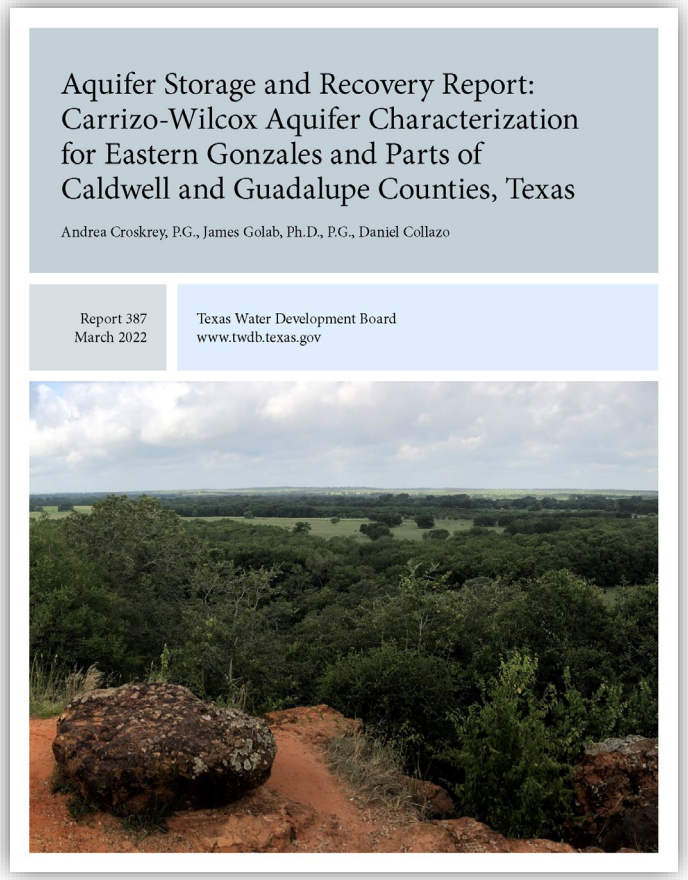
Aquifer Storage and Recovery Report: Carrizo-Wilcox Aquifer Characterization

Eastern Gonzales and Parts of Caldwell and Guadalupe Counties, Texas



Public webinar May 19, 2022 at 10:00 a.m.

https://www.twdb.texas.gov/innovativewater/asr/projects/GBRA/index.asp

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Today's speakers

Andrea Croskrey, P.G.

TWDB ASR discipline lead

Brian Perkins, P.E.

GBRA deputy executive manager of engineering

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TWDB coauthor

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TWDB coauthor

Webinar reminders and format

TURN OFF YOUR CAMERAS

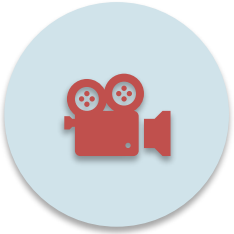
MUTE YOUR MICROPHONES

TYPE QUESTIONS IN THE CHAT SO WE CAN QUEUE THEM UP

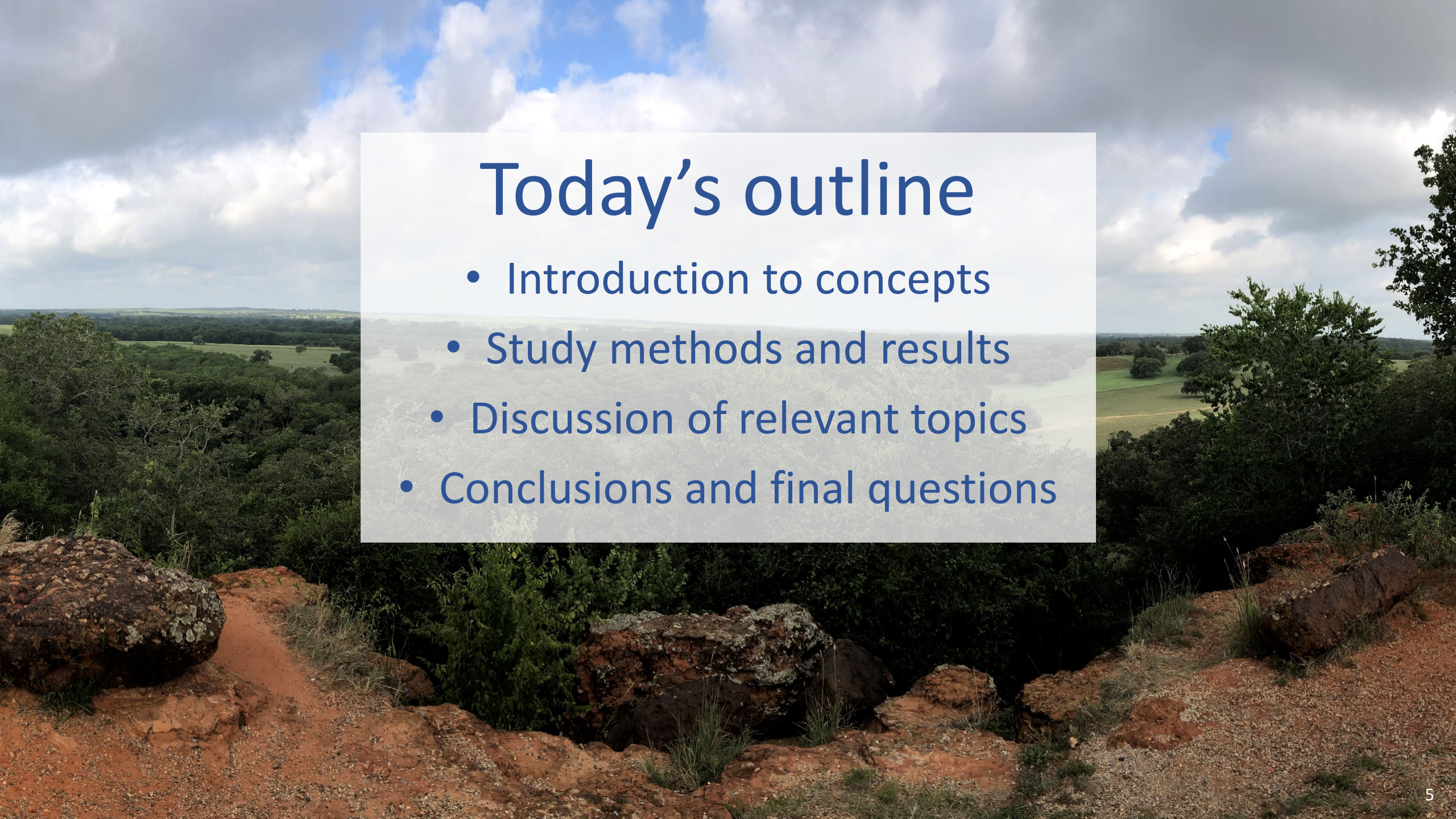
LET US KNOW IF YOU WOULD LIKE TO UNMUTE TO ASK

TOPIC-RELATED QUESTION TIME AFTER SECTIONS

QUESTION TIME AT THE END TOO!



WEBINAR IS BEING RECORDED



Today's outline

- Introduction to concepts
- Study methods and results
- Discussion of relevant topics
- Conclusions and final questions

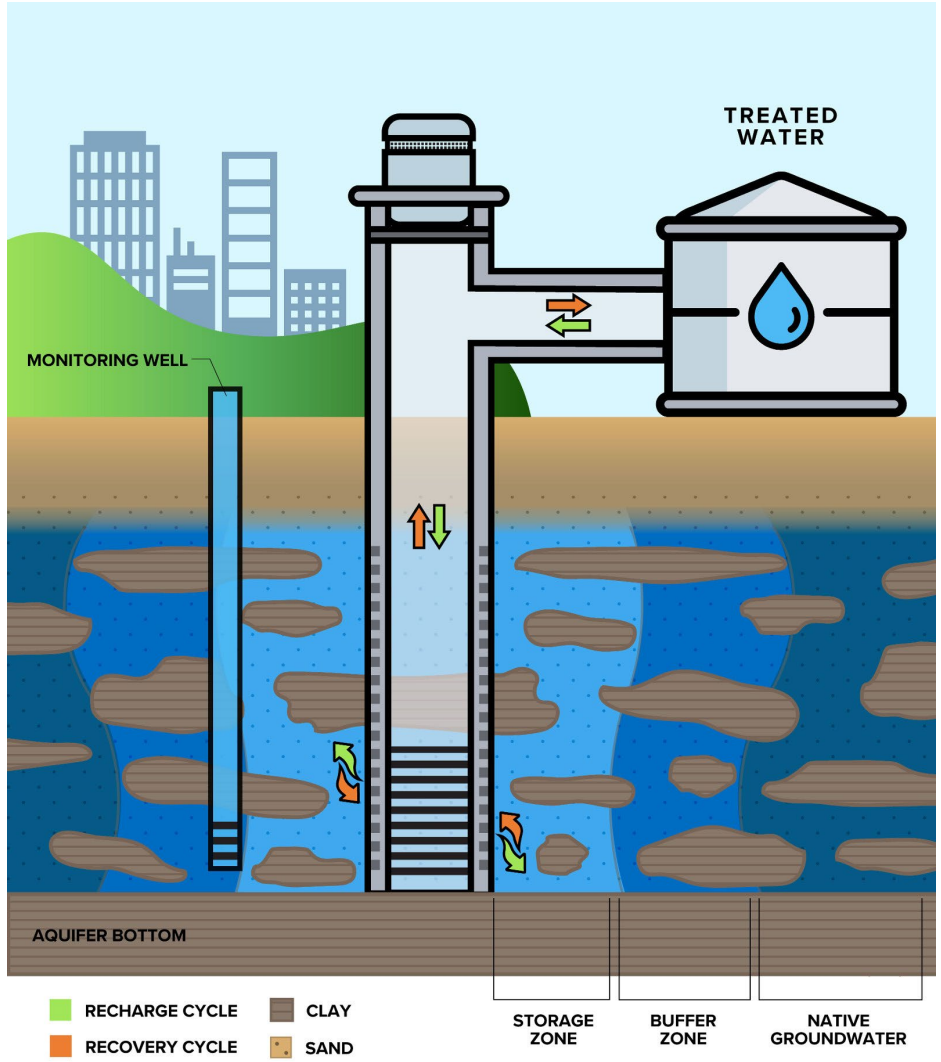
Introduction – what is ASR?

Aquifer Storage and Recovery (ASR)

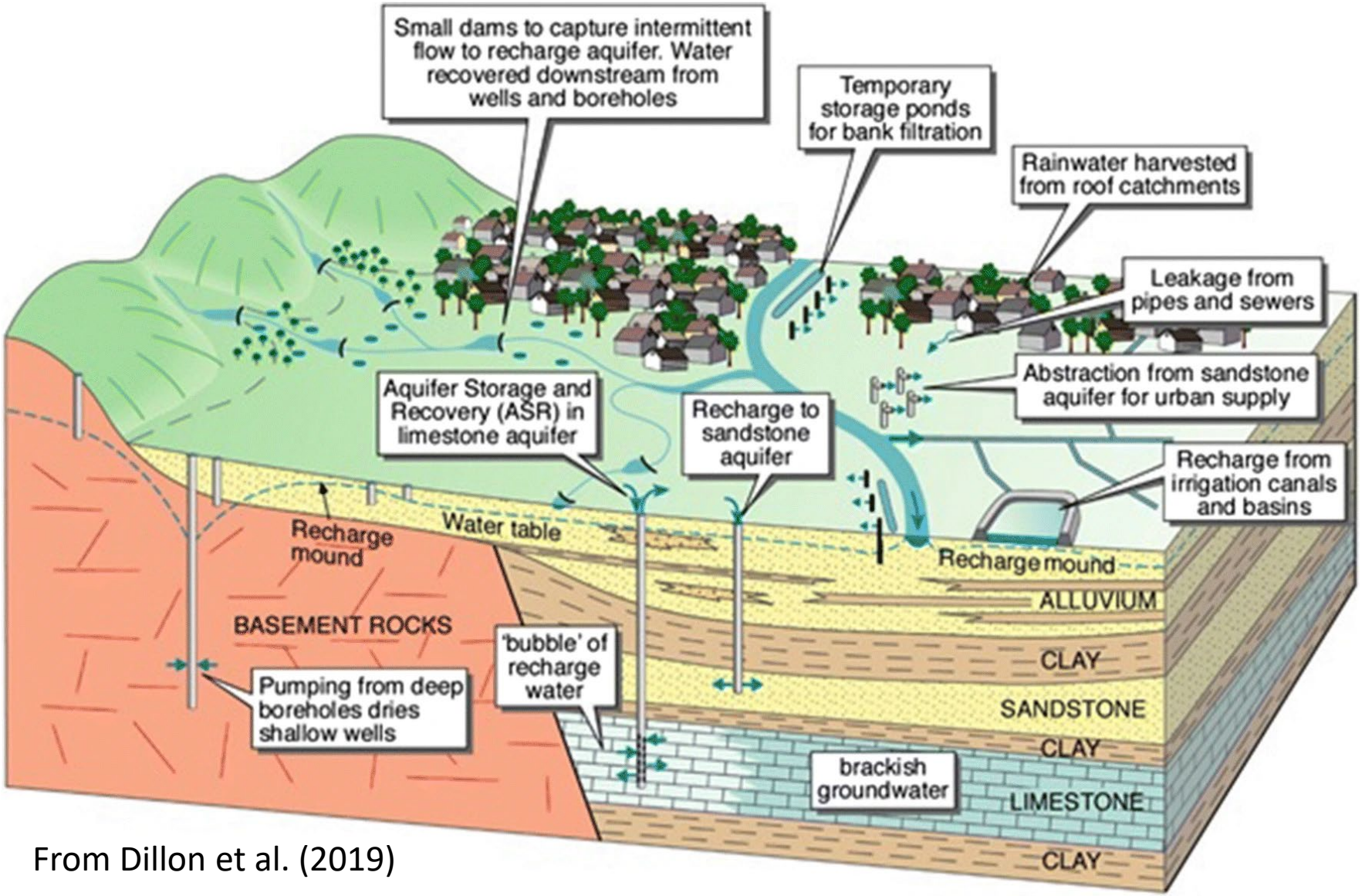
- Texas Water Code § 27.151

  "…a project involving the injection of water into a geologic formation for the purpose of subsequent recovery and beneficial use by the project operator."

- ASR uses the same well to inject and retrieve
- Other forms of managed aquifer recharge (AR, ASTR…) might use basins or different wells for injection and recovery



What is needed for an ASR project?



