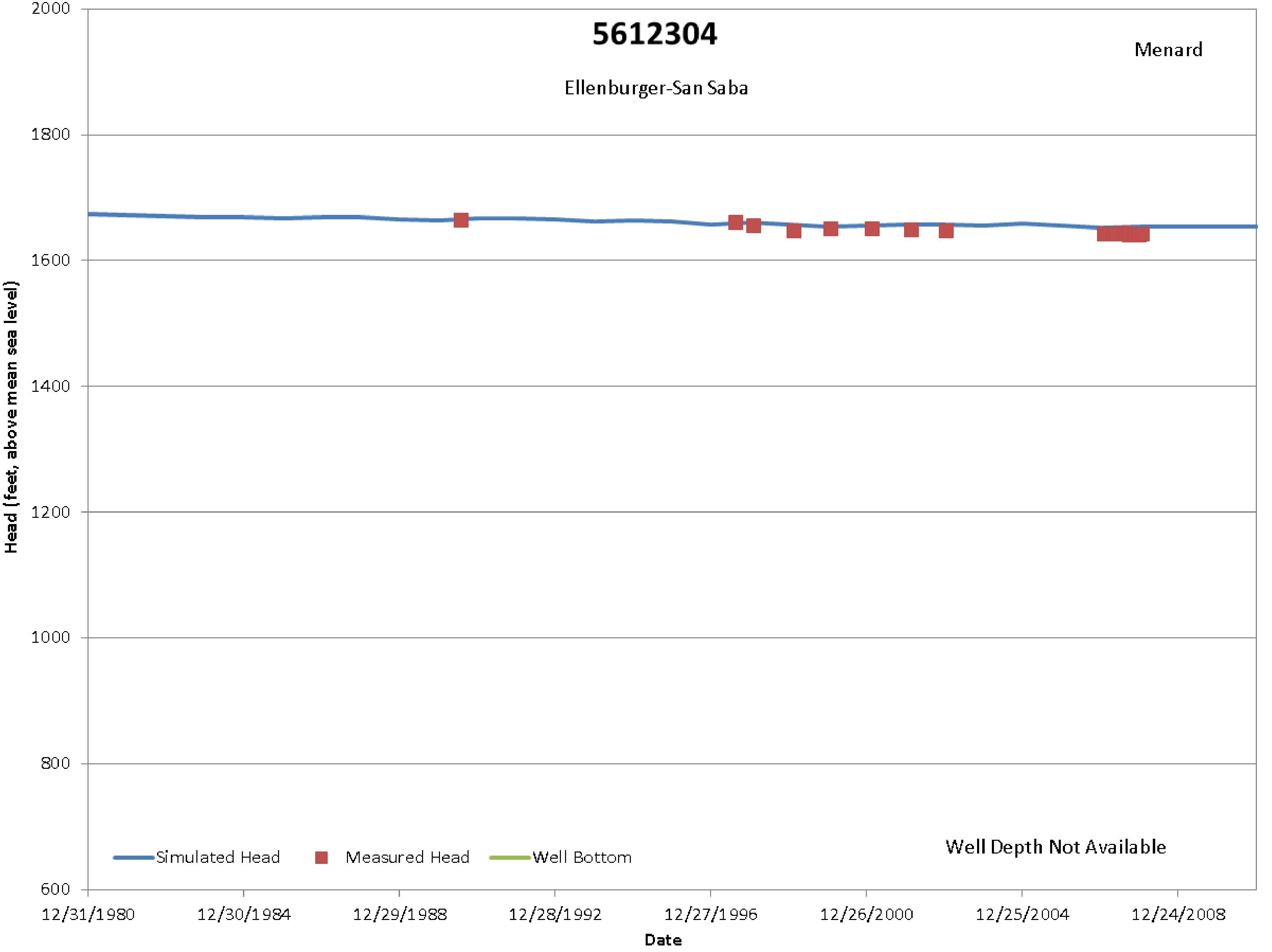
5750515
Gillespie
Ellenburger-San Saba
Head (feet, above mean sea level)
2000
1800
1600
1400
1200
1000
800
600
Simulated Head
Measured Head
Well Bottom
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date

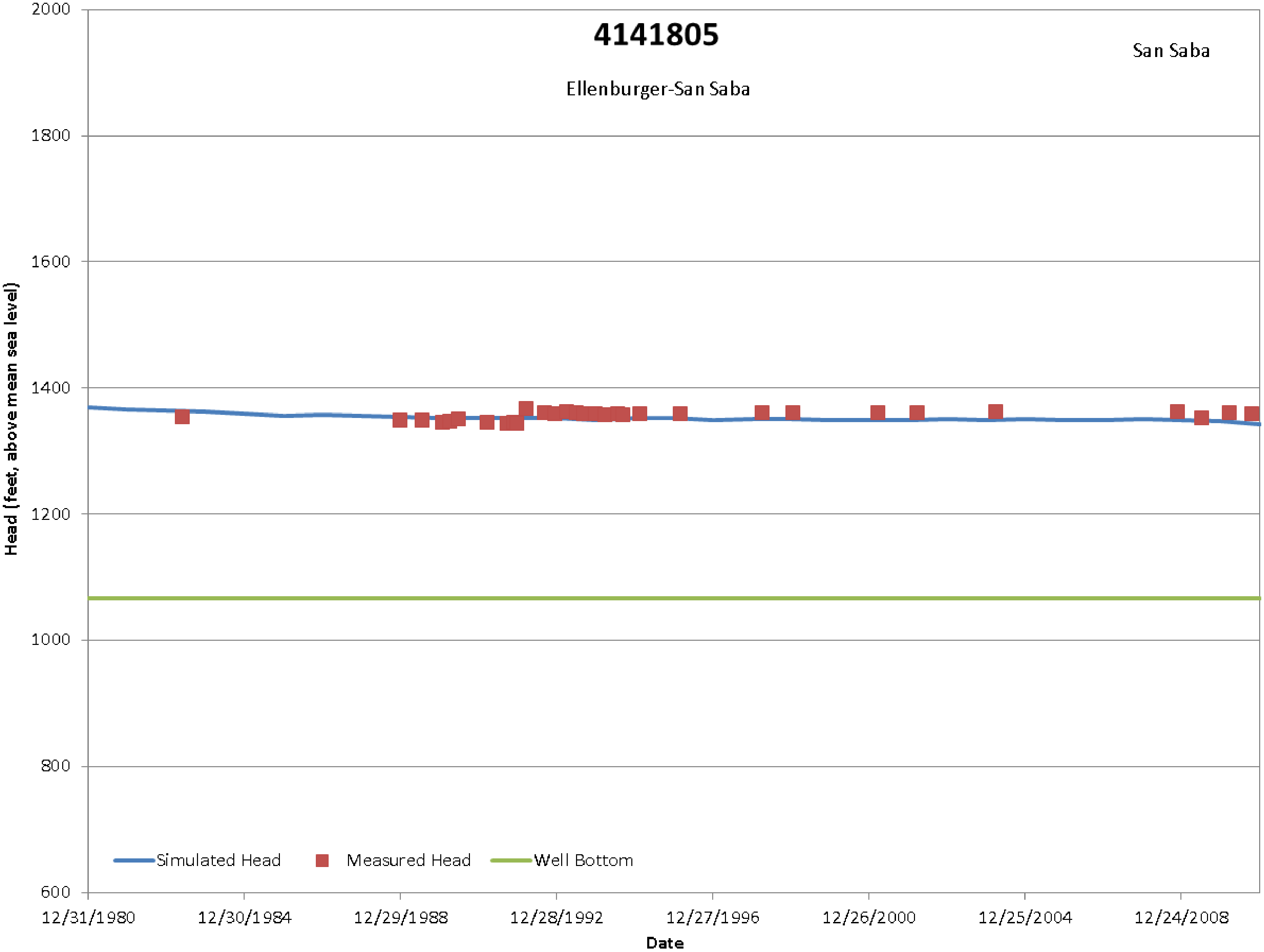


4161303
Lampasas
Ellenburger-San Saba
2000
1800
1600
1400
1200
1000
800
600
Head (feet, above mean sea level)
Simulated Head
Measured Head
Well Bottom
Well Deeper Than Vertical Scale
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date

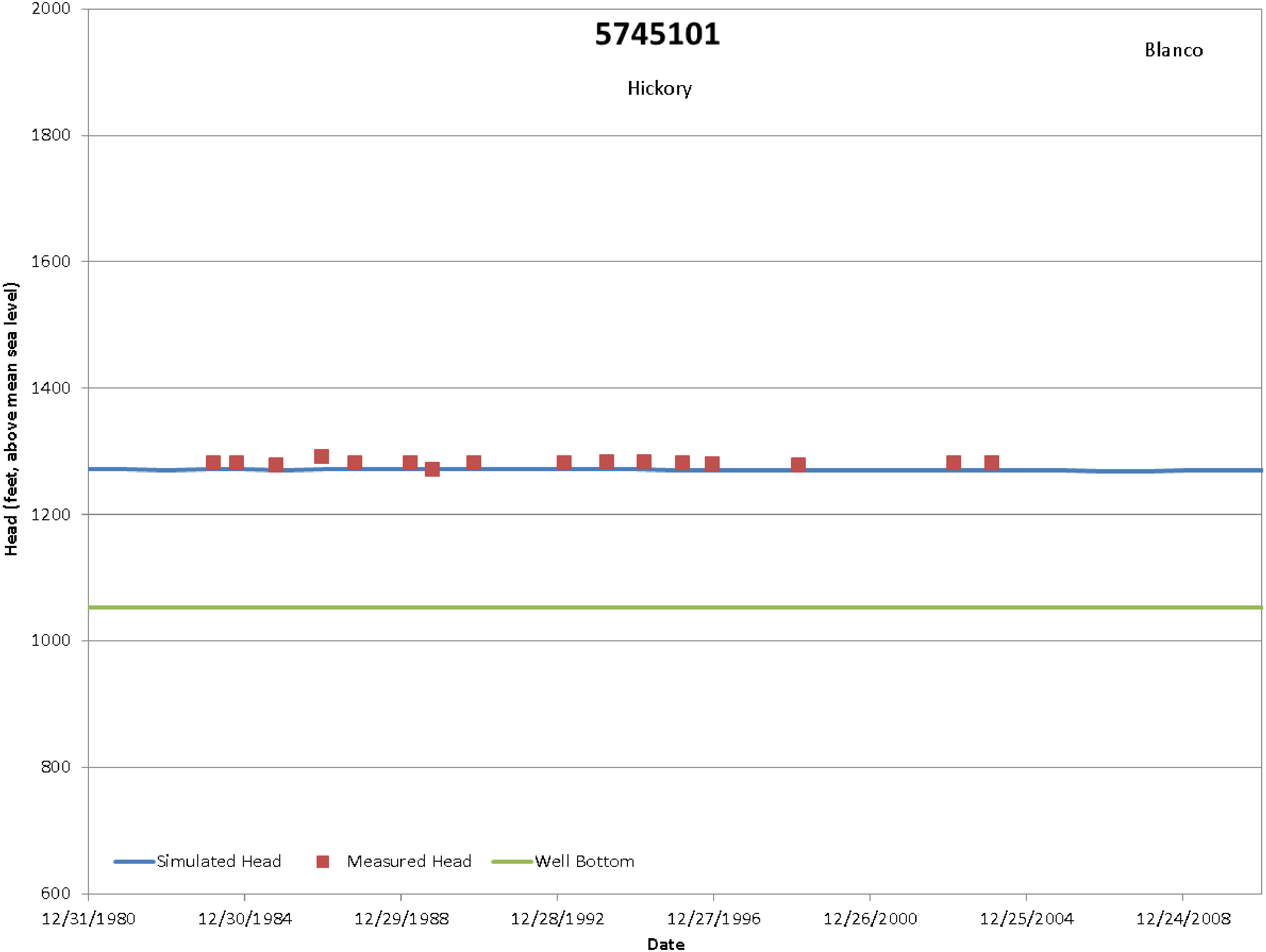


4255801
McCulloch
Ellenburger-San Saba
2000
1800
1600
1400
1200
1000
800
600
Head (feet, above mean sea level)
Simulated Head
Measured Head
Well Bottom
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date

