# Mining Water Use in Texas

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# Acknowledgments & Disclaimers

This study is based on excellent databases maintained by the TWDB, the TCEQ, the TRRC, the US Geological Survey, and the US Energy Information Administration.

We are grateful for thoughtful project management and insights of Katie Dahlberg and Yun Cho of the TWDB. We are also grateful for cooperation provided by C. J. Tredway of the Texas Oil and Gas Association.

This study was funded by the USGS under Cooperative Agreement No. G20AC00339. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Geological Survey. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Geological Survey.

# Project Overview

**Oil and Gas Industry**

- Quantify current and historical water use for hydraulic fracturing (HF) and produced water (PW) volumes
- Identify the sources and quality of water for hydraulic fracturing
- Develop projections of future water demand for hydraulic fracturing for oil & gas (2030–2080)

**Coal Mining**

- Identify locations of operations and quantify current and projected future water use for coal mining

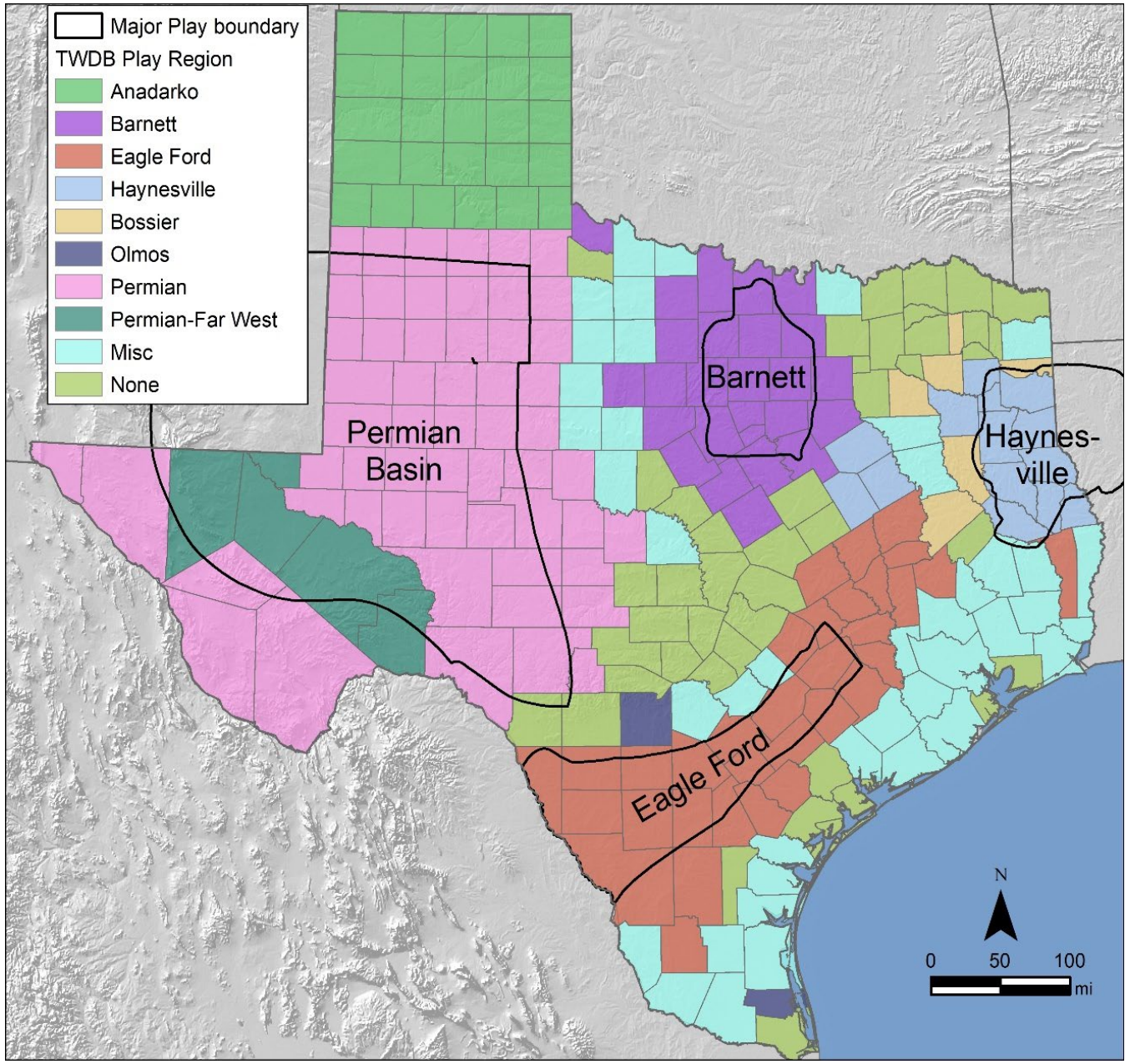
**Aggregates Mining**

- Identify locations of operations and quantify current and projected future water use for aggregates mining

# Hydraulic Fracturing (HF) – Sources & Methods

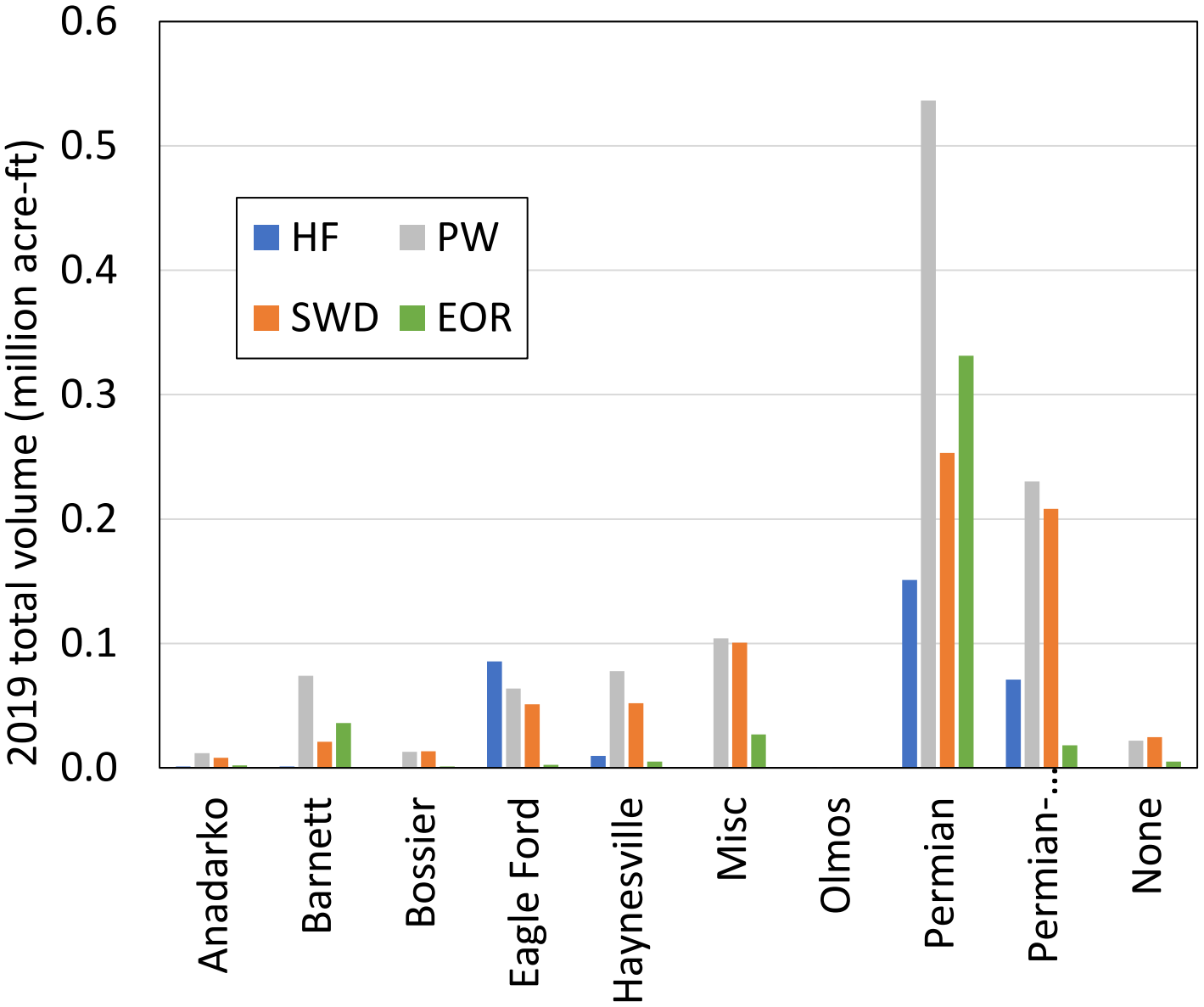
| | |
|---|---|
| Water Volumes | IHS database, FracFocus database, B3 Insight (all sourced from Texas RRC). Includes HF, Produced Water (PW), Salt Water Disposal (SWD), and Enhanced Oil Recovery (EOR). |
| HF Water Quality | FracFocus database, TWDB groundwater database, Kriged maps of water quality (probability of TDS > 1000 mg/L) by aquifer from a previous report combined with O&G industry groundwater well locations. |
| HF SW/GW splits | General water source availability and industry reporting. |
| Projections | Primarily based on of Total Recoverable Resource (TRR) analysis and population growth trends. |

# Oil and Gas Play Regions in Texas



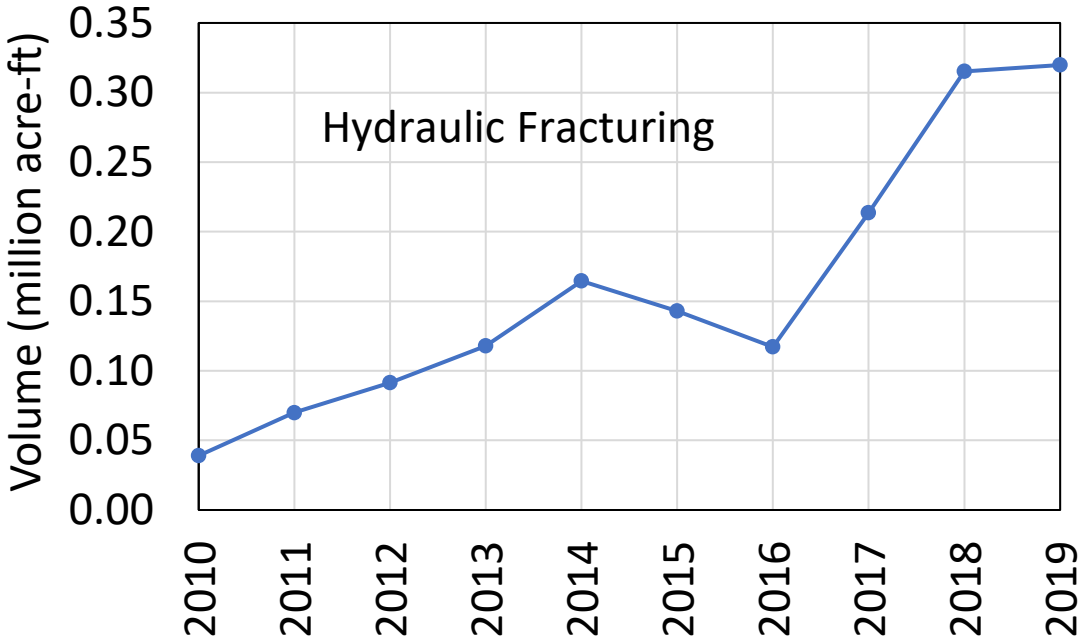

- Distribution of oil and gas plays and regions in Texas for county areas as defined by TWDB (shaded areas).
- Generalized boundaries of the four major unconventional plays (outlined areas).

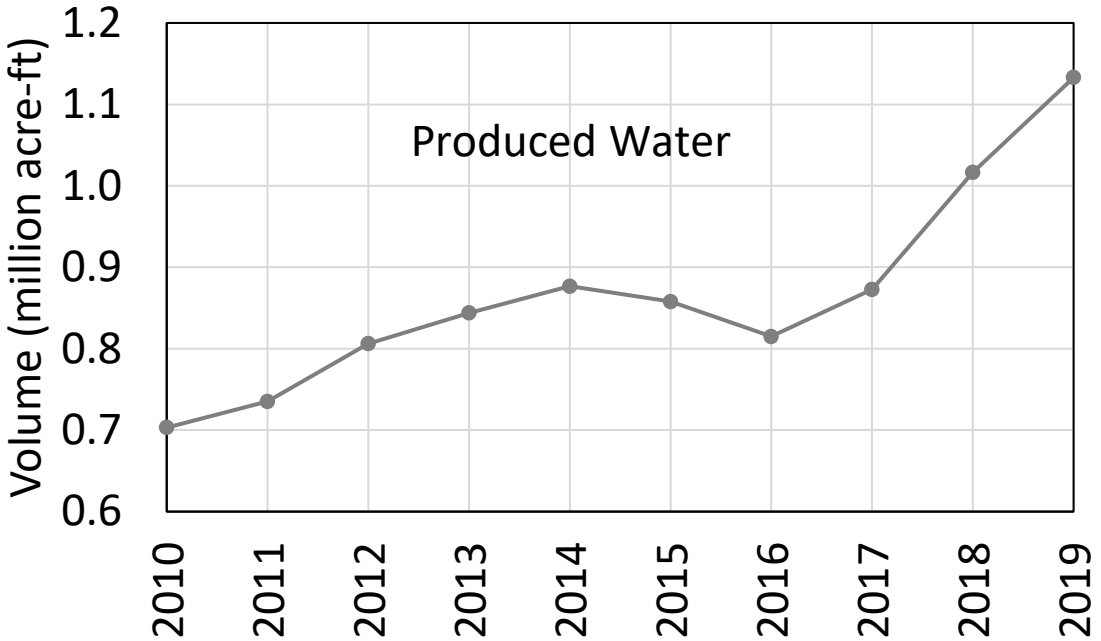
# Oil and Gas Industry Water Volumes in 2019




- Relative volumes of HF, PW, SWD, and EOR by play.
- The Permian Basin (including Far West) dominates in all categories.
- This study focused on the four major unconventional plays:
  - Barnett
  - Eagle Ford
  - Haynesville
  - Permian

