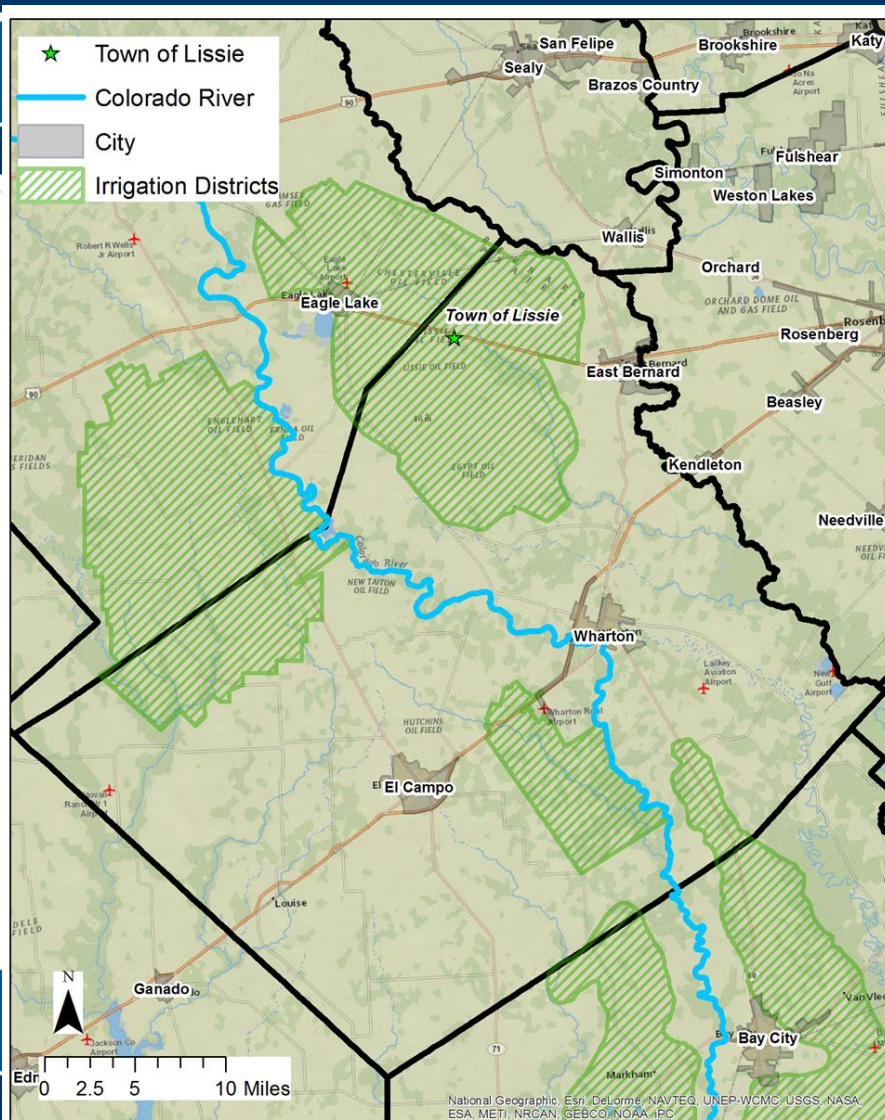


Investigation into the Recent Water Level Declines in Shallow Wells Near the Town of Lissie



**Presentation to
Coastal Bend, GCD
Wharton, Texas**

By Steven Young, Ph.D., PE. PG.



April 21, 2015

Presentation Outline

- **Summary: Conditions Contributing to Water Level Declines**
- **Review of Gulf Coast Aquifer Deposits**
- **Monitoring Data**
- **Reported Production**
- **Simulated Historical Water Levels**
- **Simulated Future Water Levels**
- **Summary: Conditions Contributing to Water Level Declines**
- **Recommendations for Future Well Installation**

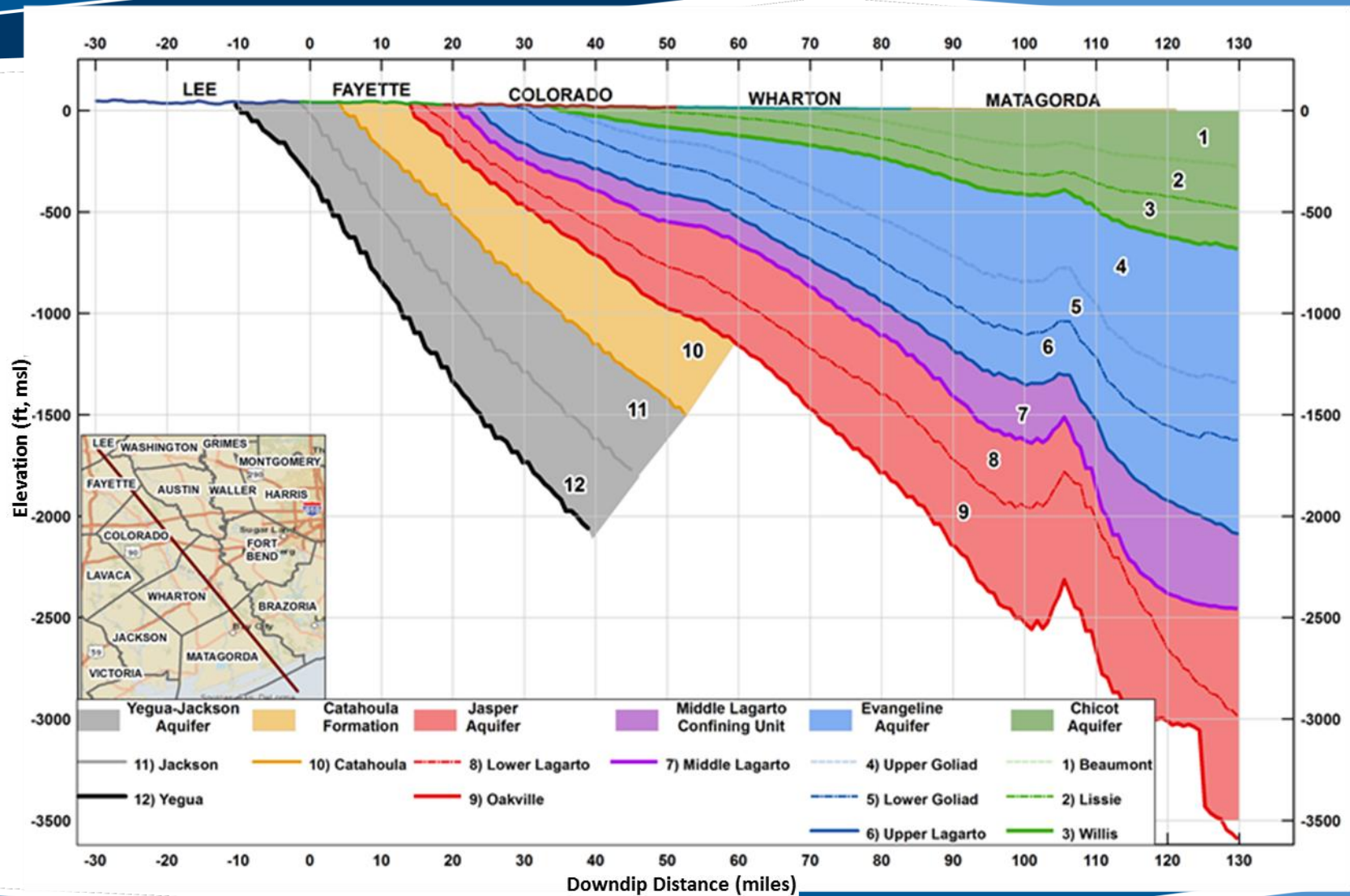
Summary: Conditions Contributing to Water Level Declines and Related Problems with Pumping in Shallow Wells

- **Relatively low historically water level decline in shallow wells pre-2000**
- **Significant increase in permitted pumping last five years**
- **Because of local geological conditions, the shallow wells are susceptible to drawdown impacts caused by permitted pumping**
- **Pumping problems is seasonal**
- **If pumping increases, future seasonal water level declines in shallow wells will be similar or worst than in Summer 2014**
- **Recommended depth for exempt well is > 250 feet**