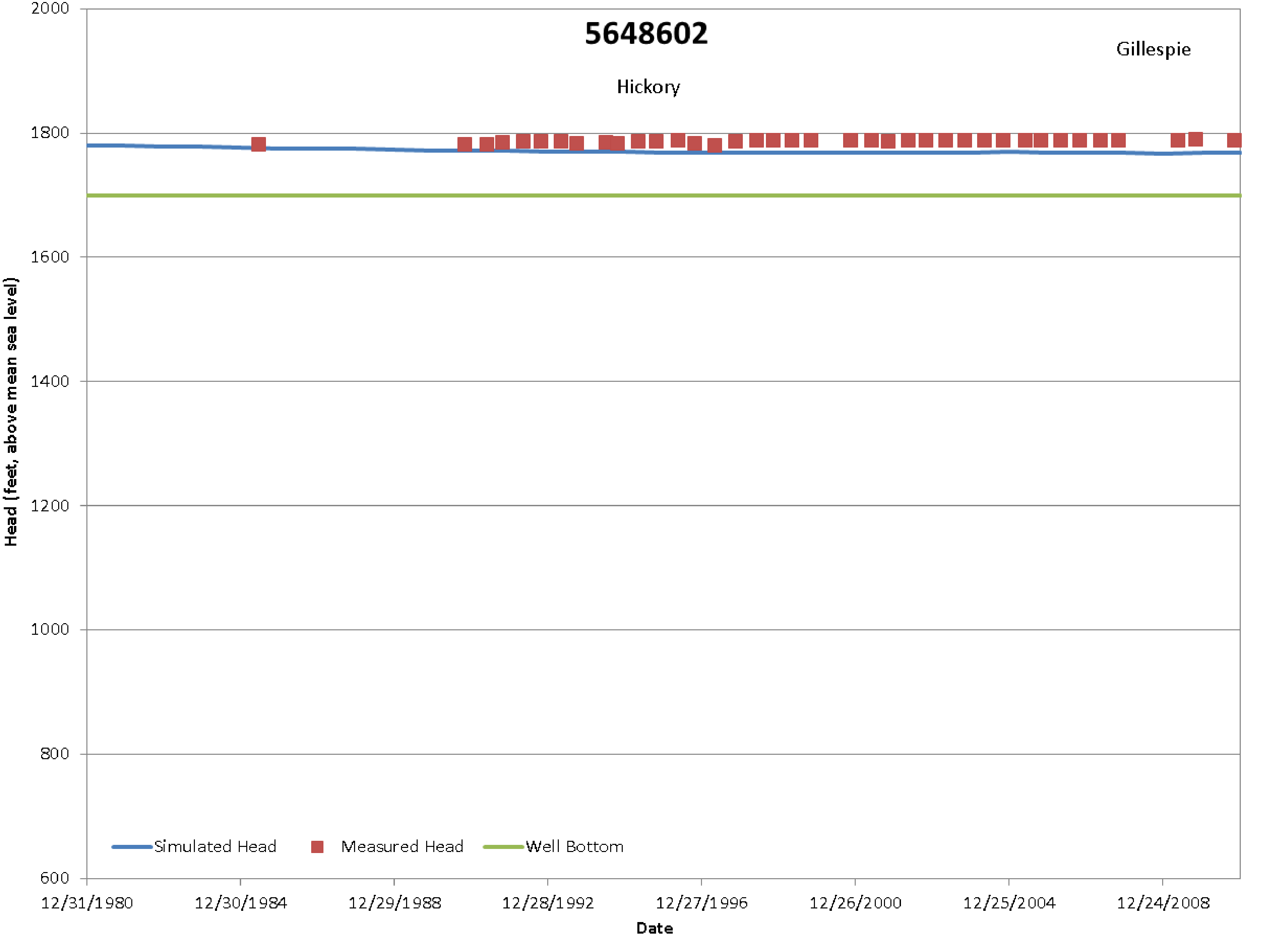

5612304
Menard
Ellenburger-San Saba
Head (feet, above mean sea level)
2000
1800
1600
1400
1200
1000
800
600
Simulated Head
Measured Head
Well Bottom
Well Depth Not Available
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date



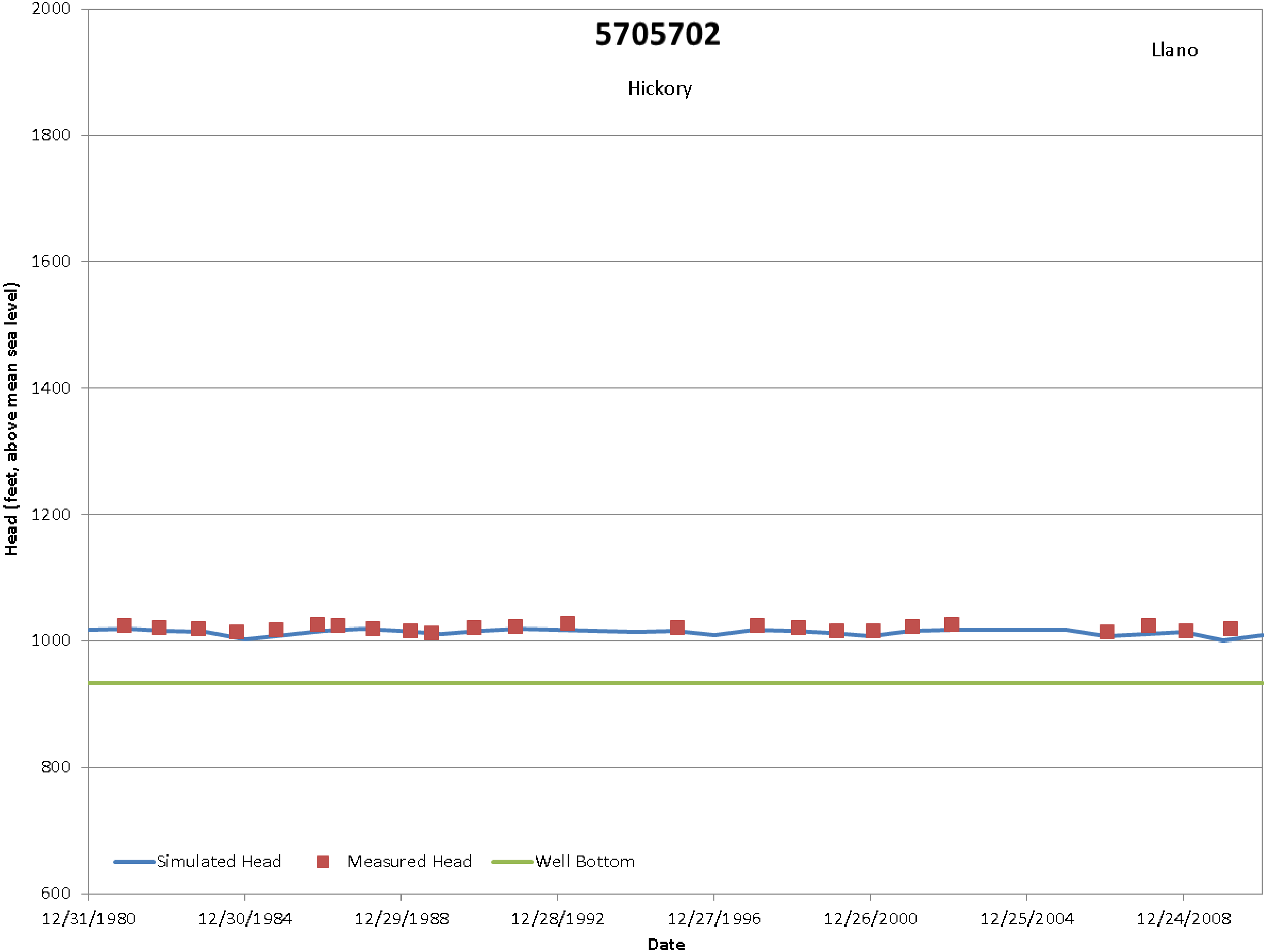
4141805
San Saba
Ellenburger-San Saba
Head (feet, above mean sea level)
2000
1800
1600
1400
1200
1000
800
600
Simulated Head
Measured Head
Well Bottom
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date

