Llano Water Workshop – 08/28/14

Personal Information:

- Robert Foster, resident of Llano County since March of 2009.
- Lost 25% of my oak trees and my stock tank was dry in 2011.
- My primary water well was failing in October of 2011, I understand your concerns.

Credentials:

- Graduated Magna Cum Laude in 1985 from Texas A&M with a BS in Geophysics.
- 30 years experience as a geophysicist with Shell Oil Company.
- Currently Chief Geophysicist for Shell Oil Co. responsible for all geophysical analysis and risking in North and South America with an annual exploration budget of $1.2 billion.

Personal Agenda:

- Not being a resident of the city, I have nothing to gain or lose from the decisions made affecting the Llano municipal water supply.
- However, I would prefer that the town of Llano remains prosperous.

Disclaimer: I am here today as a private citizen of Llano county expressing my own personal views and opinions. Those views and opinions in no way reflect the views of Shell Oil Co. or its affiliates. The material shown in this presentation was gathered from a variety of sources and reports. Sources are annotated on each slide.

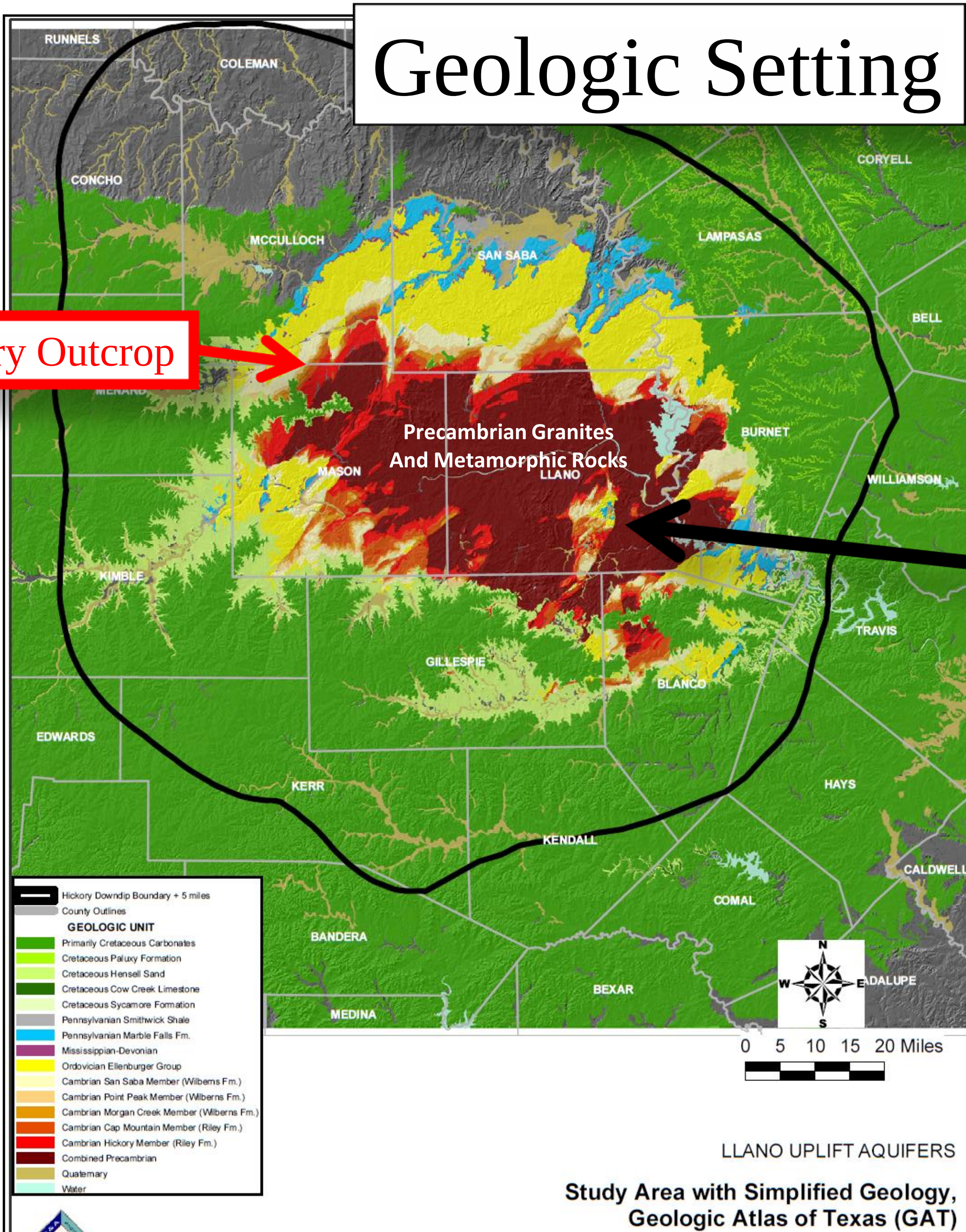
Mission Statement

Goal: Drill a municipal supply water well in the vicinity of Riley Mountain that is capable of producing 100 gpm of potable water from an aquifer large enough to sustain production for 4 months and is capable of being recharged to provide a renewable resource.

Problem: The existing studies have done a great job of describing the physical conditions and constraints, but they have not quantified the cumulative risk of this venture.

