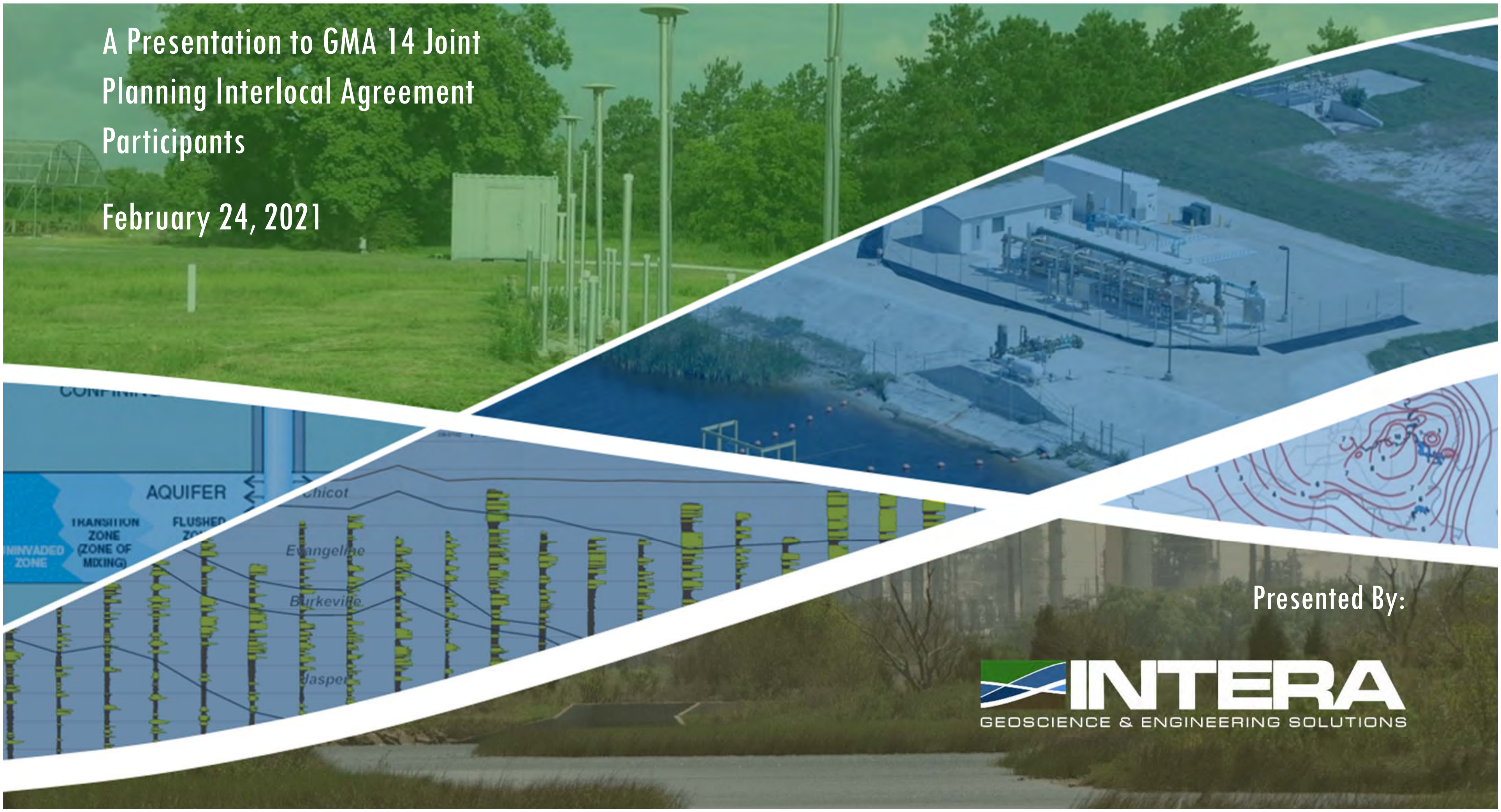
Discussion and Consideration of Factors Relevant to DFCs



A Presentation to GMA 14 Joint Planning Interlocal Agreement Participants

February 24, 2021

Presented By:

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Consideration of Factors

- Aquifer uses or conditions
- Water supply needs and management strategies
- Hydrological conditions
- Other environmental impacts
- Impact on subsidence
- Socioeconomic impacts
- Impact on private property rights
- Feasibility of achieving the DFC
- Any other relevant information

Schedule

2019

Main Joint Planning Topics for Meetings	January	February	March	April	May	June	July	August	September	October	November	December
Factor 1: Aquifer Uses and Conditions	■											
Factor 2: Water Supply Needs and Management Strategies		■	■									
Factor 3: Hydrological Conditions				■	■	■						
Factor 4: Environmental Impacts												
Factor 5: Impact on Subsidence												
Factor 6: Socioeconomic Impacts												
Factor 7: Private Property Interests and Rights												
Factor 8: Feasibility of Achieving the DFCs												
Factor 9: Other Relevant Information												
Balancing Test Model Runs							■	■				
Selection of Model Runs for Evaluation									■	■		
Review of Model Run Results											■	■
Draft Explanatory Report Development												
Propose DFC(s) for Adoption (Deadline May 1, 2021)												
Meeting Dates	*		*			*		*		*		*

2020

Main Joint Planning Topics for Meetings	January	February	March	April	May	June	July	August	September	October	November	December
Factor 1: Aquifer Uses and Conditions												
Factor 2: Water Supply Needs and Management Strategies												
Factor 3: Hydrological Conditions												
Factor 4: Environmental Impacts								■	■			
Factor 5: Impact on Subsidence						■	■					
Factor 6: Socioeconomic Impacts								■	■			
Factor 7: Private Property Interests and Rights										■	■	
Factor 8: Feasibility of Achieving the DFCs												■
Factor 9: Other Relevant Information												■
Balancing Test Model Runs												
Selection of Model Runs for Evaluation												
Review of Model Run Results	■	■	■	■	■							
Draft Explanatory Report Development						■	■	■	■	■	■	■
Propose DFC(s) for Adoption (Deadline May 1, 2021)												
Meeting Dates		*		*	*		*		*		*	

2021

Main Joint Planning Topics for Meetings	January	February	March	April	May
Factor 1: Aquifer Uses and Conditions		■			
Factor 2: Water Supply Needs and Management Strategies		■			
Factor 3: Hydrological Conditions		■			
Factor 4: Environmental Impacts		■			
Factor 5: Impact on Subsidence		■			
Factor 6: Socioeconomic Impacts		■			
Factor 7: Private Property Interests and Rights		■			
Factor 8: Feasibility of Achieving the DFCs	■	■			
Factor 9: Other Relevant Information	■	■			
Balancing Test Model Runs					
Selection of Model Runs for Evaluation					
Review of Model Run Results					
Draft Explanatory Report Development	■	■	■	■	■
Propose DFC(s) for Adoption (Deadline May 1, 2021)		■			
Meeting Dates	*	*			

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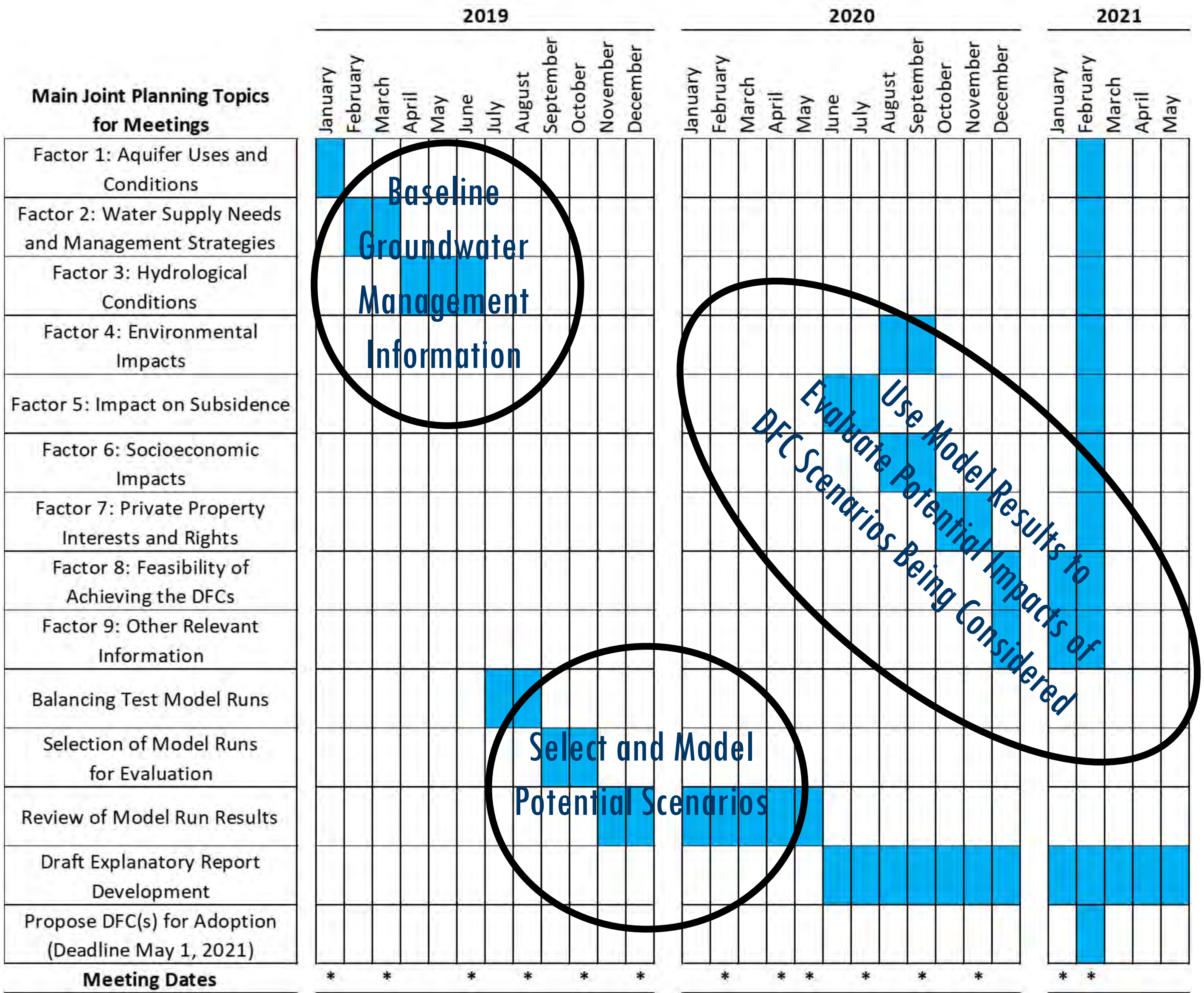
Schedule



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Balancing Test

- DFCs must provide "*a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater and control of subsidence in the management area*"

Balancing Test

Conservation, Preservation, Prevention of Subsidence, etc.

Aquifer uses or conditions

Environmental Impacts

Water supply needs and management strategies

Socioeconomic Impacts

Subsidence Impacts

Feasibility of achievement

Hydrological Conditions

Private Property Rights

Highest Practicable Level of Groundwater Production

Aquifer uses or conditions

Water supply needs and management strategies

Socioeconomic Impacts

Feasibility of achievement

Private Property Rights

Hydrological Conditions

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DFC Language for Scenarios Under Evaluation

In each county in GMA 14:

- *No less than (70%*/80%) median available drawdown remaining, and*
- *No more than 1.0 feet average additional subsidence between 2009 and 2080.*

To allow for growth while ensuring the distribution of groundwater availability remains realistic, modeled pumping in each county will not exceed 30,000 acre-feet per year above the maximum projected water demand between 2020 and 2070 in the State Water Plan.

*For the 70% median available drawdown remaining scenario, we use the base well files of the 2016 round of DFCs and Run D.

Potential Benefits

- DFCs are consistent throughout GMA while still accounting for local differences in conditions
- Both process and result directly address statutory factors
- Process has less direct link to the existing pumping distribution

Potential Drawbacks

- Districts must monitor more than one aquifer characteristic
- It's a new(ish) concept

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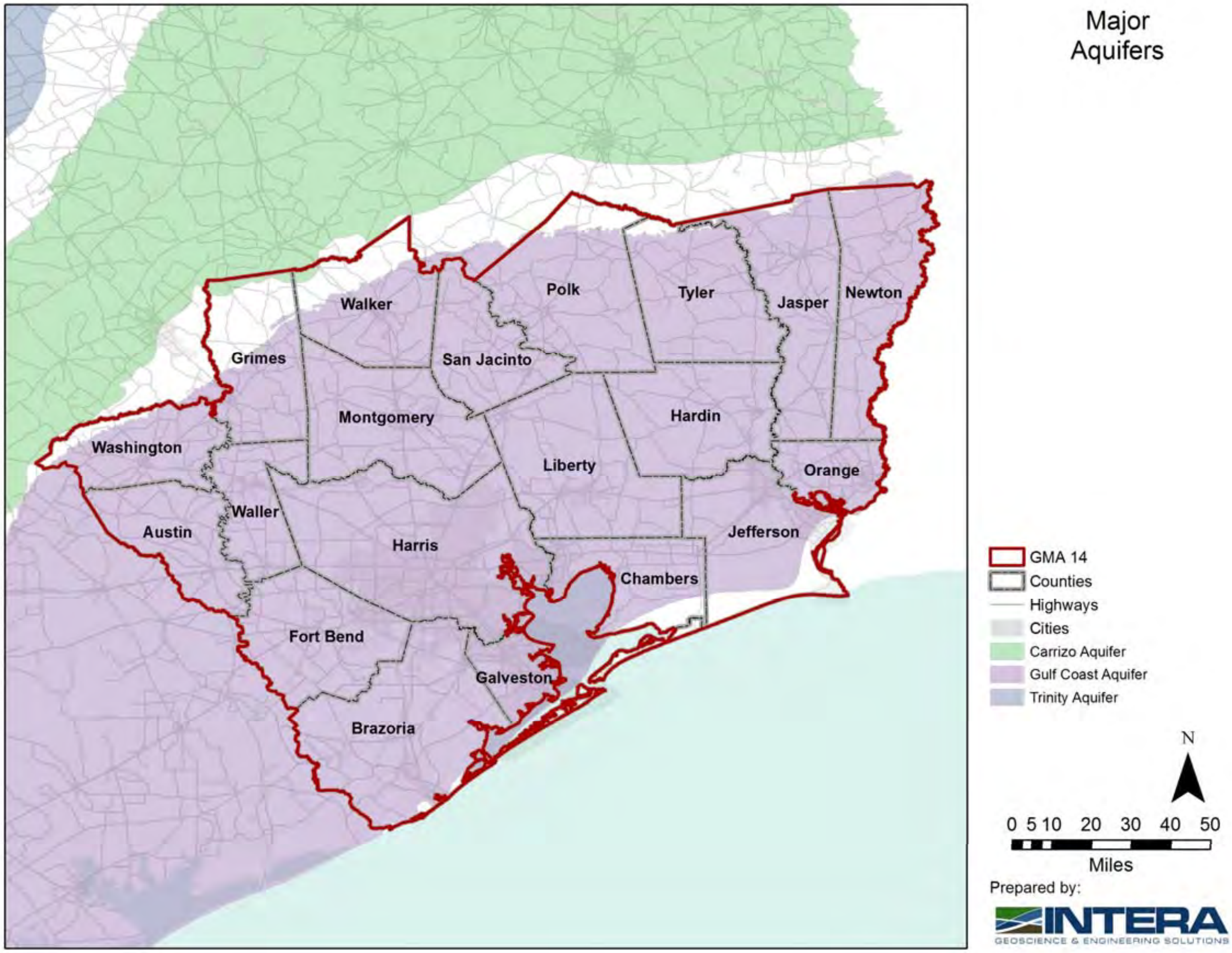
Aquifer Uses and Conditions