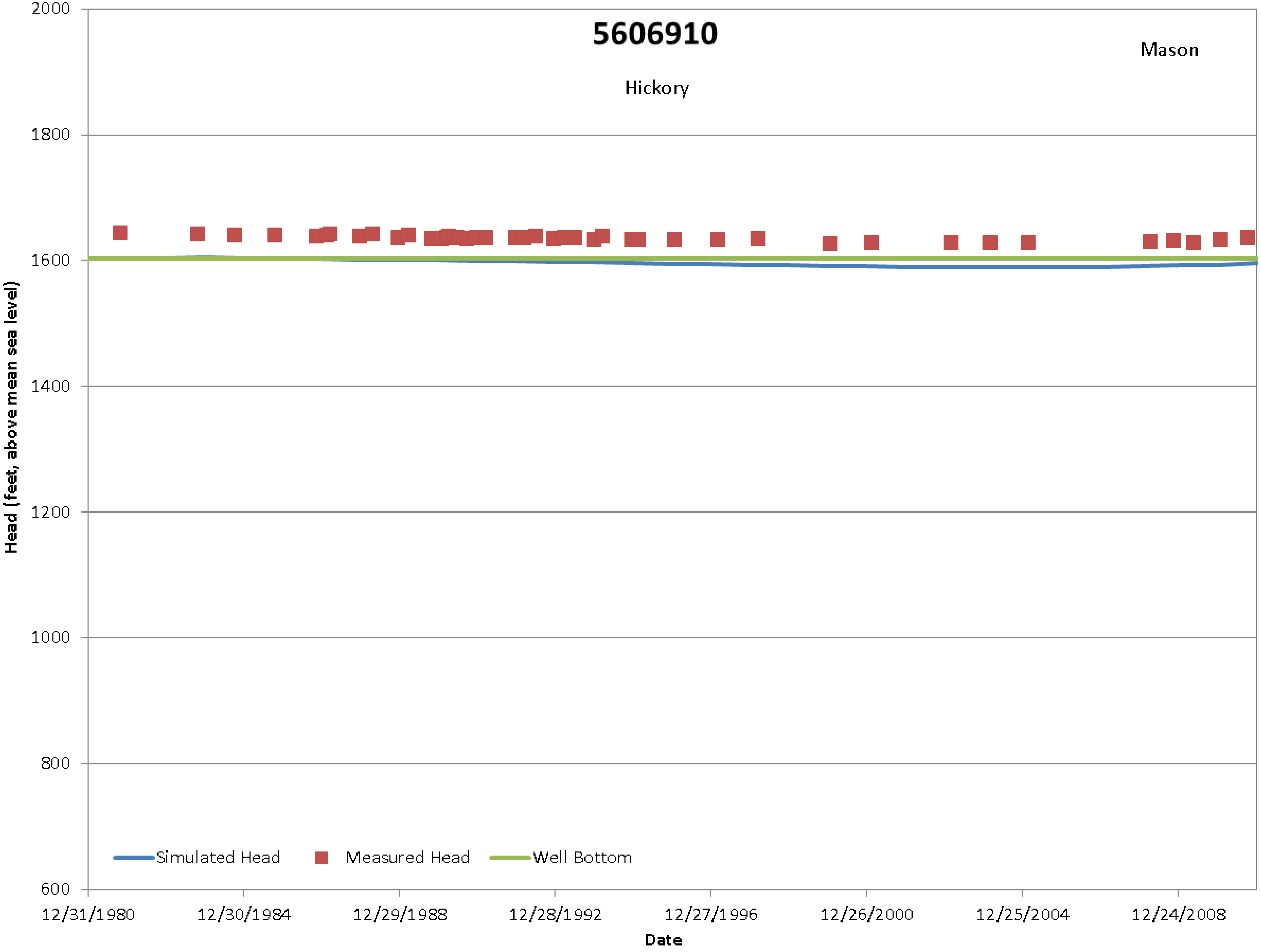


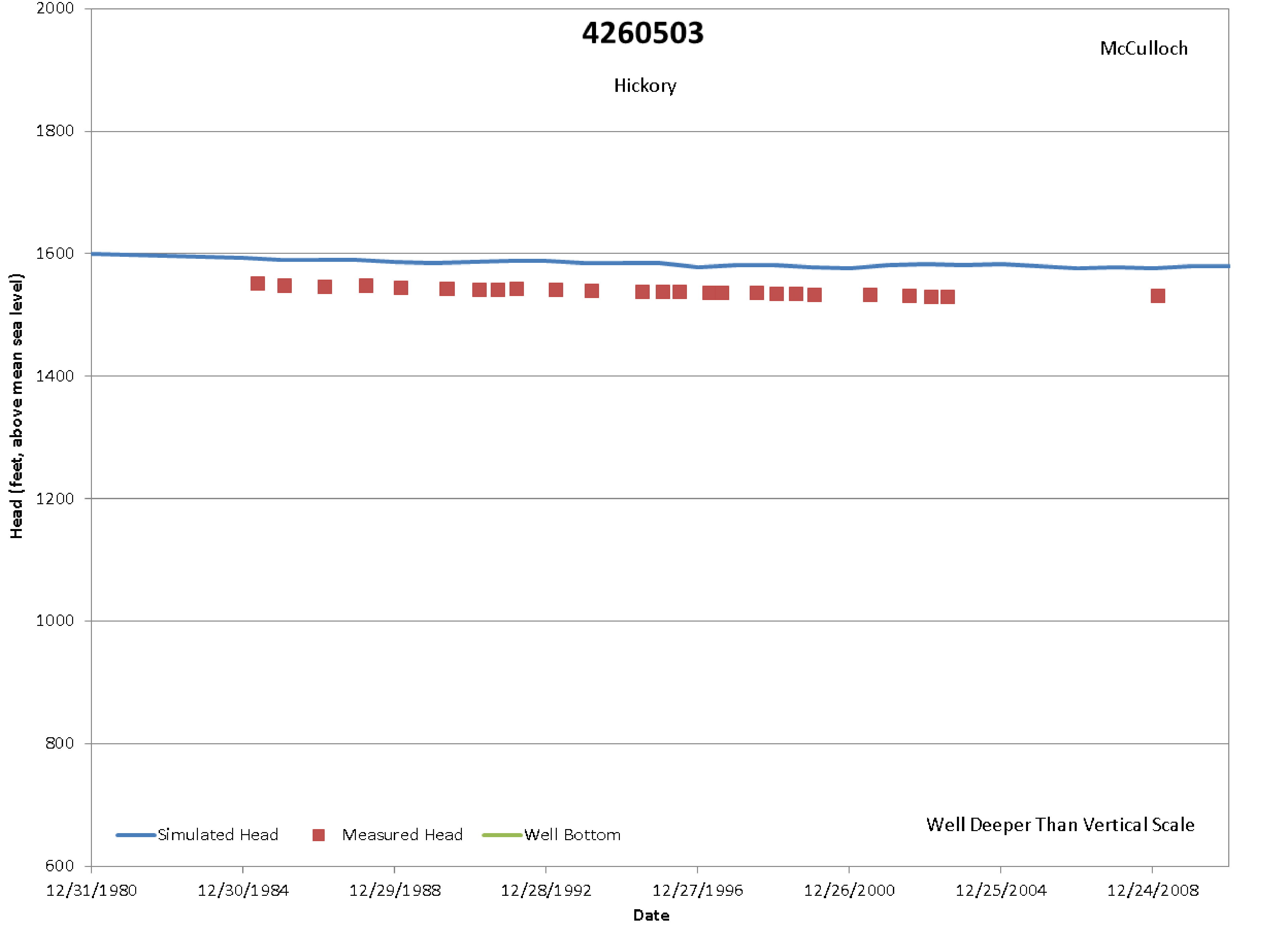
5745101
Hickory
Blanco
Head (feet, above mean sea level)
2000
1800
1600
1400
1200
1000
800
600
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date
Simulated Head
Measured Head
Well Bottom



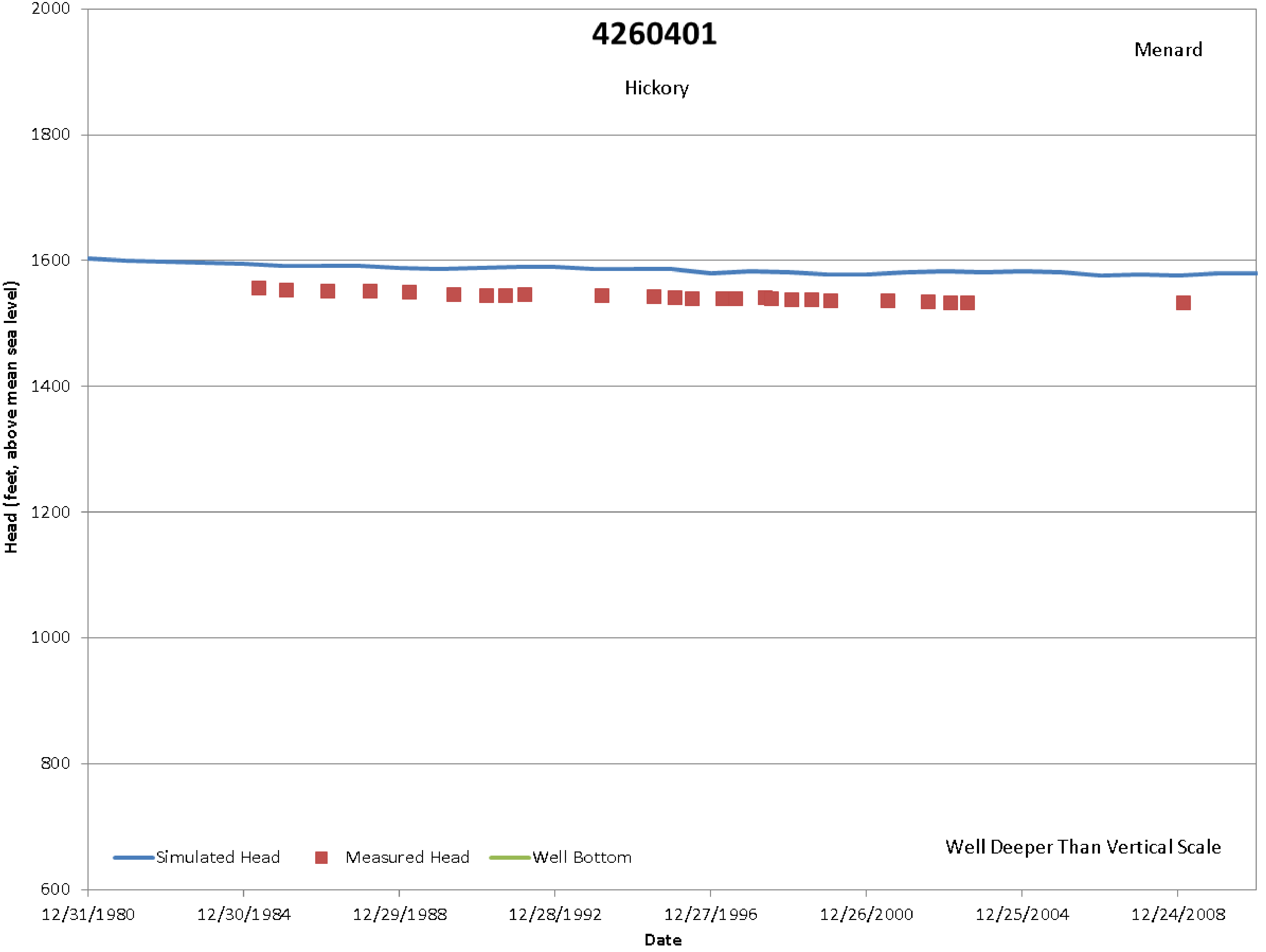
5648602
Gillespie
Hickory
2000
1800
1600
1400
1200
1000
800
600
Head (feet, above mean sea level)
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date
Simulated Head
Measured Head
Well Bottom