Geologic Setting

Hickory Outcrop

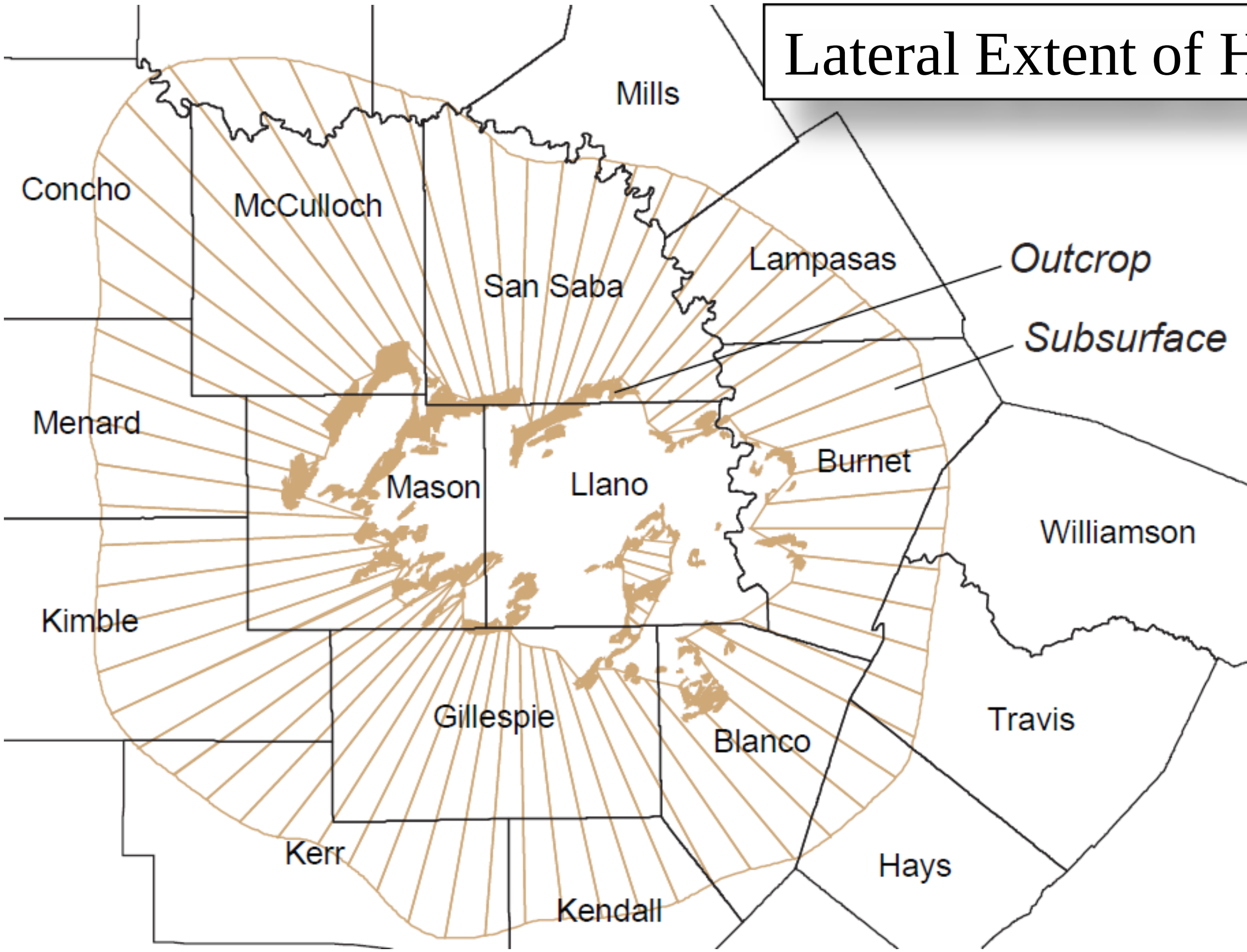


Riley Mountain

Colors represent geologic age at the surface. Rapid color change indicates significant deformation, faulting and erosion.

Source: Llano Uplift Aquifers Structure and Stratigraphy, Allan Standen & Robert Ruggiero, Prepared for TWDB, 2007.