# HF and PW Volumes in Texas for 2010-2019



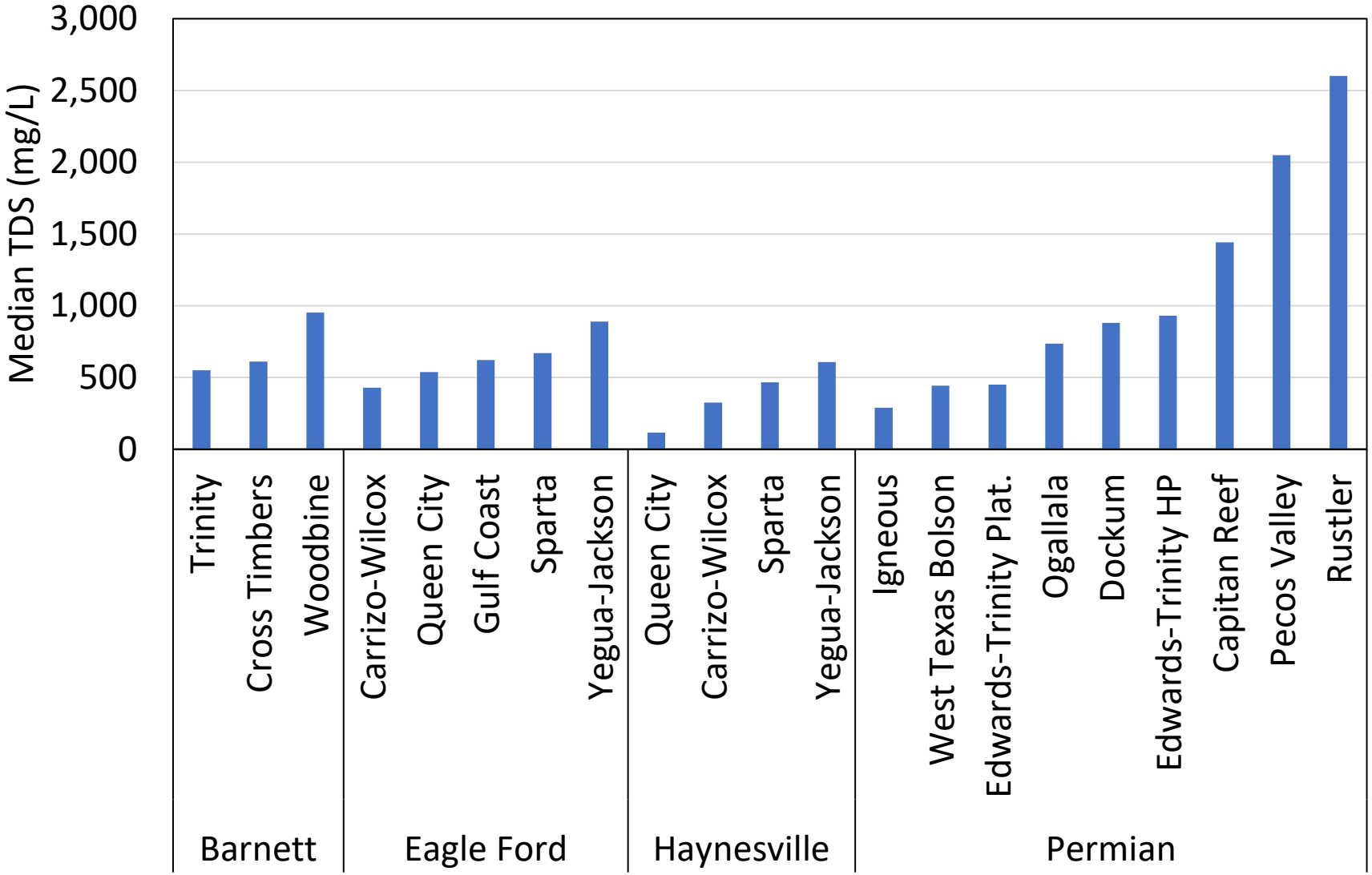

HF increased by ~700%

Currently ~320,000 ac-ft/yr

PW increased by about ~60%

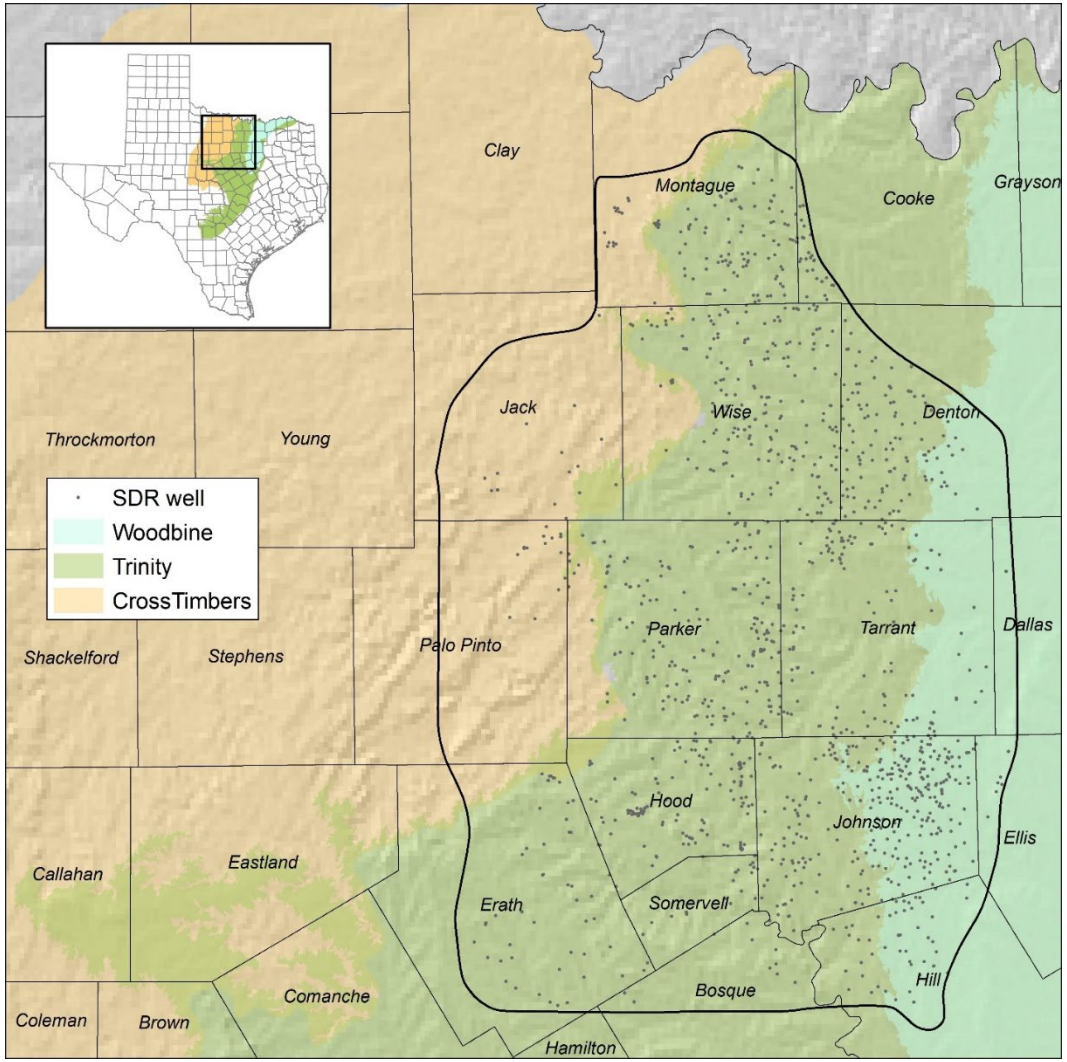
Currently ~ 1,133,000 ac-ft/yr

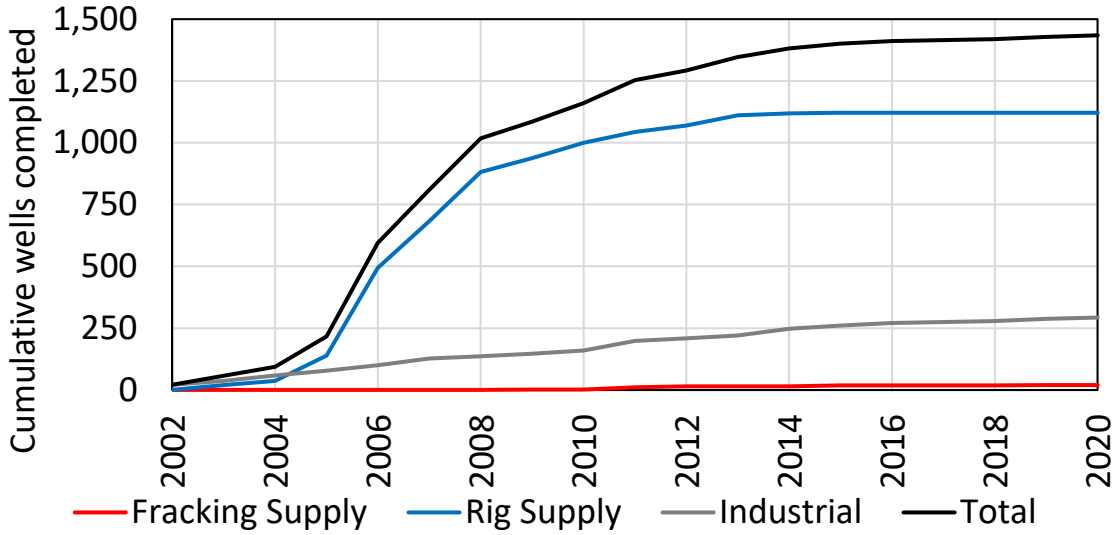
# Groundwater Quality Based on TWDB GW Database




- At the play level, most aquifers have median TDS concentrations <1000 mg/L.
- FracFocus database did not contain significant water source or quality information.