From Dillon et al. (2019)

Needs

- Municipal
- Industrial
- Agricultural
- Environmental

Excess water*

- Surface Water
- Reclaimed Water
- Groundwater

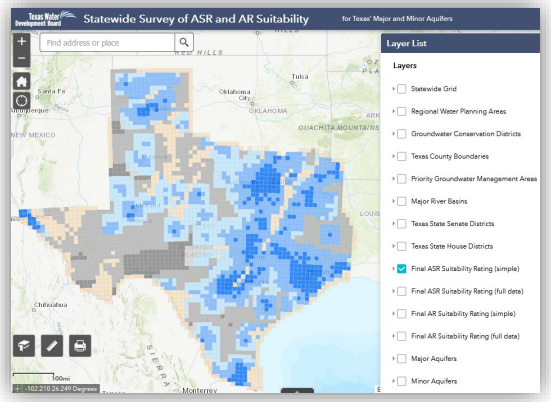
Hydrogeologic characteristics*

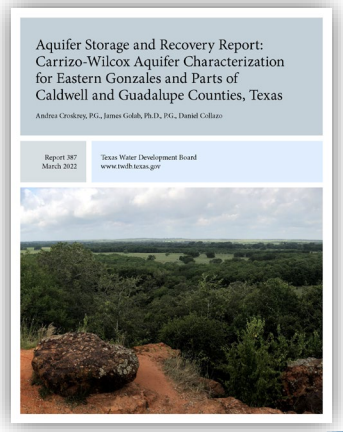
- Storage
- Recharge
- Recoverability

***Compatible water quality**

Introduction – mandate

Texas Water Code § 11.155 - Two ASR related mandates for the TWDB





1. Statewide survey of aquifer suitability for ASR or AR projects in Texas

   Webpage

   https://www.twdb.texas.gov/innovativewater/asr/projects/Statewide/index.asp

   StoryMap

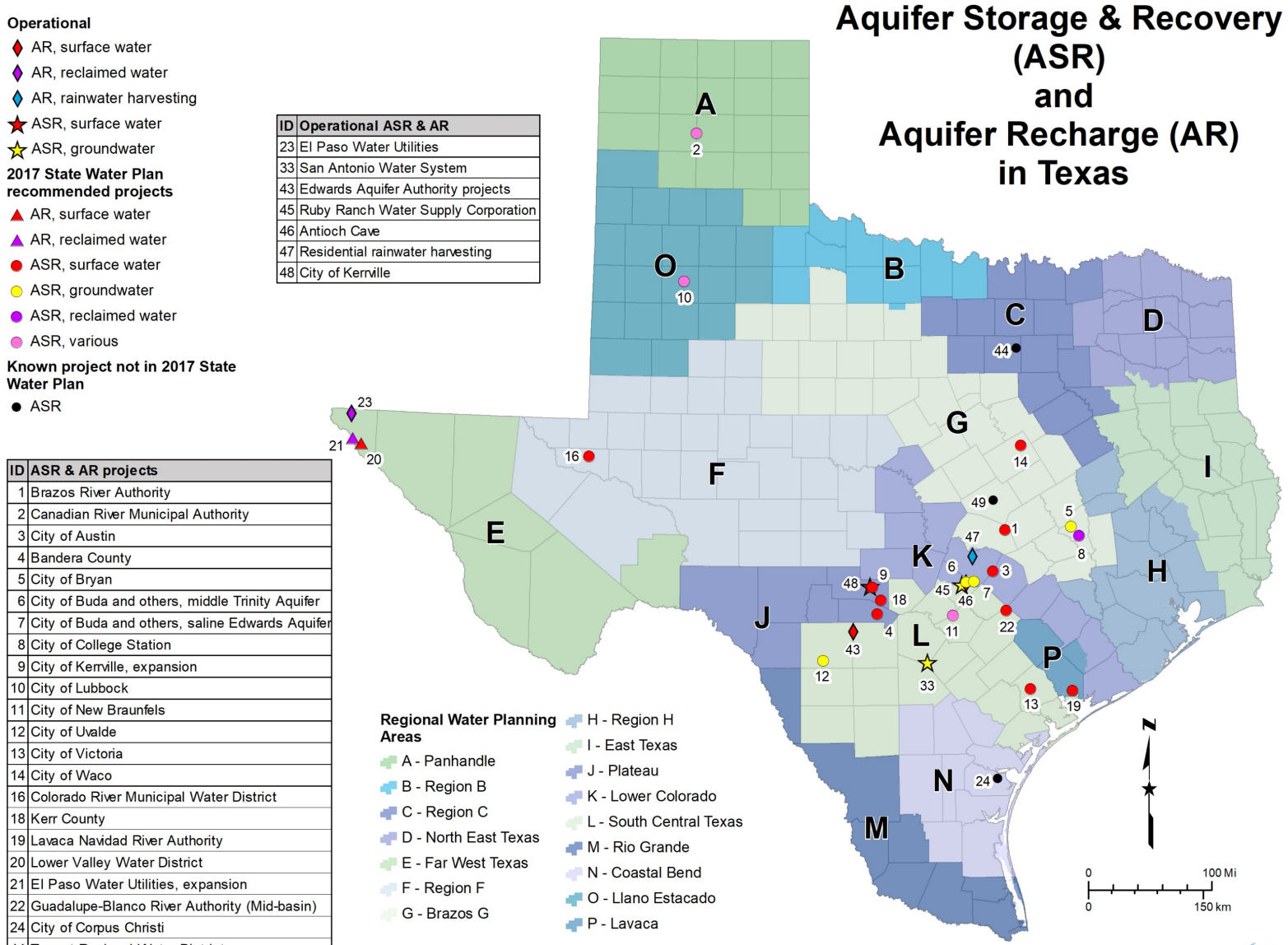
   https://twdb-wsc.maps.arcgis.com/apps/MapSeries/index.html?appid=75313de26daf4994bcb590fdb8846b80

2. Conduct studies - work with appropriate interested persons to conduct studies of ASR and AR projects in the state water plan or identified by others and report the results of these studies to the regional water planning groups and interested persons

Introduction – study selection process

2017 State Water Plan Recommended ASR projects

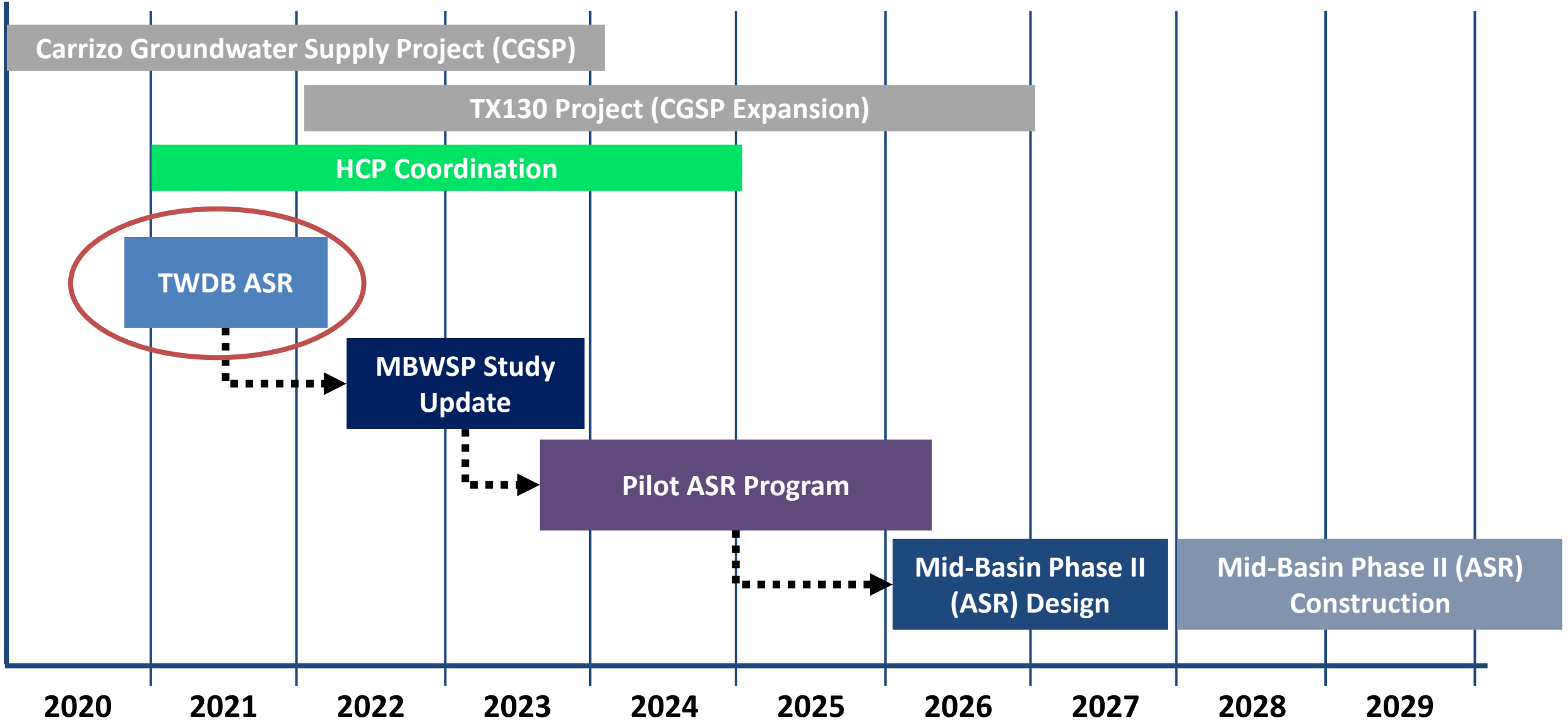
1. Sponsor interest
2. Staff skill and availability
3. Source type
4. Data availability
5. Planning status
6. Online decade



Introduction – GBRA Mid-Basin Water Supply Project

- Phase I – development of groundwater supply from the Carrizo Groundwater Supply Project and associated infrastructure
- Phase II – ASR well field and other infrastructure
  - Water source: treated surface water from Guadalupe River
  - Storage target: Carrizo-Wilcox Aquifer

Mid-Basin Water Supply Project Schedule



MBWSP Study Update

- Project Demands (Geographic Customer Areas)
- ASR Siting & Sizing
- ASR Piloting Plan
- River Diversion & Siting
- Integration of Lower Basin Water Rights
- Raw & Treated Water Transmission – Routing and Sizing
- Off-Channel Storage and/or Wetlands
- Water Treatment Plant Siting & Sizing
- State & Federal Permitting

<u>Deliverables</u>

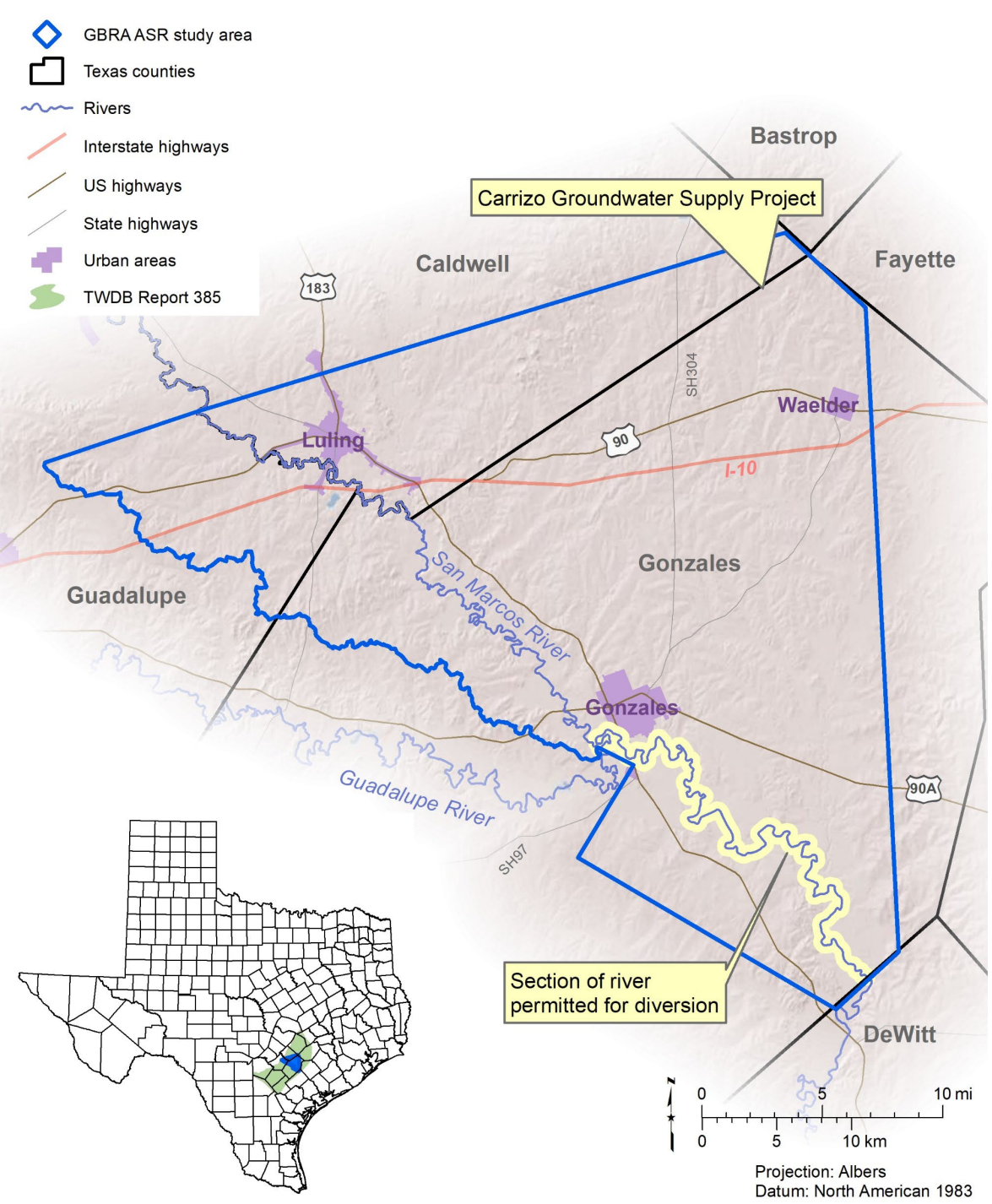
Feasibility Report; Recommendation; Piloting Plan