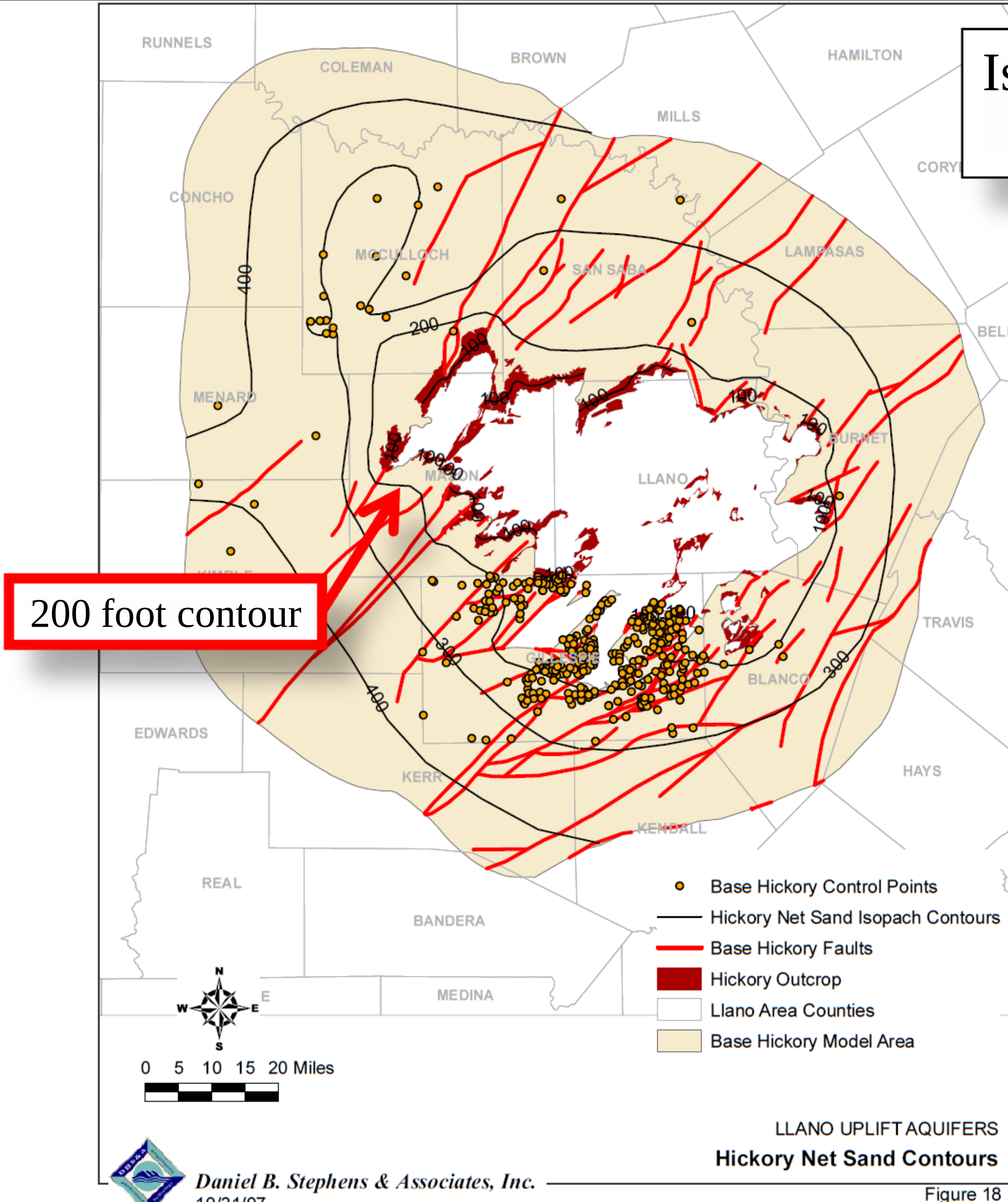
Lateral Extent of Hickory Sands



Solid color indicates outcrop at the surface, hachured area indicates the presence of Hickory Sands in the subsurface. The average dip of the Hickory Member is 1.5 degrees radially away from the Llano uplift.

Source: Aquifers of Texas, Peter G. George et. al., TWDB Report 380, 2011.