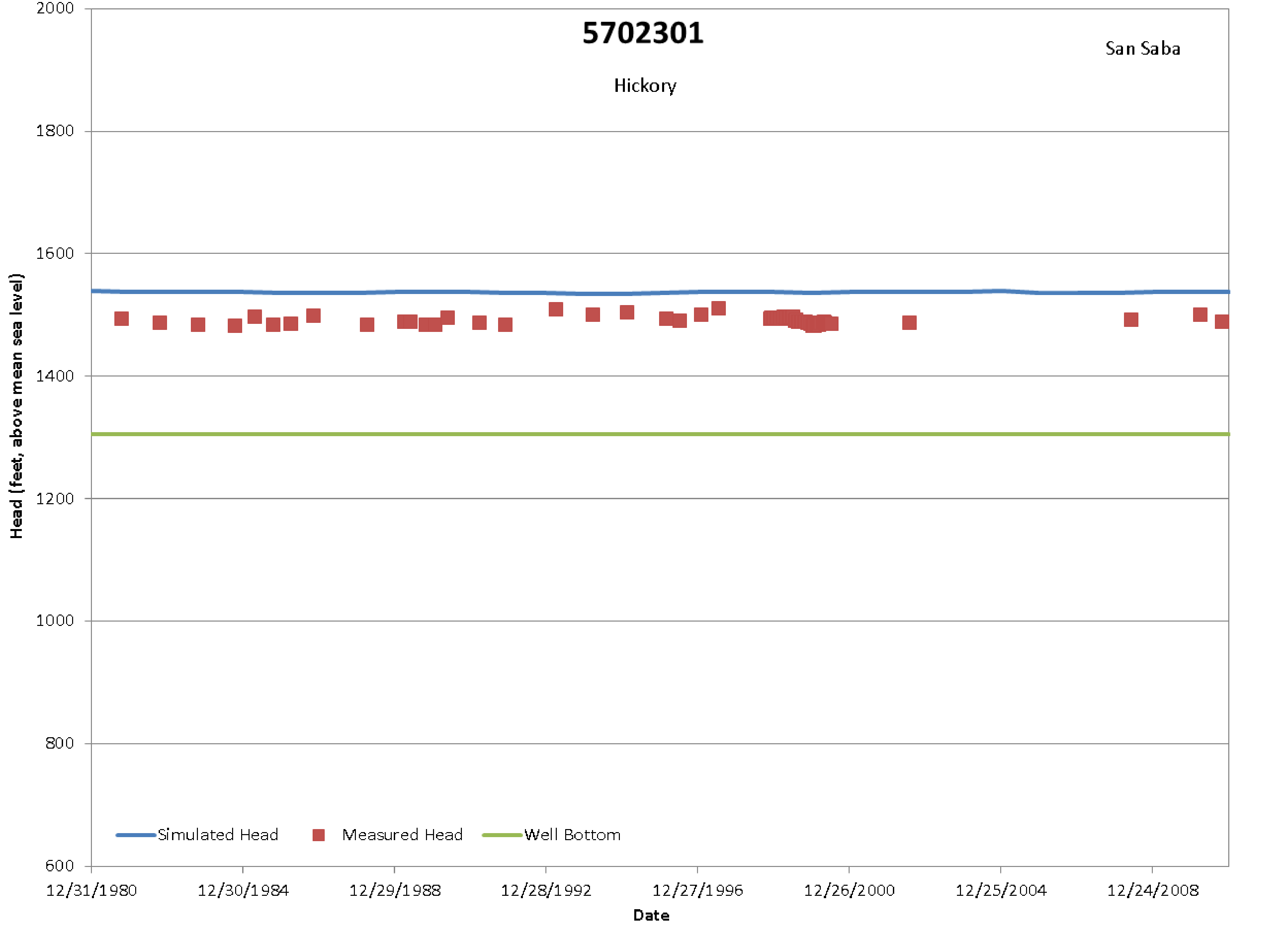

5705702
Hickory
Llano
Head (feet, above mean sea level)
2000
1800
1600
1400
1200
1000
800
600
Simulated Head
Measured Head
Well Bottom
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date


5606910
Mason
Hickory
2000
1800
1600
1400
1200
1000
800
600
Head (feet, above mean sea level)
Simulated Head
Measured Head
Well Bottom
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date



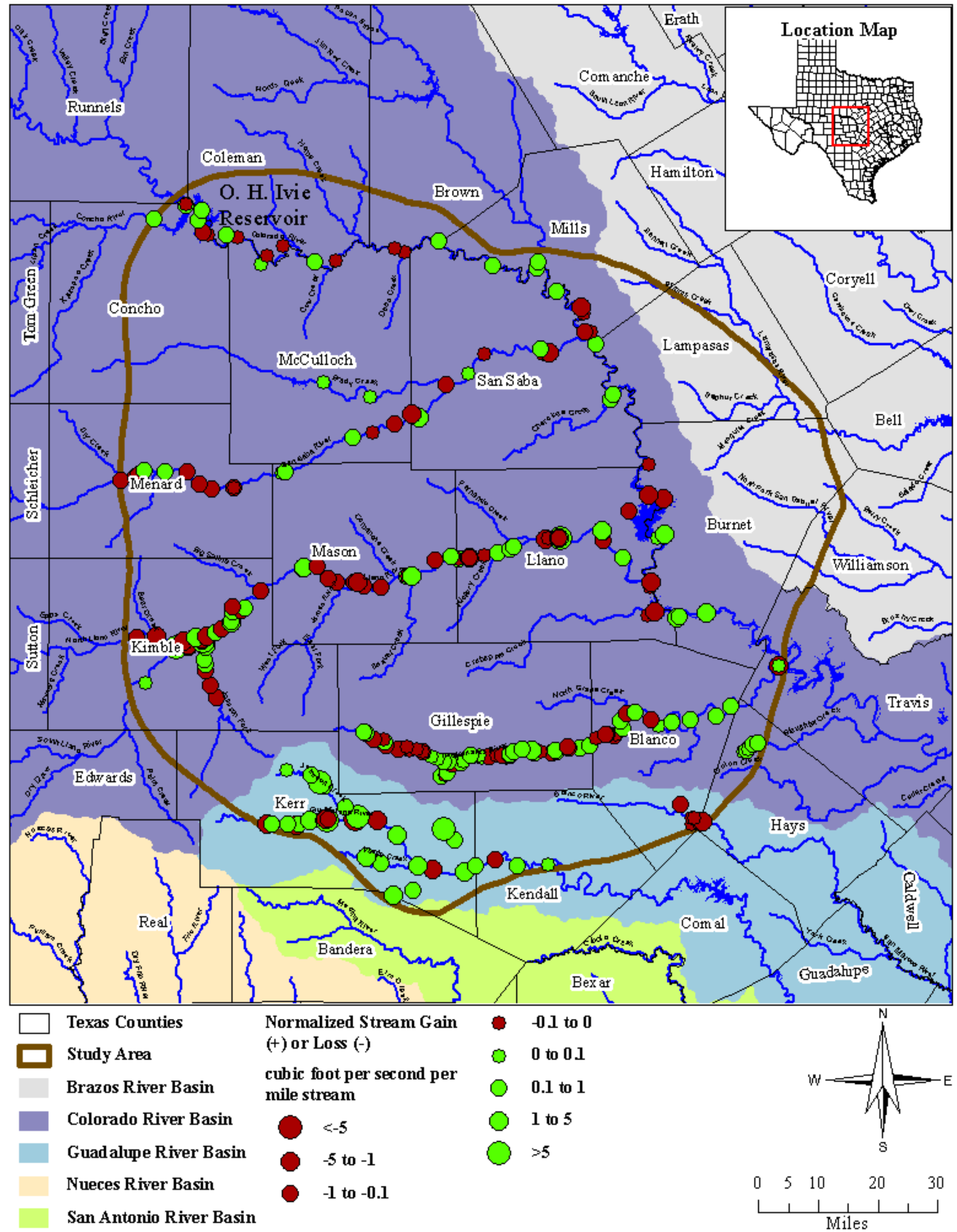
4260503
McCulloch
Hickory
2000
1800
1600
1400
1200
1000
800
600
Head (feet, above mean sea level)
Simulated Head
Measured Head
Well Bottom
Well Deeper Than Vertical Scale
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date


4260401
Menard
Hickory
2000
1800
1600
1400
1200
1000
800
600
Head (feet, above mean sea level)
Simulated Head
Measured Head
Well Bottom
Well Deeper Than Vertical Scale
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date

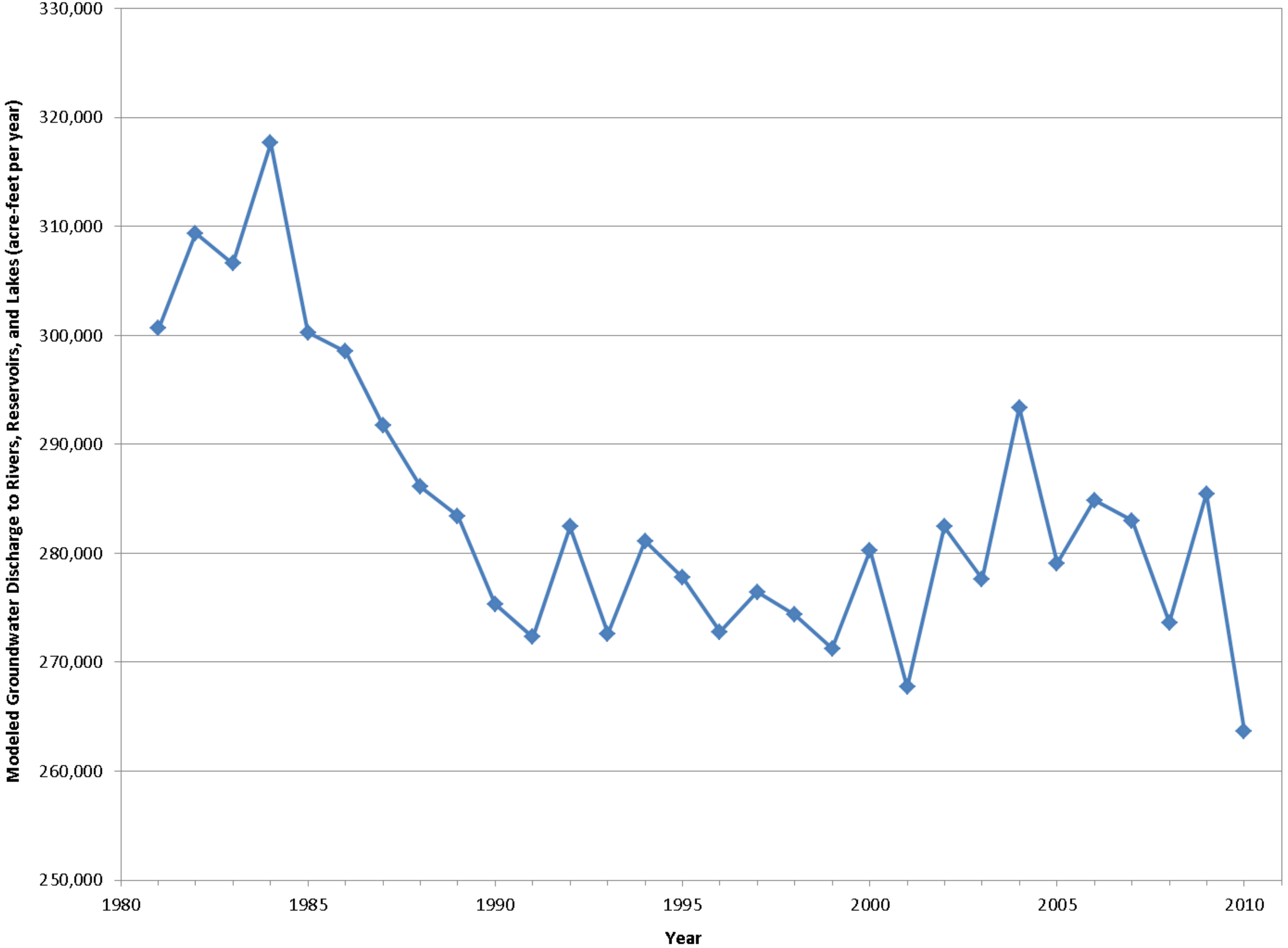

5702301
San Saba
Hickory
2000
1800
1600
1400
1200
1000
800
600
Head (feet, above mean sea level)
Simulated Head
Measured Head
Well Bottom
12/31/1980
12/30/1984
12/29/1988
12/28/1992
12/27/1996
12/26/2000
12/25/2004
12/24/2008
Date