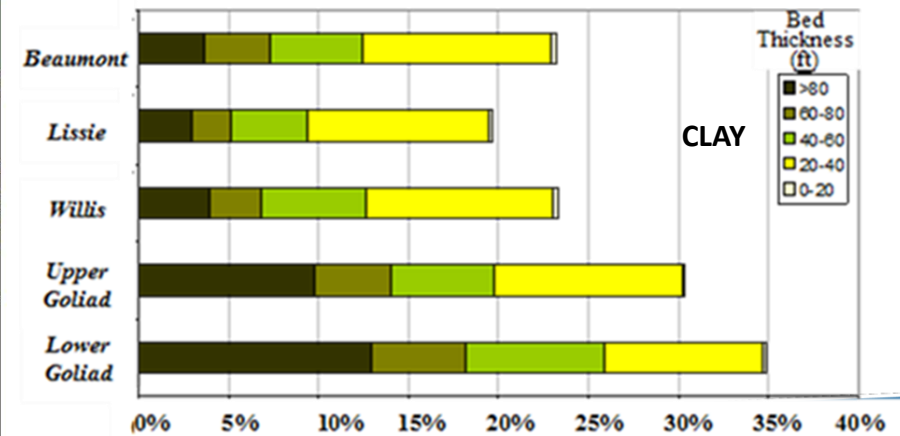
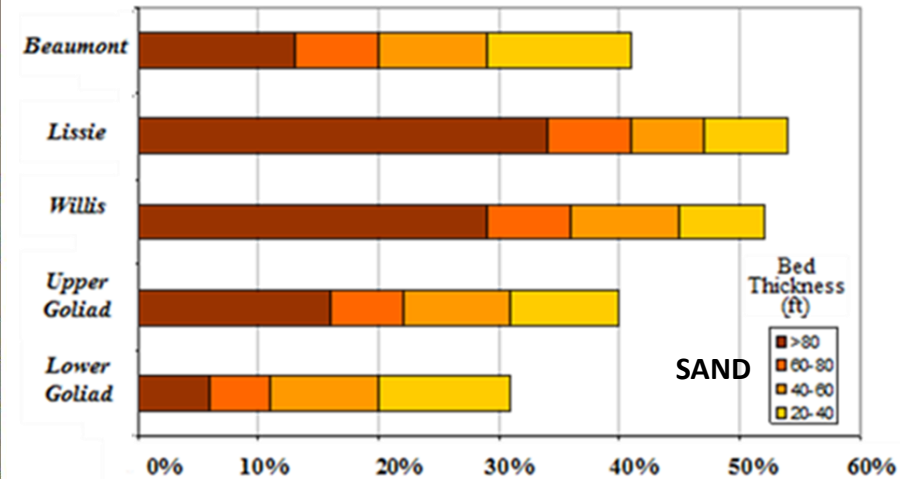
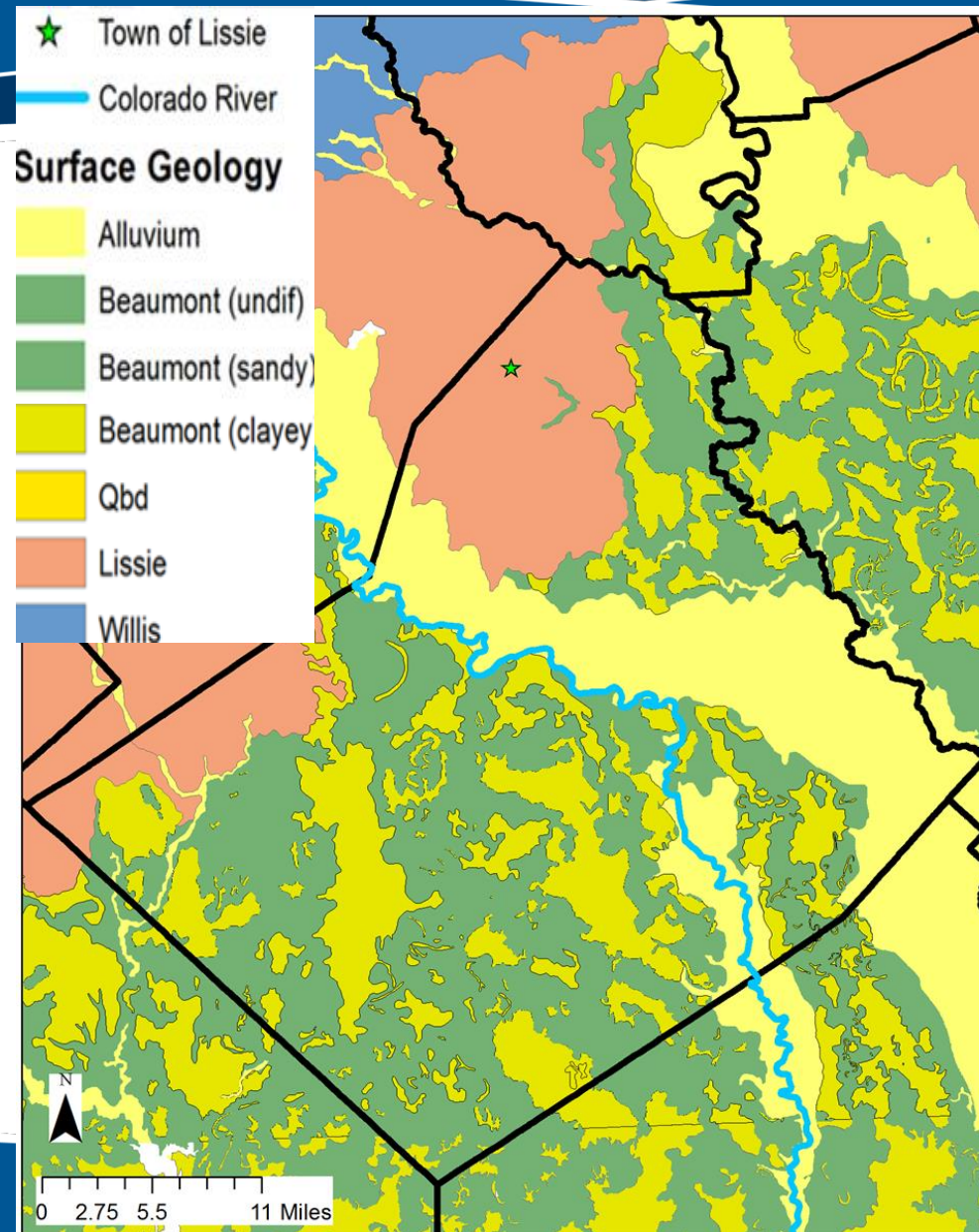
Geologic Column

ERA	Epoch		Est. Age (M.Y)	Geologic Unit	Hydrogeologic Unit	
Cenozoic	Pleistocene		0.7	Beaumont	CHICOT AQUIFER	
			1.6	Lissie		
			Pliocene			3.8
	Miocene	Late	11.2	Upper Goliad	EVANGELINE AQUIFER	
			14.5	Lower Goliad		
		Middle	17.8	Upper Lagarto		BURKEVILLE
				Middle Lagarto		
				Lower Lagarto		
		Early	24.2	Oakville	JASPER AQUIFER	
			Oligocene			32
		34			Vicksburg	

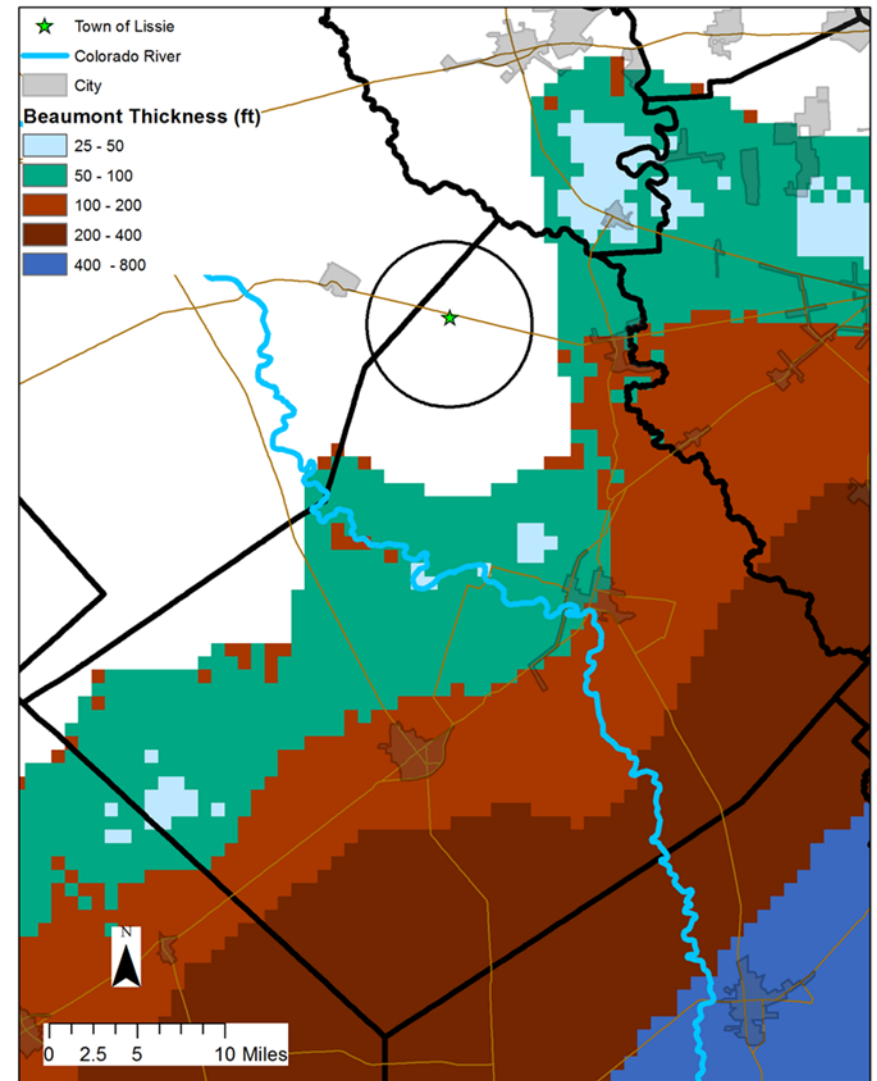
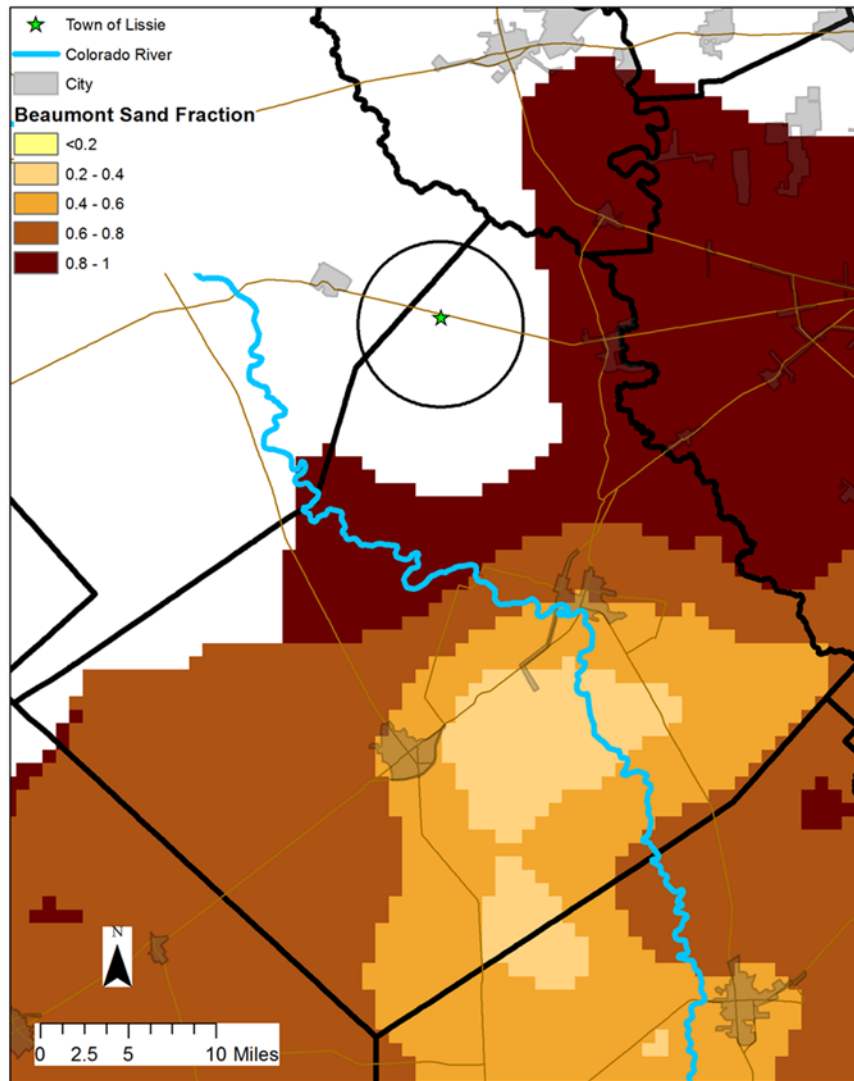
Geologic Column



