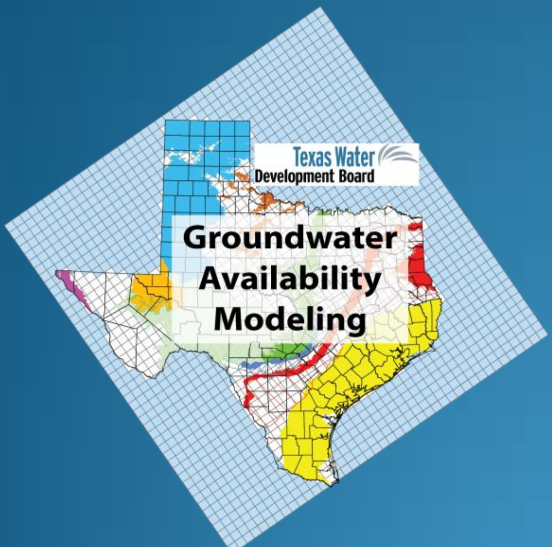
Llano Uplift Minor Aquifers GAM Stakeholder Advisory Forum Number 2



Groundwater Availability Modeling
Texas Water Development Board

Hill Country University Center
Fredericksburg, Texas

September 30, 2014

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)

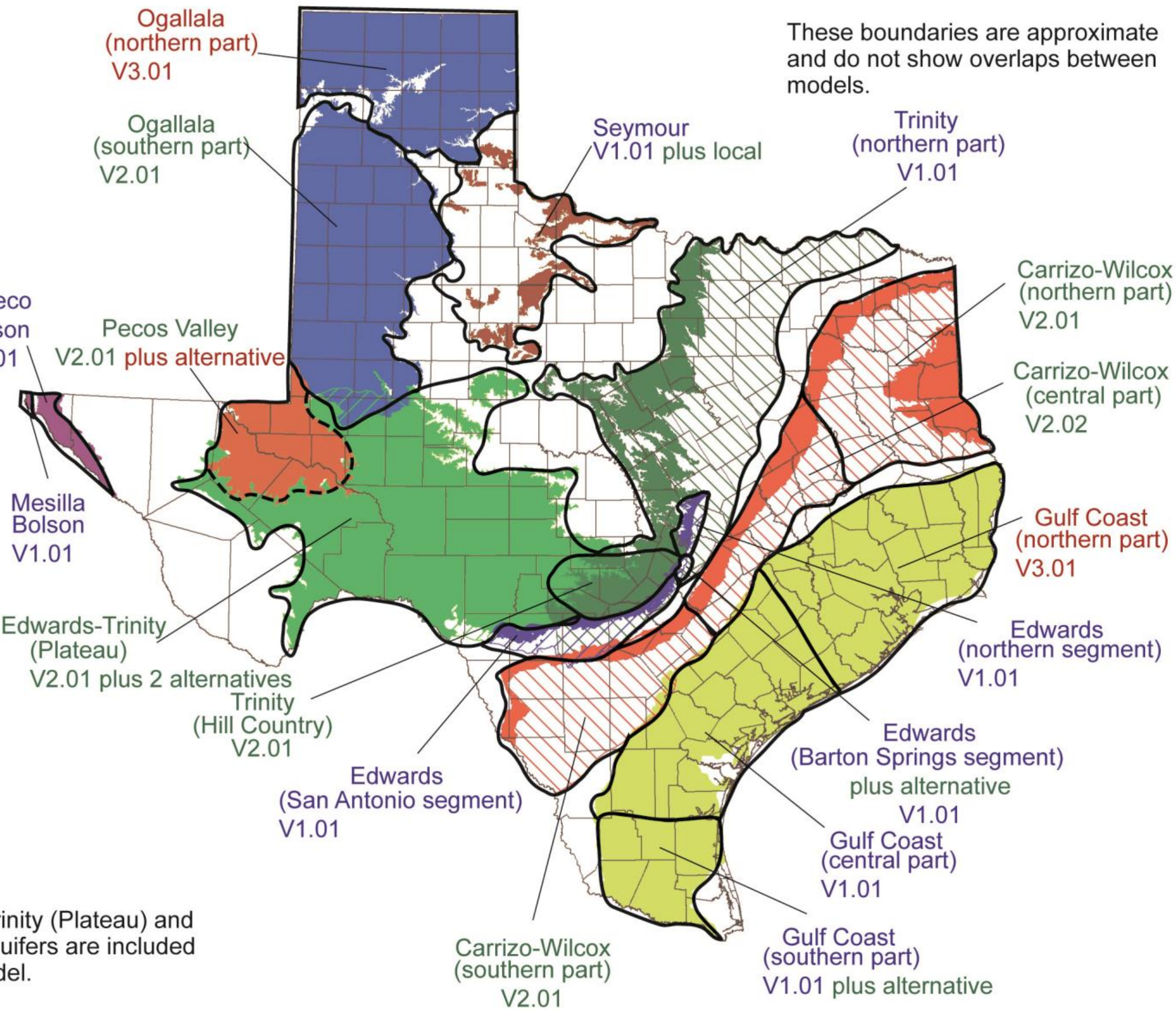
Cindy Ridgeway, P.G.
Manager of Groundwater Availability Modeling
Texas Water Development Board

Hill Country University Center
Fredericksburg, Texas
September 30, 2014

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.

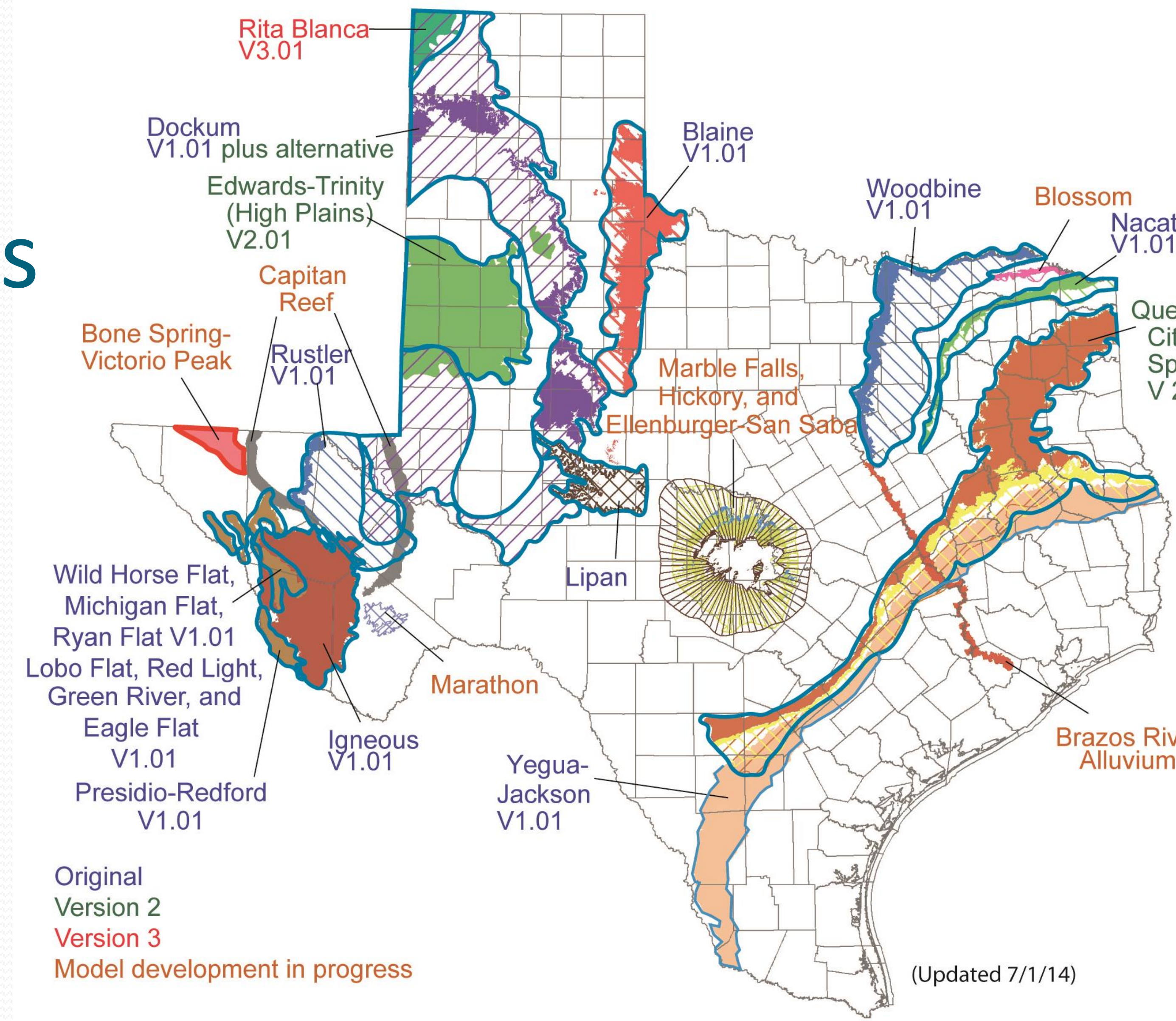
Major Aquifers



Original
Version 2
Version 3

Note:
The Edwards-Trinity (Plateau) and Pecos Valley aquifers are included in the same model.

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

Cindy Ridgeway, P.G.
Manager of Groundwater Availability Modeling
512-936-2386
Cindy.ridgeway@twdb.texas.gov

Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711-3231

Web information:
www.twdb.texas.gov/groundwater

Llano Uplift Minor Aquifers Conceptual Flow Model

Jerry Shi, Ph.D., P.G.
Radu Boghici, P.G.
William Kohlrenken
Texas Water Development Board

And

William Hutchison, Ph.D., P.E., P.G.
Independent Groundwater Consultant

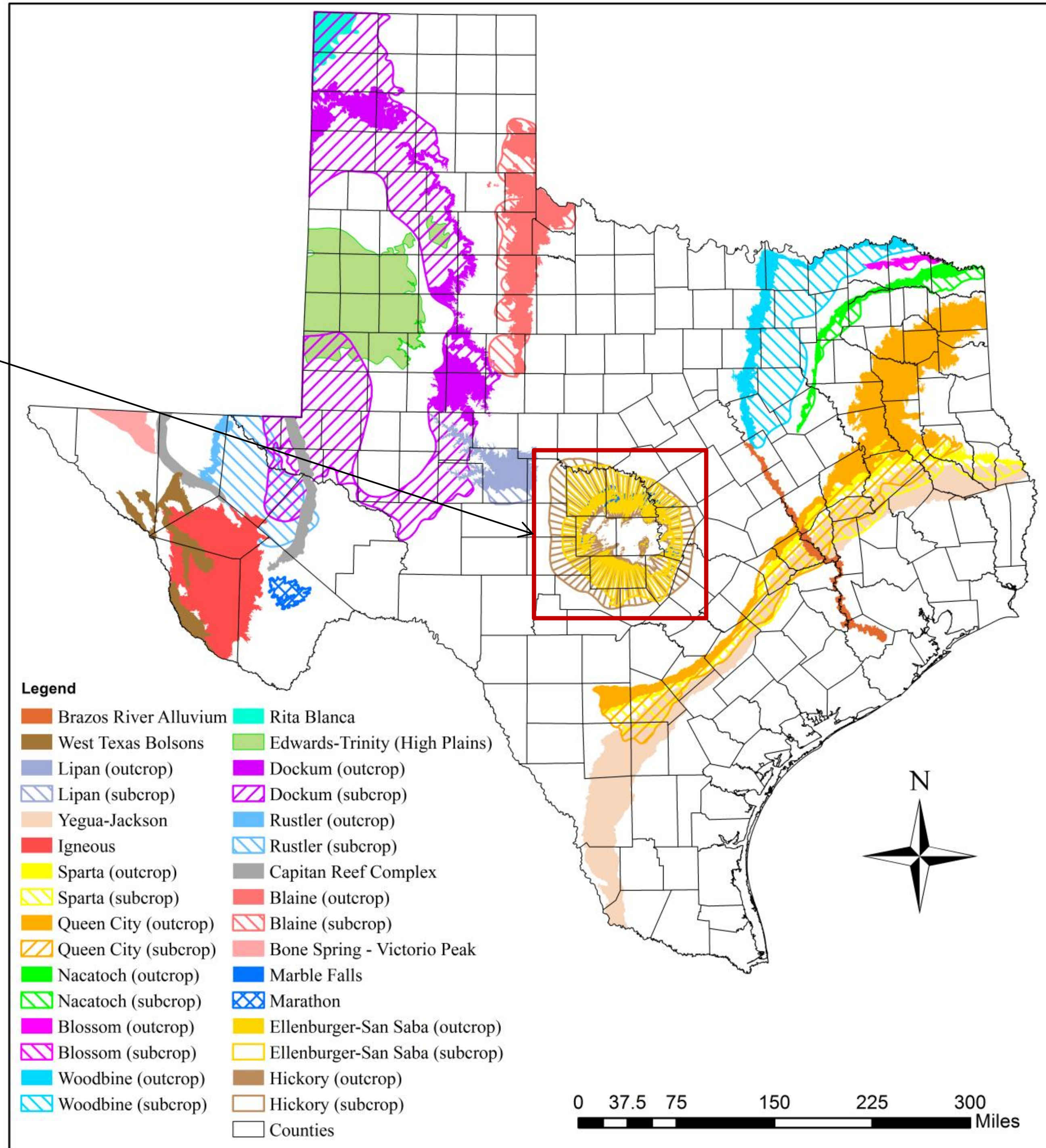
Hill Country University Center
Fredericksburg, Texas
September 30, 2014

Outline

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

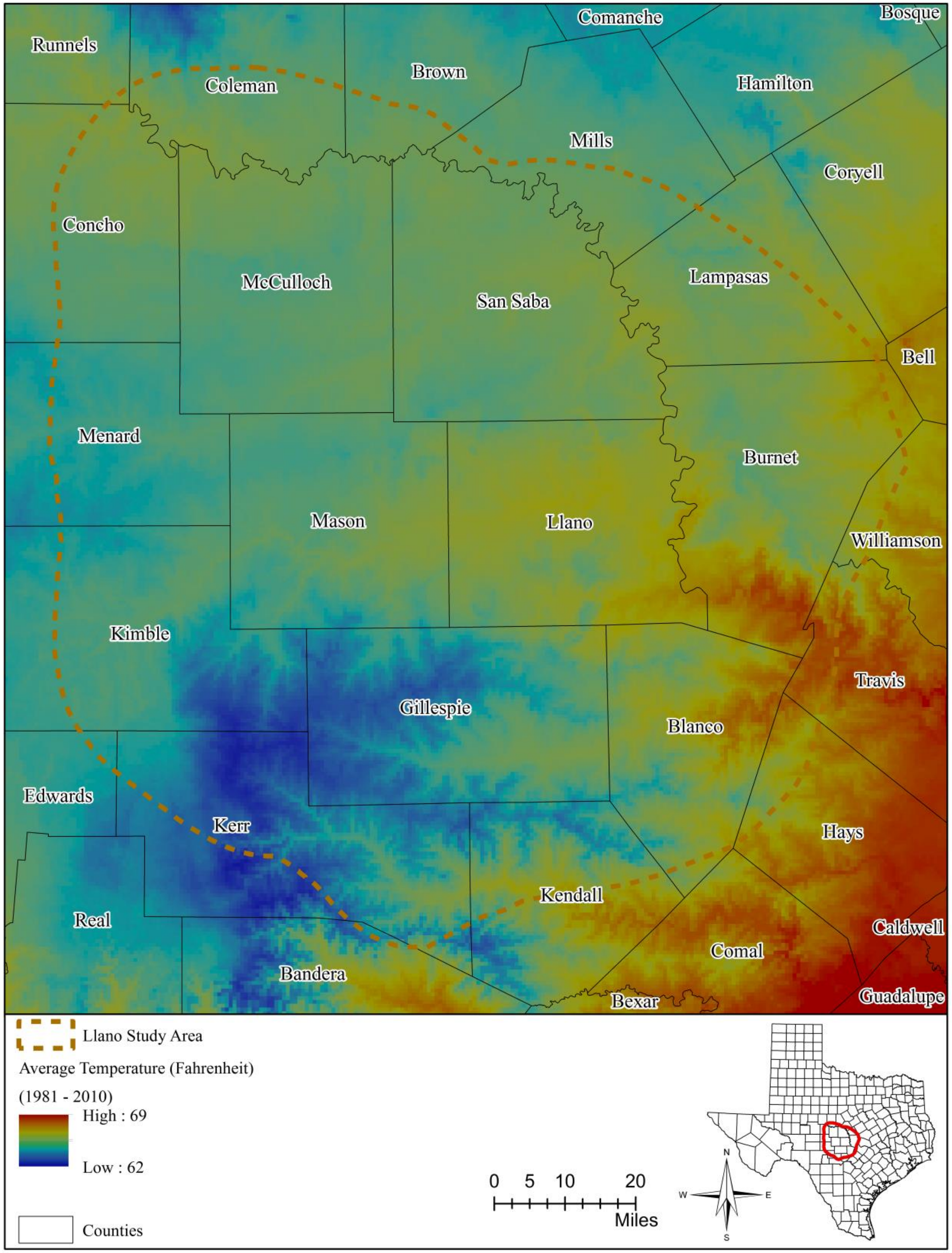
Study Area

Study Area

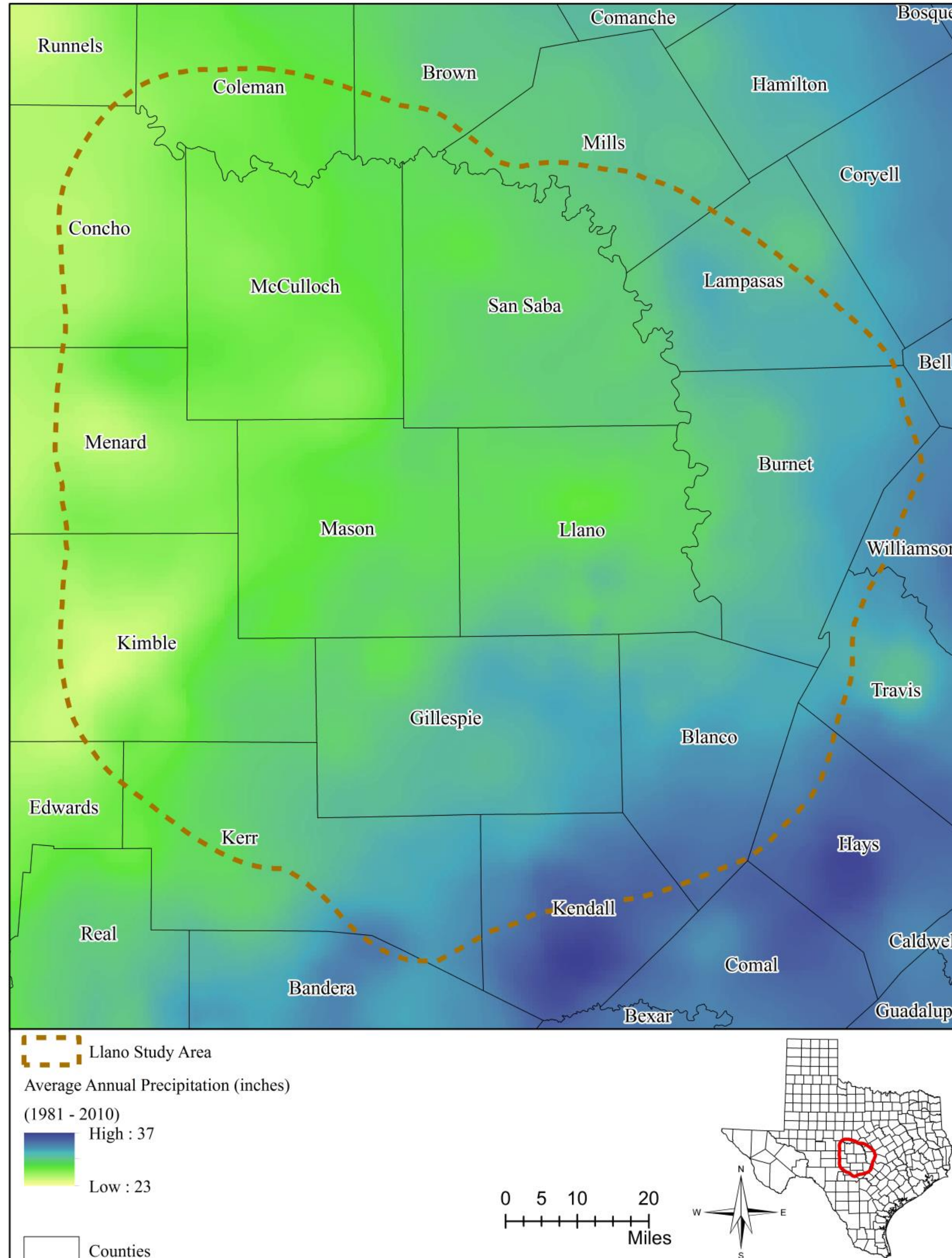

Legend
Brazos River Alluvium
West Texas Bolsons
Lipan (outcrop)
Lipan (subcrop)
Yegua-Jackson
Igneous
Sparta (outcrop)
Sparta (subcrop)
Queen City (outcrop)
Queen City (subcrop)
Nacatoch (outcrop)
Nacatoch (subcrop)
Blossom (outcrop)
Blossom (subcrop)
Woodbine (outcrop)
Woodbine (subcrop)
Rita Blanca
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

