Injection Well Permitting Challenges (W-14, H-1/H-1A)

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July 2025

Overview of Injection Well Permitting Challenges

- Aquifer Exemptions (AE) and AE Map
  - https://www.rrc.texas.gov/oil-and-gas/applications-and-permits/injection-storage-permits/oil-and-gas-waste-disposal/injection-disposal-permit-procedures/aquifer-exemptions/
- Pressure – East Texas
  - https://www.rrc.texas.gov/oil-and-gas/applications-and-permits/injection-storage-permits/oil-and-gas-waste-disposal/injection-disposal-permit-procedures/pressure-east-texas/
- Seismicity Review and Seismicity Response
  - https://www.rrc.texas.gov/oil-and-gas/applications-and-permits/injection-storage-permits/oil-and-gas-waste-disposal/injection-disposal-permit-procedures/seismicity-review/

Overview of Rules to Support Permitting Procedures

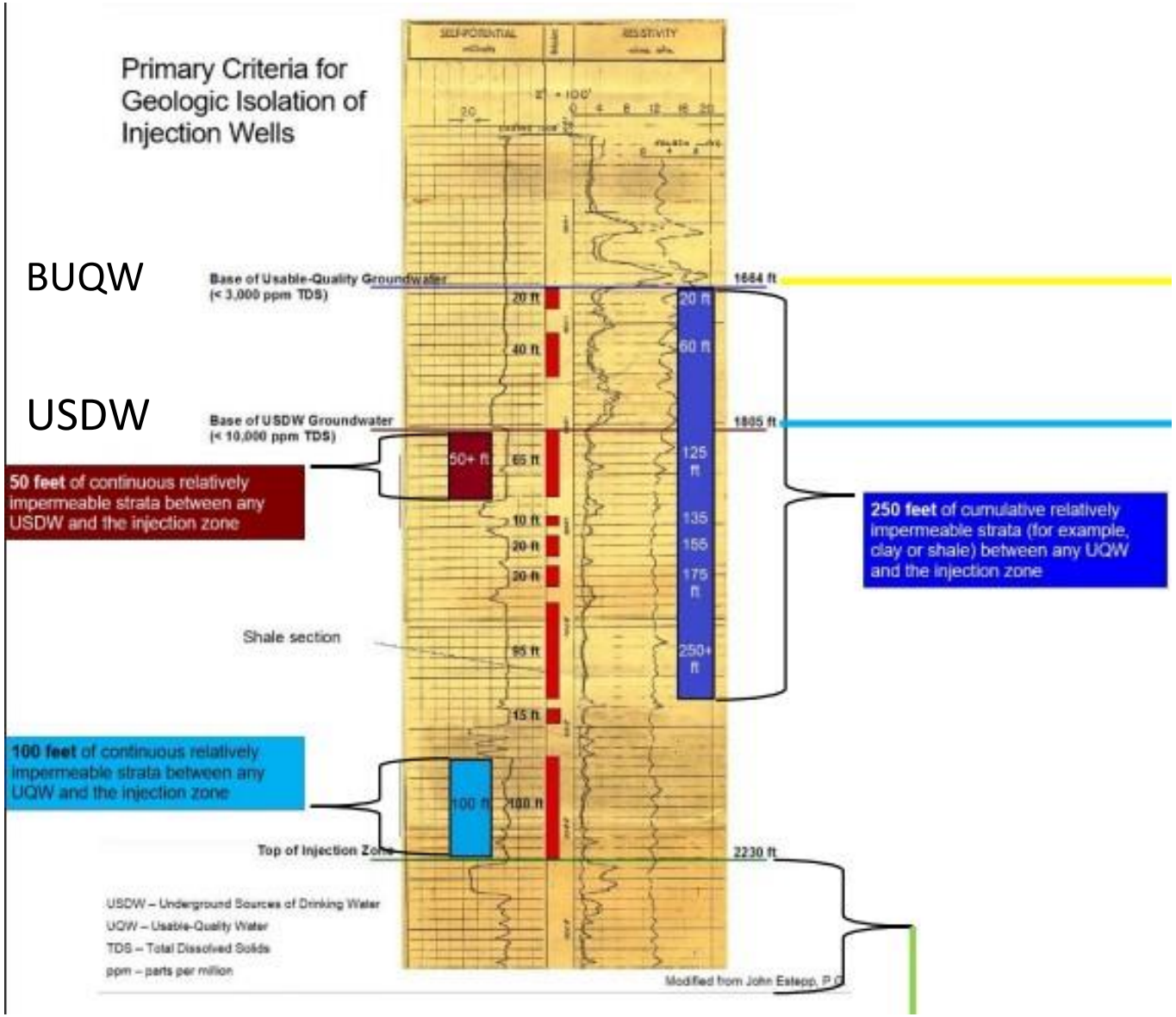
- U.S. Safe Drinking Water Act (SDWA)
  - US EPA Rules
  - 40 CFR §146.4 Criteria
  - 40 CFR §144.7 Application
  - 40 CFR §144.7 Procedures
- Texas Water Code, Chapter 27
  - RRC Statewide Rules
  - §3.9 Disposal Wells
  - §3.46 Fluid Injection into Productive Reservoirs
- RRC Statewide Rules support permitting procedures
  - Filing of application with additional information
- Permitting attempts to avoid subsequent commission action
  - Fresh water is protected
  - Injection fluids are contained
  - Not likely contributing to seismic activity
  - Prevent waste of oil, gas, or geothermal resources

Injection Well Geologic Isolation Example

EPA approved RRC Class II UIC program on April 23, 1982.

Section 1425 of SDWA allows EPA to approve state programs that are effective in preventing endangerment of USDWs.

Result: Surface casing depth protects BUQW.



https://www.rrc.texas.gov/oil-and-gas/applications-and-permits/injection-storage-permits/oil-and-gas-waste-disposal/injection-disposal-permit-procedures/technical-review/#isolation

Definition of USDW

- from 40 CFR §144.3, §146.4
- from RRC Statewide Rules
  - §3.79 Definitions

Underground source of drinking water (USDW) means an aquifer or its portion which is not an exempt aquifer and which:

(A) supplies any public water system; or

(B) contains a sufficient quantity of ground water to supply a public water system; and

(i) currently supplies drinking water for human consumption; or

(ii) contains fewer than 10,000 milligrams per liter (mg/l) total dissolved solids.