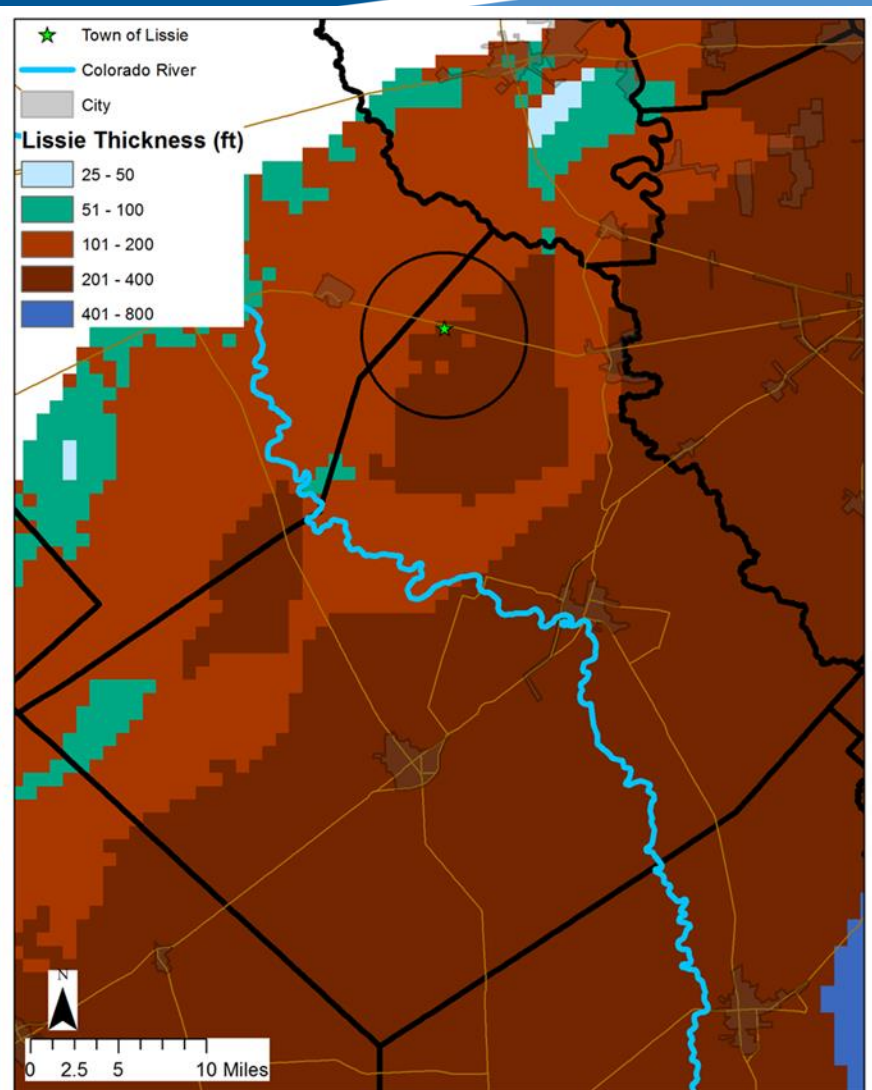
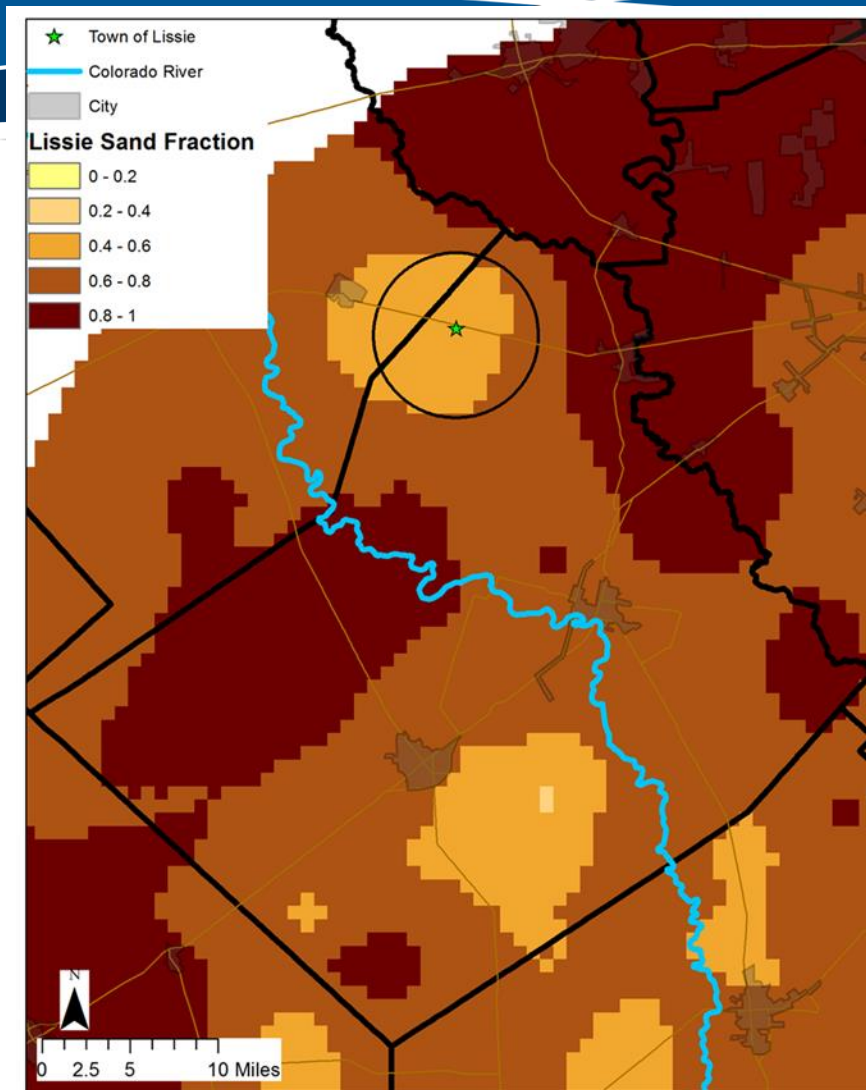
Surface Geology and Sand & Clay Bed Thickness