# Barnett Play O&G Groundwater Sources

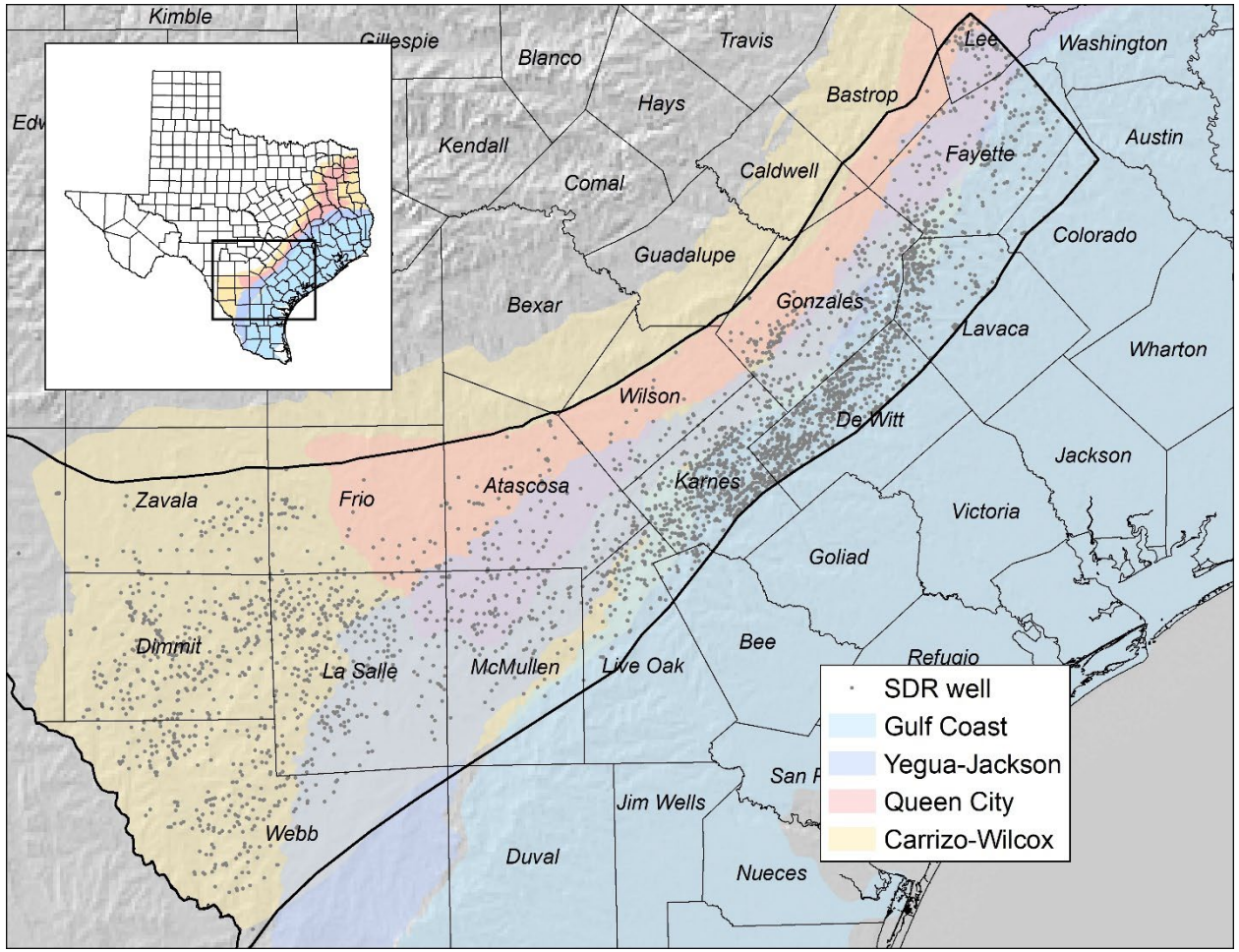


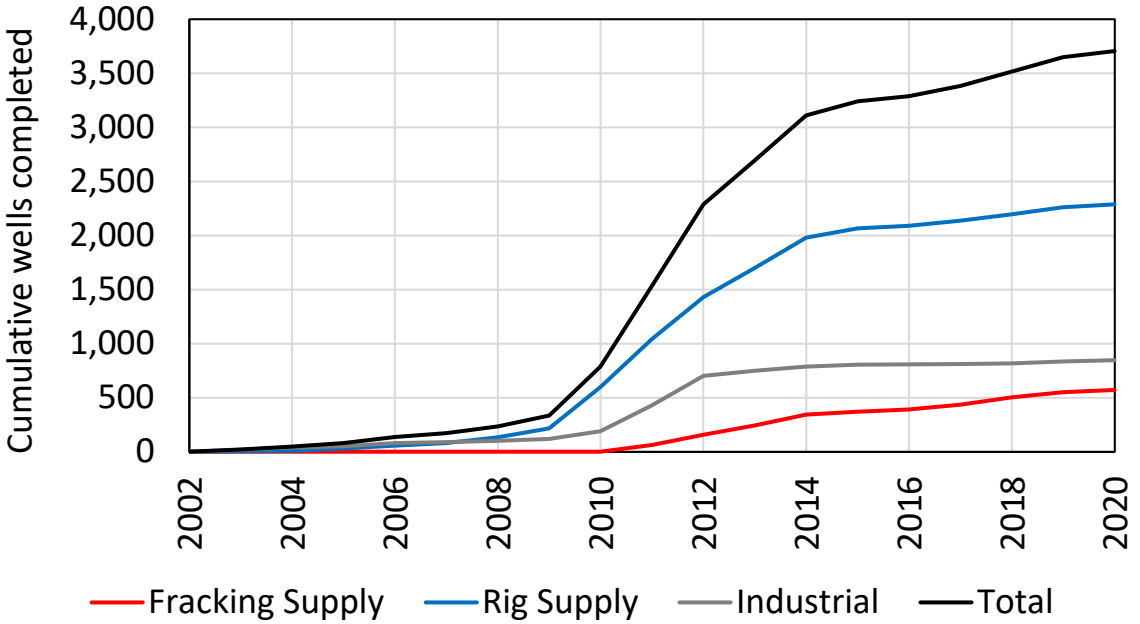




1,448 GW wells completed

- 96% Trinity
- 4% Woodbine & Cross Timbers

# Eagle Ford Play O&G Groundwater Sources

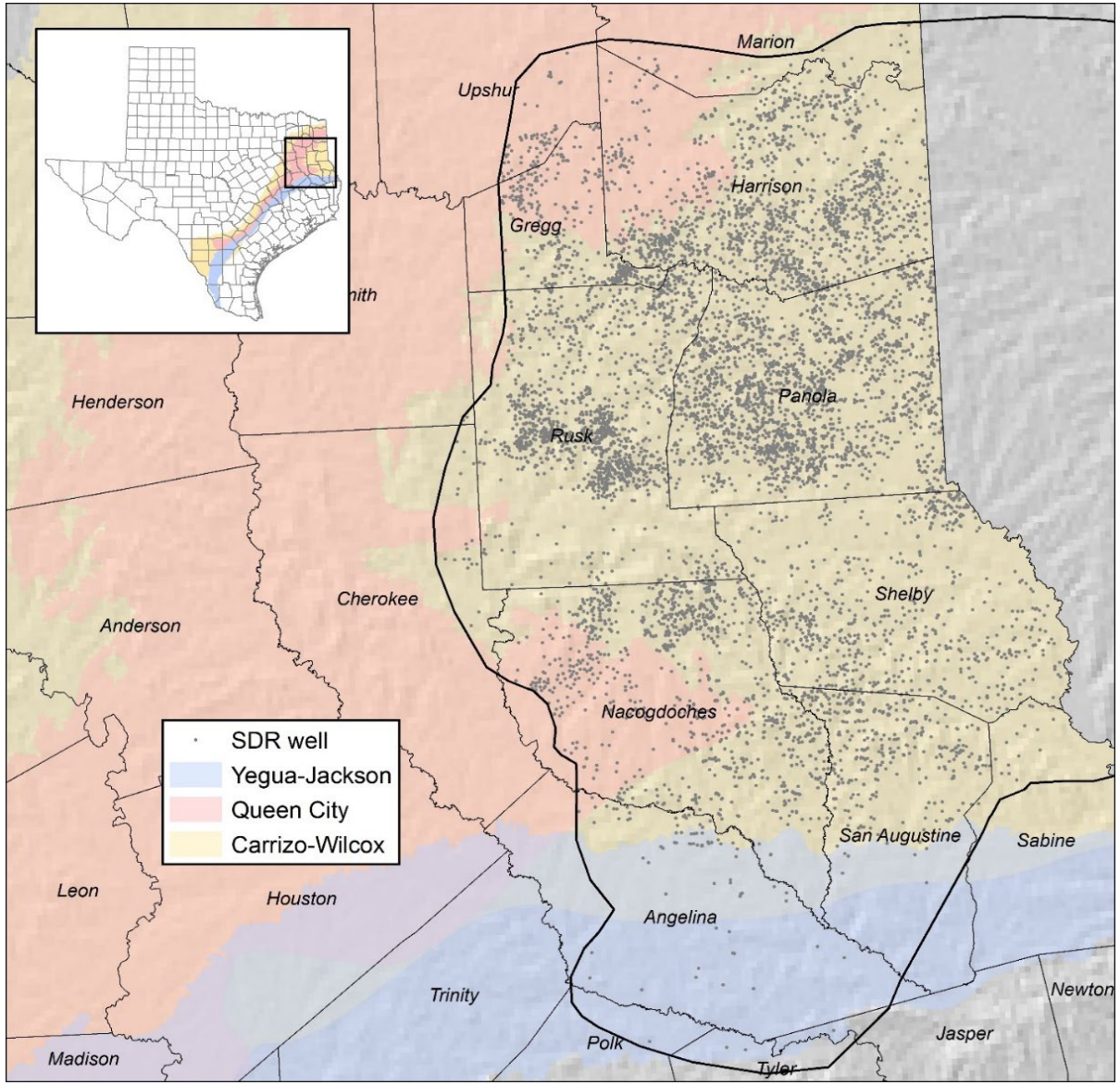


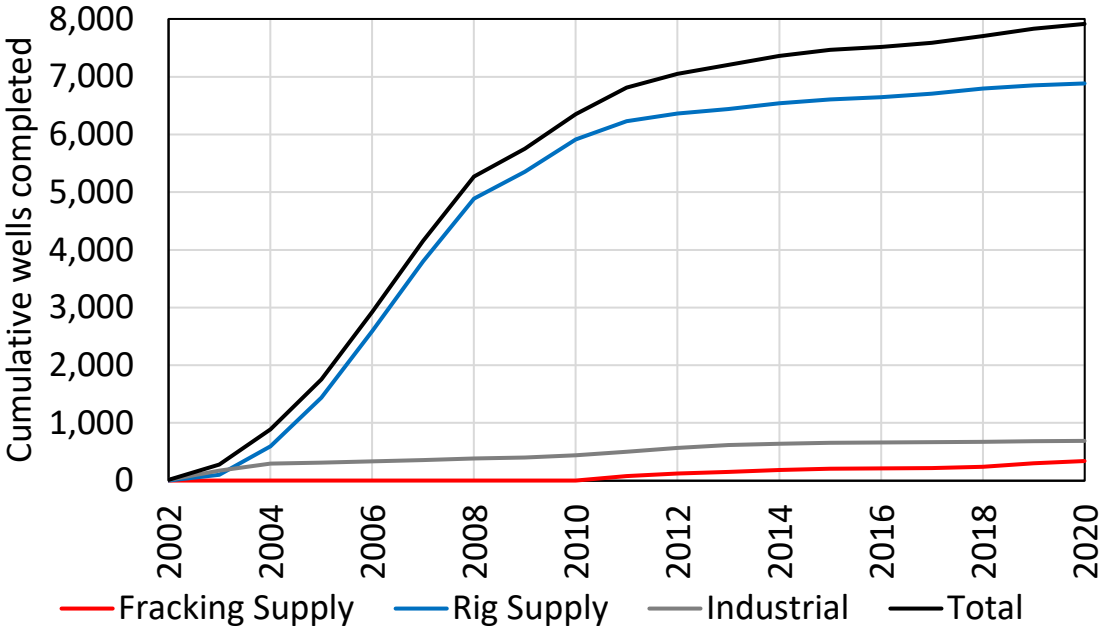




## 3,707 GW wells completed

- 35% Gulf Coast
- 32% Carrizo-Wilcox
- 26% Yegua-Jackson
- 7% Queen City

# Haynesville Play O&G Groundwater Sources

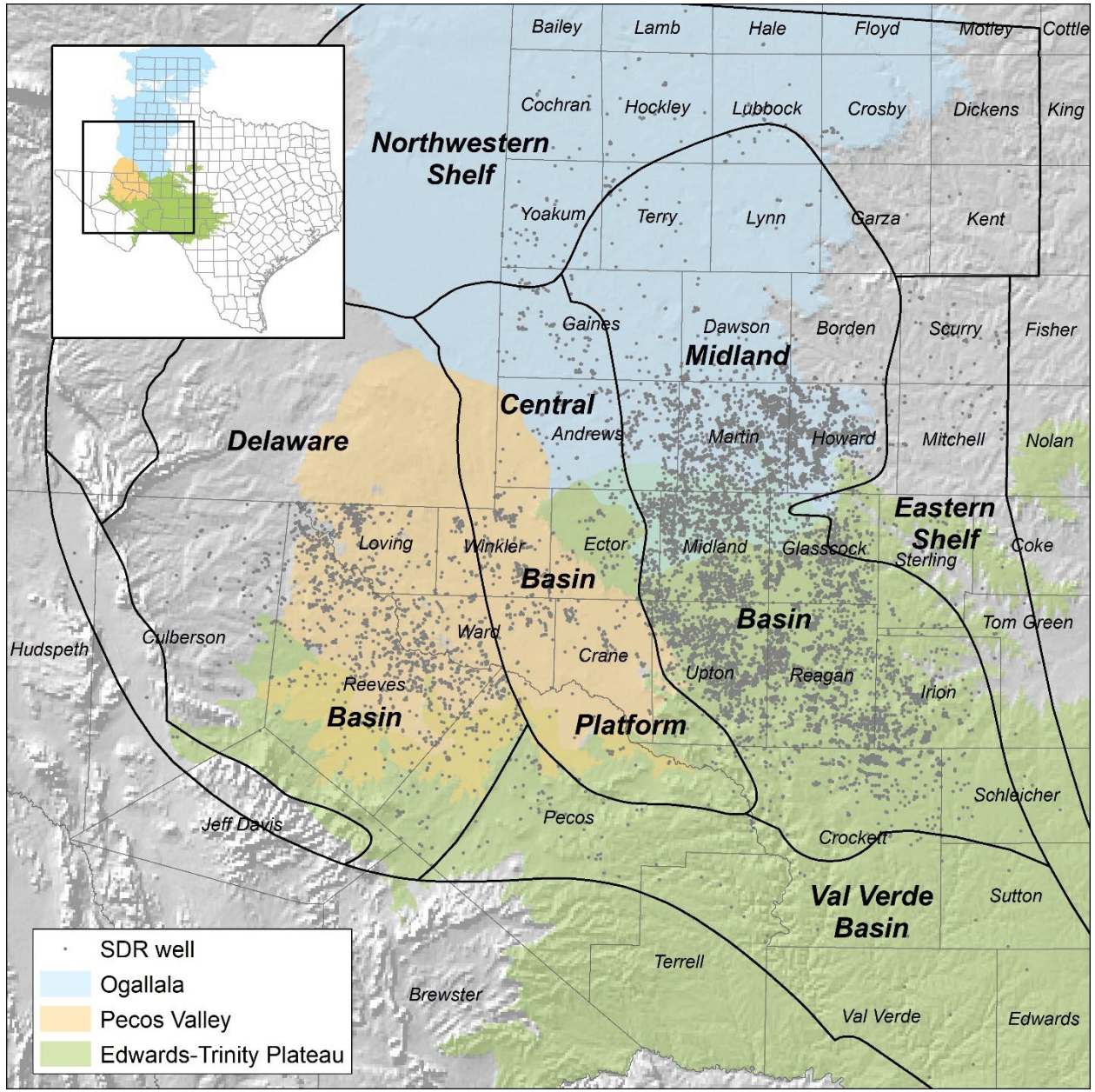


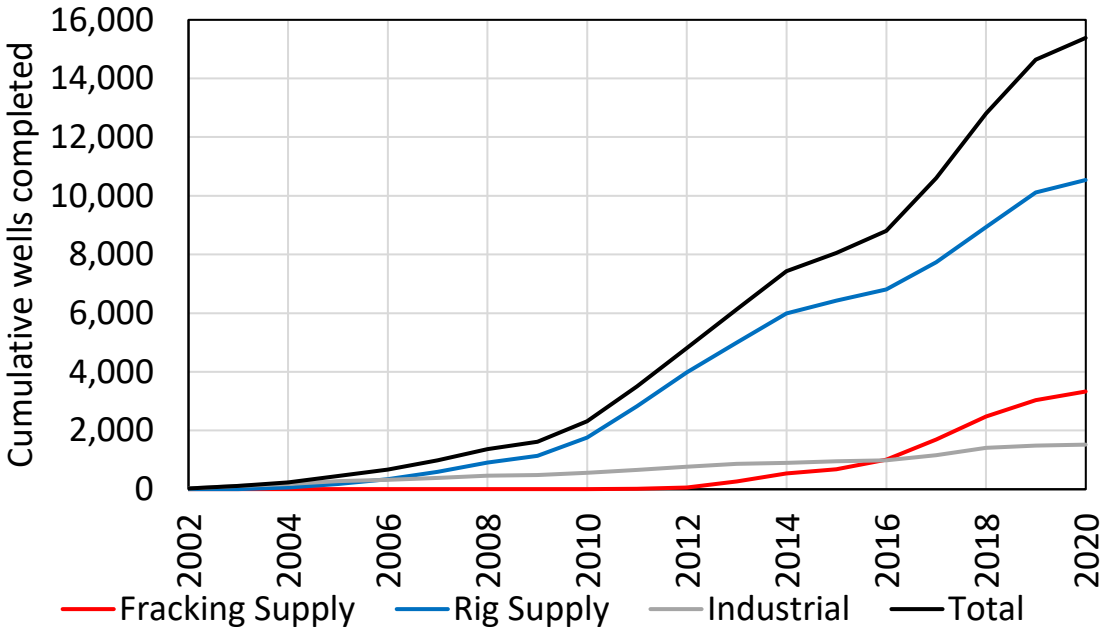




## 7,919 GW wells completed

- 96% Carrizo-Wilcox
- 3% Queen City
- 1% Yegua-Jackson

# Permian Basin O&G Groundwater Sources

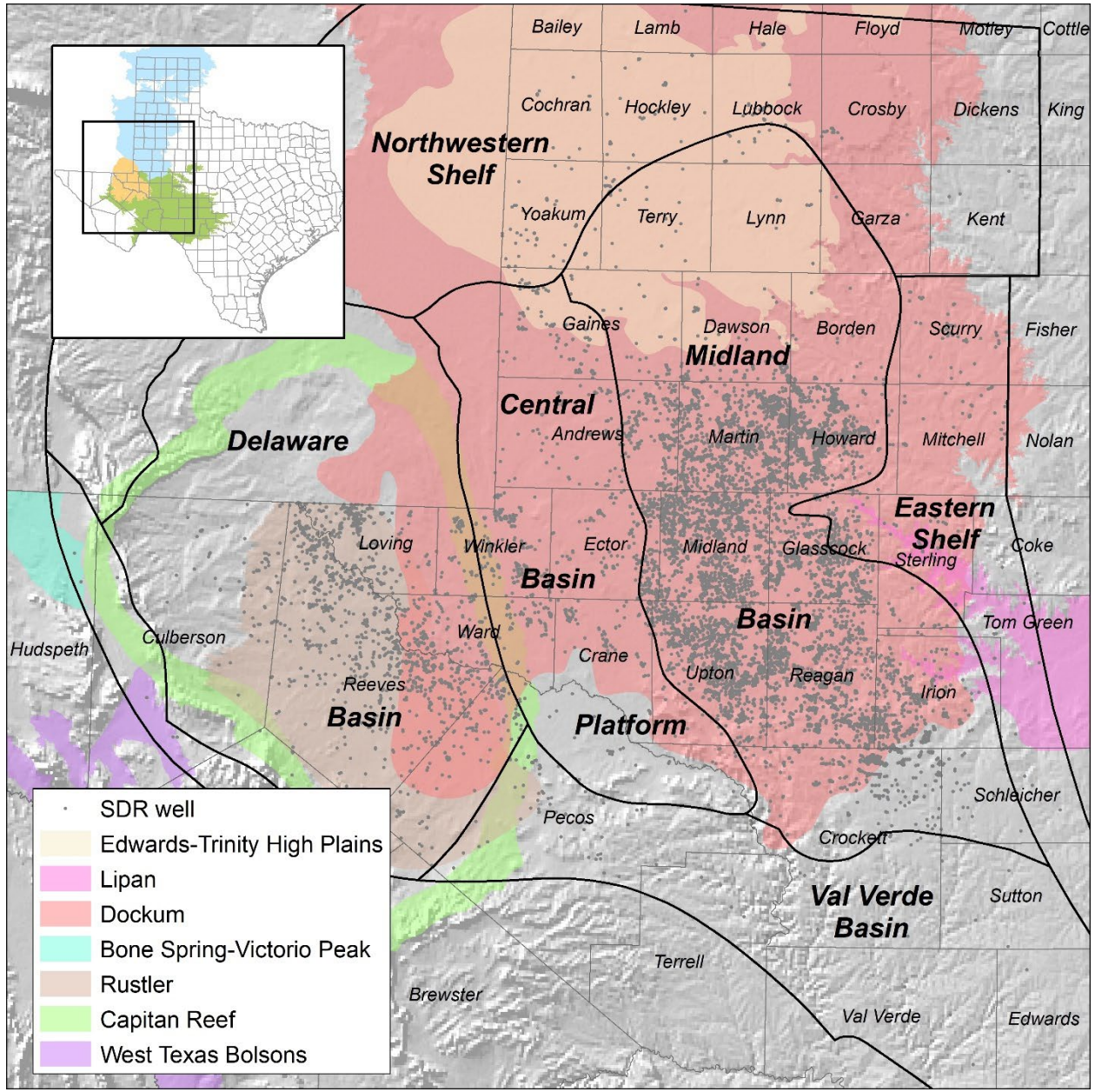


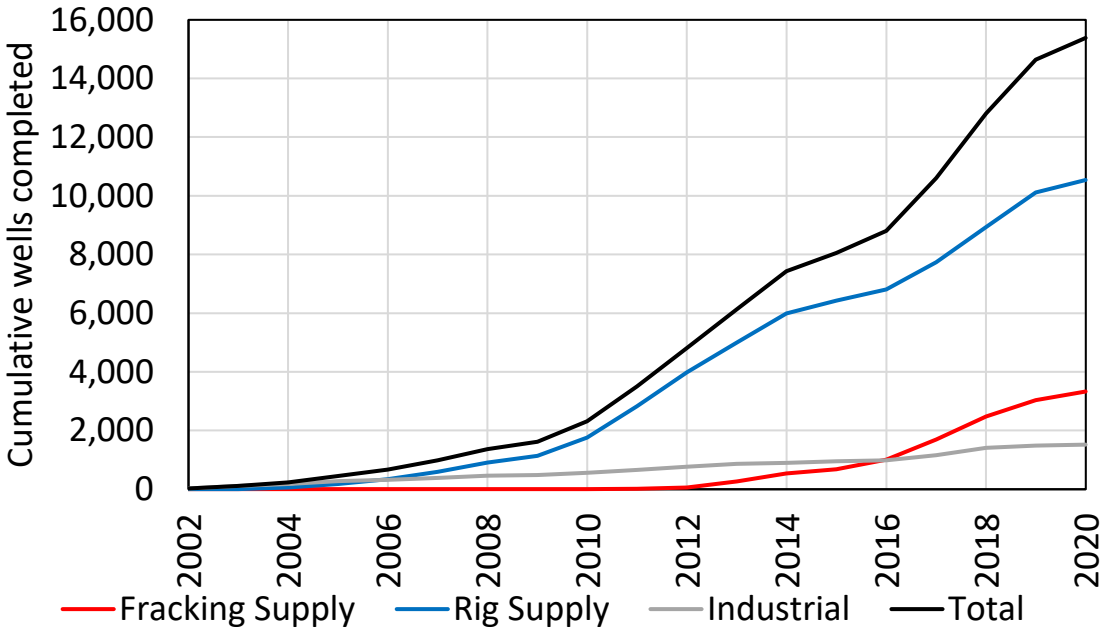




## 15,440 GW wells completed

- 37% Ogallala
- 32% Dockum
- 12% Edwards-Trinity Plateau
- 9% Permian (not mapped)
- 6% Pecos Valley
- 4% all others