Climate

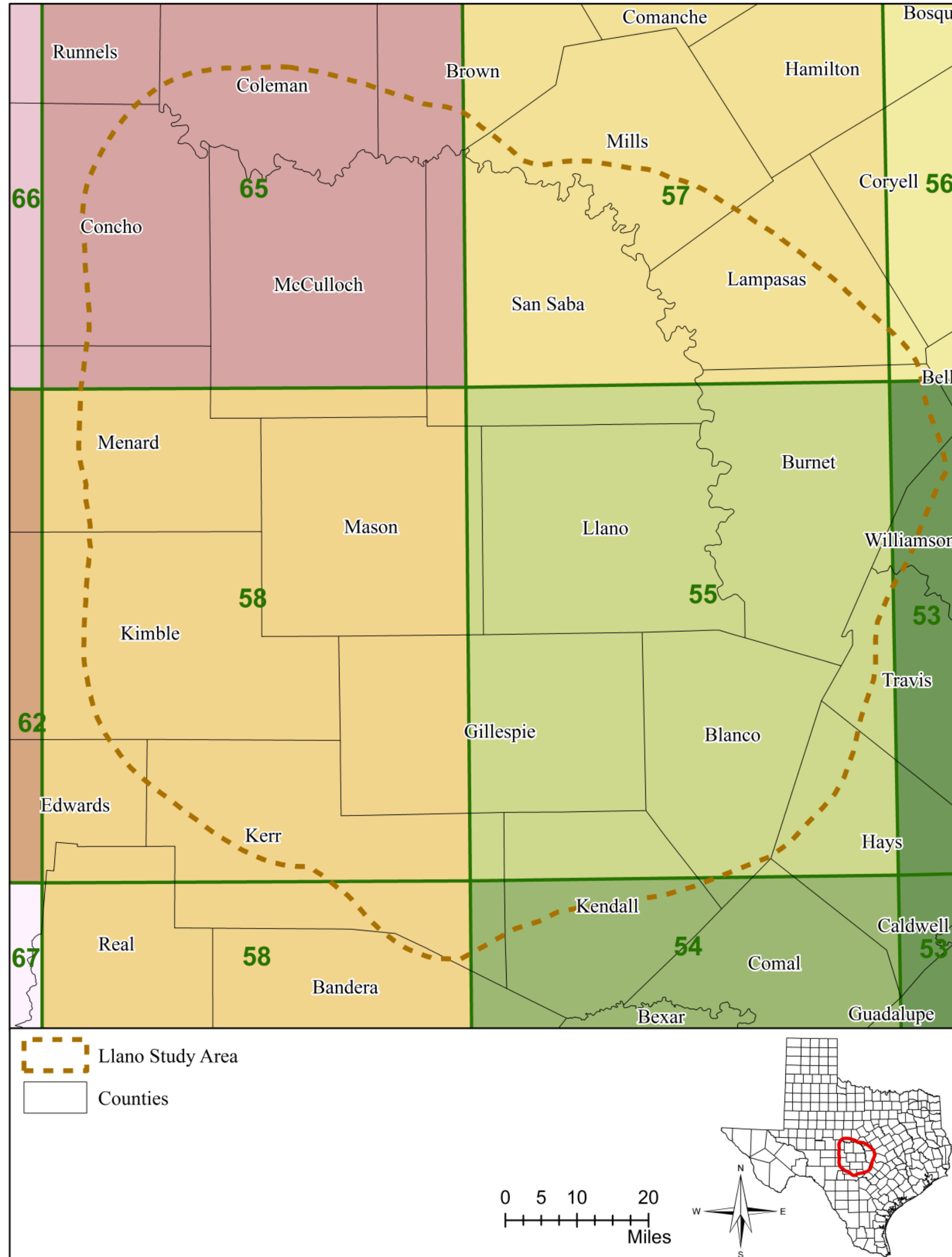
Average Annual Air Temperature



Average Annual Precipitation

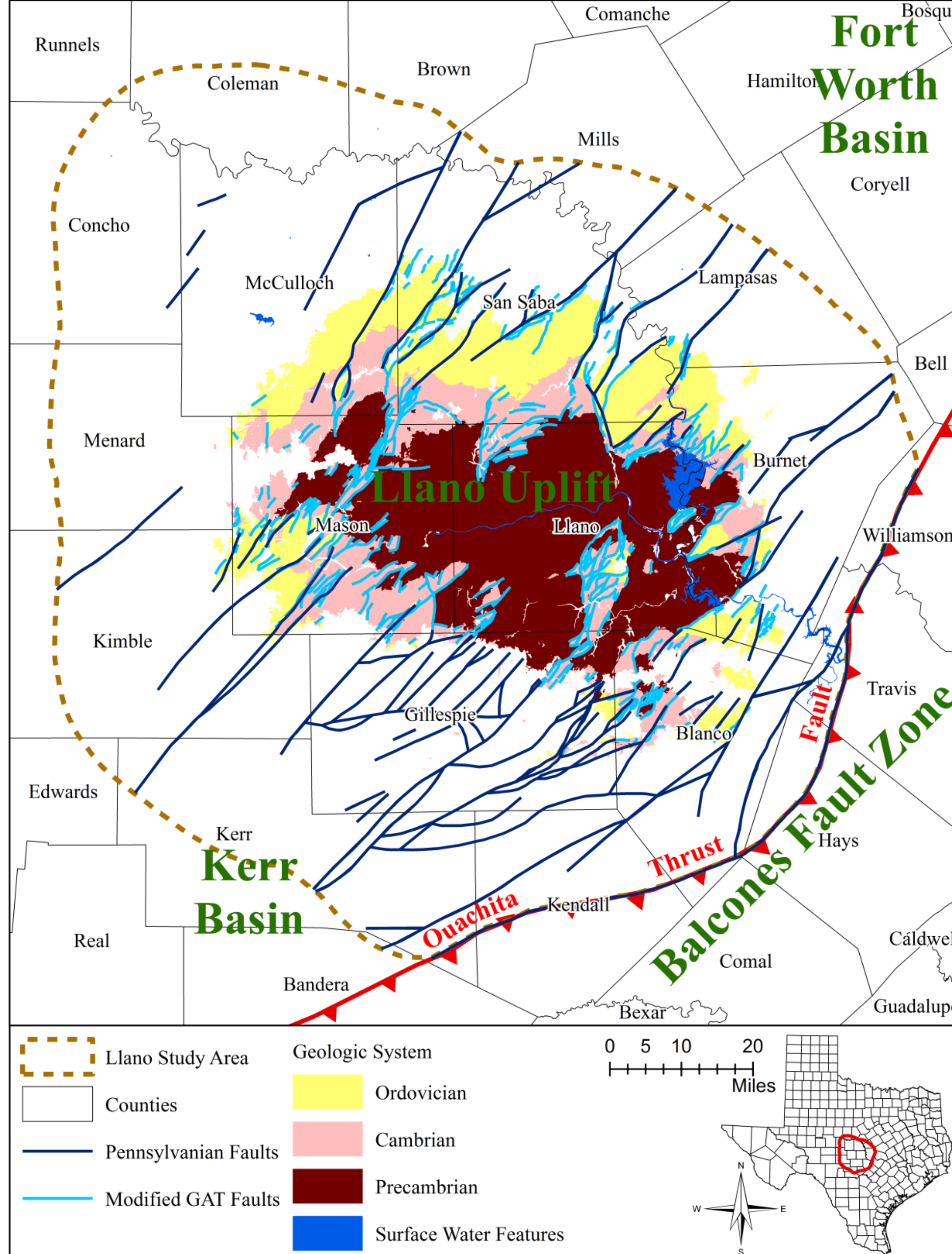


Average Annual Net Pan Evaporation



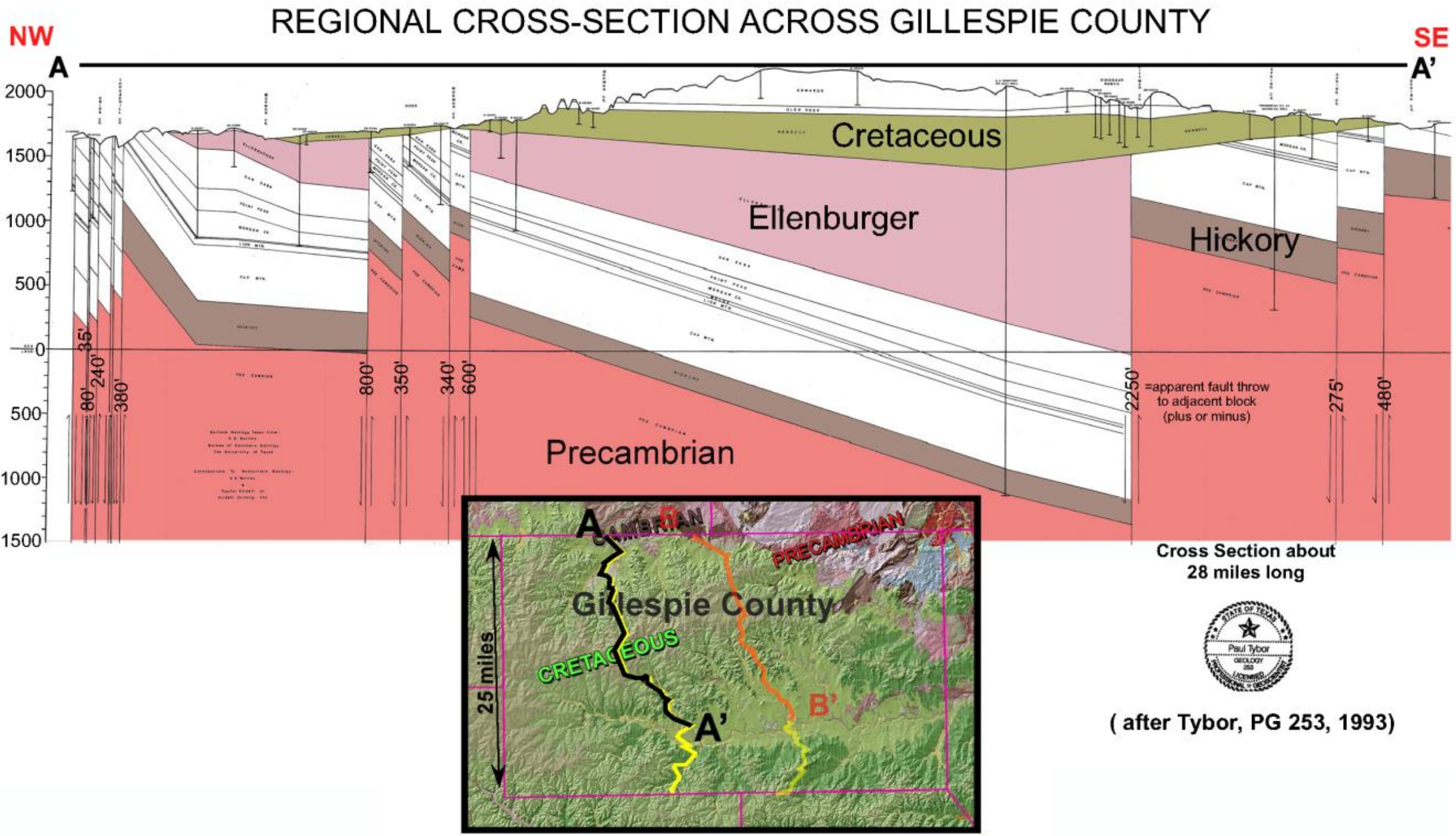
Geology

Faults

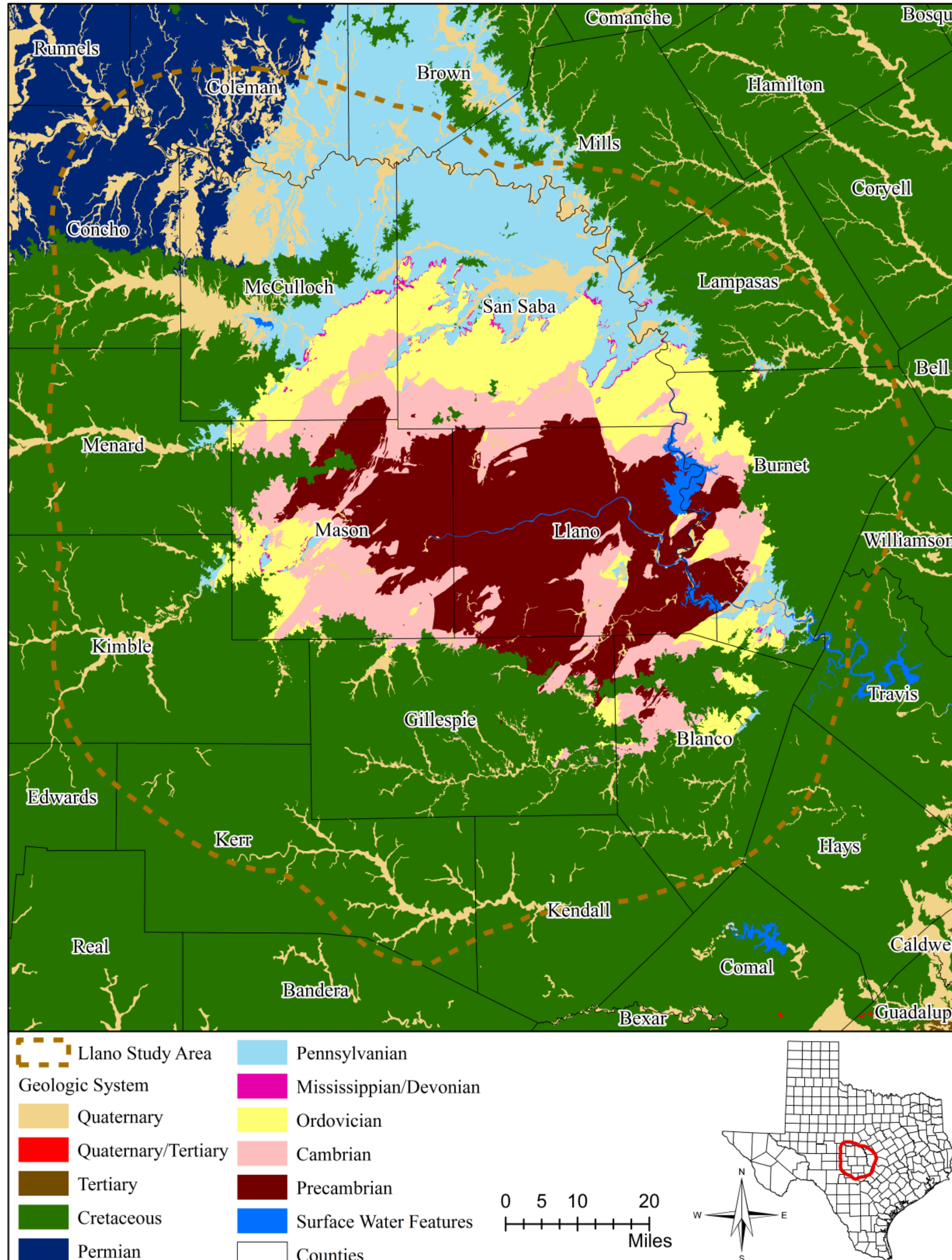


Runnels
Coleman
Brown
Comanche
Bosque
Fort Worth Basin
Hamilton
Mills
Coryell
Concho
McCulloch
San Saba
Lampasas
Bell
Menard
Llano Uplift
Burnet
Mason
Llano
Williamson
Kimble
Gillespie
Travis
Blanco
Edwards
Kerr
Kerr Basin
Hays
Balcones Fault Zone
Ouachita Thrust Fault
Kendall
Real
Bandera
Comal
Caldwell
Bexar
Guadalupe
Llano Study Area
Counties
Pennsylvanian Faults
Modified GAT Faults
Geologic System
Ordovician
Cambrian
Precambrian
Surface Water Features
0 5 10 20
Miles

Faults


REGIONAL CROSS-SECTION ACROSS GILLESPIE COUNTY
NW
SE
A
A'
2000
1500
1000
500
0
500
1000
1500
Cretaceous
Ellenburger
Hickory
Precambrian
35'
80'
240'
380'
800'
350'
340'
600'
2250'
275'
480'
=apparent fault throw to adjacent block (plus or minus)
Cross Section about 28 miles long
Paul Tybor
(after Tybor, PG 253, 1993)
CAMBRIAN
PRECAMBRIAN
Gillespie County
CRETACEOUS
25 miles
B
B'