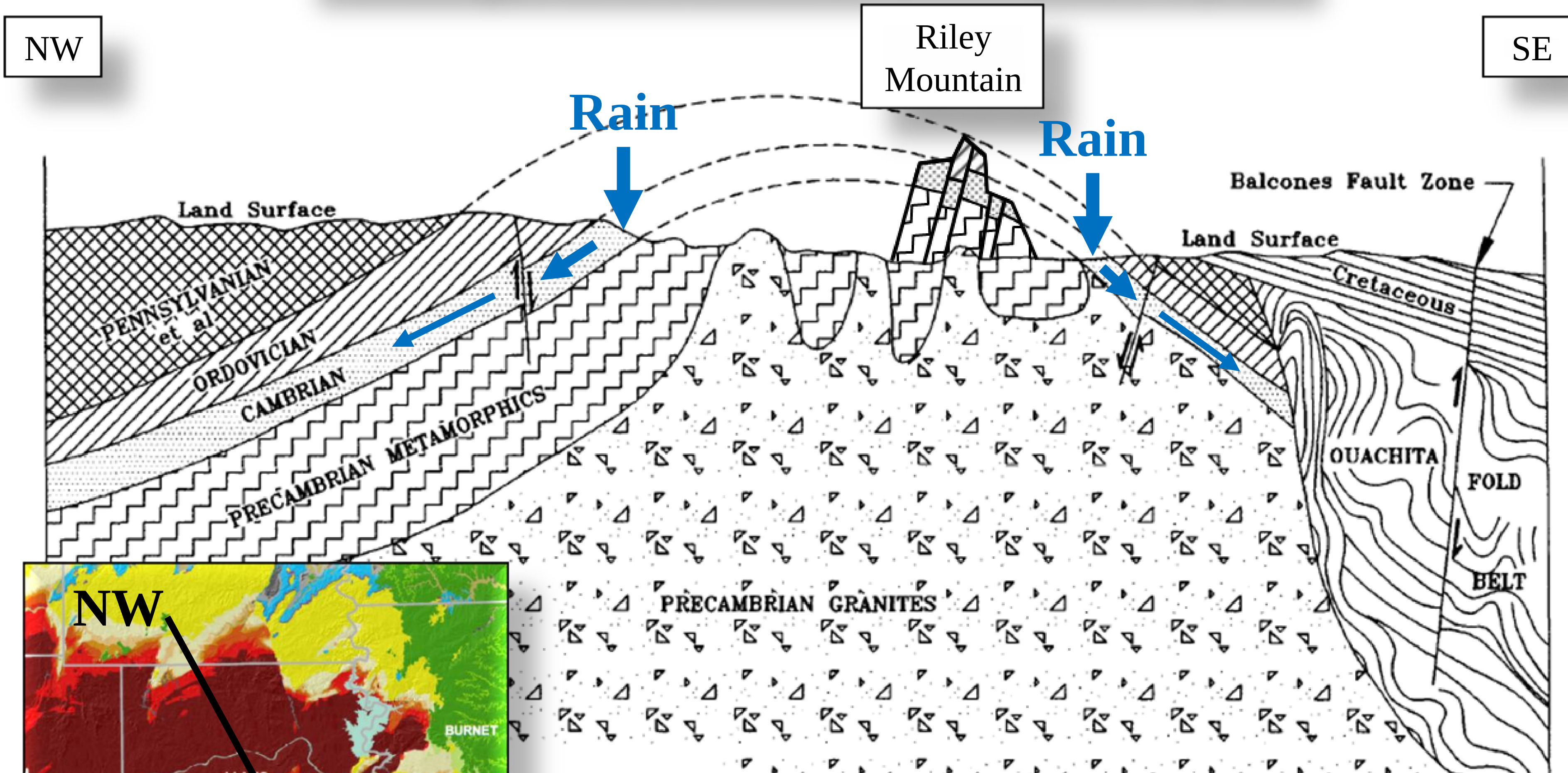
Isopach Thickness of the Hickory Sands

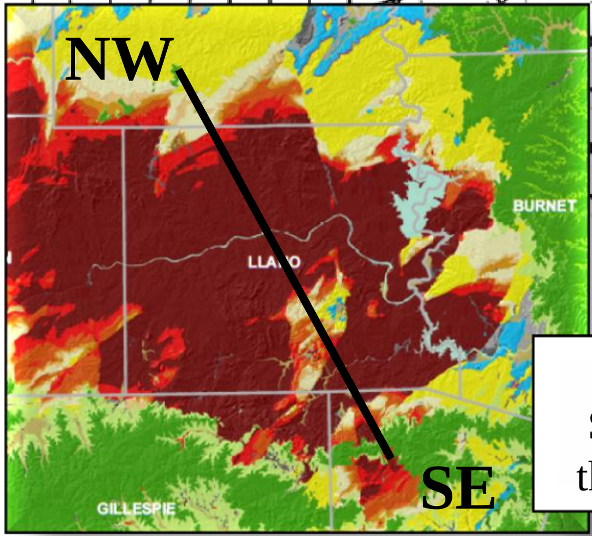


The Hickory Member pinches out on the Llano Uplift and generally thickens away from the uplift in all directions. Thickness ranges from 0 to 530 feet based on study results.

Source: Llano Uplift Aquifers Structure and Stratigraphy, Allan Standen & Robert Ruggiero, Prepared for TWDB, 2007.

Geologic Cross Section Across Llano Uplift

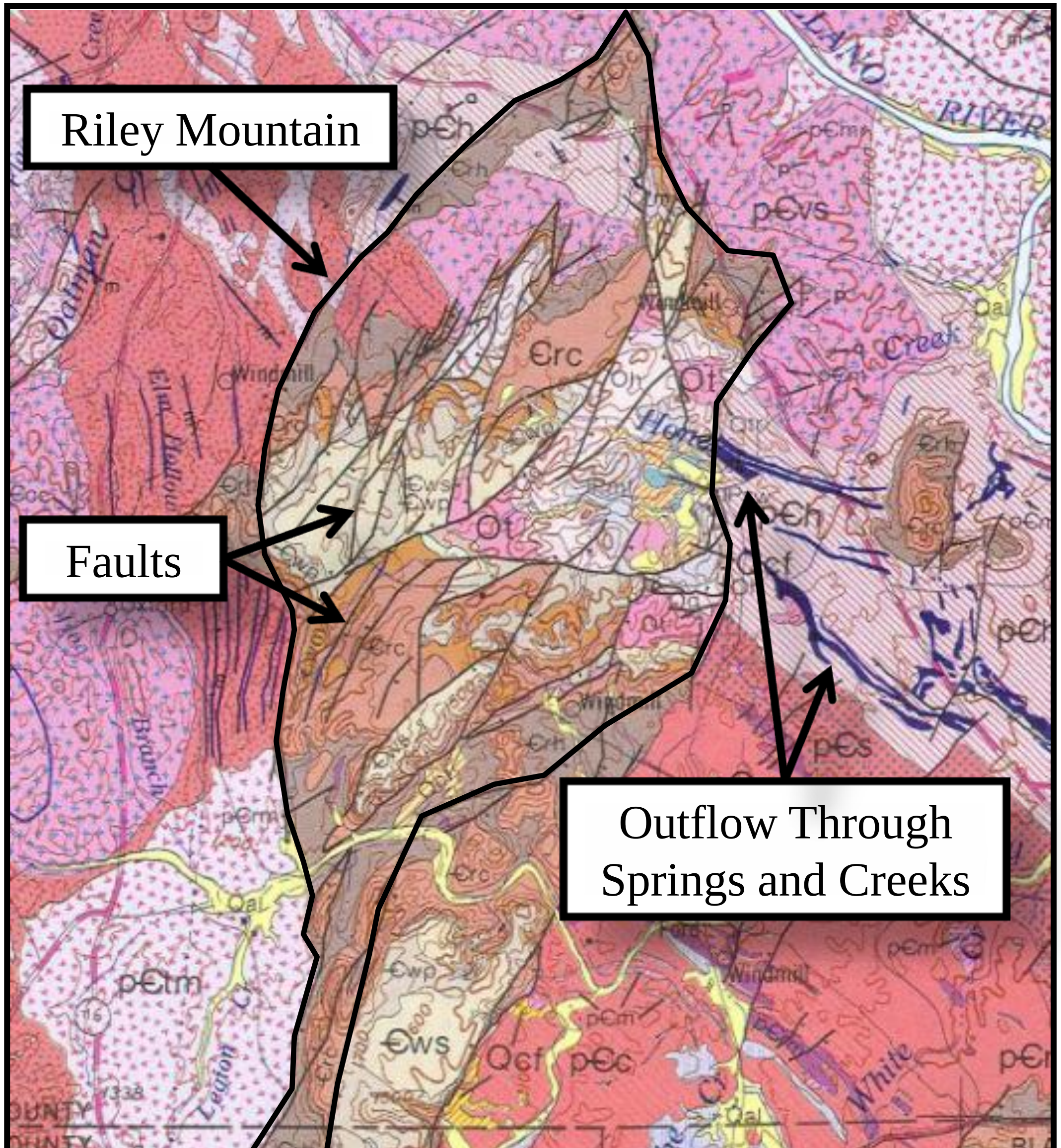




Primary recharge in clastic aquifers occurs in the outcrop areas. Secondary recharge can occur along faults. Very little recharge occurs through seepage through the impermeable layers that bound the aquifer.

Source: The Paleozoic and Related Aquifers of Central Texas, Richard D. Preston et. al., TWDB Report 346, 1996.

