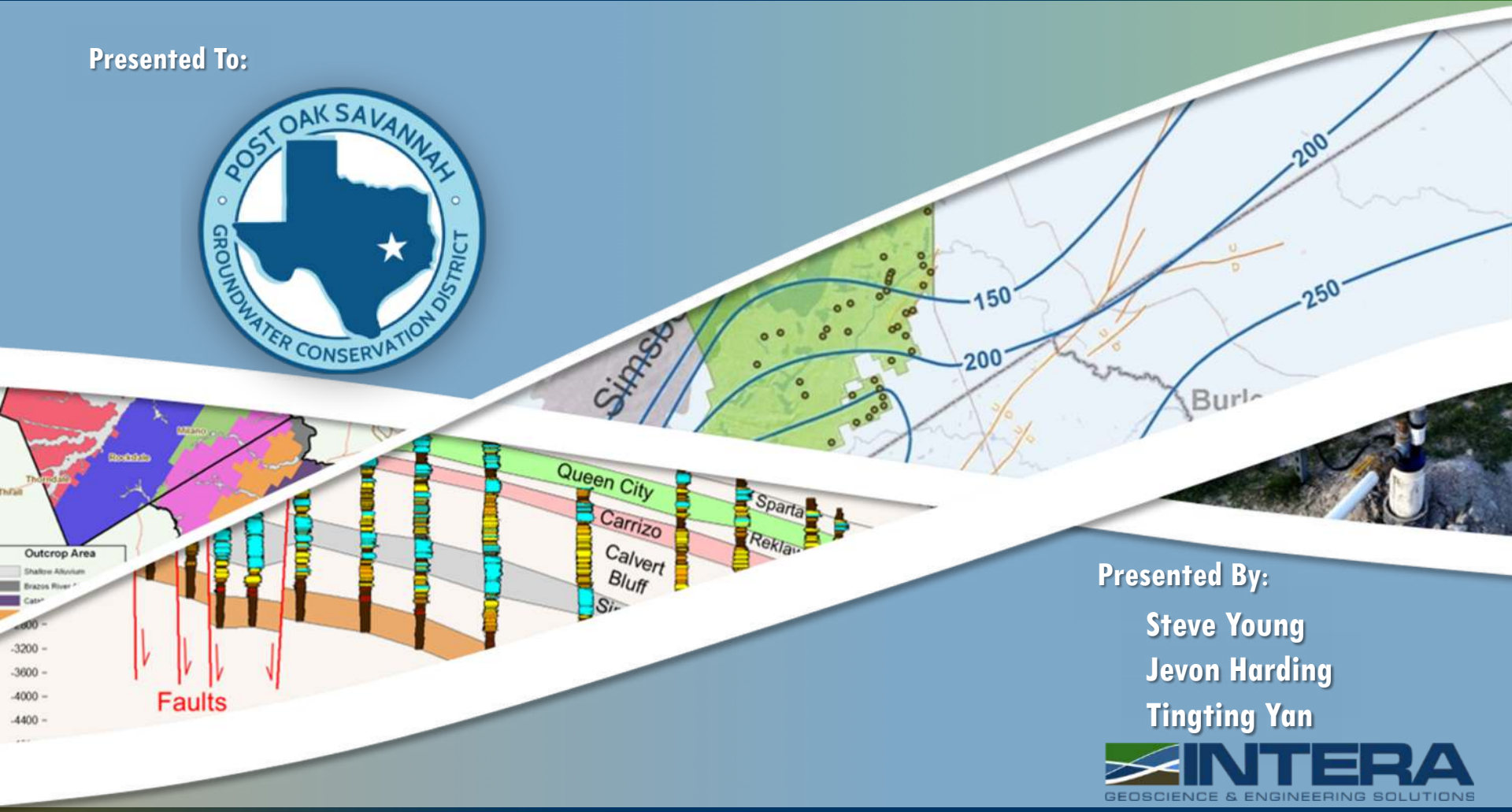
Presentation to DFC Committee

Presented To:

POST OAK SAVANNAH GROUNDWATER CONSERVATION DISTRICT



Presented By:

Steve Young
Jevon Harding
Tingting Yan

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

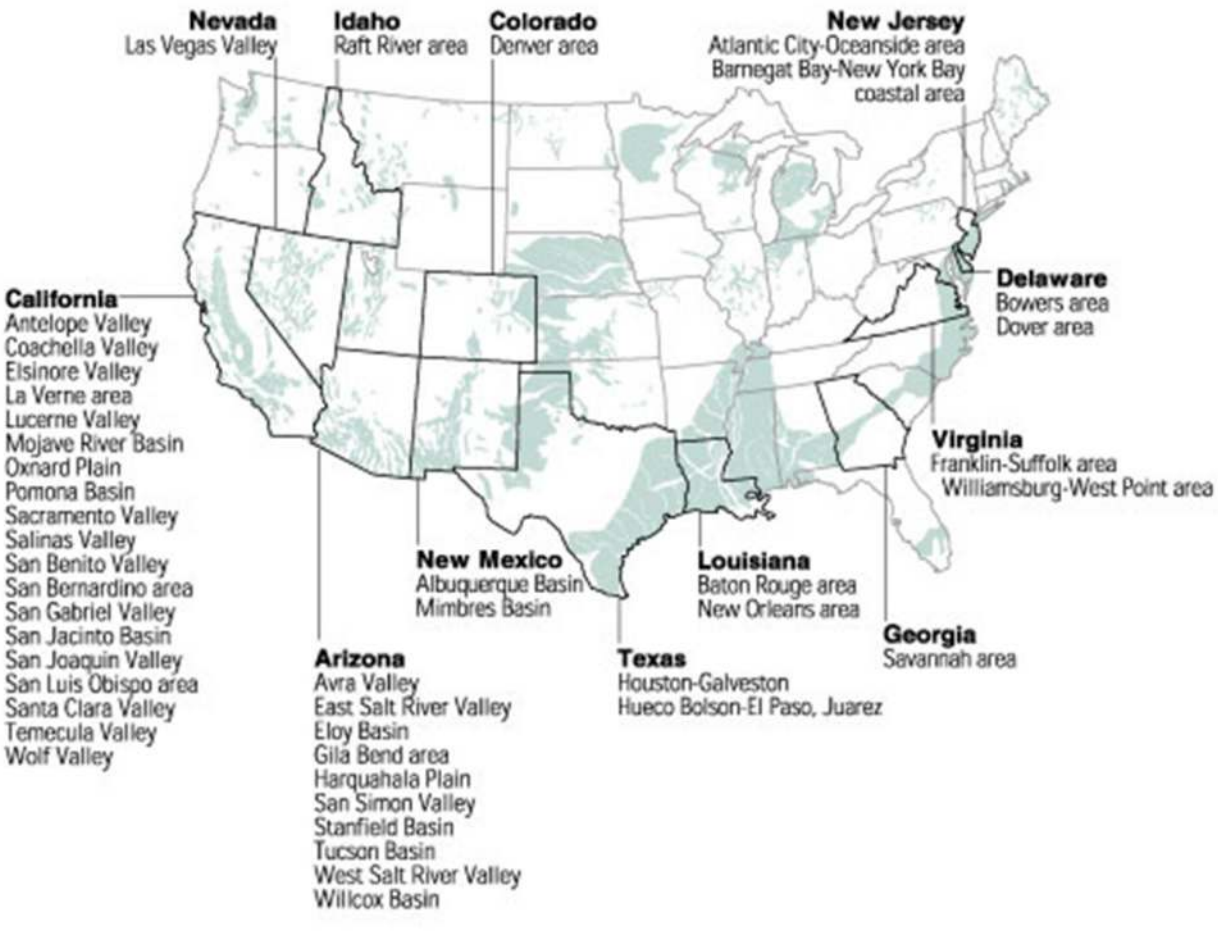
March 5, 2019

Outline

- Potential for land subsidence (Item 5)
- Possible contamination of groundwater resources due to deposits of coal ash (Item 7)
- Progress report on hydrologic studies (Item 6)
  - Predictive Simulations using Updated GAM
  - Aquifer Storage and Recovery
  - Surface Water - Groundwater Interaction
  - Update of Stratigraphy/Structure/Water Quality

Land Subsidence: Description

Deformation of land surface due to compaction, consolidation, or collapse of the subsurface

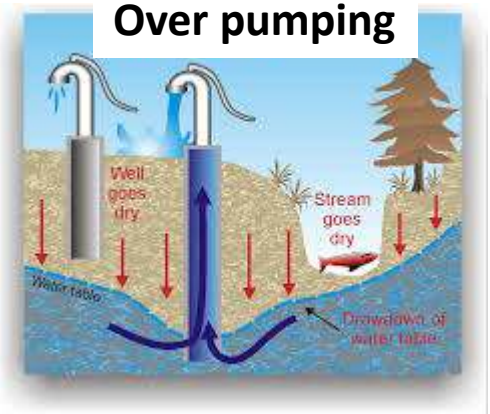


* https://www.statesman.com/news/20190124/could-groundwater-pumping-cause-ground-to-sink-its-possible-scientists-say

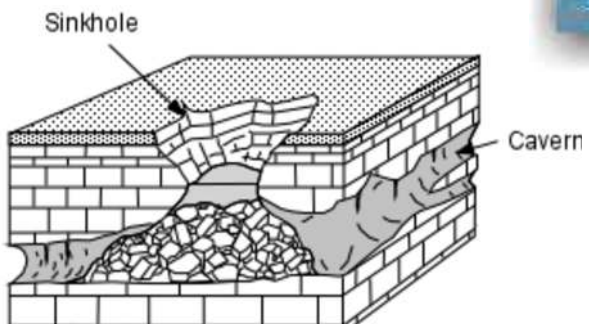
Causes of Land Subsidence

- Compaction-related subsidence can occur because of
  - accumulating soft sediment that sink under their own weight over time
  - dissolution of calcium-rich rocks
  - Over pumping of groundwater
  - removal of high pressurized fluids/gases in oil and gas producing areas
  - Tectonic subsidence occurs from movement along faults