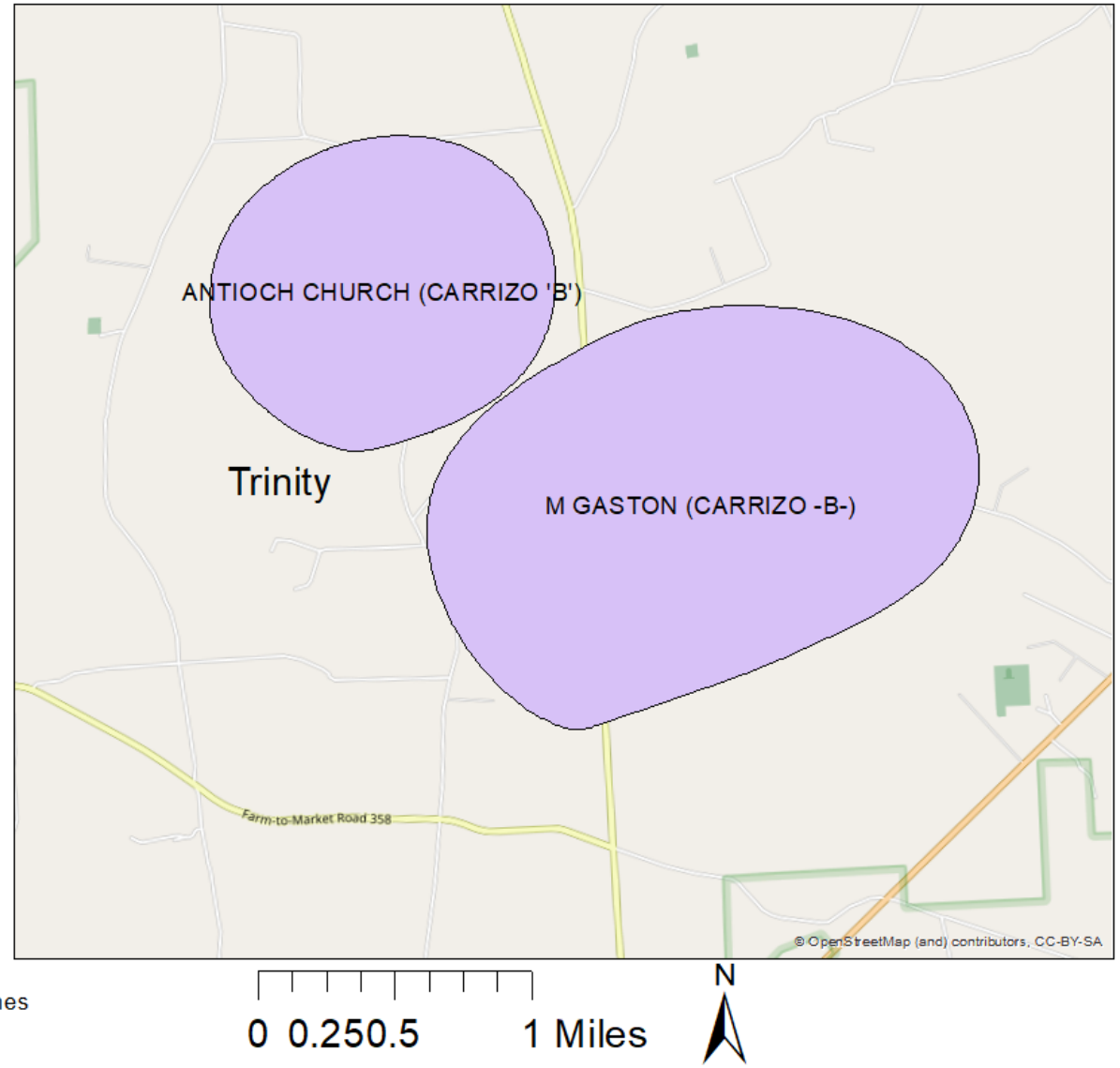
Existing Aquifer Exemptions: Example Trinity County

Aquifer exemption boundaries in Texas are associated with RRC-designated Fields.

Map areas define the horizontal extent of the AE.

Depth extent of the AE is provided in table form.

Example: an AE exists for wells inside the boundaries, with the field name, and top depth 1,771 ft, and 1,830 ft, respectively.



https://www.epa.gov/uic/aquifer-exemptions-map

New Aquifer Exemptions: Example Anderson County

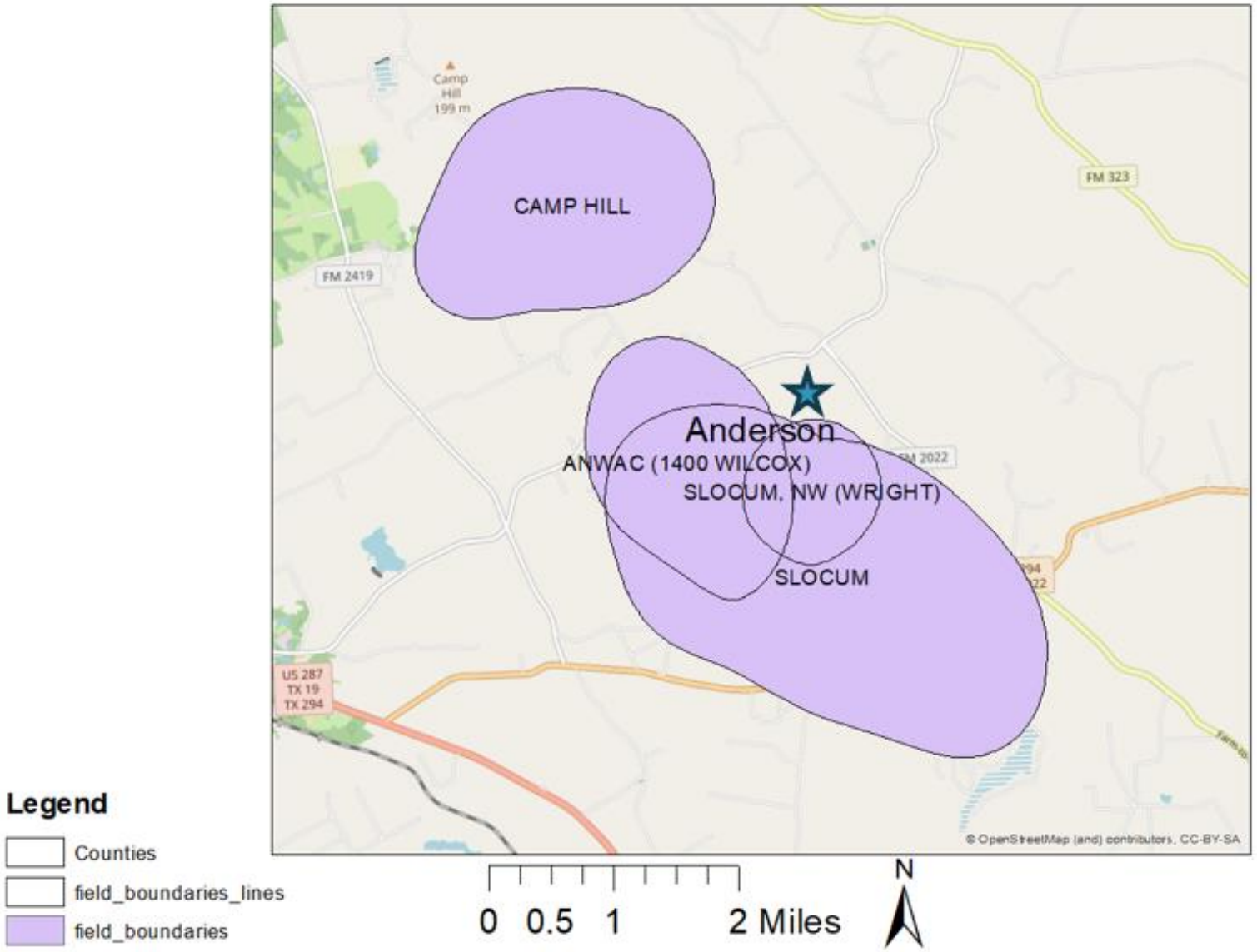
New aquifer exemptions, or expansion of AE boundaries can only be approved by EPA.