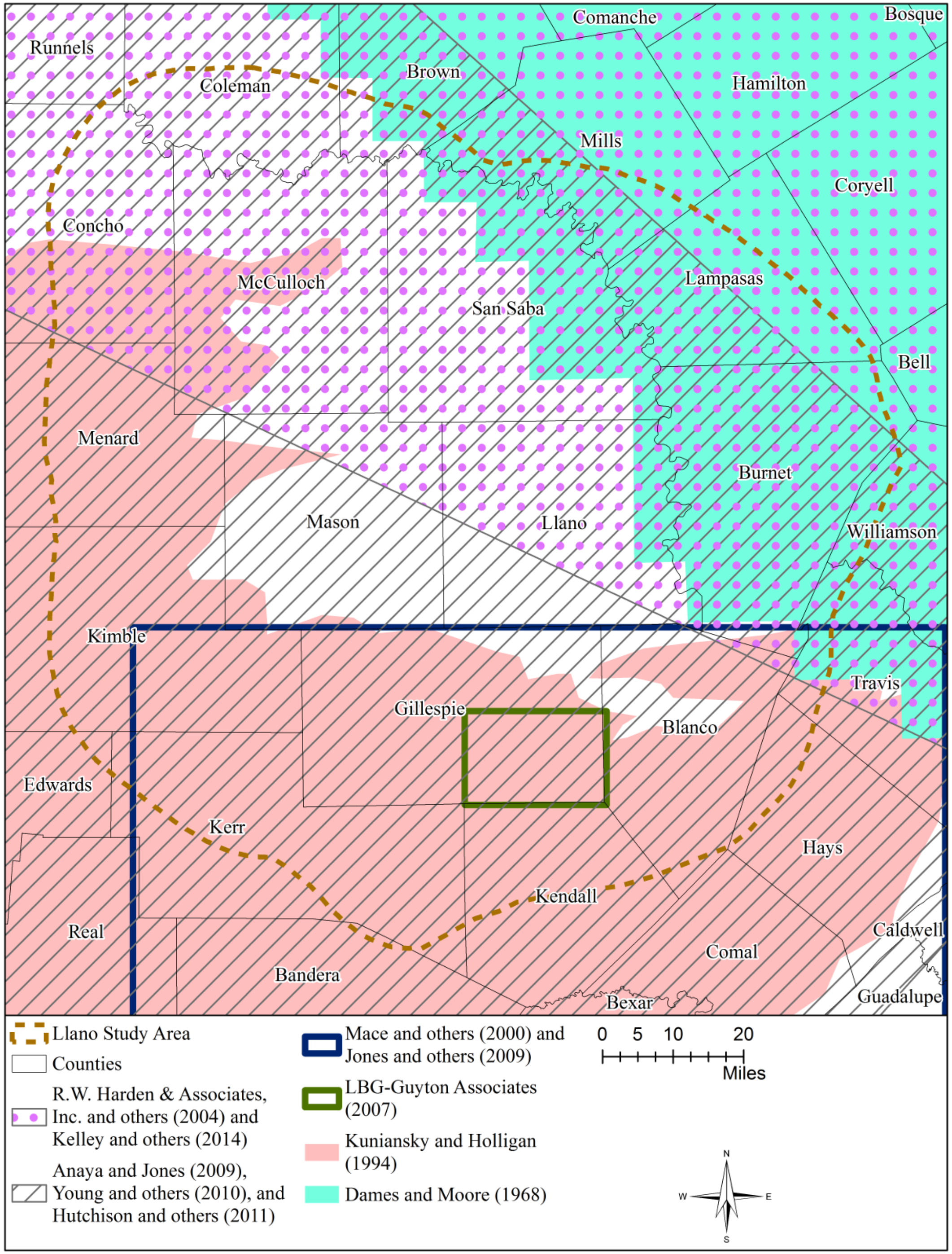
Surface Geology



Based on data

Previous Work

Previous Groundwater Models



Hydrostratigraphy/Framework

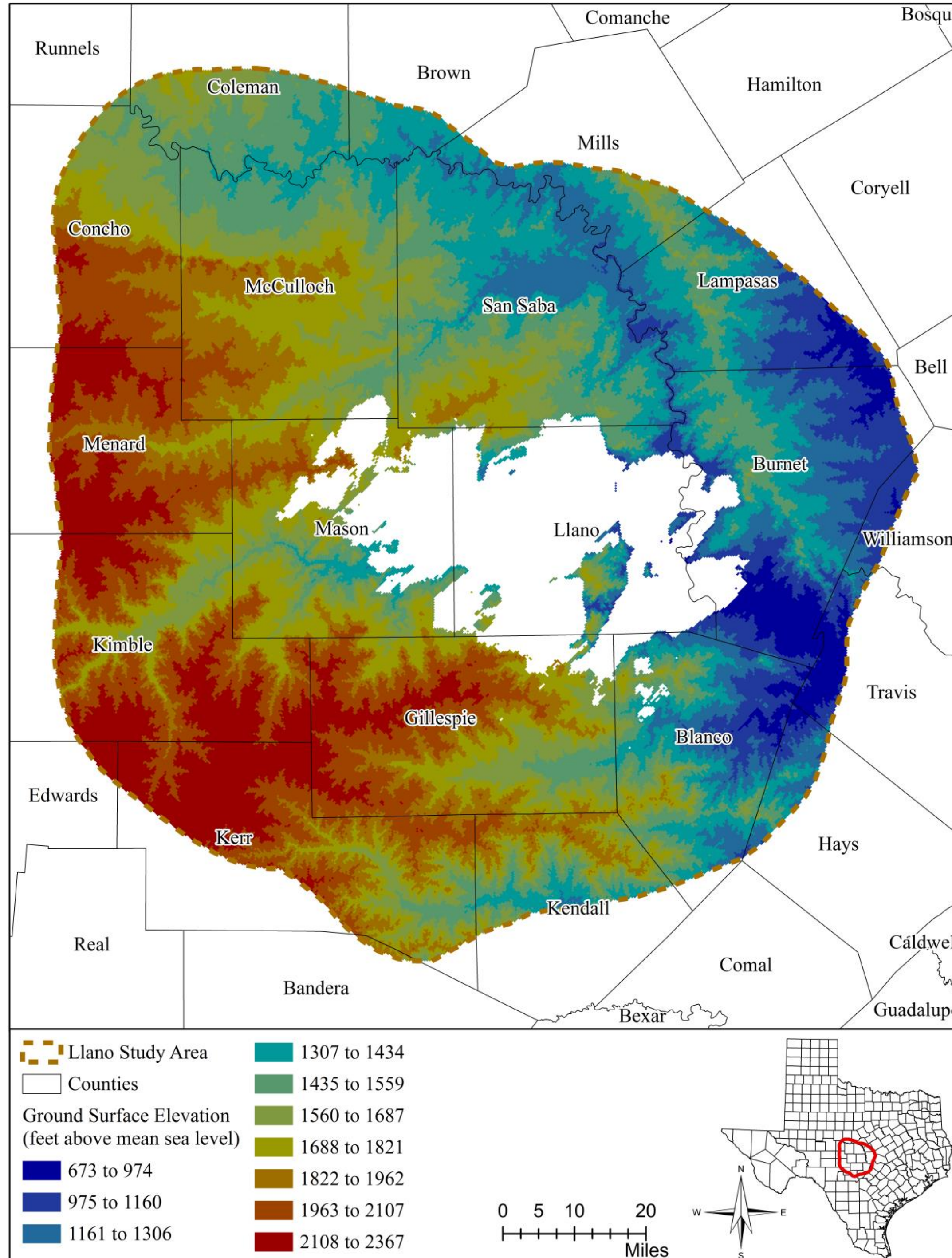
Generalized Stratigraphy

Geologic Units							Hydrogeologic Units
Era	System	North and East of Study Area			South and West of Study Area		
		Group	Formation	Member	Formation	Member	
Cenozoic	Quaternary	Loose sediments at river valley bottoms					Cretaceous Aquifer
Mesozoic	Cretaceous	Washita	Buda, Del Rio				
			Georgetown				
					Edwards Group: Segovia		
			Kiamichi				
		Fredericksburg	Edwards		Edwards Group: Fort Terrett		
			Comanche Peak				
			Walnut				
		Trinity	Antlers: Paluxy		Absent		
			Antlers: Glen Rose		Glen Rose		
			Antlers: Travis Peak	Hensell	Travis Peak	Hensell	
				Cow Creek/Hammett		Cow Creek/Hammett	
				Sycamore/Hosston		Sycamore/Hosston	
	Jurassic	Absent					
	Triassic	Absent					
Paleozoic	Permian	Wichita Albany	Undivided		Absent		
		Cisco	Undivided		Absent		
	Pennsylvanian				Undivided		Confining Layer
		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
Precambrian	Metamorphic (gneisses, amphibolites, and schists) and intrusive igneous (granites) rocks						Confining Layer

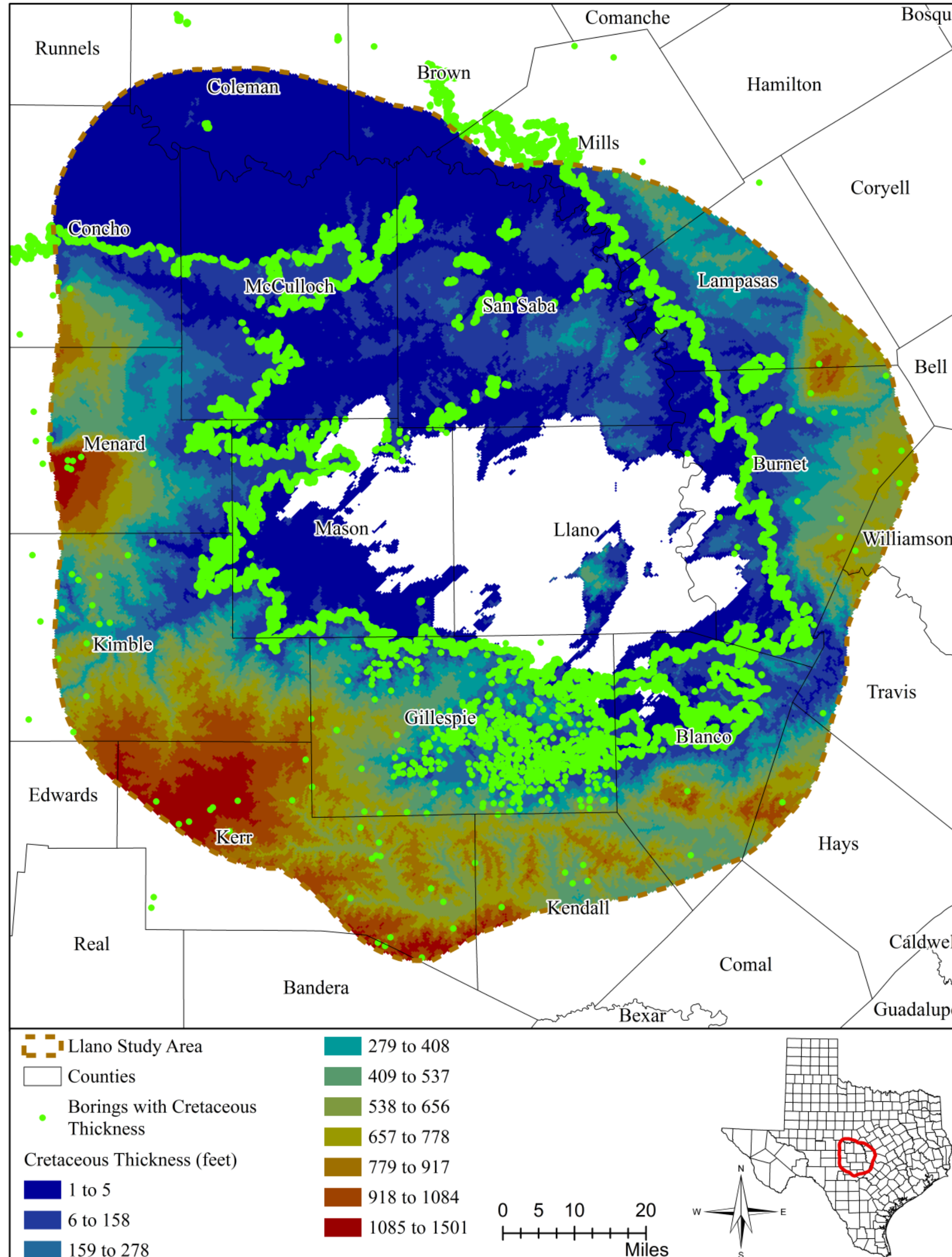
Hydrostratigraphy

Model Layer	Hydrogeologic Unit
1	Cretaceous and Younger Units
2	Confining Unit
3	Marble Falls Aquifer
4	Confining Unit
5	Ellenburger-San Saba Aquifer
6	Confining Unit
7	Hickory Aquifer
	Confining Unit (Precambrian)

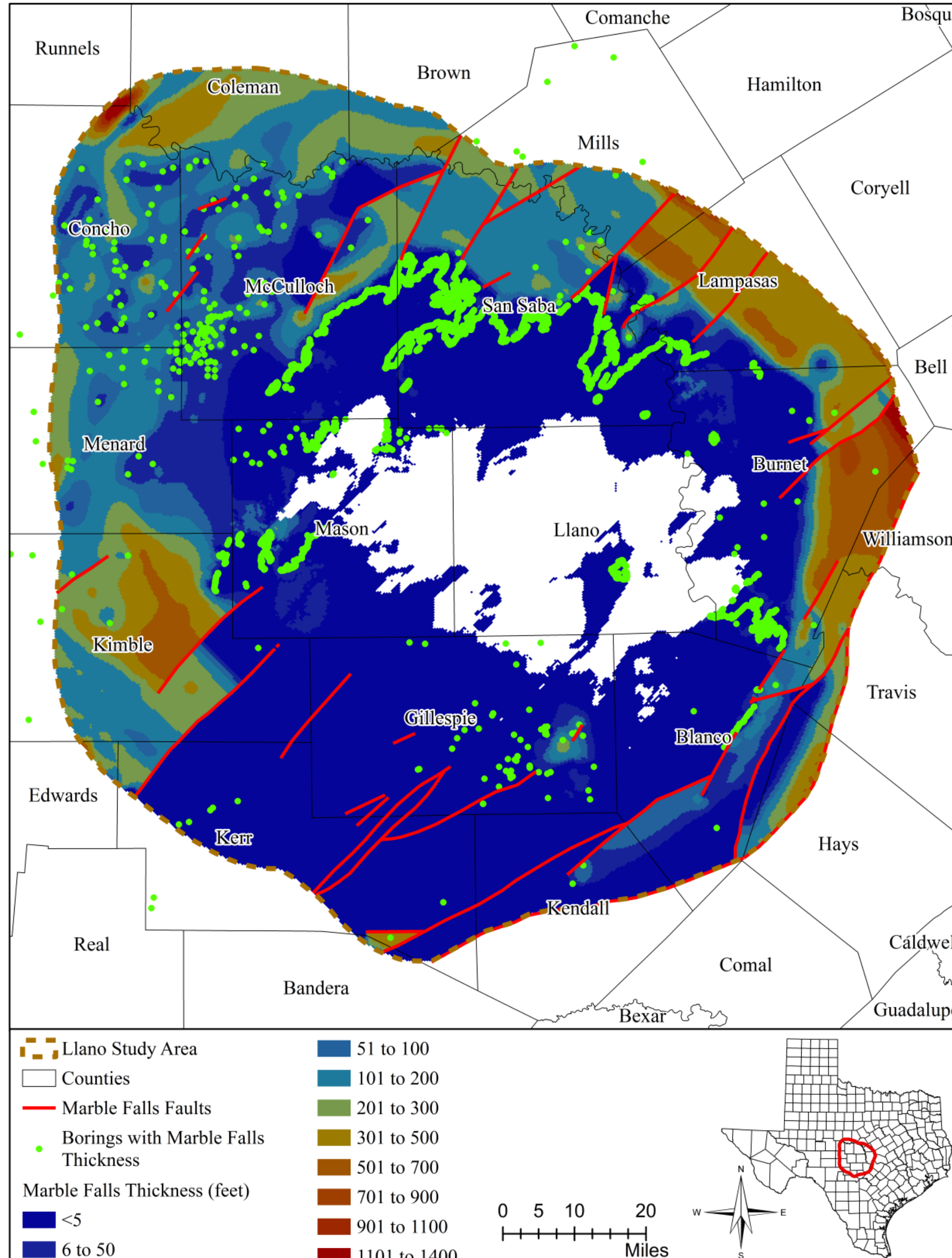
Top Elevation of Cretaceous and Younger Units (Model Layer 1) = Ground Surface



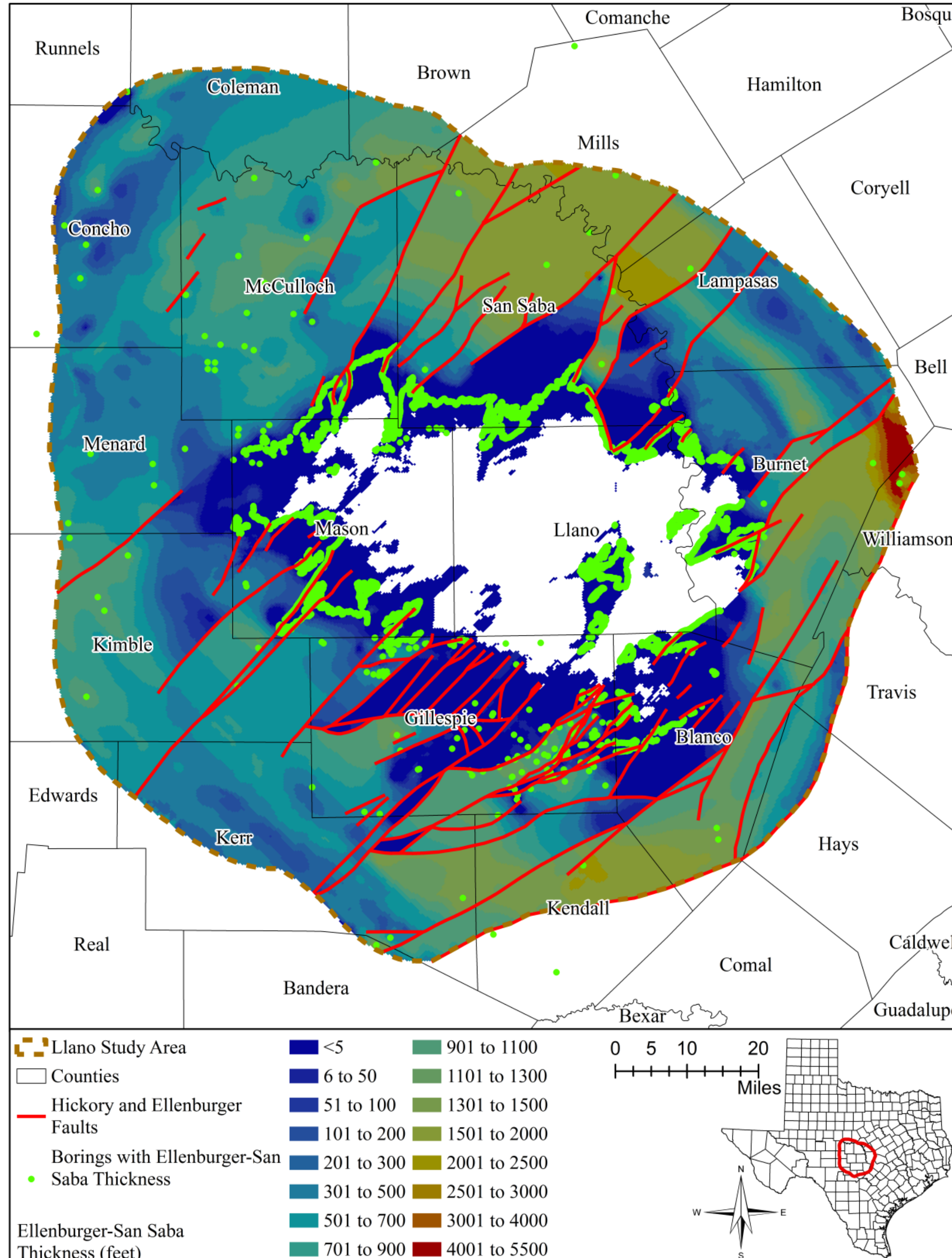
Thickness of Cretaceous and Younger Units (Model Layer 1)