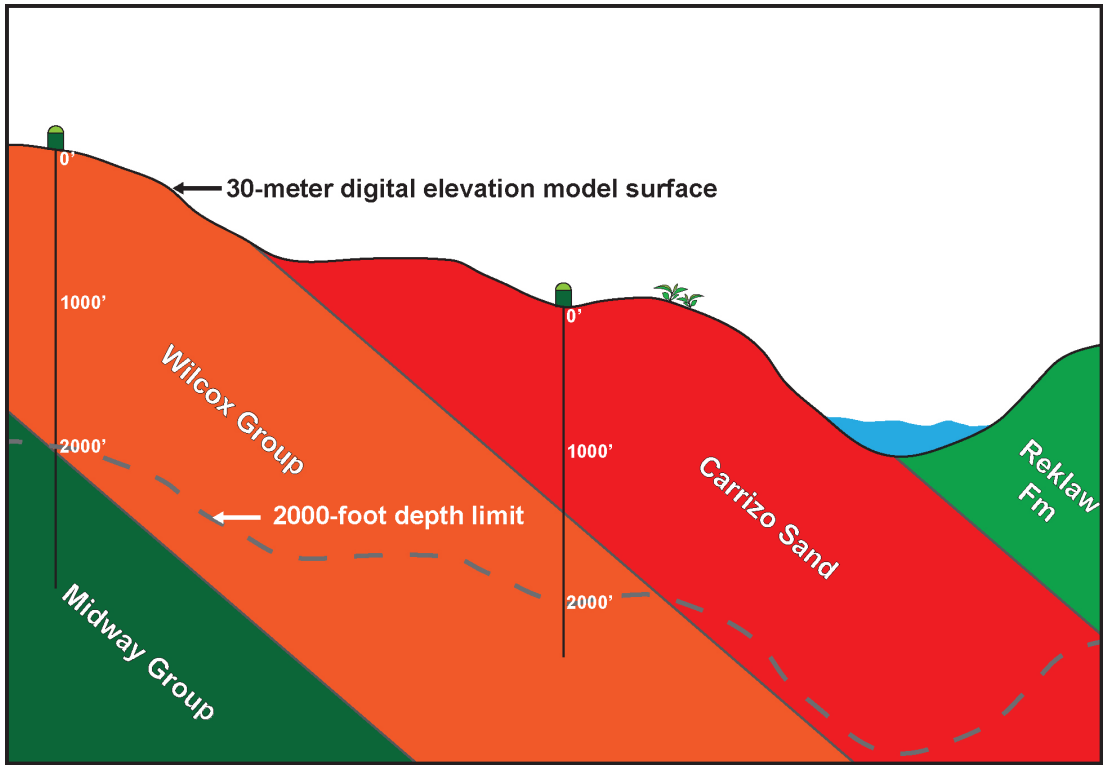
<u>Timing</u>

Apr 2022 – Dec 2023

Introduction – study area

- Existing infrastructure
- 2,000-foot depth limit





Questions on the study scope?

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Introduction – aquifer characterization

- Stratigraphy
- Lithology
- Groundwater salinity

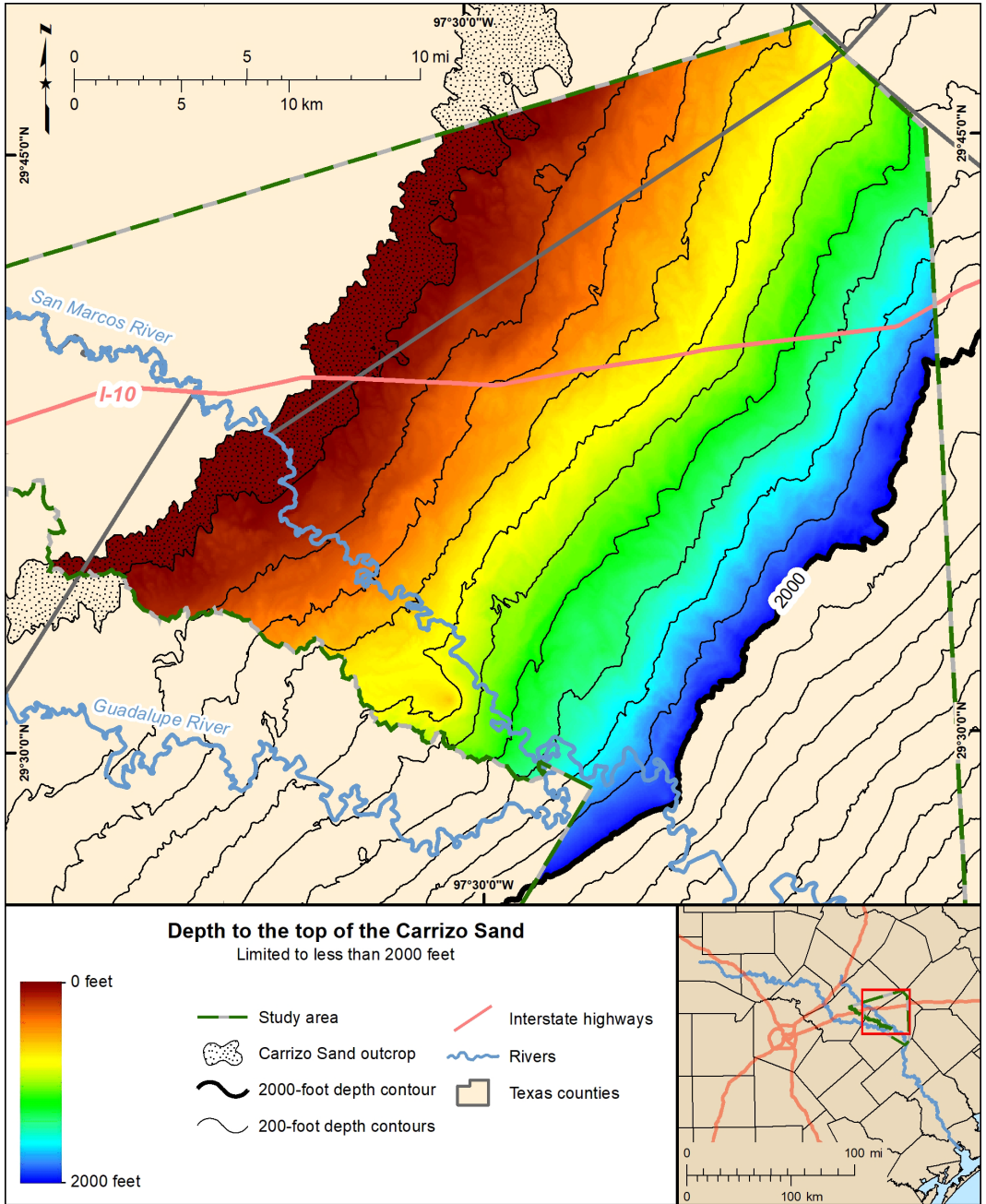
Stratigraphy – why?

- GBRA is planning on implementing ASR in the Carrizo-Wilcox Aquifer
- Determining the depths to the top and bottom of the Carrizo Sand and Wilcox Group will be critical when planning the construction of an ASR well in the study area
- Understanding subsurface architecture will aid in site selection for a viable project

Stratigraphy – how?

- Collect data:
  - Geophysical well logs from the BRACS database
  - Picks from previous studies
  - Added Q-logs from the RRC
  - Added logs from the GBRA CGSP wells
- Additional logs increased the data density from previous studies
- Interpret stratigraphic depths from the well logs in IHS Kingdom
- Interpolate stratigraphic surfaces in ArcGIS

Stratigraphy – results

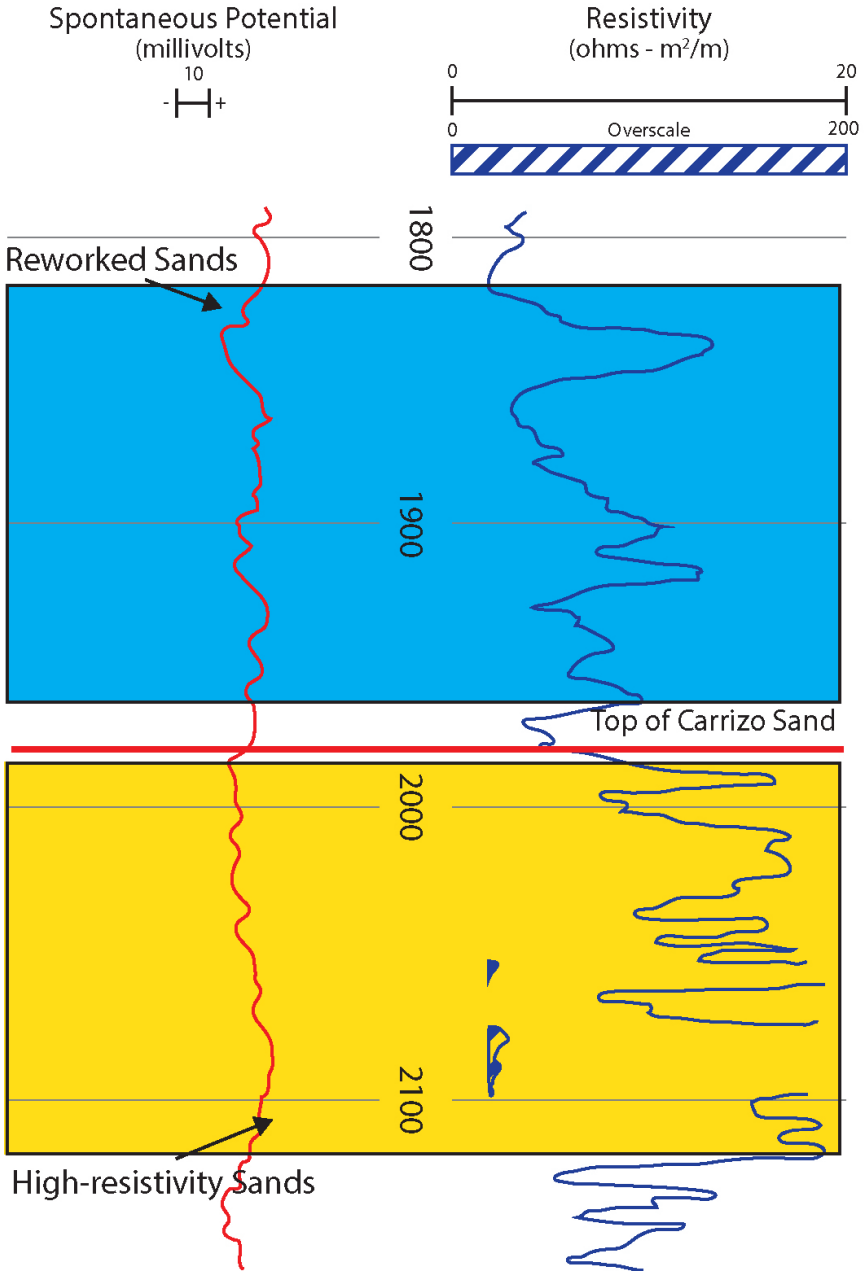


Top of the Carrizo Sand

- Depth increases to the SE, towards the Gulf of Mexico
- The map is limited to where the Carrizo is less than 2,000 feet deep
  - Reaches a depth of 2,000 feet about 15 miles from the outcrop
- 4,547 feet deep at the farthest downdip corner of the study area

Reklaw	Clay, youngest
Carrizo	Aquifer
Wilcox	Aquifer
Midway	Clay, oldest

Stratigraphy – results



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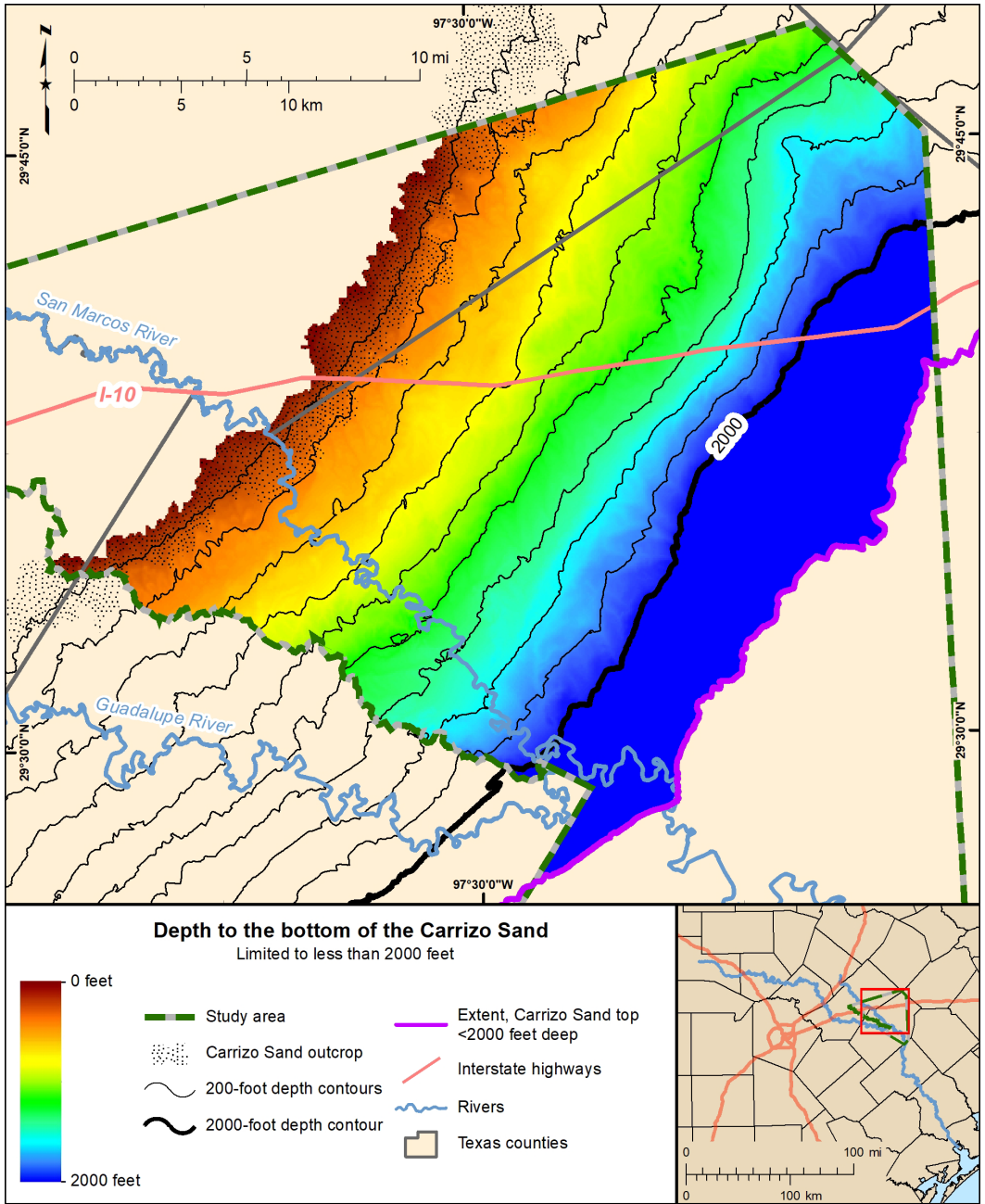