What if new injection wells are filed at the star location in the Slocum Field?

Follow the permitting steps using the AE checklist to begin the process of applying to EPA for an AE expansion.

(next slide)

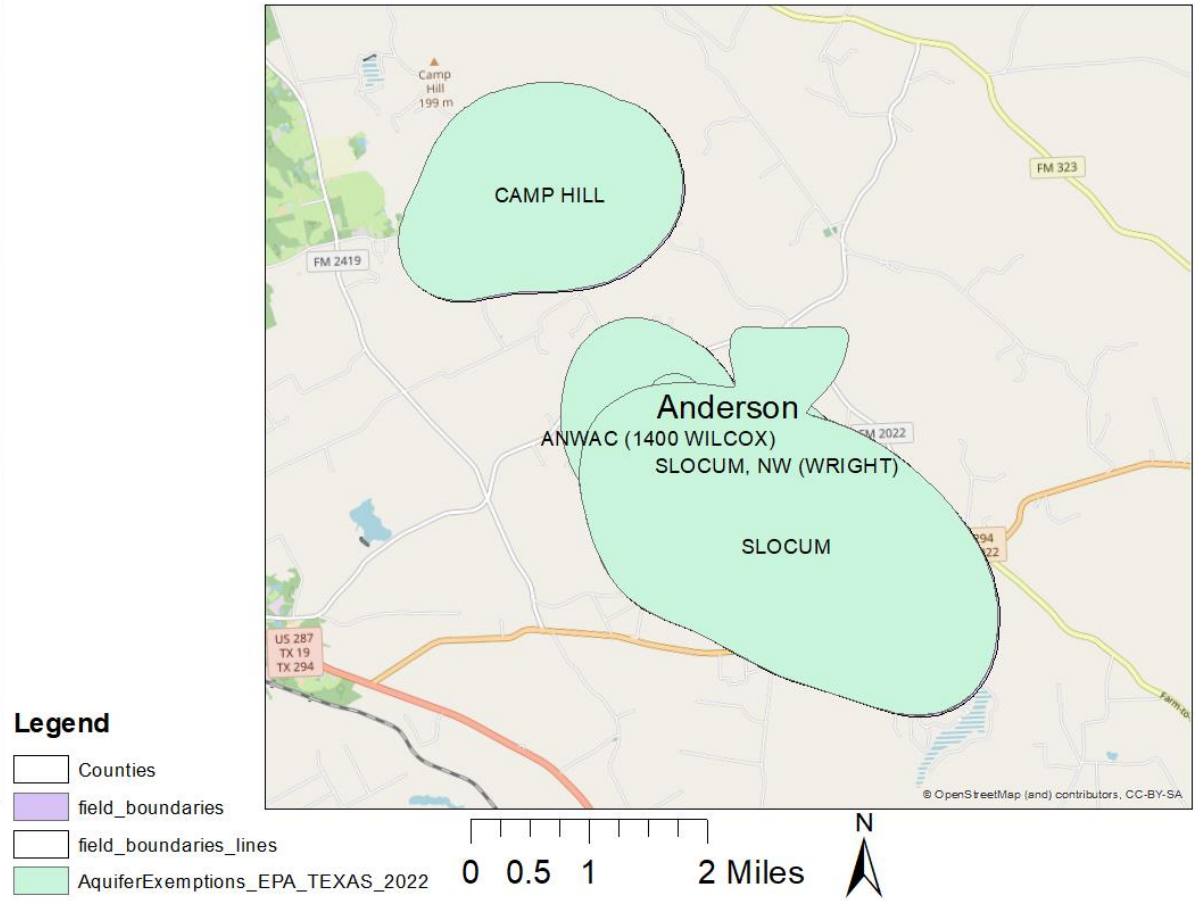
https://www.epa.gov/uic/aquifer-exemptions-map



Aquifer Exemption Review and EPA Checklist

- Aquifer Exemption Review
  - https://www.rrc.texas.gov/oil-and-gas/applications-and-permits/injection-storage-permits/oil-and-gas-waste-disposal/injection-disposal-permit-procedures/aquifer-exemptions/aquifer-exemption-review/
- (excerpt from above webpage) …wells must meet the criteria under 146.4(a) and criteria specified by at least one of the following sections: 146.4(b)(1), 146.4(b)(2), 146.4(b)(3), 146.4(b)(4), or 146.4(c).
- For practical purposes, likely we are using 146.4(b)(1) only which is demonstration of enhanced recovery, that the aquifer or portion thereof is mineral, hydrocarbon, or geothermal energy producing.

Case Study: AE Expansion in Anderson County



Expansion of Slocum Field AE accommodates operator's new injection wells.

Overview of Pressure East Texas

East Texas Field is not part of Pressure East Texas.

The geology pinches out and partly changes going east.

Pressure East Texas applies to Harrison, Panola, and Shelby.

Some highlights (lowlights?)