Major Aquifers



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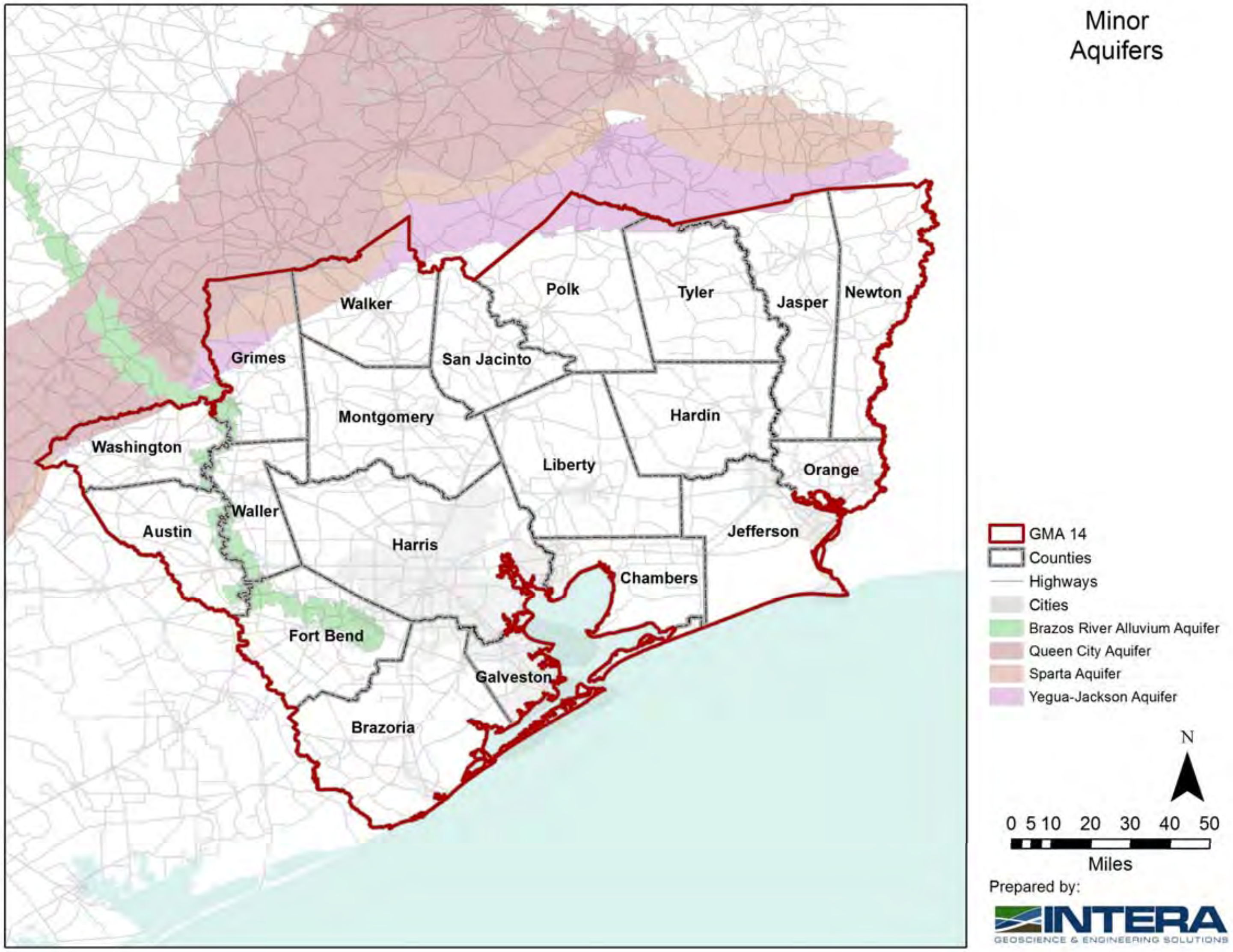
Minor Aquifers



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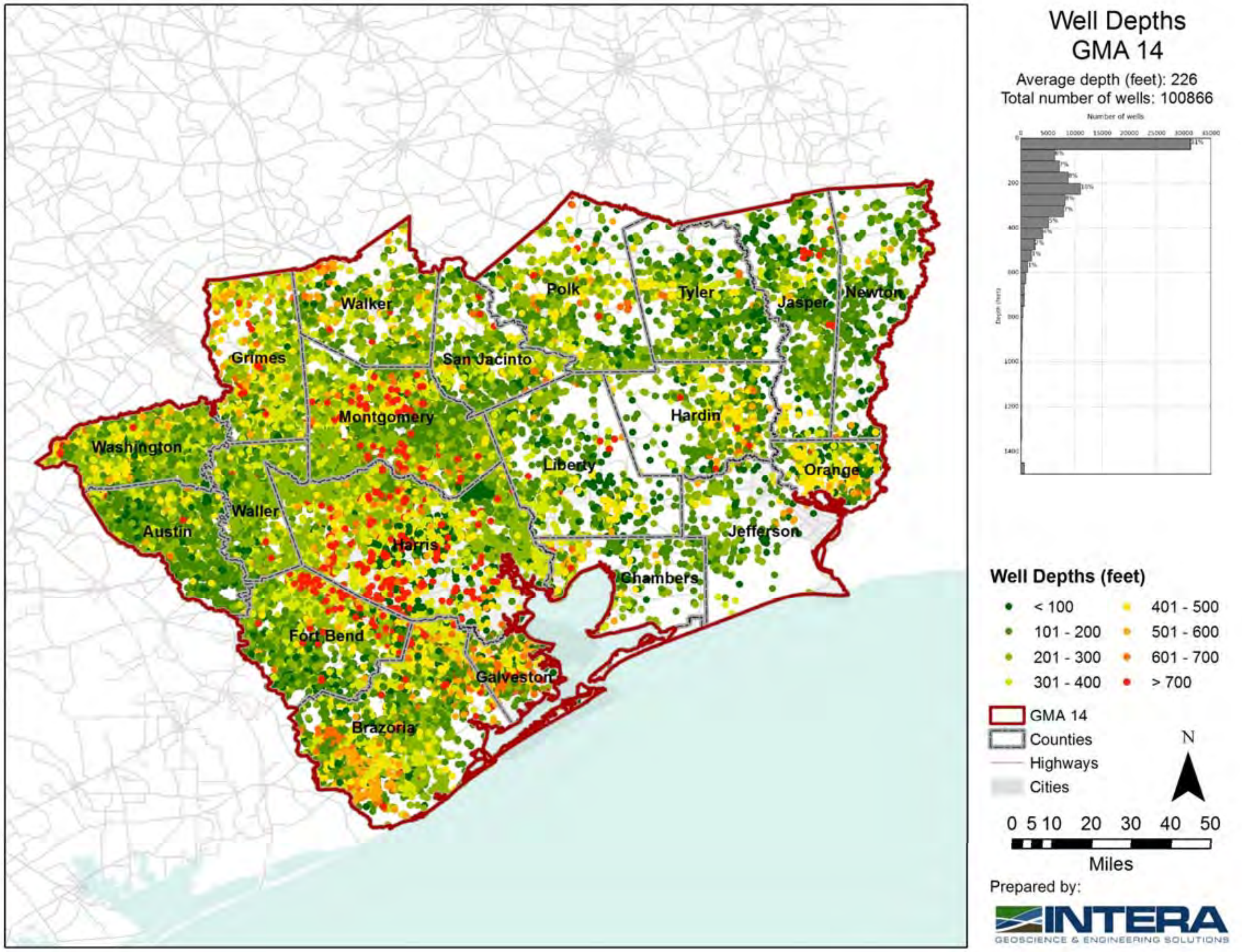
Well Depths



Well Depths
GMA 14
Average depth (feet): 226
Total number of wells: 100866
Walker
Polk
Tyler
Jasper
Newton
Grimes
San Jacinto
Montgomery
Hardin
Washington
Liberty
Orange
Waller
Austin
Harris
Jefferson
Chambers
Fort Bend
Galveston
Brazoria
Well Depths (feet)
< 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
> 700
GMA 14
Counties
Highways
Cities
N
0 5 10 20 30 40 50
Miles
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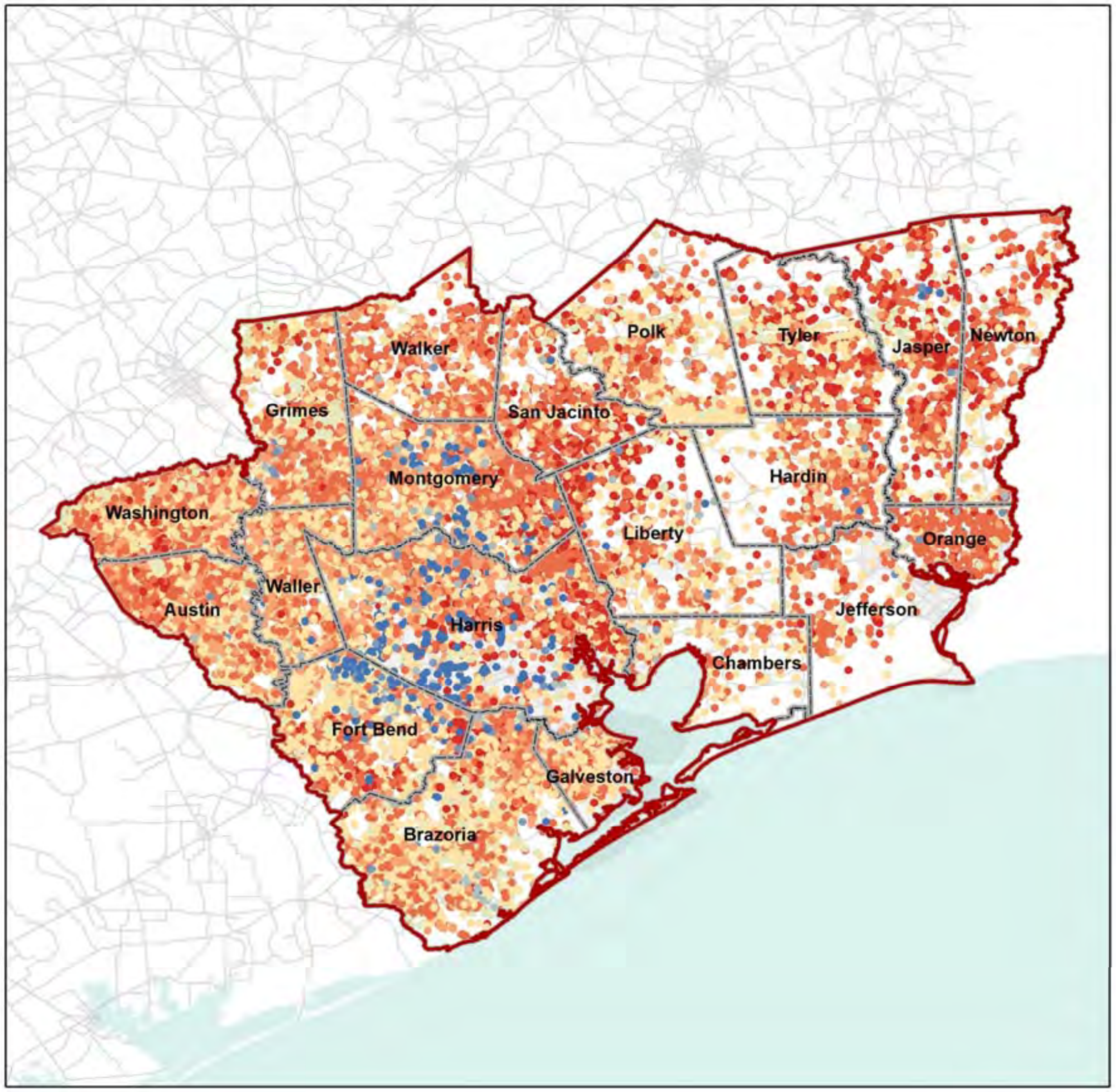
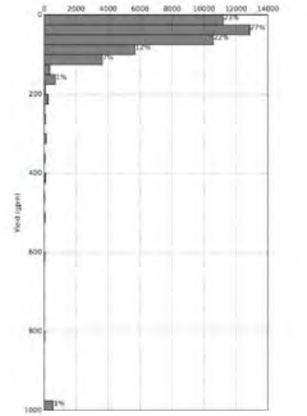
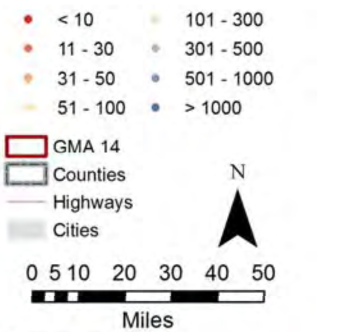
Well Yields

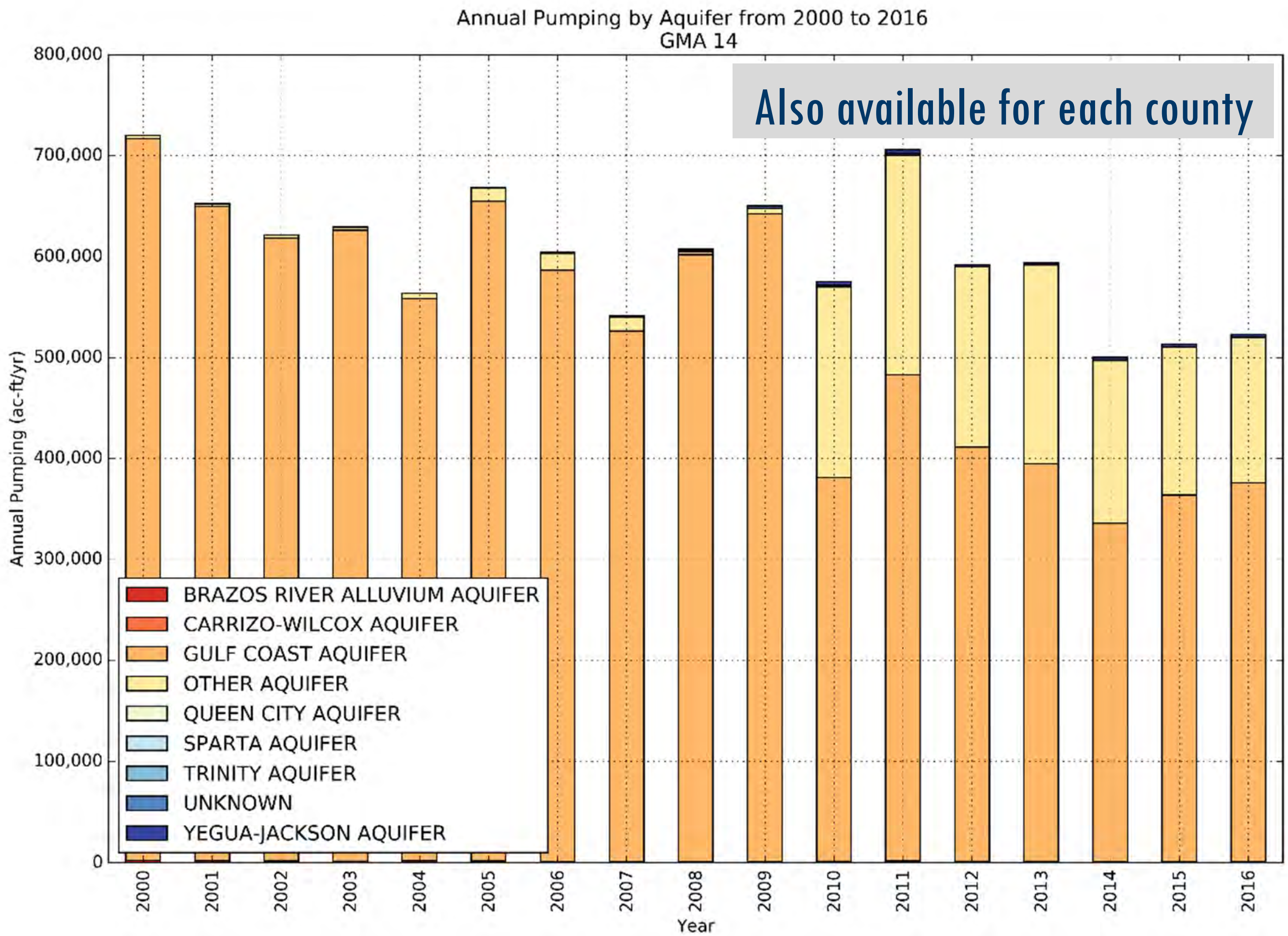




Well Yields (gallons per minute)