# Permian Basin O&G Groundwater Sources




15,440 GW wells completed

- 37% Ogallala
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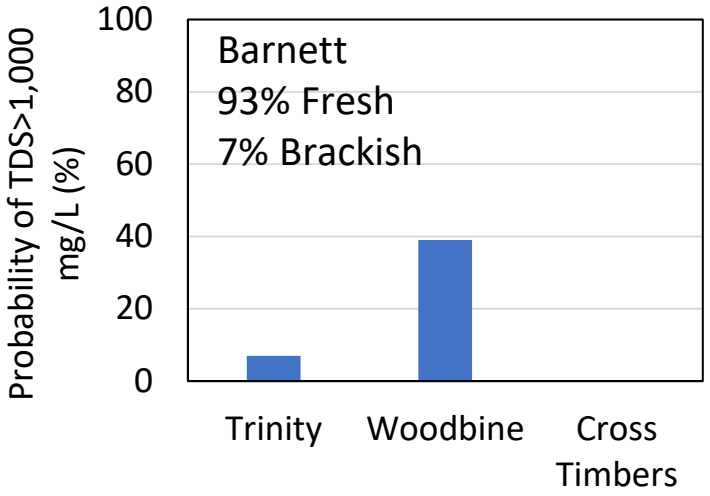
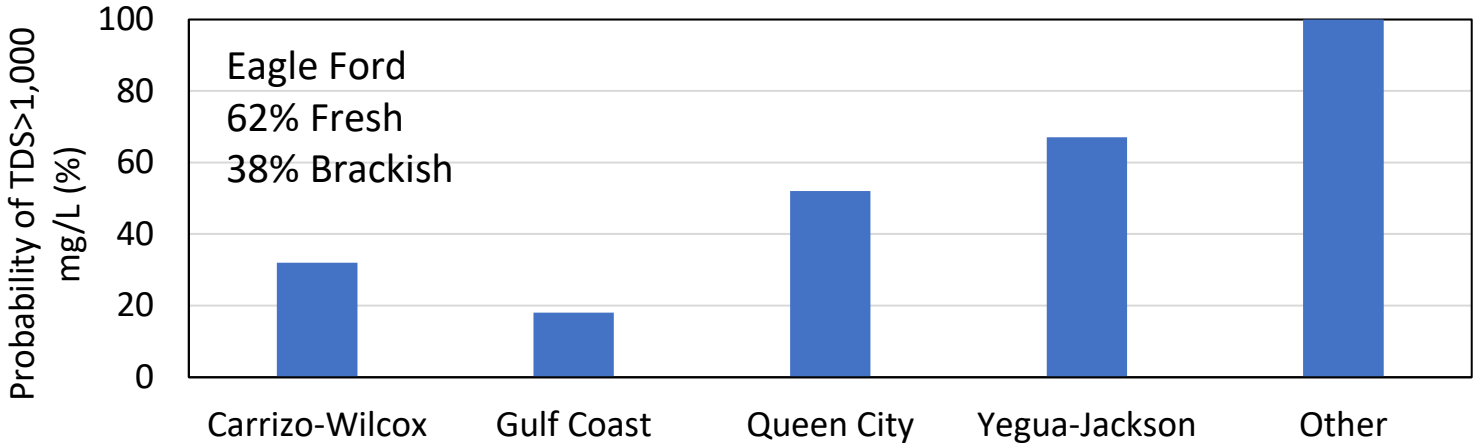
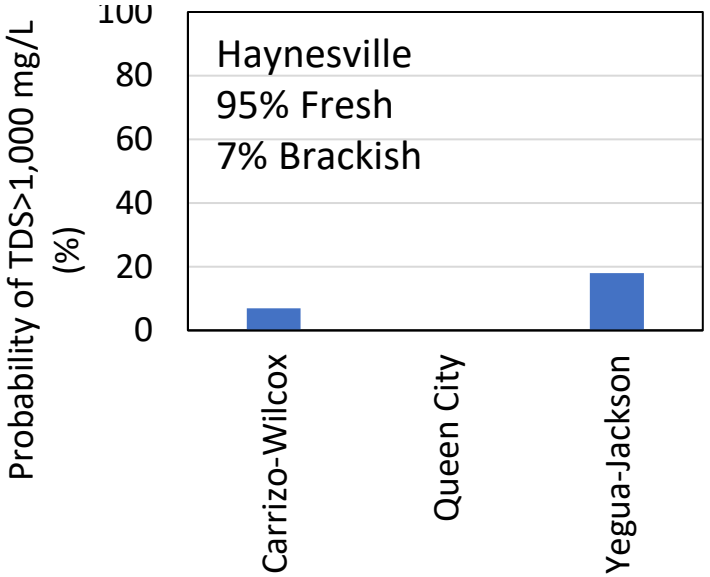
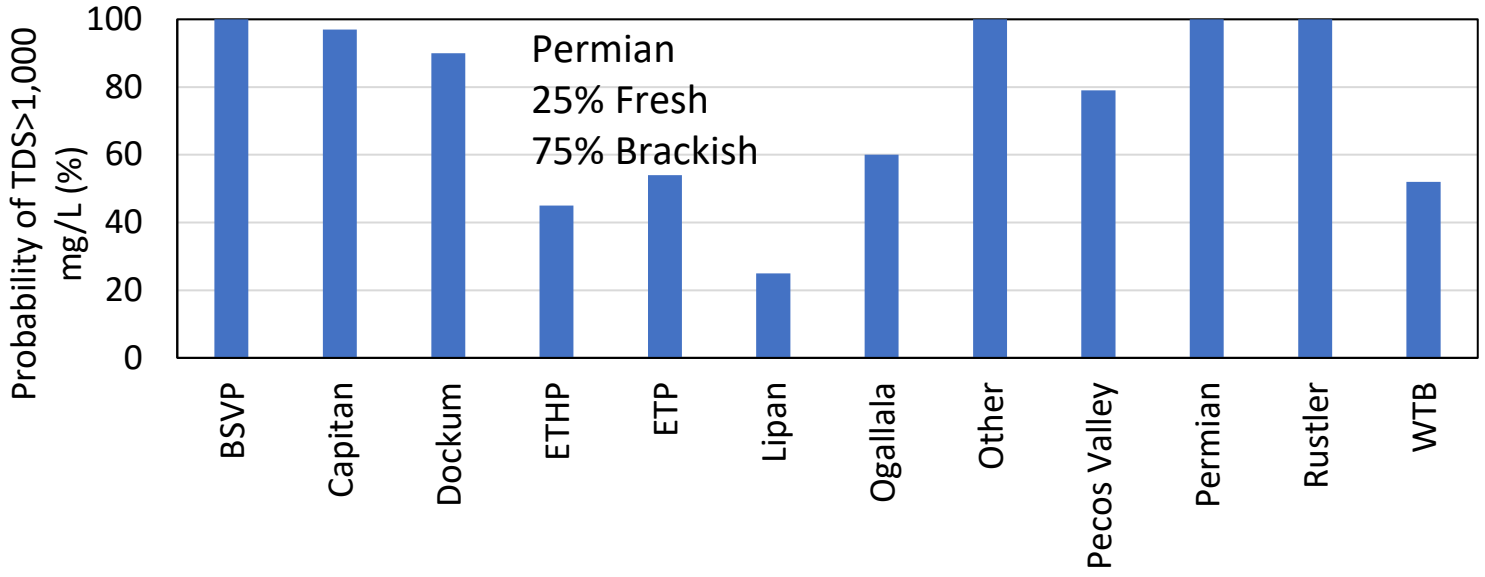
- 9% Permian (not mapped)
- 6% Pecos Valley
- 4% all others

# Estimated Groundwater Quality by Play and Aquifer



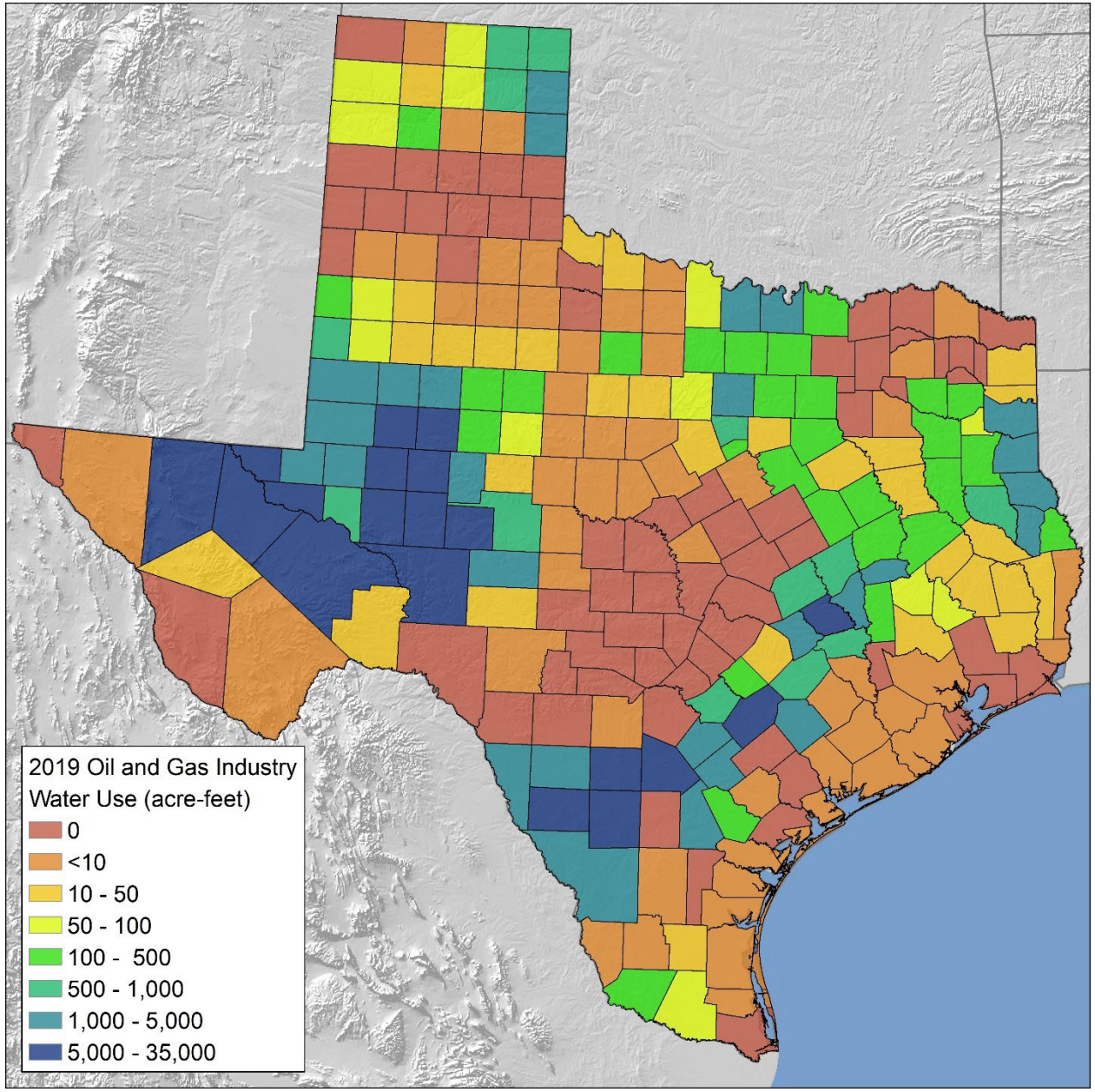




Based on kriged probability values at the locations of the O&G industry groundwater wells.

# Estimated HF Water Sources by Play

| *Play Name* | *GW (%)* | *SW (%)* | *Reuse (%)* |
|---|---|---|---|
| Anadarko | 100 | 0 | 0 |
| Barnett | 100 | 0 | 0 |
| Bossier | 70 | 30 | 0 |
| Eagle Ford | 100 | 0 | 0 |
| Haynesville | 70 | 30 | 0 |
| Misc | 100 | 0 | 0 |
| Olmos | 100 | 0 | 0 |
| Permian | 85 | 0 | 15 |
| Permian-Far West | 85 | 0 | 15 |
| None | 100 | 0 | 0 |
| Statewide | 89 | 1 | 10 |

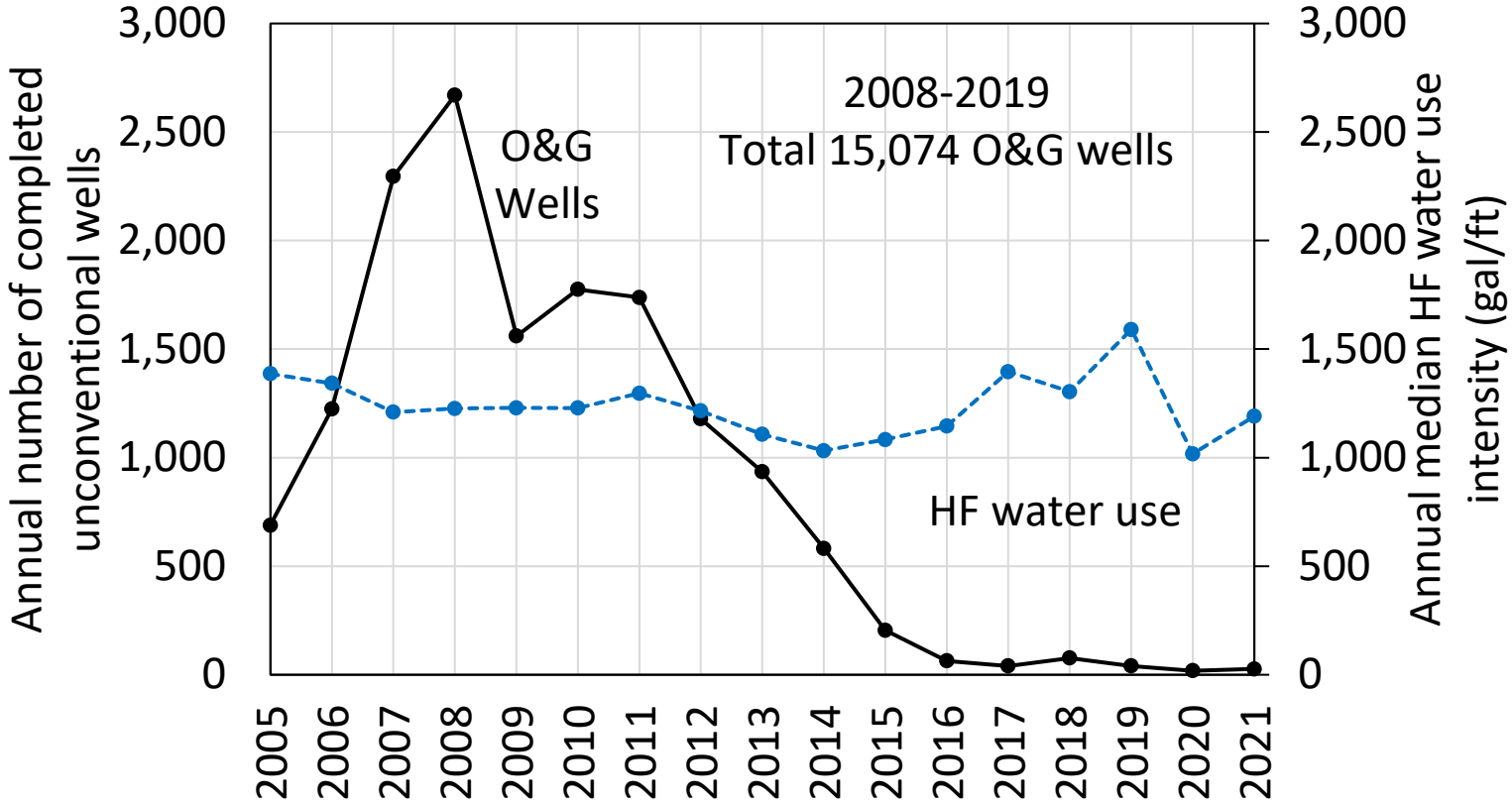
- Groundwater is the dominant source for O&G industry water due to more convenient availability and lower cost relative to surface water.
- Quantification of produced water reuse in the Permian Basin is difficult due to a lack of reporting.