Riley Mountain Surface Geology and Faults



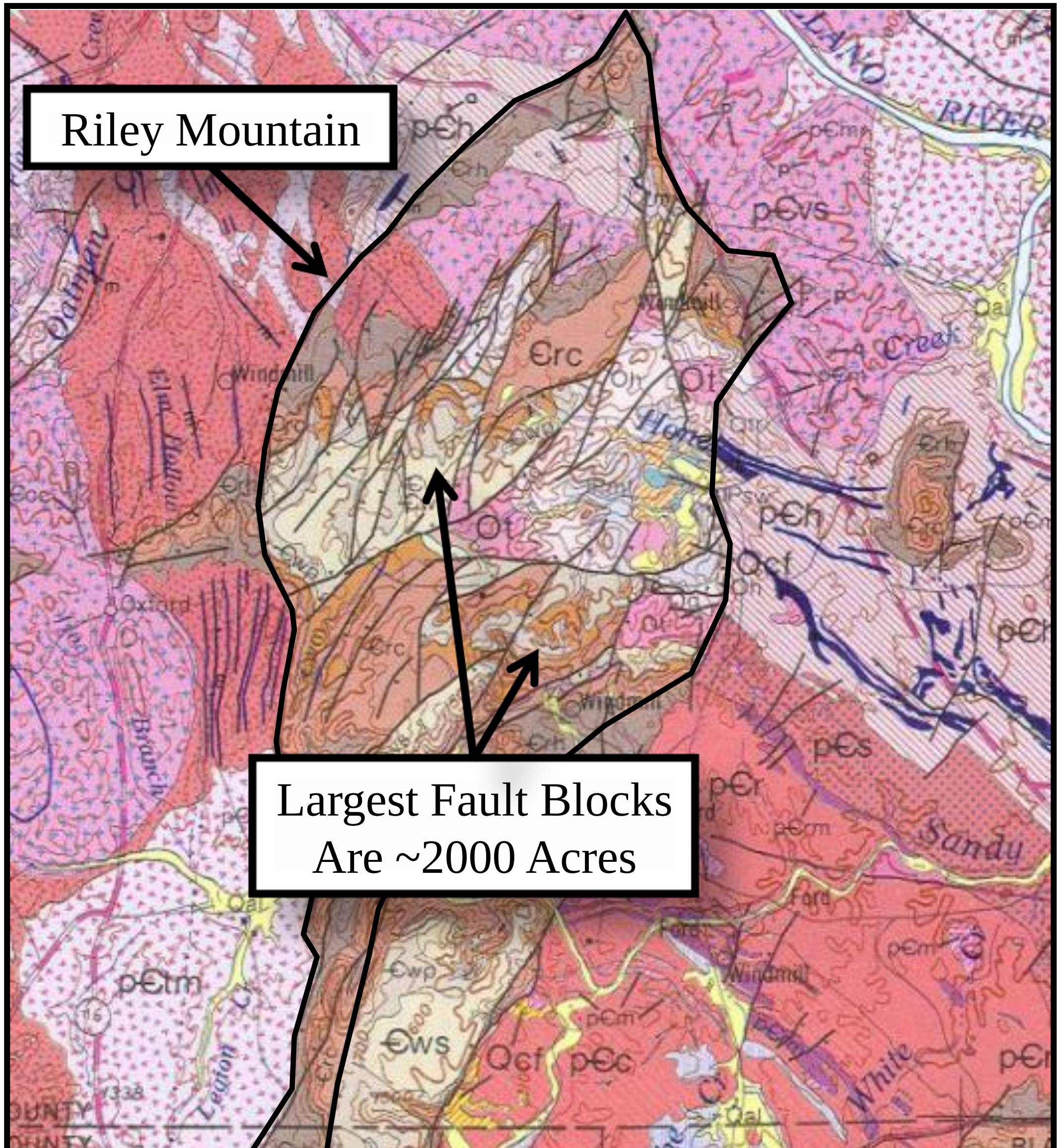
Source: Geologic Atlas of Texas, TWDB.

Faults with throws greater than the Hickory Member thickness may result in the juxtaposition of the Hickory aquifer against other aquifer units with different lateral hydraulic conductivities. Faulting can also lead to compartmentalization of the Hickory aquifer, by down dropping the Hickory into the Precambrian strata (Randolph, 1991, Wilson, 2001 and Pettigrew, 1988). Low-permeability fault gouges can cause a two to six orders of magnitude decrease of groundwater flow across faults as compared to un-deformed rock (Delaney, 1990).

Recharge Risk = 50%

Source: Llano Uplift Aquifers Structure and Stratigraphy, Allan Standen & Robert Ruggiero, Prepared for TWDB, 2007.

Riley Mountain Surface Geology and Faults



Source: Geologic Atlas of Texas, TWDB.

According to Halff, Llano needs between 213 and 325 ac-ft of water for a 4 month drought.

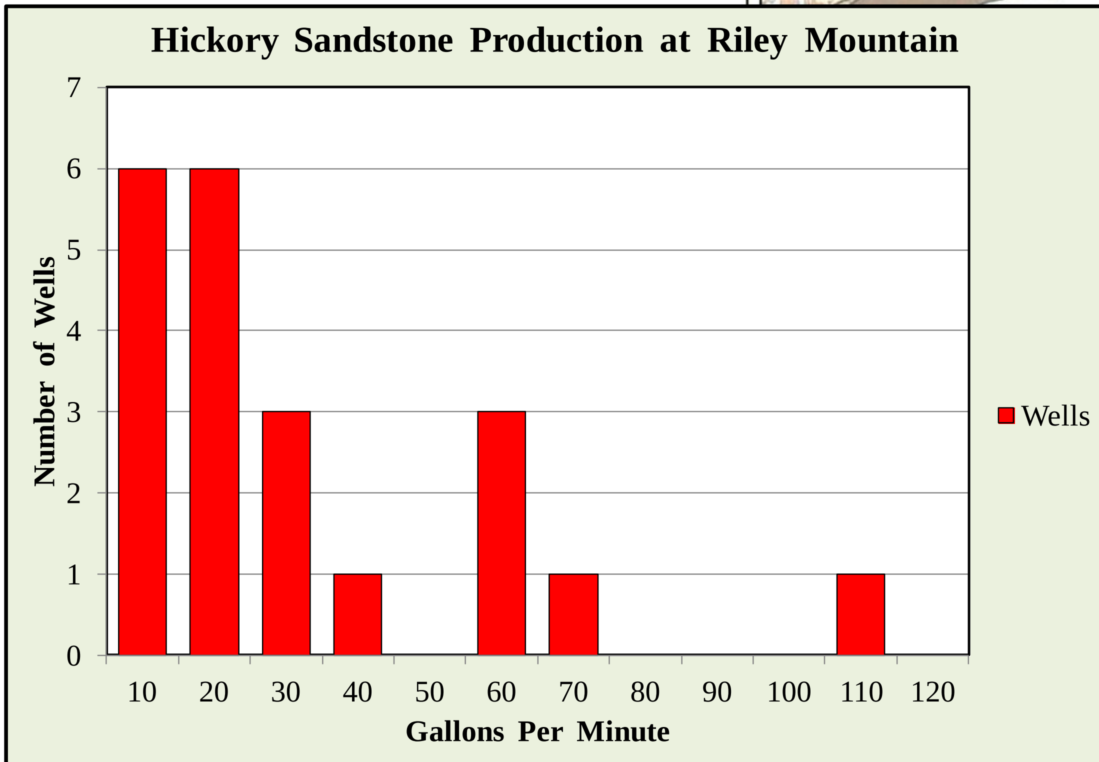
The largest fault block compartments on Riley Mountain are around 2000 acres with an average Hickory Sand thickness of 200 feet.