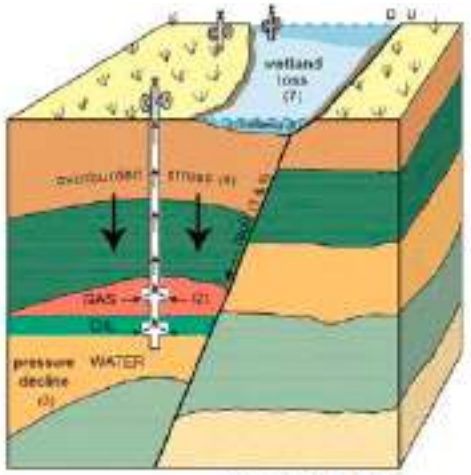
Over pumping



Collapse



Faulting and Geostatic Pressure



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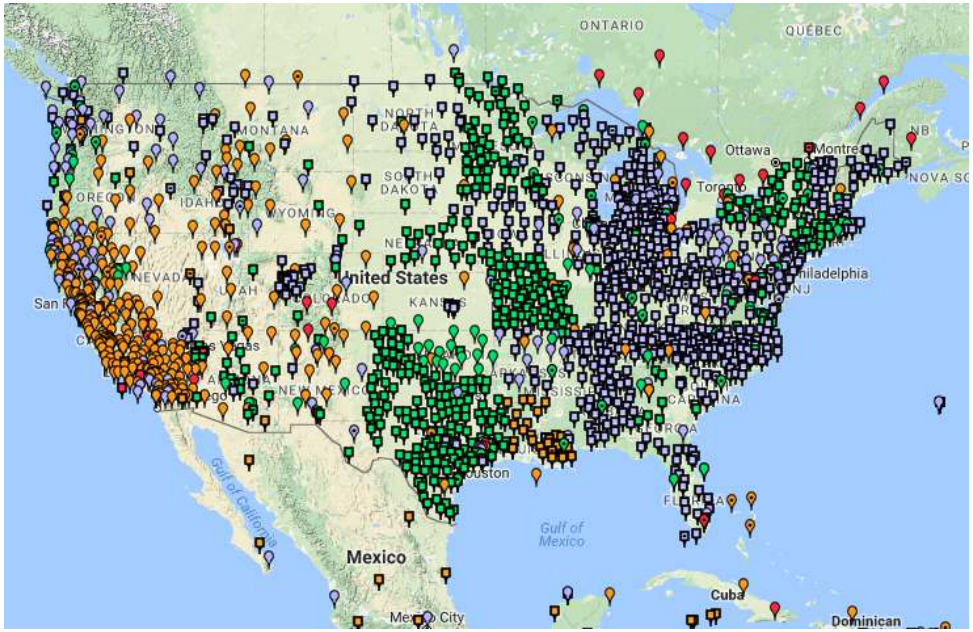
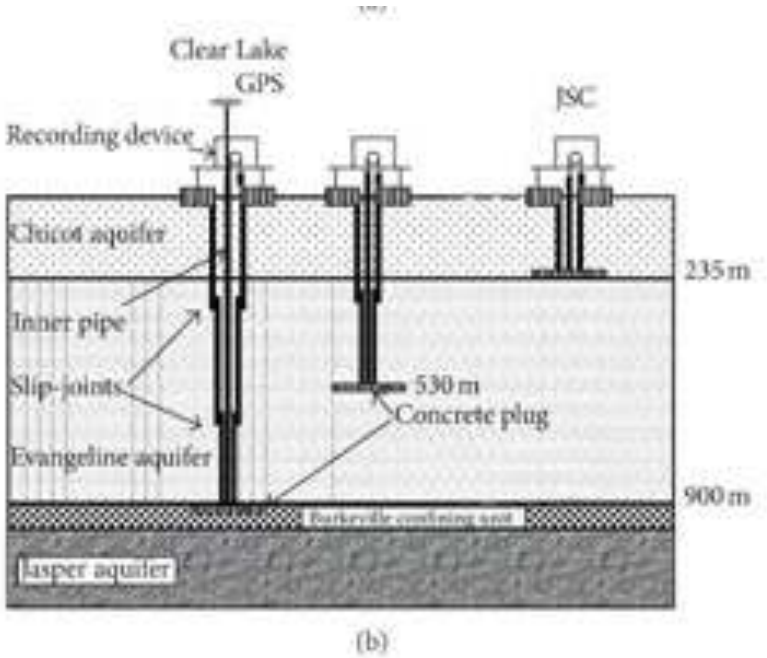
Measurement of Land Subsidence

- Continuously Operating Reference Stations (CORS) – GPS units Mounted a top of land surface -- total land subsidence --
- Extensometers – pipes covered with slip joints – at which depth interval subsidence is occurring





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Assessment of Land Subsidence

- Three key factors to assess potential for land subsidence
  - Amount of drawdown
  - Total thickness of clay
  - Compressibility of clay
- Factors affecting Compressibility of Clay
  - Type of clay
  - Depth of burial
  - Age of clay
  - History of compaction
- Other potentially important factors
  - Permeability of clay (affects timing)
  - Thickness of individual clay layers

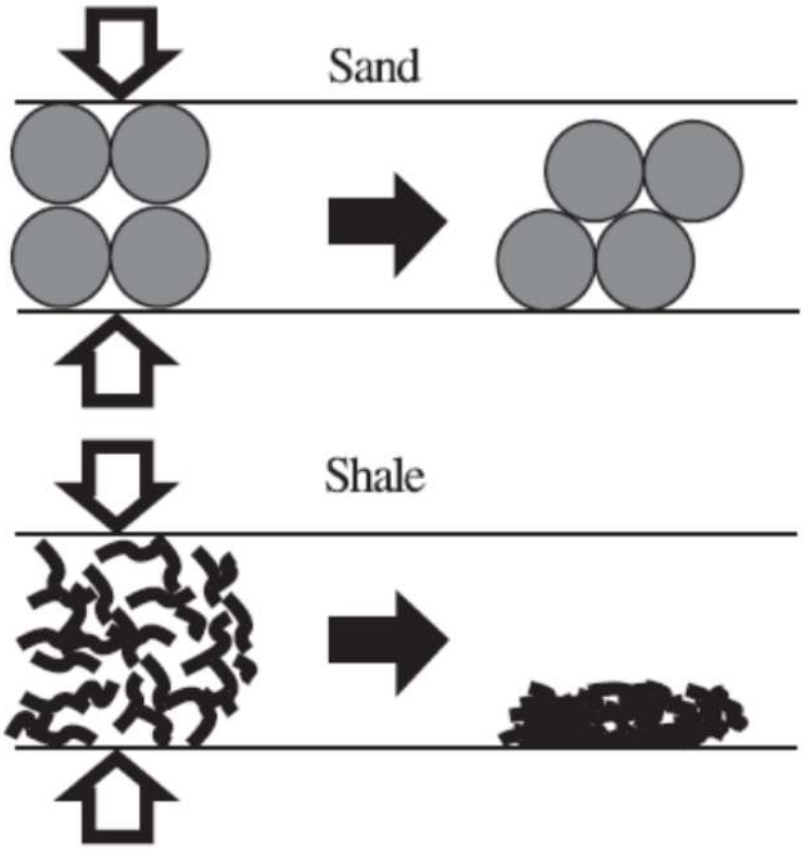

Figure 1 Schematic showing the reorientation and shifting of sand grains and clay particles associated with compaction caused by increased effective stress

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Land Subsidence Presentation to Lost Pines GCD: Austin Statesman Article*

- "consultants hired by the Texas Water Development Board presented to the Lost Pines Groundwater Conservation District an overview of how subsidence is projected to affect southeast Central Texas as Bastrop and Lee counties become an increasingly popular source for groundwater supply "

- " the groundwater pumping in the region over the next several decades will contribute to up to two feet of sinking"

- "The model LRE Water created rated an aquifer's subsidence risk on a scale of 1 to 10. The Gulf Coast Aquifer was rated the most at-risk with a 5.9 rating. While the Carrizo-Wilcox was given an overall 4.7 rating, "which is at the low end of the aquifers that are considered to have high risk – "But the Bastrop and Lee county region specifically, he added, was rated higher at 5.3."

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TWDB Report Model for Risk Vulnerability: Risk Matrix Factors

Table 1.1. Aquifer subsidence risk matrix factors, weights, classes, and class values.

Subsidence Risk Factor (Weight)	Subsidence Risk Factor Class	Subsidence Risk Value	Max Score
Clay Layer Saturated Thickness and Extent (6)	Regional Extent – Greater than 300 feet	5	*30*
	Regional Extent – 200 to 300 feet	4	
	Regional Extent – 100 to 200 feet	3	
	Regional Extent – Greater than 0 to 100 feet	2	
	Local Extent or No Clay	1	
Clay Compressibility (5)	Plastic Clay	3	*15*
	Stiff Clay	2	
	Hard or No Clay	1	
Aquifer Lithology (4)	Unconsolidated Clastic	4	*16*
	Consolidated Clastic	3	
	Carbonate/Evaporite	2	
	Igneous	1	
Preconsolidation Characterization (3)	Current Static Water Level Less than Historic Low Water Level Plus 25 Feet	3	*9*
	Current Static Water Level Greater than Historic Low Water Level Plus 25 Feet and Less than Historic Low Water Level Plus 50 Feet	2	
	Current Static Water Level Greater than Historic Low Water Level Plus 50 Feet	1	
Predicted 50-Year Water Level Decline based on Trend (2)	Greater than 200 feet	5	*10*
	Between 100 and 200 feet	4	
	Between 50 and 100 feet	3	
	Between 0 and 50 feet	2	
	Less than 0 feet	1	
Predicted DFC* Water Level Decline (1)	Greater than 200 feet	5	*5*
	Between 100 and 200 feet	4	
	Between 50 and 100 feet	3	
	Between 0 and 50 feet	2	
	Less than 0 feet	1	
			85

*DFC = Desired Future Condition

https://www.statesman.com/news/20190124/could-groundwater-pumping-cause-ground-to-sink-its-possible-scientists-say

Listing of Aquifers with High Risk for Land Subsidence

Table 1.2. High total weighted risk by aquifer (ranked by third quartile cutoff).

Aquifer	Aquifer Type	Predominant Aquifer Lithology	Number of Wells Analyzed	Average Aquifer Thickness (ft)	Average Clay Thickness within Aquifer (ft)	Estimated Water Level Trend (negative for decline) (ft/year)	Third Quartile Cutoff on Total Weighted Risk for All Wells Analyzed in Aquifer	Weighted Subsidence Risk Category
Gulf Coast	Major	Unconsolidated Clastic	105,292	650	66	-0.000167	5.9	High: Subsidence Risk is high with high subsidence risk in large areas of the aquifer
Yegua-Jackson	Minor	Unconsolidated Clastic	3,373	828	110	0.0000372	5.9	
Pecos Valley	Major	Unconsolidated Clastic	1,952	549	36	-0.266	5.5	
Hueco-Mesilla Bolson	Major	Unconsolidated Clastic	2,360	810	23	-0.00276	5.4	
Brazos River Alluvium	Minor	Unconsolidated Clastic	985	54	1	-0.000237	5.3	
Ogallala	Major	Unconsolidated Clastic	63,522	223	17	-0.864	5.2	
Carrizo-Wilcox	Major	Unconsolidated Clastic	23,519	401	66	-0.332	4.7	

Potential Concerns with Land-Subsidence Study

- Unclear what the risk factor for subsidence vulnerability represents
  - calculation is based of aquifer factors that are relative to subsidence but several important factors are missing such as age of clay, permeability of clay, type of clay, and depth or burial
  - no data to show a correlation of risk factor and actual land subsidence
- No maps of measured land subsidence in report
- No validation or checking of tool for predicting subsidence with measured subsidence

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Additional Concerns with Land-Subsidence Study

- Very Limited Data Regarding Land Subsidence of the Gulf Coast Aquifer
  - Unknown to what extent it is occurring – maybe it is not occurring?
  - Very little, if any, data appears to have been used for developing approach based on numerous studies by Bob Gabrysch and other USGS researchers in 70's and 80's
- The large sources of uncertainty are not adequately conveyed
- The risk rating of 5.3 for Brazos River Alluvium with future drawdown of 6 ft (page 4-109) raises question regarding validity of risk rating

* https://www.statesman.com/news/20190124/could-groundwater-pumping-cause-ground-to-sink-its-possible-scientists-say