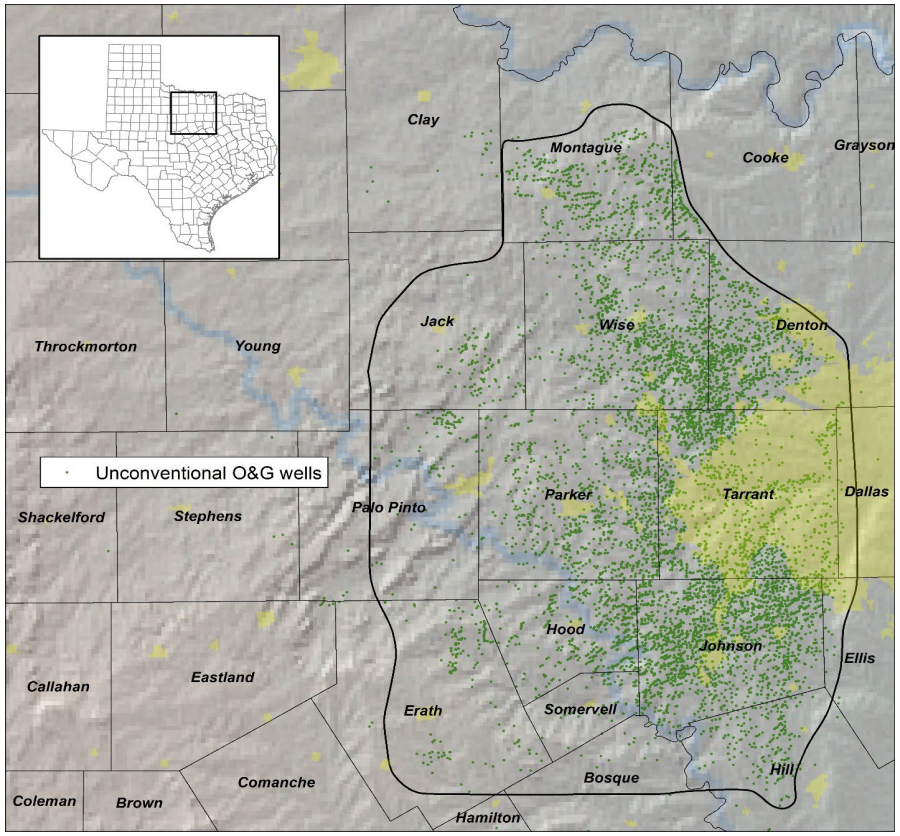



# Total O&G Water Use by County Area

- Statewide total HF water use was 320,000 ac-ft for completion of 11,300 unconventional wells representing 80% of total mining water use.
- Water use was primarily in the Permian Basin (69%) and Eagle Ford Play (27%).
- The Haynesville represented 3% and all other areas combined represented 1%.

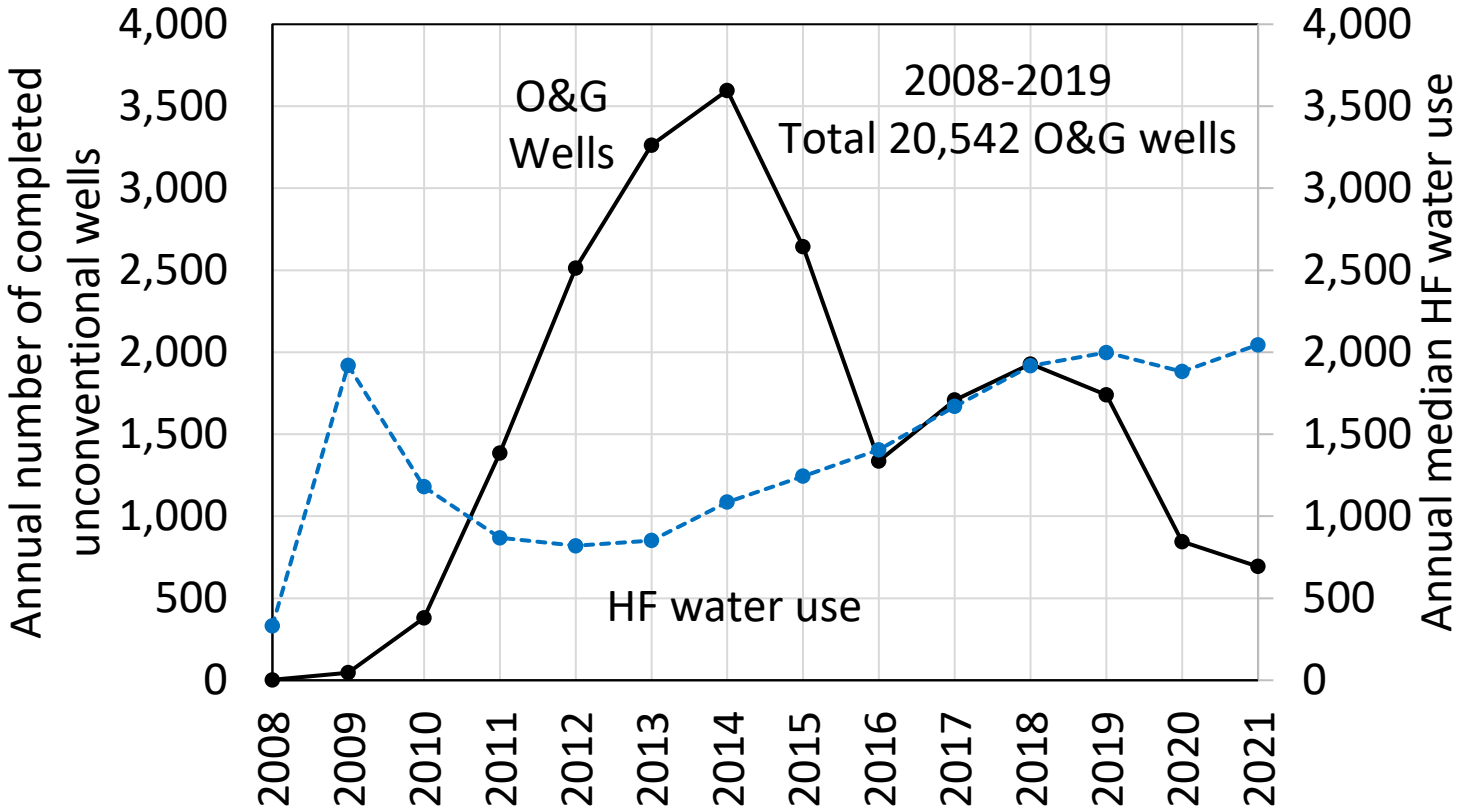
# Barnett Play HF Water Use Projections

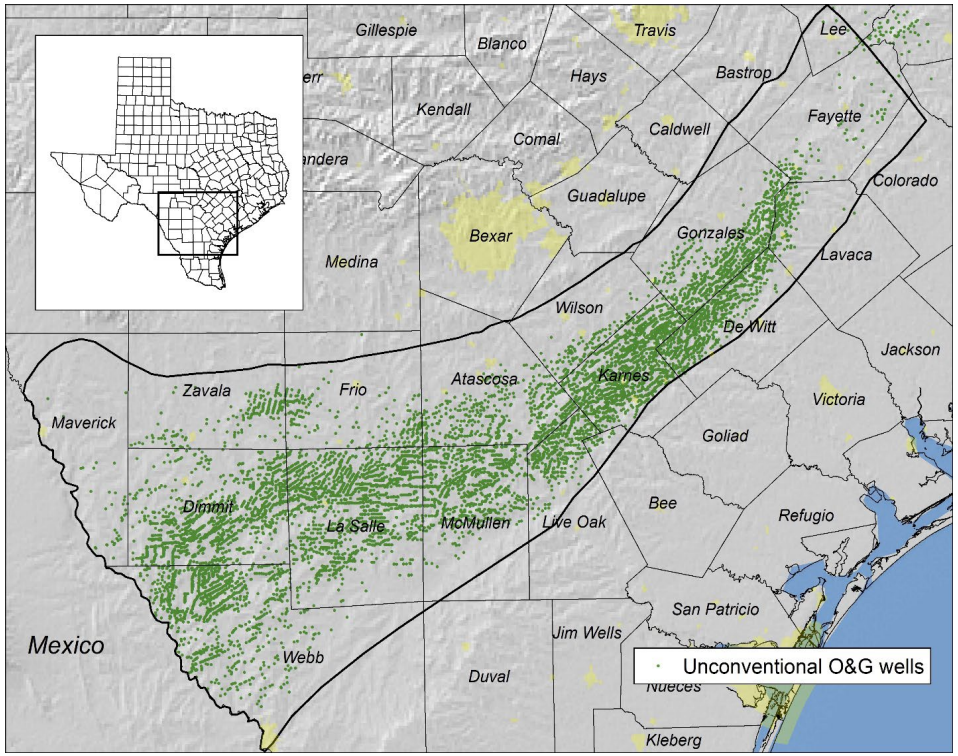



- The Barnett Play is considered largely mature.
- Projected water use is estimated to be ~1,000 ac-ft/yr focused in the core area (Denton, Johnson, Tarrant, and Wise counties).
- Trends since 2015 indicate that new drilling may cease in about 2030 with a total remaining HF water use demand of 11,400 ac-ft.

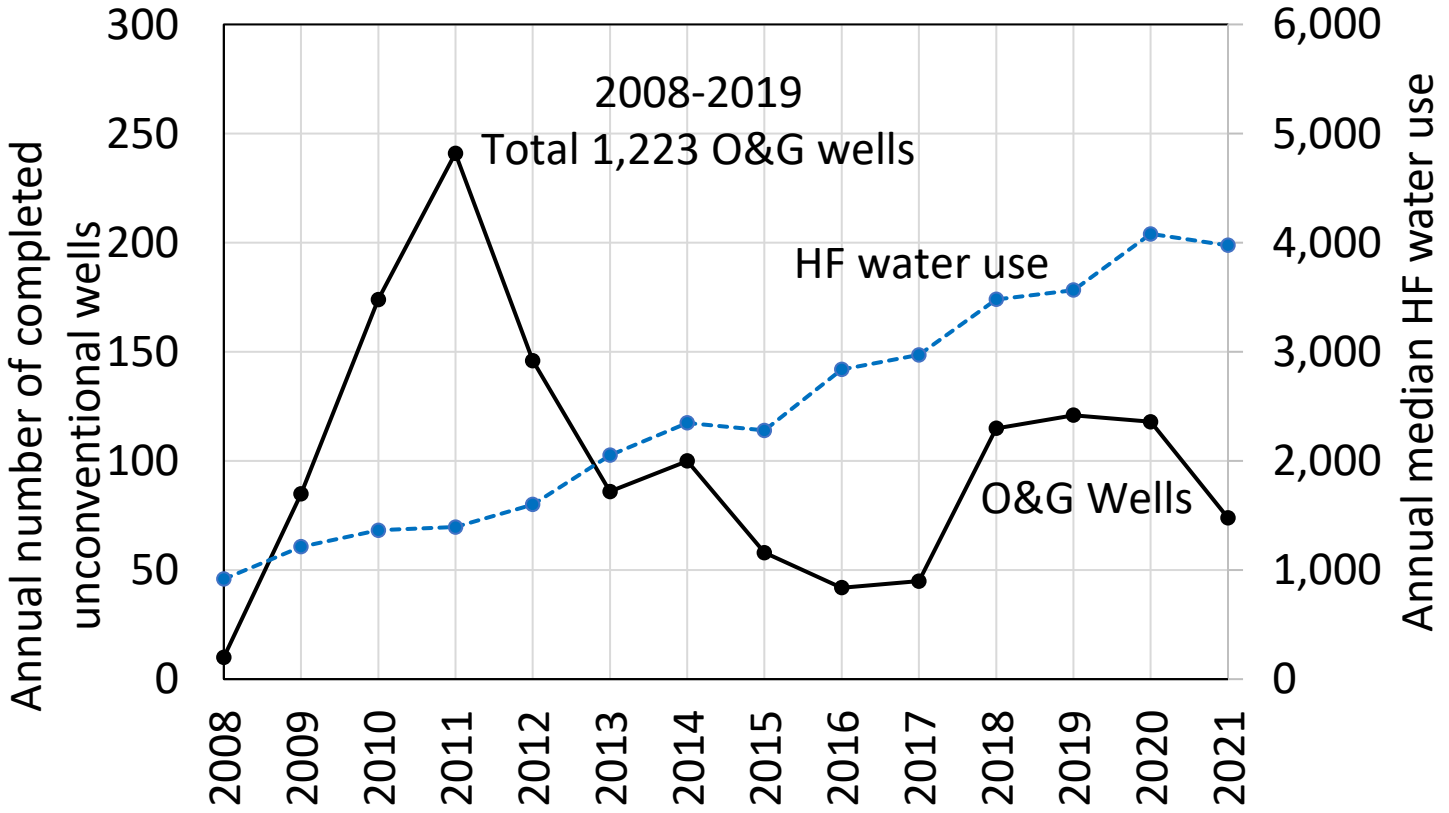
# Eagle Ford Play HF Water Use Projections

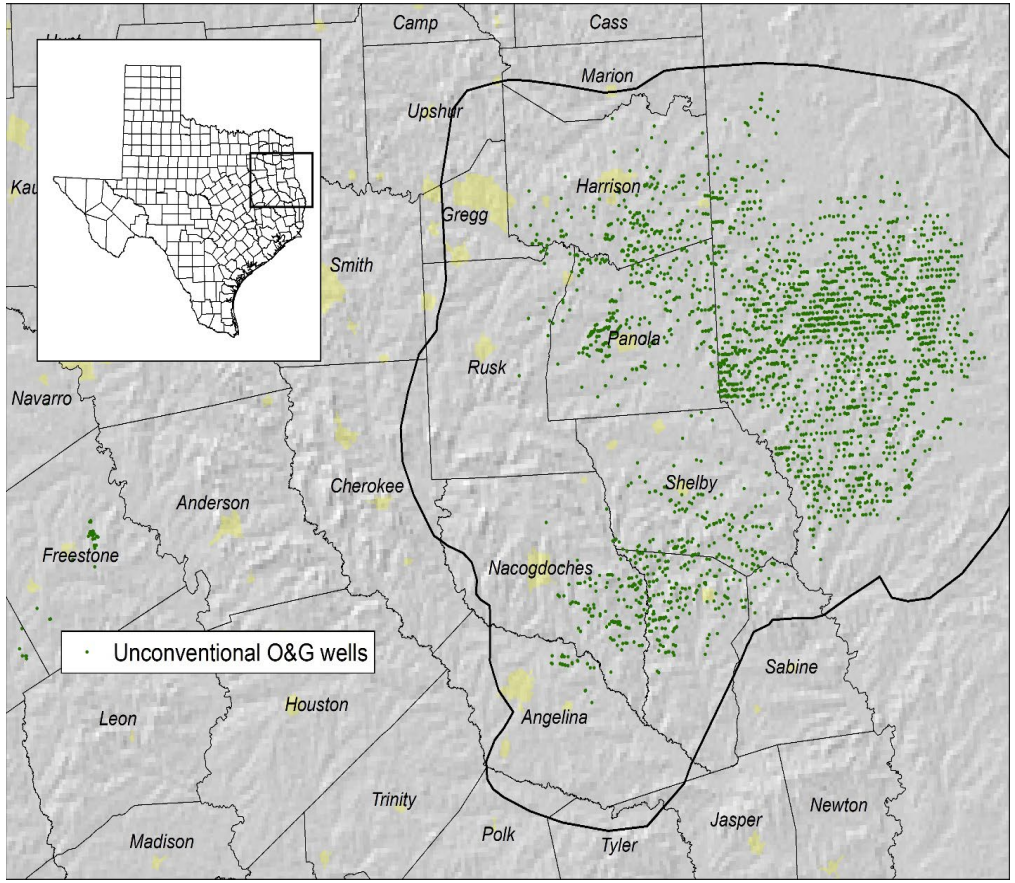



- Based on TRR analysis, the Eagle Ford Play is projected to have ~112,000 O&G wells at maturity. Assuming 1,800 wells/yr, drilling will be complete in 2071.
- Based on a water use intensity of 2,000 gal/ft, projected water use is estimated to be ~56,000 ac-ft/yr with a total of ~2.9 million ac-ft remaining.