Bottom of the Carrizo Sand (top of the Wilcox Group)

- Depth increases to the SE, towards the Gulf of Mexico
- Reaches a depth of 2,000 feet about 12 miles from the outcrop
- The depth ranges from 0 at the outcrop to 5,517 feet

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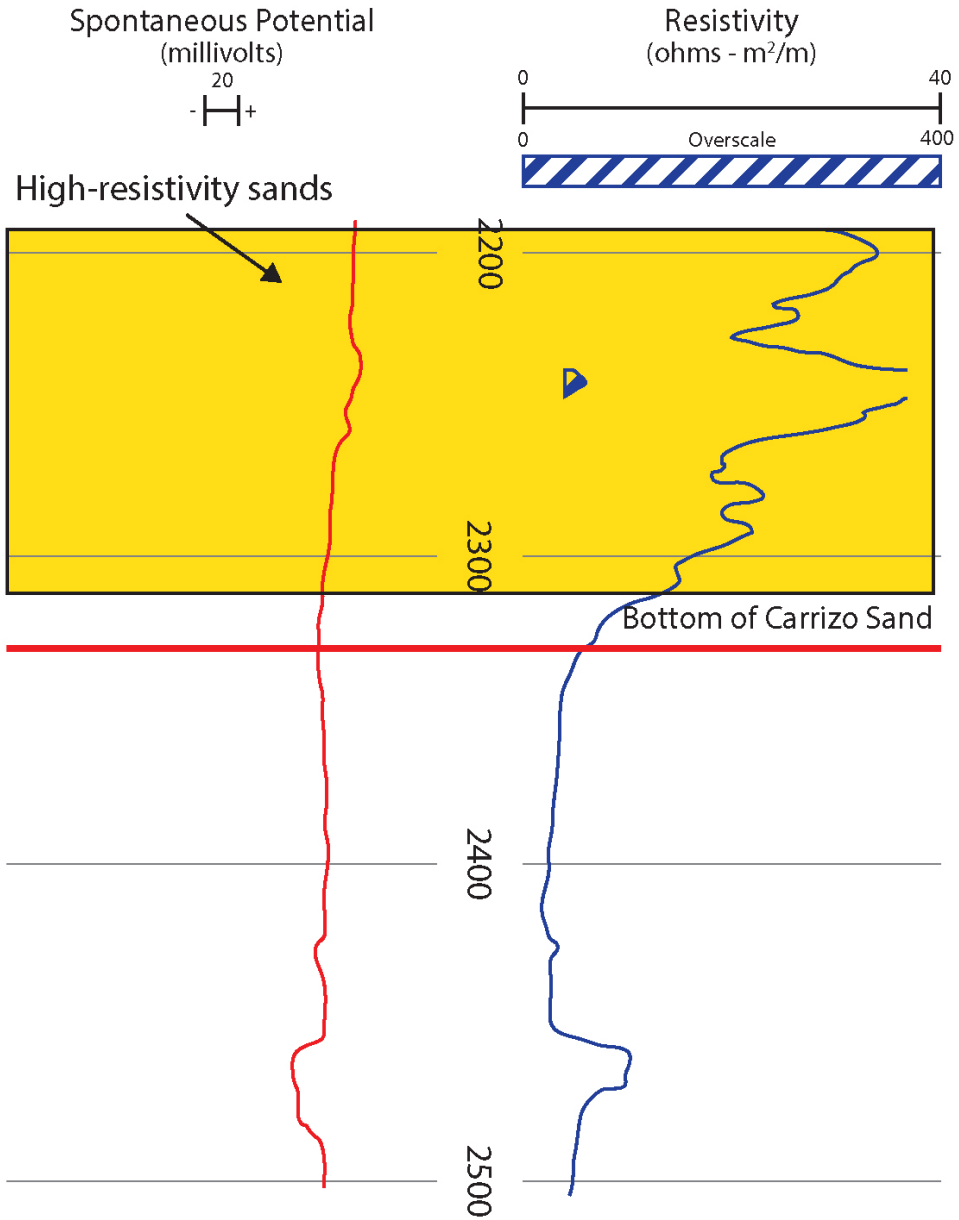

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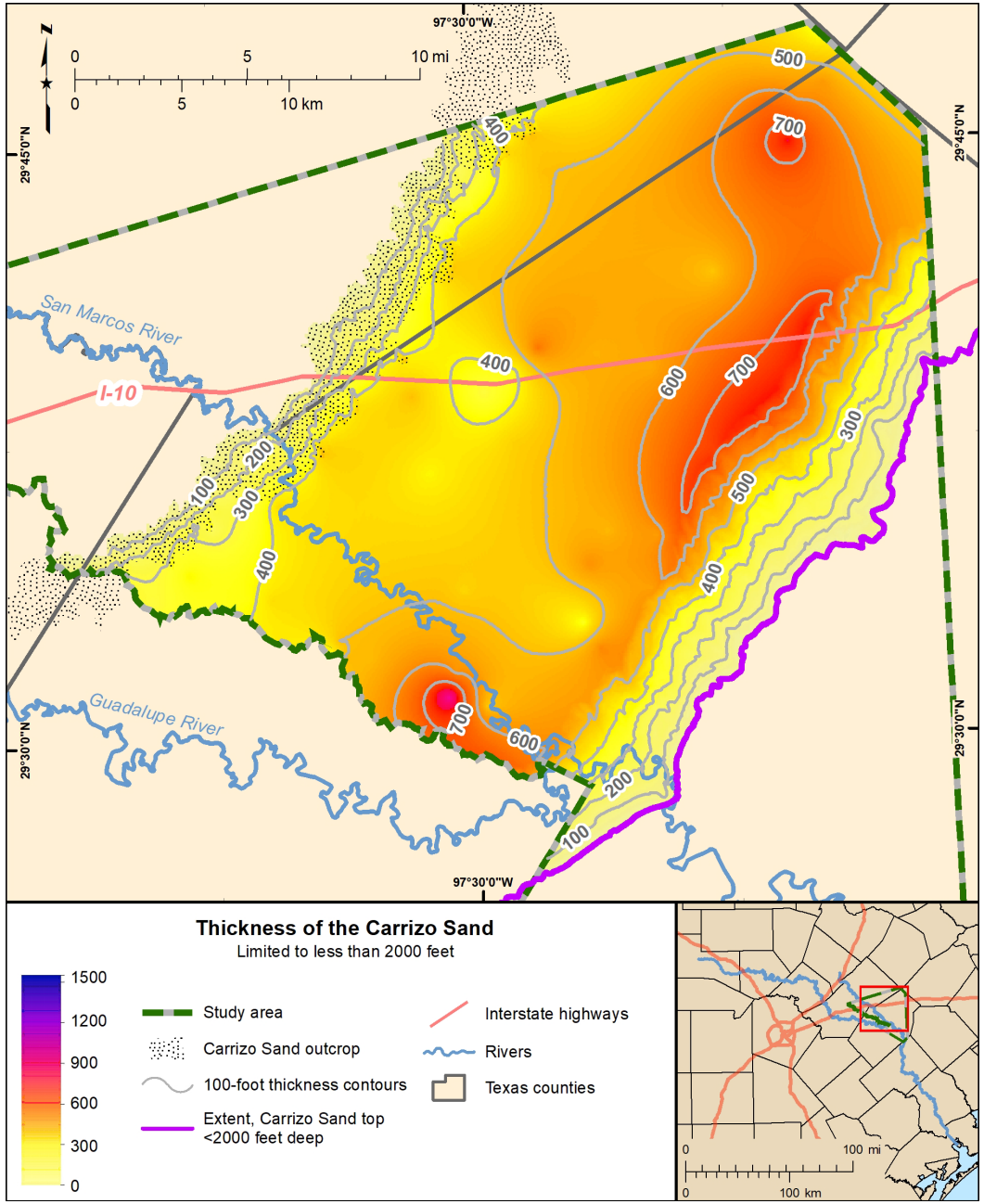
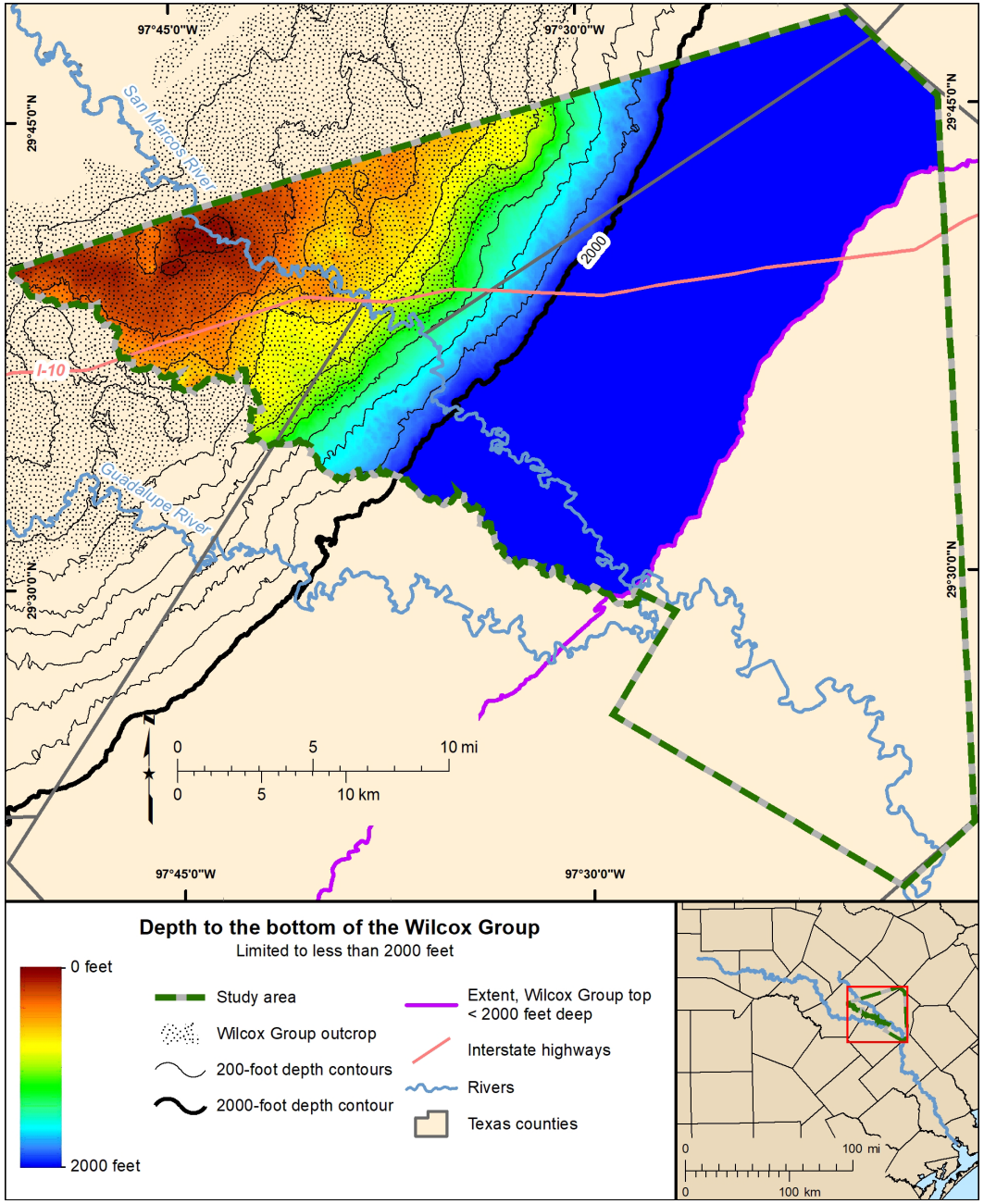


Carrizo Sand thickness

- Map limited to less than 2,000 feet deep:
  - Max thickness is 904 feet
  - Pinches out as the dip of the formation reaches the 2,000 ft depth limit to the SE
- Thickness of the entire formation increases to the SE, towards the Gulf of Mexico
  - Ranges from 0 to 1,173 feet thick
- Thicker where the formation overlies the Yoakum Canyon

Stratigraphy – results



Bottom of the Wilcox Group (Top of the Midway)

- Depth increases to the SE, towards the Gulf
- The bottom of the Wilcox ranges from 121 to 8,167 feet below the ground surface
- The map is limited to where the top of the Wilcox is less than 2,000 feet deep