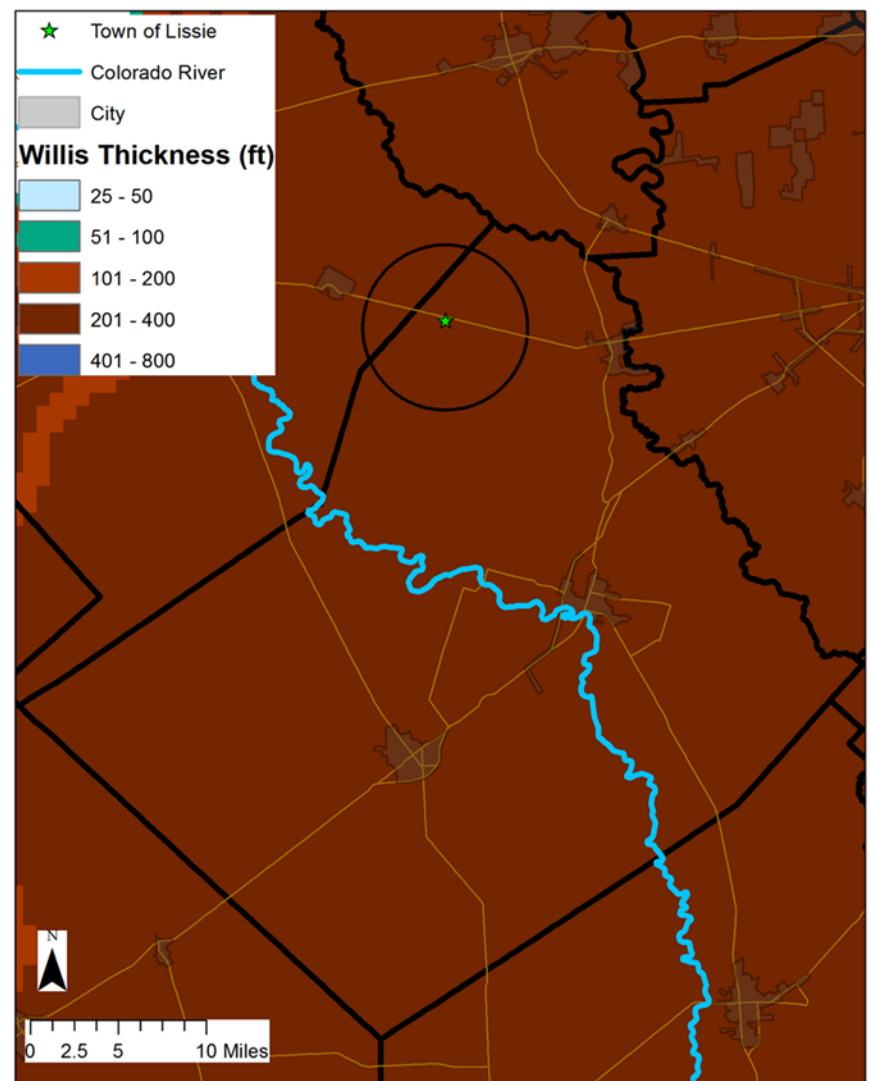
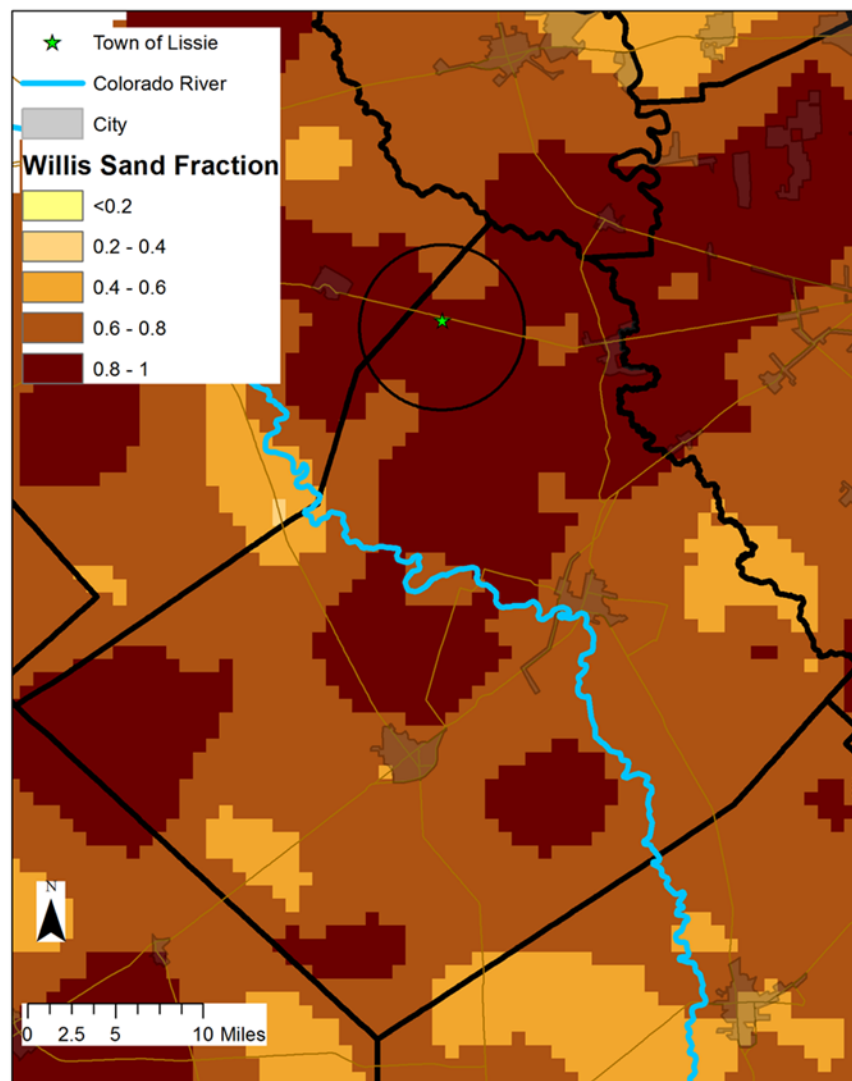
Beaumont Formation



Lissie Formation

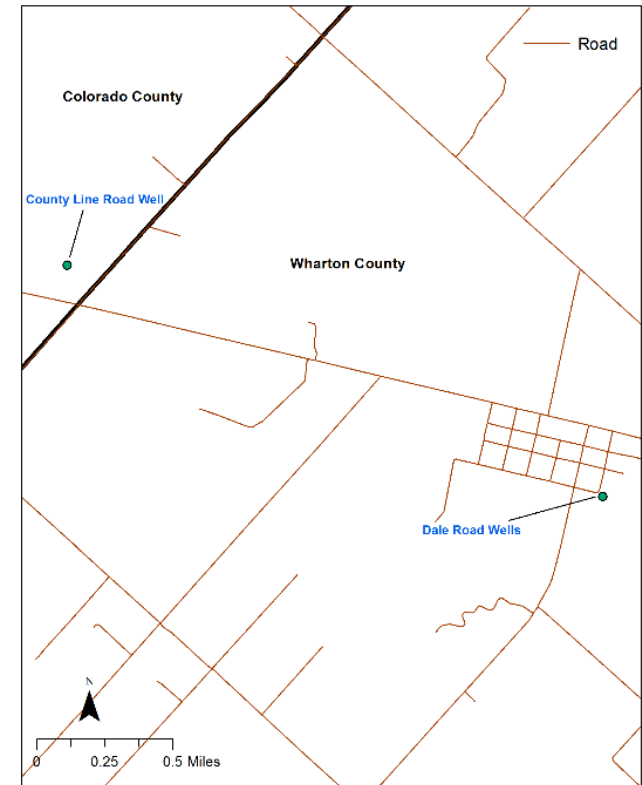


Willis Formation

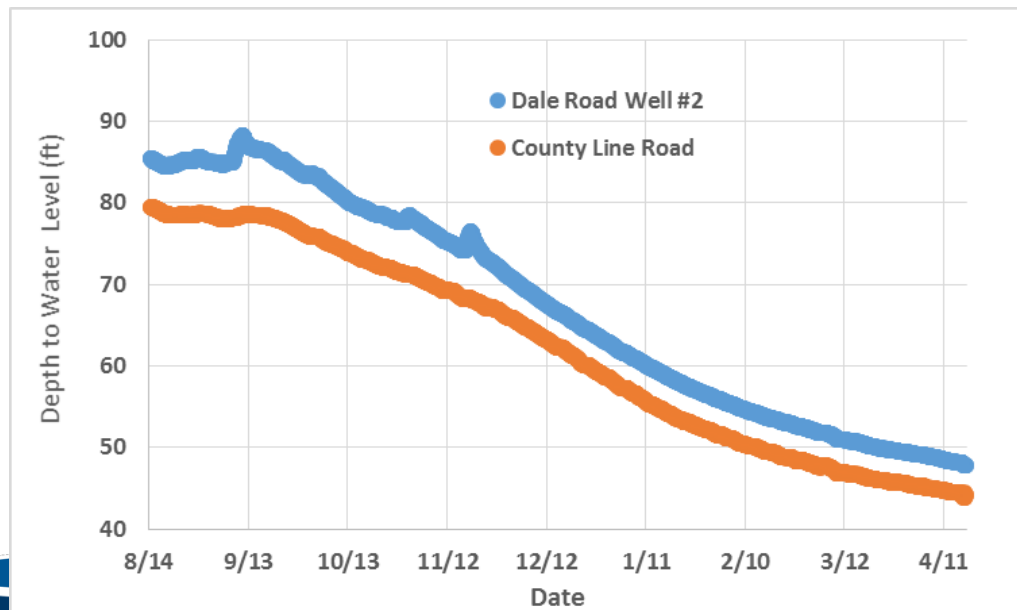
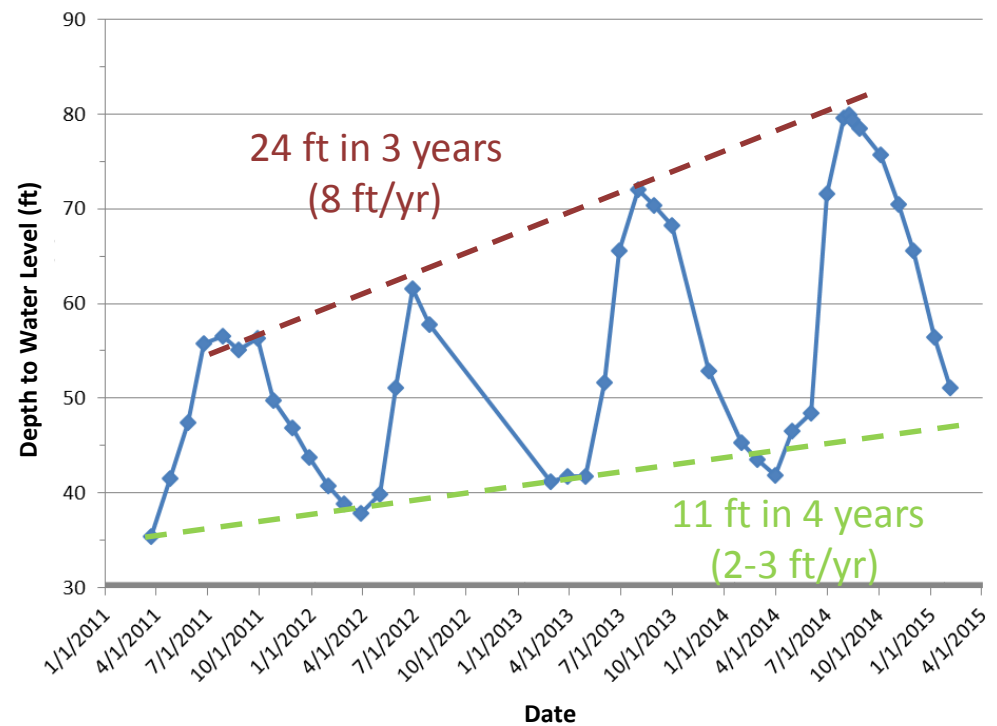
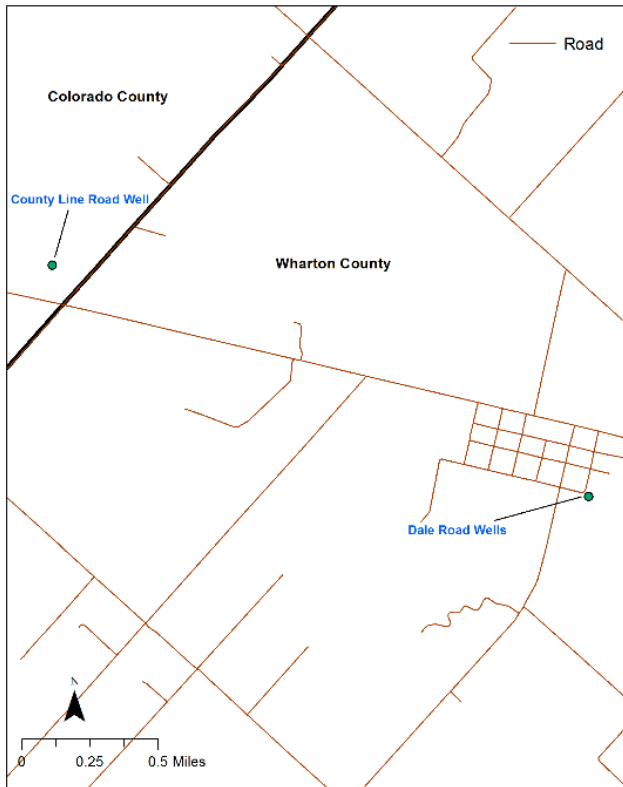