Annual Pumping by Aquifer



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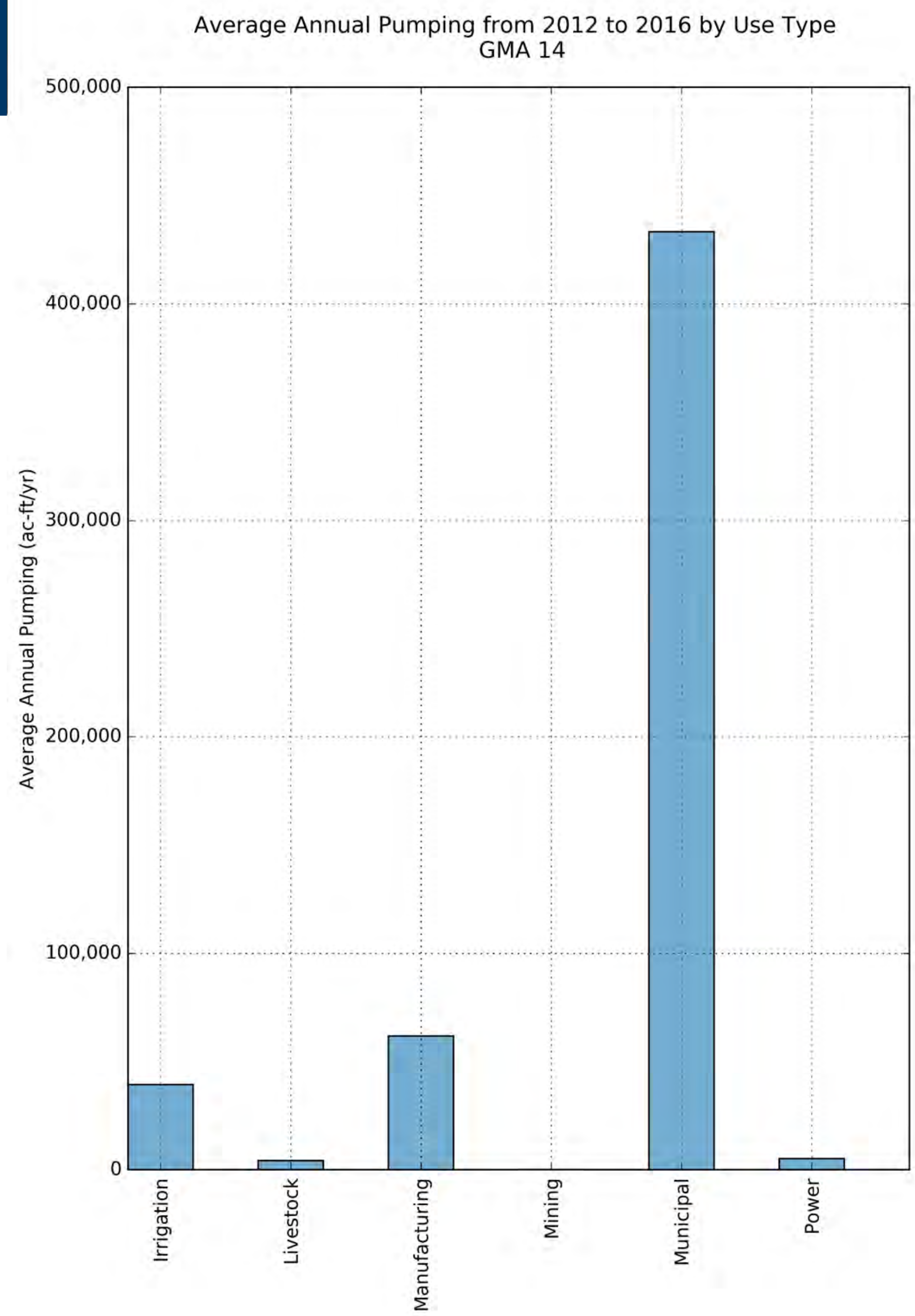
Annual Pumping by Type

- Also available for each county



Water Supply Needs and Strategies

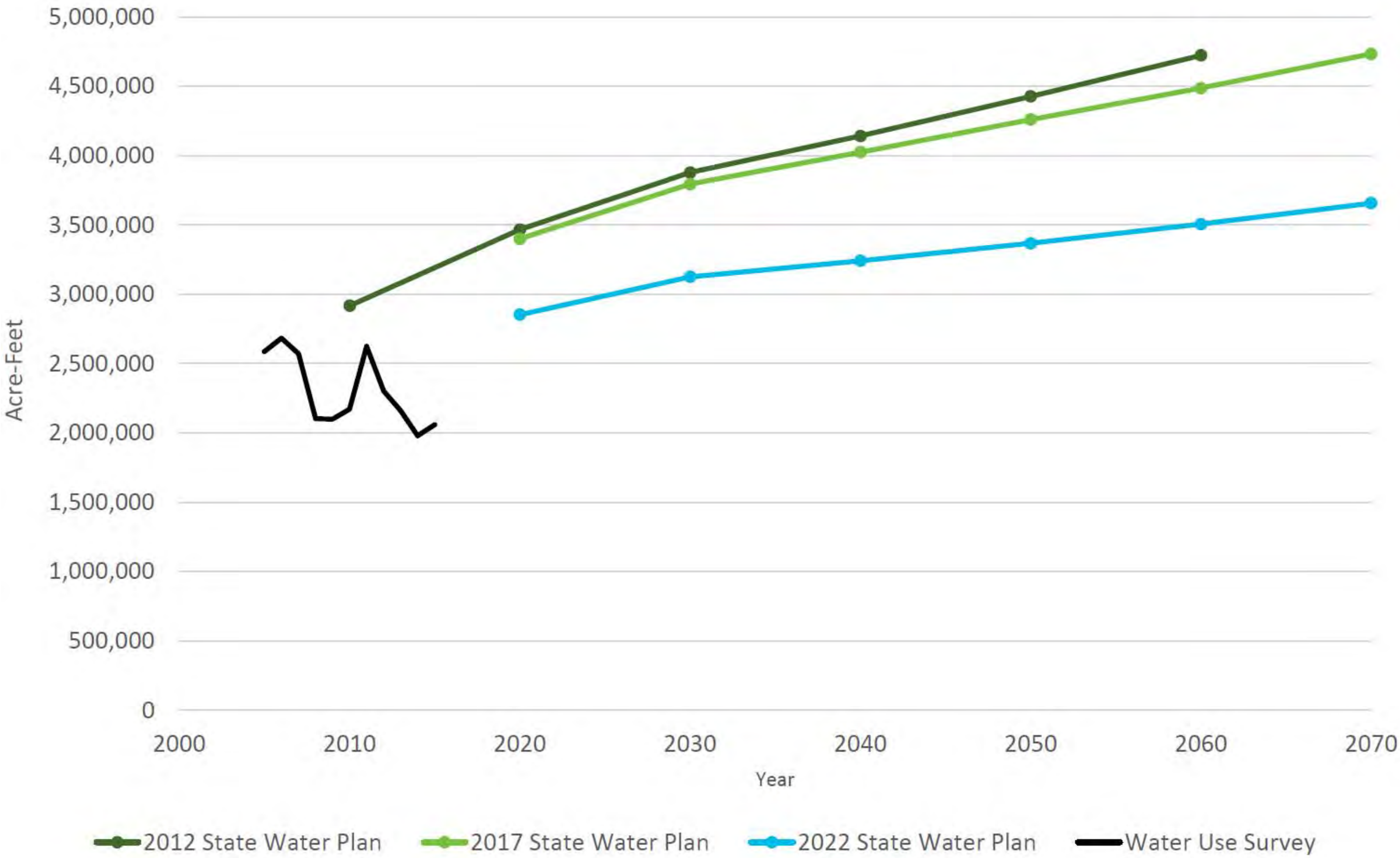
Terminology (as defined by the TWDB)

- Water Demand – The volume of water required to carry out the anticipated domestic, public, and/or economic activities of a water user group during drought conditions.
- Existing Water Supply – The maximum amount of water that is physically and legally accessible from existing sources for immediate use by a water user group under a repeat of drought of record conditions.

Water Need = Water Demand – Existing Water Supply

- Water Management Strategy – A plan to meet a need for additional water by a discrete water user group, which can mean increasing the total water supply or maximizing an existing supply, including through reducing demands.

Total Projected Water Demands



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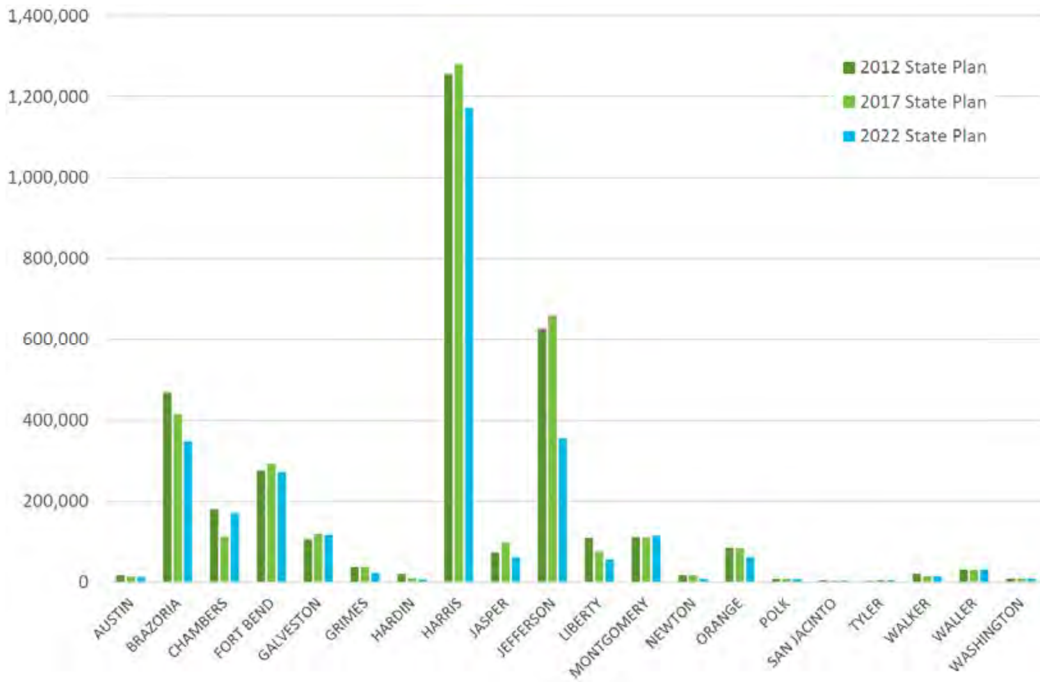
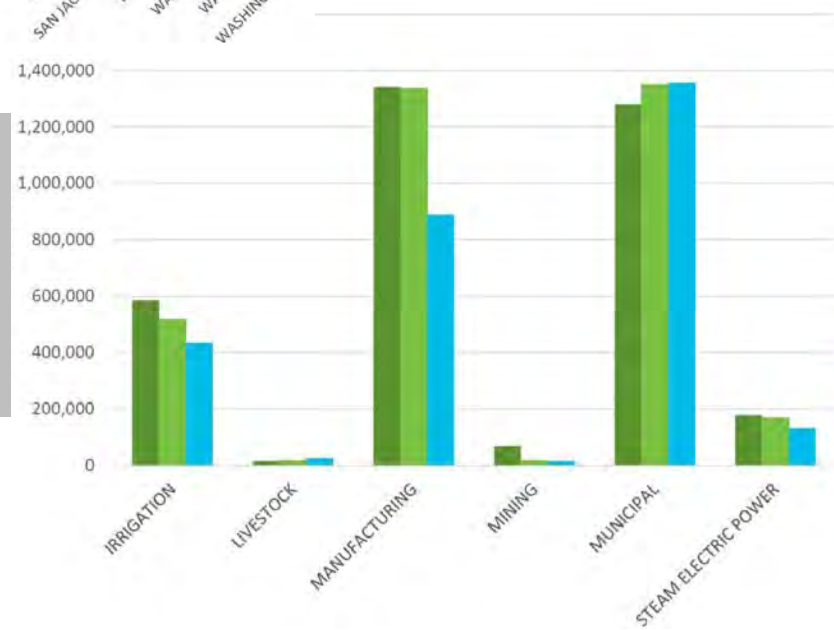
Total Projected Water Demands

By County [acre-feet]



Detailed by county demand projections for each water use category are available

By Water Use [acre-feet]



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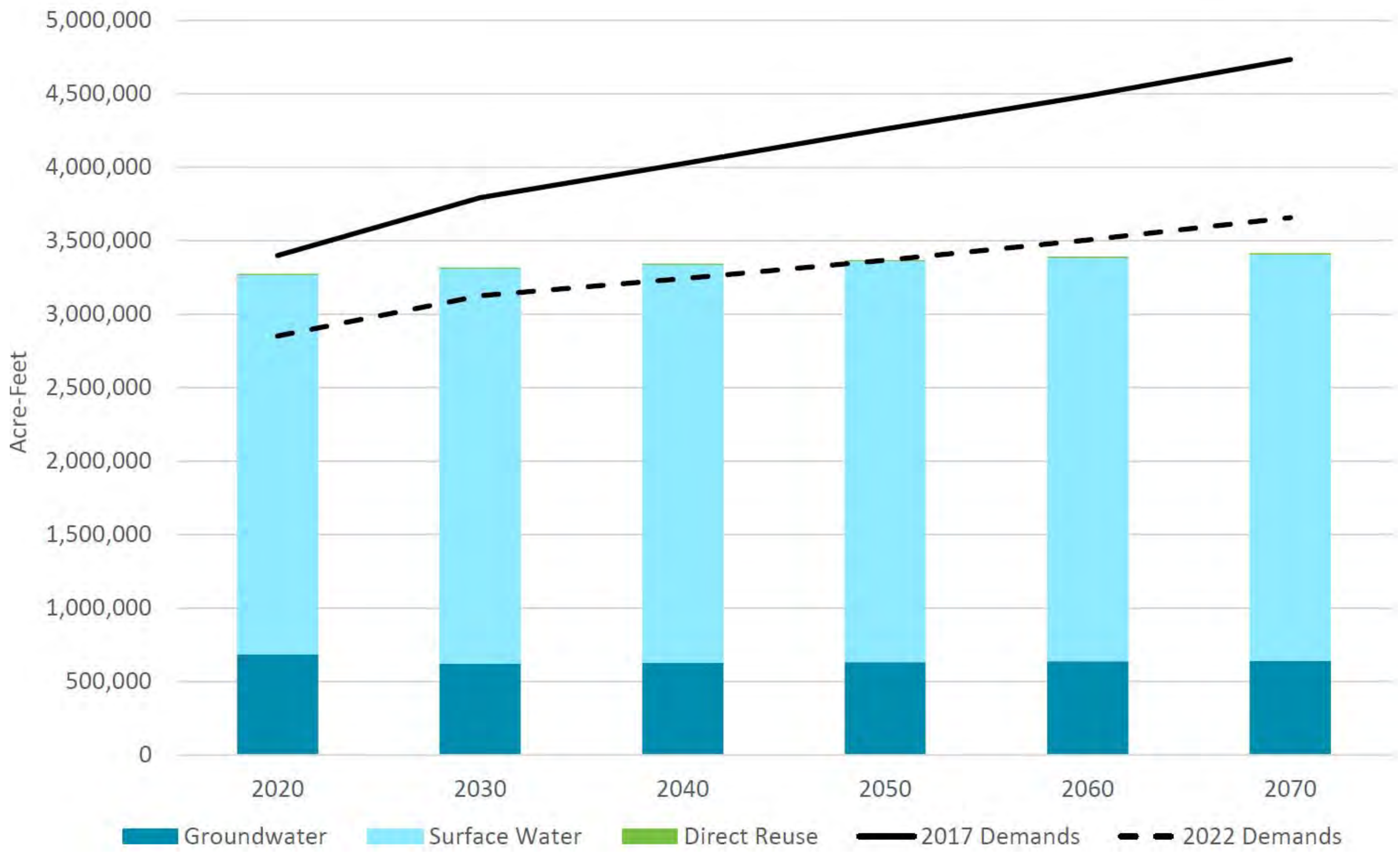
Total Existing Supplies (2017 State Water Plan)



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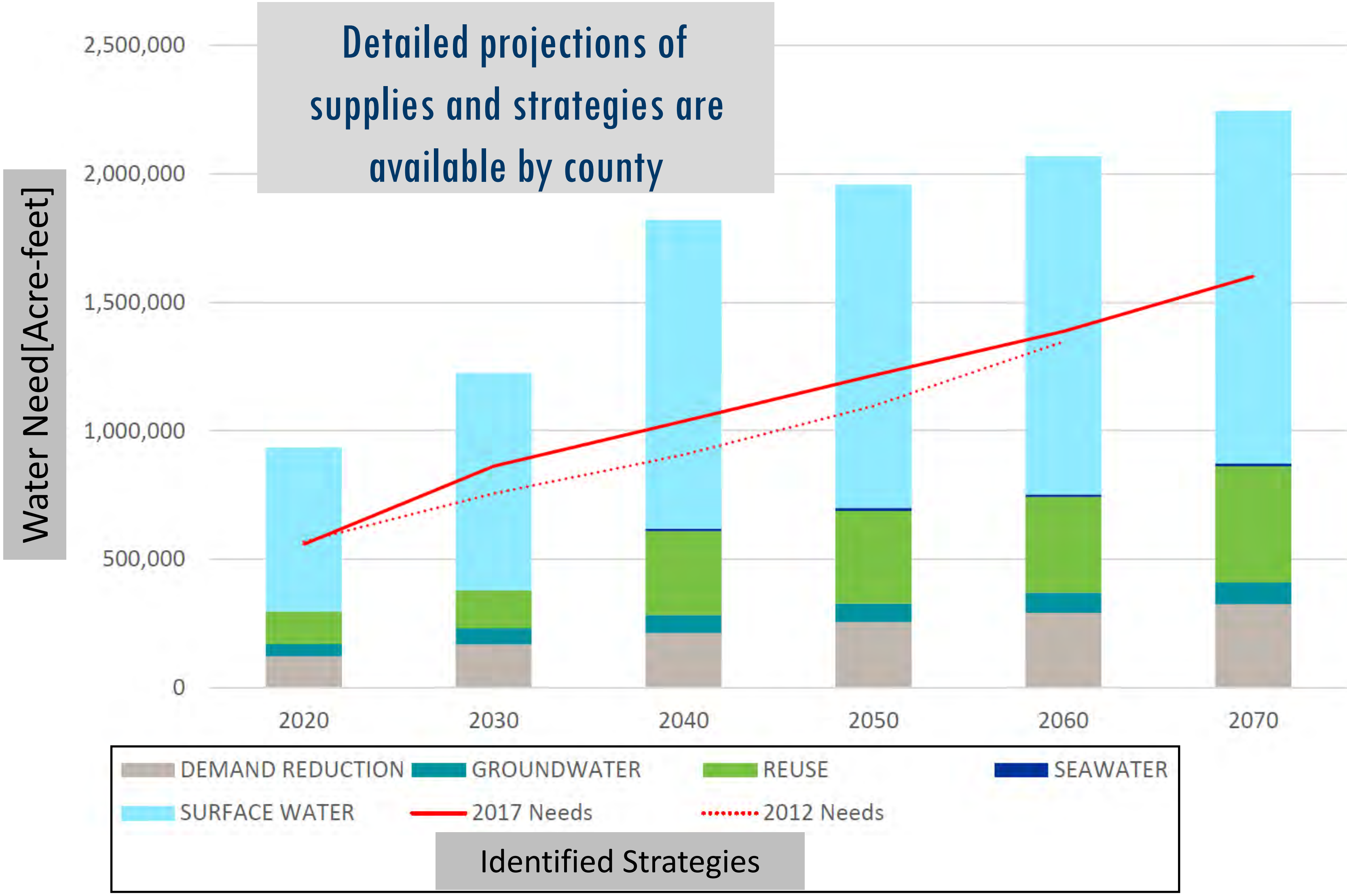
Total Needs and Identified Strategies (2017 State Water Plan)