Comparison of River Gain from Groundwater in Colorado and Guadalupe River Basins

River Gain/Loss (Slade and others, 2002)



Modeled River Gain



River Leakage Comparison (acre-feet per year)

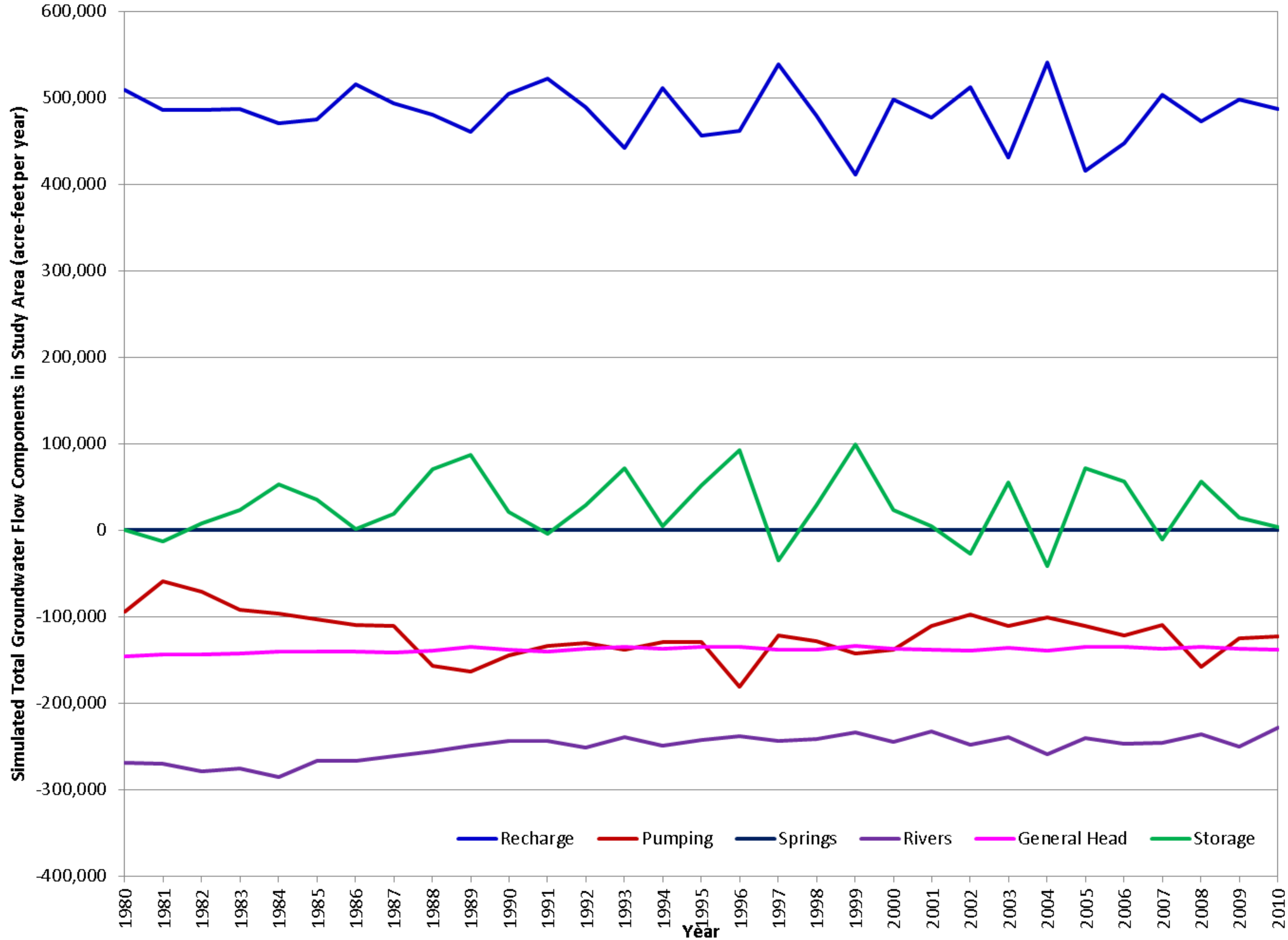
Based on Slade and others (2002)	Based on Model
450,000	284,000 (264,000 to 318,000)

- River gain/loss by Slade and others (2002) was based on data collected primarily before 1950s
- Modeled gain was from 1981 through 2010 when pumping was much higher which reduced base flow

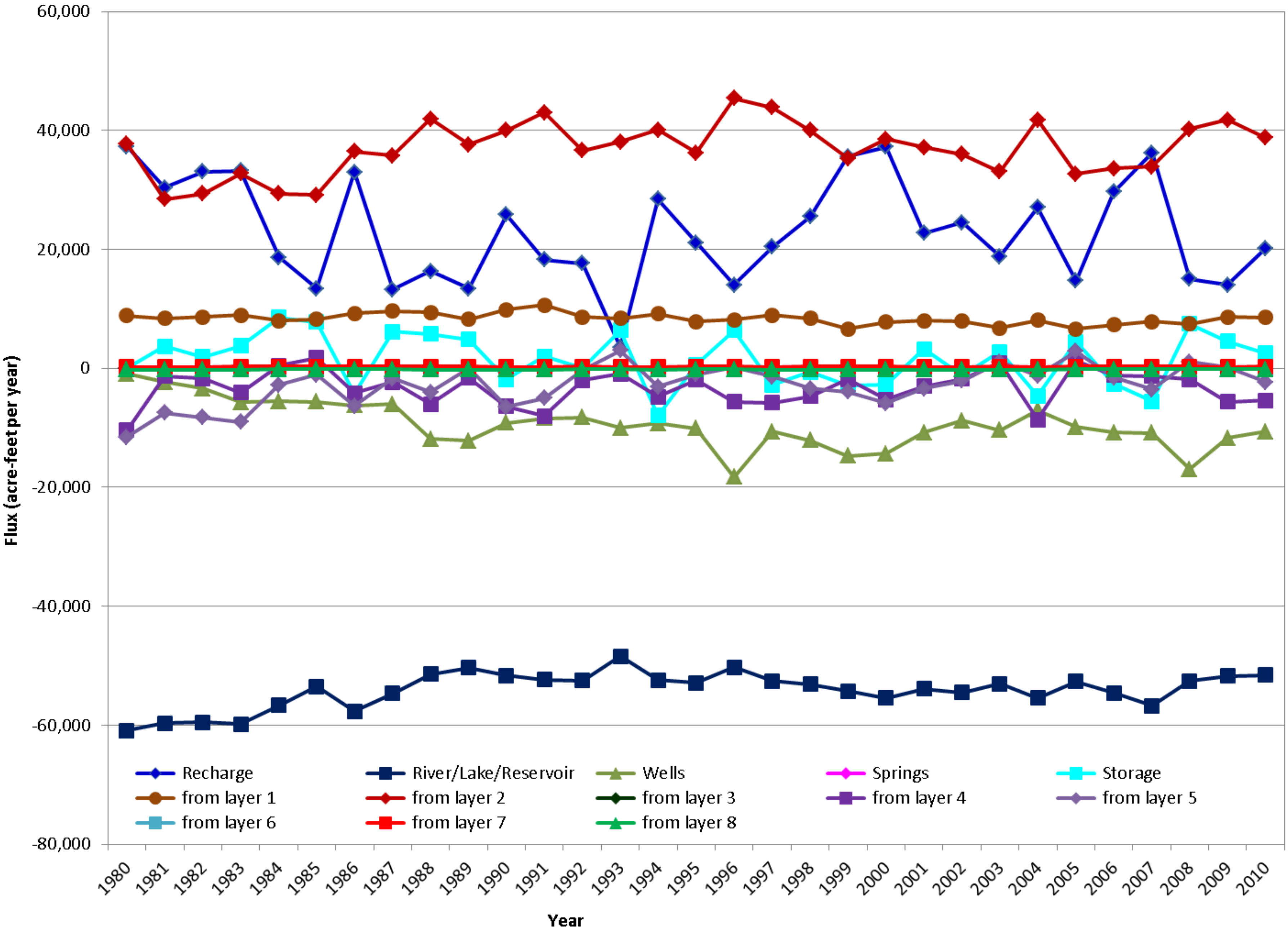
Thus, river gain is expected lower between 1981 and 2010 than Slade and others (2002)