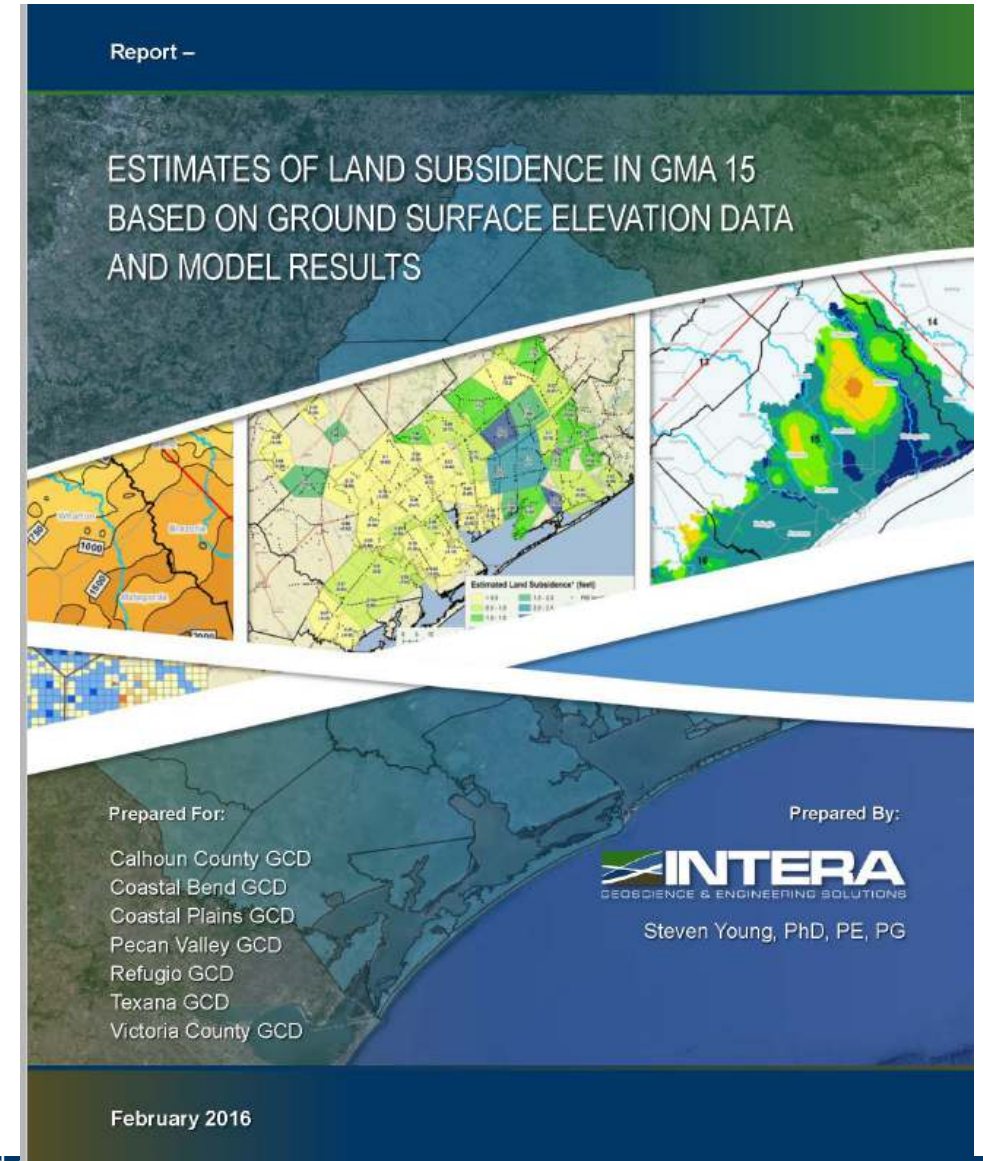
Interim Evaluation

- Significant questions with validity of TWDB Risk Rating for Aquifer Vulnerability to Land Subsidence
- Significant concerns regarding prediction tool for land subsidence
  - not validated using data from areas with land subsidence has been measured
  - report does not adequately address sources of uncertainty
- Data gap regarding assessment of historical land subsidence Texas including GMA 12 is real
- Additional work with subsidence is recommended in GMA 12

* https://www.statesman.com/news/20190124/could-groundwater-pumping-cause-ground-to-sink-its-possible-scientists-say

Suggested Future Work

- Investigate evidence of subsidence near City of Bryan and College Station using Lidar and National Geodectic Survey Data
- Meet with TWDB to discuss Vulnerability Rating Matrix with TWDB
- Perform testing of TWDB tool for predicting subsidence



[1] https://www.statesman.com/news/20190124/could-groundwater-pumping-cause-ground-to-sink-its-possible-scientists-say

AX Coal Ash Landfill

- AX Landfill is in Milam County discussed in recent EIP report
- EIP report covers 16 Texas Coal-fired Power Plants
- Drinking Water Standards exceeded at Sandow Facility

Groundwater Contamination from Texas Coal Ash Dumps

New Data Reveal Pollution Leaking from 100 Percent of Coal Power Plants With Available Records

EIP ENVIRONMENTAL INTEGRITY PROJECT

JANUARY 17, 2019

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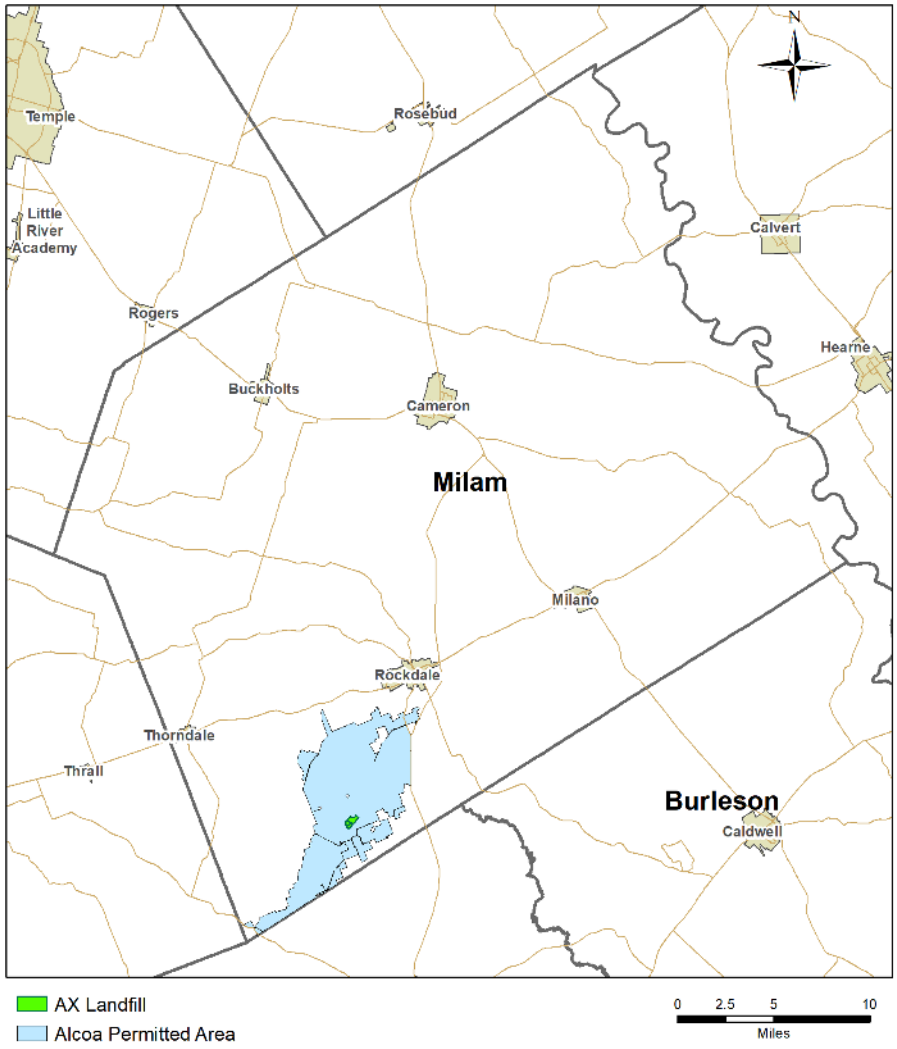
AX Landfill: History and Location

- Landfill created to handle fly ash from Sandow 5 Generating Plant, which came online in 2009
- Covers approximately 160 acres
- Located approximately 8 miles southwest of Rockdale
- Landfill registered with TCEQ as Class 2 non-hazardous waste landfill in 2008 and updated in 2015
- Fly ash and bottom ash are transported to landfill via trucks
- Ash is disposed as dry material
- Information available at https://www.luminant.com/ccr/#



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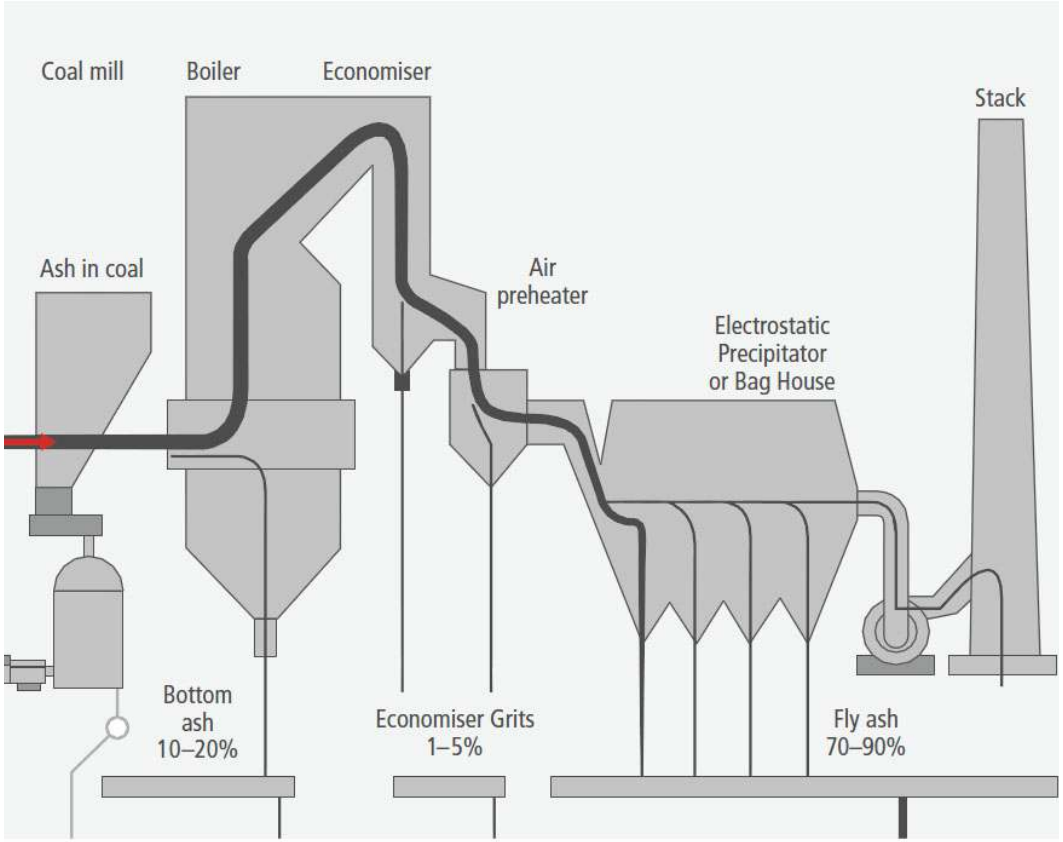
Fly Ash and Bottom Ash

- Ash is non-flammable minerals or residue remaining after coal is incinerated
- Ash
- Bottom Ash
  - About 20% of ash
  - Coarse residual at bottom of combustion chamber
- Fly Ash
  - About 80% of ash
  - Finer residual at caught in gas in combustion chamber
- Disposal of Ash
  - Historically through mid 80's, mainly sluiced to ponds
  - Since 80's dry stacking has become increasingly prevalent



http://report.hazelwoodinquiry.vic.gov.au/part-four-health-wellbeing/health-wellbeing-background/ash-2.html