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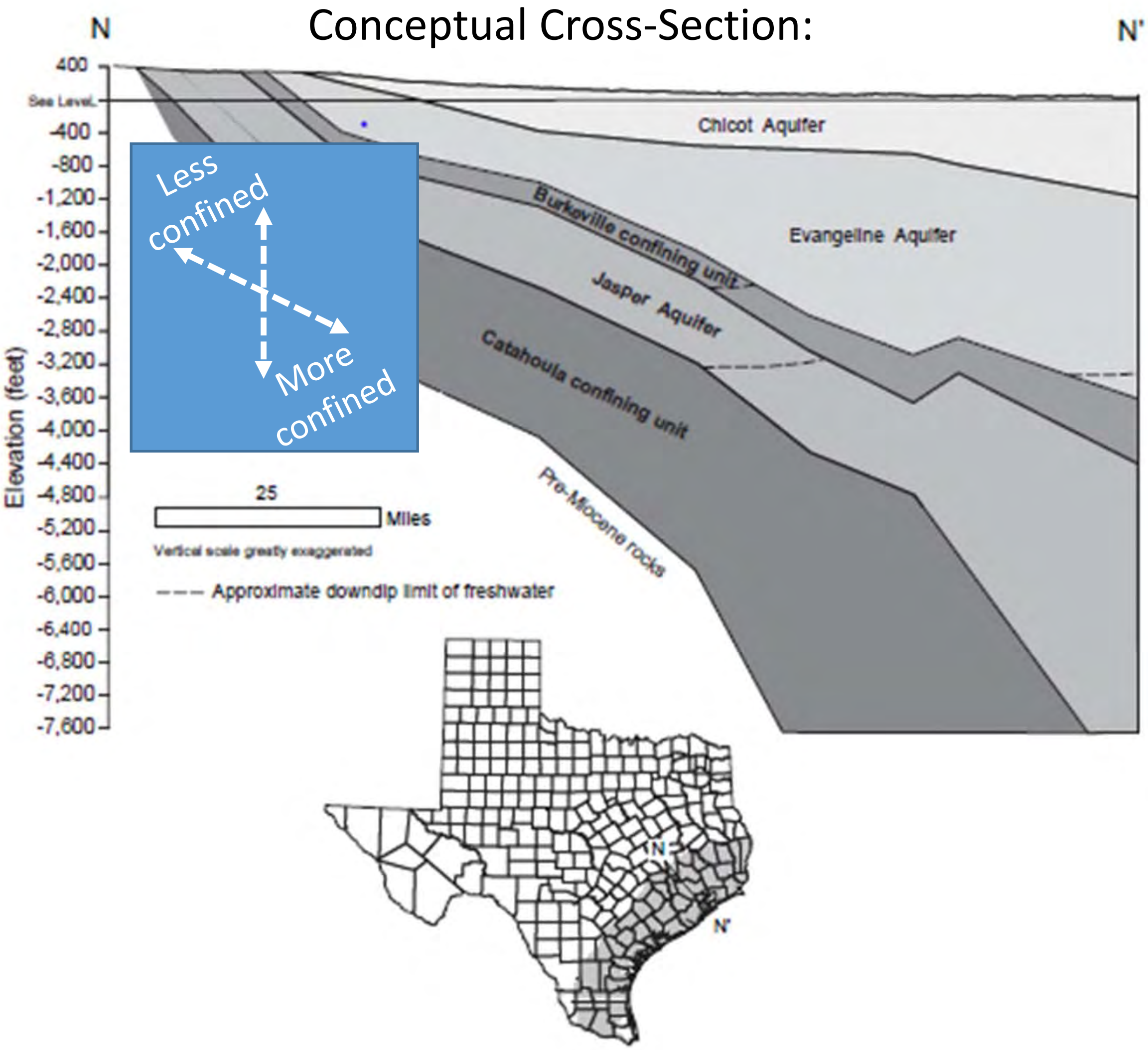
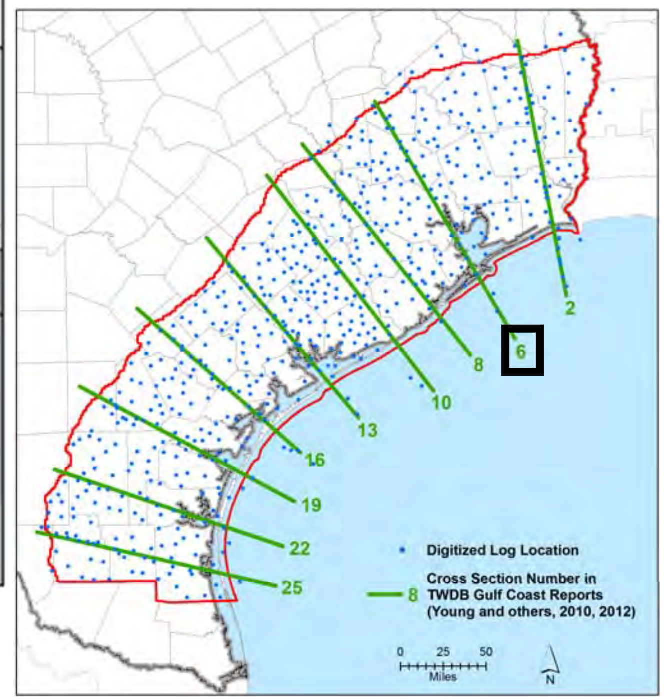
Hydrological Conditions

Gulf Coast Aquifer

Conceptual Cross-Section:



Data Driven Cross-Sections:



Young and others (2016)

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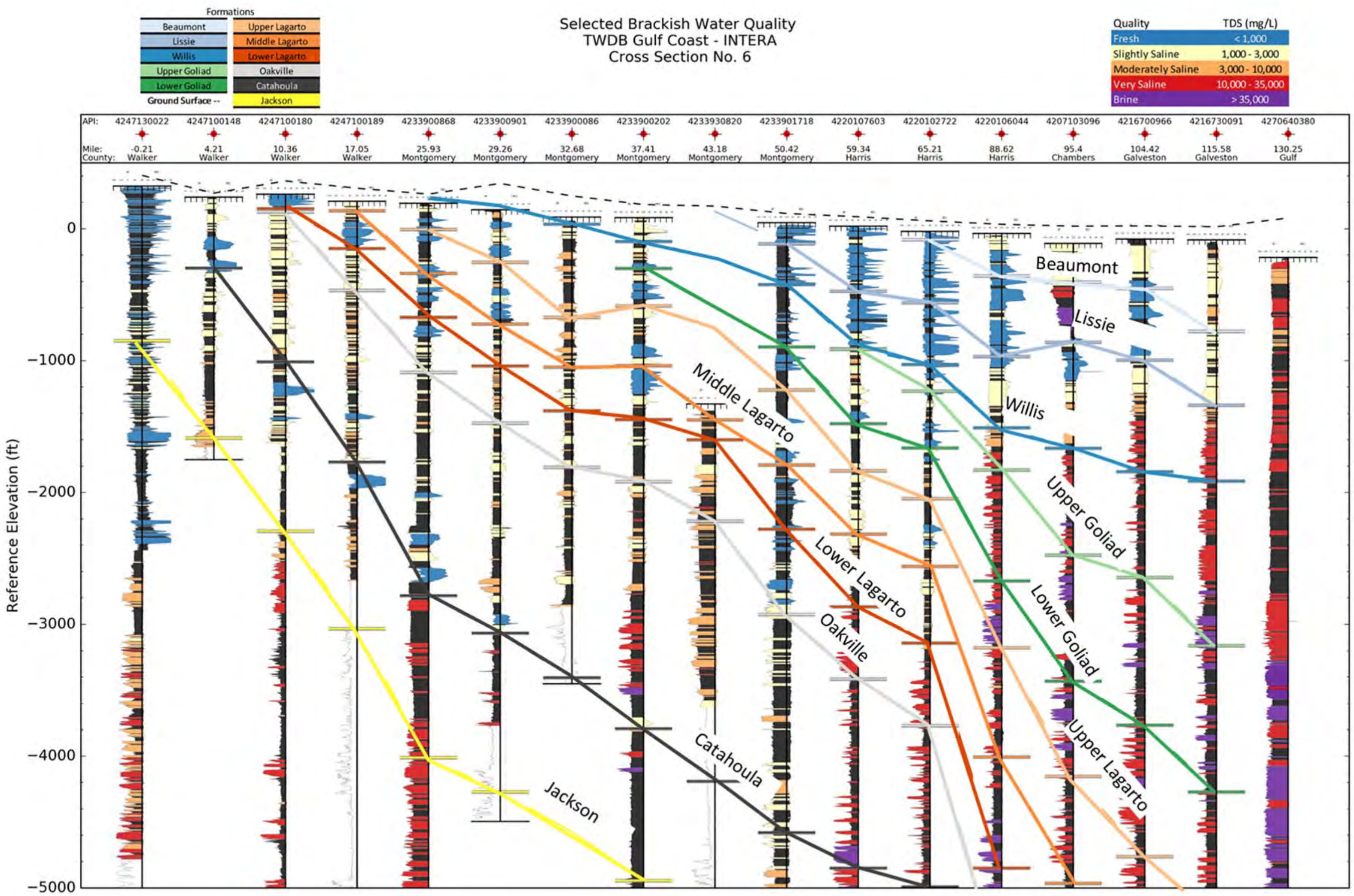
Gulf Coast Aquifer Cross-Section #6



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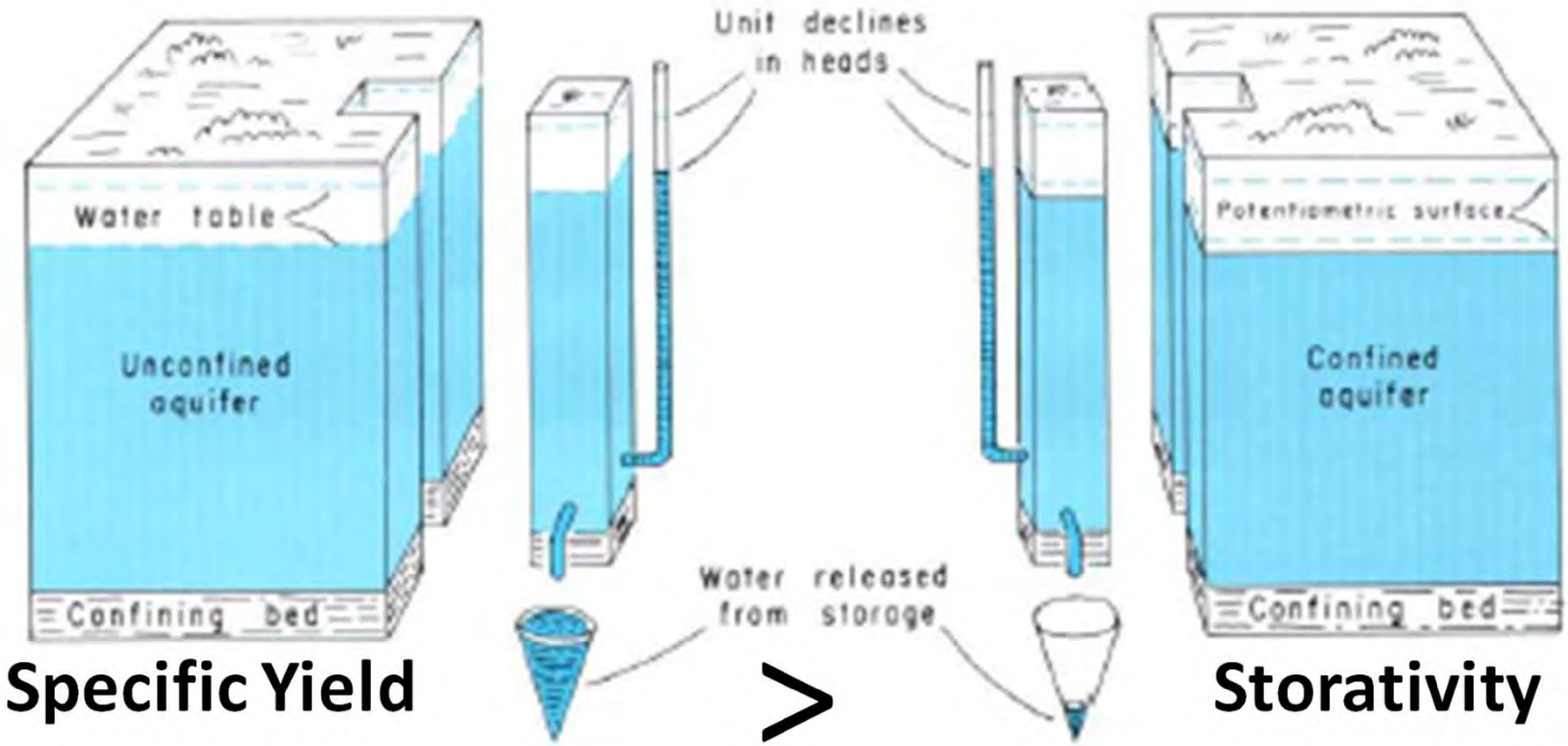
Unconfined vs. Confined Storage

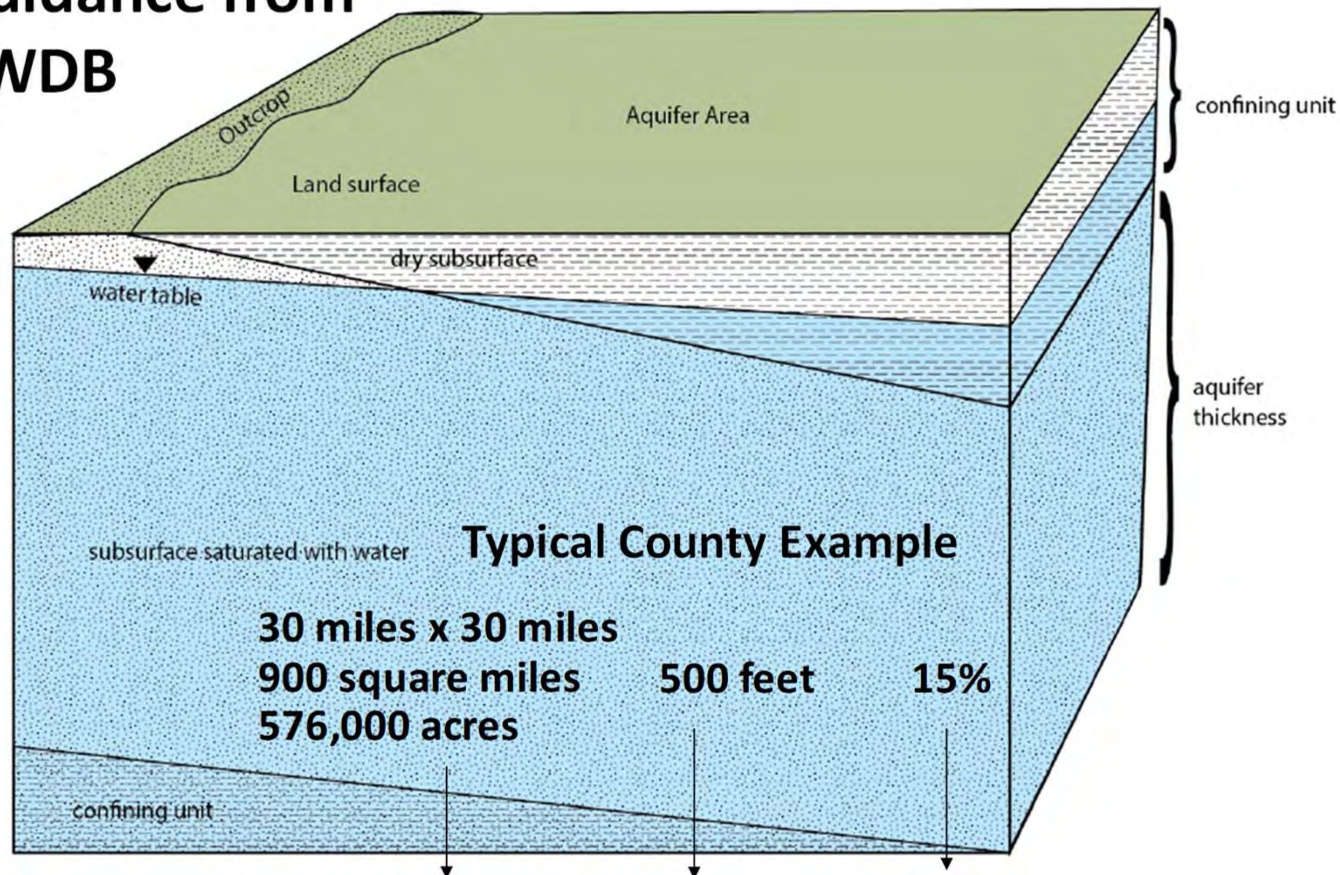


Takeaway: In theory, each foot of drawdown yields much more water when an aquifer is unconfined than when it is confined.