Modeled Water Budget

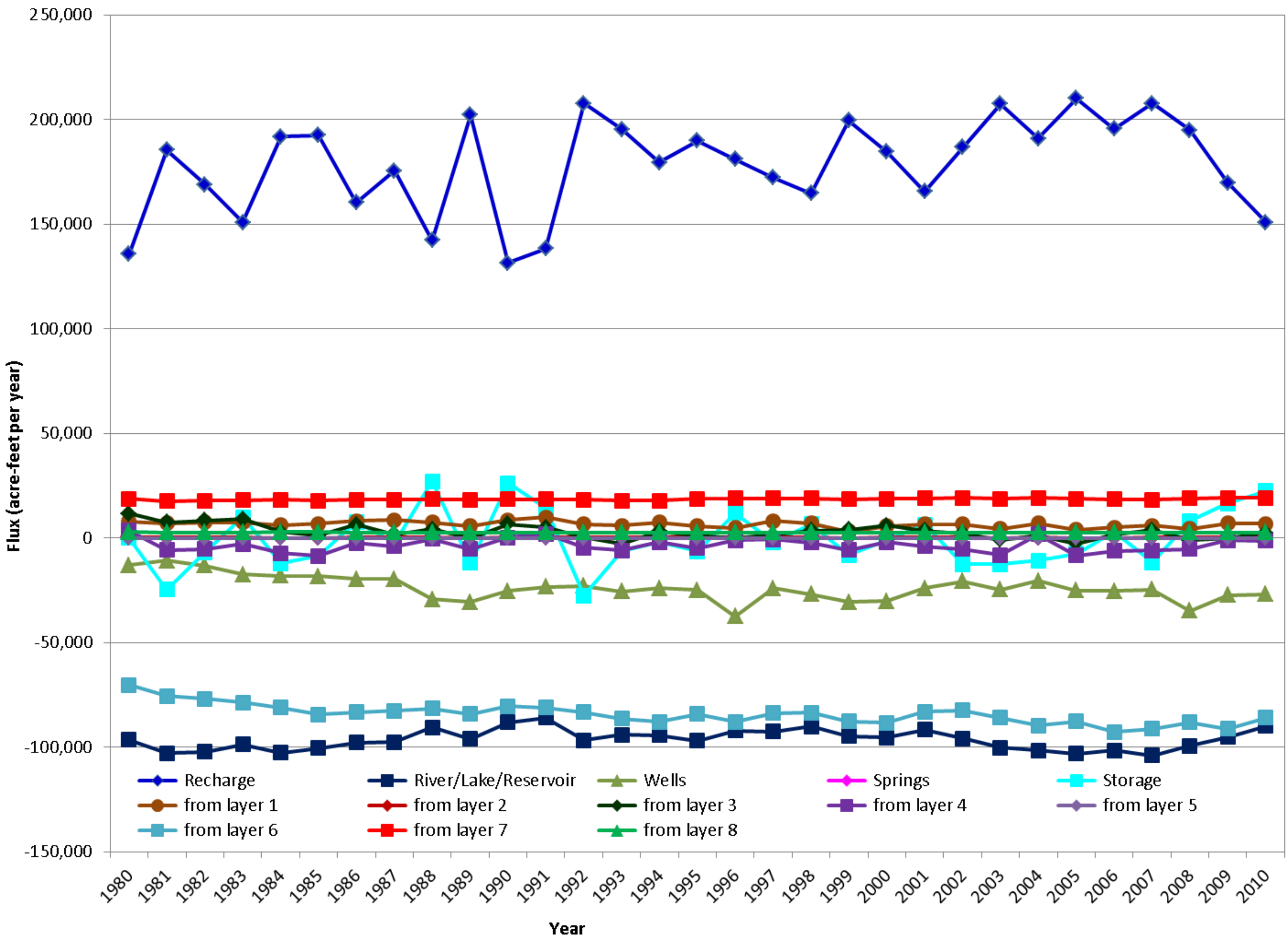
Overall Water Budget



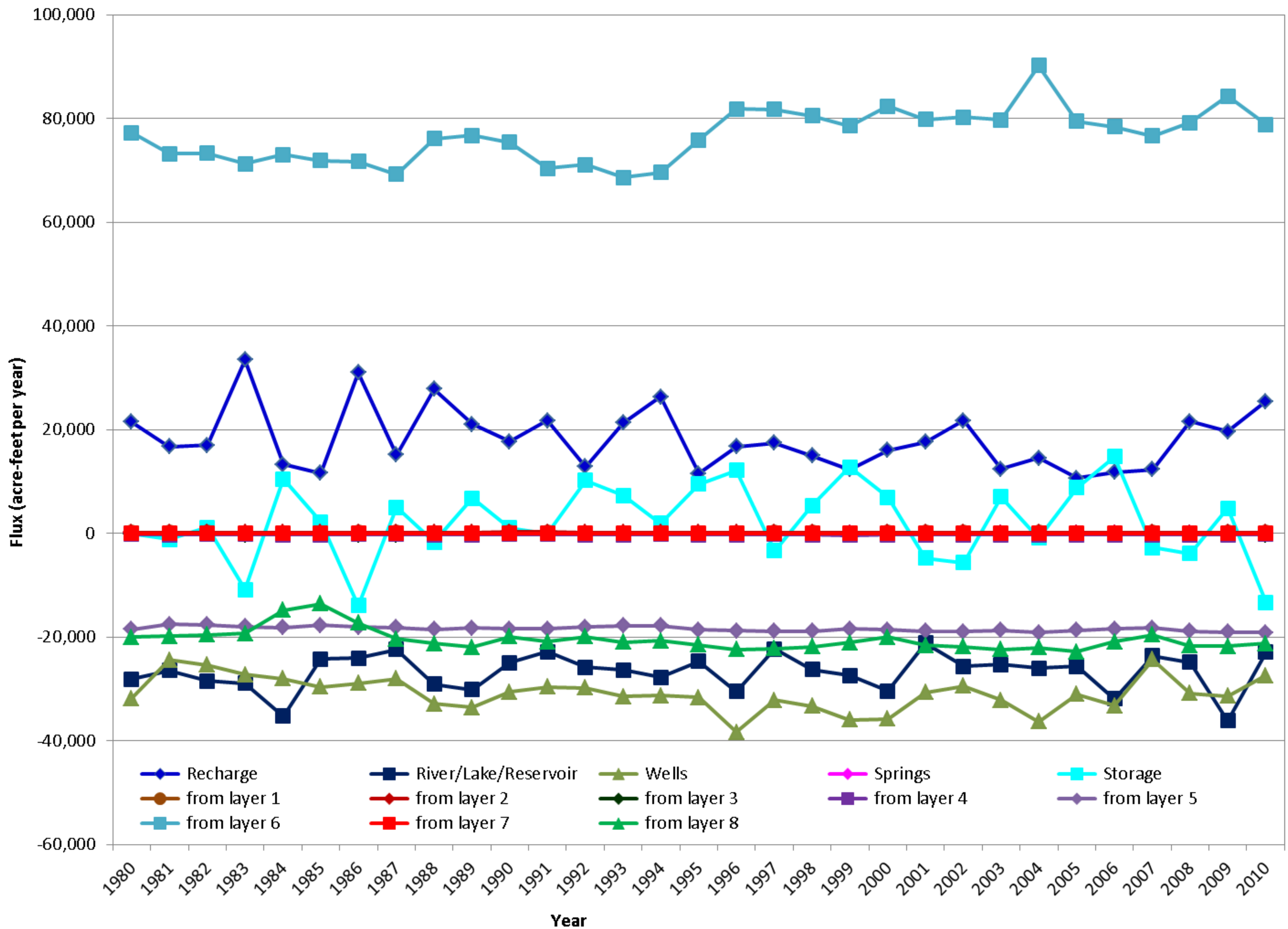
Water Budget for Marble Falls Aquifer/Unit



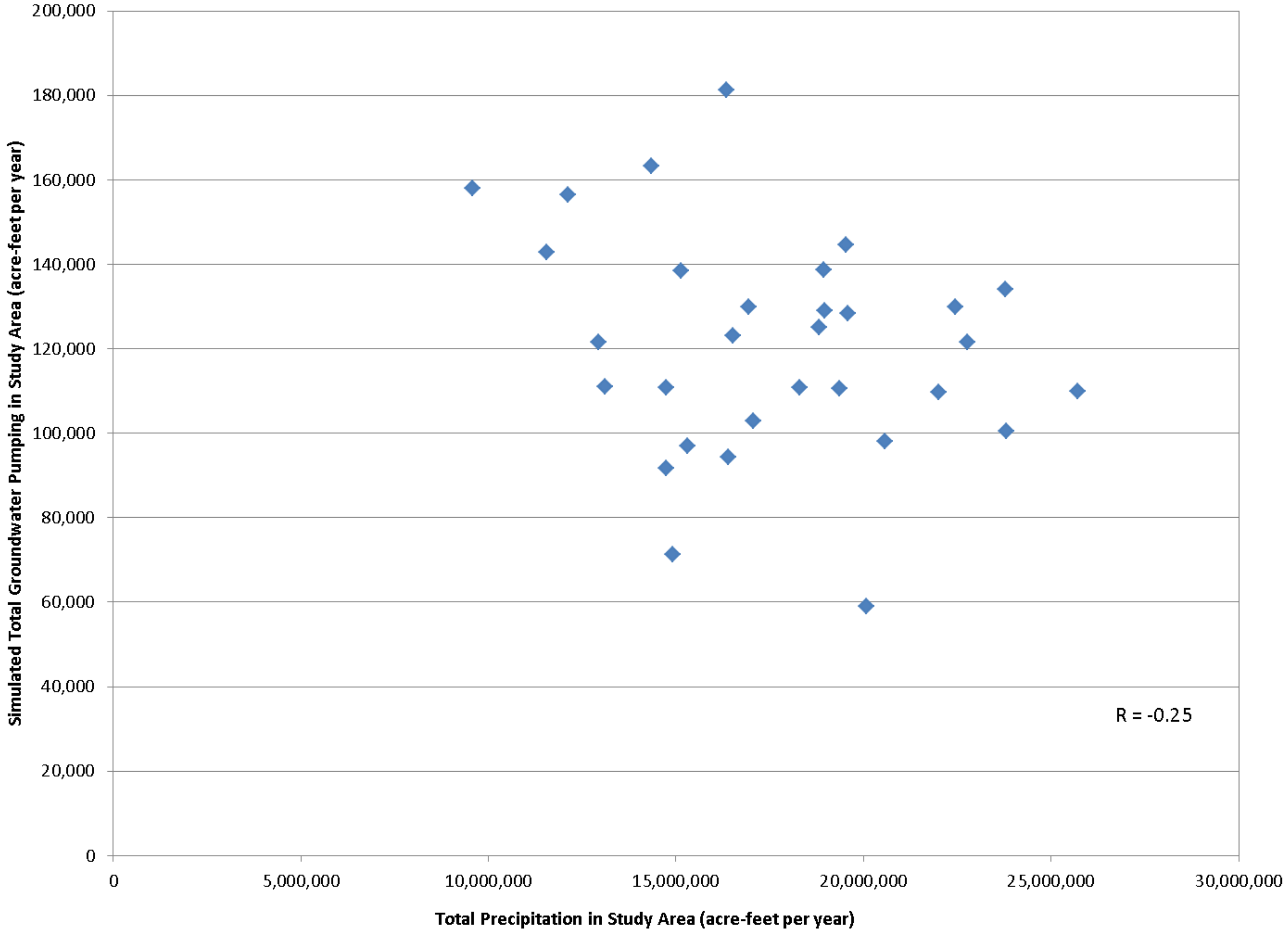
Water Budget for Ellenburger-San Saba Aquifer/Unit