Monitoring Data

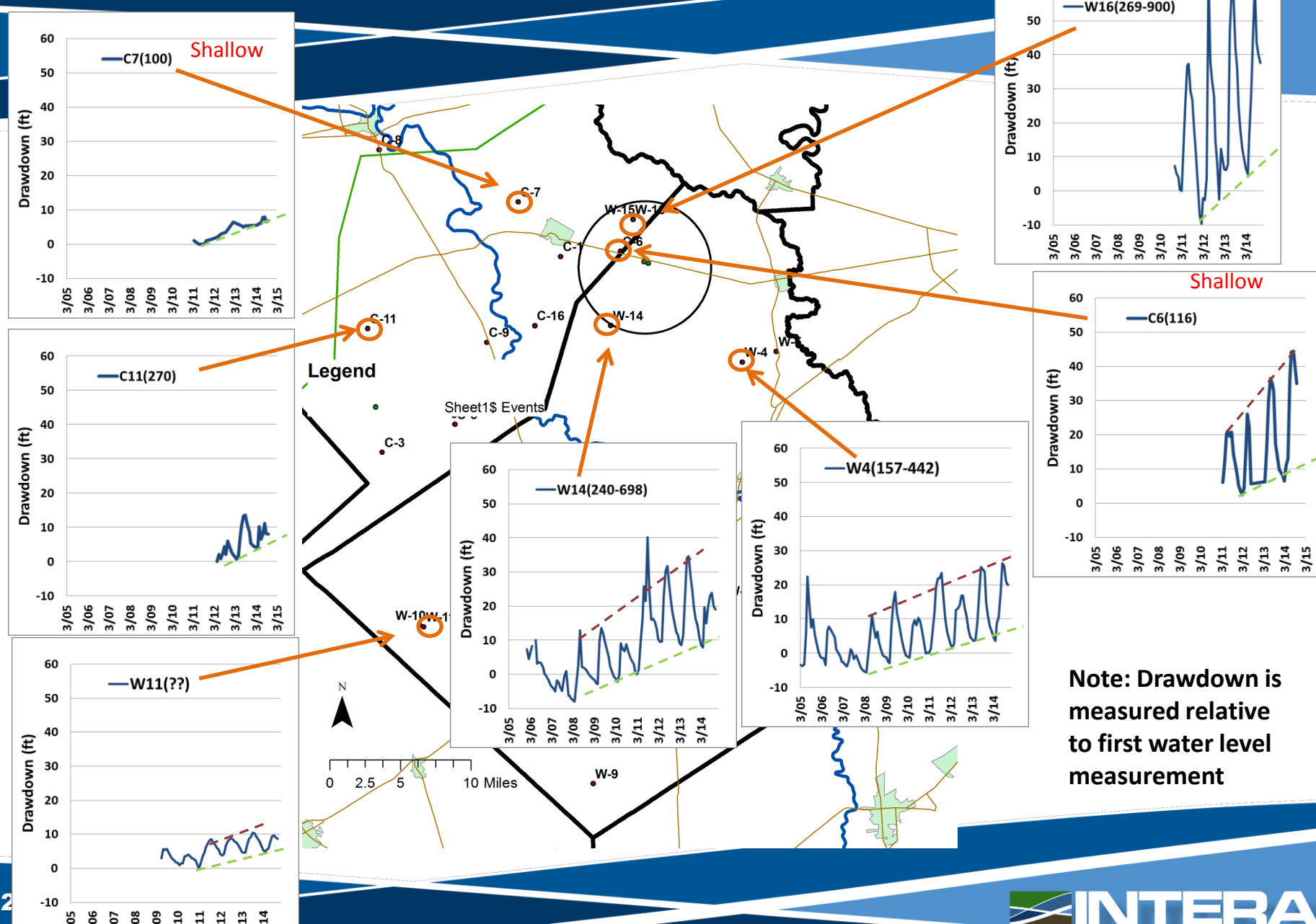
Well		County	Estimated Depth (ft), Below Ground Surface		Measured Depth (ft) of Water Level Below Ground Surface	
Name	Location		Well	Transducer	Aug 14, 2014	Sept 22, 2014
Kelley Well	County Line Road	Colorado	116	110.3	76.2	74.6
Guthman – Shallow (Well # 2) – Dale Road Well #2	Corner of Dale Street and Kansas	Wharton	105	100	83.3	82.9
Guthman – Deep (Well #1) – Dale Road Well #1		Wharton	150	130	83.12	83.3