Reklaw	Clay, youngest
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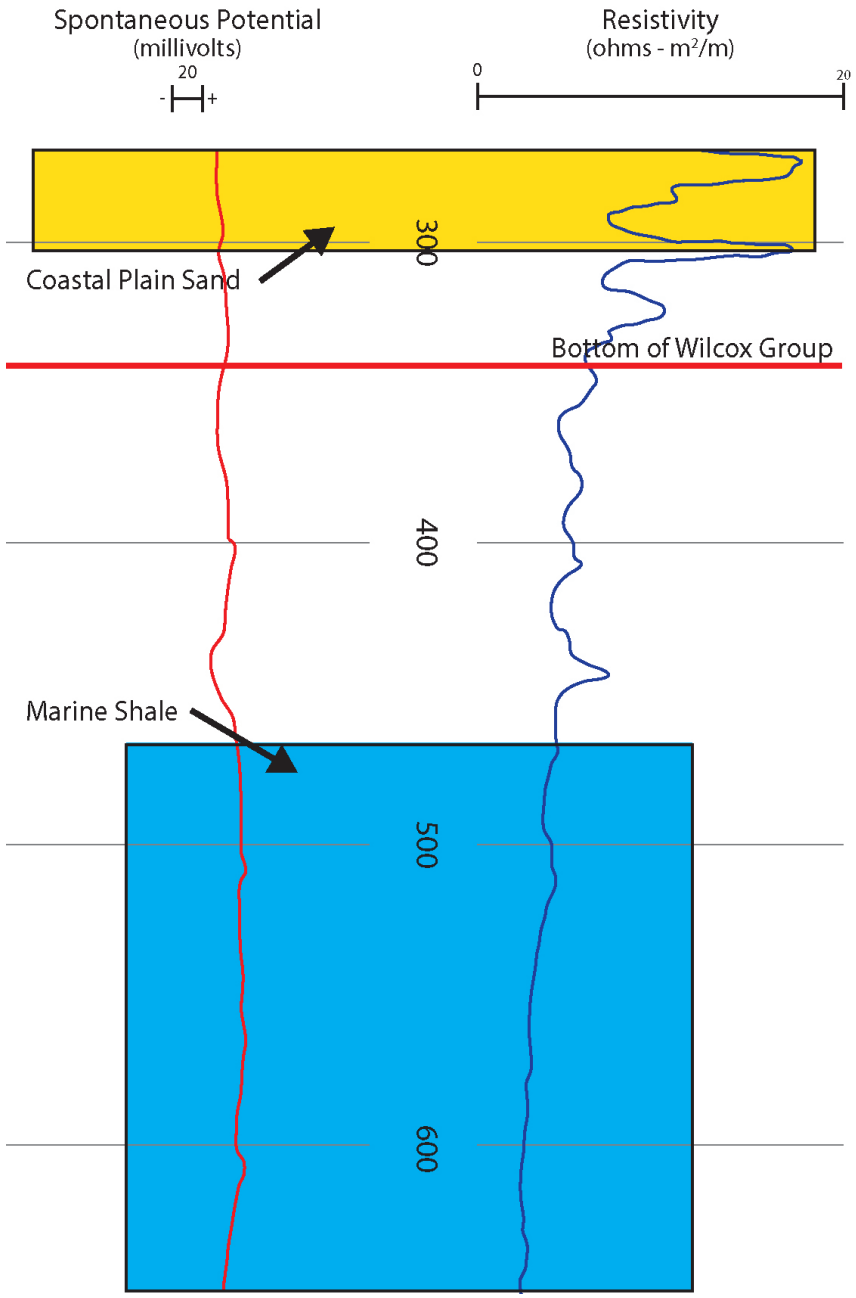
Stratigraphy – results



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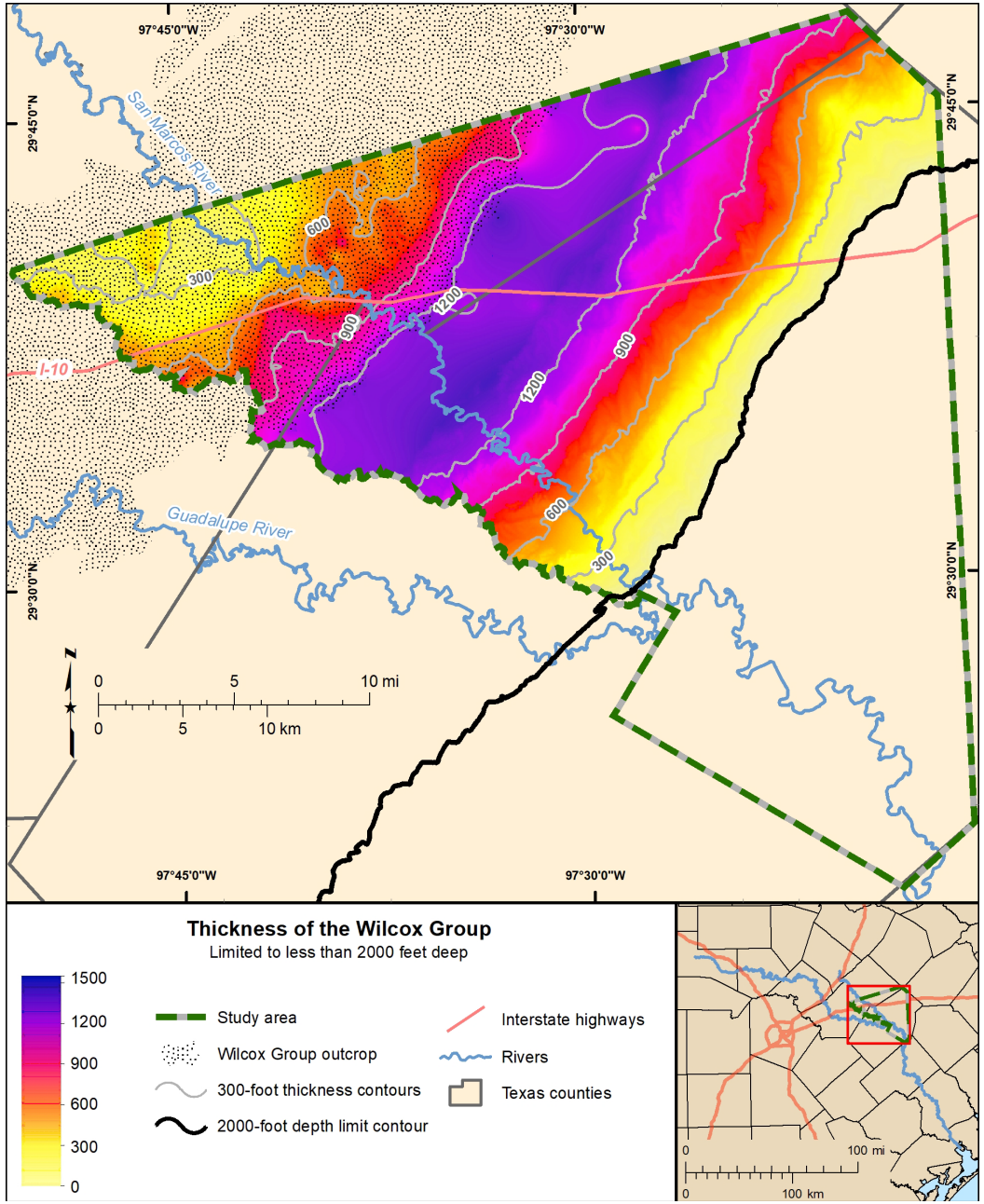

Wilcox Group thickness

- Thickness of the entire formation increases to the SE, towards the Gulf
  - Ranges from 121 to 2,990 feet thick
- Thinnest within the Yoakum Canyon
- When limited to less than 2,000 feet deep, the maximum thickness is 1,528 feet

Questions on the stratigraphy?

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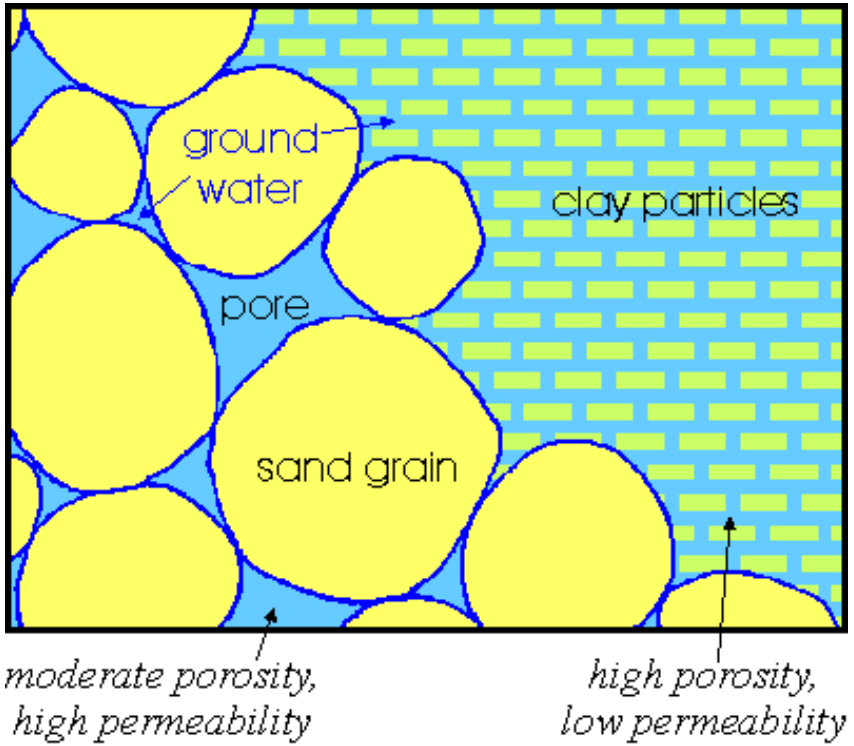
Lithology – why?

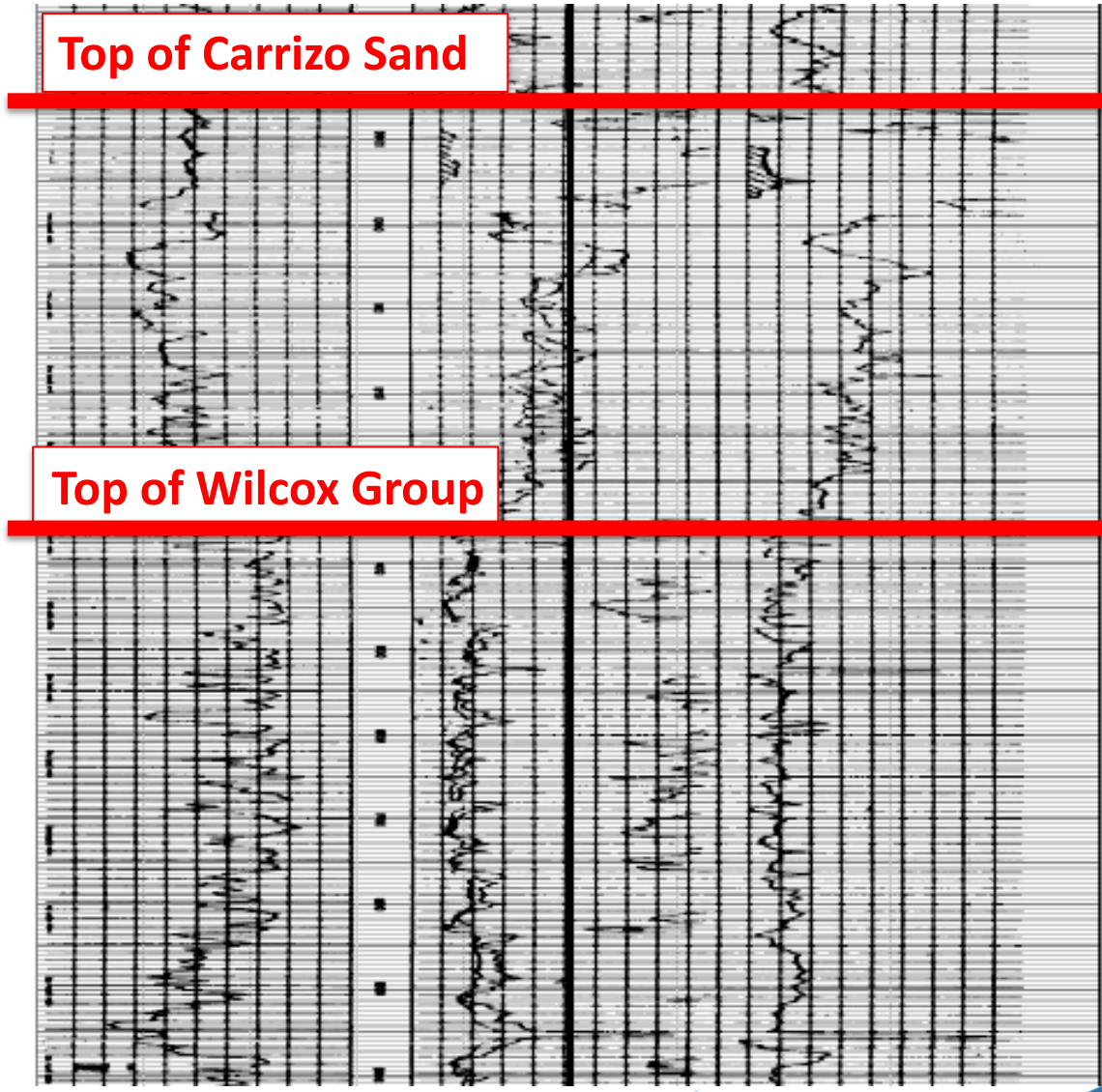
- The dominant lithologic characteristics of strata have a direct effect on the recharge, storage, and recoverability of water
- “Clean” (little to no clay) sand layers produce groundwater more economically and are better suited for ASR projects
- Porosity and permeability of the strata can be inferred from the lithologic characteristics



Lithology – how?

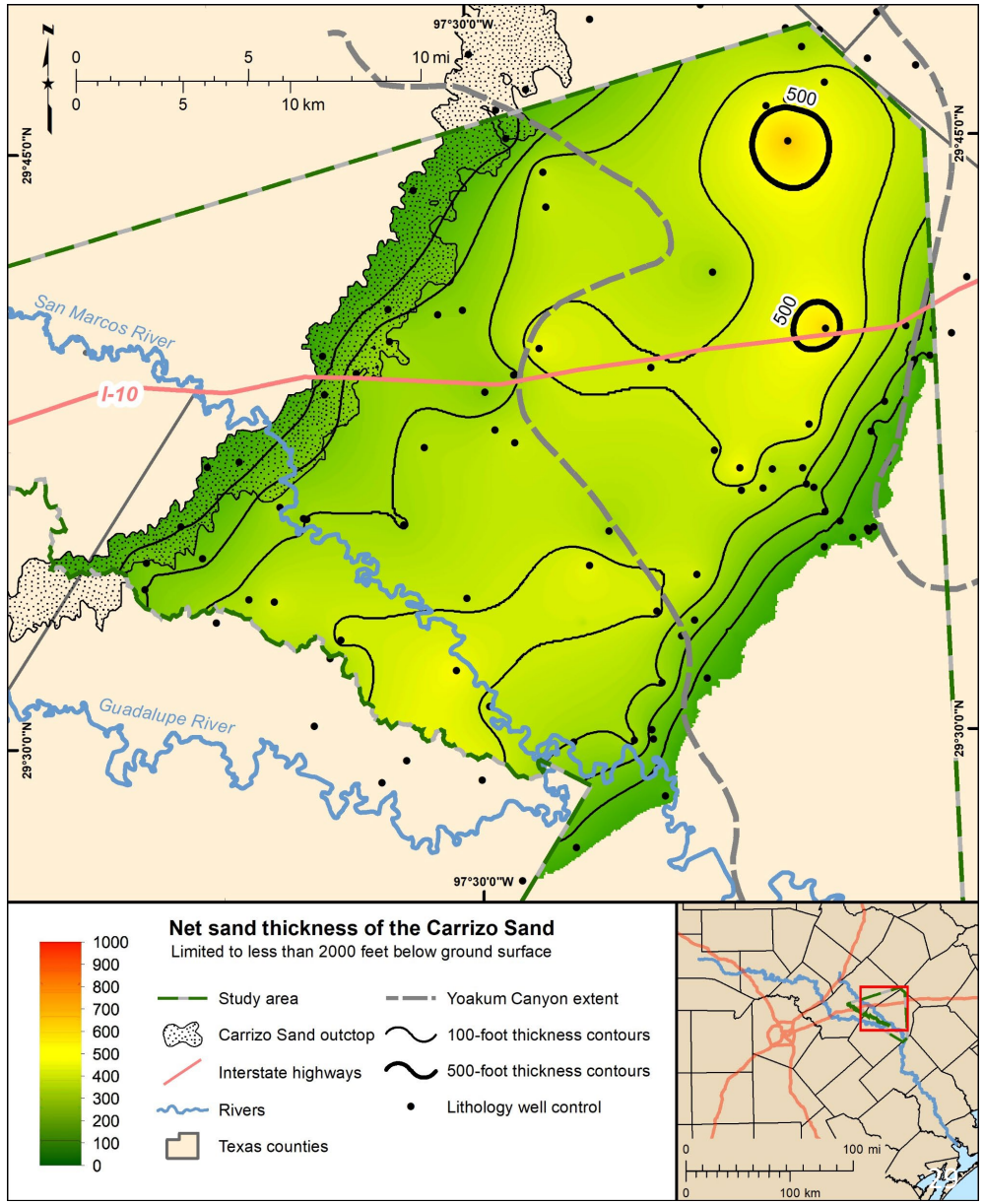
- The Carrizo Sand and Wilcox Group in the study area consist primarily of interbedded sands and clays
- Net sands is the total thickness of sand layers within a given interval
- Net sands may be calculated from driller's logs or geophysical logs
- Lithology was evaluated using a four-tier method