From Heath (1983)

TERS – How it's calculated

Guidance from TWDB



Typical County Example

30 miles x 30 miles
900 square miles
576,000 acres

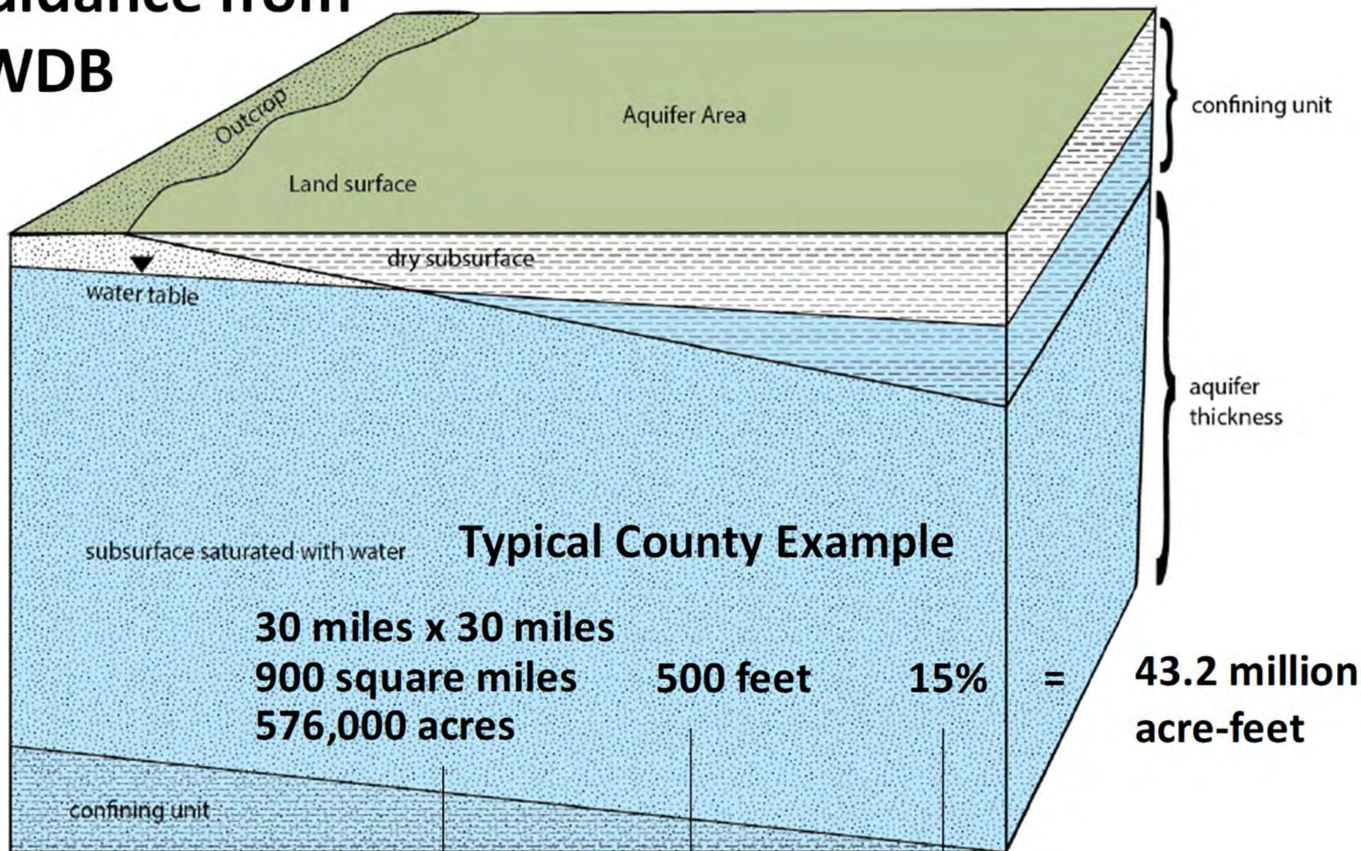
500 feet

15%

Storage volume = area x thickness x specific yield
(Plus some for the confined storage)

TERS – How it's calculated

Guidance from TWDB



Storage volume = area x thickness x specific yield
(Plus some for the confined storage)

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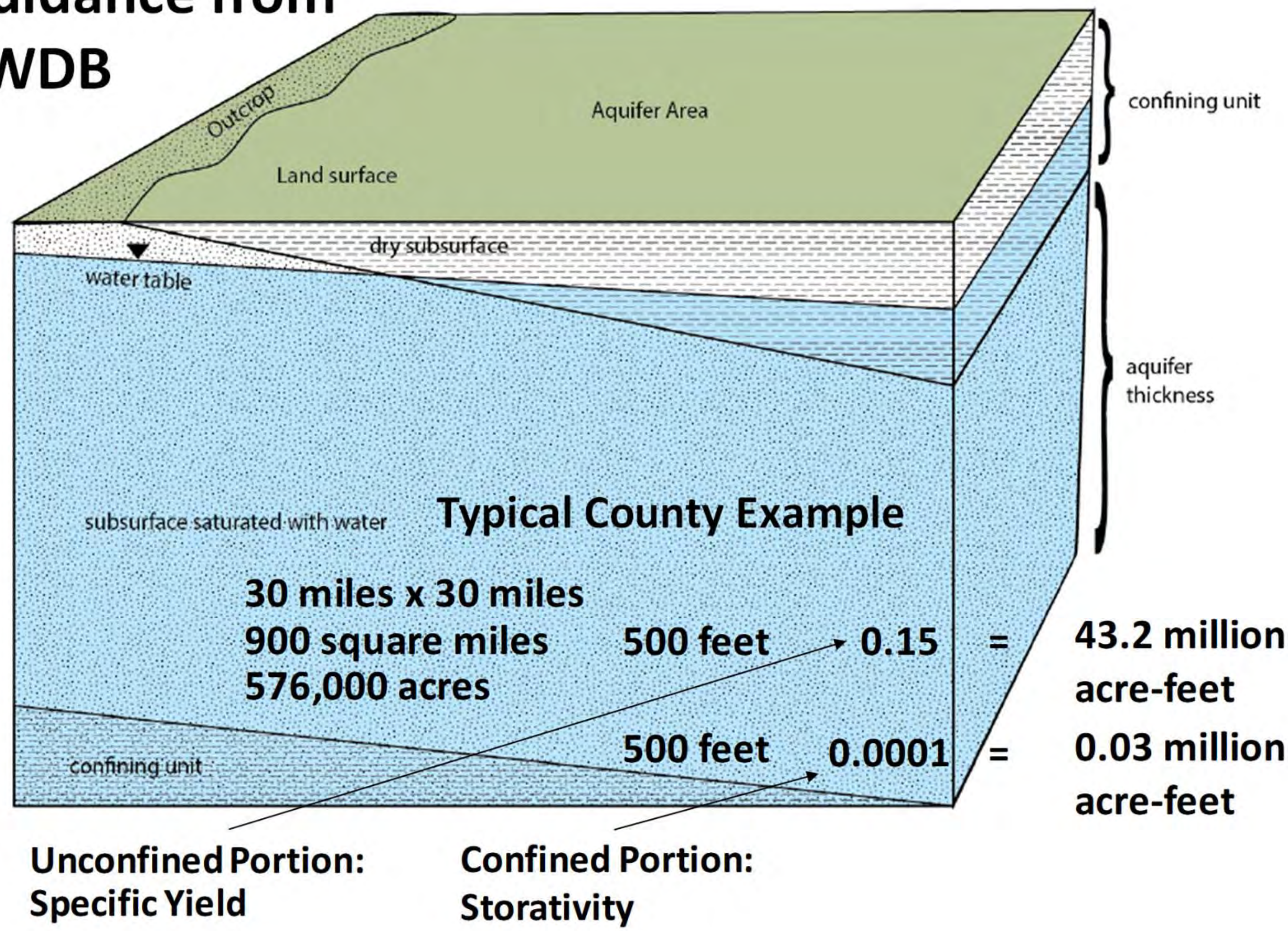
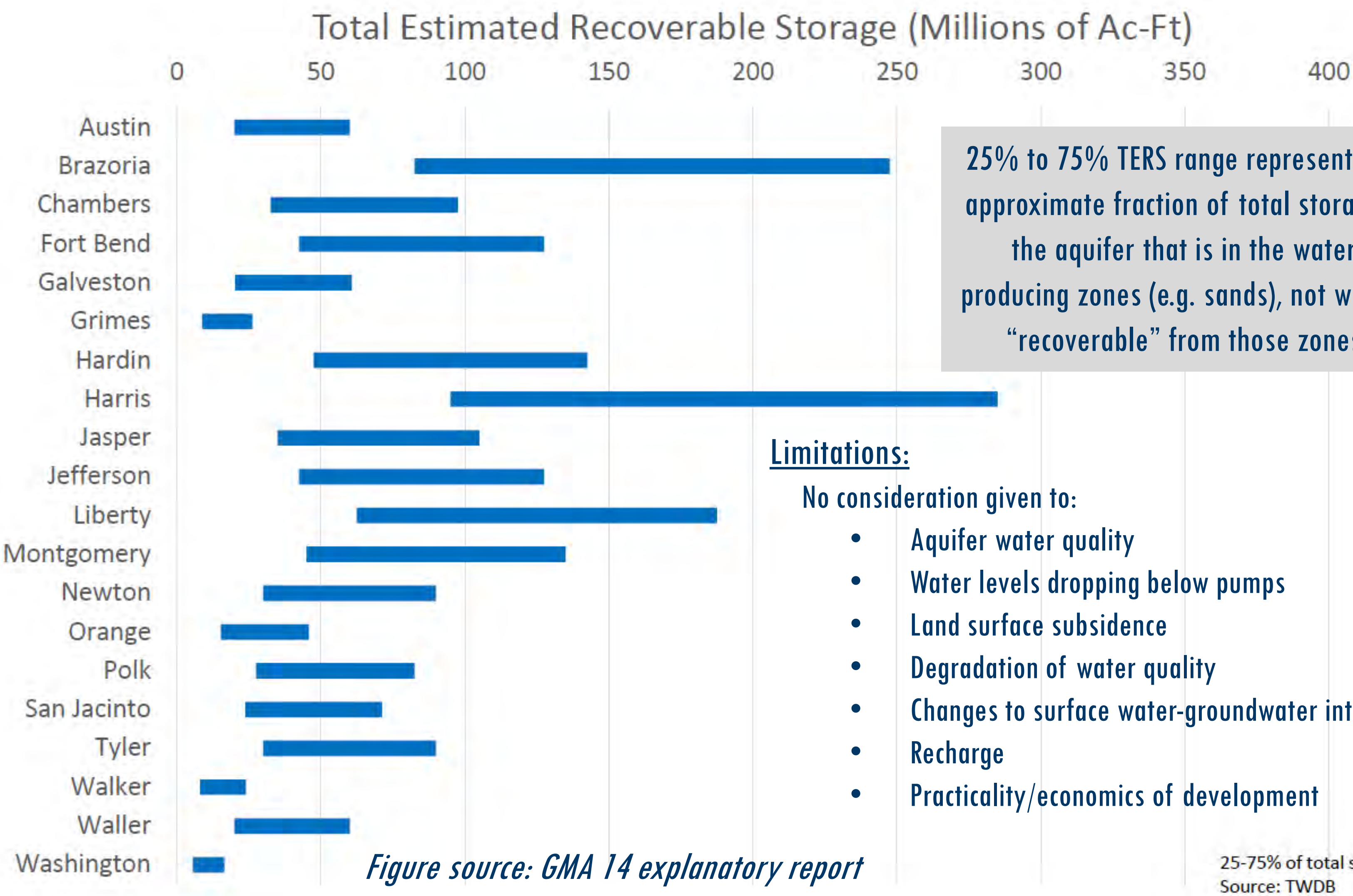
TERS – How it's calculated

Guidance from TWDB



Gulf Coast Aquifer – Total Estimated Recoverable Storage



25% to 75% TERS range represents the approximate fraction of total storage in the aquifer that is in the water-producing zones (e.g. sands), not what is "recoverable" from those zones.

Limitations:

No consideration given to:

- Aquifer water quality
- Water levels dropping below pumps
- Land surface subsidence
- Degradation of water quality
- Changes to surface water-groundwater interaction
- Recharge
- Practicality/economics of development

Figure source: GMA 14 explanatory report prepared by Freese and Nichols. Values from TWDB unchanged from 2nd round of joint planning.

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Water Budgets

Waller County				
Inflow	**Chicot**	**Evangeline**	**Burkeville**	**Jasper**
Recharge/Stream Loss (GHB)	24,327	775	—	—
Storage	13,993	1,525	82	928
Leakage From Upper Unit	—	24,350	88	35
Leakage From Lower Unit	1	—	—	—
Lateral Flow From Austin	1,573	3,271	3	422
Lateral Flow From Fort Bend	847	428	0	42
Lateral Flow From Grimes	74	1,593	2	852
Lateral Flow From Harris	193	892	1	364
Lateral Flow From Montgomery	76	190	0	—
Lateral Flow From Washington	—	942	5	245
Total Inflow	41,084	33,965	182	2,888

Outflow	Chicot	Evangeline	Burkeville	Jasper
Wells	803	24,992	—	169
Evapotranspiration/Stream Gain (GHB)	13	960	—	—
Storage	328	306	74	2
Leakage To Upper Unit	—	1	142	76
Leakage To Lower Unit	24,350	88	35	—
Lateral Flow To Austin	437	527	0	71
Lateral Flow To Fort Bend	7,311	1,686	1	70
Lateral Flow To Grimes	2	287	1	203
Lateral Flow To Harris	6,854	4,044	3	1,113
Lateral Flow To Montgomery	987	1,027	1	1,166
Lateral Flow To Washington	—	188	1	18
Total Outflow	41,084	34,107	258	2,889
Inflow - Outflow	0	-142	-76	0
Storage Increase (+)/Decrease(-)	-13,666	-1,218	-8	-926

All values are average acre-feet per year from 2000 through 2009.