Coal Combustion Rule (CCR) and Reporting

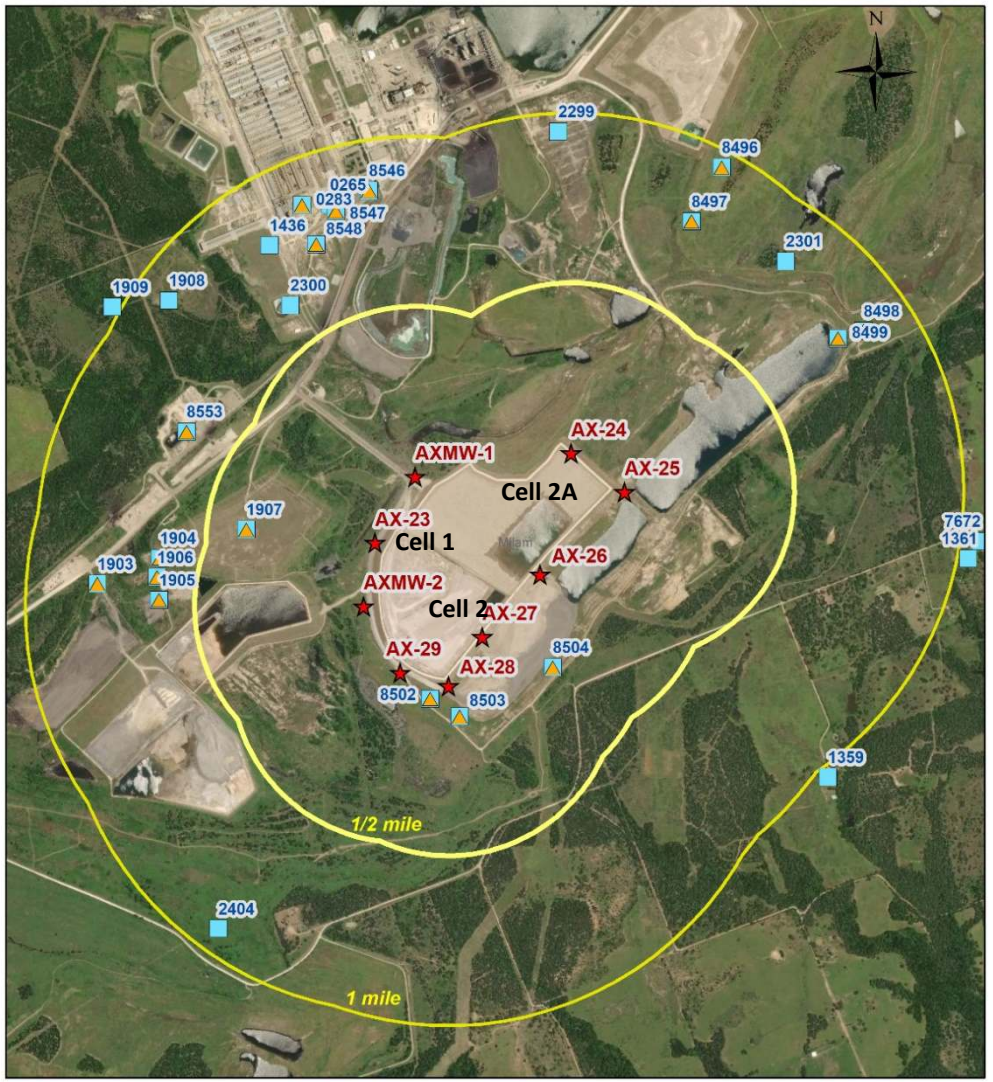
- CCR(40 CFF 257 Subpart D) effected on Oct 19, 2015
  - Operation standards for active landfills for bottom ash and fly ash
  - In 2012, 470 coal plants and over 1,000 landfills and surface impoundments
- CCR Action Items
  - Record keeping
  - Install groundwater wells and groundwater monitoring by October 2017
  - Construction standards
  - Landfill closure plans
  - Internet site that posts documentation
- Rule is self-implementing meaning facilities must comply with requirements without regulatory oversight
- States not required to adopt the program
- Citizens have ability to enforce under RCRA citizen suit authoring

Parameters That Must be Monitored

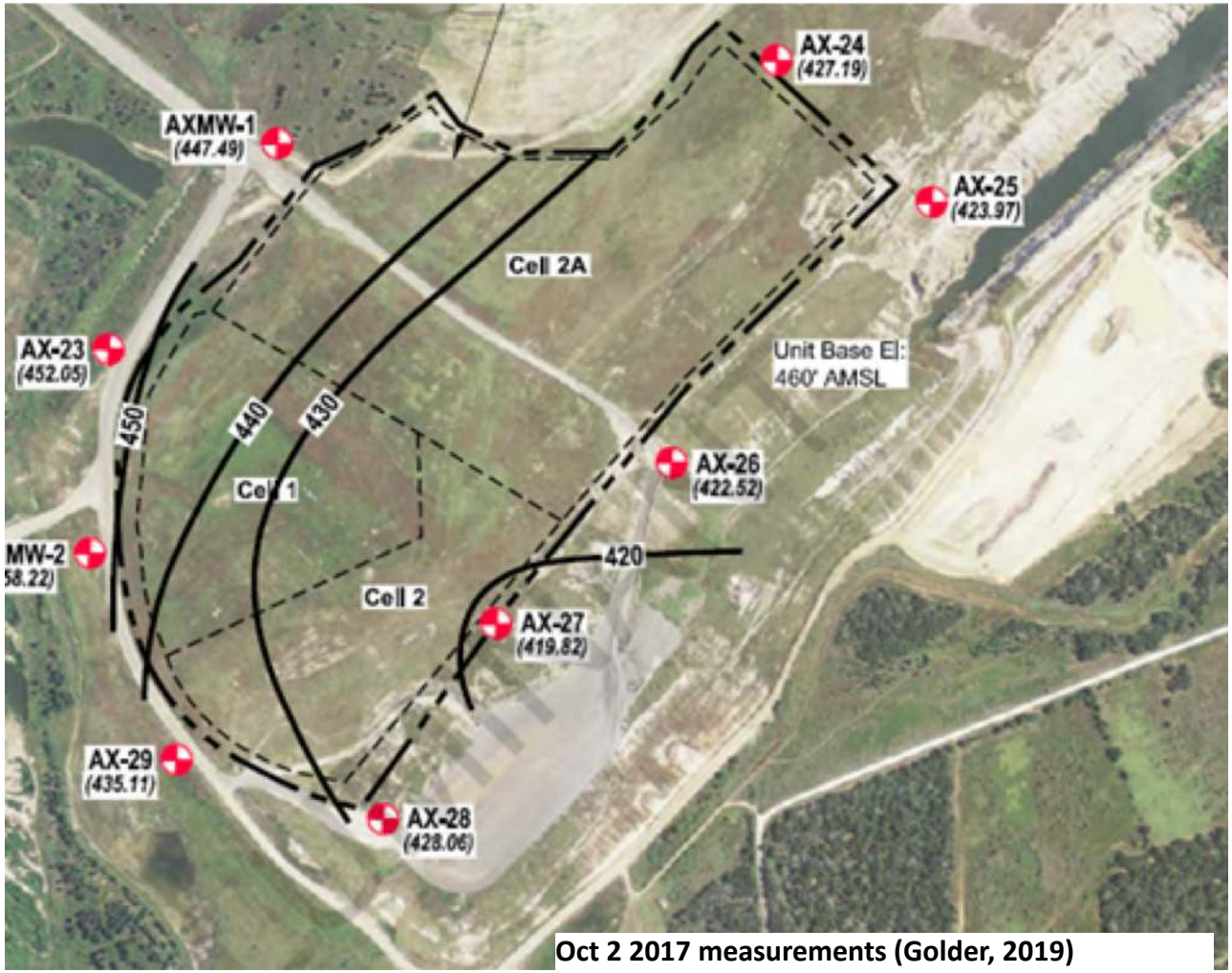
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Fluoride
- Lead
- Lithium
- Mercury
- Molybdenum
- Selenium
- Thallium
- Radium 226 and 228 combined

Monitoring Well Locations

- AX Landfill Construction
  - Cell 1 constructed in 2013
  - Cell 2 constructed in 2015
  - Cell 2a has not received CCR wastes (PBW, 2018)
  - Cells 1 and 2 have low-permeability geotextile liner
  - Under liner is clay with a low permeability
  - Constructed using excavated material from mining lignite coal
- AX Well Construction
  - All have 10 ft or 20 ft well s
  - MW-1 and MW-1 installed in 2012 and have max depth of 63 feet
  - Other wells installed in 2015 had have max depth of 98 feet
- Monitoring
  - Sampled bimonthly from 2015 to 2016
  - Identify which constituents are above background concentrations in 2019 report
  - 2019 identified another source other than landfill as source of several elevated concentrations

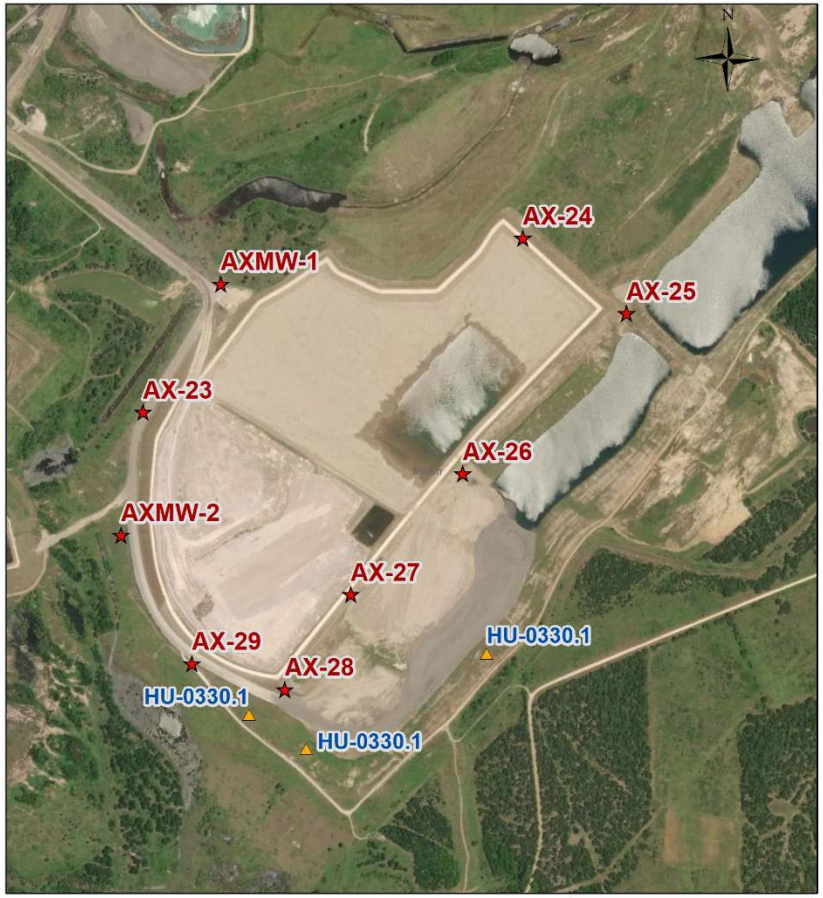


Measured Water Levels



Oct 2 2017 measurements (Golder, 2019)