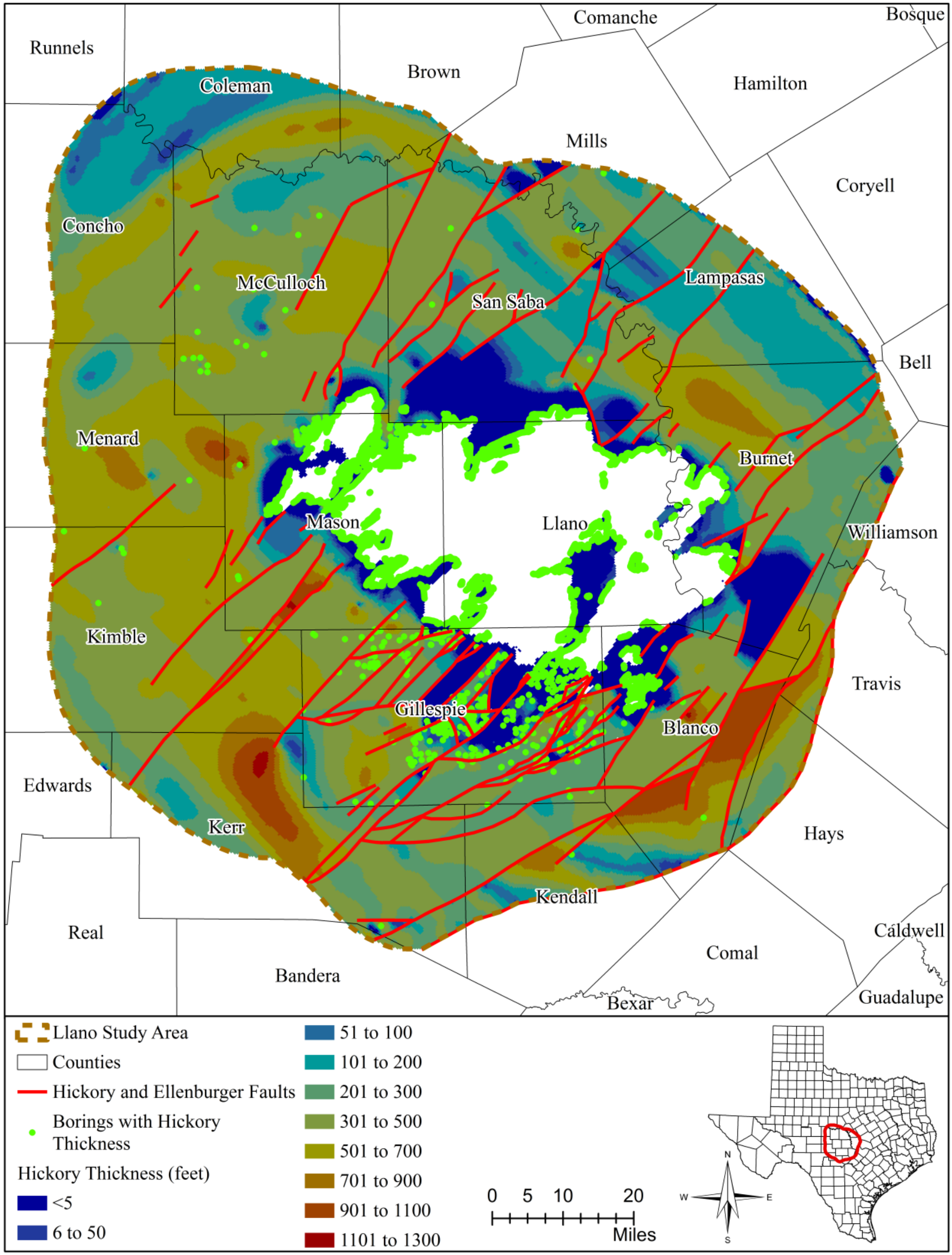
Thickness of Marble Falls (Model Layer 3)



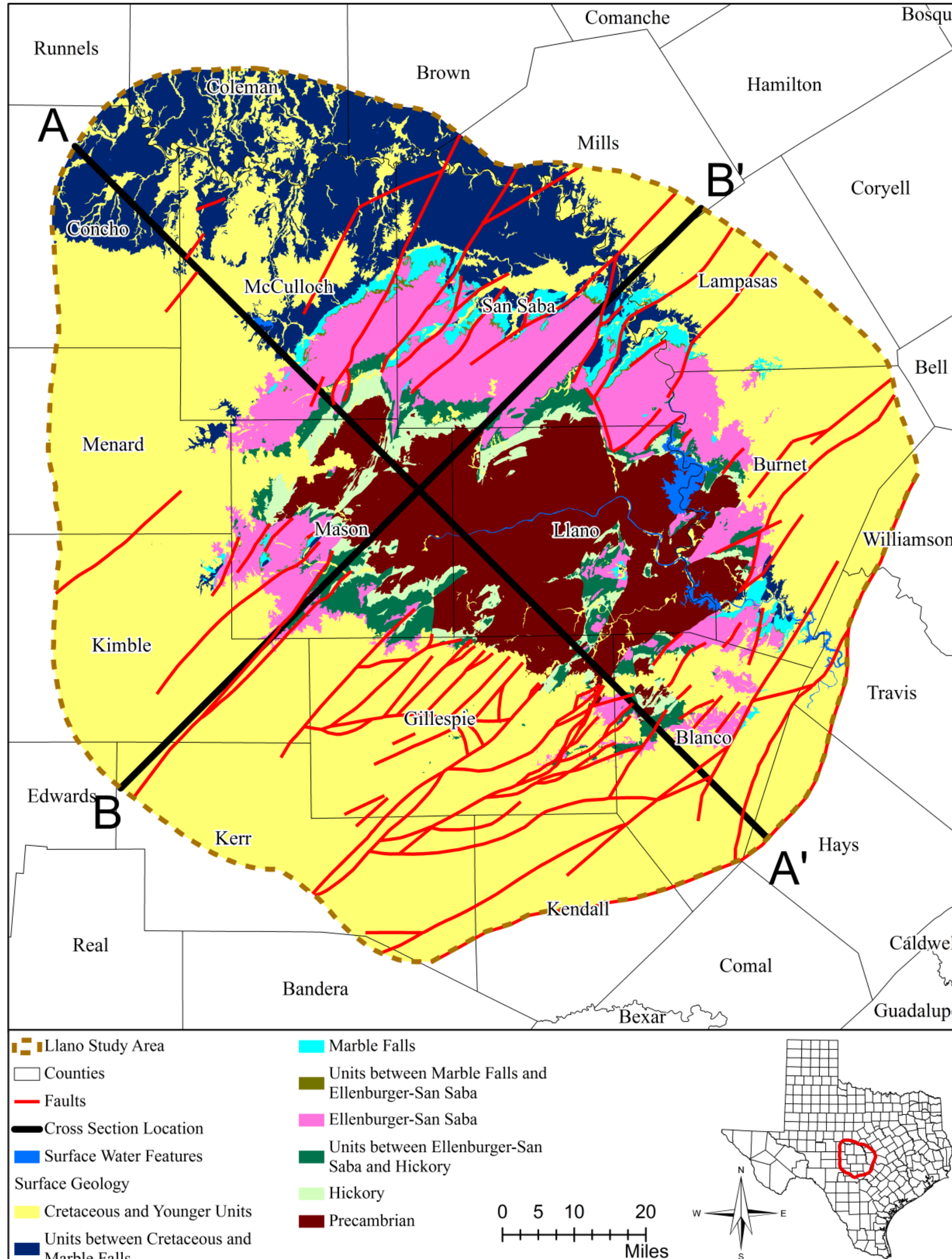
Thickness of Ellenburger-San Saba (Model Layer 5)



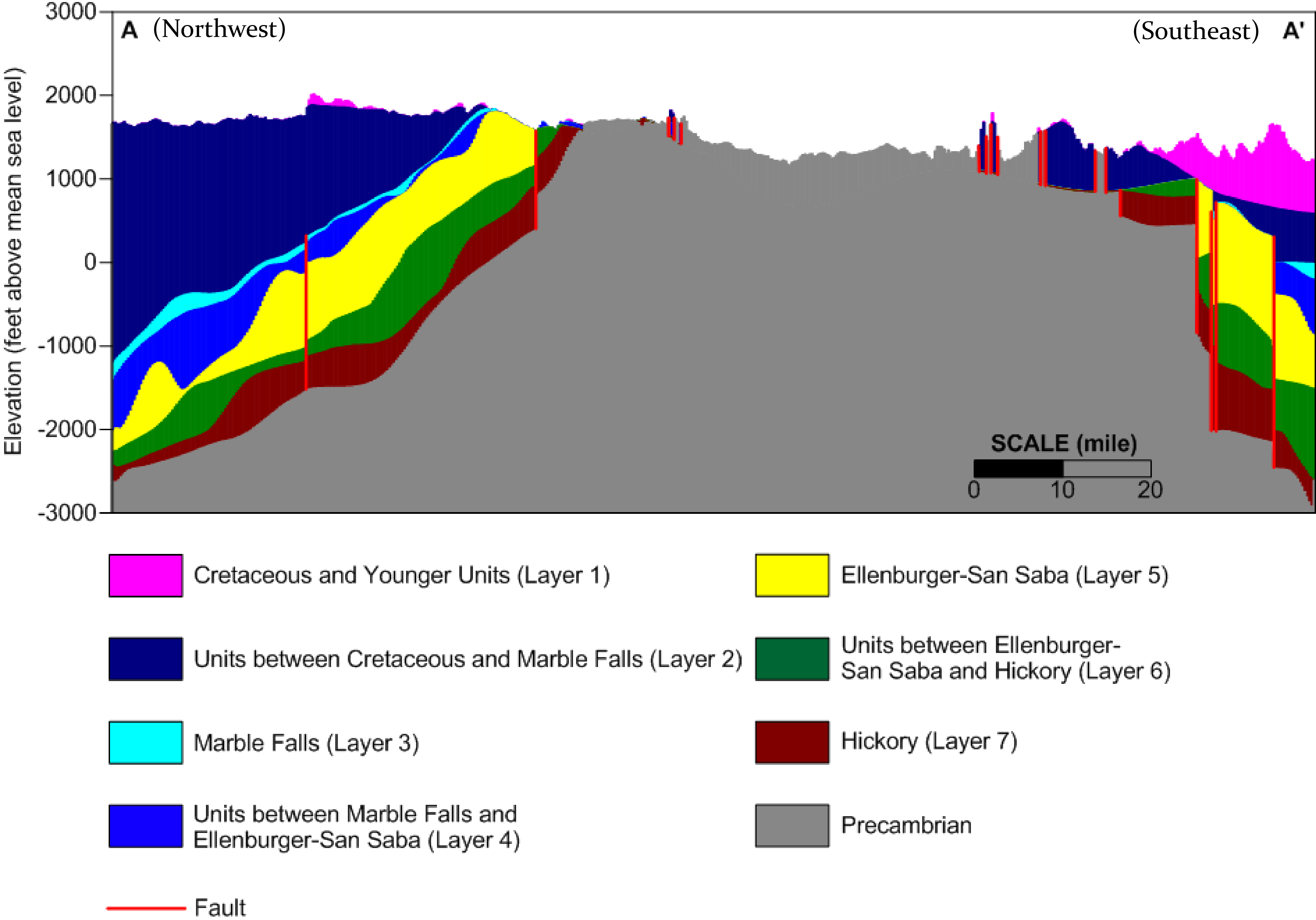
Thickness of Hickory (Model Layer 7)



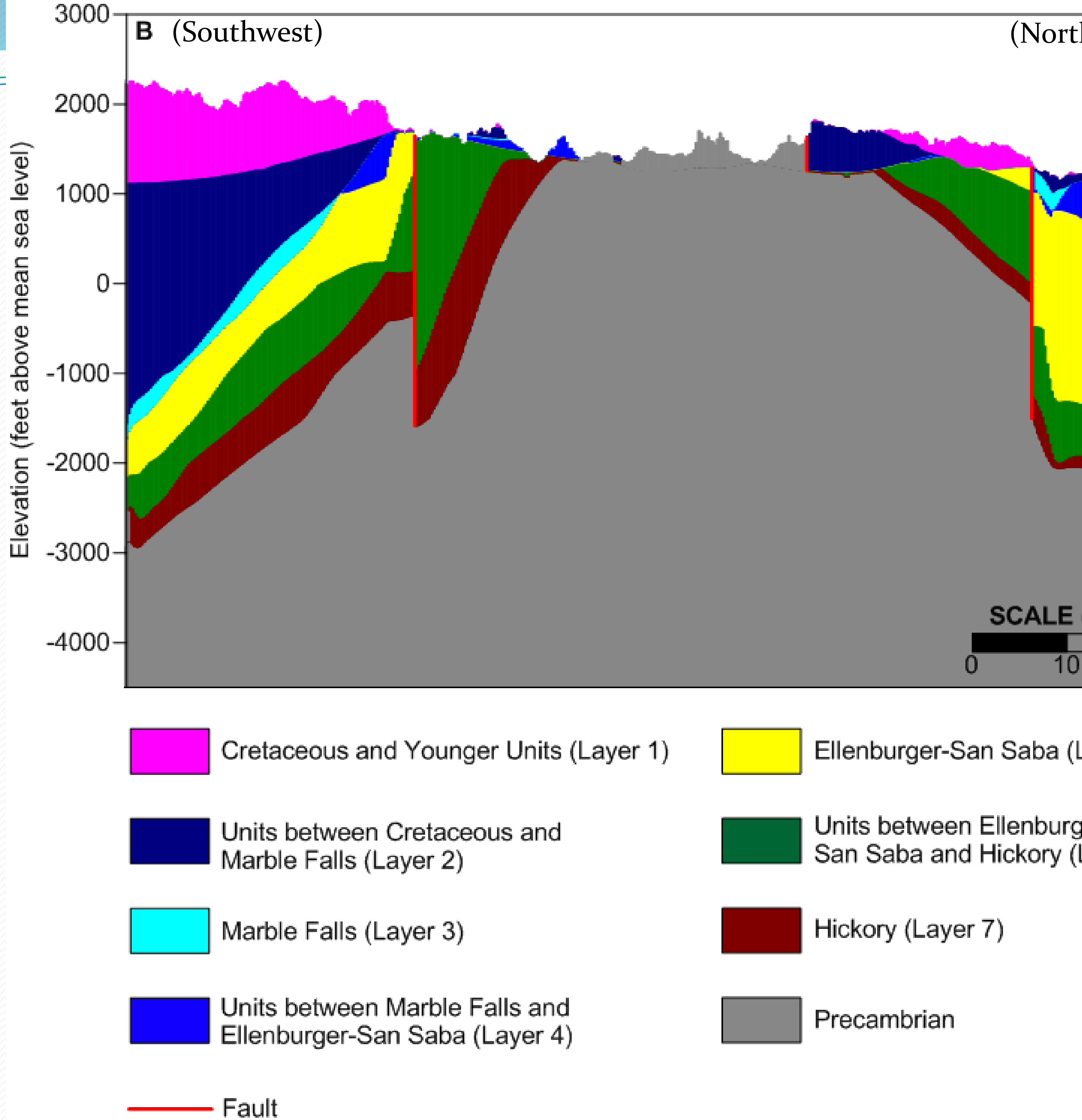
Location of Cross Sections



Cross Section A - A’

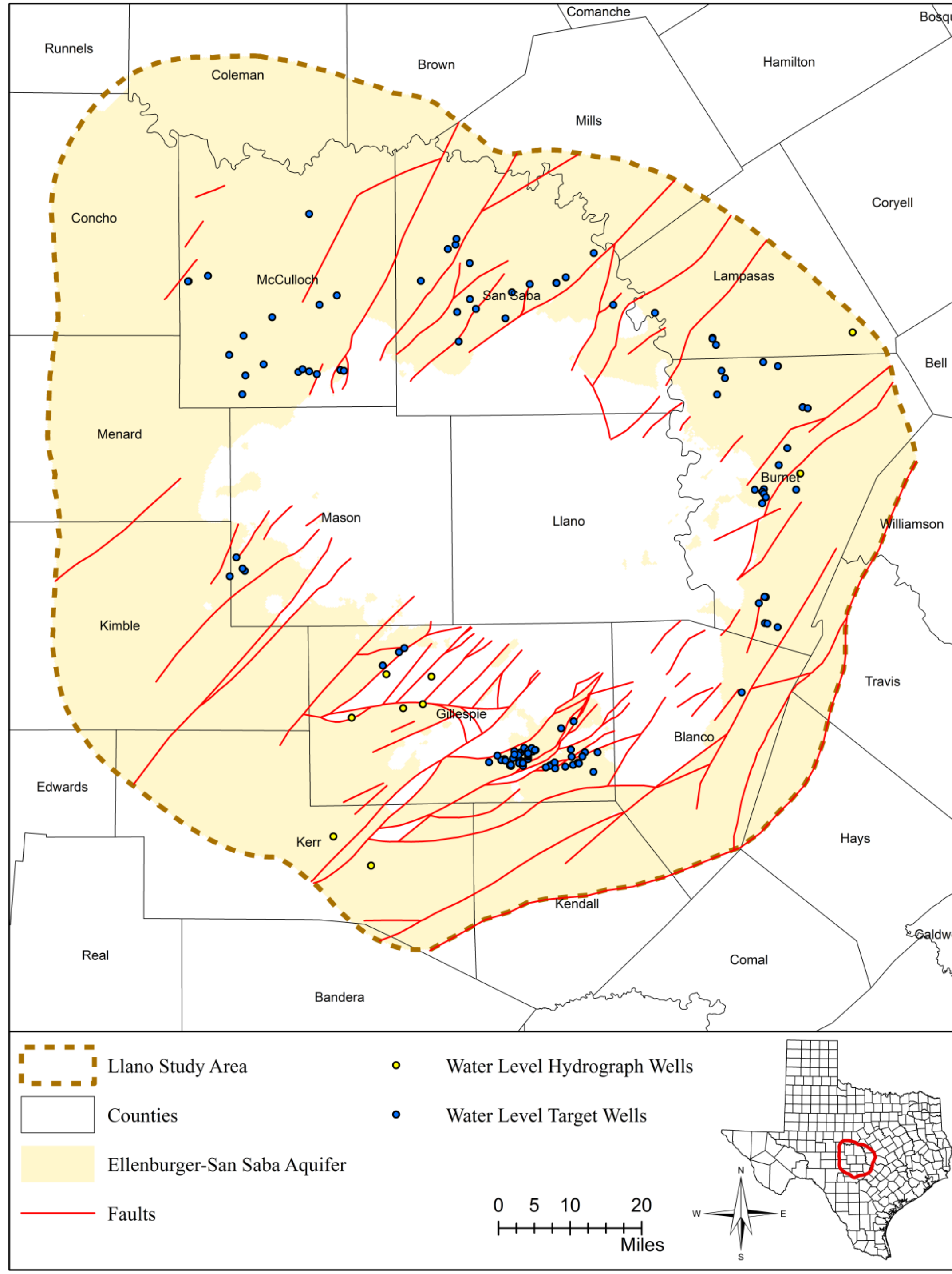


Cross Section B - B’