- Overpressure of Class I EPA/TCEQ wells in Harrison
- Induced seismicity NW Shelby
- Elevated pressure crossing state line in NE Shelby
- Very high bottom hole pressure (BHP) measured in N Shelby

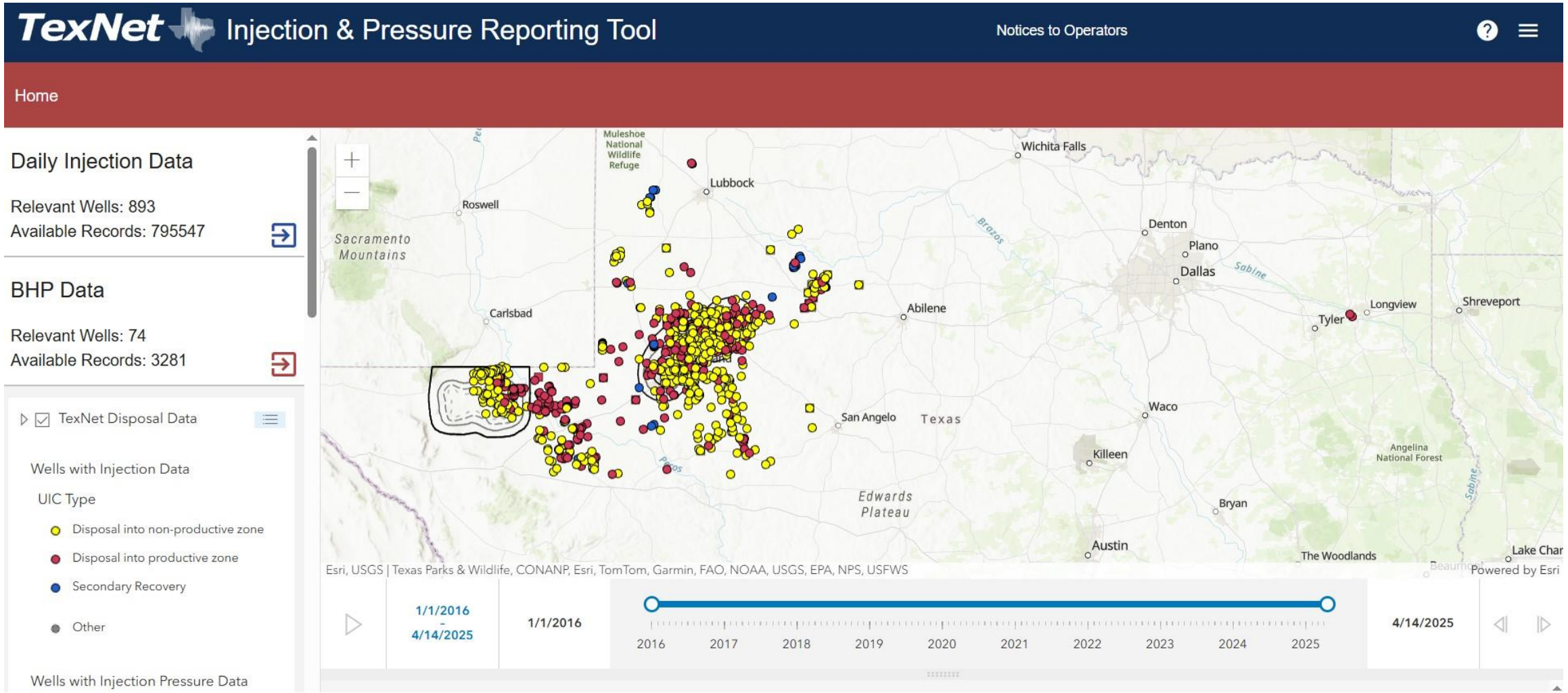
Pressure - East Texas Review and Checklist

- Pressure – East Texas Review
  - https://www.rrc.texas.gov/oil-and-gas/applications-and-permits/injection-storage-permits/oil-and-gas-waste-disposal/injection-disposal-permit-procedures/pressure-east-texas/
- (excerpt from above webpage) …formations include Duck Creek, Goodland Lime, Rodessa, Pettit, and Travis Peak…
- Checklist
  - ½ - mile Top of Cement Table
  - Porosity and Permeability Data
  - Annotated Log
  - Historic H-10 data for surrounding injection/disposal wells

Permit Special Conditions and Monitoring

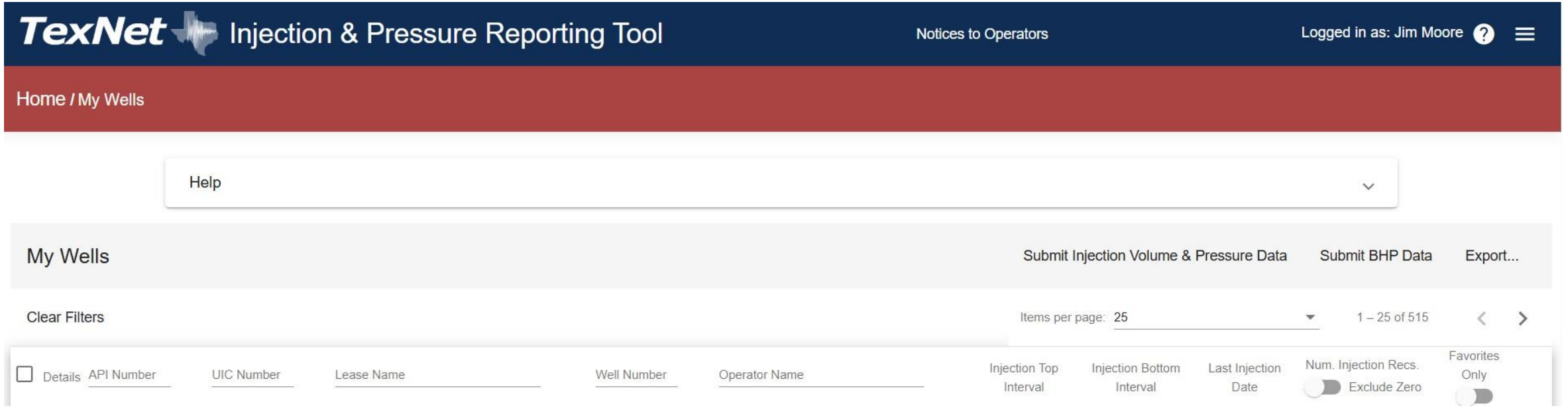
- Static Bottom Hole Pressure Tests (BHP) are required for most granted applications inside of the three-county concern area. The frequency of these tests is determined during the review process by the UIC group.
  - BHP Reporting is available at TexNet Injection & Pressure Reporting Tool (next slide)
- The UIC group may limit maximum daily injection volumes and maximum surface injection pressures.
- Cement Bond Log (CBL) may be required to verify cement behind production casing.
- Tracer Surveys may be requested to show fluid containment to permitted injection interval and formation(s).