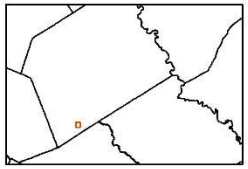
Monitoring Results

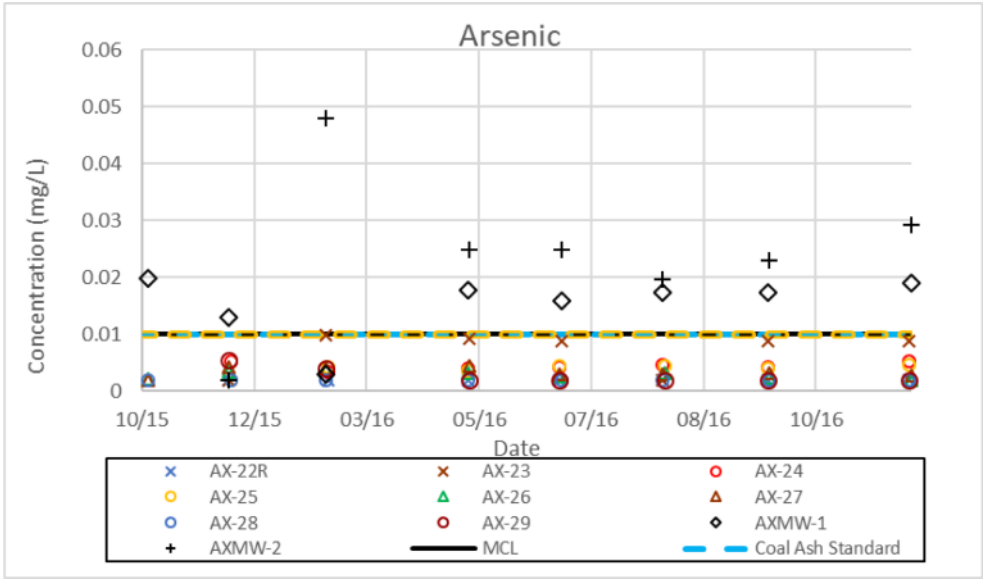


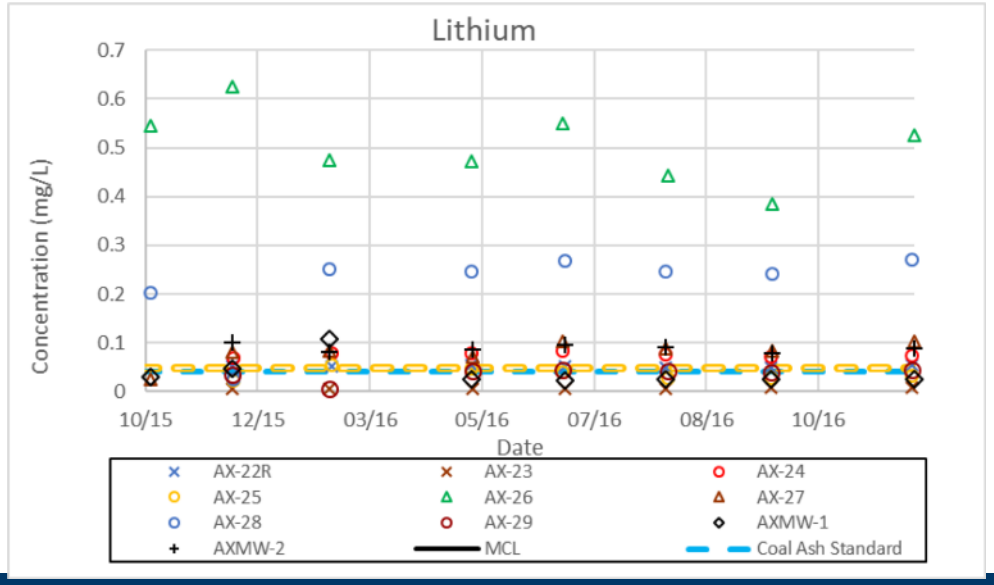
POSGCD Wells near Sandow Mine

- Sandow Mine wells
- Permitted Well

0 0.05 0.1 0.2
Miles







Note: yellow line marks state Protective Concentration (PCL) Limits

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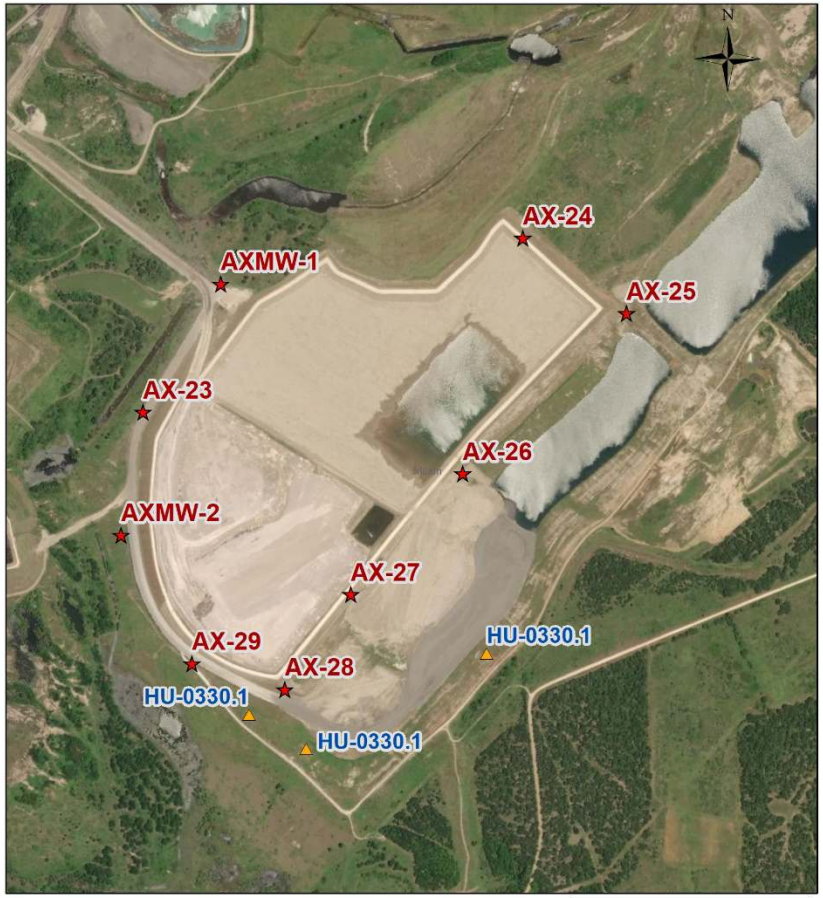
Monitoring Results



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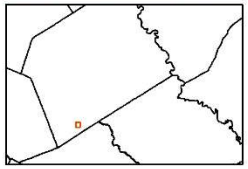

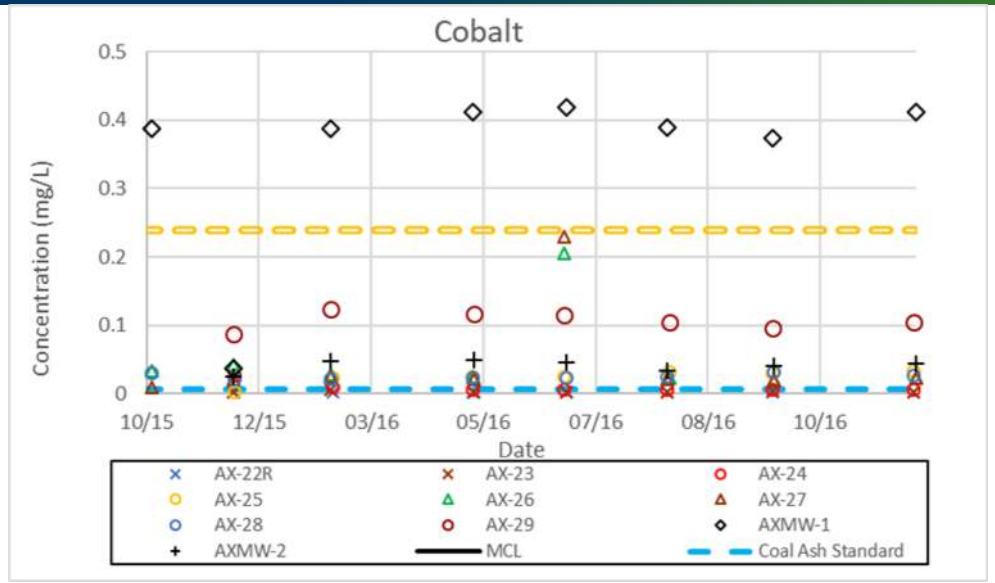

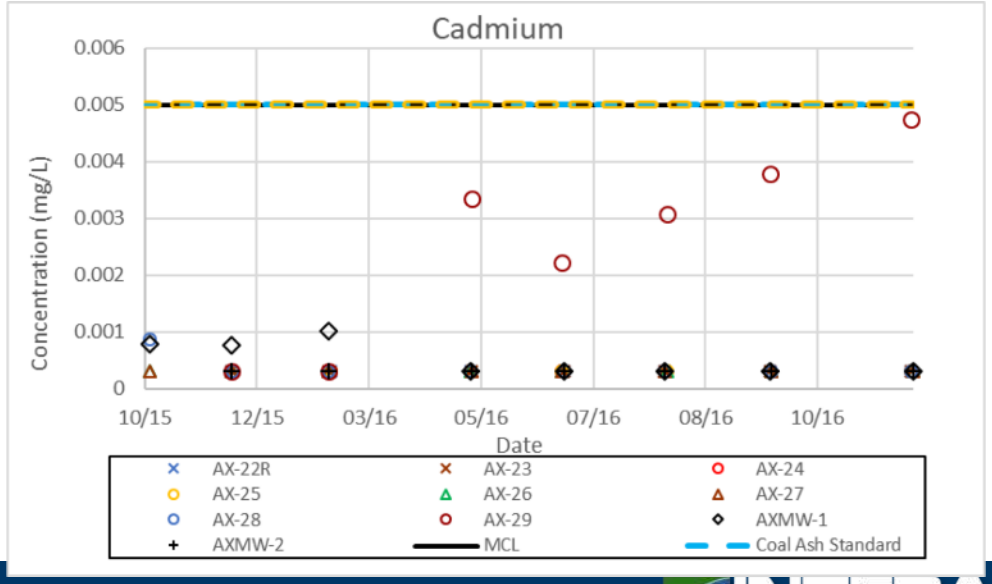

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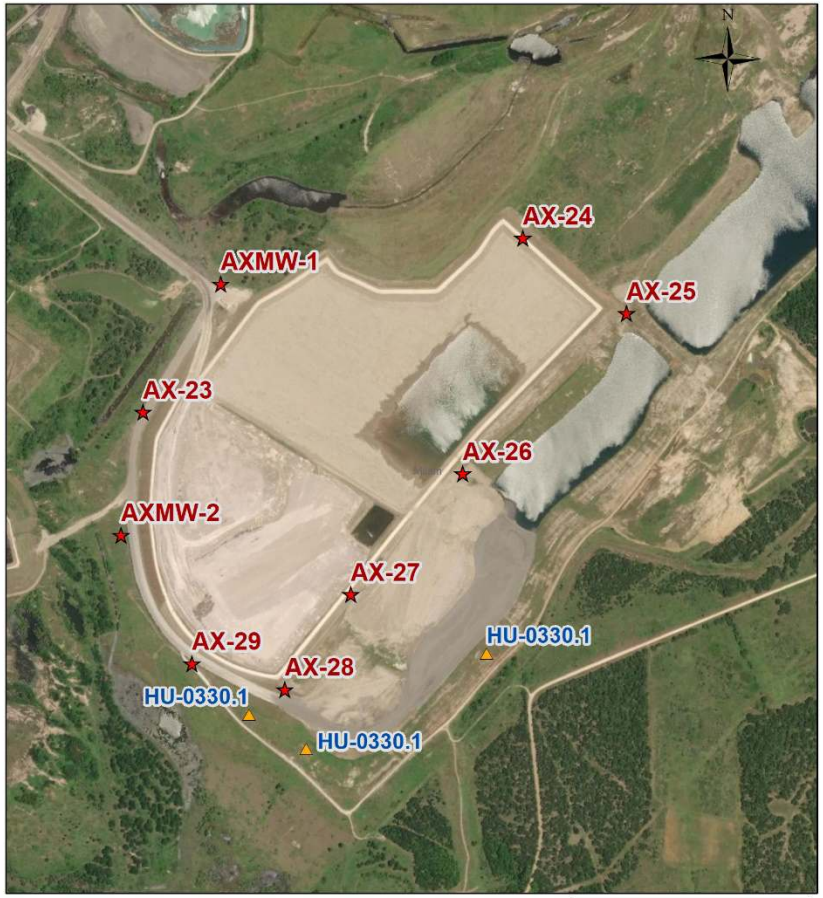
INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Monitoring Results