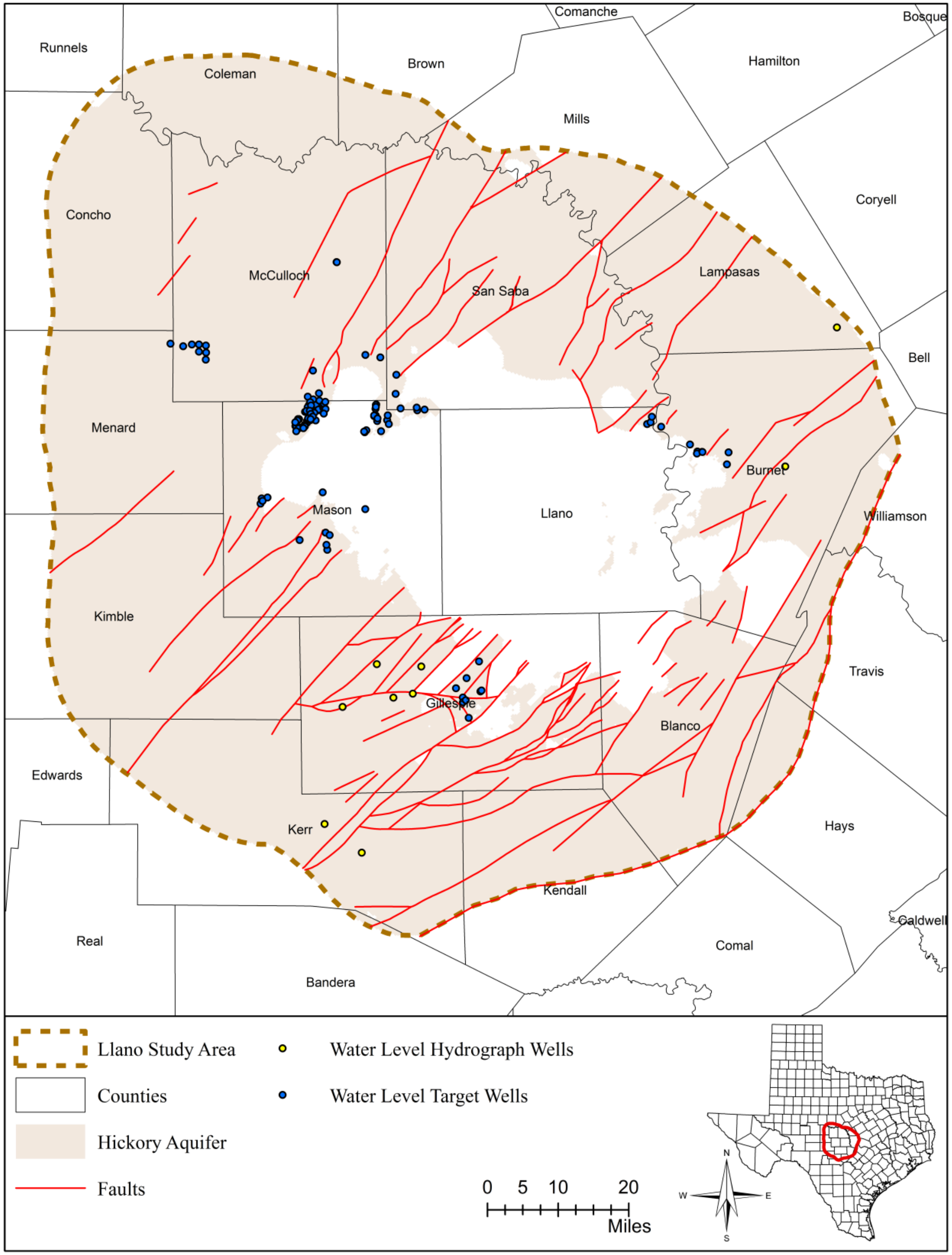


Water Levels/Regional Groundwater Flow

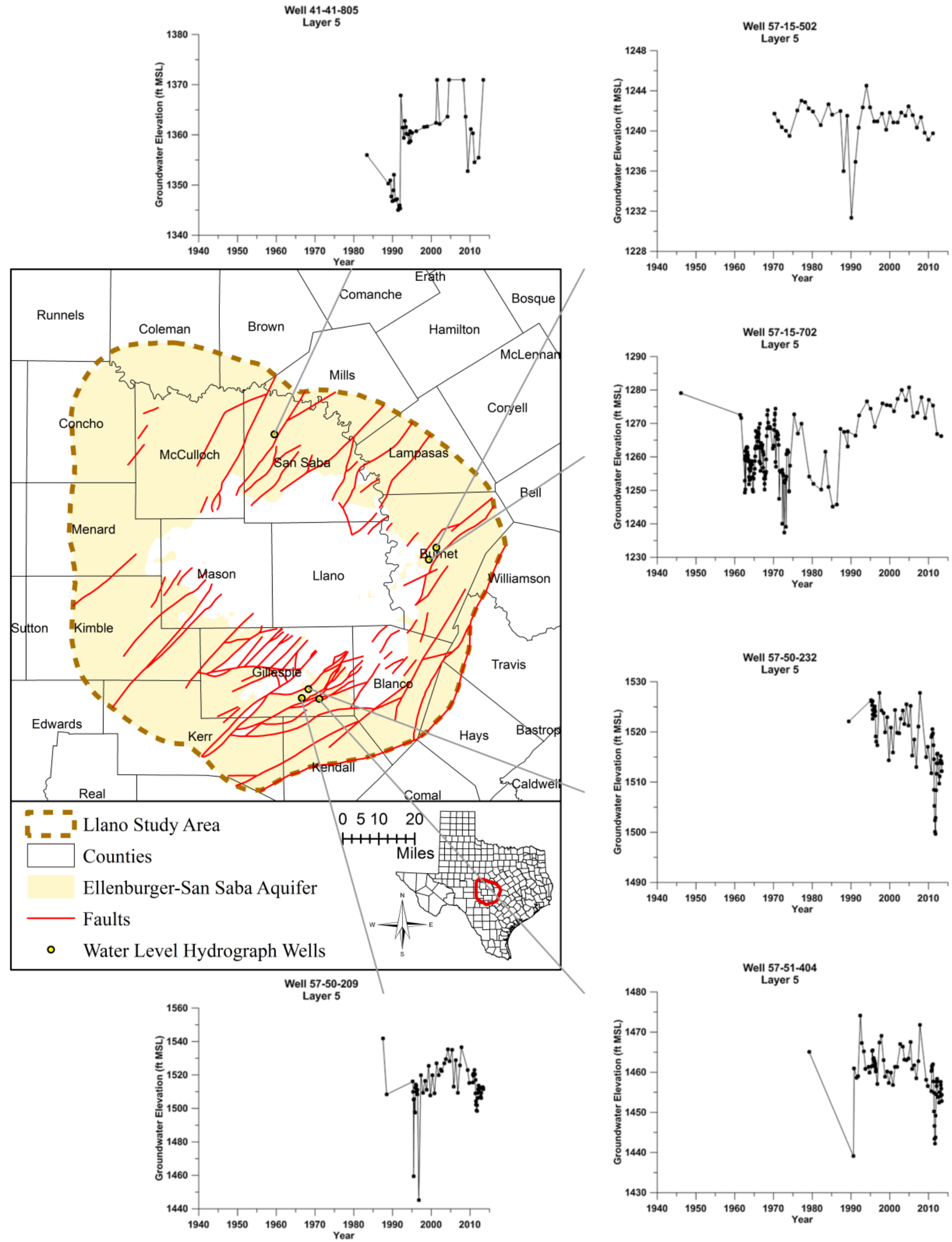
Wells with Water-Level Data (Ellenburger-San Saba)



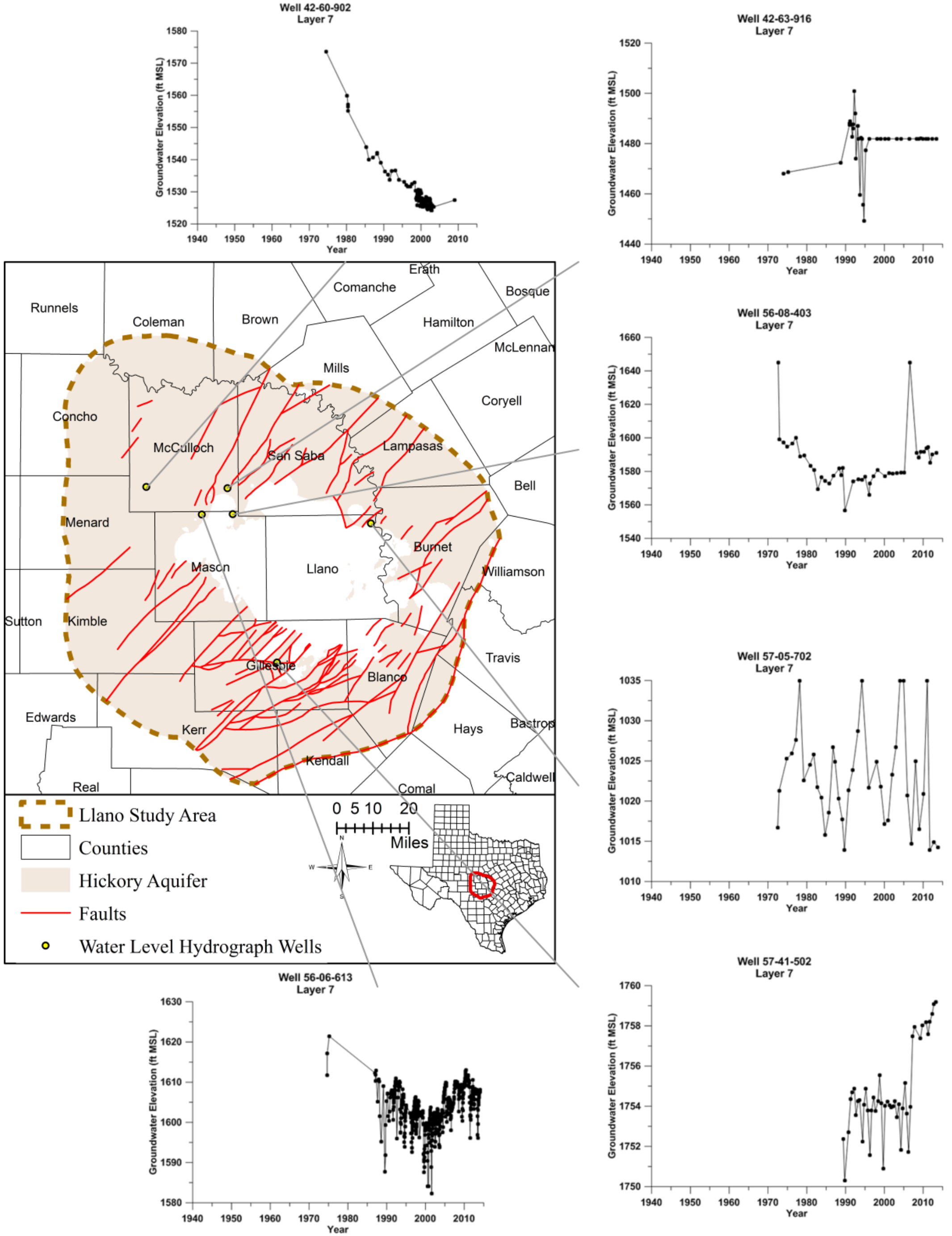
Wells with Water-Level Data (Hickory)



Change of Water Levels (Ellenburger-San Saba)

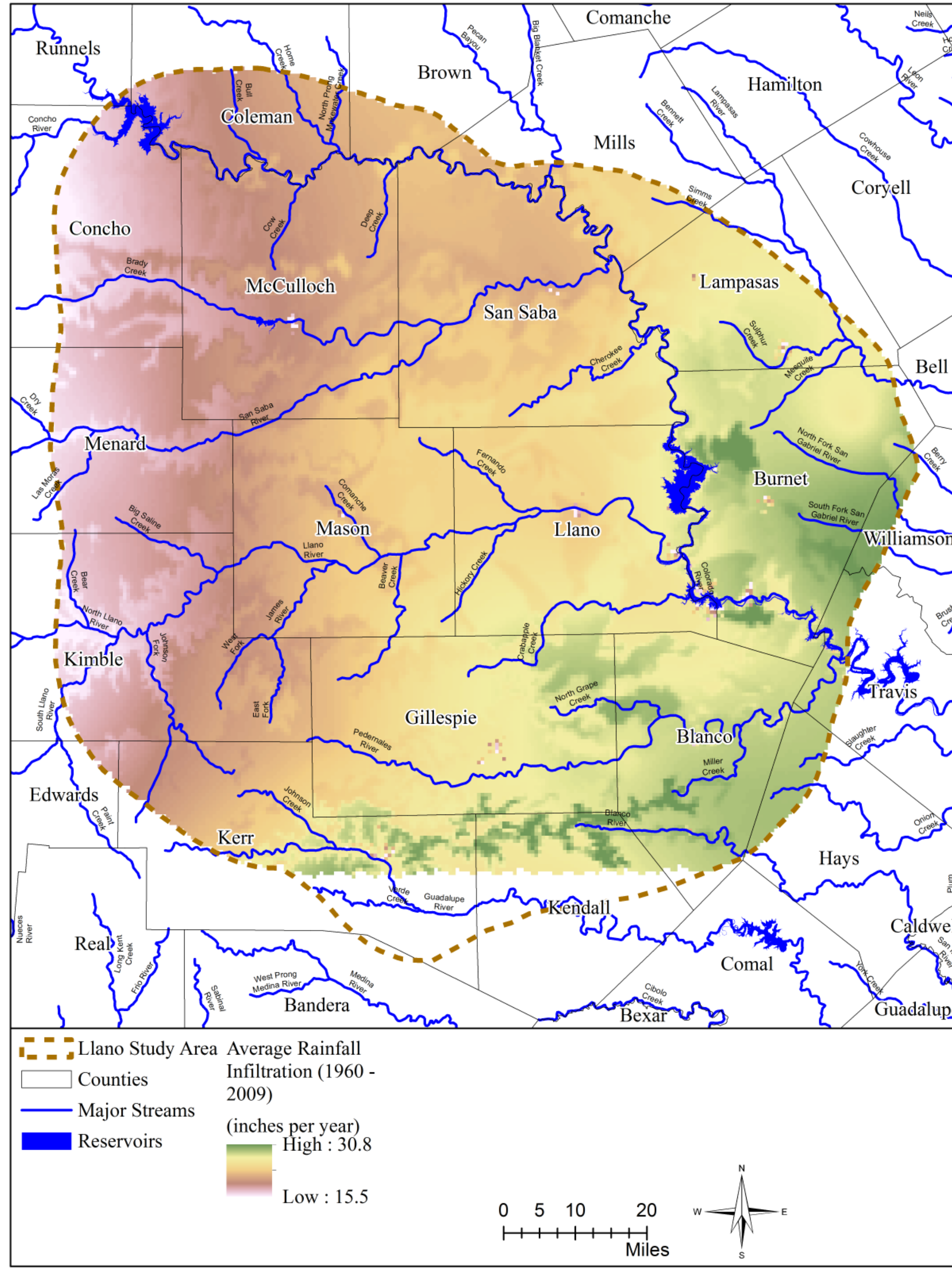


Change of Water Levels (Hickory)

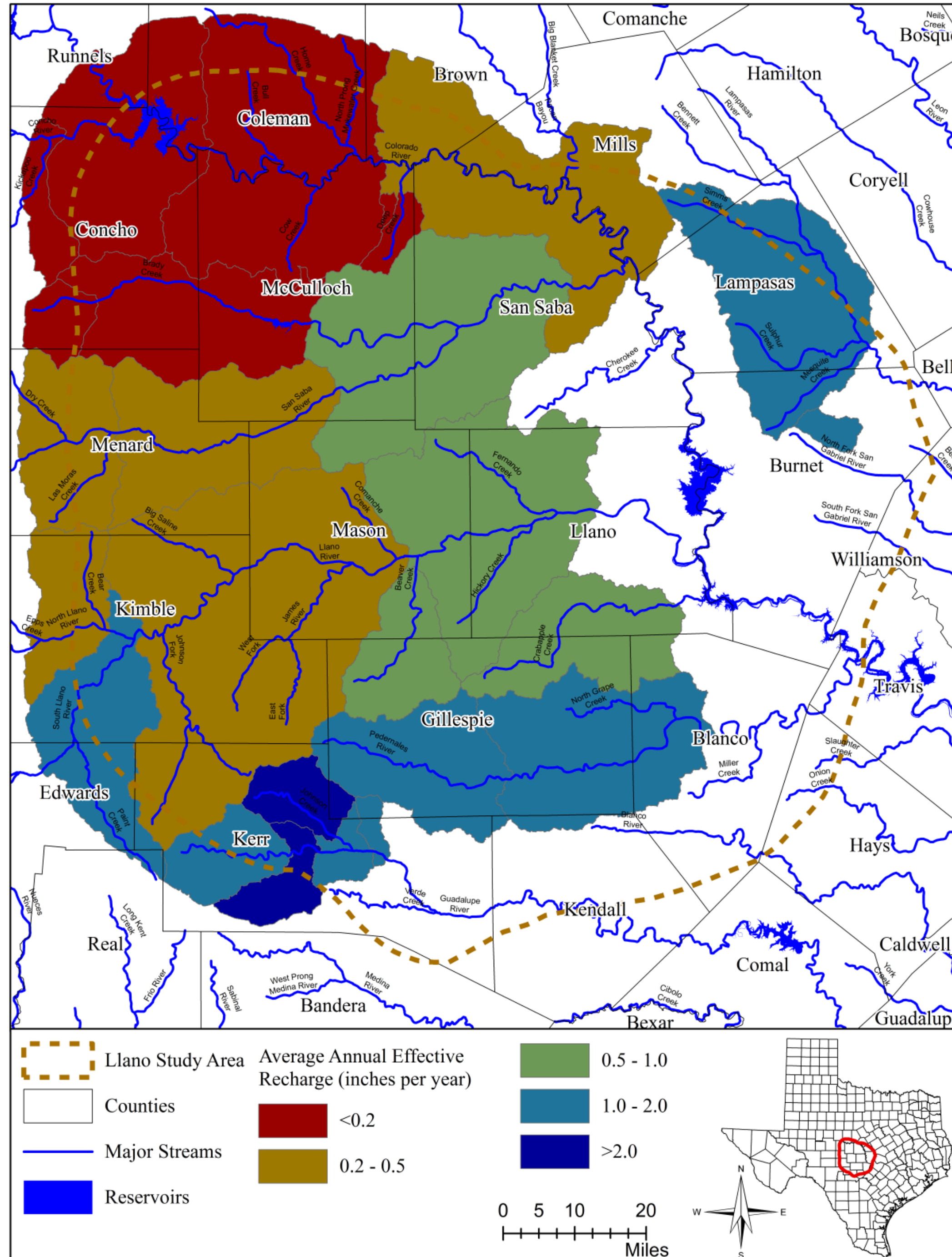


Recharge

Average Annual Rainfall Infiltration (1960 – 2009) (Kirk and others, 2012)