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Other Environmental Factors

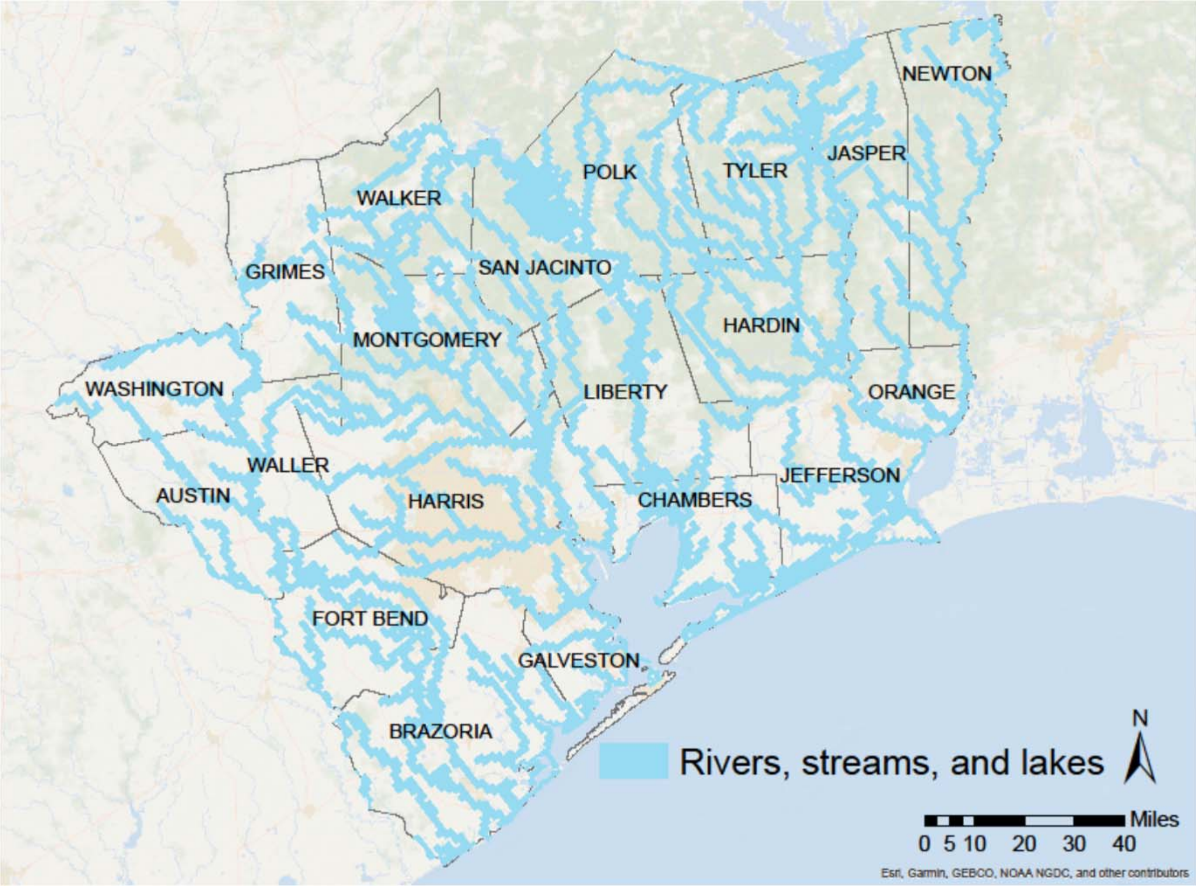
Groundwater-Surface Water Interaction

Environmental impacts assessment focused on interaction between groundwater and surface water consistent with TWC Ch. 36

MODFLOW General-Head Boundary Package used to simulate all surficial processes

- Recharge
- Groundwater-Surface Water Interaction

Stream cells identified using EPA RF1 dataset



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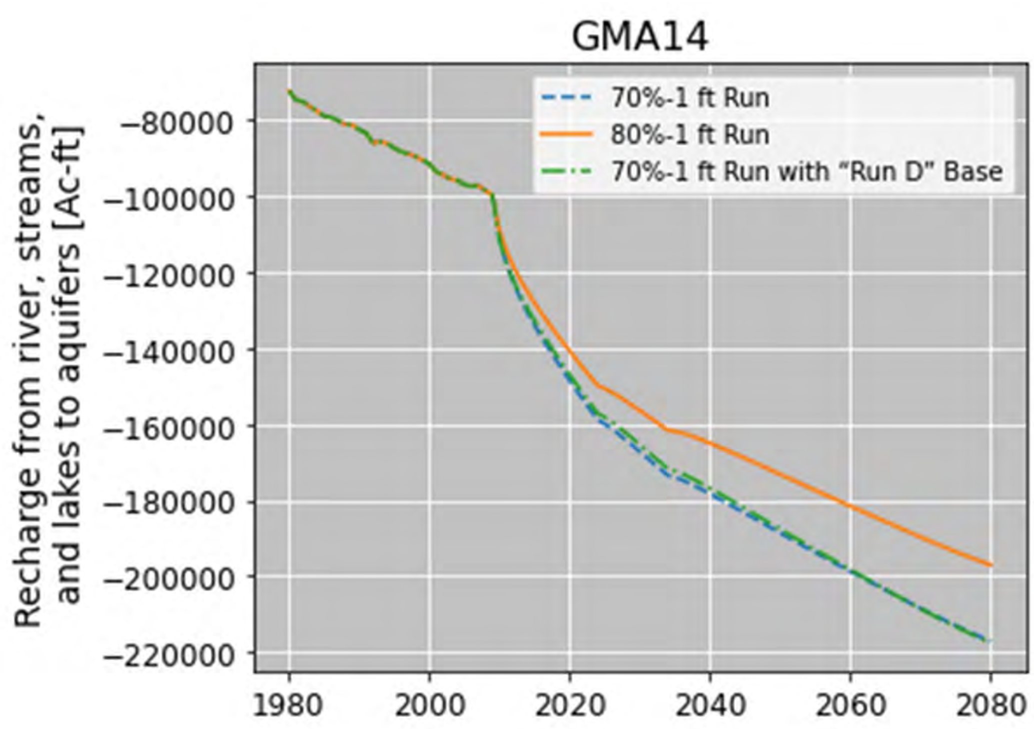
Groundwater-Surface Water Interaction

As water levels in the aquifer decline:

– Outflow to surface water decreases

– Inflow from surface water increases

*The MODFLOW General Head Boundary Package does not limit to how much water could flow into the aquifer. This also applies to recharge in non-stream cells.



Key Findings:

- Environmental impacts are similar for the two 70% available drawdown/1-foot average subsidence limited runs
- Model used consistent with TWDB approach, but new model under develop should better characterize this component
- According to the current model, all counties would begin drawing on surface water for each of the scenarios considered…<u>however, this hinges on a known model limitation so use the results with caution</u>

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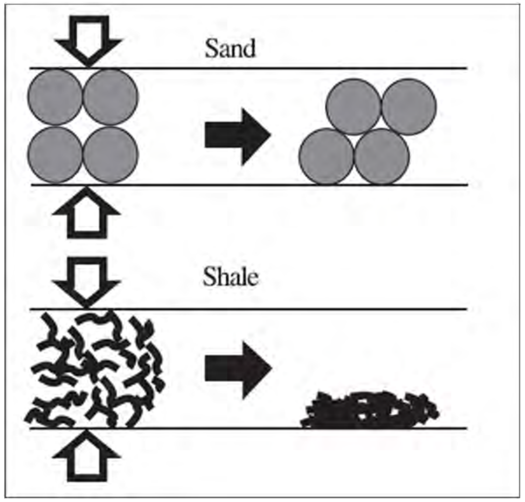
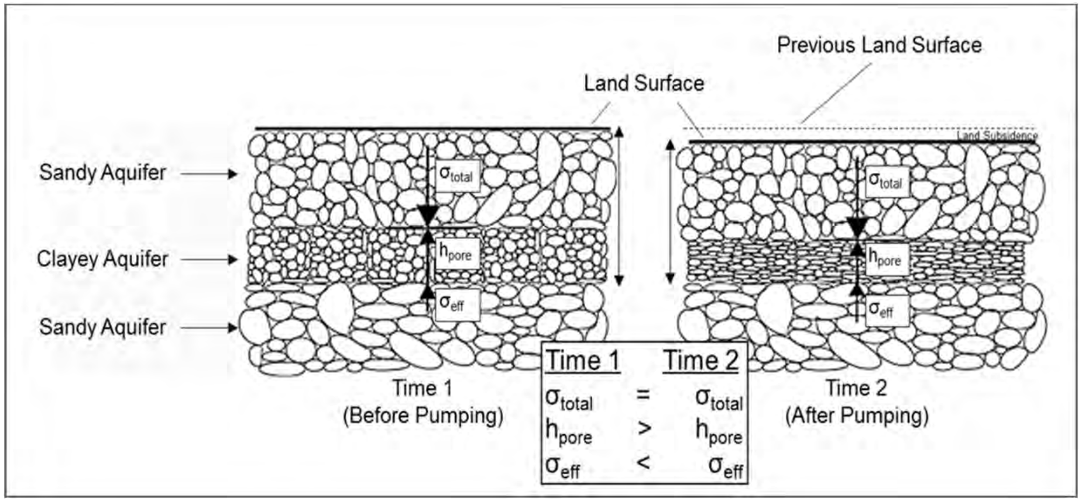
Subsidence Impacts

Subsidence Concepts

Subsidence: Lowering or sinking of the land surface, typically in response to removal of subsurface support ← **At the surface**

Compaction: A decrease in the volume (i.e. thinning) of a geologic formation ← **Beneath the surface**





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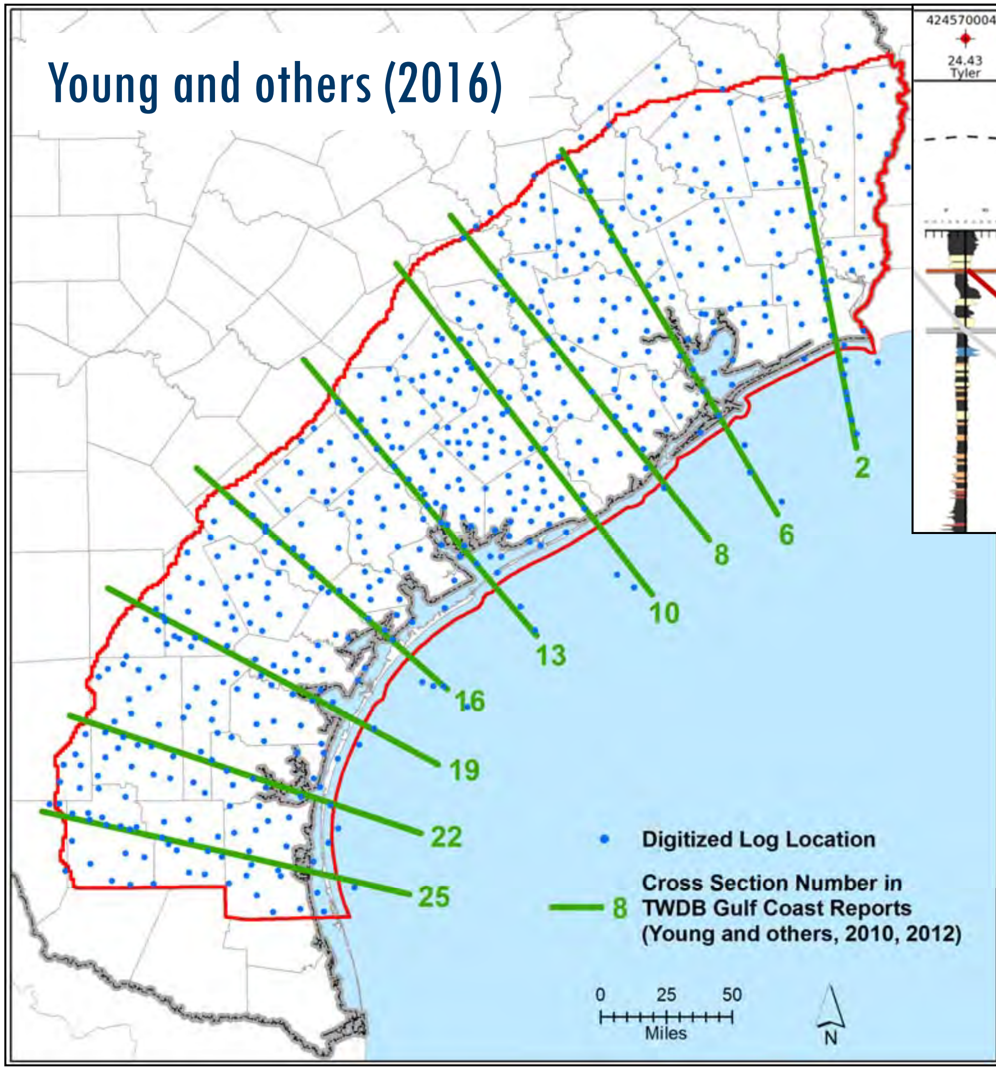
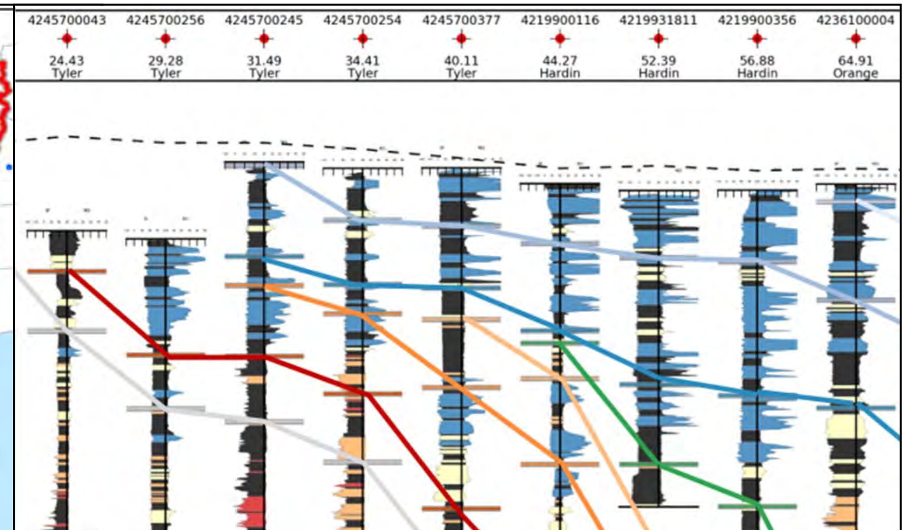
Improved Understanding of Spatial Extent of Fine Interbeds

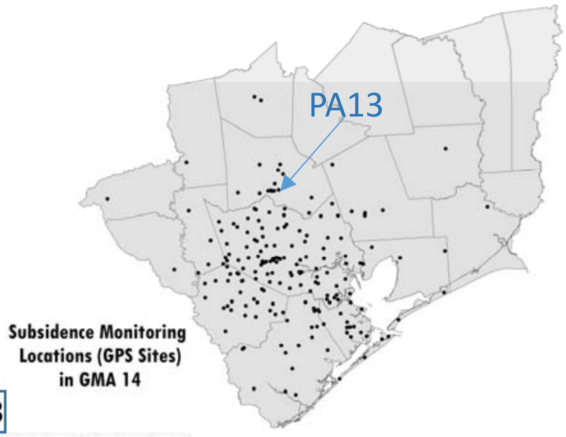


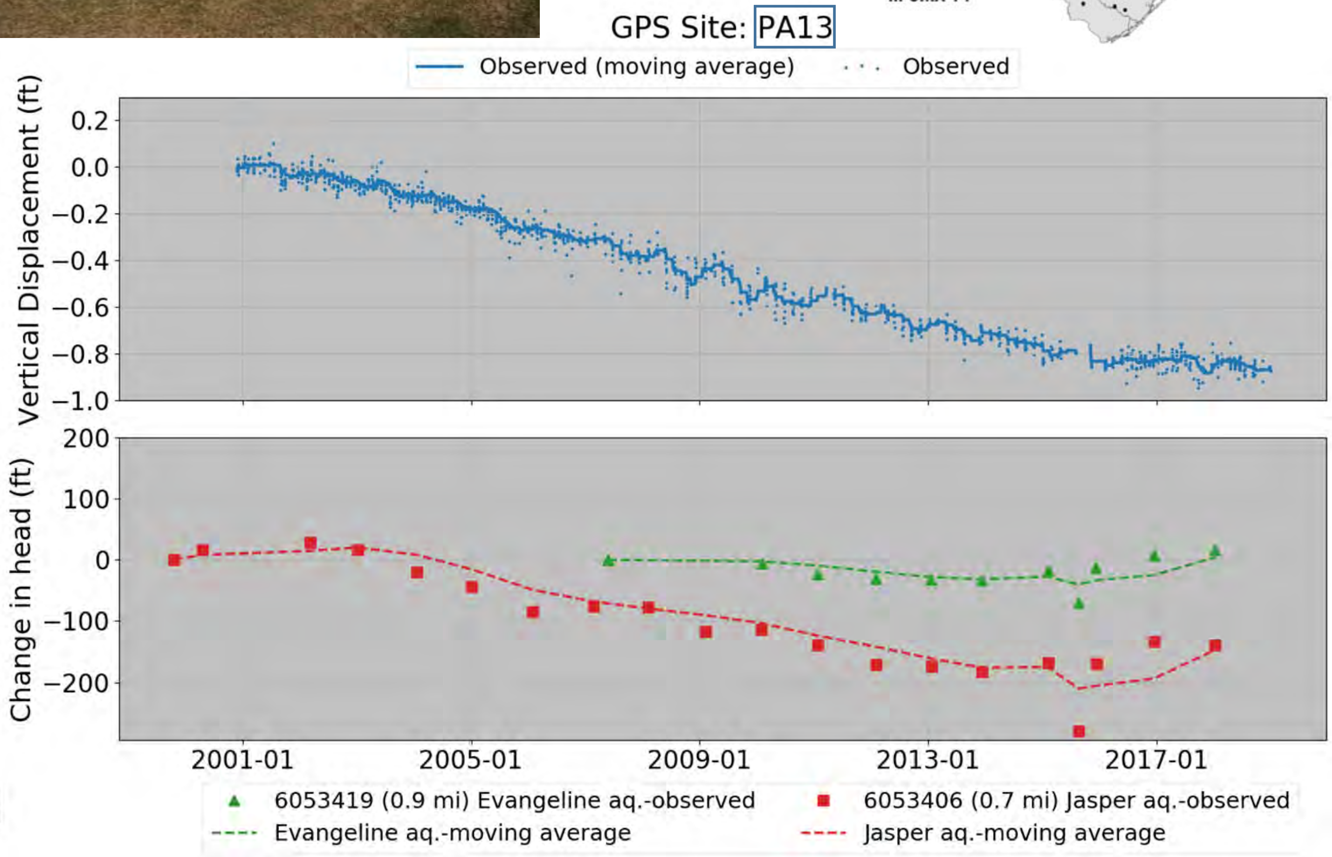


Factors that can influence subsidence:

- depth of burial
- total clay thickness
- thickness of individual beds
- sediment age, etc.