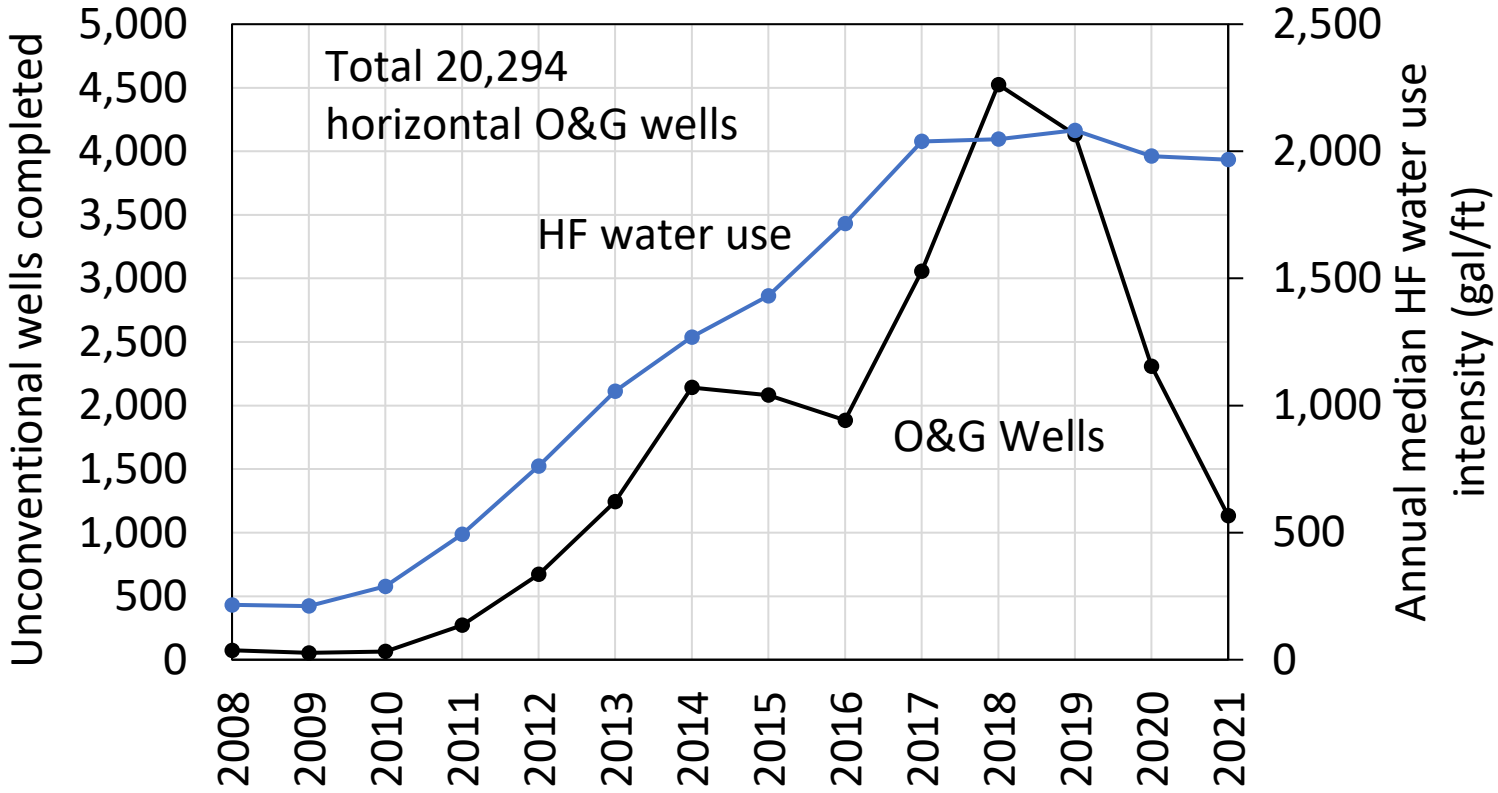
# Haynesville Play HF Water Use Projections

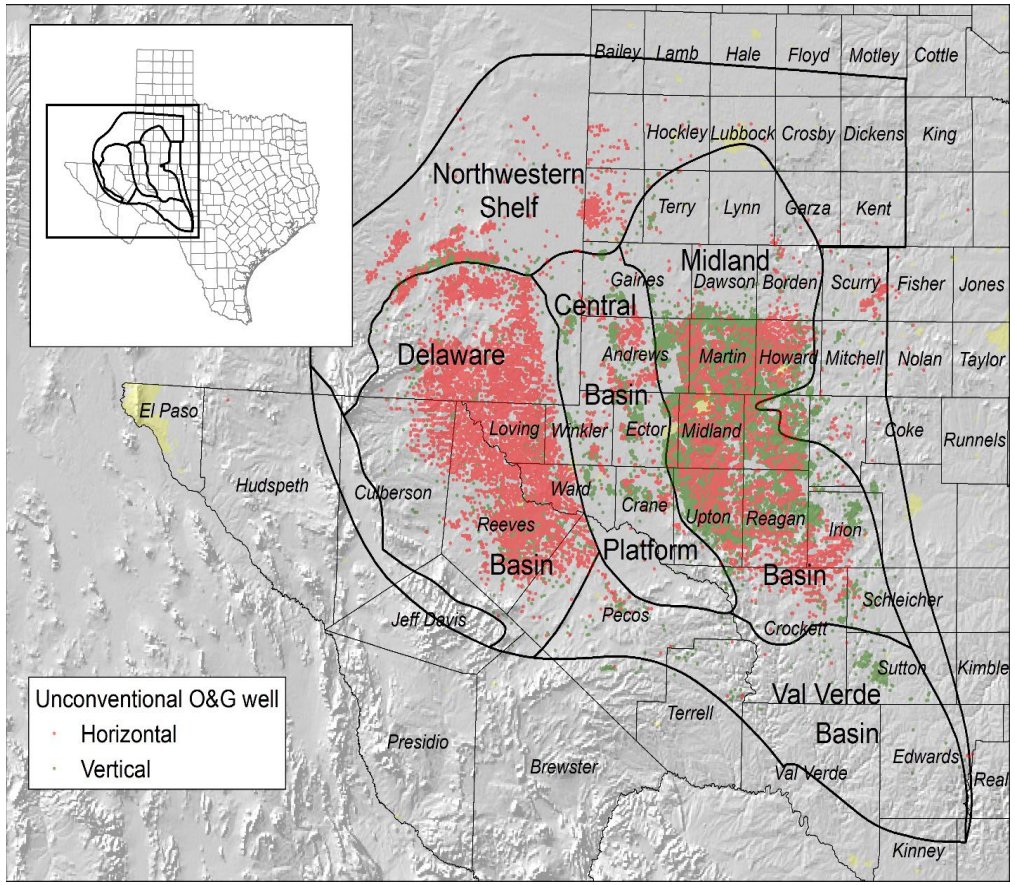



- Based on TRR analysis, the Haynesville Play in Texas is projected to have ~17,600 O&G wells at maturity. Assuming 120 wells/yr, drilling will be completed in 2156.
- Based on a water use intensity of 2,700 gal/ft, projected water use is estimated to be ~7,500 ac-ft/yr with a total of ~1.0 million ac-ft remaining.

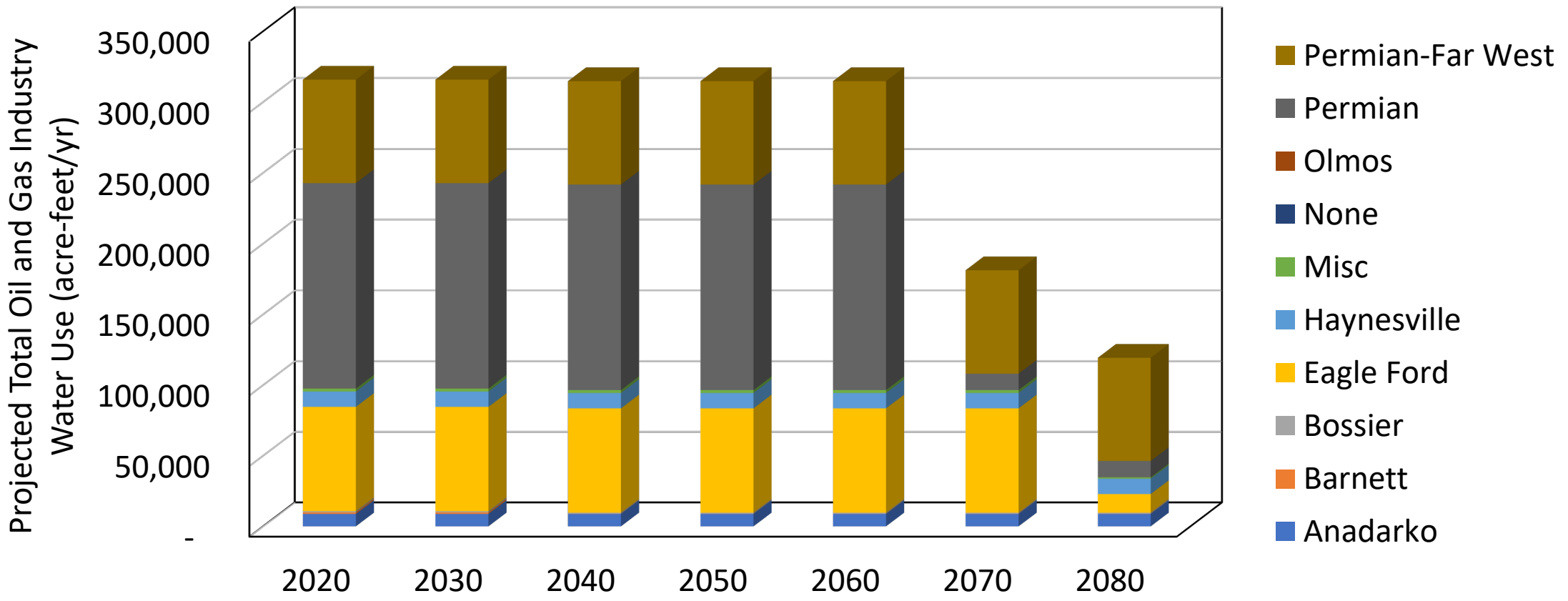
# Permian Basin HF Water Use Projections




- Based on TRR analysis for only the Wolfcamp A & B formations, the Permian basin in Texas is projected to have ~240,000 O&G wells at maturity. Assuming 1,700 wells/yr in the Delaware Basin and 2,400 wells/yr in the Midland Basin, drilling will be complete in 2096.
- Based on a water use intensity of 2,000 gal/ft, projected water use is estimated to be ~210,000 ac-ft/yr with a total of ~12.1 million ac-ft remaining.

# Oil and Gas Industry Water Use Projections

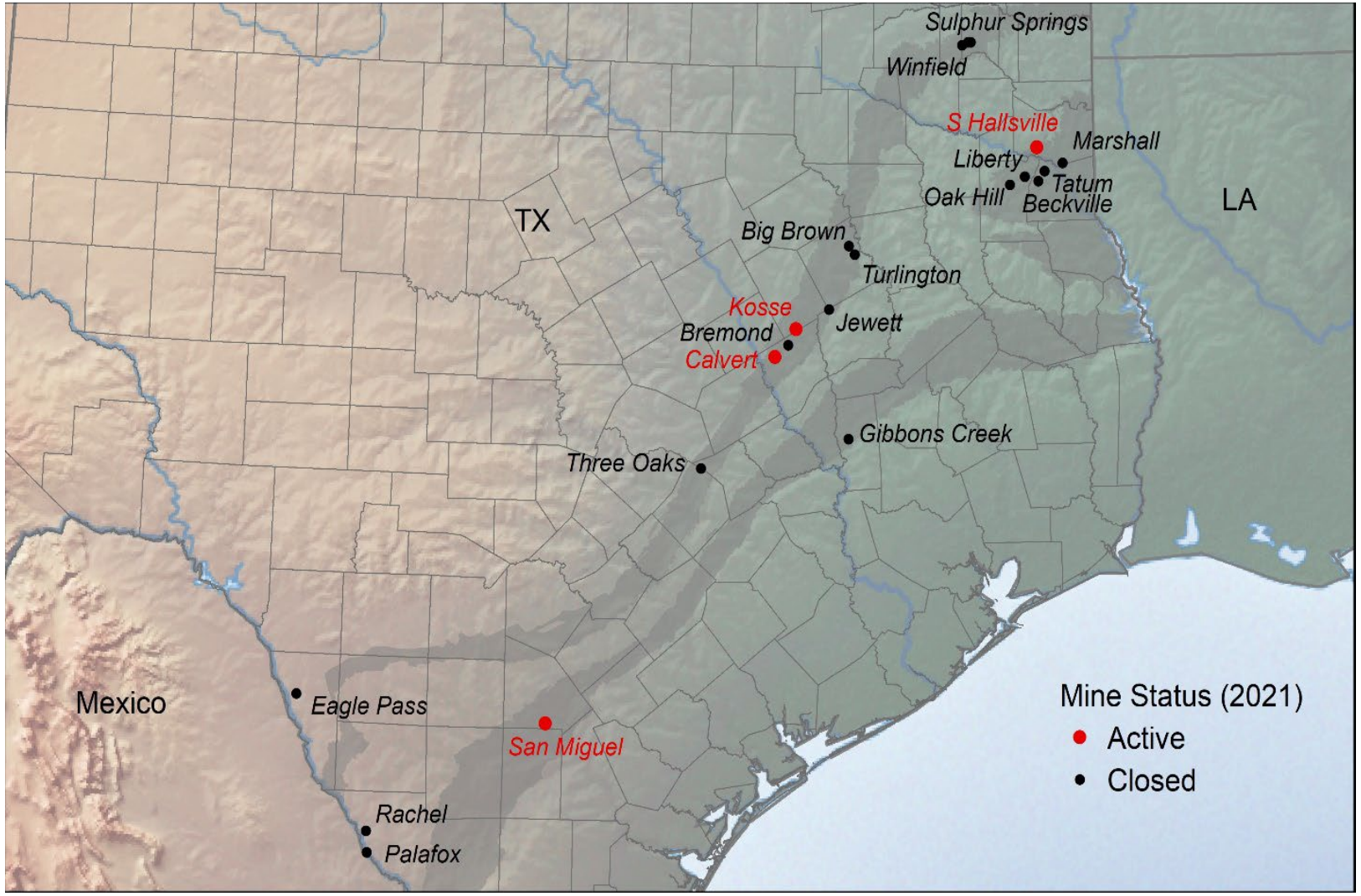



Total annual water use by the O&G industry is projected to be ~315,000 ac-ft/yr for the next several decades. Projections are shown by basin assuming steady drilling rates and median HF water use intensities as described previously.

# Coal Mining Water Use – Sources & Methods

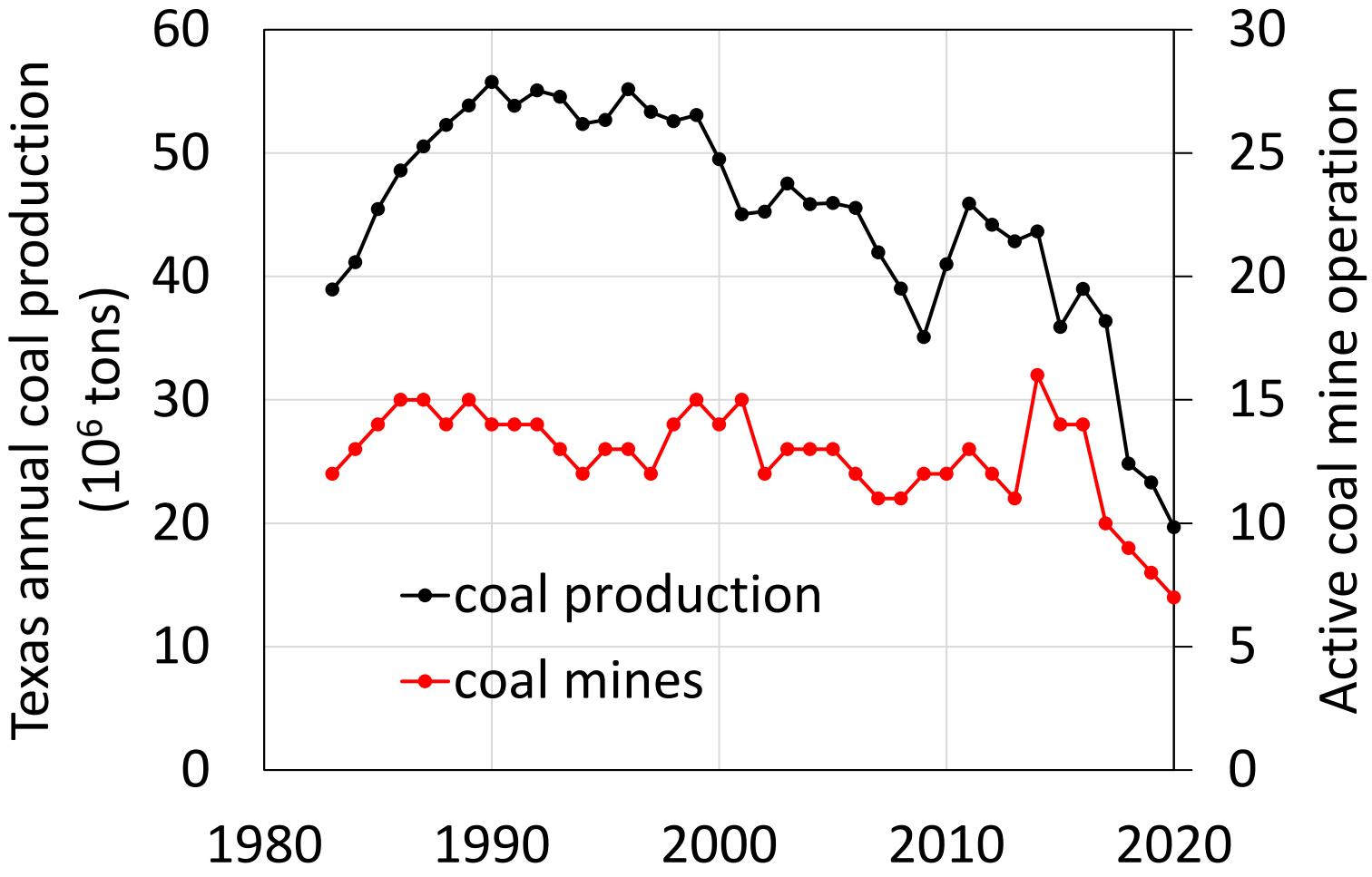
- Water volumes and sources provided by mine operators to TWDB through annual water use surveys with 100% of active coal mining operations responding
- Water use projections are based on current industry plans and/or associated power plant equipment (boiler) life spans.