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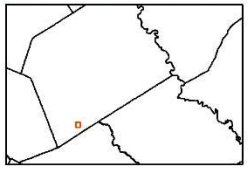
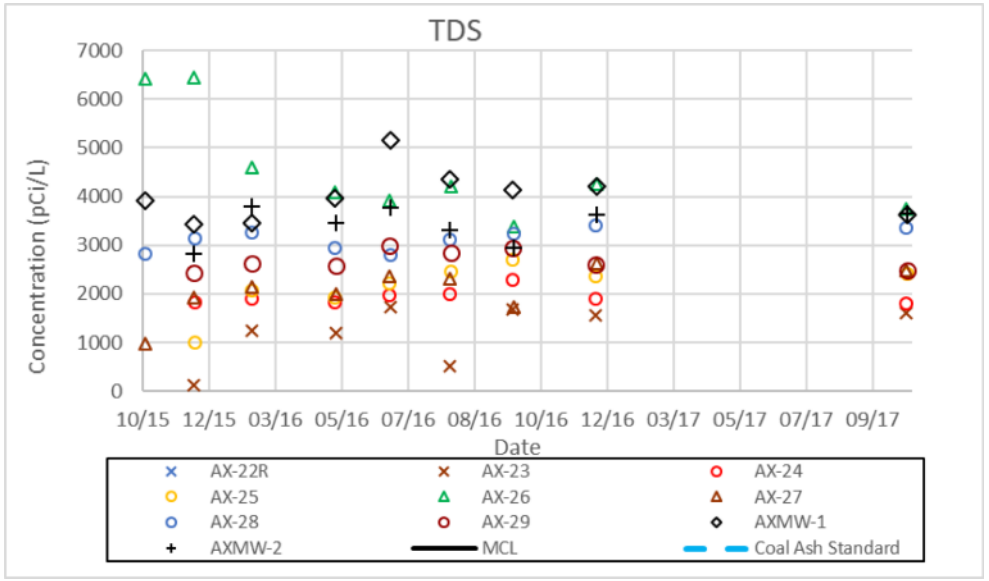
Miles

N





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On-going Activity

- CCR Rule
  - Continued monitoring and reporting for active facilities
  - In August 2018, DC Circuit Court ruled that CCR Rule should apply also to inactive sites
  - March 2019 -- Ruling on Appeal to DC Circuit Court expected l
- TCEQ
  - Notifying Coal Ash Facilities that if analyte concentrations exceeds TRRP Tier 1 PCLs, then they need to be reported to TCEQ Remediation Division (Corrective Action Group)
  - Exceedances of PCL triggers
    - Drinking Water Survey Report
    - Affected Property Assessment Report

TCEQ REGULATORY GUIDANCE

Remediation Division

RG-366/TRRP-12 • Revised May 2010

Affected Property Assessment Requirements under TRRP

- Identifying source areas and types of Chemicals of Concern (CoCs)
- Characterizing the geologic and hydrogeologic properties of the area that influence COC fate and transport
- Determining COC migration pathways, and
- Evaluating exposure pathways

Hydrologic Studies

- Predictive Simulations using Updated GAM
- Aquifer Storage and Recovery (ASR) and Enhance Recharge
- Surface Water and Groundwater Interaction
- Characterizing of Aquifer Surfaces and Lithology

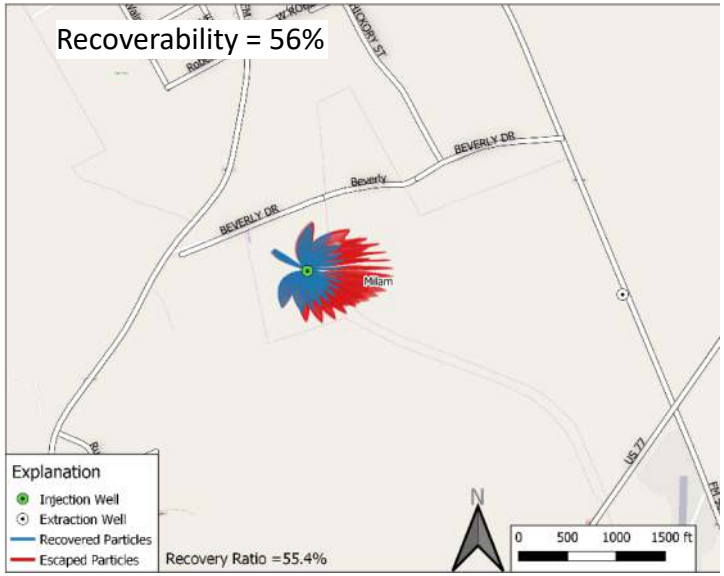
Predictive Simulations using Updated GAM

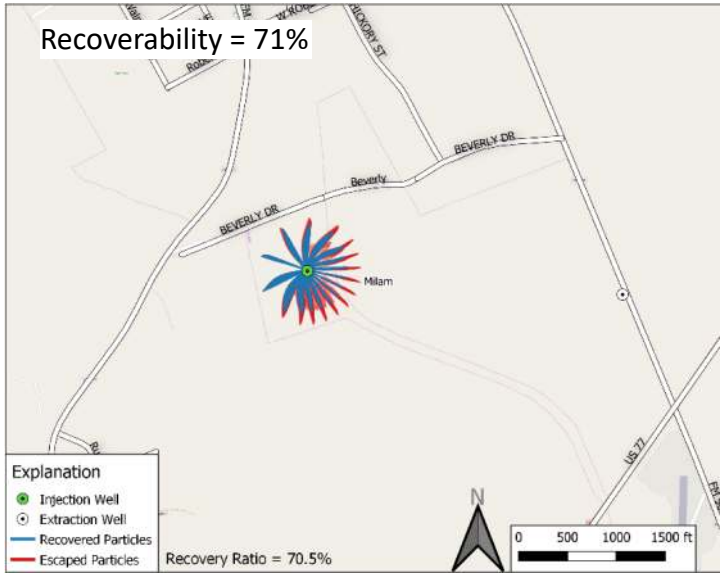
- GCDs are working jointly to assign wells to grid cells
- Shared information on wells and GAMs
- Two Modeling Scenarios
  - All permits active
  - Best Estimate of Future Water Use

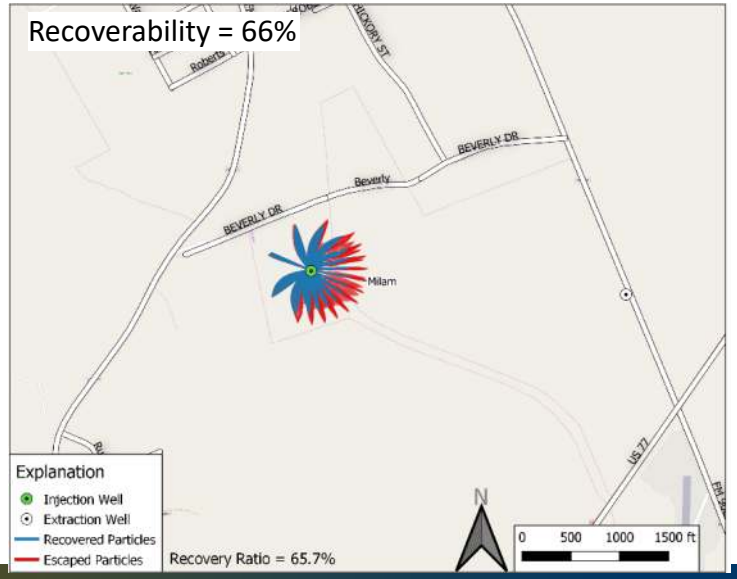
Aquifer Storage and Recovery Report

- Introduction to ASR and ER operations
- Overview of ASR in Texas
- House Bill 655
- Concept of Recoverability
- Modeling Approaches to ASR
  - Analytical (simple)
  - Numerical (complex)
- Modeling Results for POSGCD
- Monitoring Considerations

Aquifer Storage and Recovery Report: Result from One Scenario







ASR Injection/Pumping Schedule

- Inject at 280 gpm for 29 months
- Extract at 2,030 gpm For 4 months
- Inject at 280 gpm for 32 months
- Extract at 2,240 gpm for 4 month