Water Budget for Hickory Aquifer/Unit

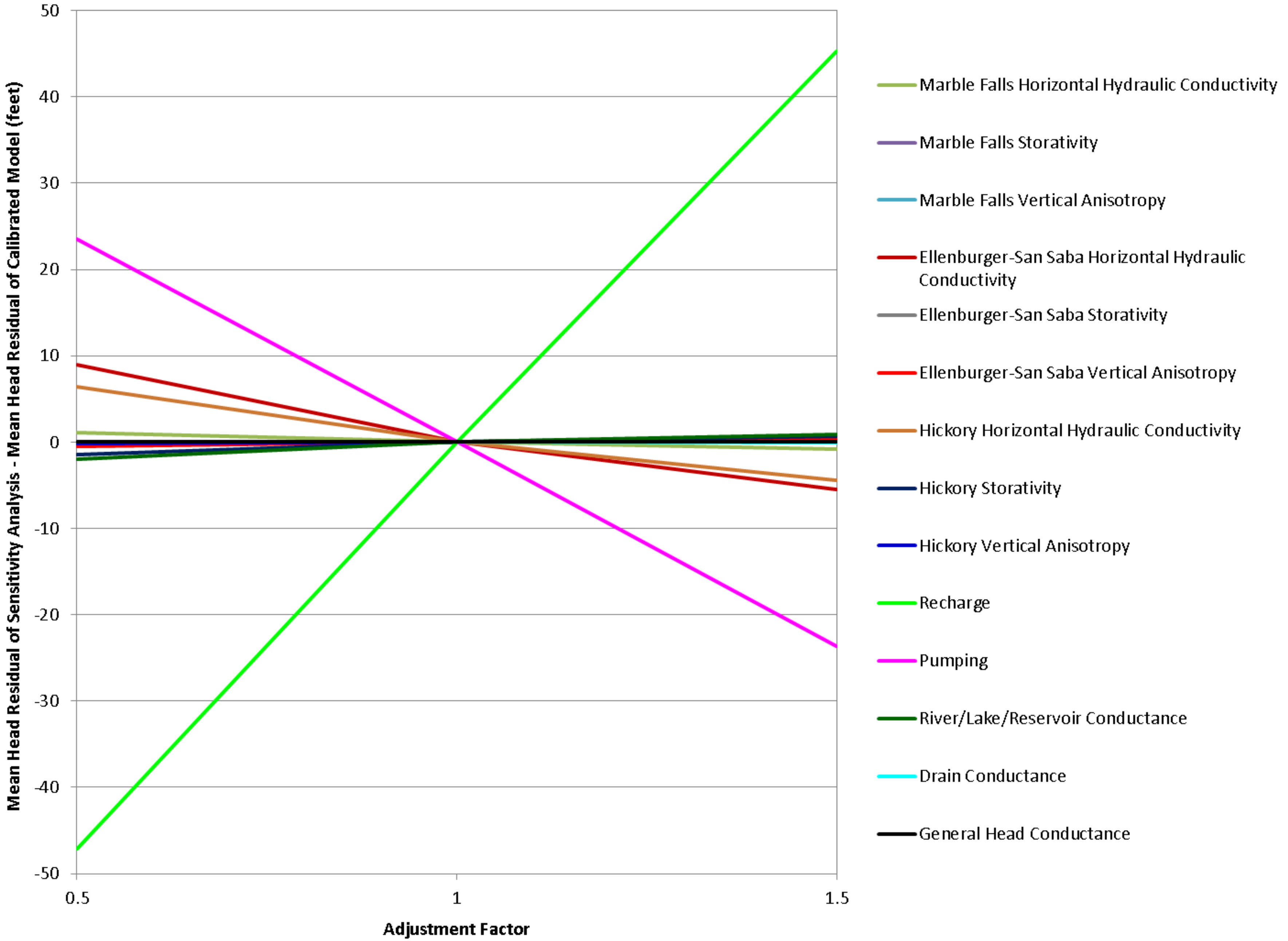


Correlation between Pumping and Recharge

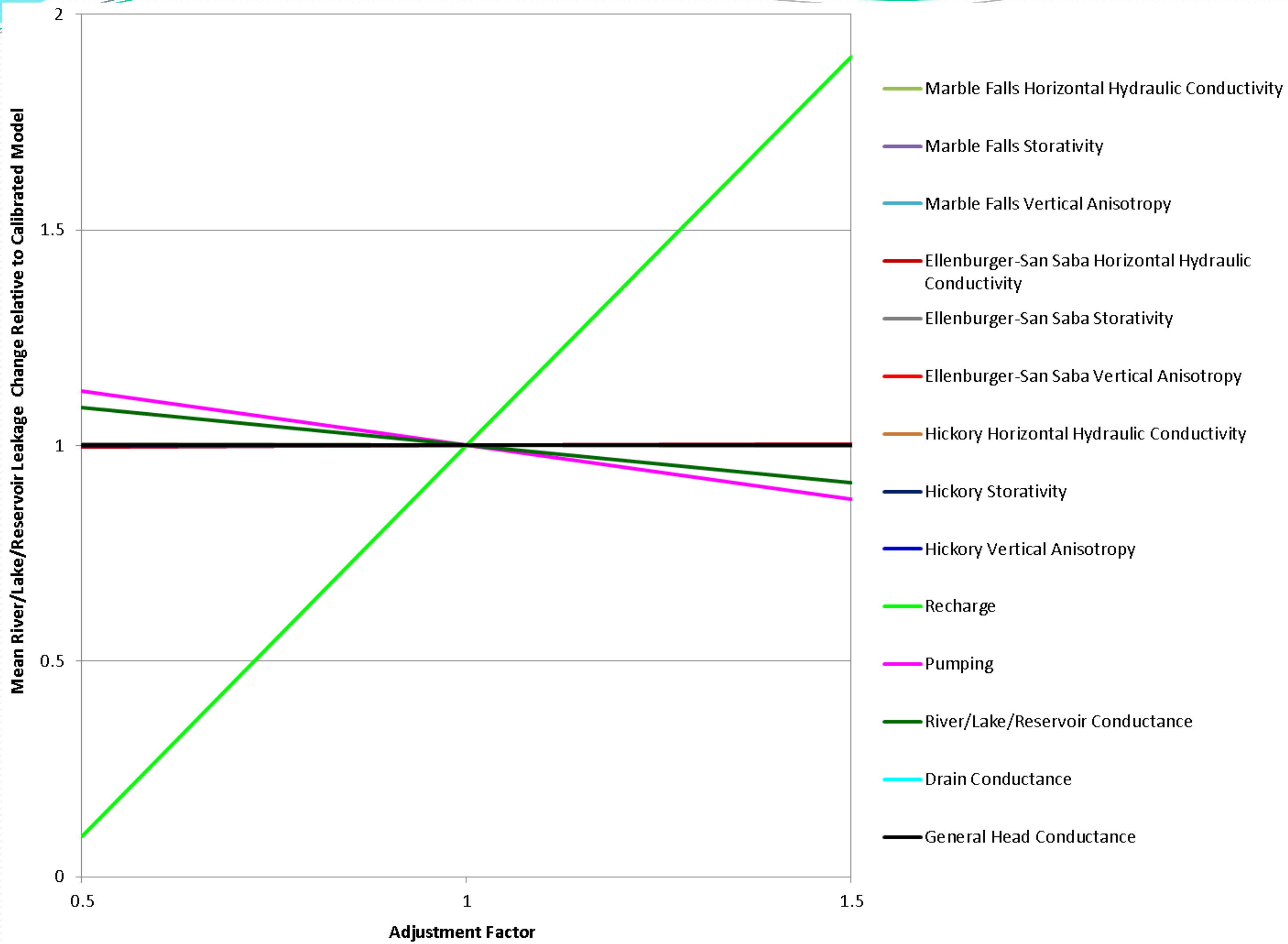


Sensitivity Analysis

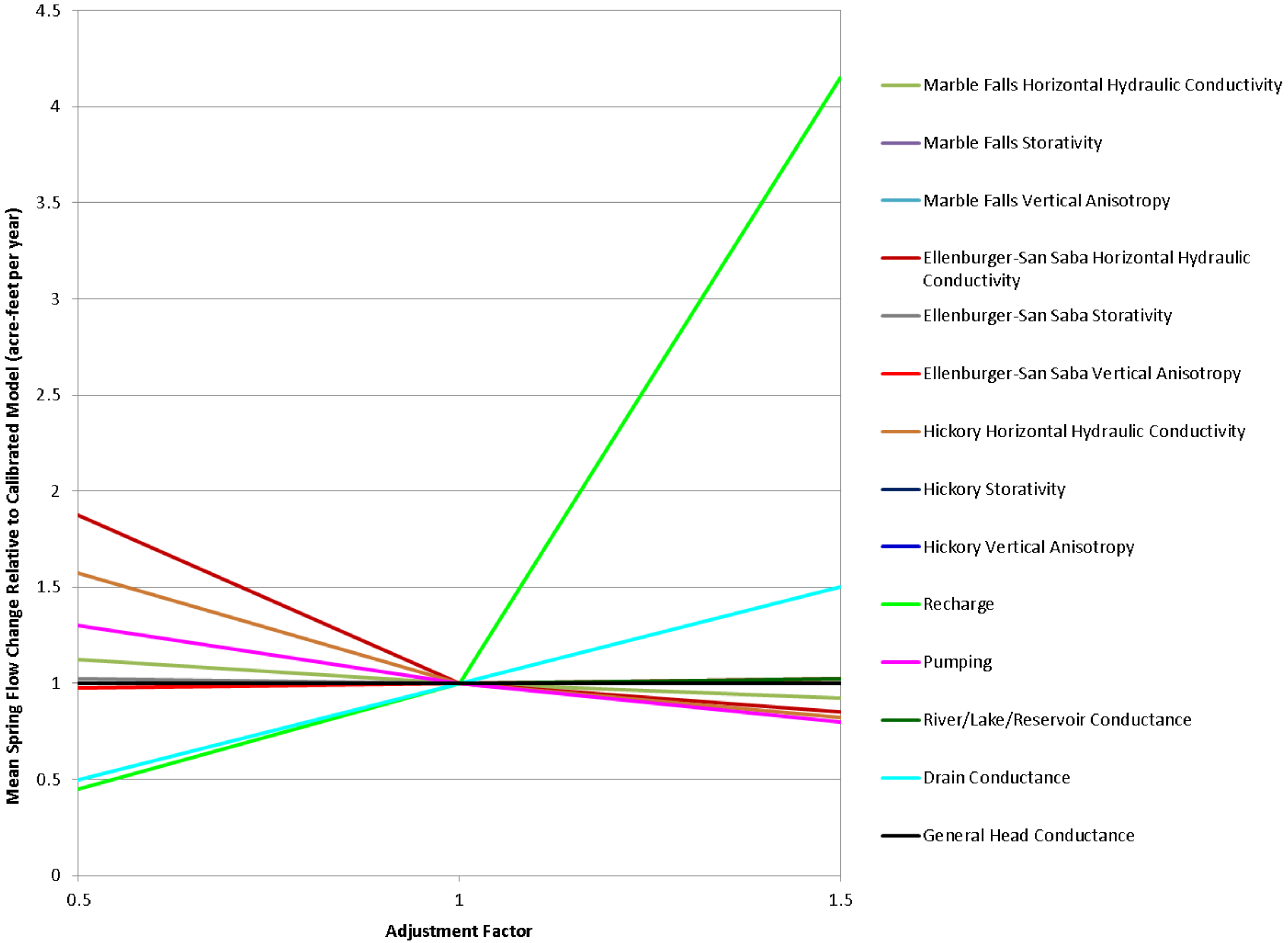
Sensitivity of Head Residuals



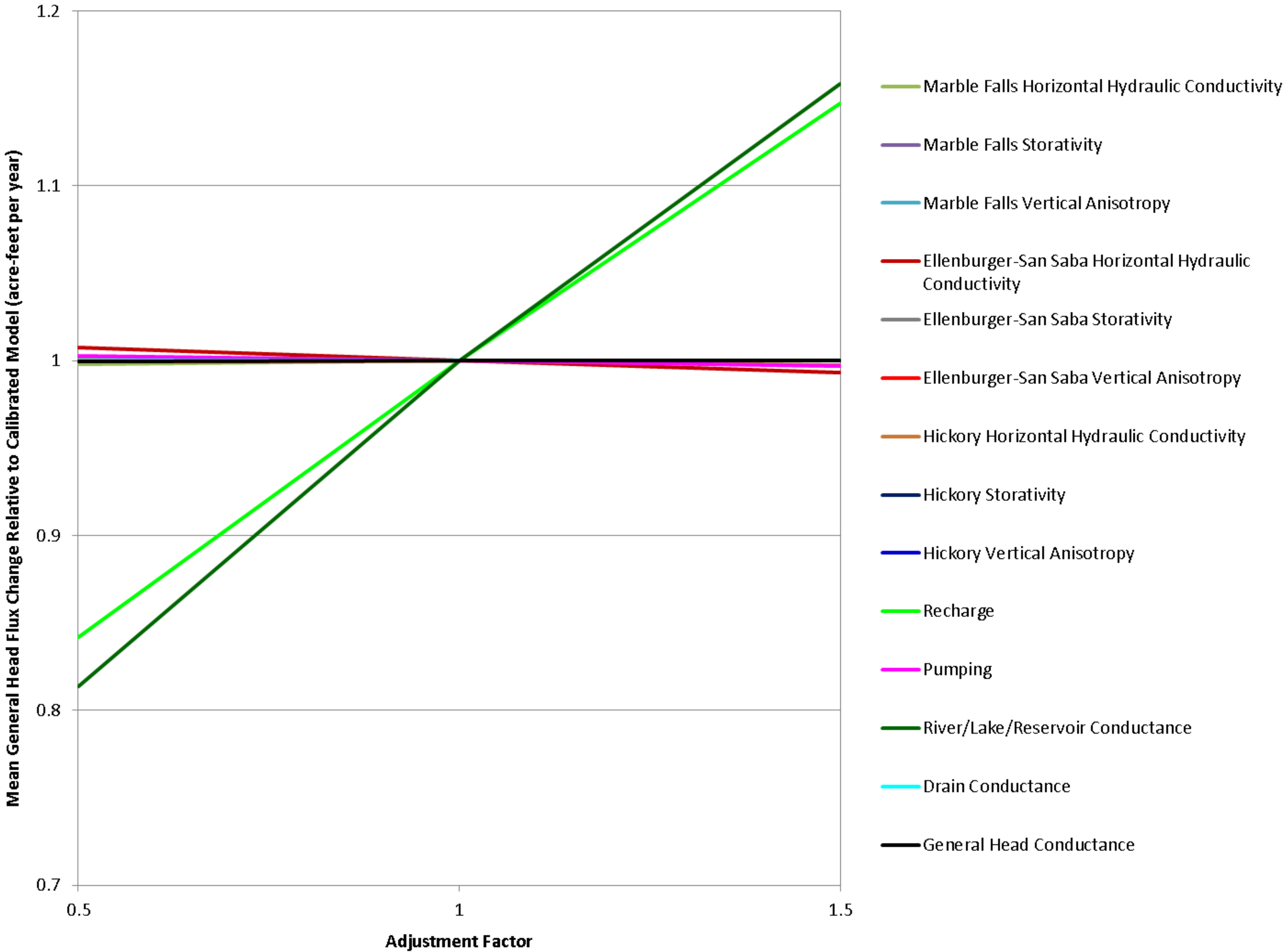
Sensitivity of River/Lake/Reservoir Leakage



Sensitivity of Spring Flow



Sensitivity of General Head Flow



Summary

- Model is well calibrated to water levels
- Model compared well with historical river gain/loss study
- Declining groundwater discharge to rivers, lakes, and reservoirs predicted by model is consistent with measured surface water flow
- Modeled water levels, river gain/loss, and spring flow are most sensitive to recharge and, to a lesser degree, to pumping

Limitation

- Edwards-Trinity (Plateau) and Trinity aquifers are not the focus of this GAM project. Thus, TWDB does not recommend this model for simulating groundwater flow in these two aquifers.
- Landscape and modeled aquifer structure could change significantly over a short distance due to faulting, erosion, and other tectonic events. The model only produces an average condition over each ¼-mile by ¼-mile grid. Thus, the model is designed for regional groundwater flow evaluation and not for addressing local concerns such as well spacing or predicting water levels at a single well.

Acknowledgements

- All stakeholders
- Mr. Paul Tybor (Hill Country Underground Water Conservation District)
- Mr. Ron Fieseler (Blanco-Pedernales Groundwater Conservation District)
- Mr. Charles Schell and Mr. Mitchell Sodek (Central Texas Groundwater Conservation District)
- Hickory Underground Water Conservation District No. 1
- Allan Standen and Robert Ruggiero
- TWDB GAM team especially Cindy and Roberto

PROJECT SCHEDULE

Project Tasks and Proposed Schedule

Milestone	Completion Date
Stakeholder Advisory Forum #1	July 2012
Draft Conceptual Model Report	September 2014
Stakeholder Advisory Forum #2	September 2014
Final Conceptual Model Report	October 2014
Model construction & calibration/draft model report	February 2016
Stakeholder Advisory Forum # 3	March 2016
Final Report	June 2016 (?)

* Please send your comments to us **before March 24, 2016**

Contact Information

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512-463-5076

Jerry.shi@twdb.texas.gov

Texas Water Development Board

P.O. Box 13231

Austin, Texas 78711-3231

Web information:

www.twdb.texas.gov/groundwater

Meeting Minutes for the Second Llano Uplift Minor Aquifers Groundwater Availability Model (GAM) Stakeholder Advisory Forum (SAF) Meeting

March 16, 2016

Hill Country University Center, Fredericksburg, Texas

The third Stakeholder Advisory Forum (SAF) Meeting for the Llano Uplift Minor Aquifers Groundwater Availability Model (GAM) was held on March 16, 2016 at 1:30 PM at the Hill Country University Center located at 2818 E. US Highway 290 in Fredericksburg, 78624. A list of meeting participants is provided at the end of this meeting note.

The purpose of the second SAF meeting was to provide an update to the conceptualization of the Llano Uplift minor aquifers. The meeting also provided a forum for discussing the project schedule and provided an opportunity for feedback from stakeholders.

SAF Presentation: Jerry Shi, Ph.D., P.G., TWDB

Dr. Shi first gave a brief introduction to the GAM Program and discussed how GAMs are used in Texas water resources planning such as estimating modeled available groundwater (MAG), management plan, and recoverable aquifer storage of groundwater conservation districts. Dr. Shi then presented a prepared presentation structured according to the following outline:

1. Overview of Llano Uplift Minor Aquifers
2. Numerical model
3. Project schedule

Questions and Answers:

Q 1: James Beach: What are the units of recharge as reported in the presentation?
Jerry Shi: inches/year.

Q2: Some values for effective recharge in the table in the presentation were over 15 inches. Do these values include river leakage etc. or do they reflect just areal recharge?
Jerry Shi: It’s just areal recharge.

Q3: We sent some aquifer test results. How do the values in the model compare to?
Jerry Shi: Hydraulic conductivity values were incorporated in calibration by allowing them to vary by a factor of two where aquifer test data was available.

Q4: I know that models should be used on a regional basis but this area is so faulted. So is the

model appropriate for use even on a local basis?
Jerry Shi: The model should be able to simulate on a regional scale since the code is capable of disconnected formations. However, use with caution on model results on a local scale.

Q5: In GMA 9, northwestern Blanco County, we are treating the Hickory and Llano aquifers as non-relevant. If we run this model in the future, some people may complain about the applicability of the model. The models are just tools they are not the final answer.
Jerry Shi: Yes models are tools and there are other tools that are available. All tools provide us with answers. However, models will probably provide us with a less wrong answer compared to the other tools.

Q6: James Beach: Are you interested in pump test data at this point?
Jerry Shi: Sure. Have you sent the data to Bryan Anderson on our groundwater staff.
James Beach: City of San Angelo provided the data.
Jerry Shi: Then probably, Bill Hutchison has access to the data.
James Beach: Should we submit it to you?
Jerry Shi: Yes, please.

Q7: When you talked about numerical instability in the model. What was it?
Jerry Shi: We had a lot of issues in the beginning trying to get the model to converge. We spent almost three months in getting the model to run stably.
James Beach: Did you have pumping the steady-state?
Jerry Shi: Yes, we did.
James Beach: Did that help with numerical stability?
Jerry Shi: It did. There were some other issues too. Some formations were totally disconnected from the others and we had to carefully analyze that in several places in the model.
James Beach: If you'd have to go back to the 1850s. How would you simulate steady-state? Put in more rivers, drains to allow discharge?
Jerry Shi: Probably. But discharge varies a lot based on recharge which changes dynamically too.
James Beach: Those blocks you showed for recharge. Were they obtained from soil types, rainfall etc.?
Jerry Shi: We looked at well logs, hydraulic conductivity values, pumping at various locations to look at how much recharge is happening.

Llano Uplift Minor Aquifers GAM Stakeholder Advisory Forum 3

March 16, 2016

Attendance

Name	Affiliation
Jerry Shi	Texas Water Development Board
Rohit Goswami	Texas Water Development Board
Gene Williams	Headwaters Groundwater Conservation District
Mitchell Sodek	Central Texas Groundwater Conservation District
Vince Clause	ARS, LLC
Allan Standen	ARS, LLC
Tim Lehmberg	Gillespie County Economic Development Commission
Don Casey	Blanco-Pedernales Groundwater Conservation District
James Beach	LBG-Guyton
Bill Riley	City of San Angelo
Ron Fieseler	Blanco-Pedernales Groundwater Conservation District
David Jeffery	Bandera County River Authority and Groundwater
Paul Tybor	Hill Country Underground Water Conservation District