# Coal Mines in Texas

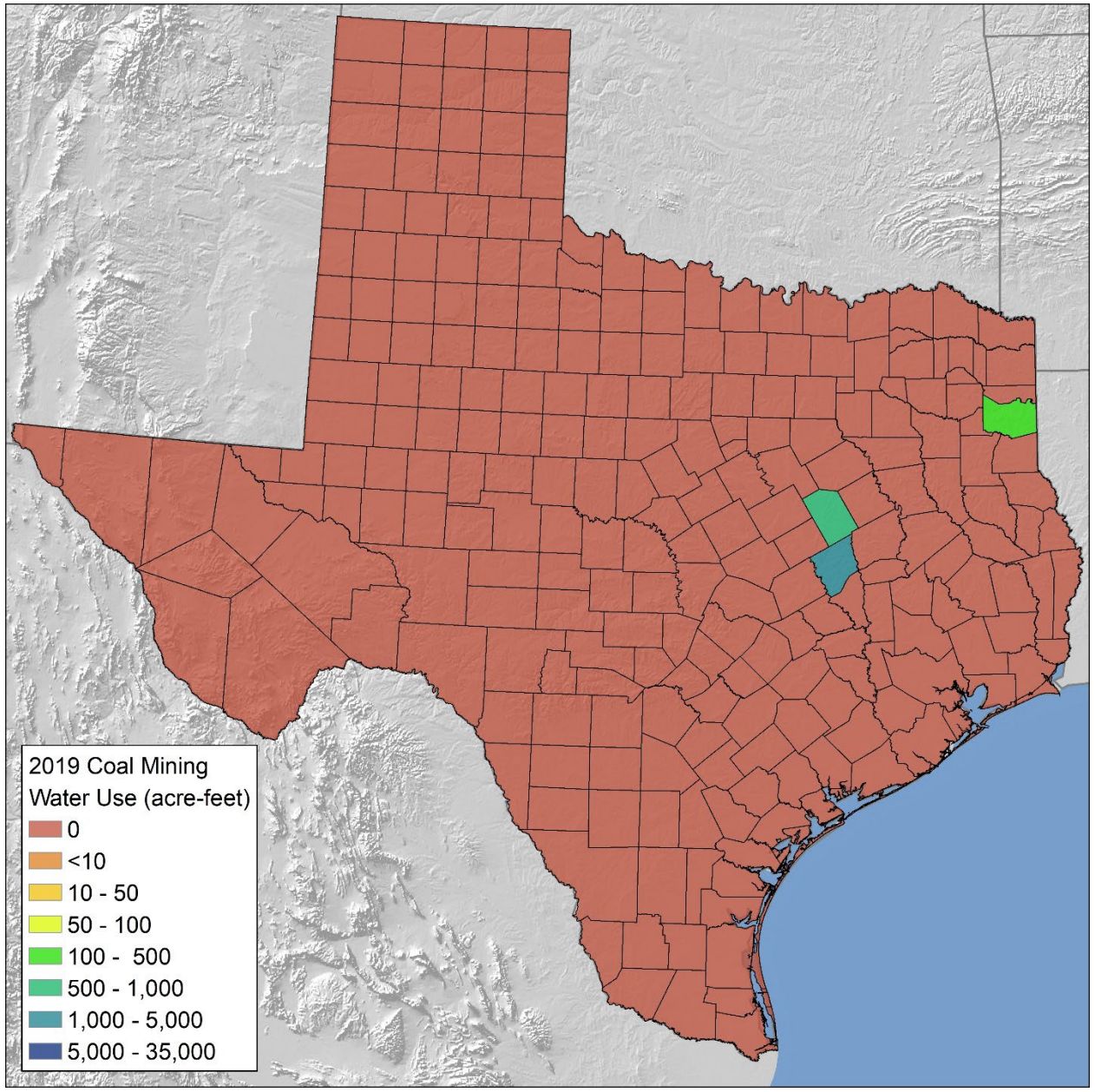



- Locations of active and recently closed coal mines in Texas. Mines are generally associated with either the Wilcox Group or the Jackson Group.
- Texas coal occurs almost completely as lignite, with the exception of bituminous grade coal in the Eagle Pass mine.
- All mines are or were surface operations. Water use is generally for dewatering or depressurizing purposes.

# Coal Mining in Texas 1983-2020



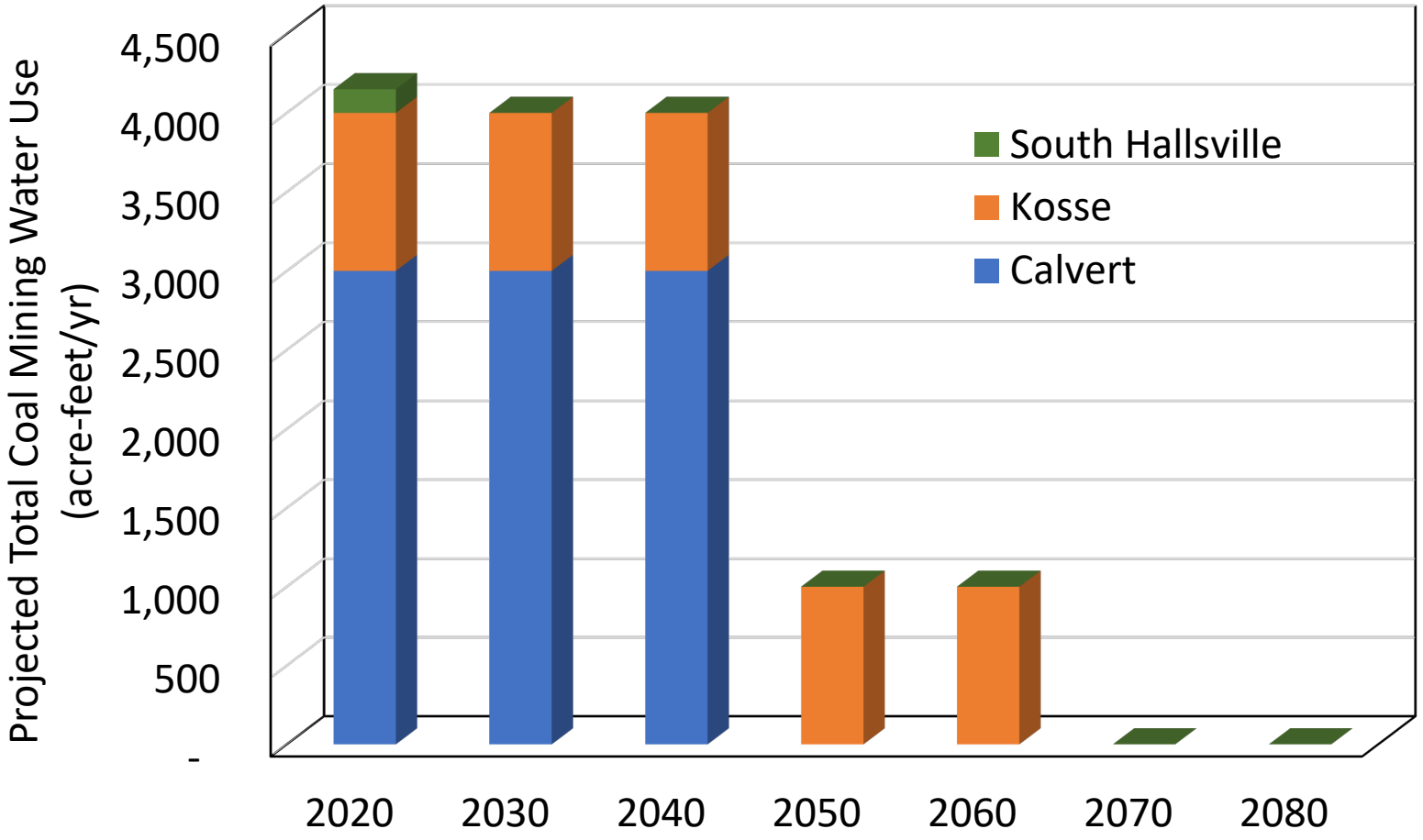

- Coal mining in Texas is in steep decline due to a shift away from Texas lignite to cleaner sub-bituminous coal from the Powder River Basin and also to closures of generation plants due to a general shift away from coal towards natural gas and other energy sources.
- There are currently (2022) four remaining active coal mines in Texas. The South Hallsville Mine and its associated Pirkey Power Plant are scheduled to close in late 2023.




# Total Coal Mining Water Use by County Area

- Statewide total HF water use was 4,000 ac-ft associated with three of the remaining active coal mines representing 1% of total mining water use.
- Water use was primarily groundwater (80%) followed by surface water (20%).

# Coal Mining Water Use Projections

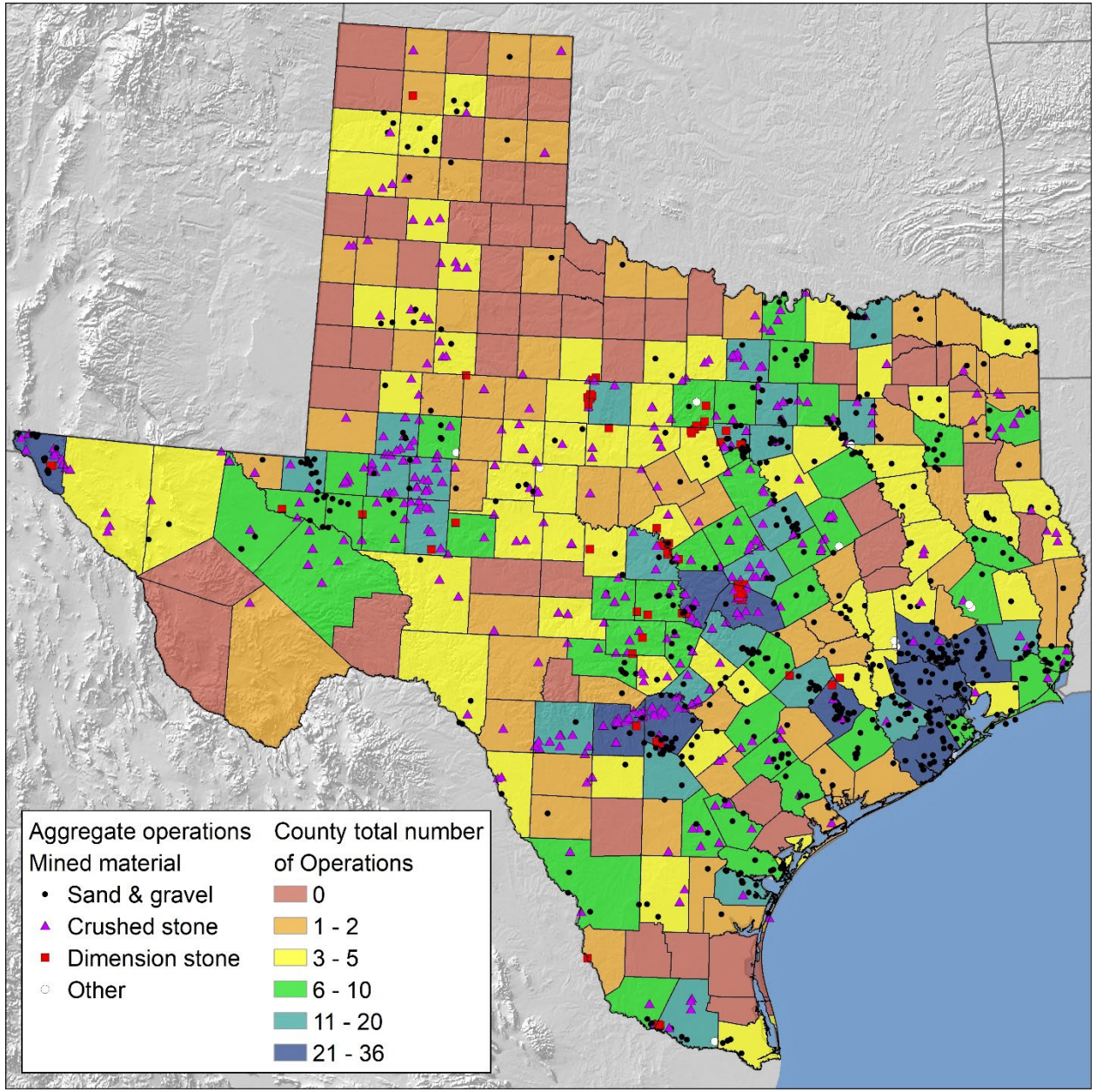



- The South Hallsville mine is scheduled to close in 2023.
- The Kosse and Calvert mines are estimated to close when the associated power plant  boilers reach their design life span.
- The San Miguel Mine reported zero water use.

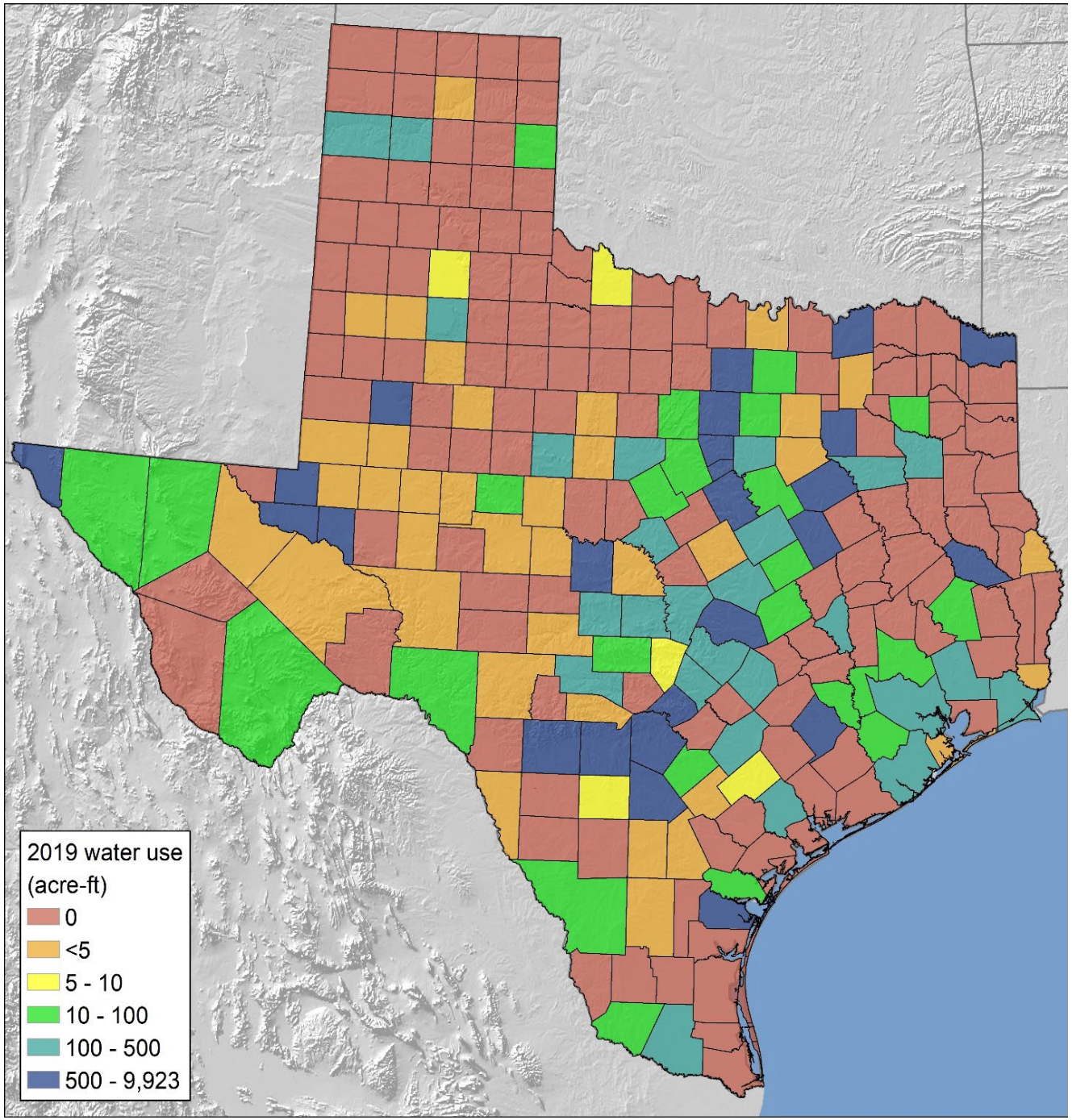
# Aggregates Mining Water Use – Sources & Methods

- Water volumes and sources were reported by operators to TWDB and TCEQ in the annual water use surveys. The TCEQ also contacted some operators directly. The two datasets were combined and justified resulting in 1,295 registered aggregate operations.
- For operators that did not respond, water use was estimated based on examination using Google imagery coupled with reported water use volumes per unit disturbed area of similar near-by operations
- Projections of aggregate water use were based on expected population changes by county as defined in the 2022 State Water Plan (TWDB).