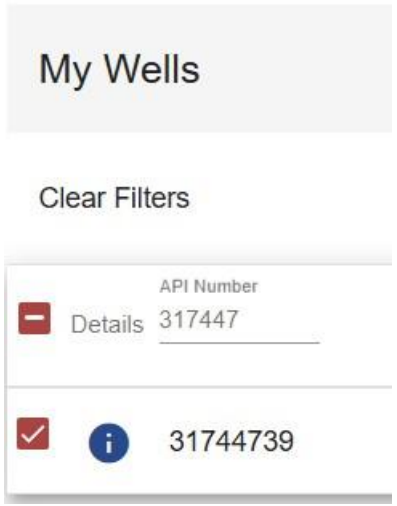
TexNet Injection & Pressure Reporting Tool



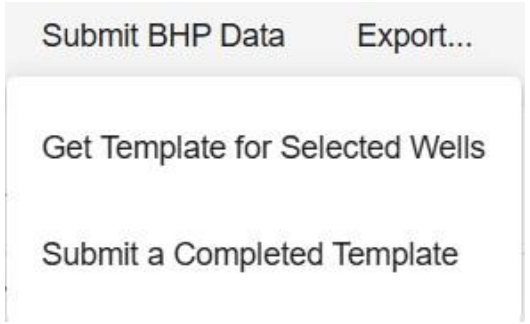
https://injection.texnet.beg.utexas.edu/

Submit BHP Data (1 of 8)





- Open My Wells
- Use filters to locate the subject well
- Select the Submit BHP Data button
- Select Get Template for Selected Wells



Submit BHP Data (2 of 8)

Which measurement method are you using?

- ○ Method 1 - Calculated BHP Method (Shut in for 24 hrs.)
- ○ Method 2 - Dip-in BHP Measurement Method (Shut in for 24 hrs.)
- ○ Method 3 - Permanent BHP Probe Method