Nearest Pumping Well

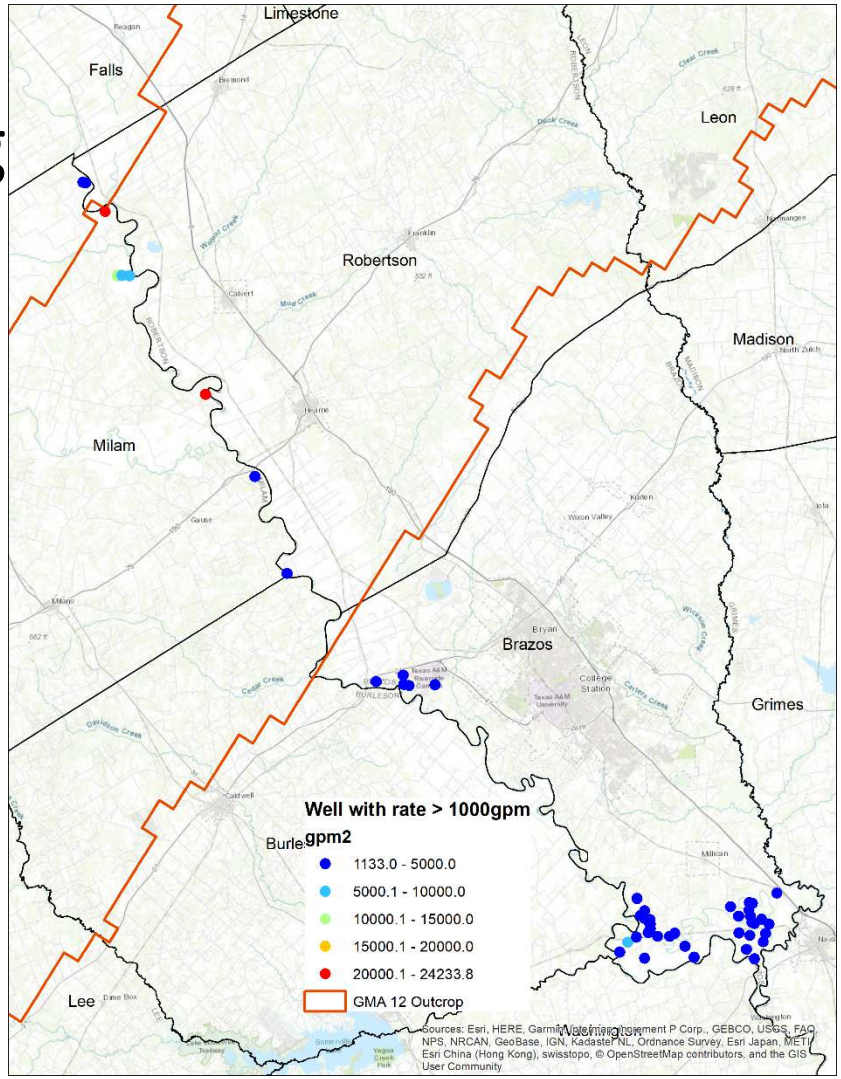
- Vary from 1500, 500, and 0 gpm

Surface Water – Groundwater Interaction

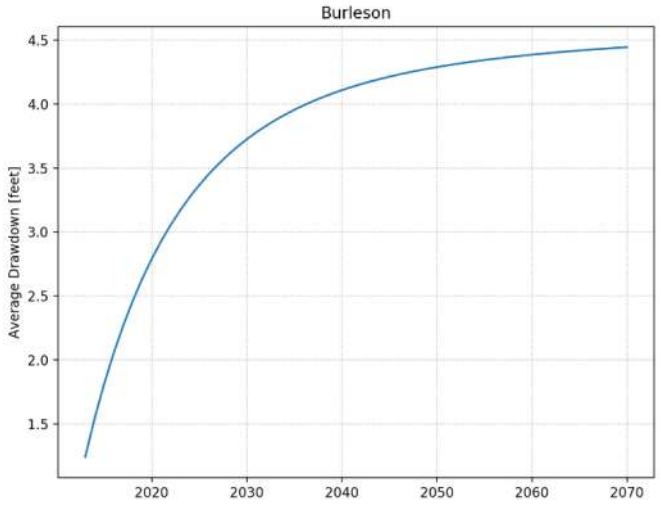
- POSGCD and BVGCD will meet with TWDB regarding MAG for Brazos Alluvium

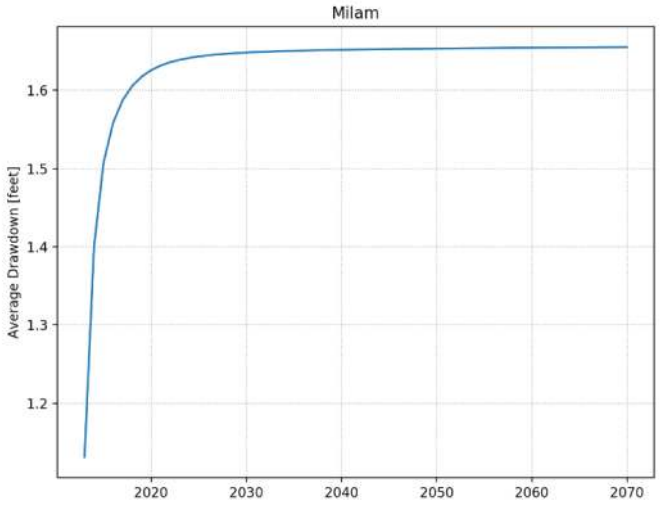
County	2020	2030	2040	2050	2060	2070
Brazos	81,581	80,311	80,081	79,976	79,913	79,872
Burleson	28,472	28,418	28,414	28,414	28,414	28,413
Falls	NR	NR	NR	NR	NR	NR
Milam	47,818	47,785	47,779	47,775	47,773	47,771
Robertson	61,161	57,959	57,633	57,544	57,503	57,480
GMA 12 Total	219,032	214,473	213,907	213,709	213,602	213,536

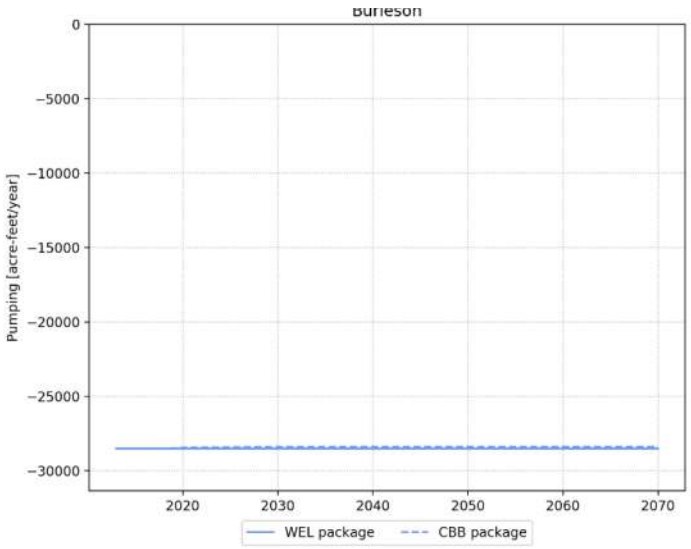
NR: Groundrazos River Alluvium Aquifer not relevant in these areas.

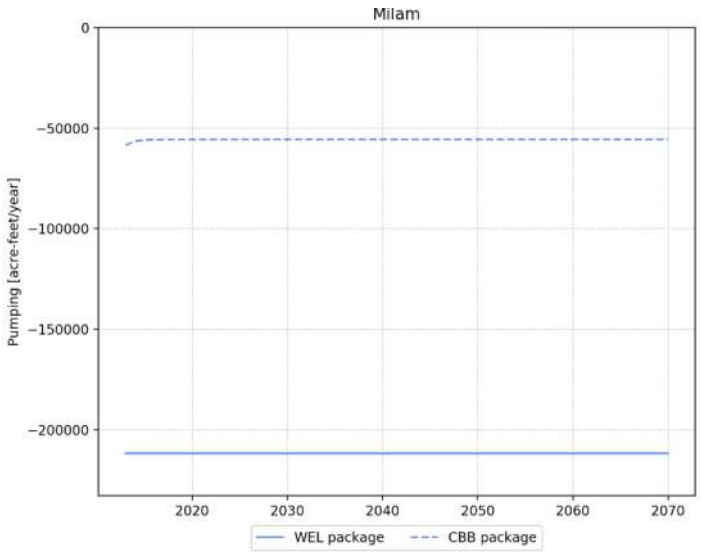


Discussion with TWDB Regarding Model Available Groundwater (MAG)

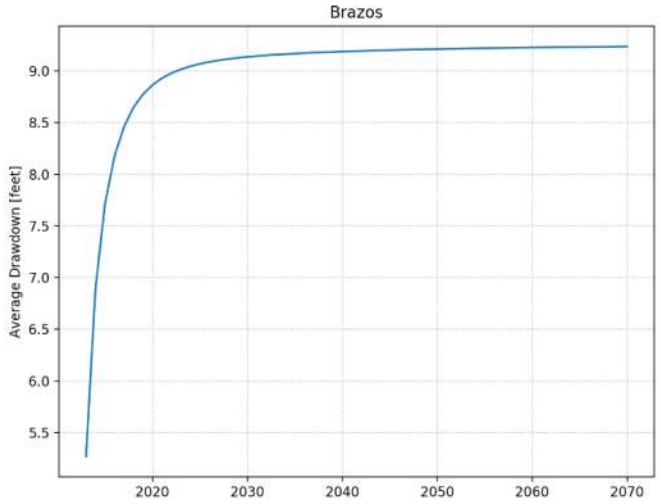


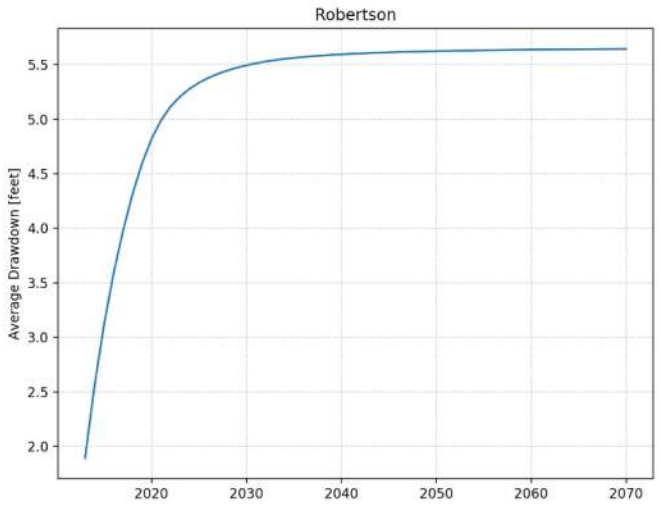


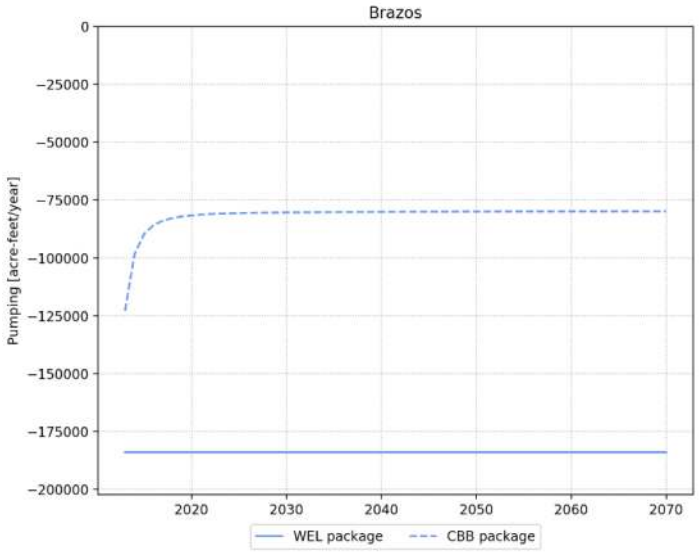


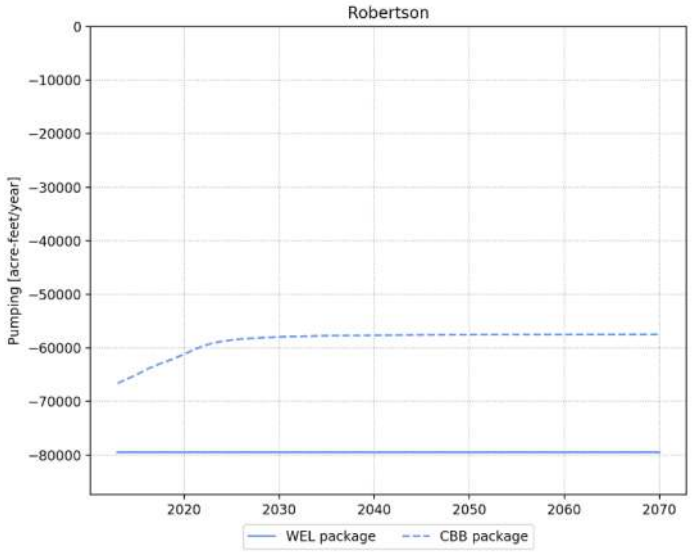


Discussion with TWDB Regarding Model Available Groundwater (MAG)