# Aggregate Mines in Texas




- There were 1,295 registered aggregate operations in the dataset.
- Coordinate or county locations were available for 1,217 (94%) of operations.
- The remaining unlocated 78 operations (6%) were either inactive or reported zero water use.
- Operations tend to cluster near population centers and in the Permian Basin where industrial (fracking) sand mining operations are prevalent.




# Aggregate Mining Water Use by County Area

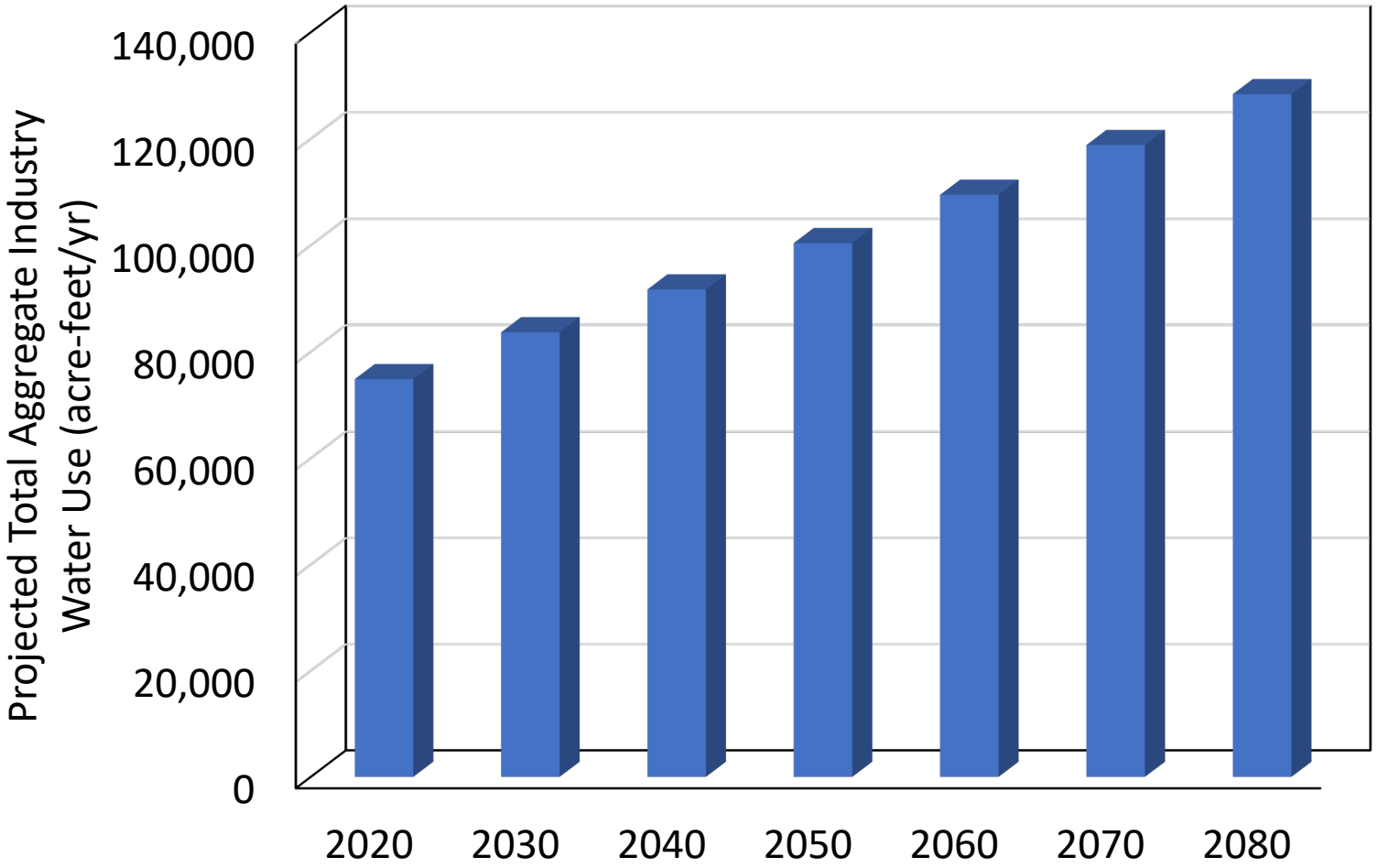
- Total estimated aggregate water use in Texas was ~74,800 ac-ft in 2019, representing 19% of total mining use.
- Reported water use accounted for 96% (71,600 ac-ft) of the total. Water use was reported by 84% of all operations, including zero water use (55%) or positive water use (29%). Zero water use includes inactive or closed operations.
- Estimated water use accounted for 4% (3,200 ac-ft) of the total. Water use was estimated for 16% of all operations, including zero water use (14%) or positive water use (2%).

# Estimated Aggregate Water Sources by Subsector

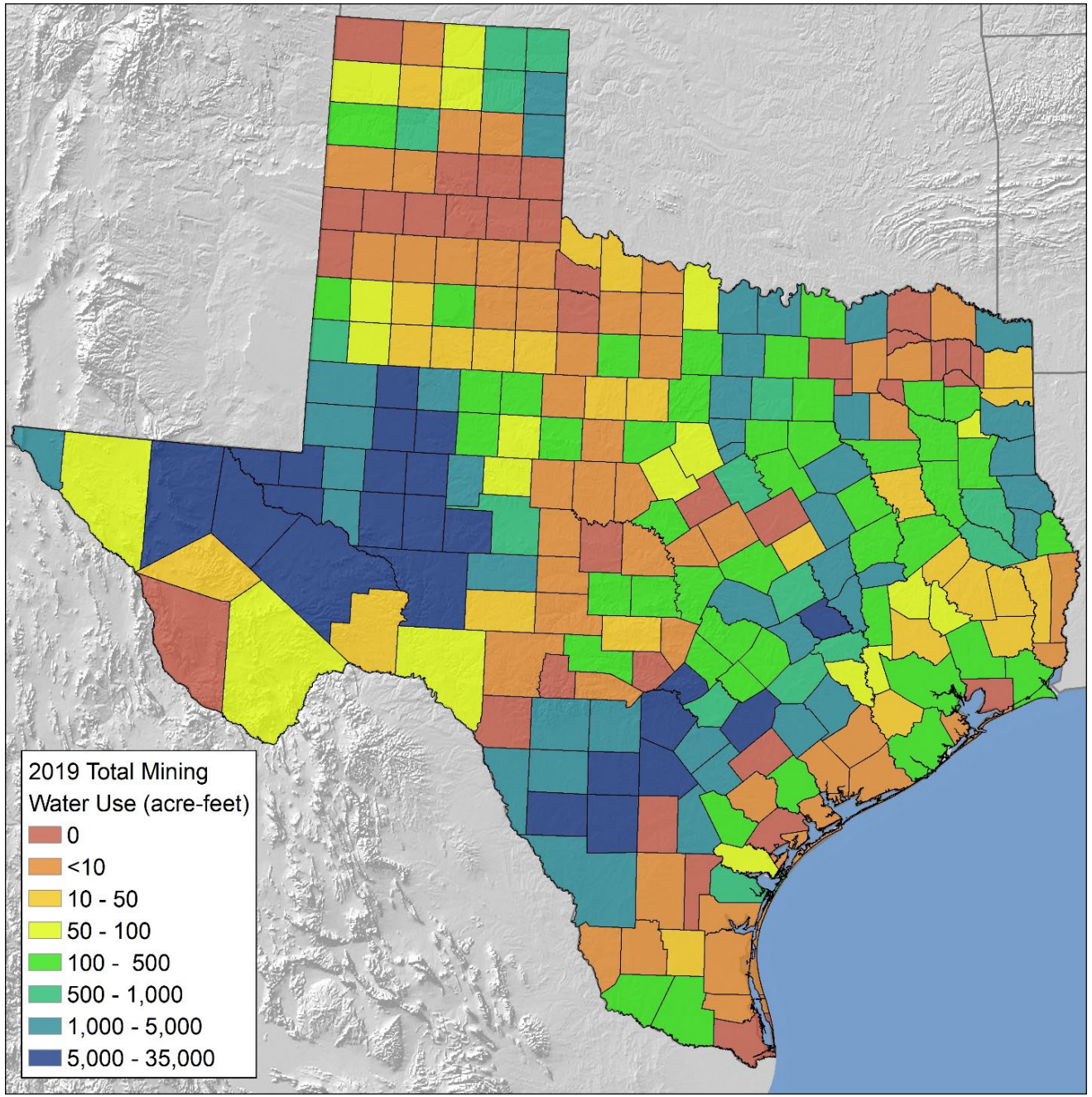
| *Aggregate Subsector* | *Number of Operations* | *Total Water Use* | | *Water Use* | | |
|---|---|---|---|---|---|---|
| | | *(ac-ft)* | *(% of Total)* | *GW (%)* | *SW (%)* | *Reuse (%)* |
| Dimension Stone | 87 | 242 | 0.3 | 98.1 | 1.9 | 0.0 |
| Crushed Stone | 461 | 26,411 | 35.3 | 87.1 | 12.9 | 0.1 |
| Sand and Gravel | 731 | 47,965 | 64.1 | 74.5 | 21.9 | 3.6 |
| Other | 16 | 204 | 0.3 | 99.5 | 0.5 | 0.0 |
| Combined Total | 1,295 | 74,822 | 100.0 | 79.1 | 18.6 | 2.3 |

- Sand and gravel mining represents 64% of water use followed by crushed stone mining at 35%.
- Water use statewide was 79% groundwater, 19% surface water, and 2% reuse.

# Aggregate Mining Water Use Projections



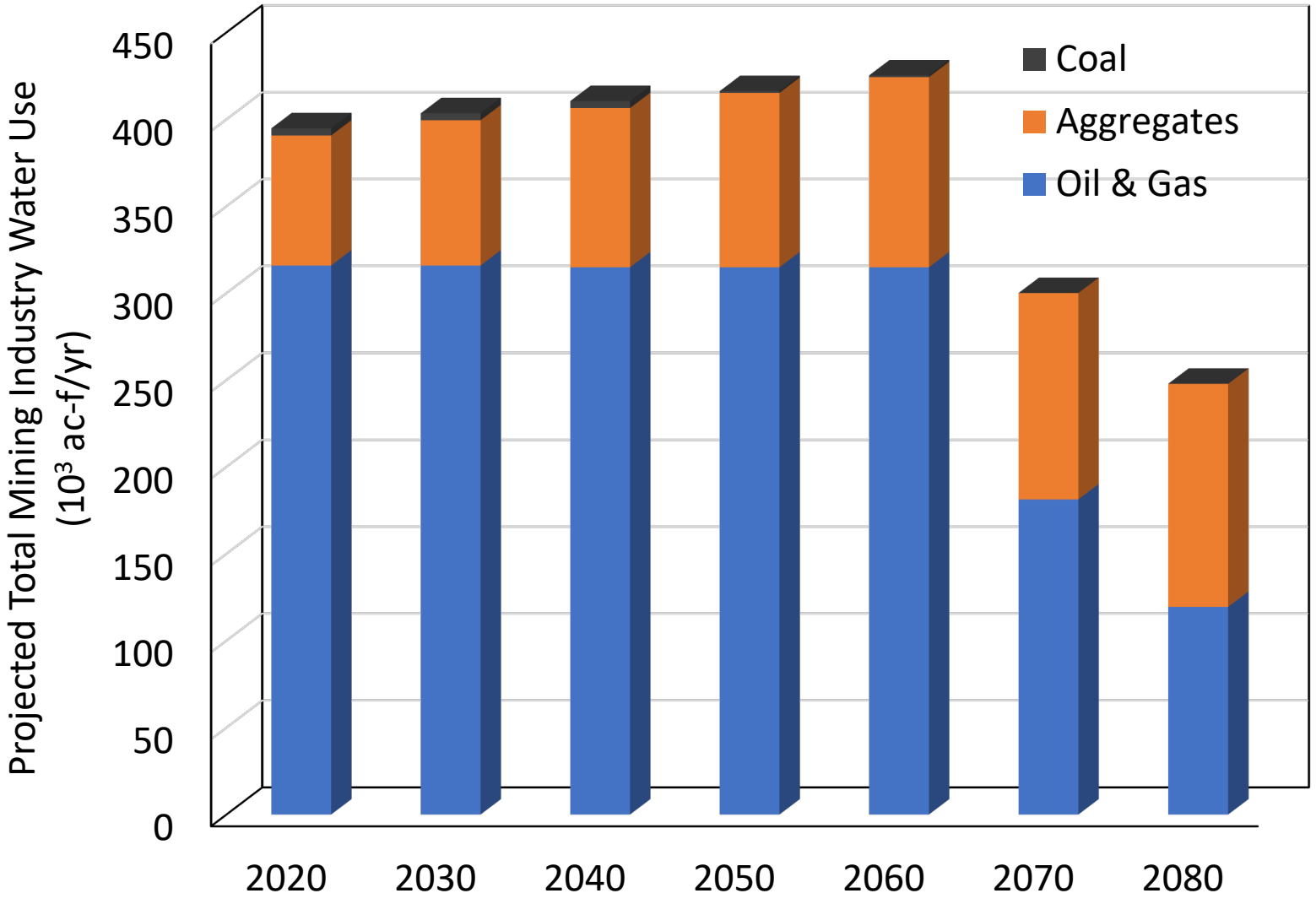

- Total aggregate mining water use is expected to grow by 8-12% per decade in pace with projected population increases (2022 State Water Plan, TWDB).
- Water use is projected to increase by ~70% from the ~75,000 ac-ft/yr currently to ~128,000 ac-ft/yr by 2080.




# Summary of Total Mining Water Use in Texas

- Total mining water use was 395,000 ac-ft in 2019 dominated by the oil and gas sector (80%) and followed by the aggregate mining (19%) and coal mining (1%) sectors.
- The greatest water use volumes are associated with counties in the Permian Basin and the Eagle Ford Play areas
- Mining water use represents 2.8% of total use in Texas (~14 million ac-ft)

# Summary of Texas Mining Water Use Projections




- Projected to gradually increase through about 2060 due to increasing demand by the aggregate industry with ongoing steady demand by the oil and gas sector.
- Projected to declining steeply overall after 2060 due to decreasing demand by the oil and gas sector as the plays mature.

# Data Access

- This final report and the historical and current water use estimates and projections by the Texas mining sector are publicly accessible via an online data dashboard developed by the TWDB and hosted on their website:

https://www.twdb.texas.gov/waterplanning/data/projections/MiningStudy/index.asp

# Future Work

Future studies of mining water use in Texas would benefit from:

- Detailed reporting by the oil and gas industry regarding water volumes by source (aquifer, surface water body, reuse of produced water) and general water quality (TDS values, fresh, brackish, brine, etc.)
- Improved assessments of Total Recoverable Resources (TRR) that incorporate economic factors may increase or decrease the projected numbers of economically feasible drilling locations.
- There are multiple unconventional oil and gas reservoirs in the Permian Basin that have not yet been evaluated for development.