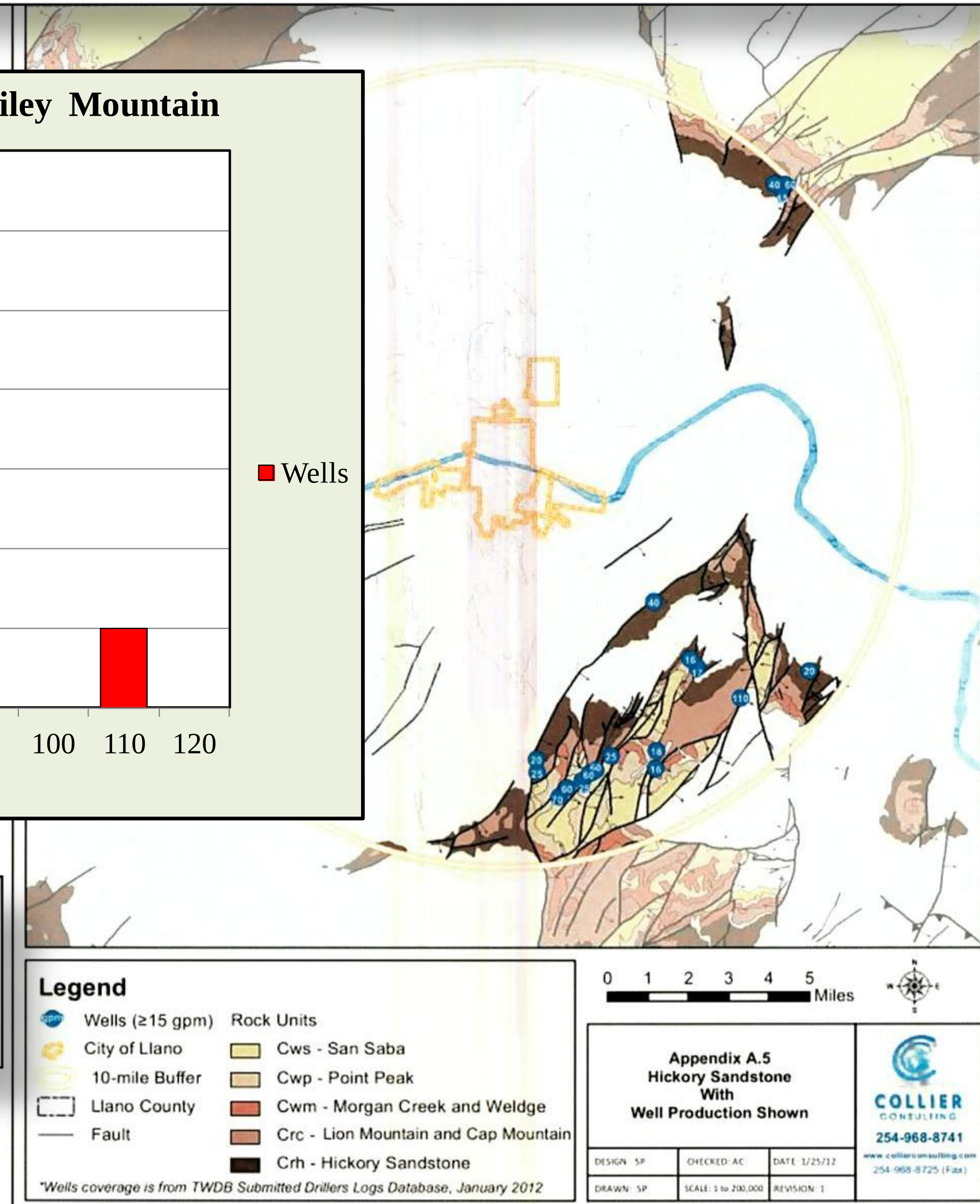
According to Bluntzer (1992), the storage coefficient for the Hickory Aquifer ranges from .0001 to .00004.

This yields a recoverable reserve of 16 to 40 ac-ft for a 2000 acre fault block, far smaller than the required reserve. Many of the fault blocks are much smaller, additionally there are a very large number of smaller faults that are not mapped.

Reserve Risk = 30%

Well Rates for Riley Mountain Wells Completed in the Hickory





At Riley Mountain, only 1 out of 21 wells in the Hickory Sandstone has yielded a rate greater than 100 gpm.