From

Select the first day
7/1/2025

To

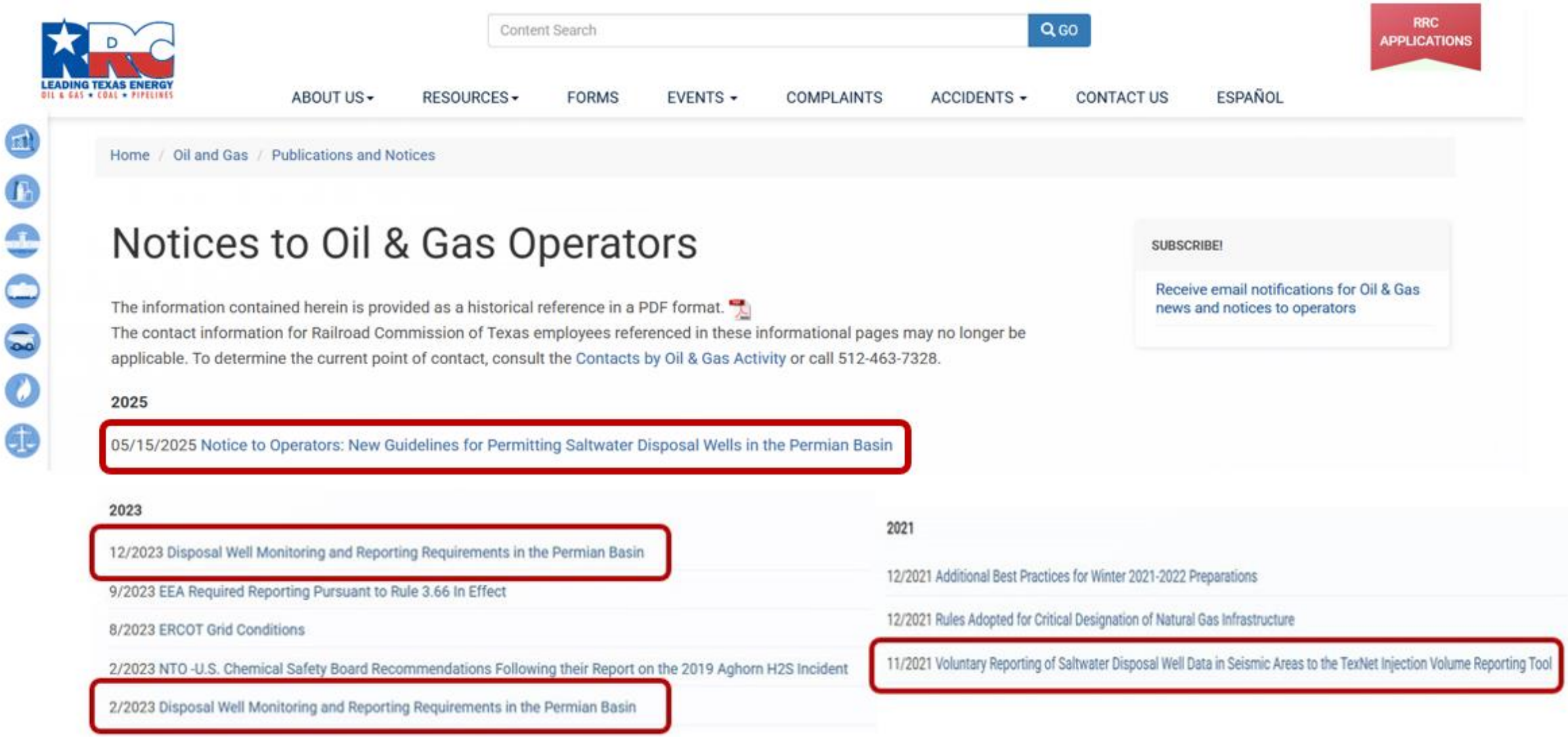
Select the last day
7/31/2025

Populate with last injection data? ☐

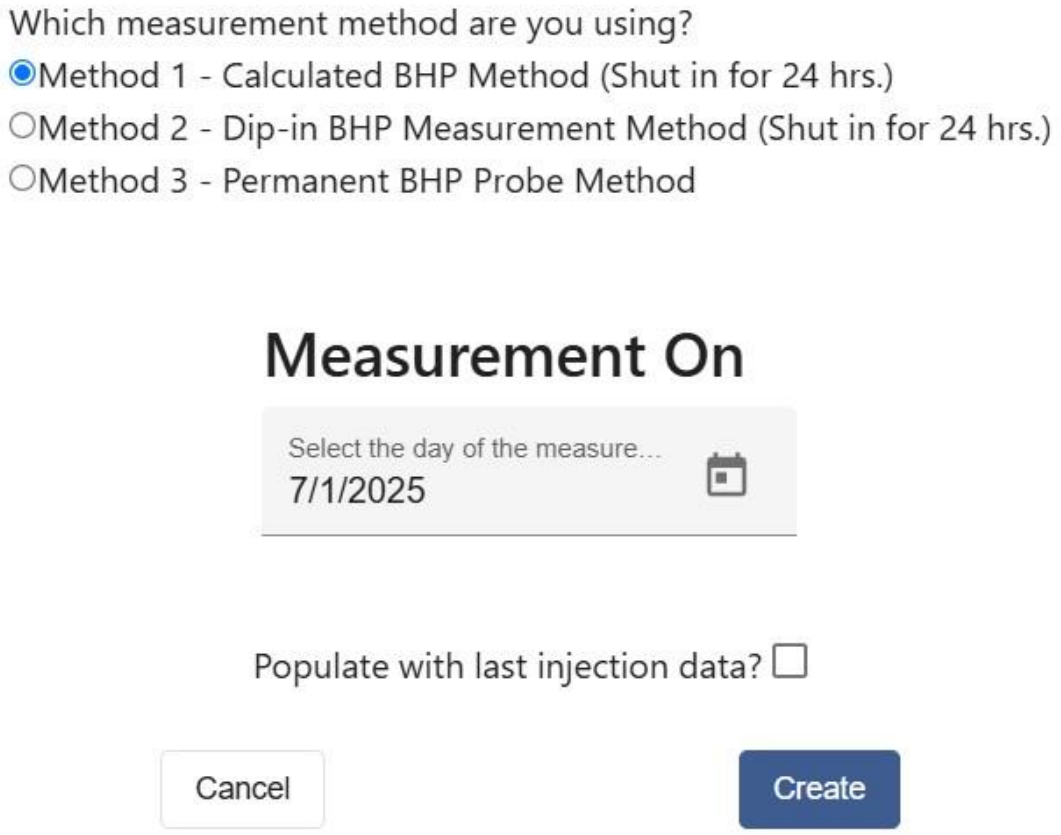
Cancel

Create

Submit BHP Data (3 of 8)



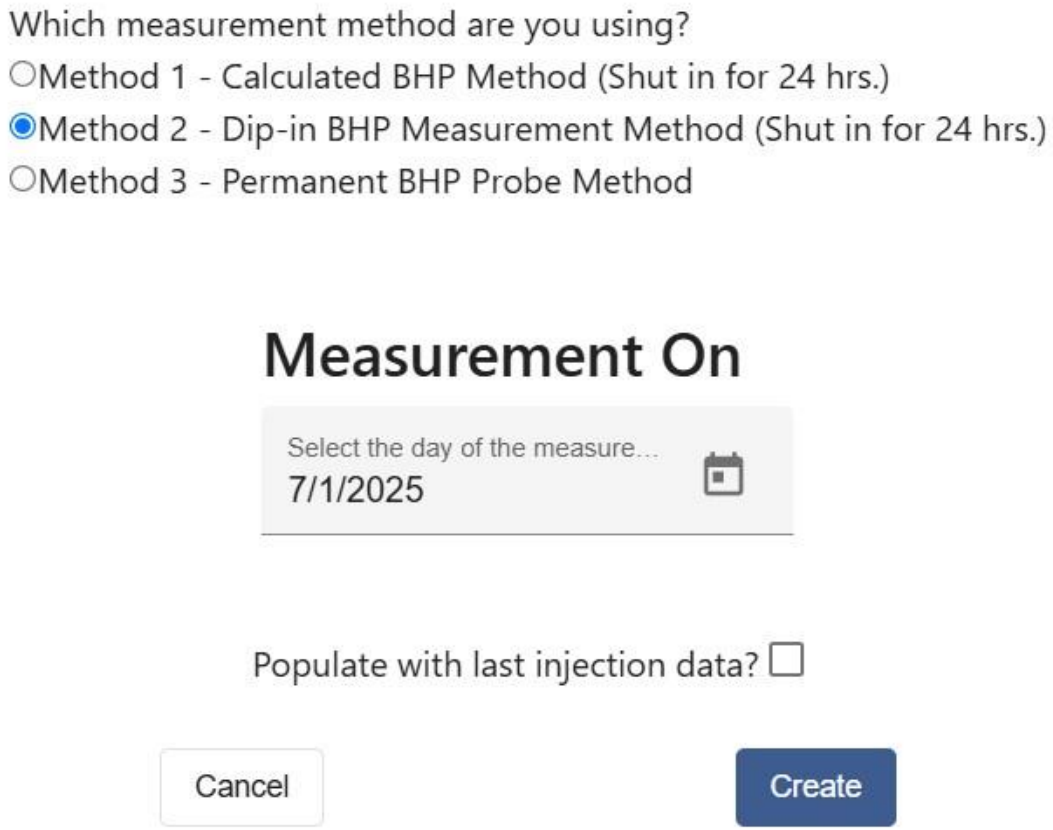
Submit BHP Data (4 of 8)



Highlighted cells in download template

- Shut-In Bottom Hole Pressure…Method 1
  - Example: 2350
- Top of Completed Interval TVD (ft.)
  - Example: 4500
- STATIC P SHUTIN TIME (Hrs)
  - Example: 24

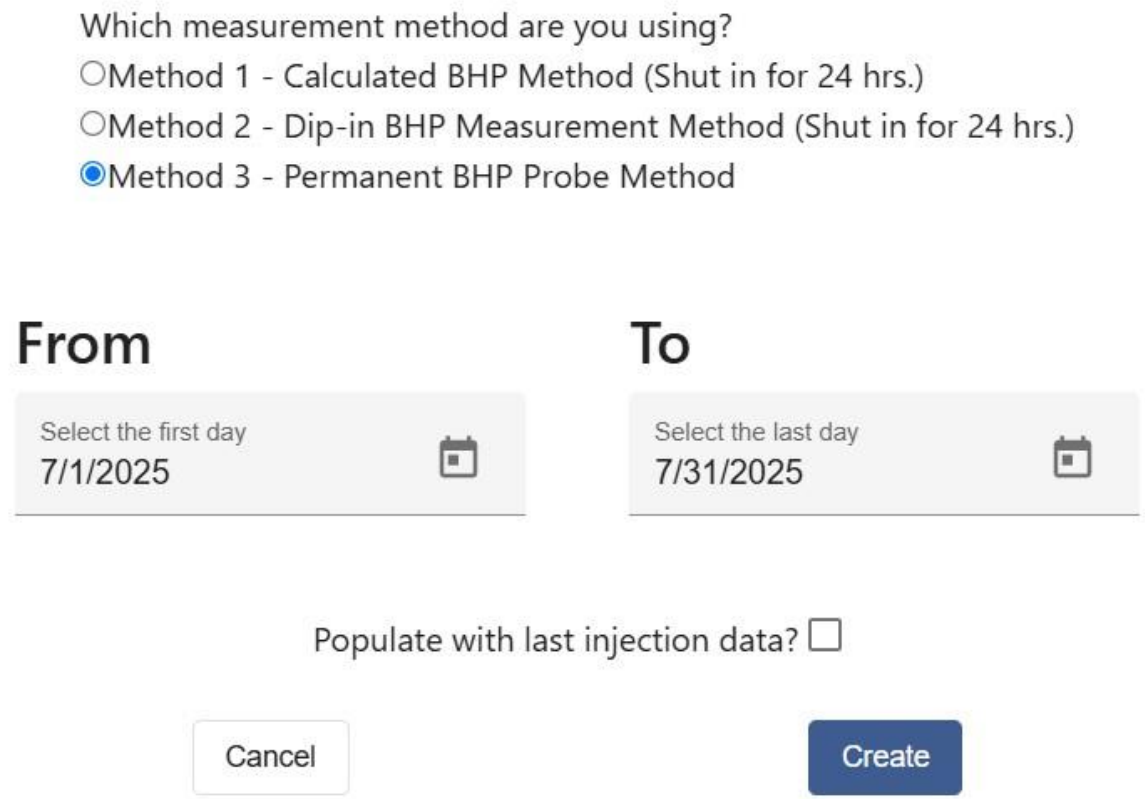
Submit BHP Data (5 of 8)