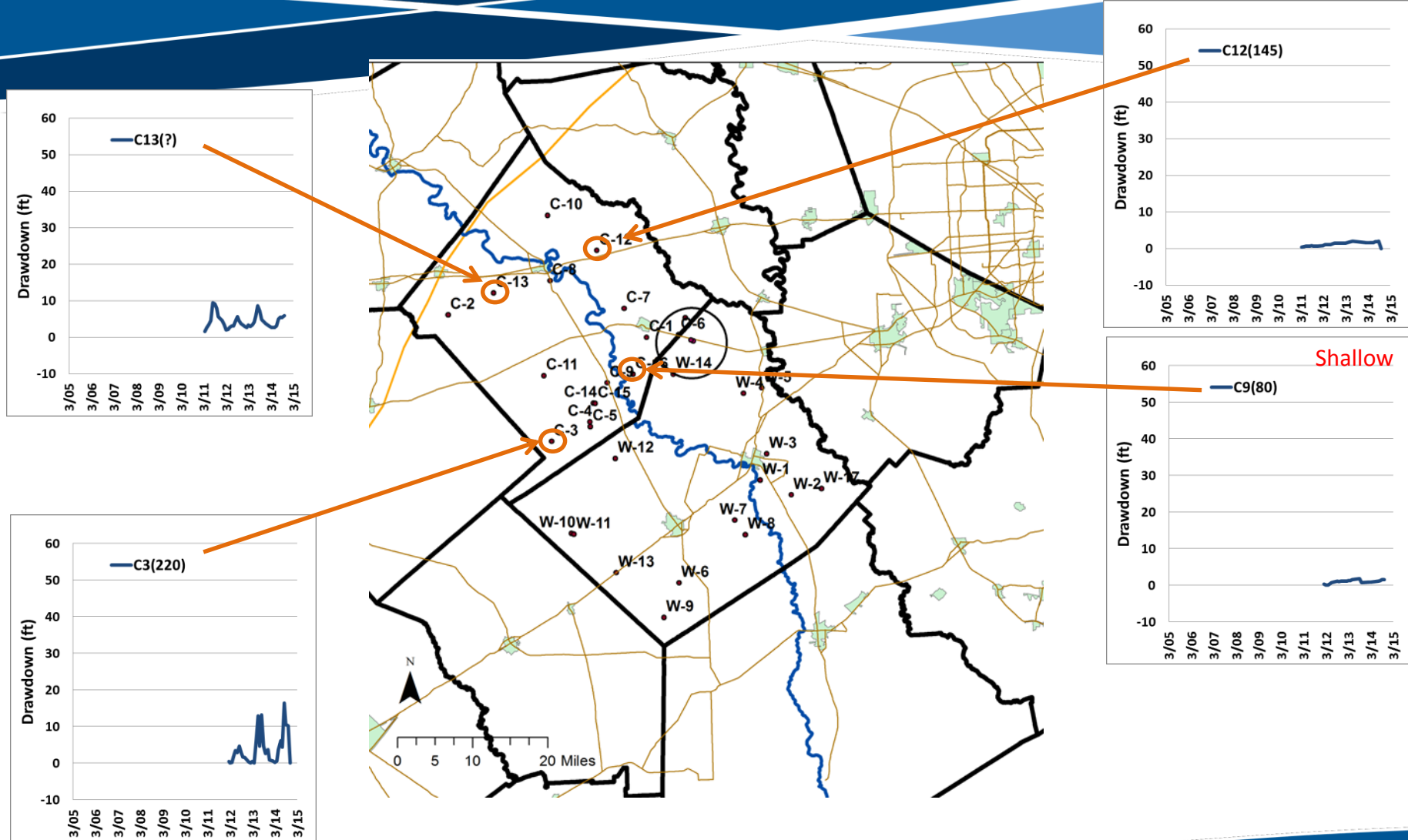
Monitoring Data



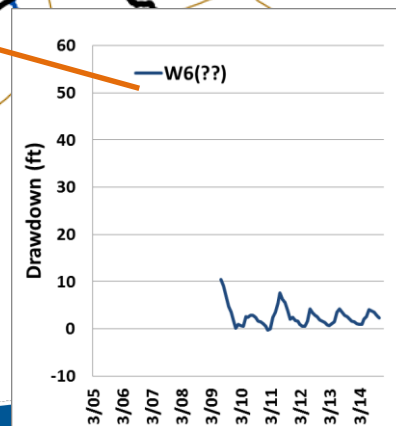
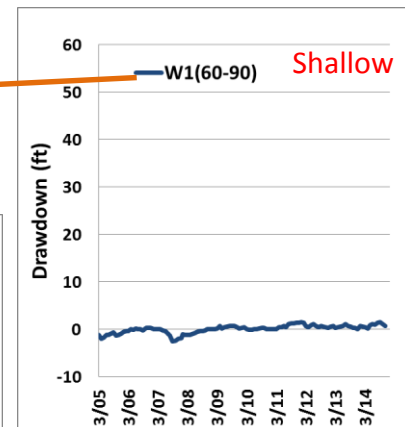
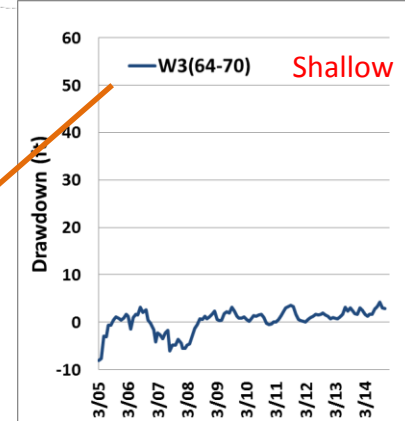
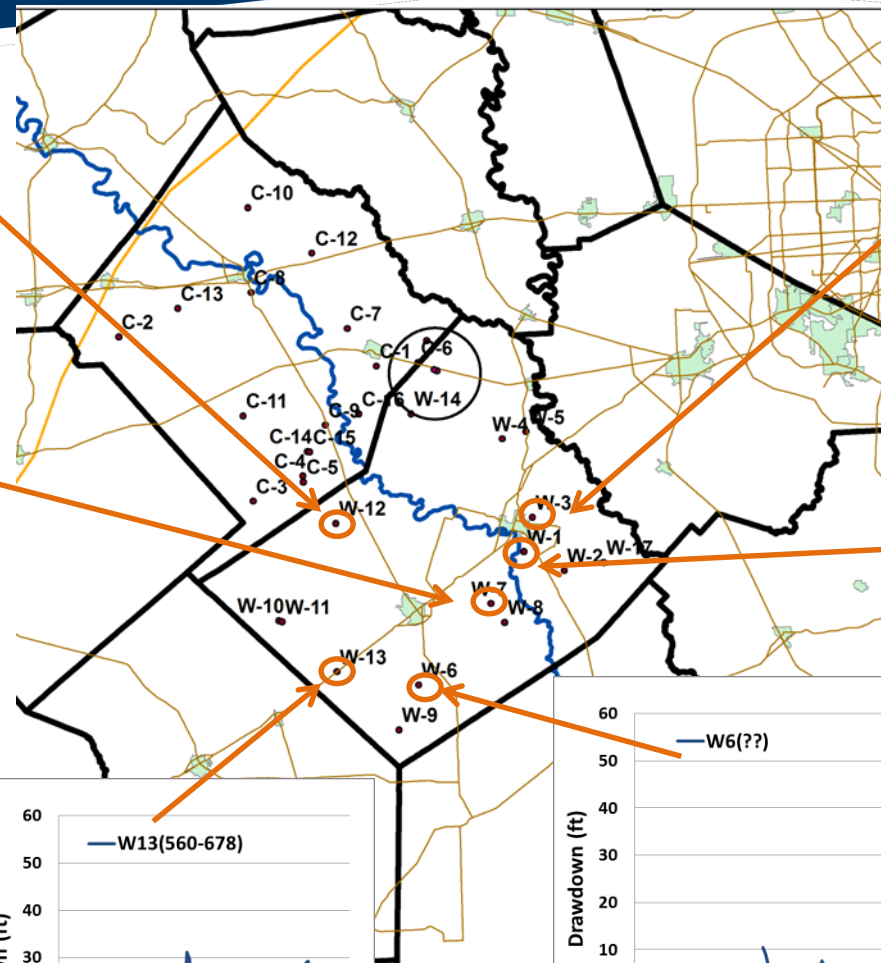
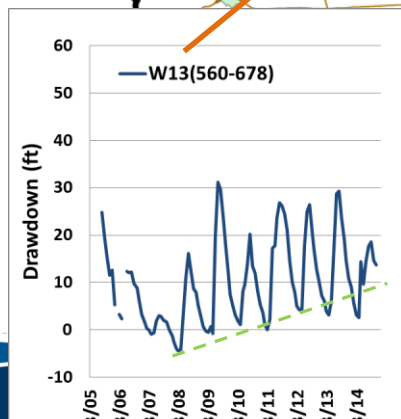
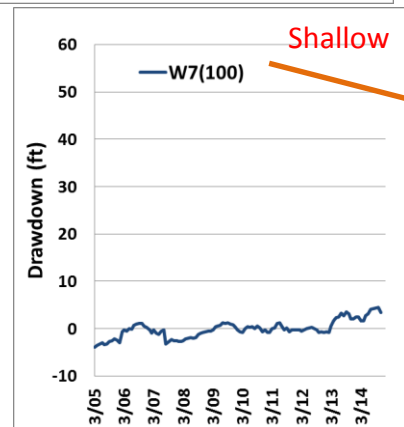
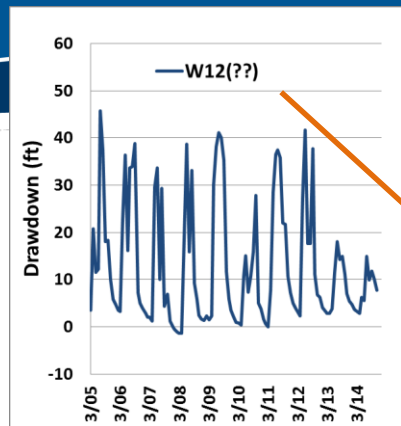
Monitoring Locations where Recent Data Indicating Possible Annual Declines in Water Levels



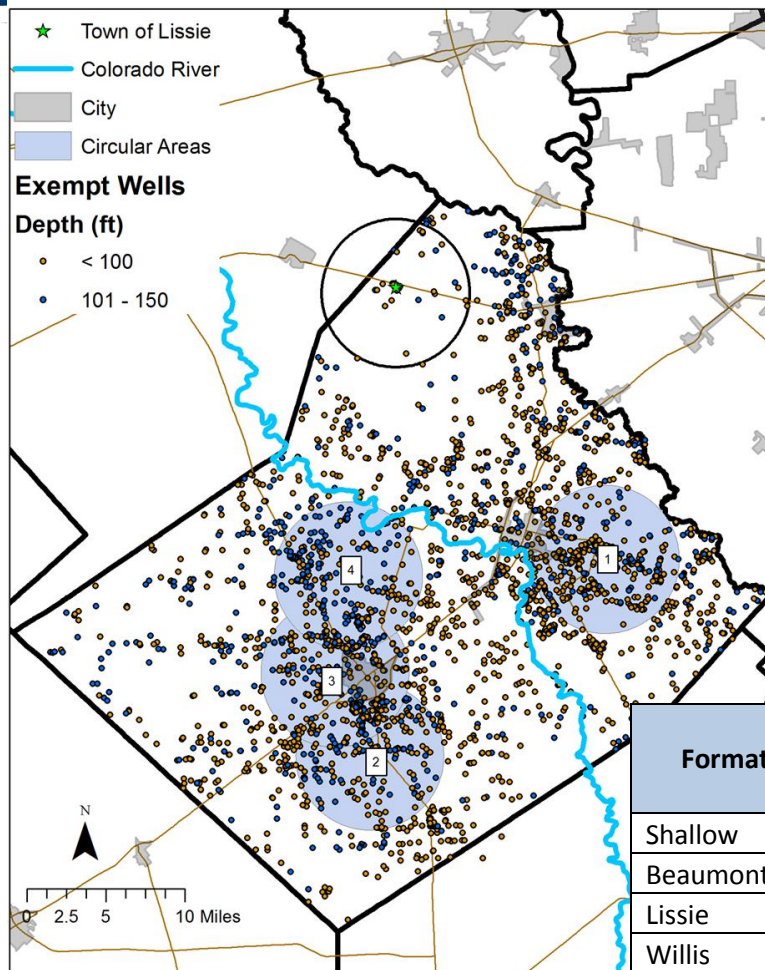
Monitoring Locations where Recent Data Indicating Small Changes in Annual Water Level



Monitoring Locations where Recent Data Indicating Small Changes in Annual Water Level



Five Circular Areas Where Reported Pumping was Compared

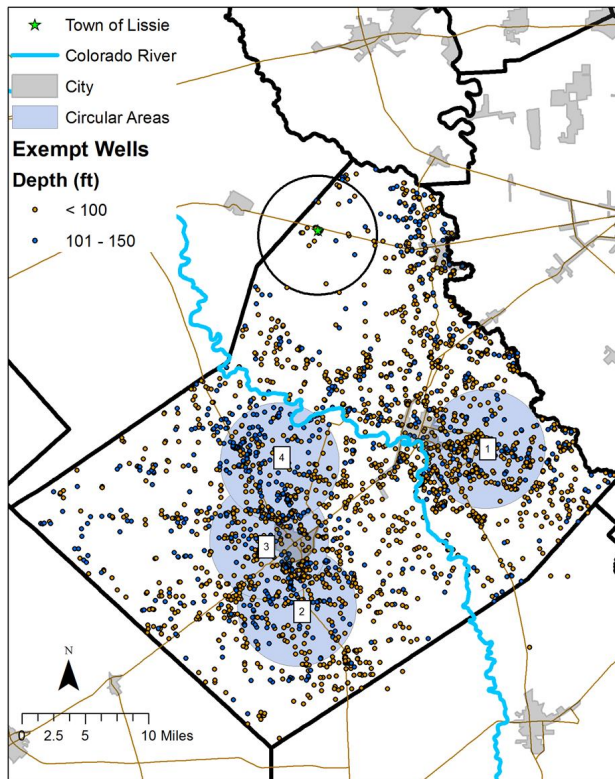


Circular Area of Interest	Maximum Depth of Exempt Well	
	<100 ft	<150 ft*
Lissie	20	45
1	297	368
2	273	396
3	418	582
4	224	384