Tier	Description
Sand	~100% sand
Sand with clay	~75% sand and ~25% clay
Clay with sand	~25% sand and 75% clay
Clay	~100% clay



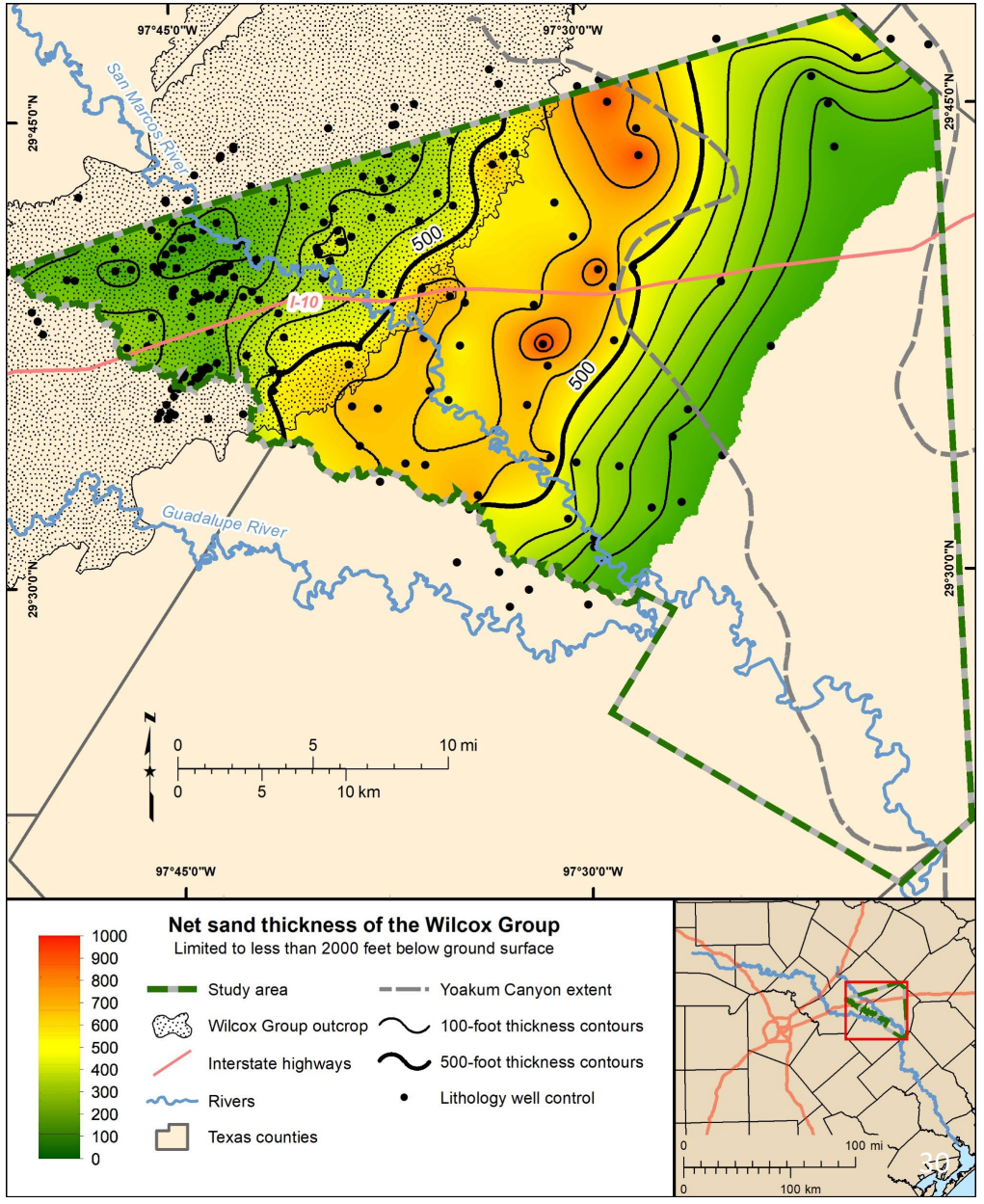
Lithology – results

- **Carrizo Sand**
  - Predominantly quartz sand with some interbedded clays and shales
  - Contains distinct thick, permeable sand units that may be over 500 feet thick
  - Deposited in a marine environment
  - 100 logs were used for interpretation
  - Between the surface and 2,000 feet below ground level there are up to 623 feet of net sands
  - Thickest net sands overlie the Yoakum Canyon



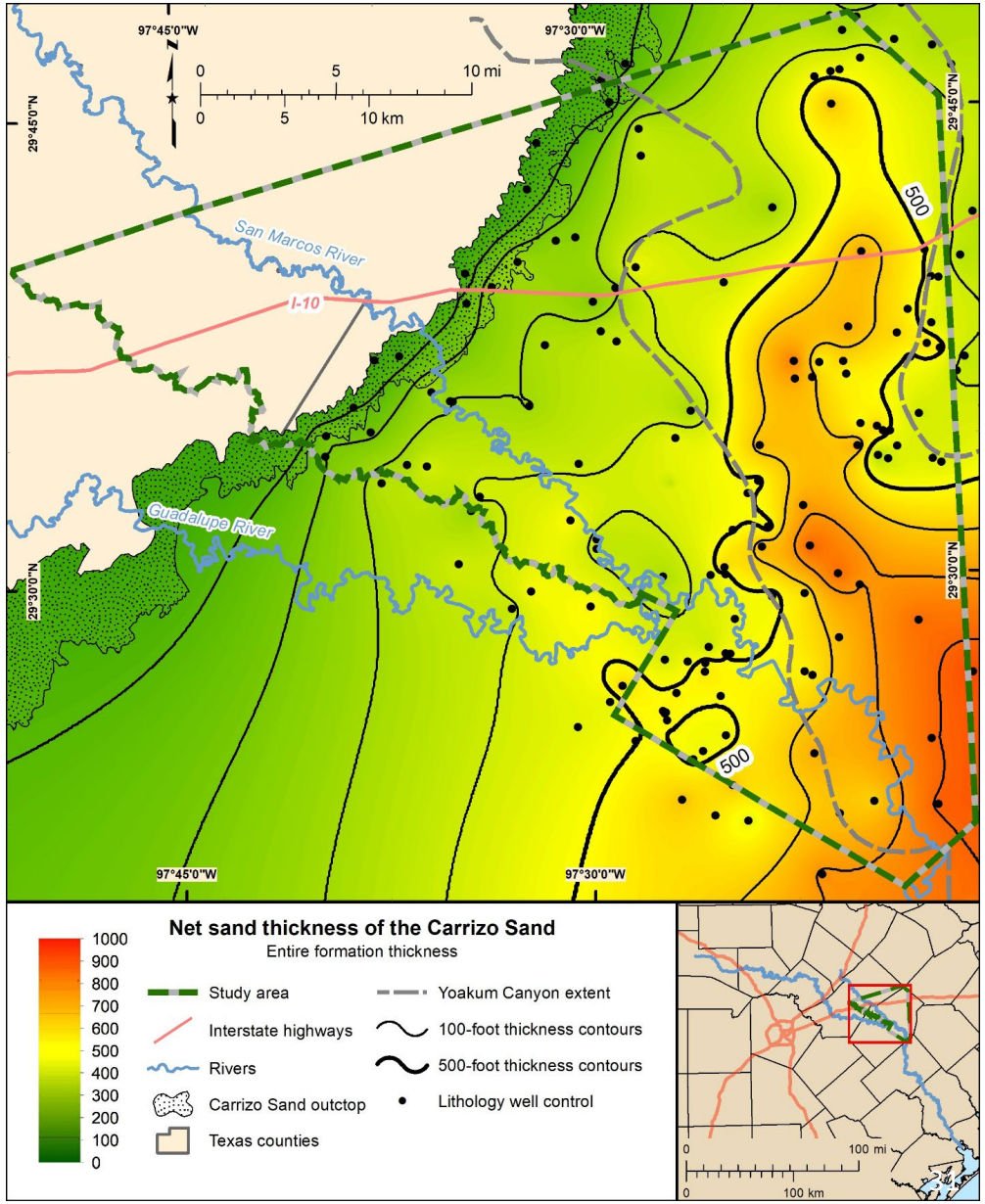
Lithology – results

- **Wilcox Group**
  - Very heterogenous: clay, silt, sand, gravel, and lignite
  - Deposited in a range of depositional environments from fluvial to marine
  - 206 logs were used to interpret net sands
  - Between the surface and 2,000 feet below ground level there are 0-920 feet of net sands
  - The thickest sands located immediately downdip of the of the Wilcox Group outcrop
  - Contains the clay-filled Yoakum Canyon



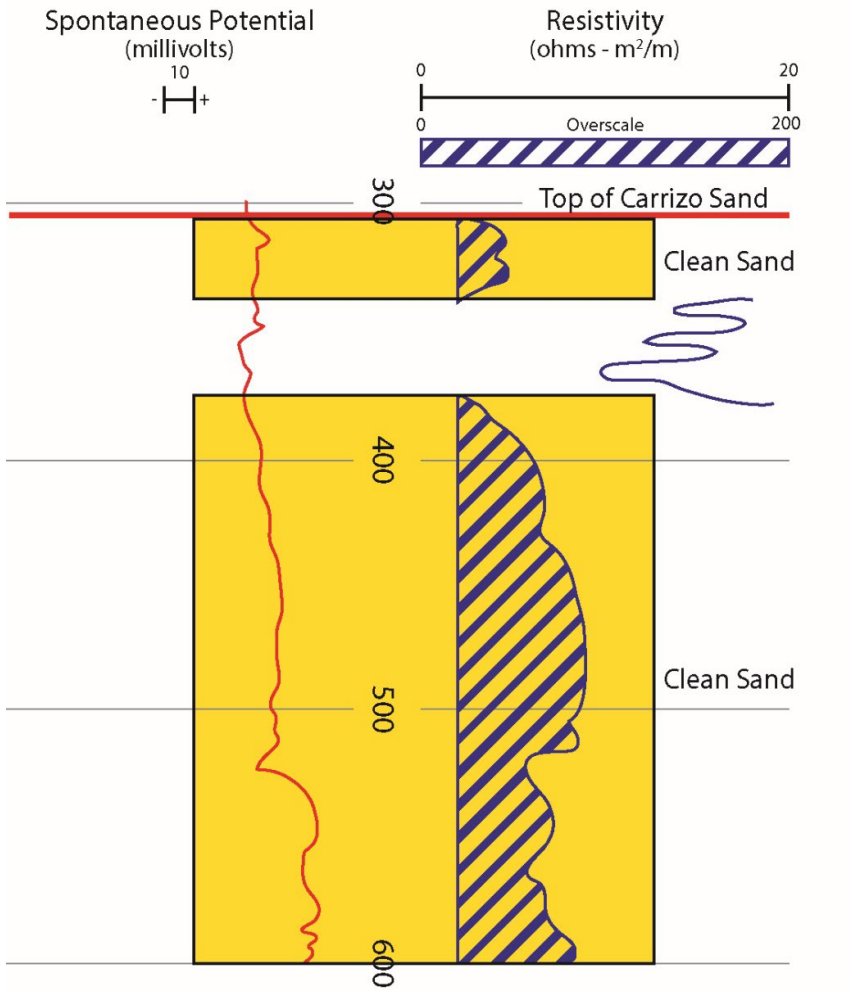
Lithology – results

- **Yoakum Canyon**
  - Located within the Wilcox Group
  - Can be followed for 67 miles from outcrop through the subsurface
  - Cut into the Wilcox Group during deposition and refilled
  - Primarily shale with some isolated sand beds near top of unit
- **Carrizo Sand that overlies the Yoakum canyon is distinct from the surrounding strata**
  - Generally thicker with more overall net sands
  - Individual sand units are thinner and vertically isolated
  - Permeability is generally lower (lower resistivity)

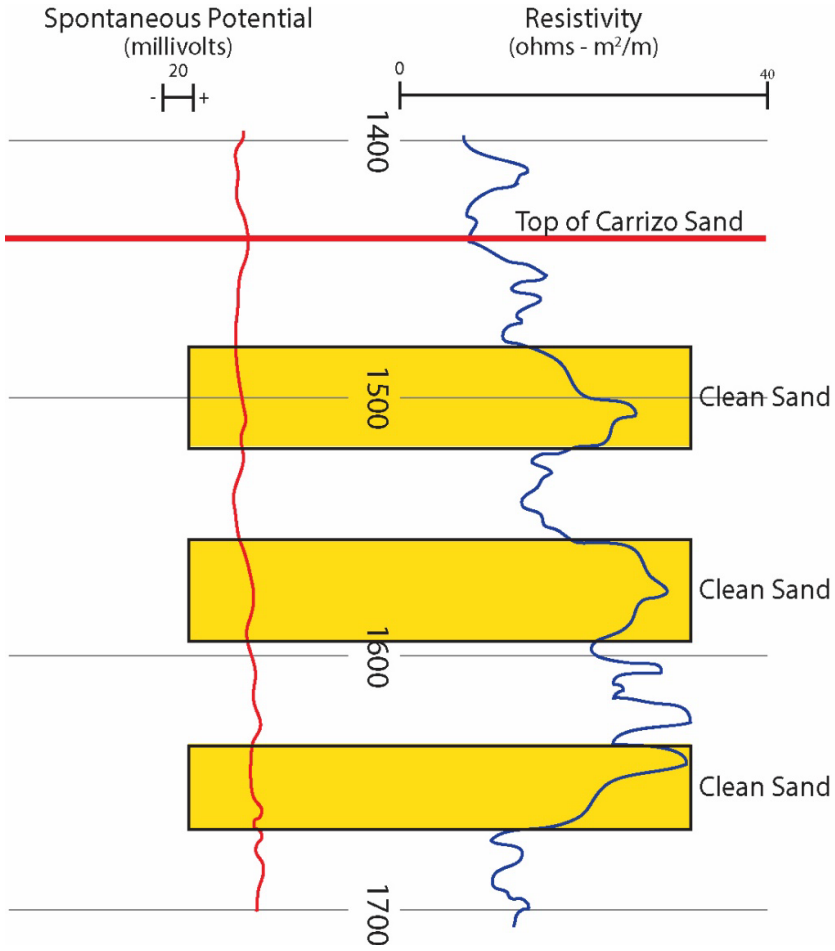


Lithology – results

Typical Carrizo Sand in the study area



Carrizo Sand overlying the Yoakum Canyon



Questions on the lithology?