Rate Risk = 5%

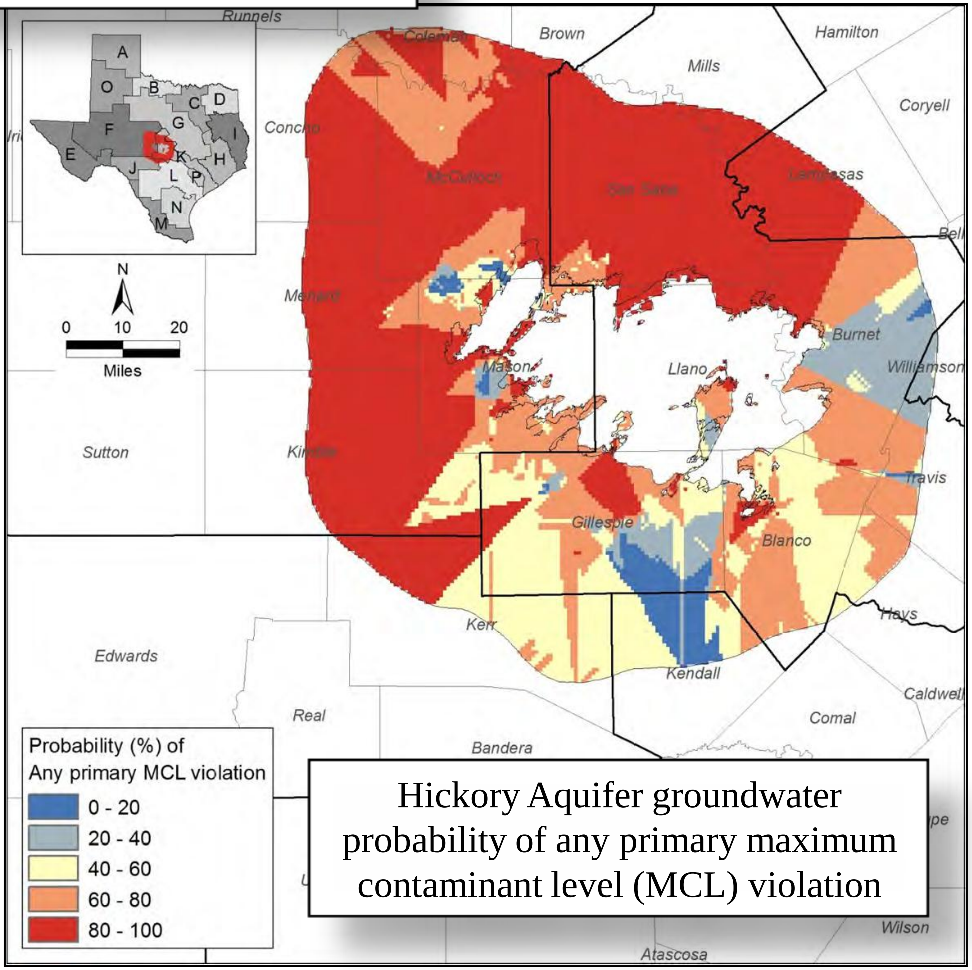
Source: Reconnaissance Hydrogeologic Report, Collier Consulting, 2012.

Radiological Contaminants

Table 35. Summary of MCL violations in Hickory Aquifer groundwater wells

	MCL	Units	Analyses	Detects	Non-detects	Median	Min	Max	> MCL	% MCL
Primary MCL										
Antimony	6	µg/L	111	0	111	NA	NA	NA	0	0
Arsenic	10	µg/L	130	24	106	NA	0.73	10	0	0
Barium	2,000	µg/L	131	129	2	79.9	6.7	460	0	0
Beryllium	4	µg/L	111	0	111	NA	NA	NA	0	0
Cadmium	5	µg/L	106	0	106	NA	NA	NA	0	0
Chromium	100	µg/L	116	27	89	NA	1.0	4.61	0	0
Copper	1,300	µg/L	129	78	51	2.3	0.96	24.7	0	0
Fluoride	4	µg/L	141	122	19	0.53	0.08	8.9	2	1
Lead	15	µg/L	121	22	99	NA	0.88	14.3	0	0
Mercury	2	µg/L	78	0	78	NA	NA	NA	0	0
Nitrate-N	10	mg/L	141	108	33	0.68	0.01	42.5	15	**11**
Nitrite-N	1	mg/L	27	3	24	NA	0.01	0.04	0	0
Selenium	50	µg/L	130	23	107	NA	1.0	9	0	0
Thallium	2	µg/L	111	2	109	NA	1.08	2.01	1	1
Gross alpha	15	pCi/L	148	140	8	9.4	1.3	104	44	**30**
Gross beta	50	pCi/L	105	99	6	14.9	2.7	131	7	7
Comb. radium	5	pCi/L	71	66	5	8.04	1.60	67.7	47	**66**
Uranium	30	µg/L	50	27	23	1.0	0.8	15.2	0	0
Secondary MCL										
Aluminum	50	µg/L	120	33	87	1.42	0.89	132	1	1
Chloride	300	mg/L	141	141	0	38	6.01	649	7	5
Copper	1,000	µg/L	129	78	51	2.3	0.96	24.7	0	0
Fluoride	2	mg/L	141	122	19	0.53	0.08	8.9	6	4
Iron	300	µg/L	140	73	67	20	0.01	10,600	22	16
Manganese	50	µg/L	131	82	49	1.77	0.15	3,180	10	8
Silver	100	µg/L	47	1	46	NA	1.48	1.48	0	0
Sulfate	300	mg/L	140	139	1	28.2	3.0	202	0	0
TDS	1,000	mg/L	134	134	0	413	150	1,590	4	3
Zinc	5,000	µg/L	131	89	42	9.14	2.0	1,260	0	0
pH	6.5-8.5		162	162	0	7.04	6.1	8.85	11	7

MCL: Maximum contamination level, *Units*: units of concentration, *Analyses*: number of wells sampled, *Detects*: number of analyses above the detection limit, *Non-detects*: number of analyses below the detection limit, *Median*: estimated median concentration, *Min*: minimum (detected) concentration, *Max*: maximum (detected) concentration, *> MCL*: number of analyses above the MCL concentration, *% MCL*: percentage of all analyses above the MCL concentration.