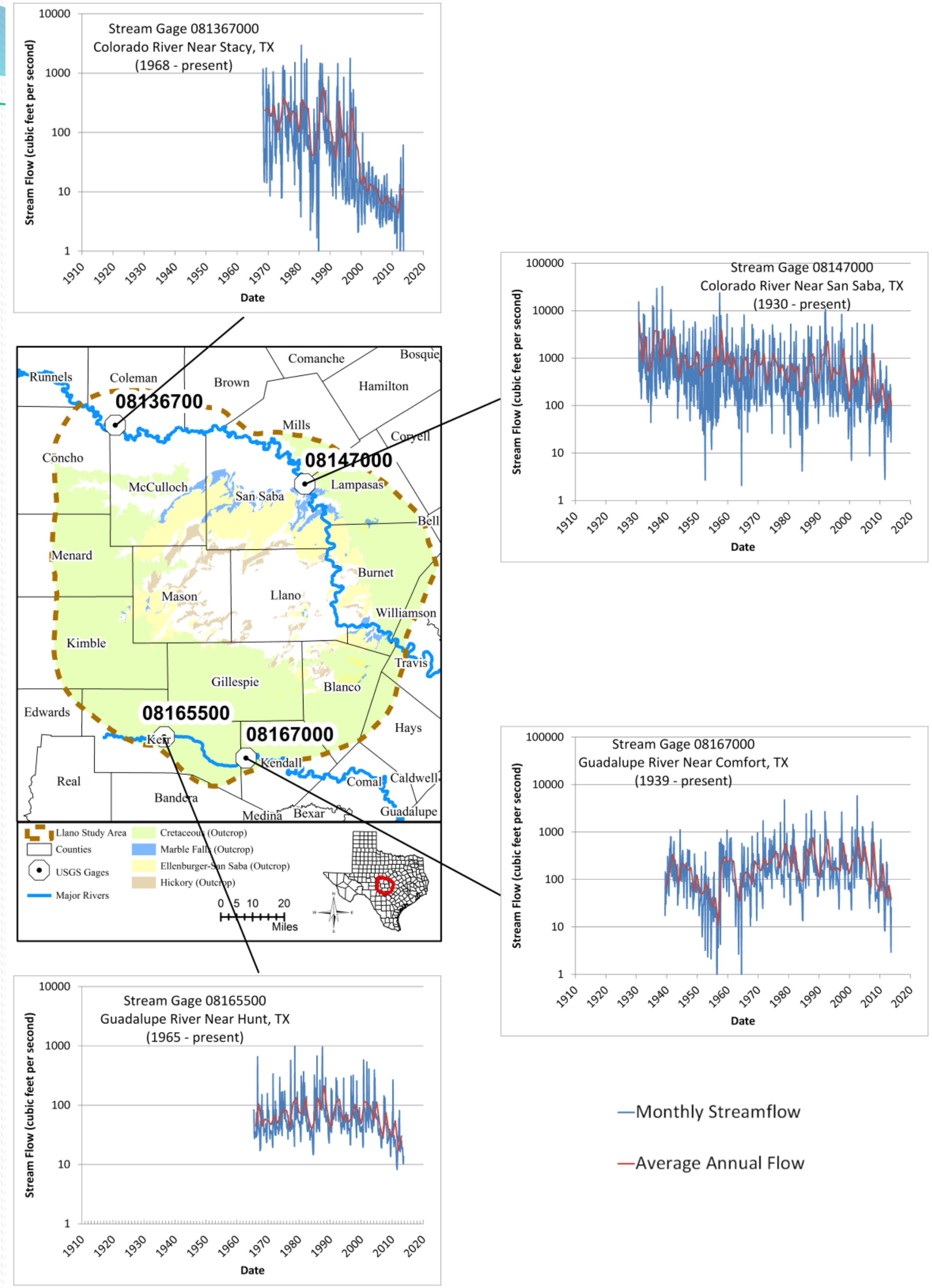


Average Annual Recharge Estimated from Stream Baseflow for Sub-basins

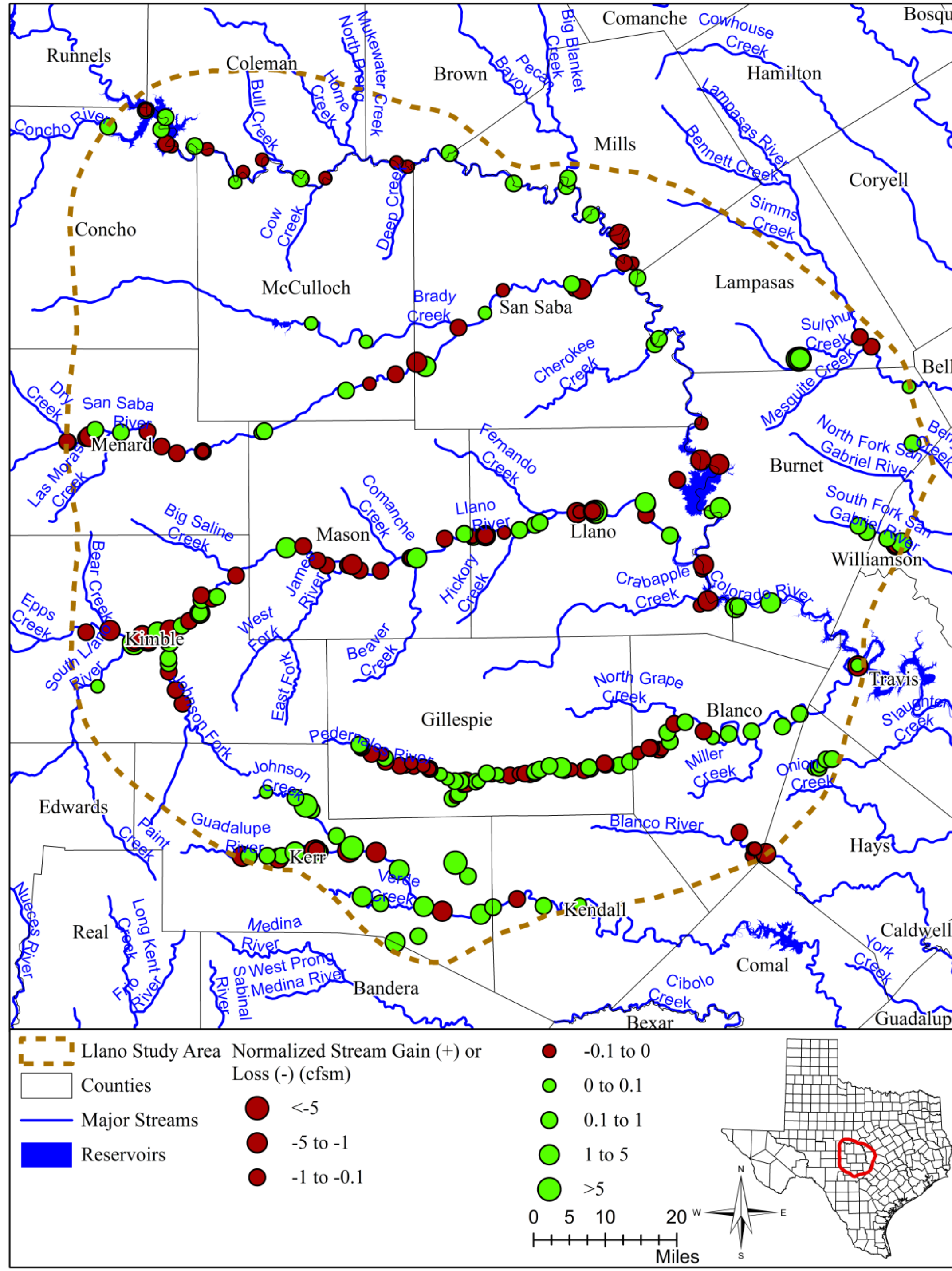


Surface Water

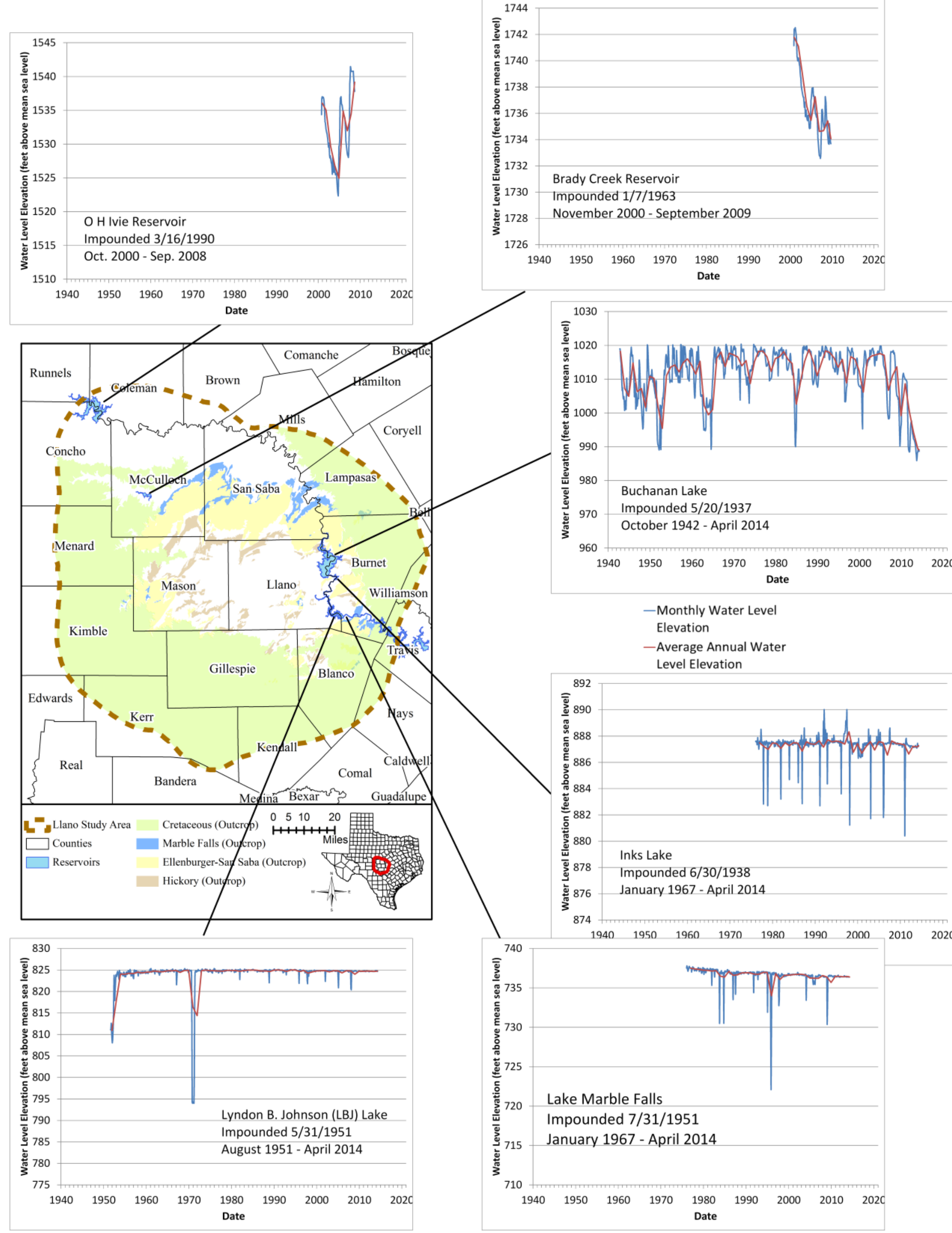
River Flow


Stream Gage 081367000
Colorado River Near Stacy, TX
(1968 - present)
Stream Gage 08147000
Colorado River Near San Saba, TX
(1930 - present)
Stream Gage 08167000
Guadalupe River Near Comfort, TX
(1939 - present)
Stream Gage 08165500
Guadalupe River Near Hunt, TX
(1965 - present)
Stream Flow (cubic feet per second)
Date
08136700
08147000
08165500
08167000
Runnels
Coleman
Brown
Comanche
Bosque
Hamilton
Mills
Coryell
Concho
McCulloch
San Saba
Lampasas
Bell
Menard
Mason
Llano
Burnet
Williamson
Kimble
Gillespie
Blanco
Travis
Edwards
Hays
Kerr
Kendall
Comal
Caldwell
Real
Bandera
Medina
Bexar
Guadalupe
Llano Study Area
Counties
USGS Gages
Major Rivers
Cretaceous (Outcrop)
Marble Falls (Outcrop)
Ellenburger-San Saba (Outcrop)
Hickory (Outcrop)
Miles
Monthly Streamflow
Average Annual Flow

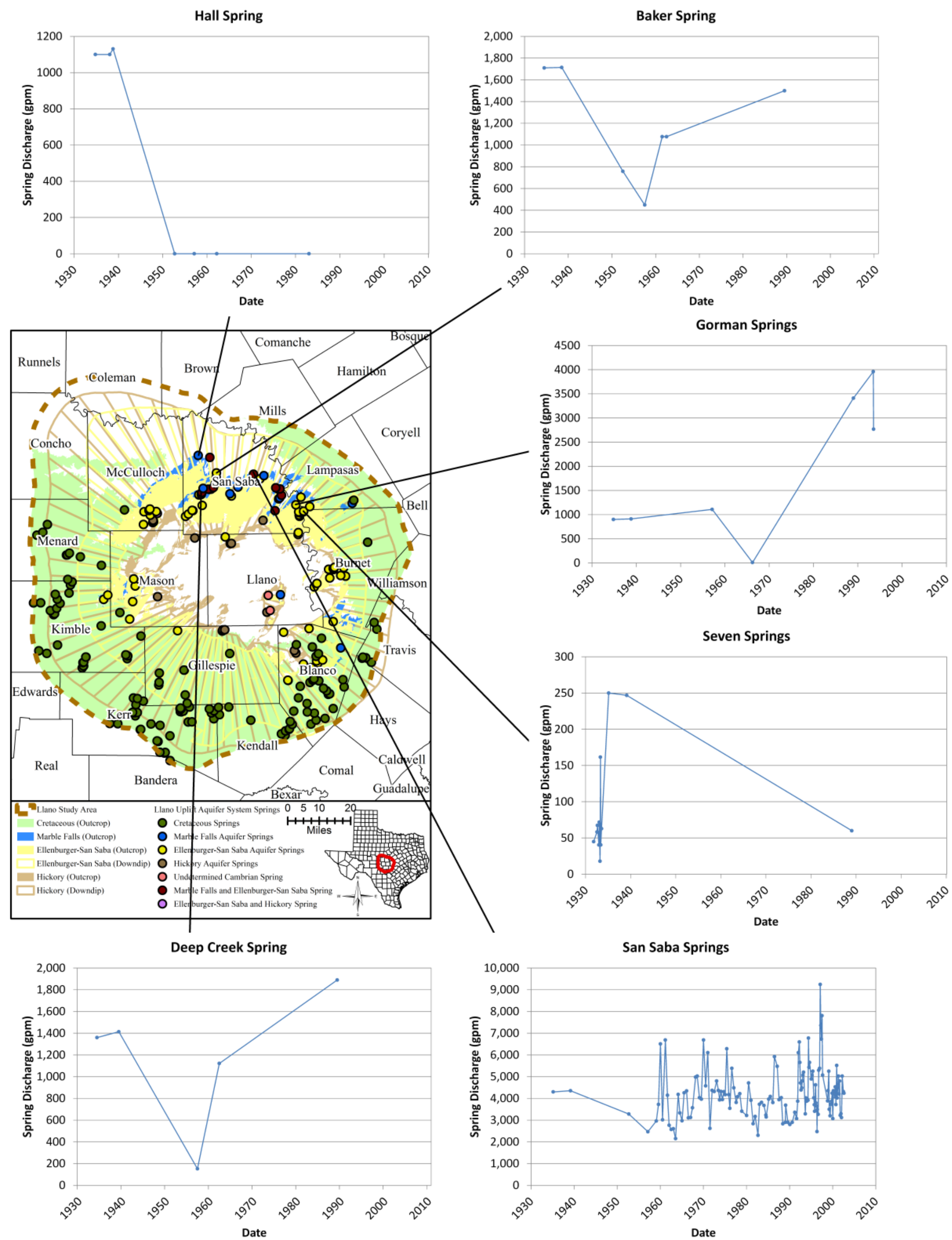
Stream Gain/Loss (based on Slade and others (2002))