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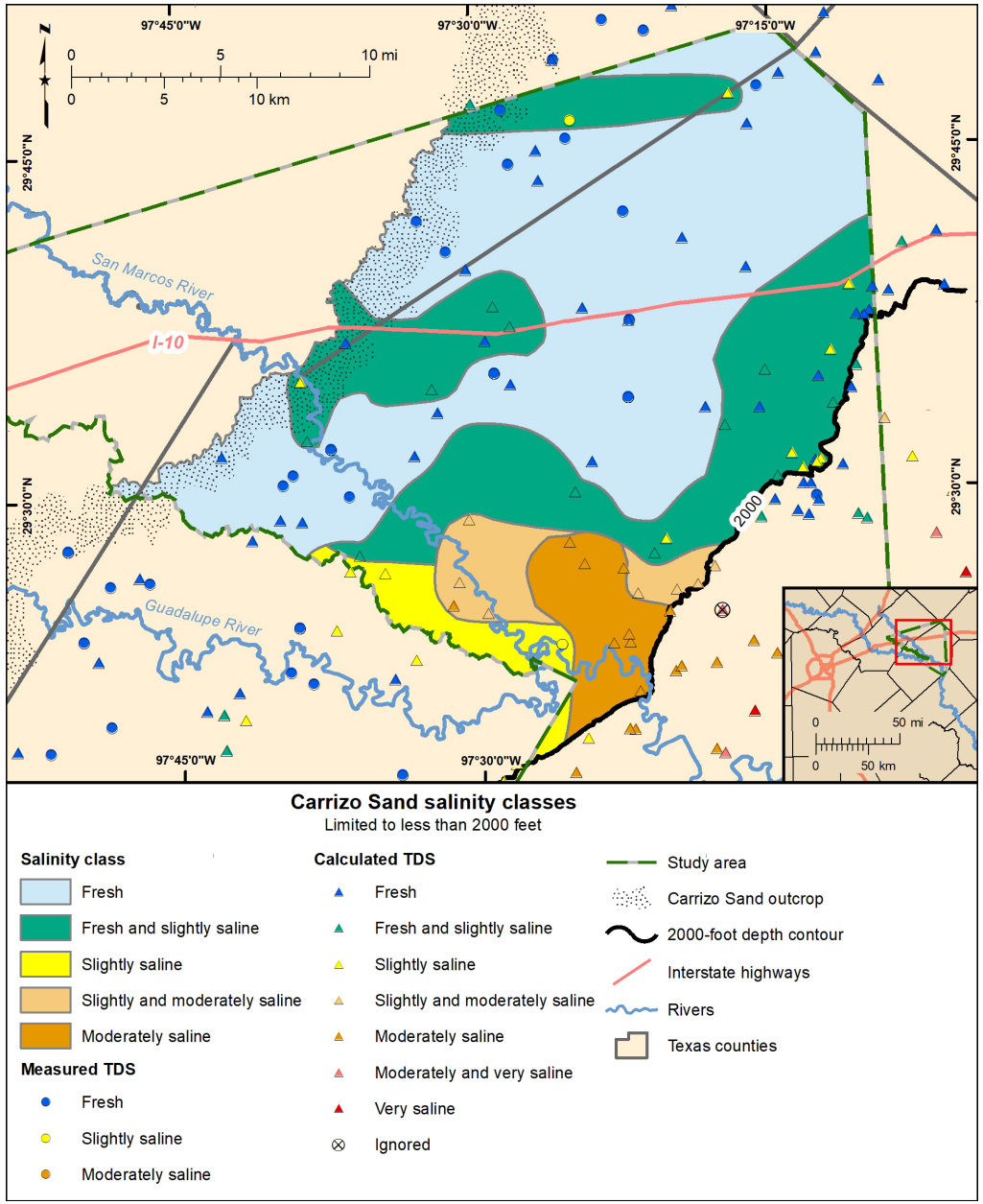
Groundwater salinity – why?

- Water quality of the native groundwater is an important hydrogeological characteristic for ASR
- Salinity is an important water quality parameter and has implications for an ASR project:
  - designing a well
  - planning operations and establishing a buffer volume
  - water treatment requirements

Groundwater salinity – how?

- Collected total dissolved solids (TDS) values from available measured water quality data
  - Most measured water quality samples come from water wells
- Measured water quality is not available in downdip area of the aquifer, so TDS was calculated from geophysical well logs
  - Values were calculated using the relationships between TDS, specific conductance, and formation resistivity
- Salinity class maps were created using both measured and calculated TDS values

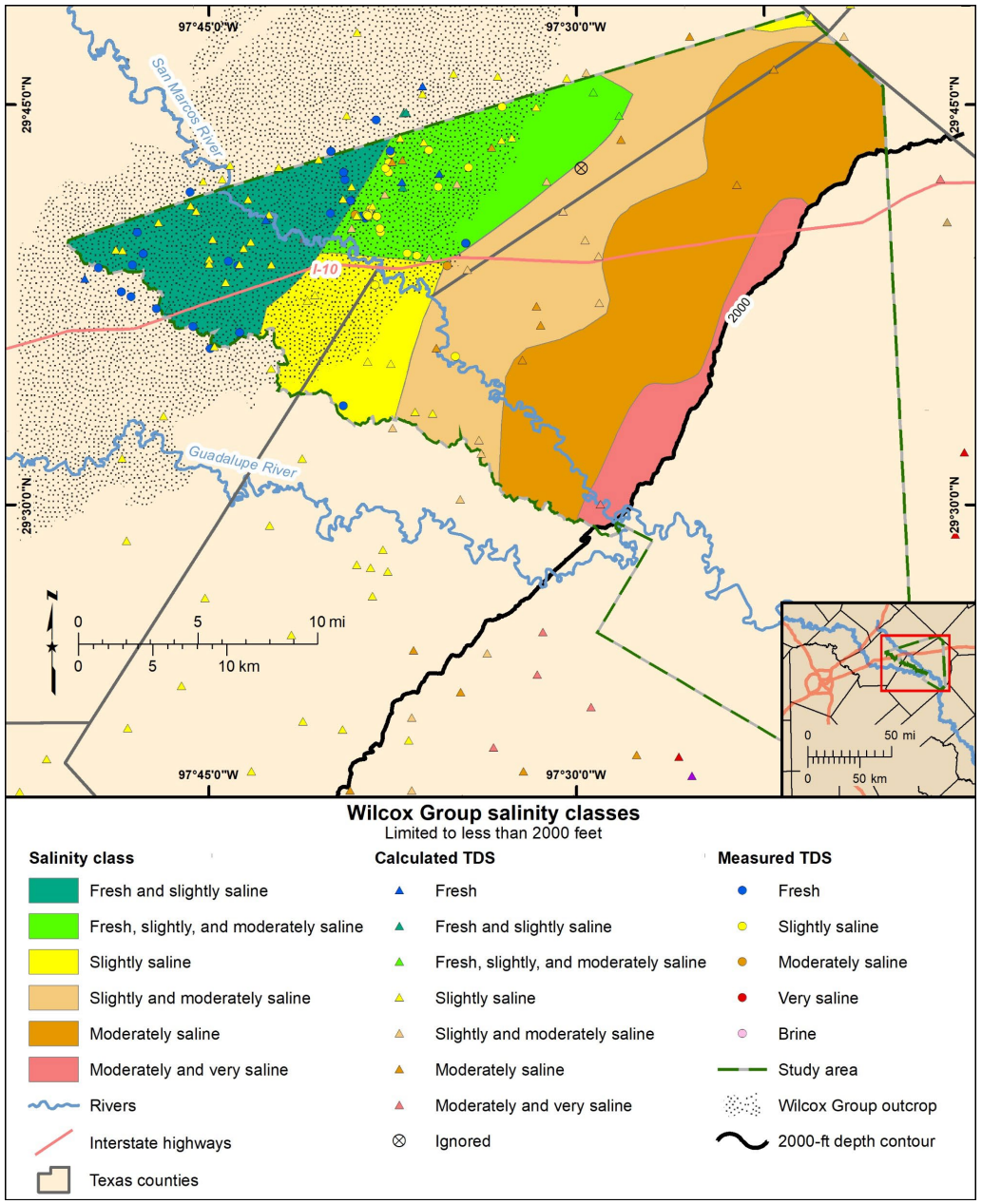
Groundwater salinity – results



Carrizo Sand

- 20 wells with 80 measured water quality samples
  - 7 fresh samples, 72 slightly saline samples, and 1 moderately saline sample
- 123 well logs for TDS calculations
- 164 salinity class intervals were assigned:
  - 63 fresh
  - 56 slightly saline
  - 35 moderately saline
  - 8 very saline
  - 2 brine
- Analysis was limited to 2,000 feet below ground surface

Groundwater salinity – results



Wilcox Group

- 50 wells with 90 measured water quality samples
  - 37 fresh samples, 51 slightly saline samples, and 2 moderately saline samples
- 168 well logs for TDS calculations
- 227 salinity class intervals were assigned:
  - 12 fresh
  - 82 slightly saline
  - 72 moderately saline
  - 57 very saline
  - 4 brine
- Wilcox can reach over 8,000 feet deep with a thickness of over 3,000 feet
- Analysis was limited to 2,000 feet below ground surface

Questions on the groundwater salinity?