Monitoring Subsidence





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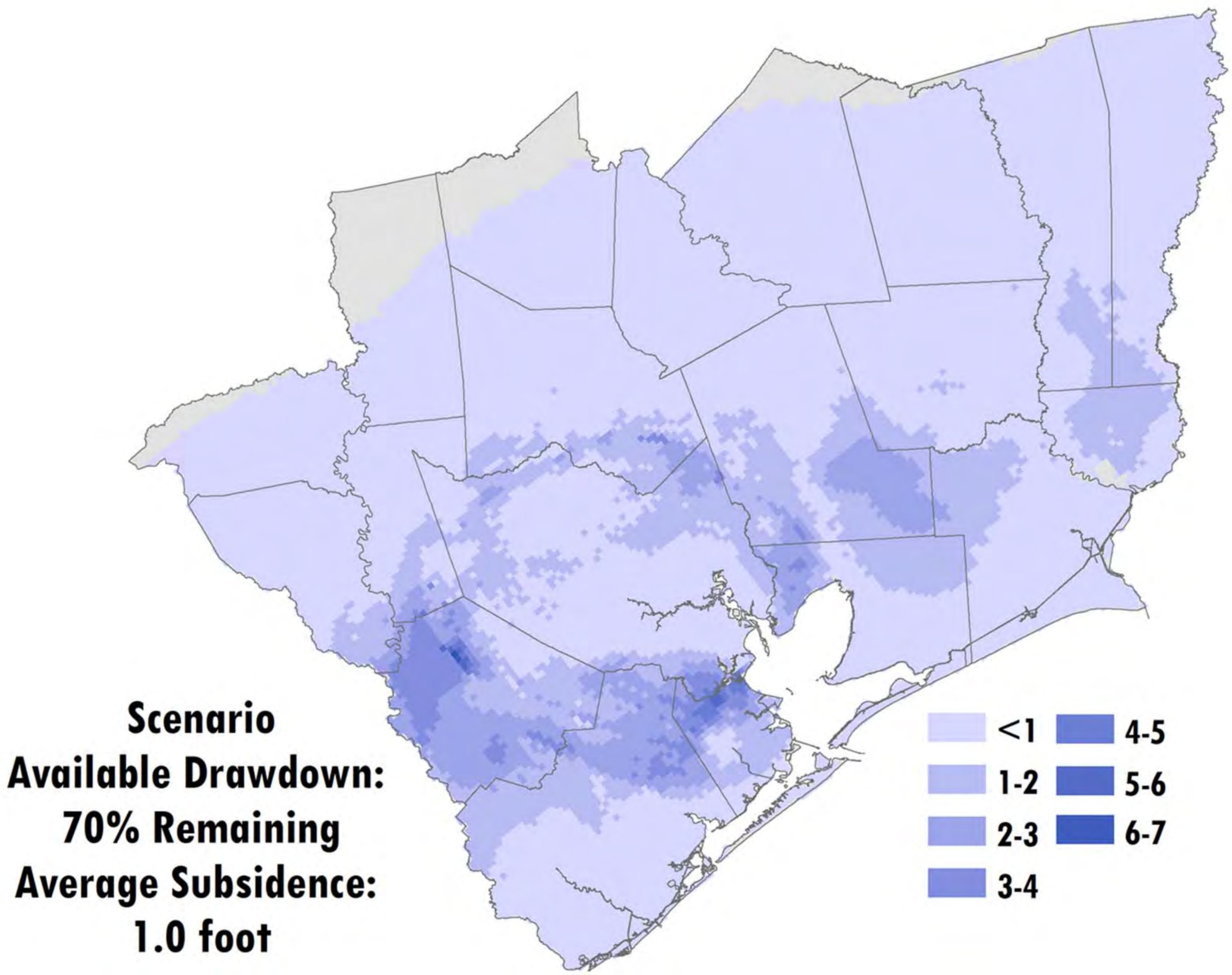
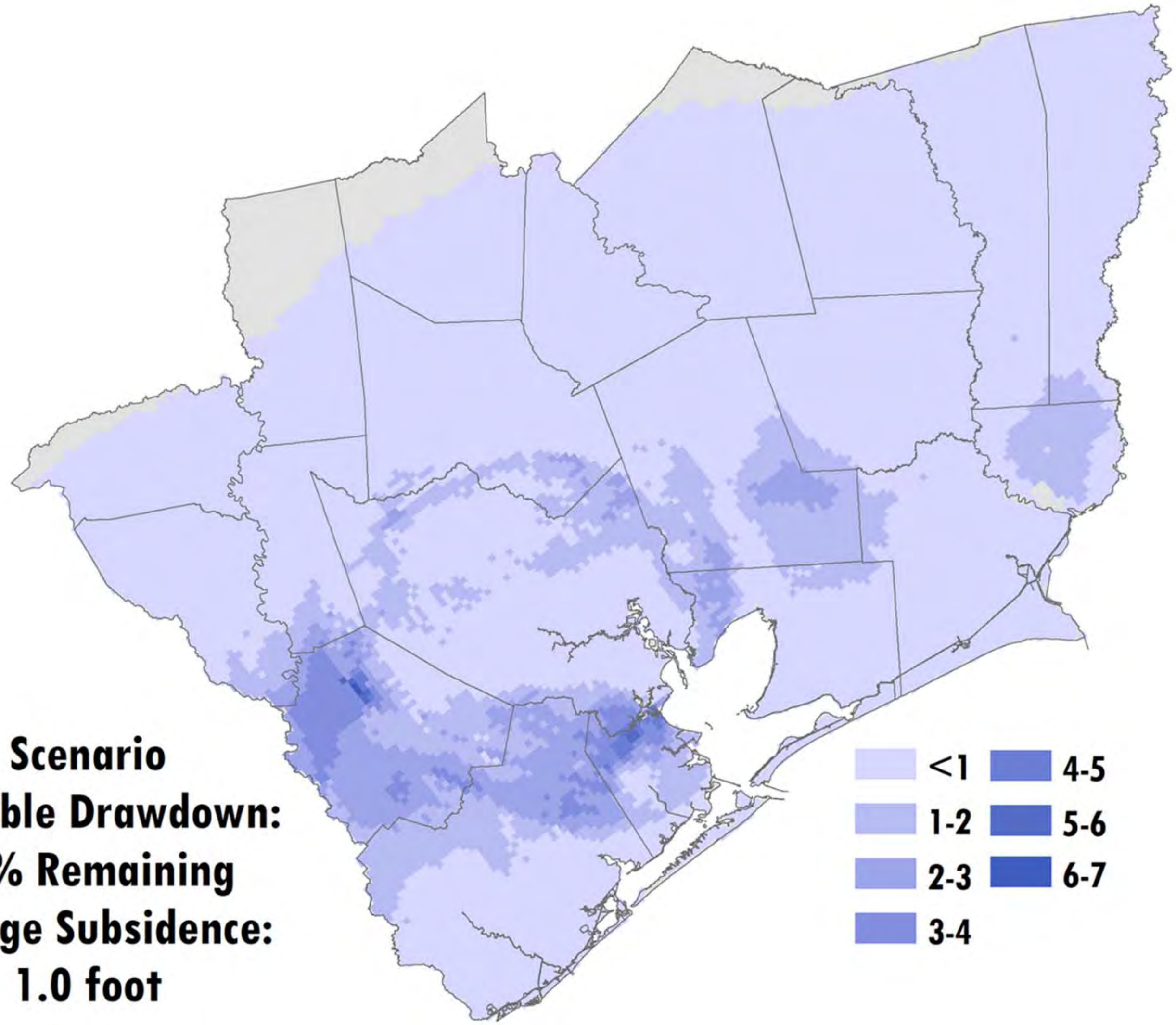
Modeled Subsidence (Scenario 70% 1.0 ft)

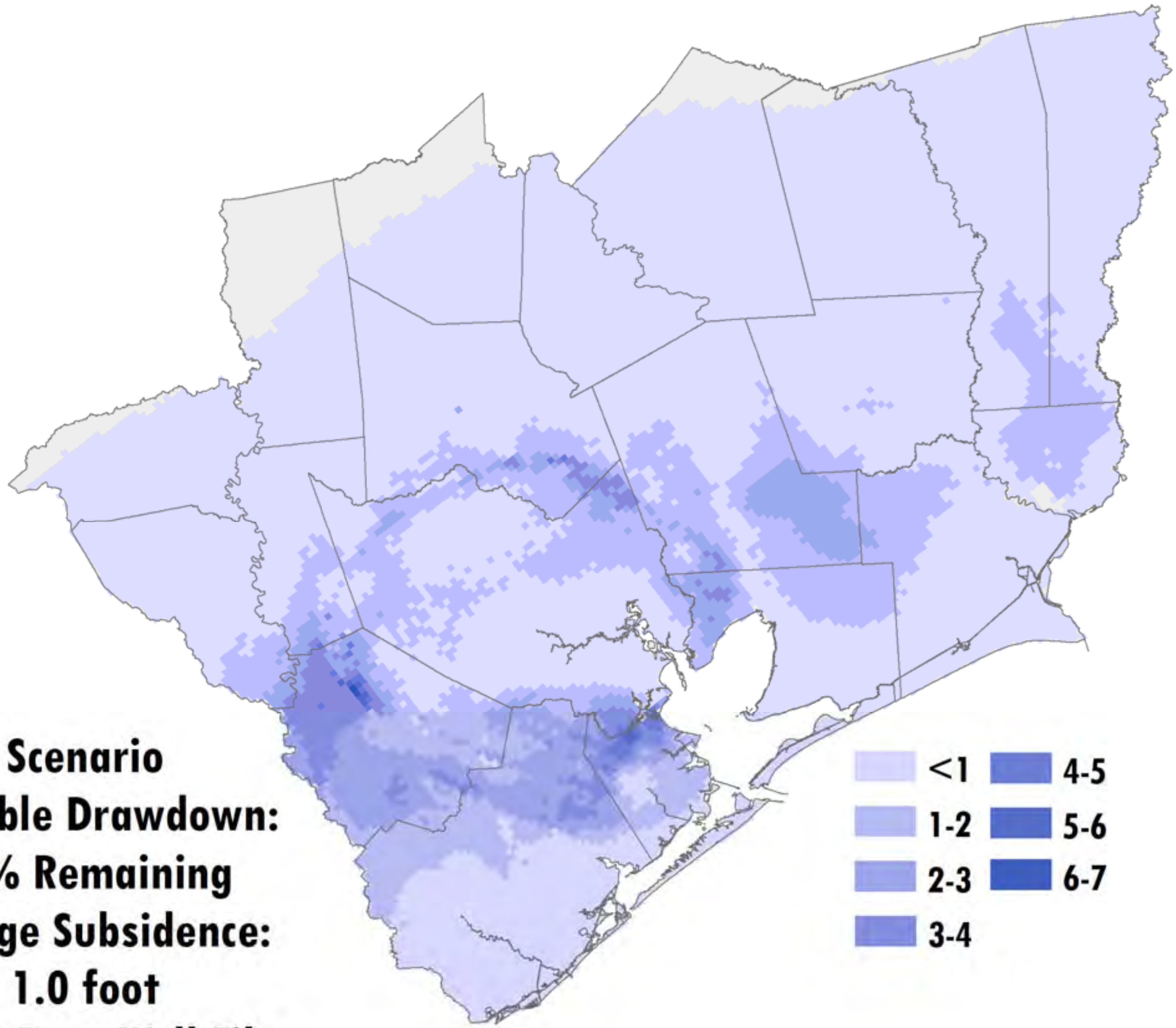


Modeled Subsidence (Scenario 80% 1.0 ft)



Scenario
Available Drawdown:
80% Remaining
Average Subsidence:
1.0 foot

Modeled Subsidence (Scenario 70% 1.0 ft, Run D Base Well File)



Scenario
Available Drawdown:
70% Remaining
Average Subsidence:
1.0 foot
Run D Base Well File

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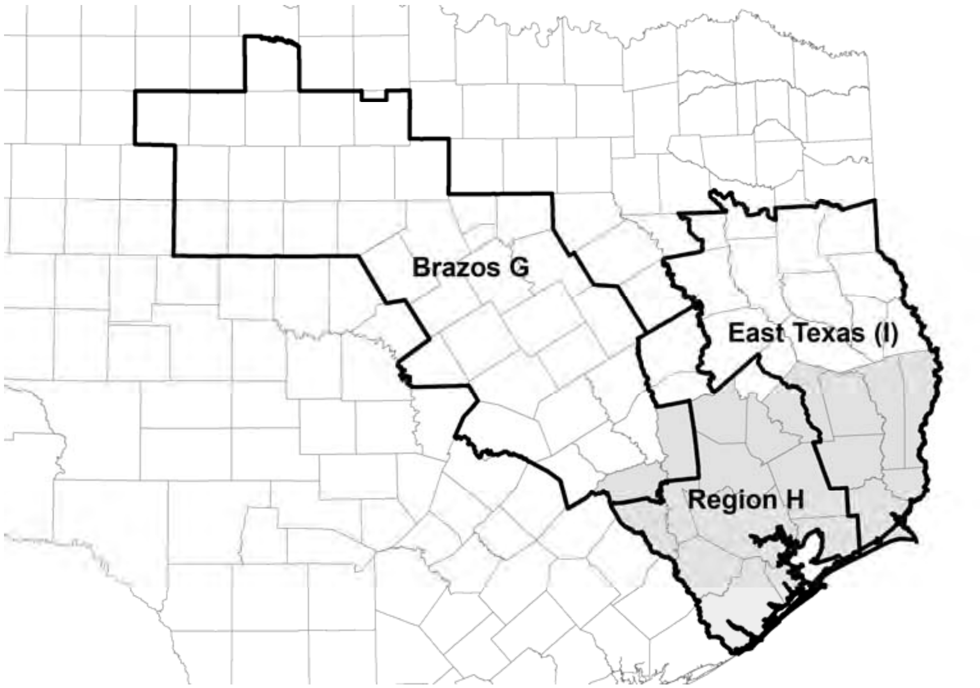
Socioeconomic Impacts

Socioeconomic Impacts in Regional Water Planning Process

- An evaluation of the impact of not meeting water needs during a repeat of the drought of record
- Analysis is limited to categories of users with an identified water need (i.e. potential shortage)
- Socioeconomic Analyses by Region:
  - Region G
  - Region H
  - Region I
  - Each of these can be found here: https://www.twdb.texas.gov/waterplanning/data/analysis/index.asp



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Socioeconomic Impacts in Regional Water Planning Process

Example of County-Level Summaries of Estimated Socioeconomic Impacts:

		Income losses (Million $)*						Job losses					
County	Water Use Category	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
GRIMES	IRRIGATION	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	1	1	1	1	1	1
GRIMES	LIVESTOCK	$18.61	$18.61	$18.61	$18.61	$18.61	$18.61	903	903	903	903	903	903
GRIMES	MINING	$125.63	$389.16	$265.42	$141.68	$11.10	-	468	1,449	988	527	41	-
GRIMES	MUNICIPAL	$0.14	$0.13	$0.11	$0.10	$0.09	$0.07	3	2	2	2	2	1
GRIMES	STEAM ELECTRIC POWER	$36.46	$36.46	$36.46	$36.46	$36.46	$36.46	-	-	-	-	-	-
GRIMES Total		$180.87	$444.39	$320.63	$196.89	$66.29	$55.18	1,374	2,355	1,894	1,433	947	905

Source TWDB: https://www.twdb.texas.gov/waterplanning/data/analysis

While the socioeconomic impact analysis developed for regional water planning is quantitative, it does not directly translate to the evaluation of potential desired future conditions:

- Limited to impacts of unmet needs
- Influenced by availability of other supply sources
- Does not consider potential negative socioeconomic impacts from groundwater production

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Balancing Socioeconomic Impacts