Changes of Lake/Reservoir Levels

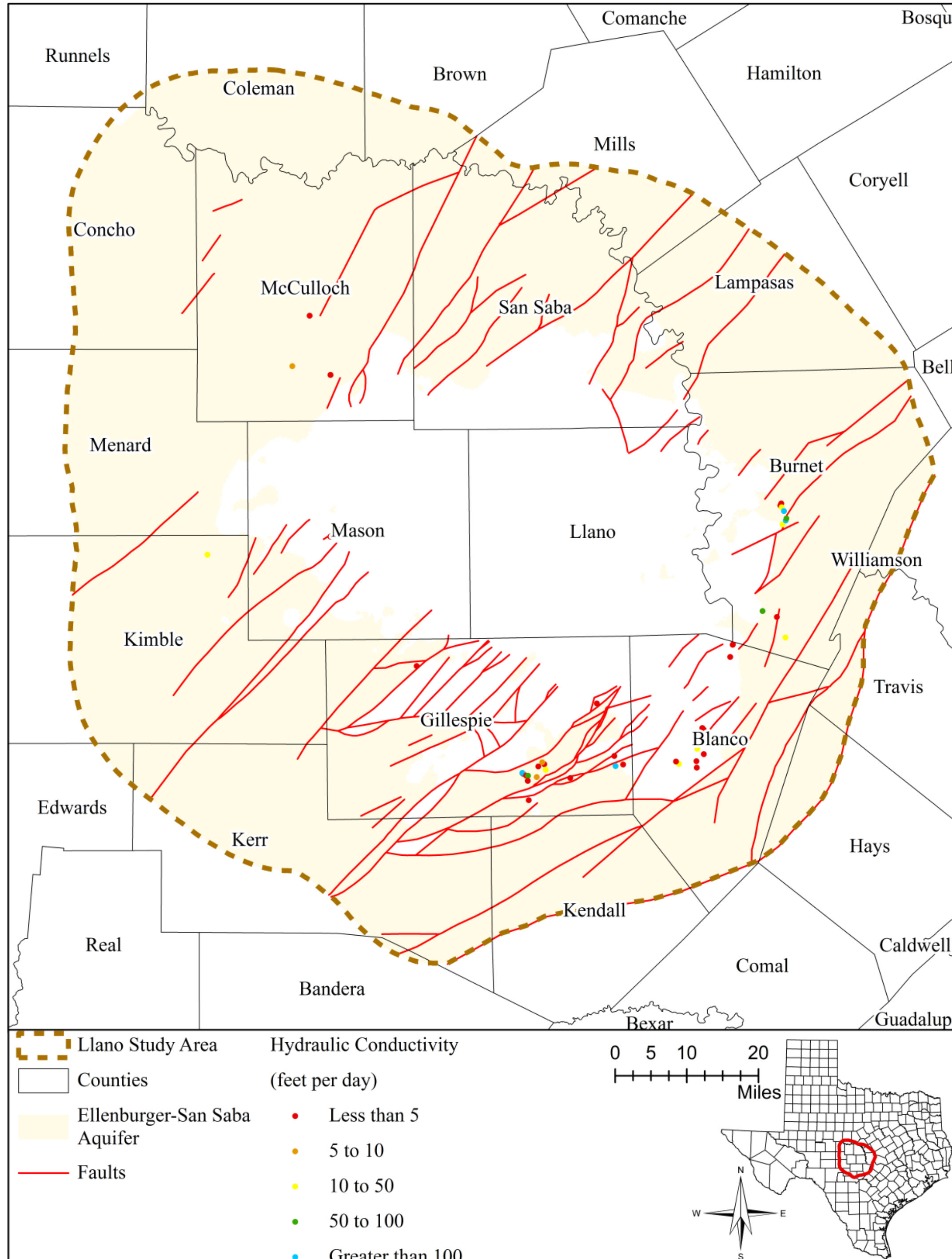


Changes of Spring Flows

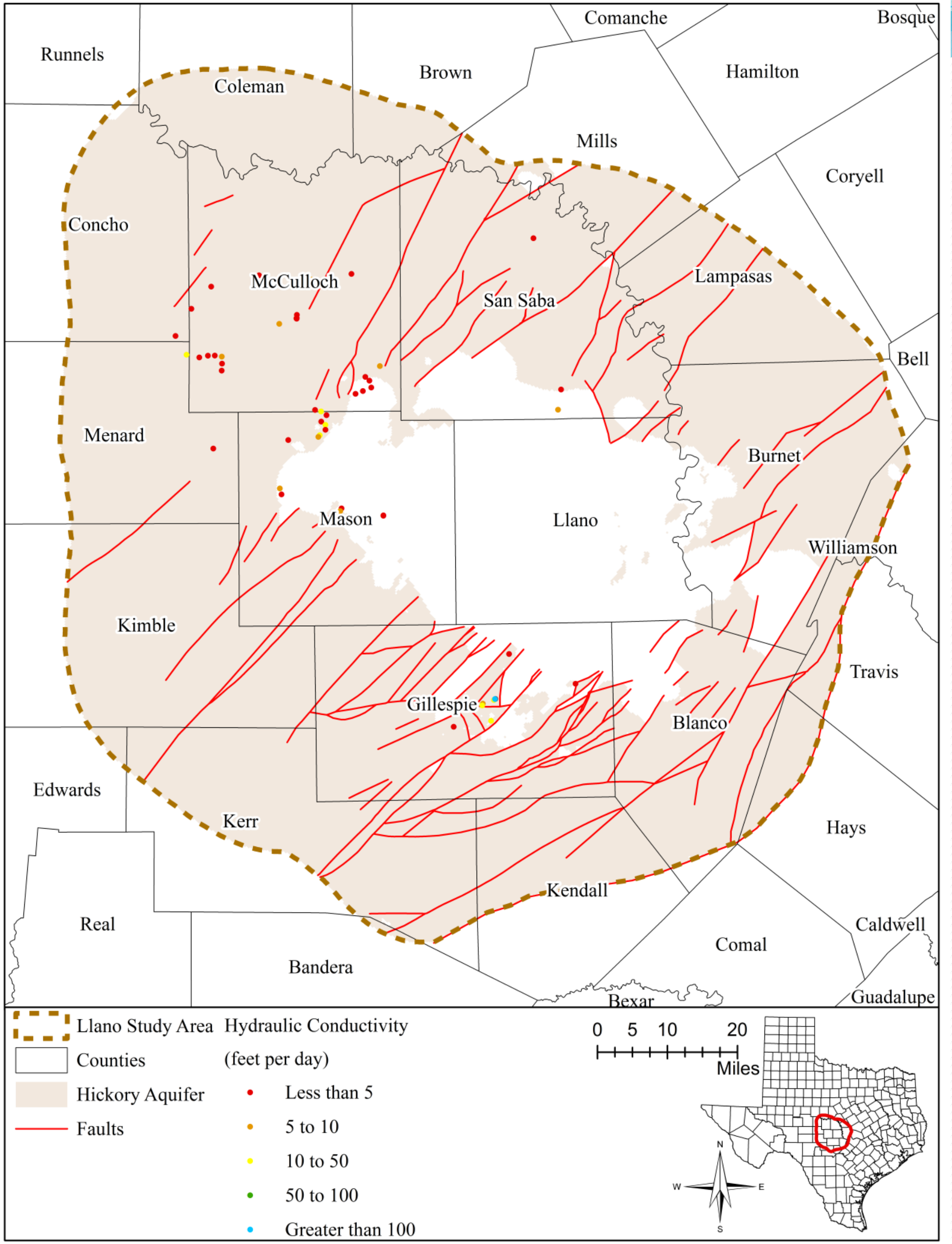


Hydraulic Properties

Distribution of Hydraulic Conductivity (Ellenburger-San Saba)

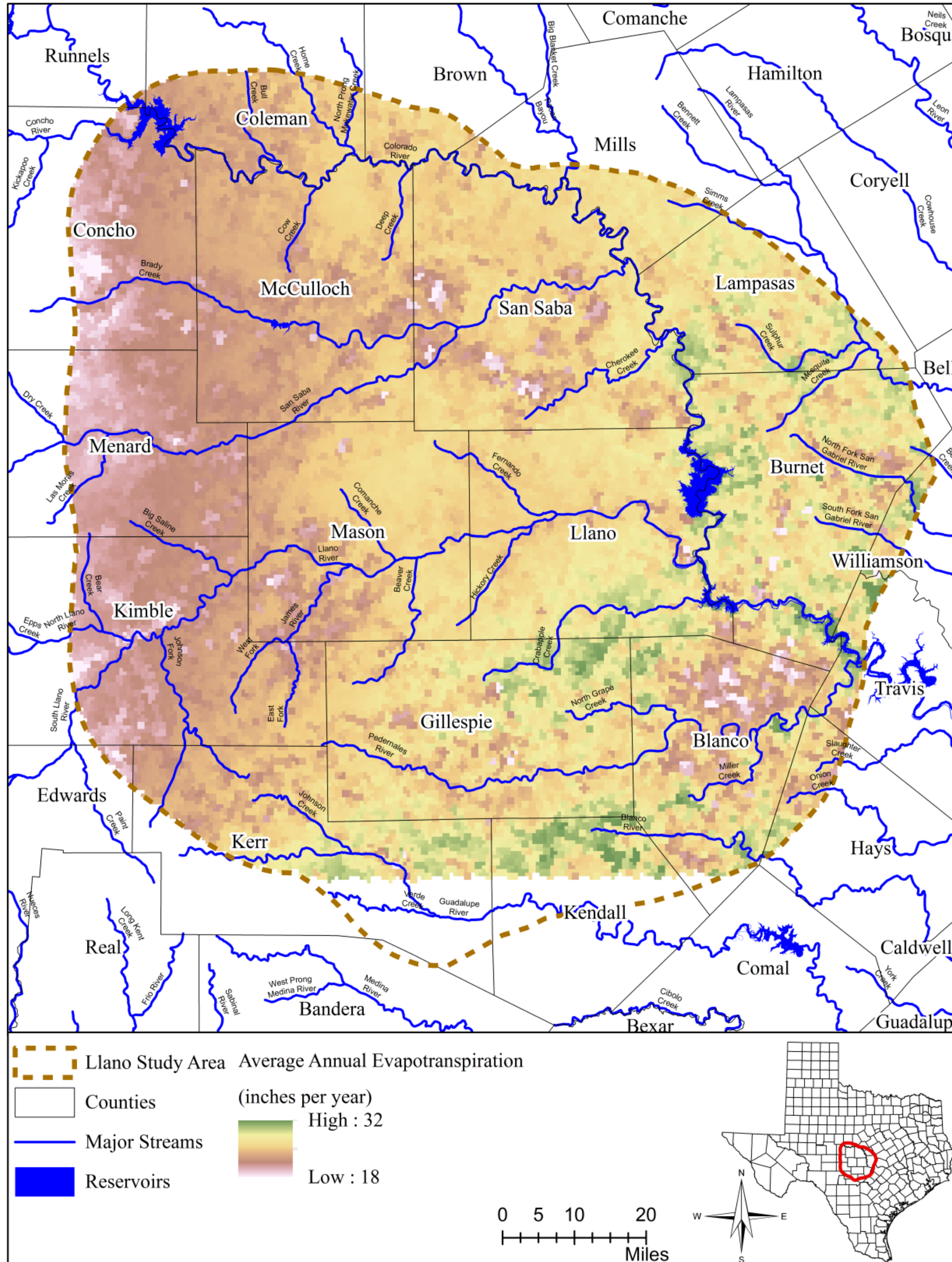


Distribution of Hydraulic Conductivity (Hickory)

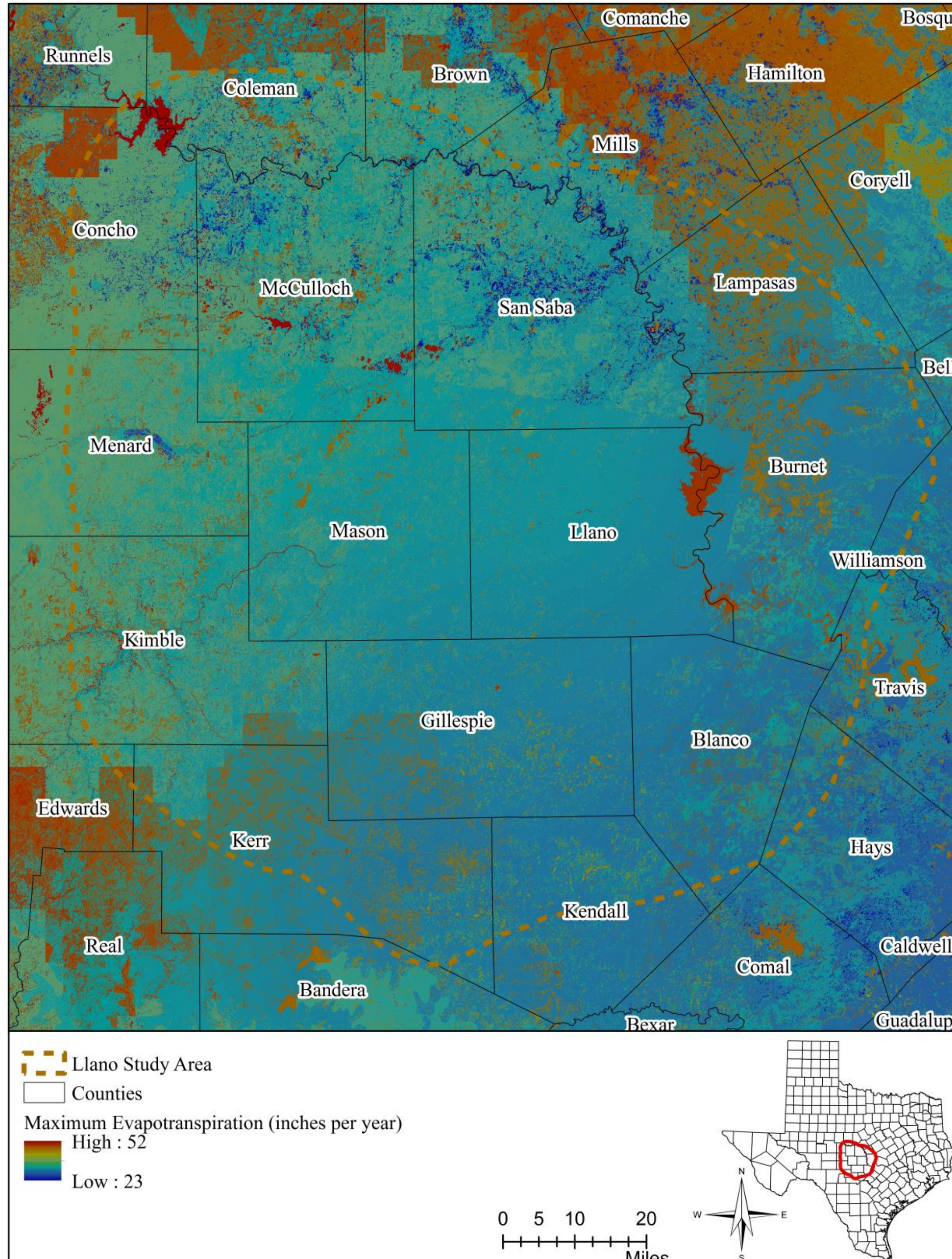


Groundwater Discharge

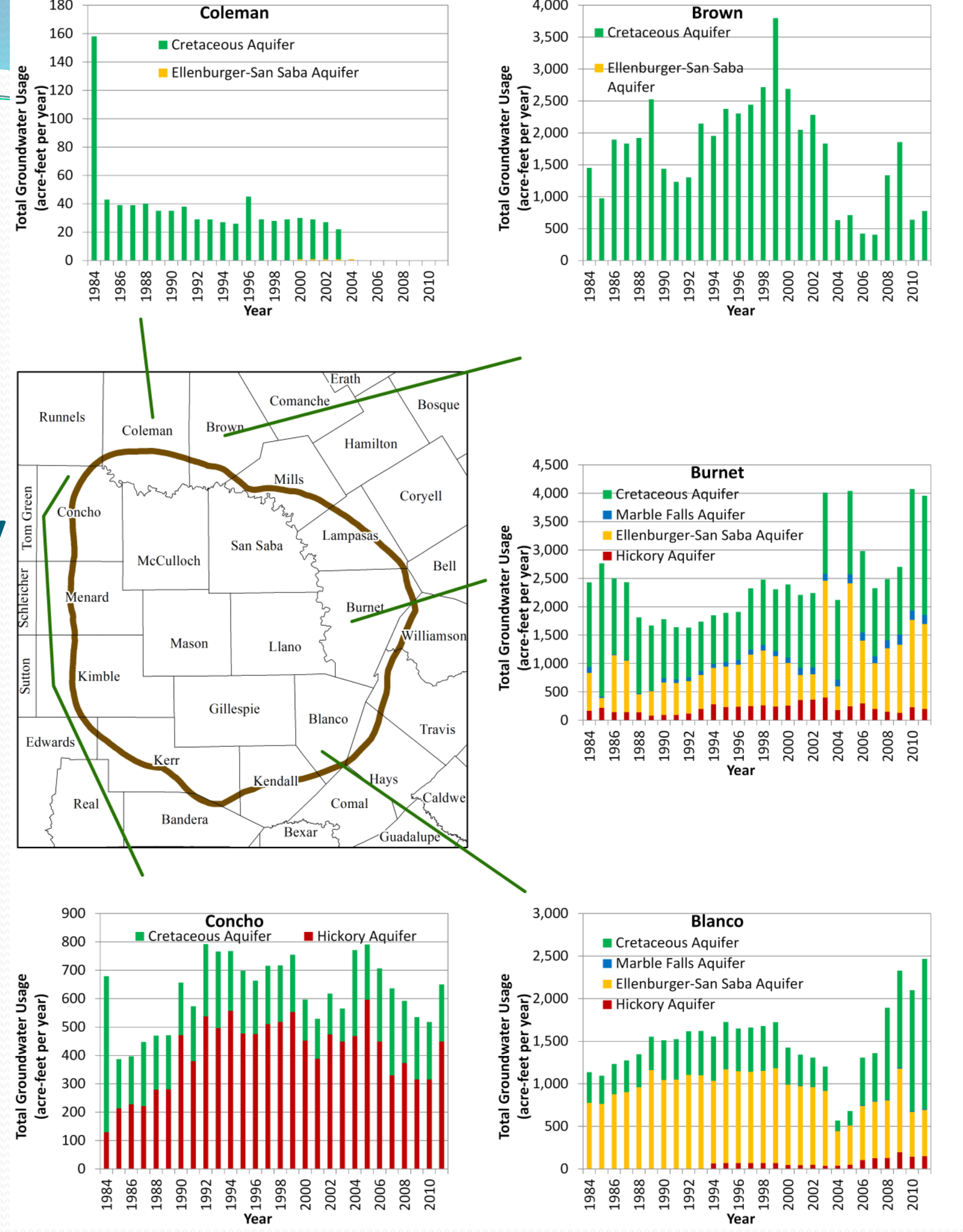
Distribution of Evapotranspiration (based on Kirk and others (2012))



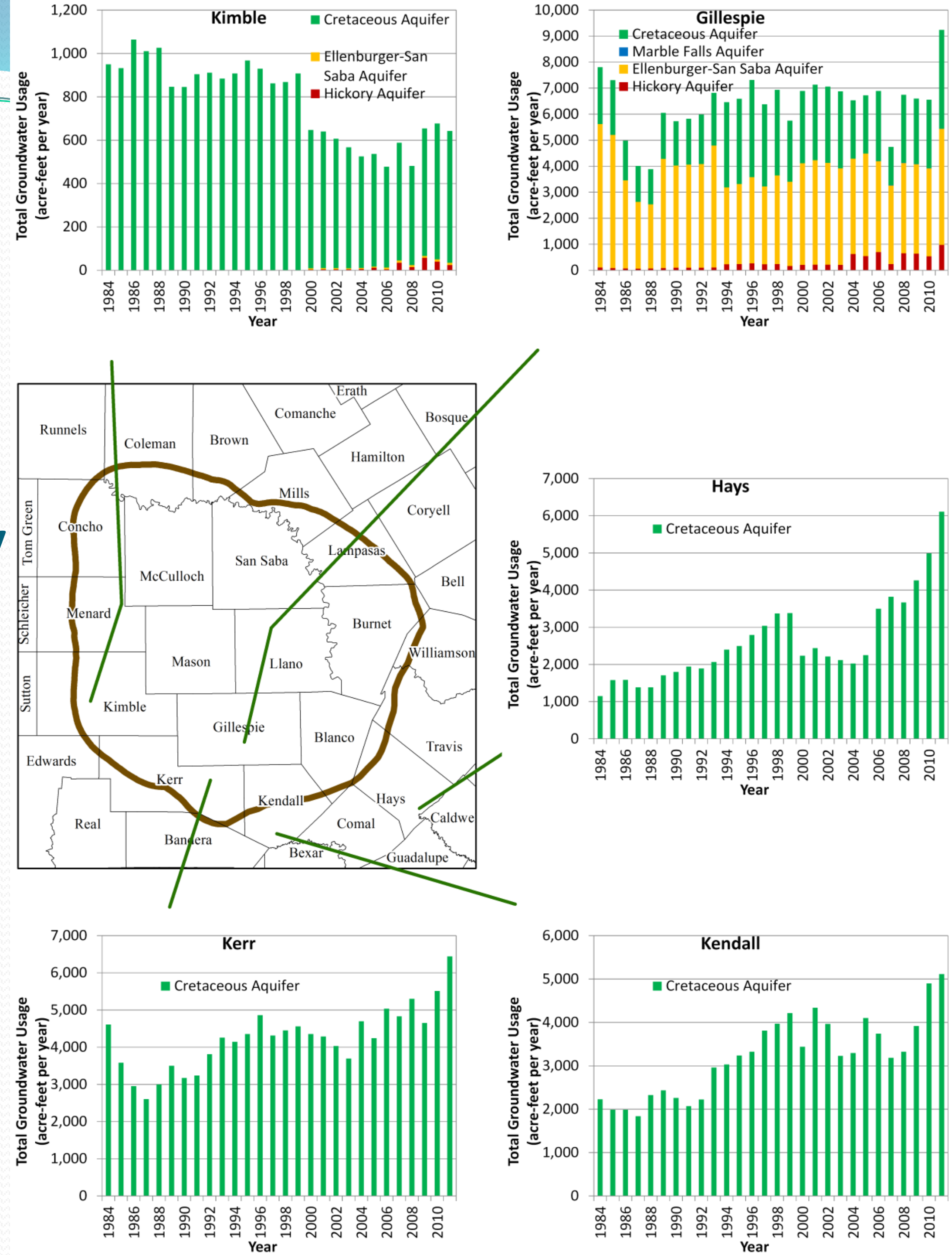
Distribution of Maximum Evapotranspiration (based on Scanlon and others (2005))