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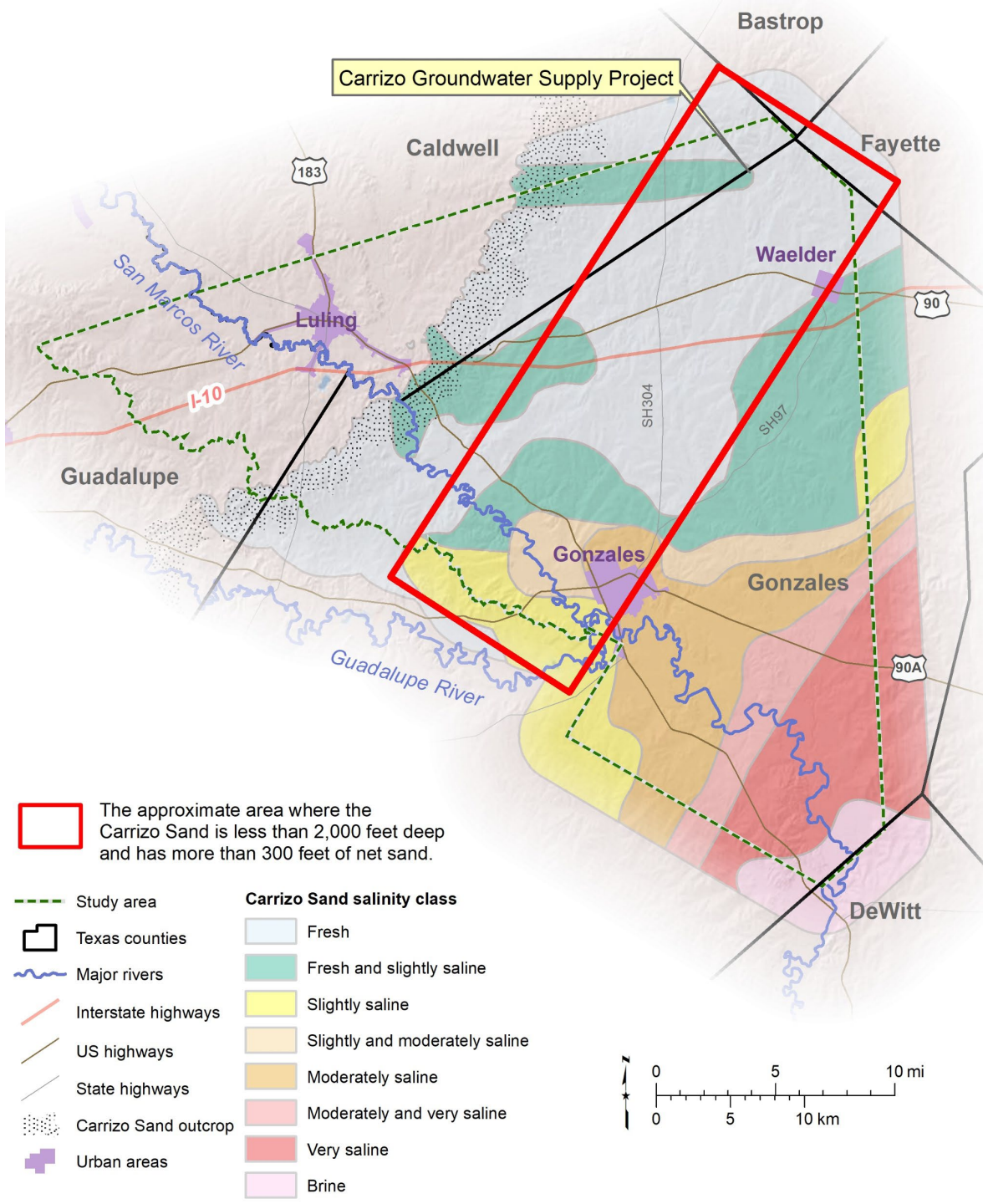
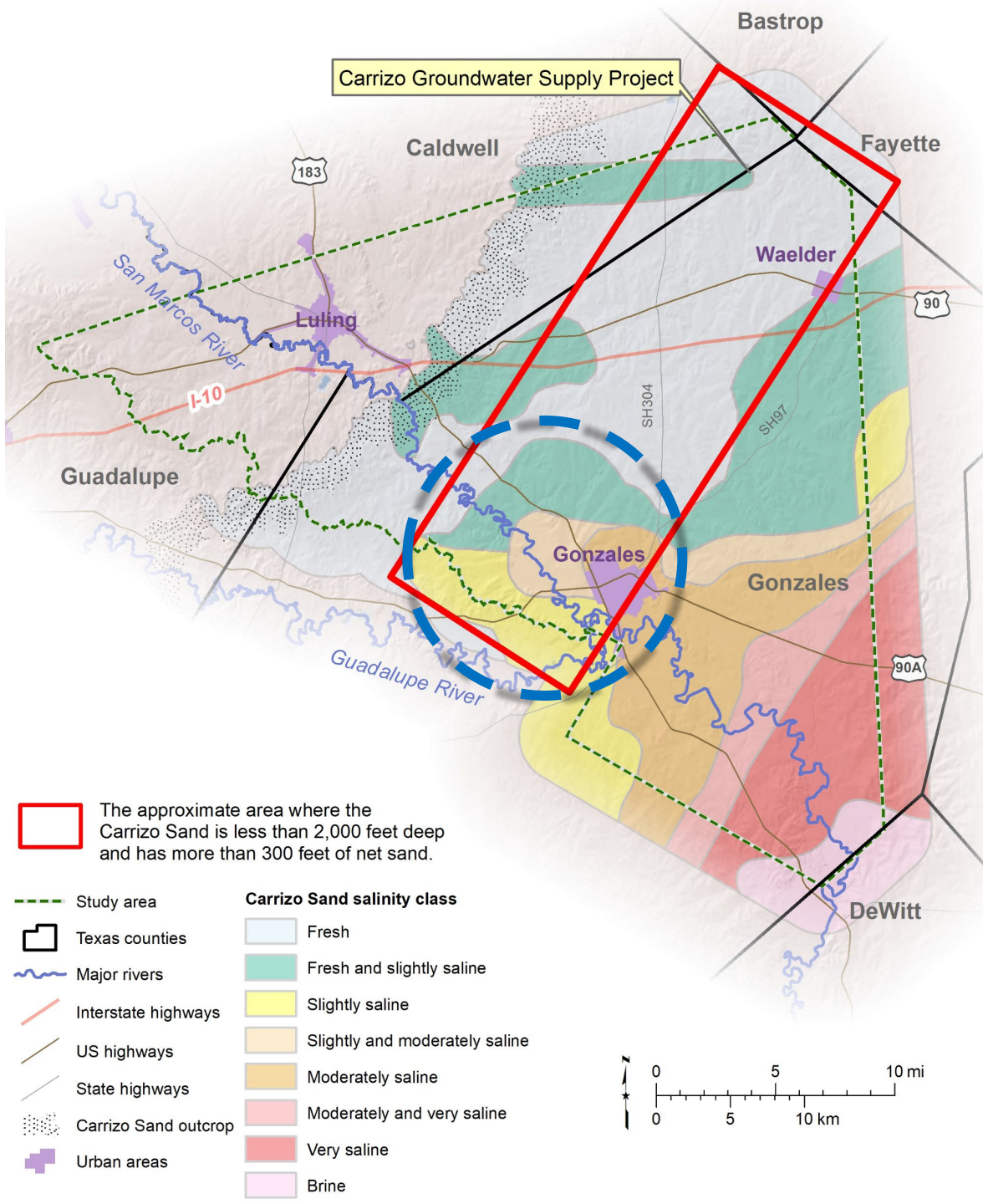
Discussion – site selection considerations

- Carrizo Sand is the better candidate for ASR based on stratigraphy, lithology, and water quality
- The middle third of the study area, Carrizo Sand contains ≥300ft of net sand <2,000ft below the ground surface
- Wells deeper than 2,500 ft would require costly multi-stage pumping
- The SAWS ASR project screens ~250ft of the Carrizo Sand



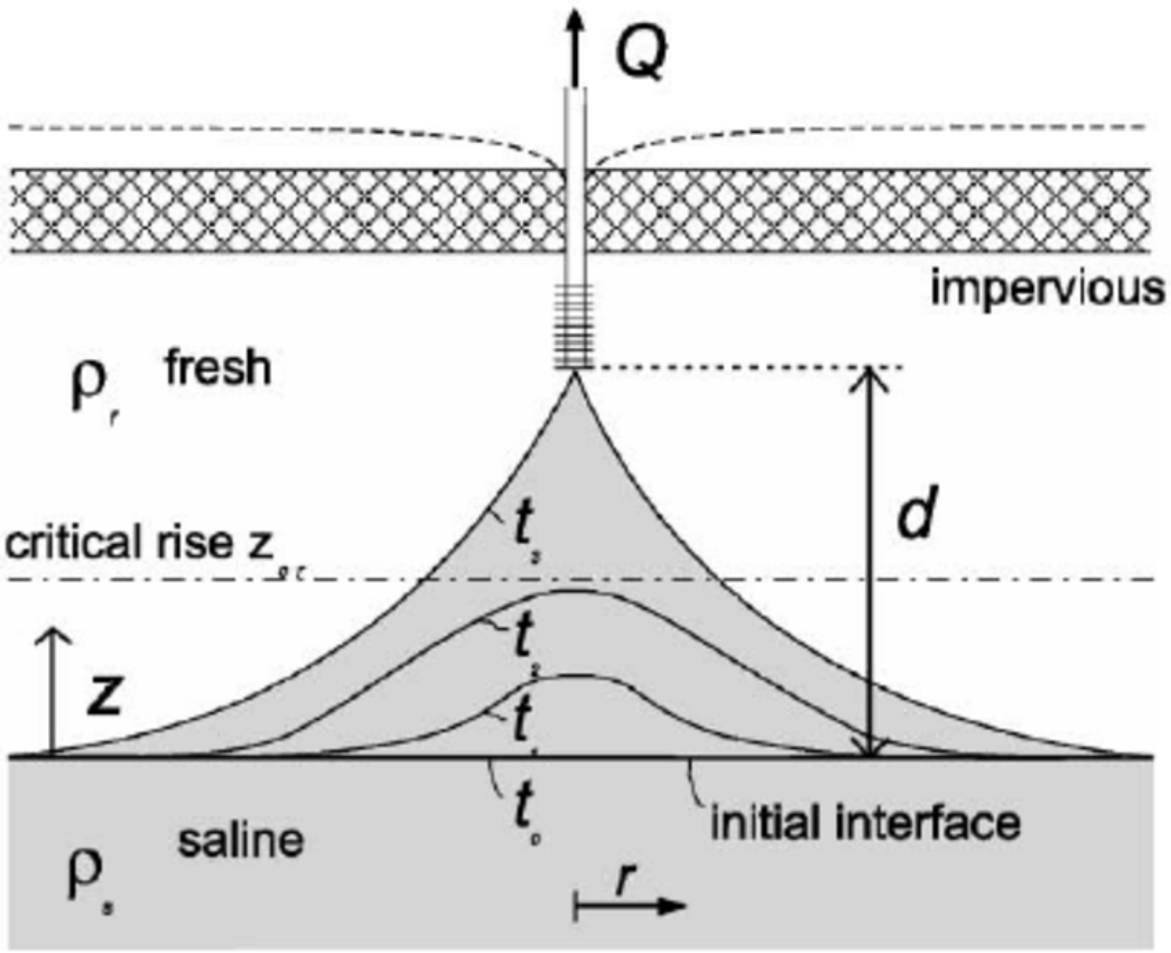
Discussion – site selection considerations

- Zone of higher salinity near the City of Gonzales
- This higher salinity zone is close to the Guadalupe River, which is the source of injected water for the project
- Site section will need to take all these considerations into account along with current and future regional infrastructure



Discussion – well construction

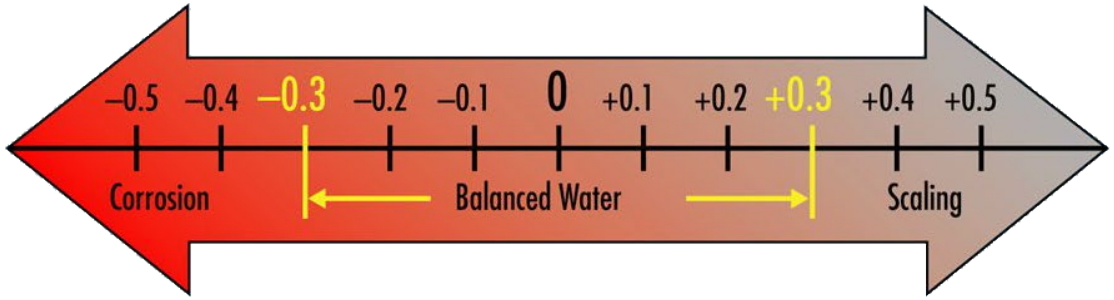
- Water quality (injected and native) has implications on well design, construction, and operations
  - Interbedded clays may lead to lower water quality
  - More saline environments will require more water loss to establish a buffer
  - The units contain many stacked salinity zones so potential drawup of more saline water may be a concern



From Essink (2001)

Discussion – well construction

- Chemical compatibility
  - Corrosive of encrusting groundwater conditions
  - Langelier Saturation Index (LSI) –shows whether water will be encrusting (positive) or corrosive (negative)
- Carrizo Groundwater Supply Project (Phase I) wells 1-3 have an LSI from -2.30 to -2.55 (corrosive) so plan casing material accordingly



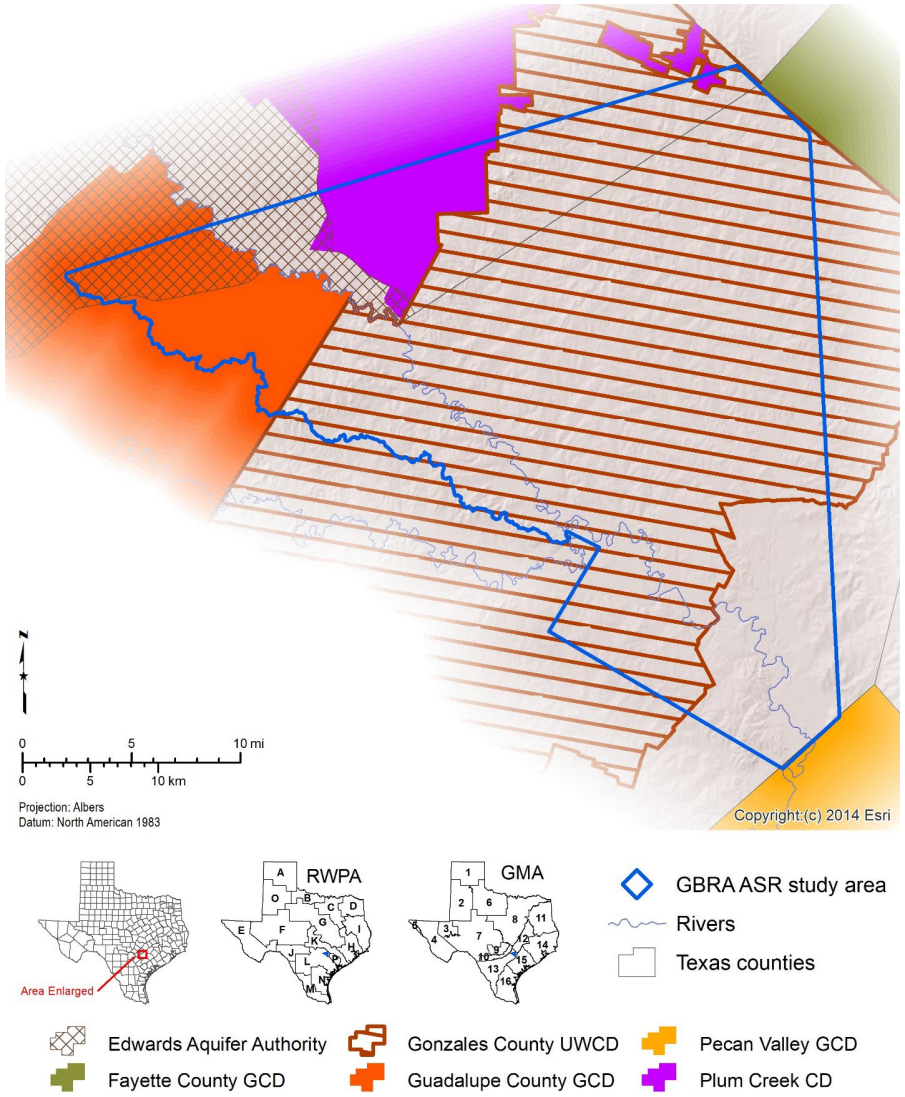
$$LSI = pH + \log\left(\frac{K_a \cdot \gamma_{Ca^{2+}} \cdot [Ca^{2+}] \cdot \gamma_{HCO_3^-} \cdot [HCO_3^-]}{\gamma_{H^+} \cdot K_{sp}}\right)$$

Discussion – limitations

- Aquifer characteristics are only one component of site selection and future work may include
  - Engaging potential stakeholders;
  - Evaluating existing and planned infrastructure;
  - Estimating total project costs;
  - Investigating environmental impacts; and
  - Calculating economic viability.
- Collection of well-field scale data on water quality and hydrogeology is recommended to evaluate a final site location for an ASR field and associated system.

Discussion – regulation and permitting

- Implementation of ASR projects is regulated by the Texas Commission on Environmental Quality (TCEQ) Underground Injection Control Program
- ASR wells permitted as Class V injection wells
- Full regulatory requirements are in 30 Texas Administrative Code § 331



Questions on the discussion section?

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Conclusions

- Publicly available aquifer characteristics of the Carrizo-Wilcox Aquifer for site selection
- ~568 sq. mi. study area, data from 662 wells
- Variability in sand and water quality distribution
- Most favorable hydrogeological characteristics found in a 9 x 25 mi. swath of Carrizo Sand
- Water quality should be considered in well design

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