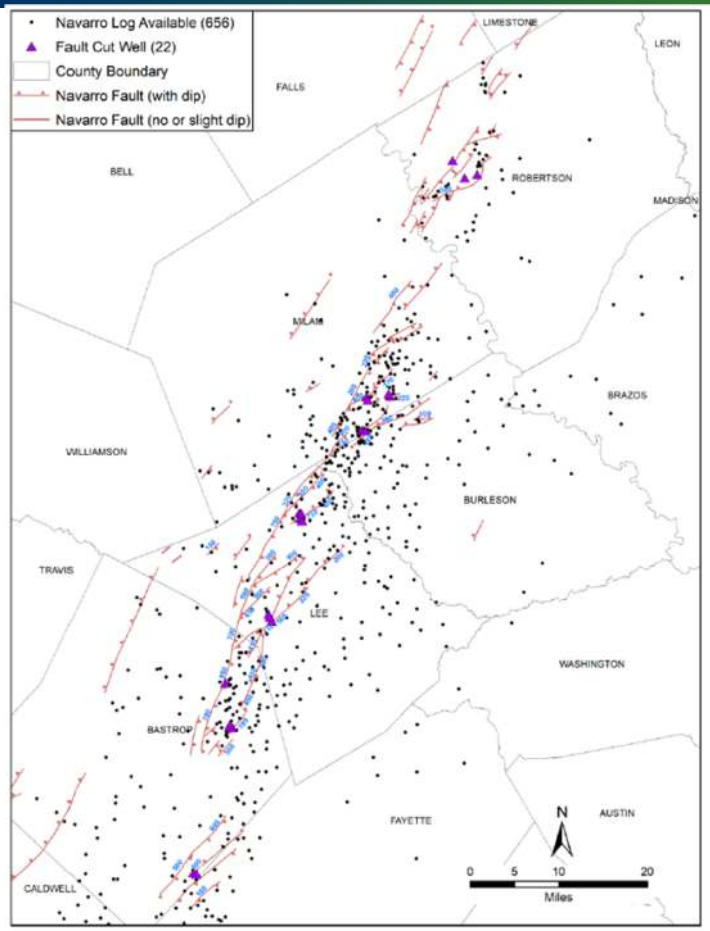


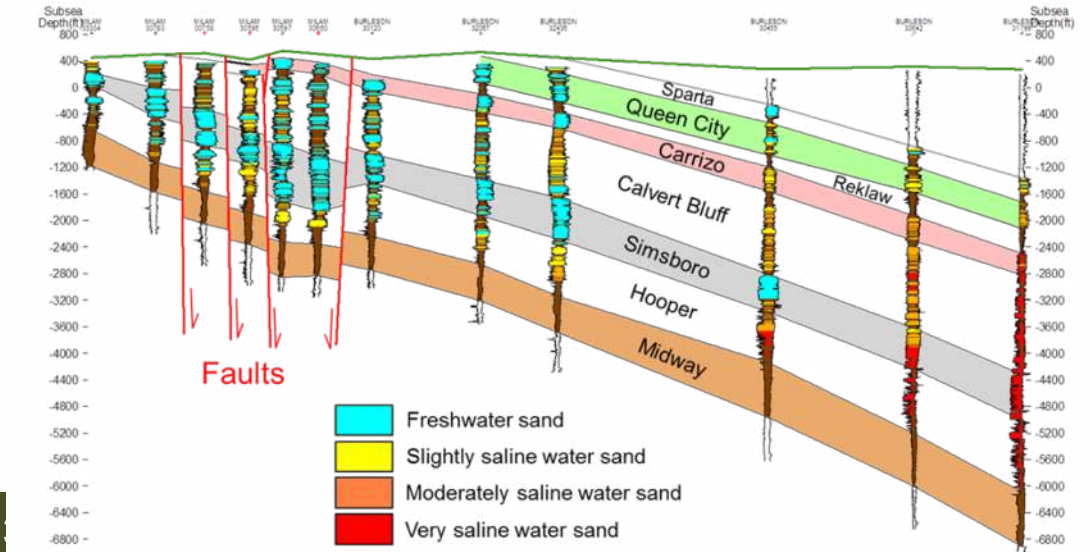


INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

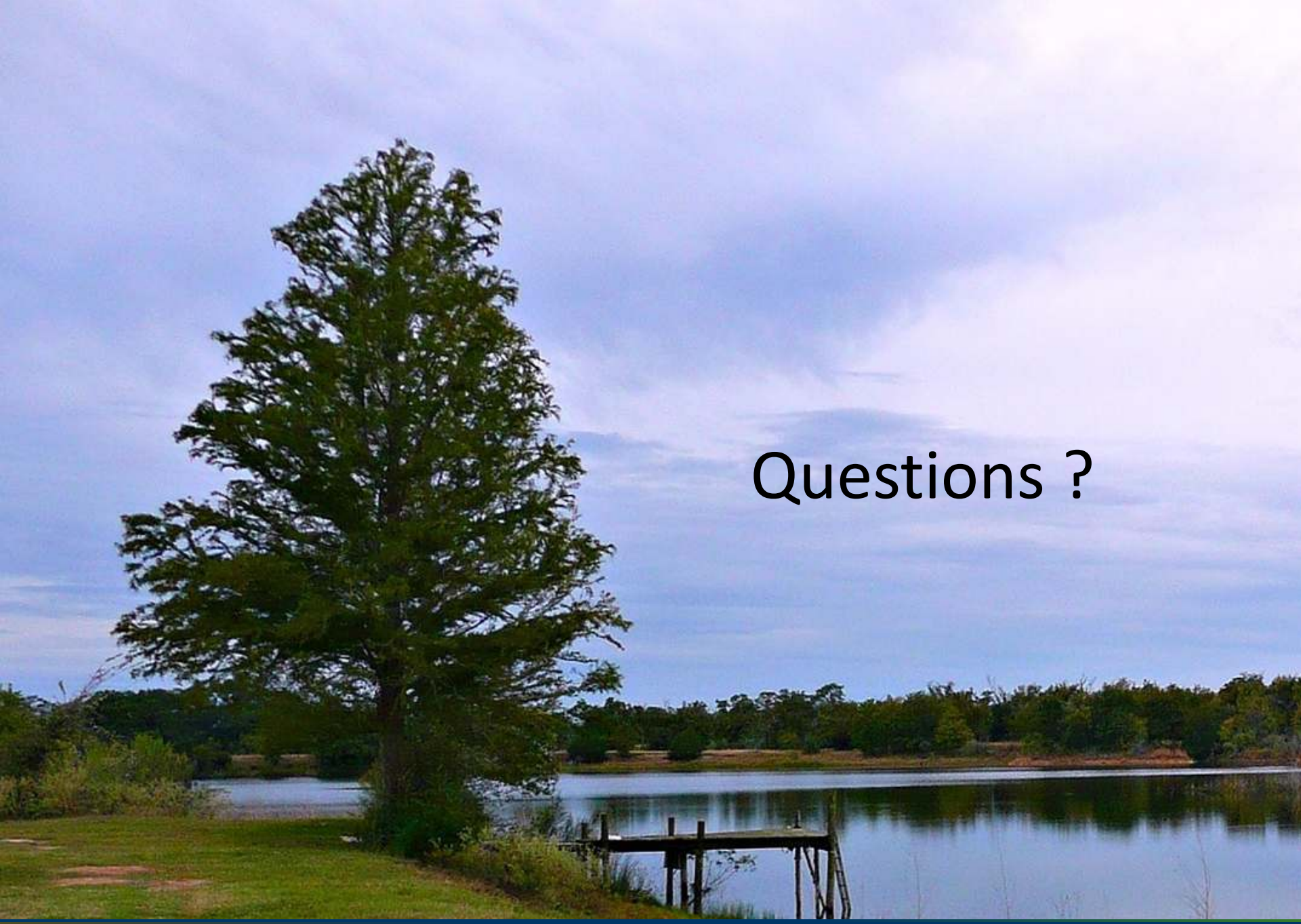
Aquifer Characterization Study

- Selection 100 geophysical logs
- Identify tops and bottoms of aquifers
- Identify sands and clays
- Assign wells to aquifers
- Construct Cross-sections and evaluate aquifer surfaces in GAMs





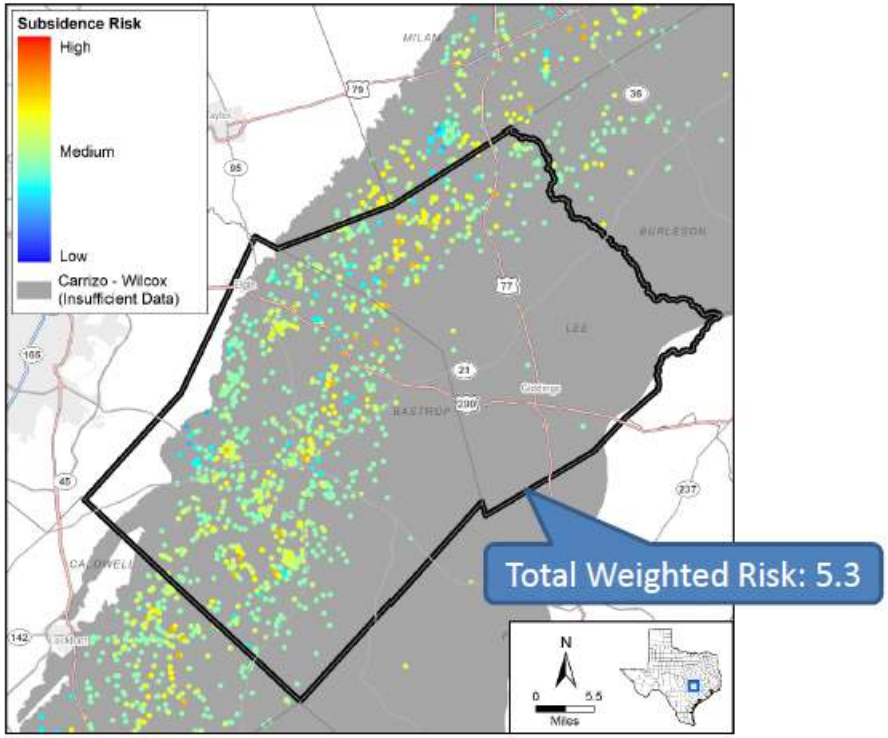
INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS


Questions ?

Carrizo-Wilcox Formations in LPGCD*

- Vulnerability of Simsboro to Land Subsidence in LPGCD is less than
  - Calvert Bluff in LPGCD
  - Hooper in LPGCD
  - Average across Yegua Jackson
  - Average across Brazos River Alluvium

Subsidence Risk Factor Variable	Carrizo	Calvert Bluff	Simboro	Hooper
Clay Layer Thickness and Extent	2	3	2	3
Clay Compressibility	1	1	1	1
Aquifer Lithology	4	4	4	4
Preconsolidation Characterization	3	3	3	3
Predicted Water Level Decline based on Trend	2	2	3	2
Predicted DFC Water Level Decline	3	3	4	3
Total Weighted Risk	**4.4**	**5.3**	**4.8**	**5.3**



* From LRE presentation to LPGCD on Jan 16 2019