Historic Groundwater Use by County

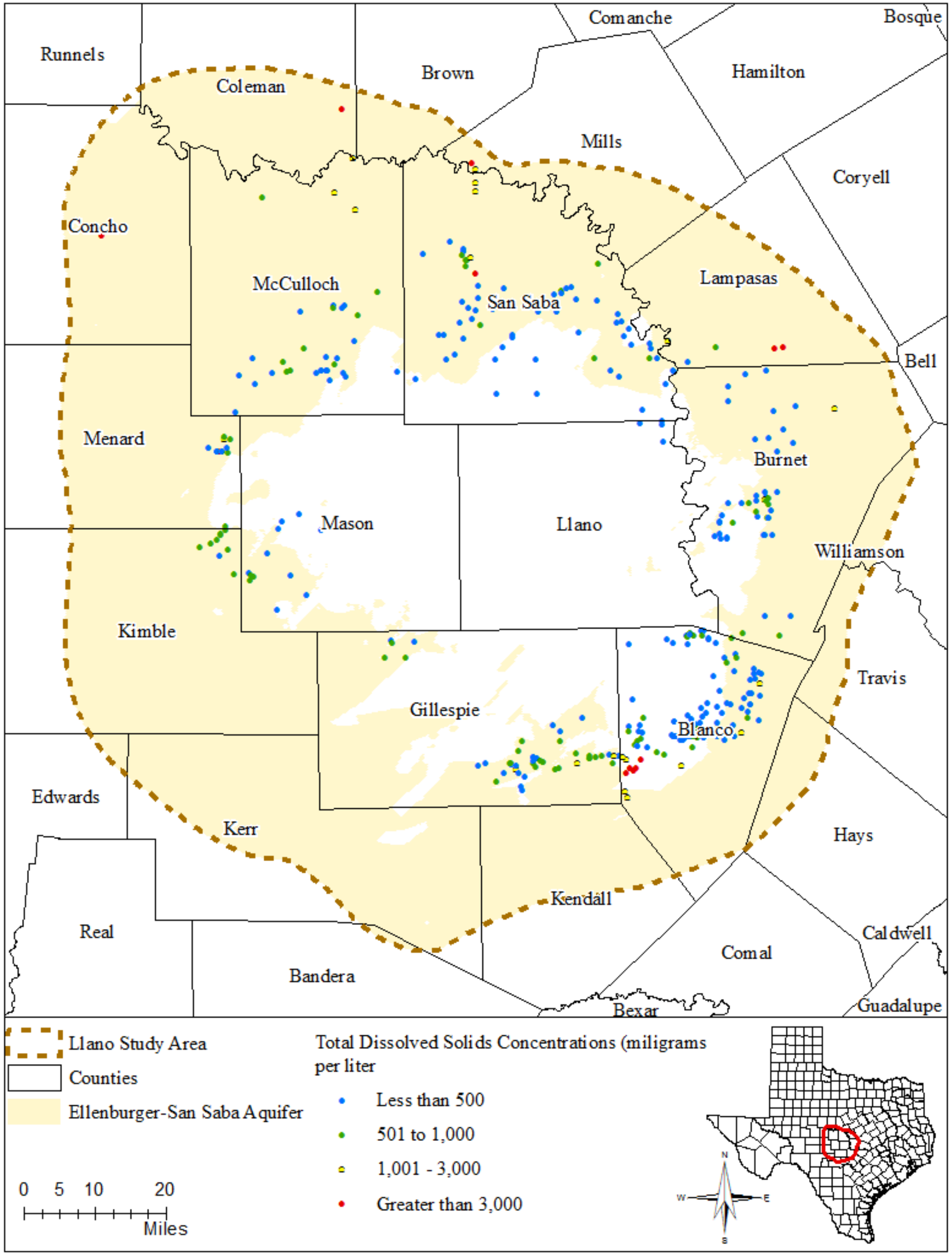


Historic Groundwater Use by County

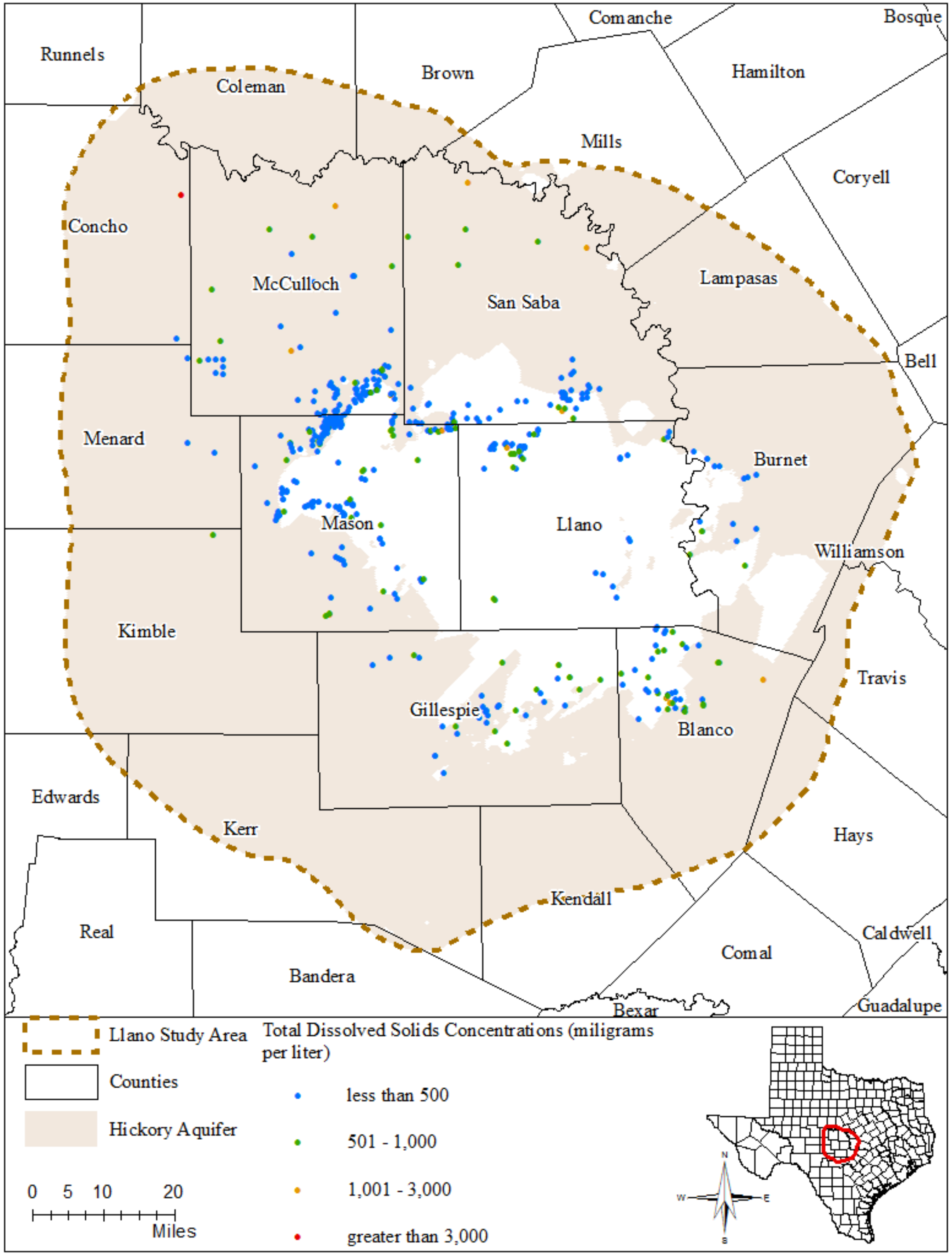


Water Quality

Total Dissolved Solids Concentration in Ellenburger-San Saba Aquifer

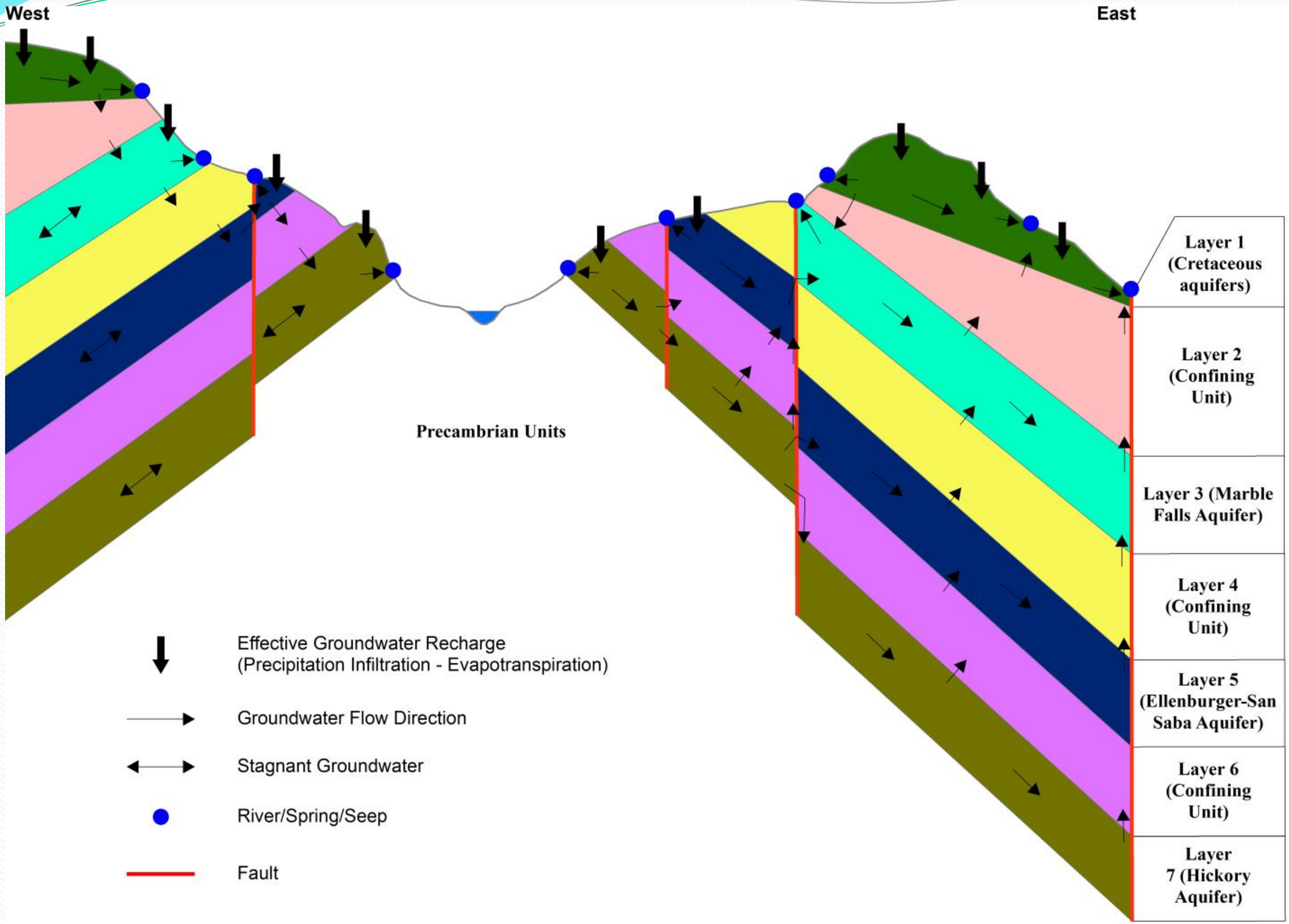


Total Dissolved Solids Concentration in Hickory Aquifer

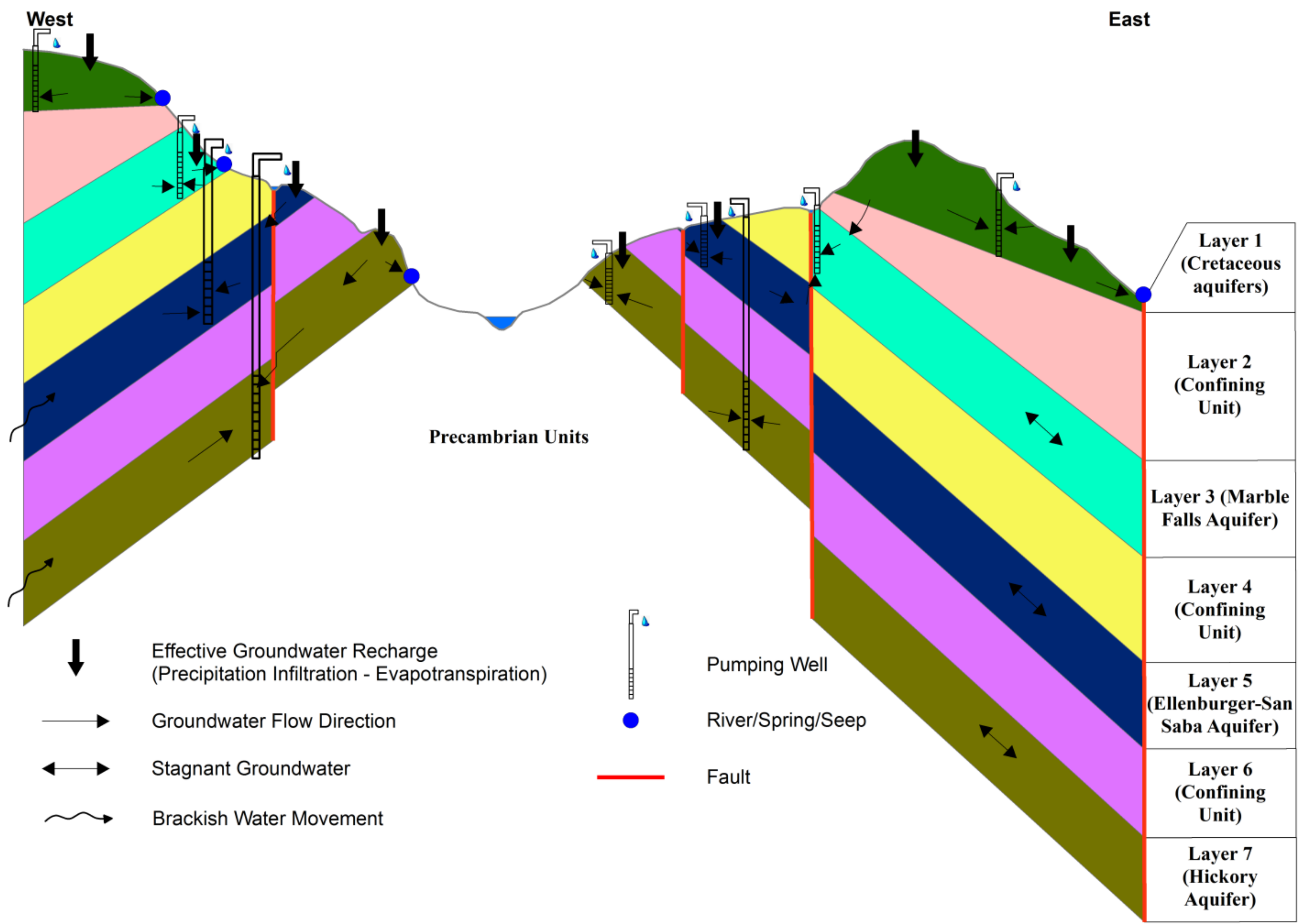


CONCEPTUAL MODEL

Conceptual Model: Pre-Development



Conceptual Model: Post-Development



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	August 2015
Stakeholder Advisory Forum # 3	September 2015
Final Report	December 2015

Contact Information

Jerry Shi, Ph.D., P.G.

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

September 30, 2014

Hill Country University Center, Fredericksburg, Texas

The second Stakeholder Advisory Forum (SAF) Meeting for the Llano Uplift Minor Aquifers Groundwater Availability Model (GAM) was held on Tuesday, September 30, 2014 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.

Meeting Introduction: Cindy Ridgeway, TWDB

The meeting was initiated by Ms. Cindy Ridgeway of the Texas Water Development Board (TWDB). She gave a brief introduction to the GAM Program and discussed how GAMs are used in Texas water resources planning. She then discussed GAMs and how they related to modeled available groundwater (MAG) as well as the importance of the stakeholder process. She closed by introducing the Llano Uplift Aquifers GAM Team and introduced the project manager Dr. Jerry Shi.

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

Dr. Shi presented a prepared presentation structured according to the following outline:

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

Questions and Answers:

Question: Have you started constructing the model at all, yet?

Answer (Jerry): We have some preliminary work done, such as the layer structure; we will have to convert that to USG. Continued by Cindy: As mentioned earlier, the conceptual model report is online for everyone to read, it will be up for a few more weeks. You might not see the final report until we're done with the model -- in case we need to change things in the conceptual model. If you have questions on the report or on this presentation, please feel free to contact either Jerry or myself. This has been one of the more challenging locations for a model.

Question: The numbers produced for the last planning session, DFCs and MAGS, were developed using an analytical method-- do you have a feel for how much different these numbers will be between this model and the analytical runs?

Answer (Jerry): I have no idea. We have to model first. Continued by Cindy: there will be a difference. We enhanced the framework quite a bit. The framework itself started with a study by Standen and Co., a while back, which was kind of a coarse grid, and we took all the geophysical logs to refine that framework. So, what we have is probably slightly different-looking from what they used in the analytical runs. I am sure this will have a bearing on any of the results that come out. How much, we don't know.

Question: Say you're doing a model run for McCulloch County. There are a number of really dramatic faults in that county. Can you do a model run within a zone between two faults?

Answer (Cindy): We can zone in a particular area. While we're developing the model, one of the bigger challenges there will be using the fault package to estimate how much flow is going across each of these faults. That will be one of the tools we'll be looking at to calibrate the model.

Question: This will be a useful tool for the district in their management plan.

Answer (Cindy): We saw the cross-sections, and there was significant displacement. There will be assumptions made as we calibrate. We won't say that we have the perfect tool, but just that this is a great foundation . As the aquifers are stressed and you see how the water levels change, we can then incorporate these in the model updates later on. We have to start somewhere, and this will be better than anybody else has. It's a very complex system. These aquifers haven't been stressed - at least some of then - yet. We will understand better the situation in areas with stagnant water or where the wells are [...unintelligible...] that downdip flow, to understand the system better. This could be a situation where, as water levels change, the flow system changes as well. It will be an extremely challenging project.

Llano Uplift Minor Aquifers GAM Stakeholder Advisory Forum 2

September 30, 2014

Attendance

Name	Affiliation
Jerry Shi	Texas Water Development Board
Ian Jones	Texas Water Development Board
Bill Hutchison	Consultant
Meghan Roussel	US Geological Survey
Natalie Houston	US Geological Survey
Jeremy White	US Geological Survey
William Kohlrenken	Texas Water Development Board
Radu Boghici	Texas Water Development Board
Mitchell Sodek	Central Texas Groundwater Conservation District
Charles Shell	Central Texas Groundwater Conservation District
Tim Lehmberg	Gillespie County Economic Development Commission
Cindy Ridgeway	Texas Water Development Board
David Jeffery	Bandera County River Authority and Groundwater District
Paul Babb	Blanco-Pedernales Groundwater Conservation District
Joel Pigg	Real-Edwards Conservation and Reclamation District
Paul Tybor	Hill Country Underground Water Conservation District
Caroline Runge	Hickory Underground Water Conservation District No. 1