Circular Area of Interest	Geological Formation	
	Beaumont	Lissie
Lissie	0	45
1	368	0
2	396	0
3	558	24
4	228	156

Formation	Number of Wells in 2013	Year			Average	
		2011	2012	2013	Total	Percent
Shallow	12	869	29	703	534	0.3%
Beaumont	167	10,268	5,479	7,233	7,660	4.7%
Lissie	608	118,986	92,880	102,553	104,806	63.8%
Willis	132	31,589	35,890	43,358	36,946	22.5%
Upper Goliad	35	14,596	12,620	15,929	14,382	8.8%
Total	954	176,308	146,898	169,777	164,328	100%

Five Circular Areas Where Reported Pumping was Compared



Year	Circular Area of Interest	Depth Interval (ft)					
		0-200	200-400	400-600	600-800	800-1000	Total
2011	Lissie	1,737*	211*	39*	4,111*	5,927*	12,025
	1	1,336	4,175	1,654	0	2,910	10,075
	2	170	2,723	4,297	3,296	3,066	13,552
	3	88	5,361	1,178	281	2,504	9,412
	4	2,132	8,497	2,732	0	0	13,360
2013	Lissie	1,146	551	2,849	5,049	6,947	16,542
	1	1,187	2,876	1,536	0	2,324	7,922
	2	204	1,962	4,233	3,648	1,247	11,293
	3	96	3,942	962	553	1,993	7,546
	4	1,932	5,846	2,441	0	0	10,218

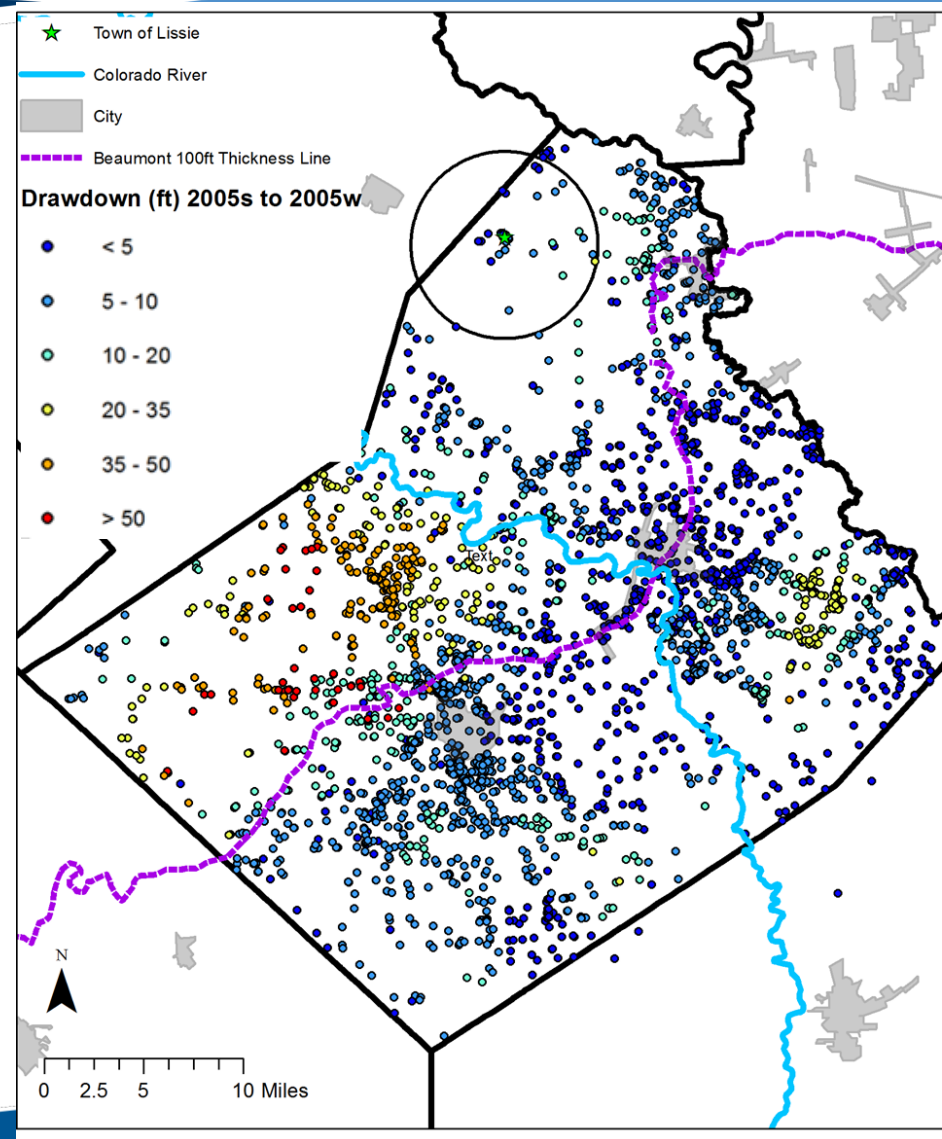
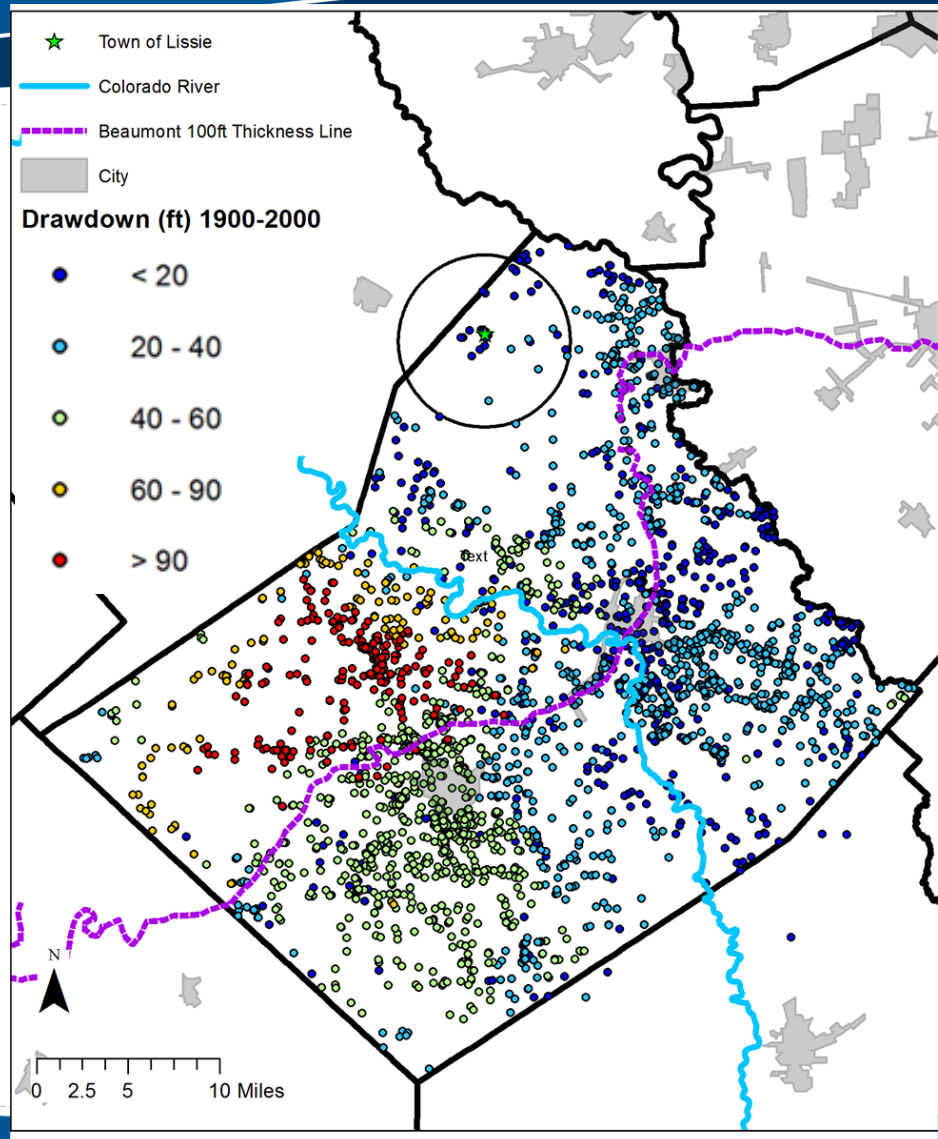
Circular Area of Interest	Depth Interval (ft)					
	0-200	200-400	400-600	600-800	800-1000	Total
Lissie	-592	340	2810	938	1020	4,517
1	-149	-1299	-118	0	-586	-2153
2	33	-761	-64	352	-1820	-2259
3	8	-1419	-215	272	-512	-1866
4	-200	-2651	-291	0	0	-3142

note: negative values indicate less pumping in 2013 than in 2011

Five Circular Areas Where Reported Pumping was Compared: Discussion of Results

- The Lissie Circle has the highest total pumping in 2013 .
- The Lissie circle has the highest average pumping rate per permitted well. This rate is 300 AFY/well.
- In 2013, the production per acre was 0.37 AF/acre and 0.24 AF/acre for the Lissie and for Wharton County, respectively
- Based on current permits, maximum production that could occur based 0.91 AF/(acre-yr) and 0.46 AF/(acre-yr) for the area near the town of Lissie and for the Wharton County, respectively.
- Only the Lissie circle shows an increase in production from 2011 to 2012 and from 2012 to 2013.
- From 2011 to 2013, approximately 64% of the reported production for Wharton County is from the Lissie Formation. In the Lissie Circle, all of the shallow wells are screened in the Lissie Formation.
- The majority of the shallow wells in Wharton County are screened in the Beaumont, which contributes less than 4% of the total pumpage.