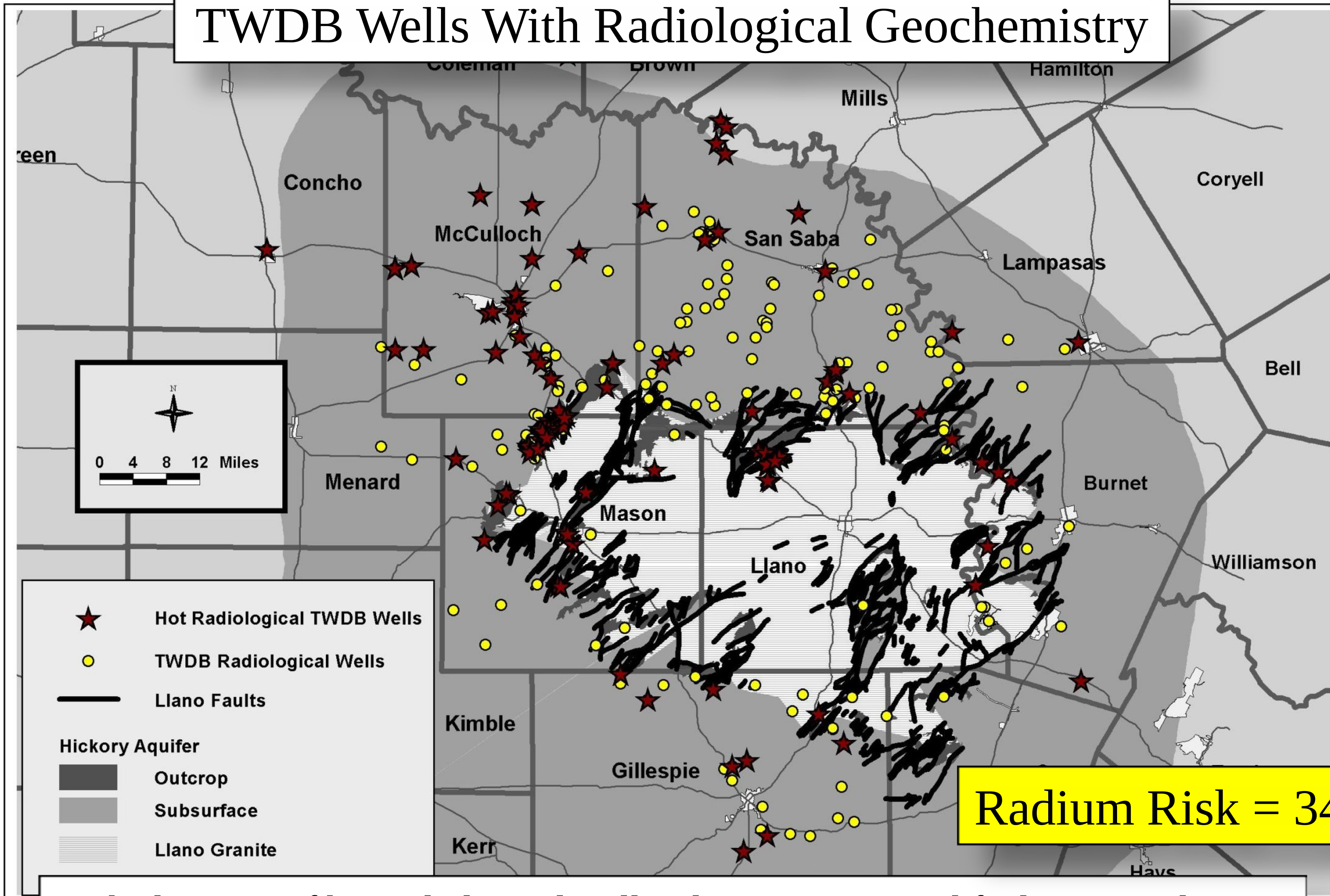


Hickory Aquifer groundwater probability of any primary maximum contaminant level (MCL) violation

Of the 71 Hickory Aquifer groundwater wells that have been tested for radium, 47 (66%) exceeded the Maximum Contamination Level (MCL).

Source: Naturally Occurring Groundwater Contamination in Texas
Final Contract Report prepared for the Texas Water Development Board
by
Robert C. Reedy, Bridget R. Scanlon, Steven Walden, and Gil Strassberg
Bureau of Economic Geology, The University of Texas at Austin

TWDB Wells With Radiological Geochemistry



Radium Risk = 34%

The location of hot radiological wells adjacent to mapped faults may indicate that faults can influence the spatial distribution of radiological contaminants. Riley Mountain is one of the most densely faulted areas in the Llano Uplift.

Source: The Spatial Distribution of Radiological Contaminants in the Aquifers Overlying the Llano Uplift, Central Texas, Allan R. Standen and Jeffery A. Kane, 2005.

Independent Risks

Flip a coin and call Heads.

Possible Outcomes

50%

50%

Flip a coin twice and call Heads both times.

Possible Outcomes

25%

25%

25%

25%

Independent risks are multiplicative, 50% times 50% equals 25%.

Conclusions

1. The Risks associated with Well Rate (5%) and Radiation Contamination (34%) are calculated based on actual Hickory Aquifer water wells on Riley Mountain.
2. The Risks associated with Recharge (50%) and Recoverable Reserves (30%) are based upon geophysical interpretation of the geologic setting.
3. Combining these Risks yields a venture with a **<u>99.75%</u>** chance of failure. You would statistically need to drill **<u>392</u>** wells to achieve a single result in line with your goal.
4. Even if you ignore the Recharge and Recoverable Reserve Risks, your chance of failure remains **<u>98.3%</u>** . You would still need to drill **<u>59</u>** wells to achieve a successful result.