Impacts of Developing Groundwater

Subsidence and associated impacts

Lowering pumps or deepening wells

Potential impacts on water quality

Impacts on groundwater production efficiency

Influence on economic growth based on water availability

Impacts of Not Developing Groundwater

Unmet water supply need

Conversion to more expensive water supply alternative(s)

Influence on economic growth based on reliability/diversity of supplies

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Impact on Private Property Rights

Private Property Impacts

the impact on the interests and rights in private property, including ownership and the rights of management area landowners and their lessees and assigns in groundwater as recognized under Section 36.002;

DFCs with Higher Pumping

Allow existing users to produce more groundwater:

- Poses risks to water supply and future needs
- Increased drainage from neighboring landowners, may reduce well efficiencies, and surface water

DFCs

District Rules

DFCs with Lower Pumping

May require some users to reduce production

- May extend groundwater supply and levels to meet future needs
- Minimizes well interference
- Limiting groundwater drainage between property owners

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Feasibility of Achieving DFCs

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Physical Feasibility:

As demonstrated in the model run, the DFCs being considered in GMA 14 can each be achieved simultaneously

Regulatory Feasibility:

The DFCs being considered in GMA 14 can be achieved using the existing regulatory tools available to the GCDs

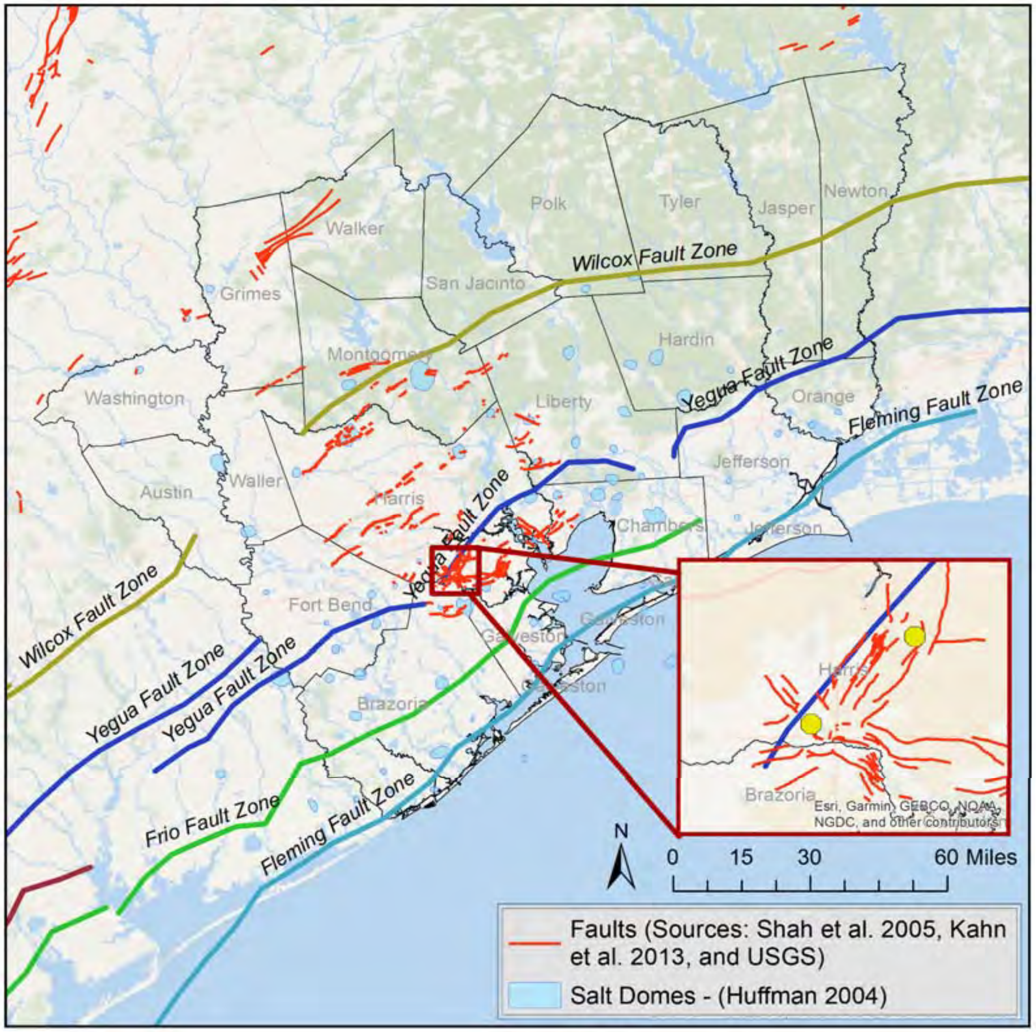
Other Factors Considered

Faulting

- Hundreds of surface faults cutting Pleistocene and Holocene sediments (i.e., Chicot aquifer) exposed at the surface have been mapped.
- Estimated that ~10% of these are active (Verbeek, 1978)
- < 3 miles tend to be associated with salt domes
- > 6 miles tend to trend ENE-NE, as do the regional growth faults

Source: Houston Geologic Society

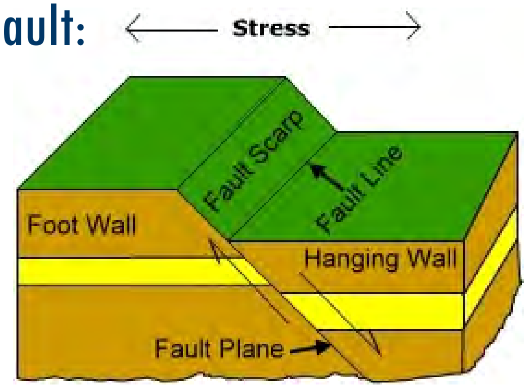
A small percentage of mapped faults

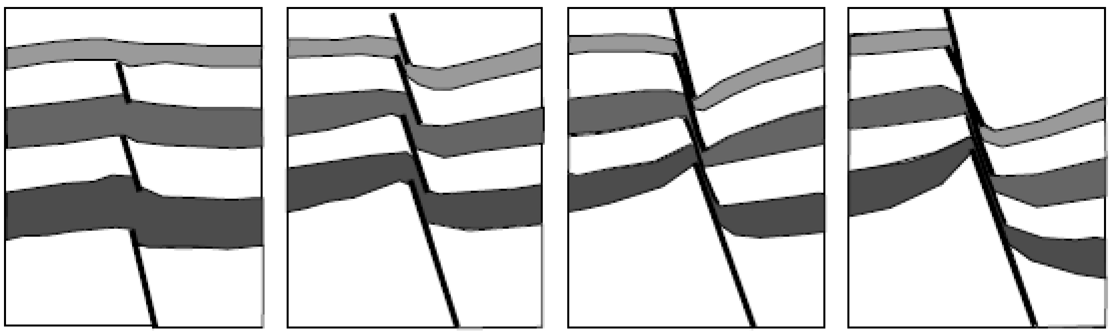


Numerous gravitationally induced “down-to-the coast” faults.

Represent the slow sliding of the land mass towards the Gulf of Mexico.

Normal fault:

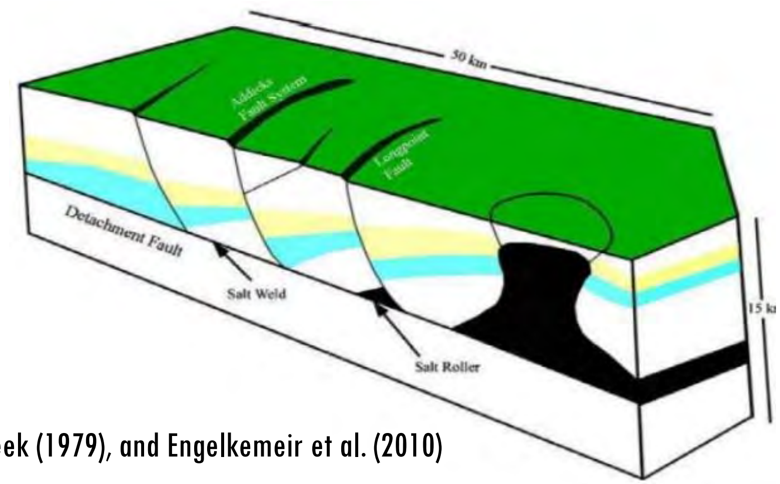




Movement is typically episodic, but average downward rates of 0.5 to 3 cm/yr

No significant earthquake has occurred on these faults in historic times, but infrastructure damage can occur

Faulting associated with rising salt domes:



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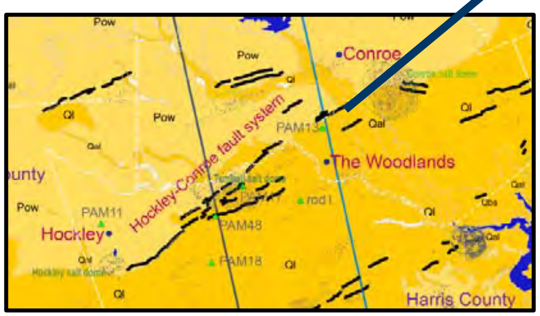
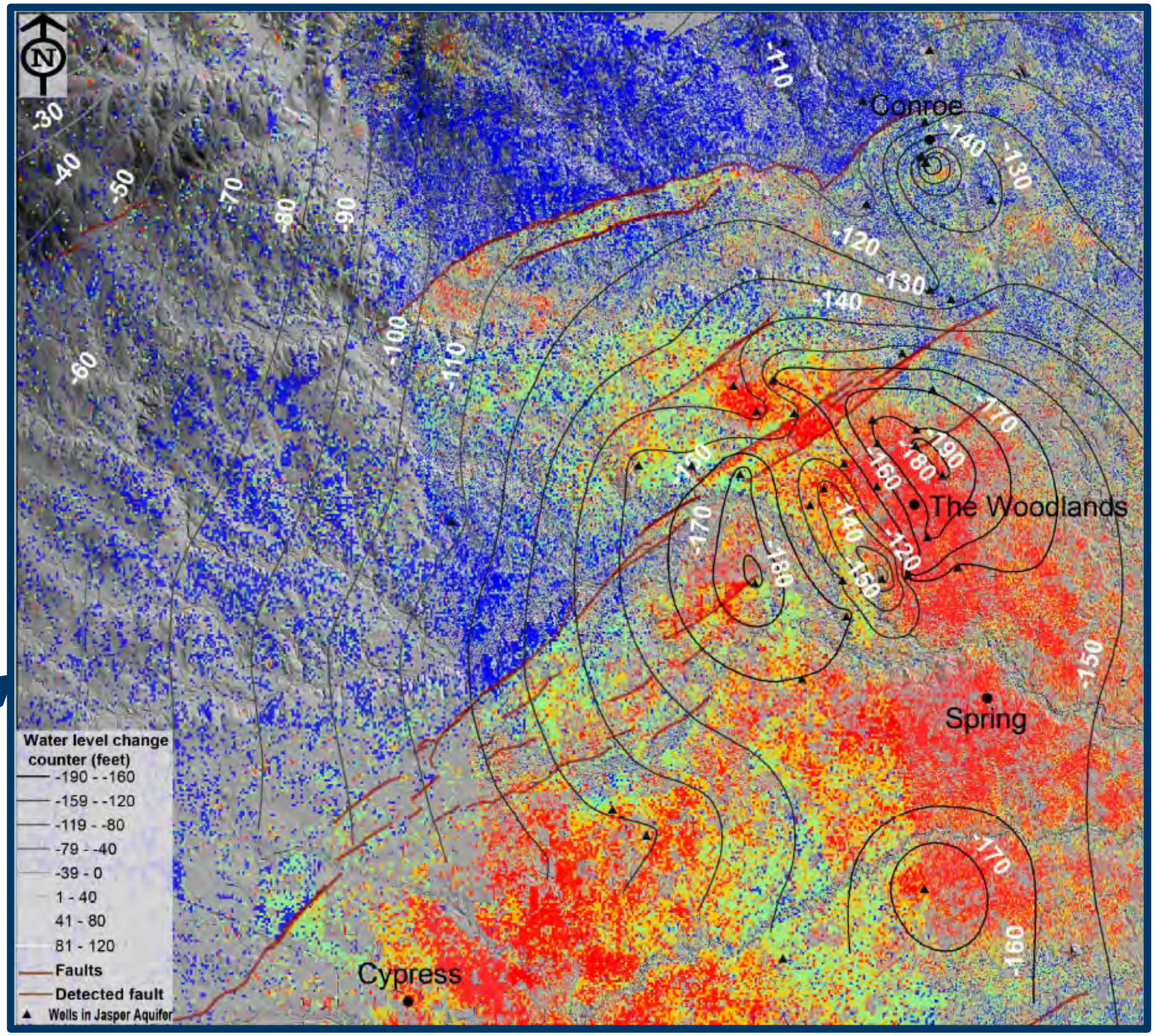
Sources: Bense and Person (2006), Brun and Mauduit (2008), Verbeek (1979), and Engelkemeir et al. (2010)

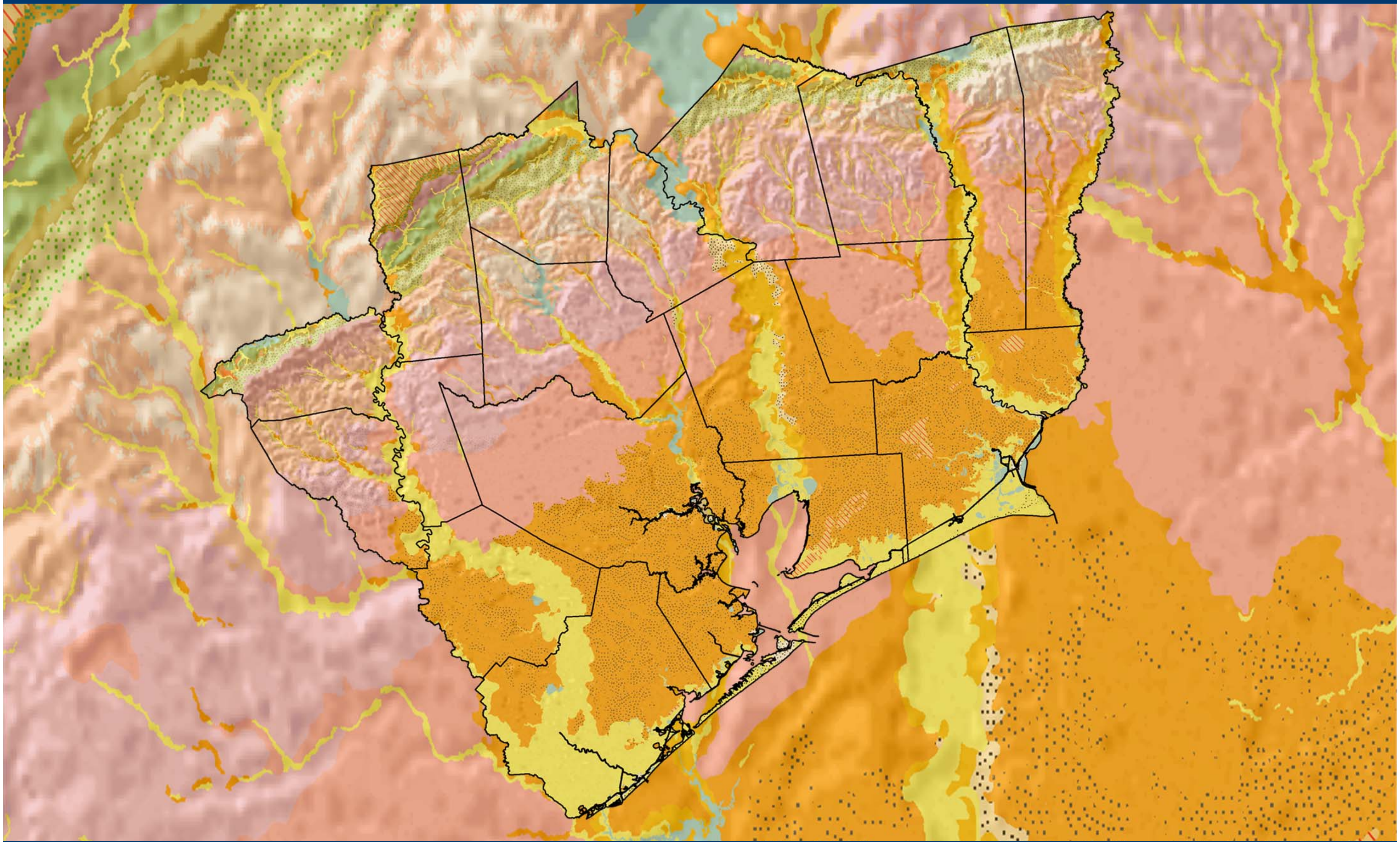
Correlations Between Drawdown and Faulting

- Groundwater pumping can increase movement along existing aseismic faults.
- Fault impacts are more localized than subsidence, but can be serious where they exist.





Source: Qu and others (2019)



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