Simulated Drawdown for Shallow Wells (depth >50 ft & < 250 ft) Produced by the LCRB Model



Future Pumping Scenarios Using the LSWP Model

2006 Pumping is the Baseline for the Entire Model

2006 for Lissie Circle

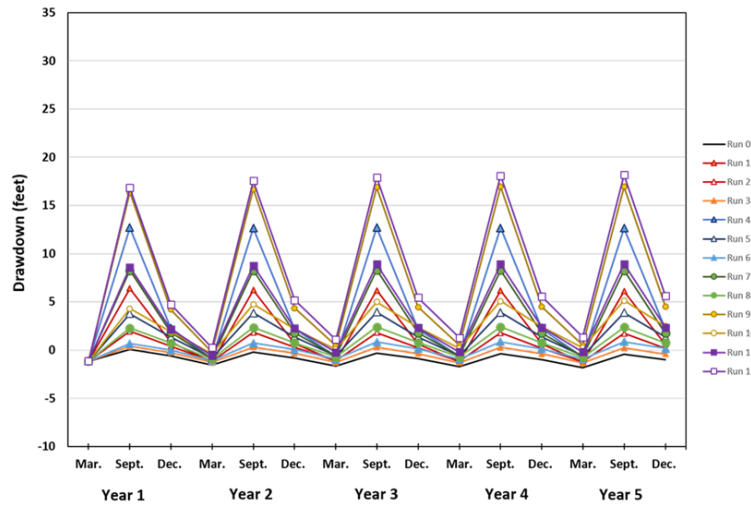
Formation	Pumping Rate (AFY)		
	Jan. - Mar.	Apr.- Sept	Oct- Dec.
Shallow	5	5	5
Lissie	728	728	728
Willis	1086	2471	1086
Upper Goliad	595	311	595
Lower Goliad	0	0	0
Total Amount	2414	3515	2414

Twelve Pumping Scenarios Created by Increasing Pumping in Lissie Circle

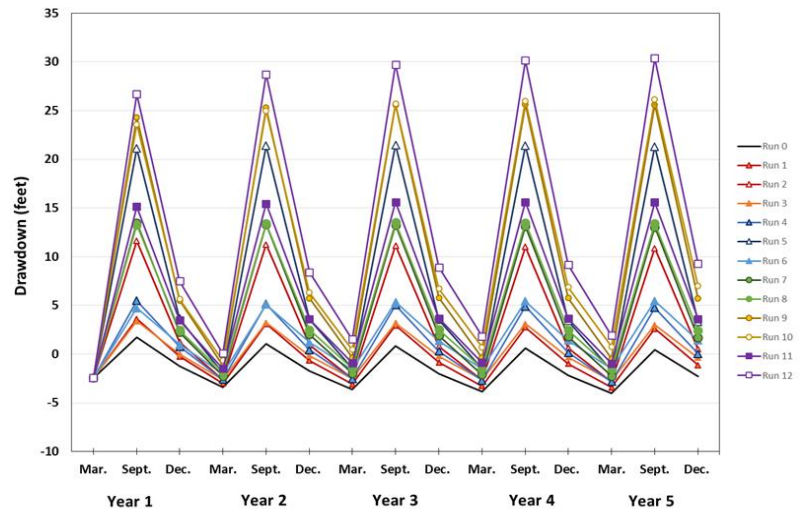
Formation	Additional Pumping (AFY) Included in LCRB Model Simulation												
	Base-line	Single-Formations Runs						Dual-Formations Runs				Tri-Formations Runs	
		1	2	3	4	5	6	7	8	9	10	11	12
Lissie	0	3500	0	0	7000	0	0	3500	0	7000	0	3500	7000
Willis	0	0	3500	0	0	7000	0	3500	3500	7000	7000	3500	7000
Upper Goliad	0	0	0	3500	0	0	7000	0	3500	0	7000	3500	7000

5-year Results for Average Drawdown in Lissie Circle for the 12 Pumping Scenarios

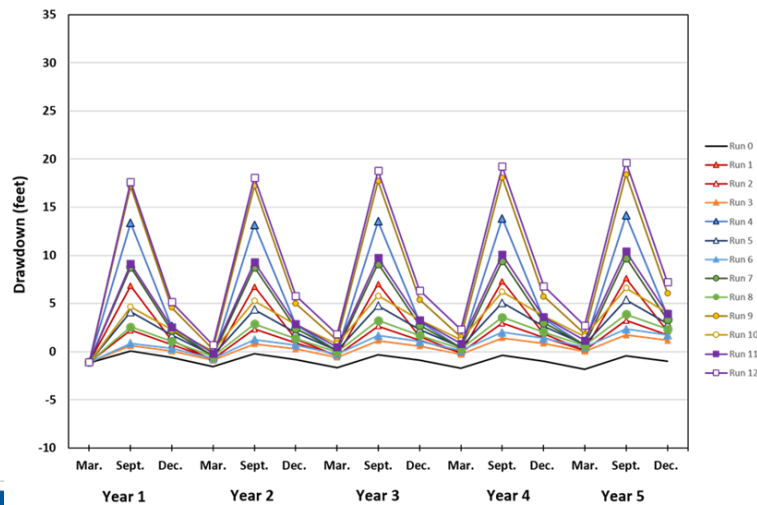
Simulated Average Drawdown in Lissie Formation



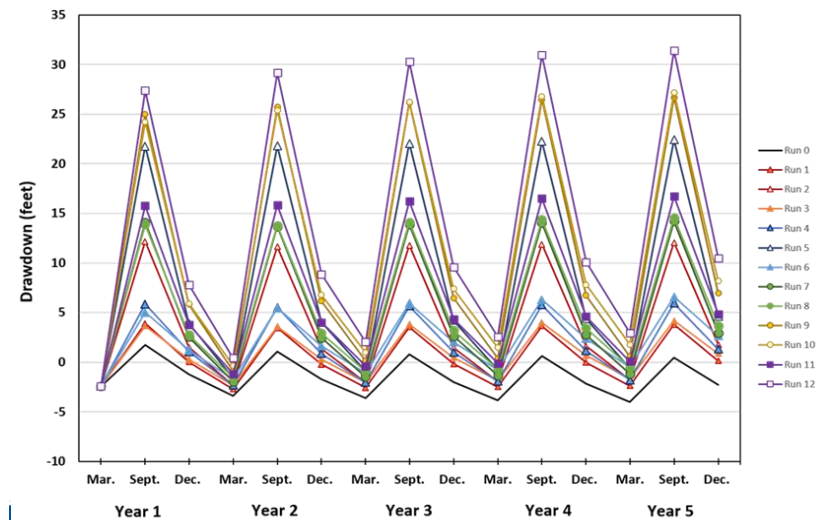
Simulated Average Drawdown in Willis Formation



Simulated Average Drawdown in Lissie Formation w/o Recharge



Simulated Average Drawdown in Willis Formation w/o Recharge



5-year Results for Average Drawdown in Lissie Circle for the 12 Pumping Scenarios: Discussion of Results

- The difference between recharging conditions and zero recharge is relatively small. The small difference indicates that a reduction of recharge is not a credible reason for significant declines in shallow well water levels in the Lissie formation.
- The pumping simulation indicate that the aquifer is not fully rebounding during the non-irrigation season, so a small amount of drawdown from irrigation pumping that is carried-forward every year.
- The relationship between pumping rate and drawdown in the Lissie, Willis, and Upper Goliad Formations is nearly linear relationship -- meaning that if the pumping rate is doubled, then the drawdown will nearly be double.
- For every foot of drawdown that occurs in the Willis Formation as a result of pumping in the Willis Formation about 0.5 feet of drawdown occurs in the Lissie Formation.
- Every foot of drawdown that occurs in the Upper Goliad Formation as a result of pumping in the Upper Goliad Formation, about 0.3 feet of drawdown occurs in the Lissie Formation.

Considerations for Recommended Depth for Exempt Well

- Productive sands to a depth of 600 ft
- Estimated Future Drawdowns based on Kelley Well #1
 - Associate 2,000 AFY annual increase with 8 ft additional drawdown
 - Addition 24,000 AFY could be pumped
 - $(24,000 \text{ AF} / 2,000 \text{ AF}) * 8 \text{ ft drawdown} = 96 \text{ ft additional drawdown}$
- Estimated Future Drawdown based on Simulates Results
 - Simplified analysis under predicts drawdown by 3 to 4 times
 - Run 12 is 21,000 AFY in all units and predicts about 20 feet seasonal drawdown
 - $3.5 * 20 \text{ ft seasonal drawdown} = 70 \text{ ft seasonal drawdown}$
 - Total drawdown = 70 ft seasonal drawdown + 1 ft/yr (regional)
- Estimated Total depth for Exempt Well
 - 80 ft drawdown (current) + 100 ft drawdown (future) + 30 ft well screen + 40 feet operation range ~ 250 ft depth

Summary: Conditions Contributing to Water Level Declines and Related Problems with Pumping in Shallow Wells

- **Relatively low historically water level decline in shallow wells pre-2000**
- **Significant increase in permitted pumping last five years**
- **Because of local geological conditions, the shallow wells are susceptible to drawdown impacts caused by permitted pumping**
- **Pumping problems is seasonal**
- **If pumping increases, future seasonal water level declines in shallow wells will be similar or worst than in Summer 2014**
- **Recommended depth for exempt well is > 250 feet**