Highlighted cells in the download template

- Shut-In Bottom Hole Pressure…Method 2
  - Example: 2350
- Top of Completed Interval TVD (ft.)
  - Example: 4500
- STATIC P SHUTIN TIME (Hrs)
  - Example: 24

Submit BHP Data (6 of 8)



Highlighted cells in the download template

- Shut-In Bottom Hole Pressure…Method 3
  - Example: 2350
- Top of Completed Interval TVD (ft.)
  - Example: 4500

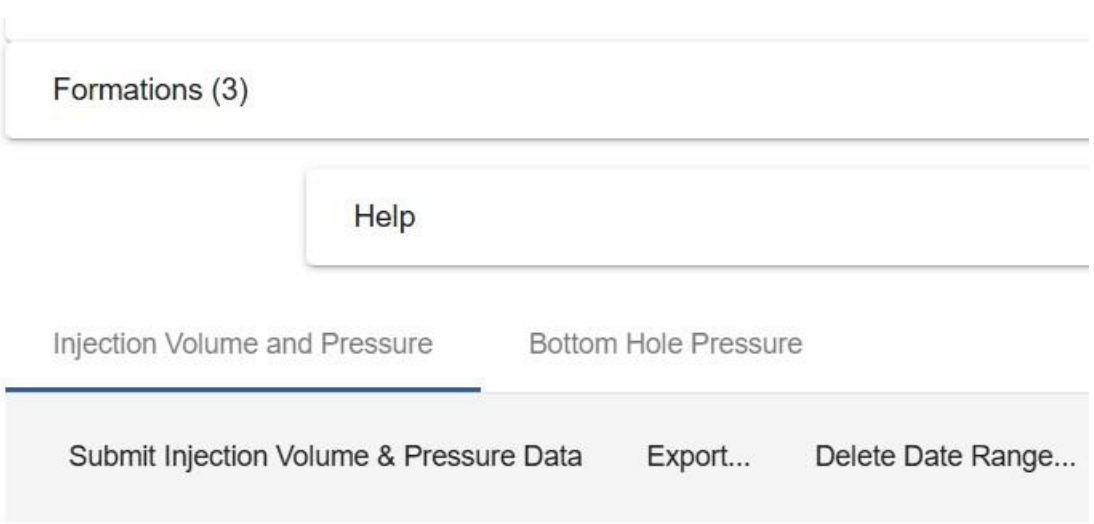
Submit BHP Data (7 of 8)

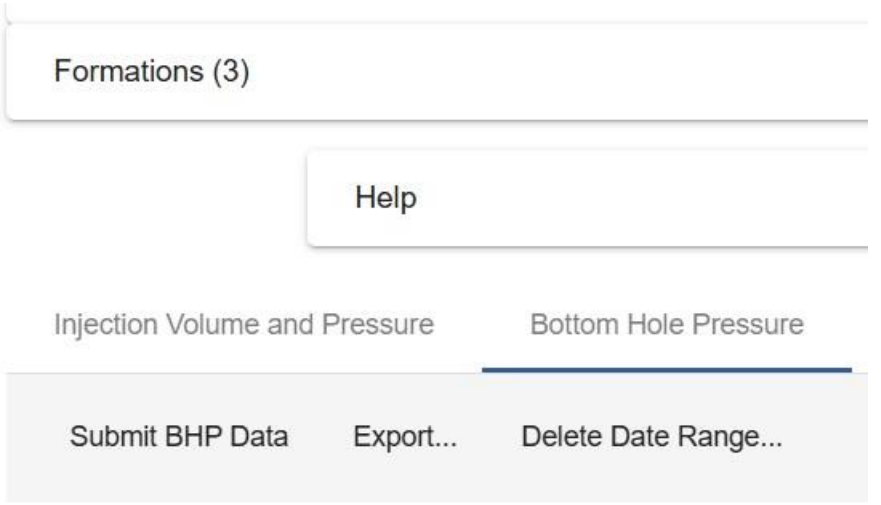
View the data submission from the My Wells/Well Details screen

Submit BHP Data (8 of 8)

Home / My Wells / Well Details:

Also, submit BHP data from the My Wells/Well Details screen



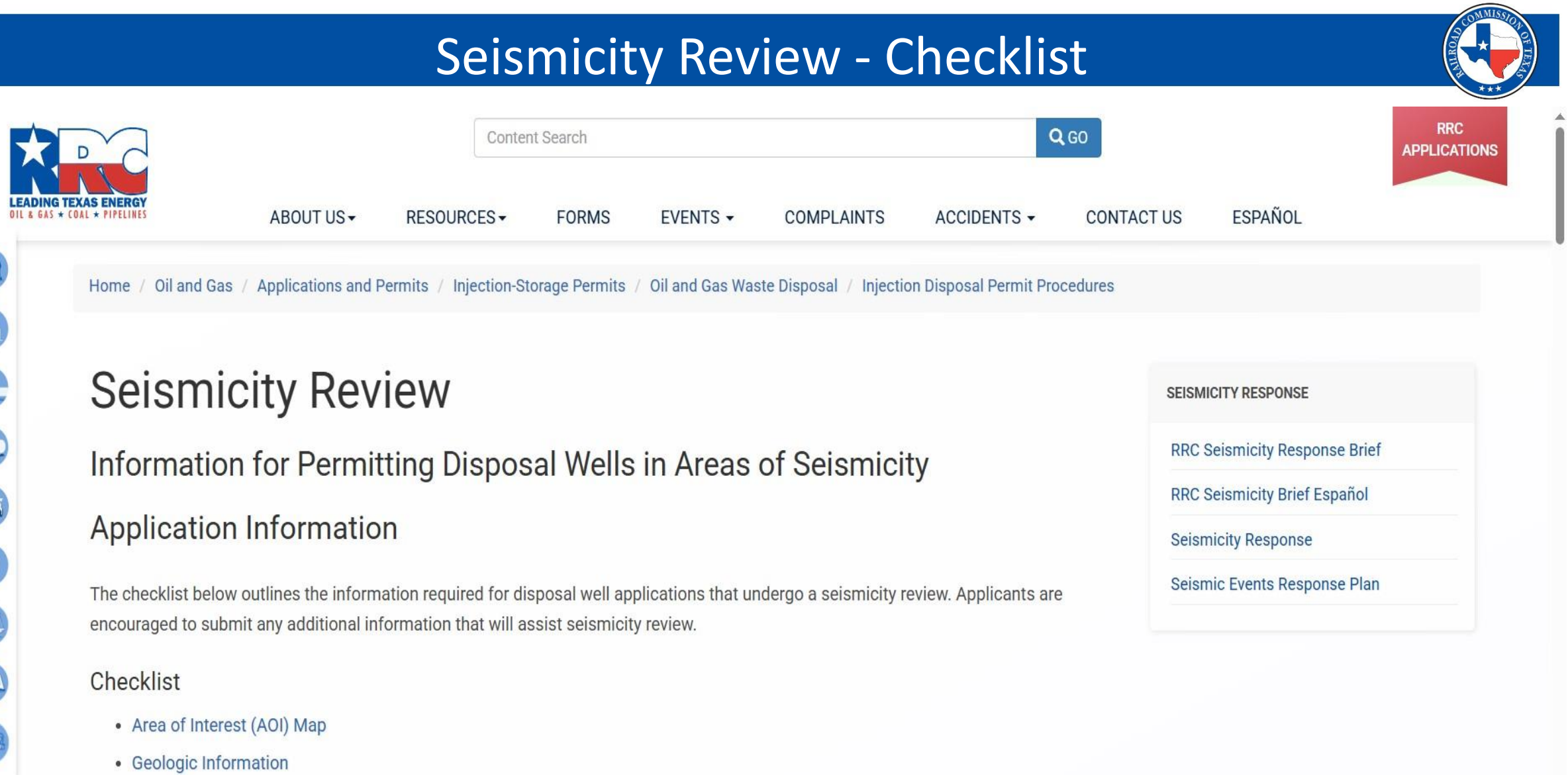


Select Period and Method — 2 Enter Bottom Hole Pressure Data — Submit

Export Excel Template | Import Excel Template

Date	Shut-In Bottom Hole Pressure - Daily (Method 3 (NTO) / Meas)	Shut-In Bottom Hole Pressure after 24 hours - Quarterly (Method 1 (NTO) / Calc)	Shut-In Bottom Hole Pressure after 24 hours - Quarterly (Method 2 (NTO) / Meas) *	Top of Completed Interval TVD (ft.) *	Liquid Density (Lbs./Gal)	MEAS BHP AVE INJ (PSIG)	MEAS BHP MAX INJ (PSIG)	CALC BHP AVE INJ (PSIG)	CALC BHP MAX INJ (PSIG)	STATIC P SHUTIN TIME (Hrs) *
2025/07/01			2350	4500						24

Seismicity Review - Checklist

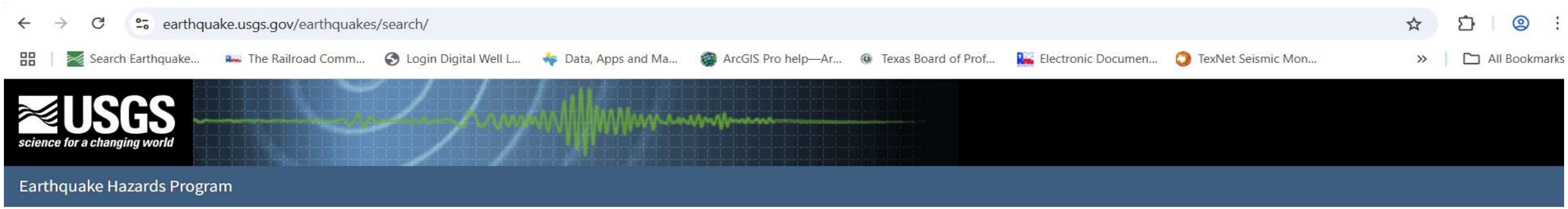


Area of Interest (AOI) Map (1 of 8)

Area Of Interest (AOI) Map

- An application for a new disposal well permit or an amendment of an existing disposal well permit for injection pressure, injection rate, or injection interval must include a survey of historical seismic events within the Area of Interest (AOI). The AOI is a circle centered on the disposal well location with a radius of 5.64 miles (9.08 km) for shallow wells and 15.53 miles (25 km) for deep wells. A disposal well is generally considered deep if the disposal interval includes geologic strata below the Wolfcamp formation or the bottom of the interval is deeper than 10,000 feet.
- For instructions on how to create a survey of historical seismic events see the Historical Seismic Events section of the Attachments for New Injection/Disposal Wells webpage.
- A seismic event of 2.0 Magnitude (M) or greater from the USGS earthquake catalog or the TexNet earthquake catalog triggers seismicity review and requires additional geologic information across the AOI. A Seismicity Review can be triggered by complex geology (for example, injection into basement or near basement strata with known faulting).

Area of Interest (AOI) Map (2 of 8)



Area of Interest (AOI) Map (3 of 8)

Basic Options

Magnitude

- ○ 2.5+
- ○ 4.5+
- ◉ Custom

Minimum

2

Maximum

Date & Time

- ○ Past 7 Days
- ○ Past 30 Days
- ◉ Custom

Start (UTC)

1973-01-01 00:00:00

End (UTC)

2025-07-01 23:59:59

Geographic Region

- ◉ World
- ○ Conterminous U.S.[1]
- ○ Custom

Worldwide

Draw Rectangle on Map

+ Advanced Options

+ Output Options

Area of Interest (AOI) Map (4 of 8)

- Advanced Options

Geographic Region

Decimal degree coordinates. North must be greater than South. East must be greater than West.

North

West

East

South

Circle

Center Latitude: 32.1

Center Longitude: -102.1

Outer Radius (km): 9.08

Depth (km)

Minimum

Maximum

Azimuthal Gap

Minimum

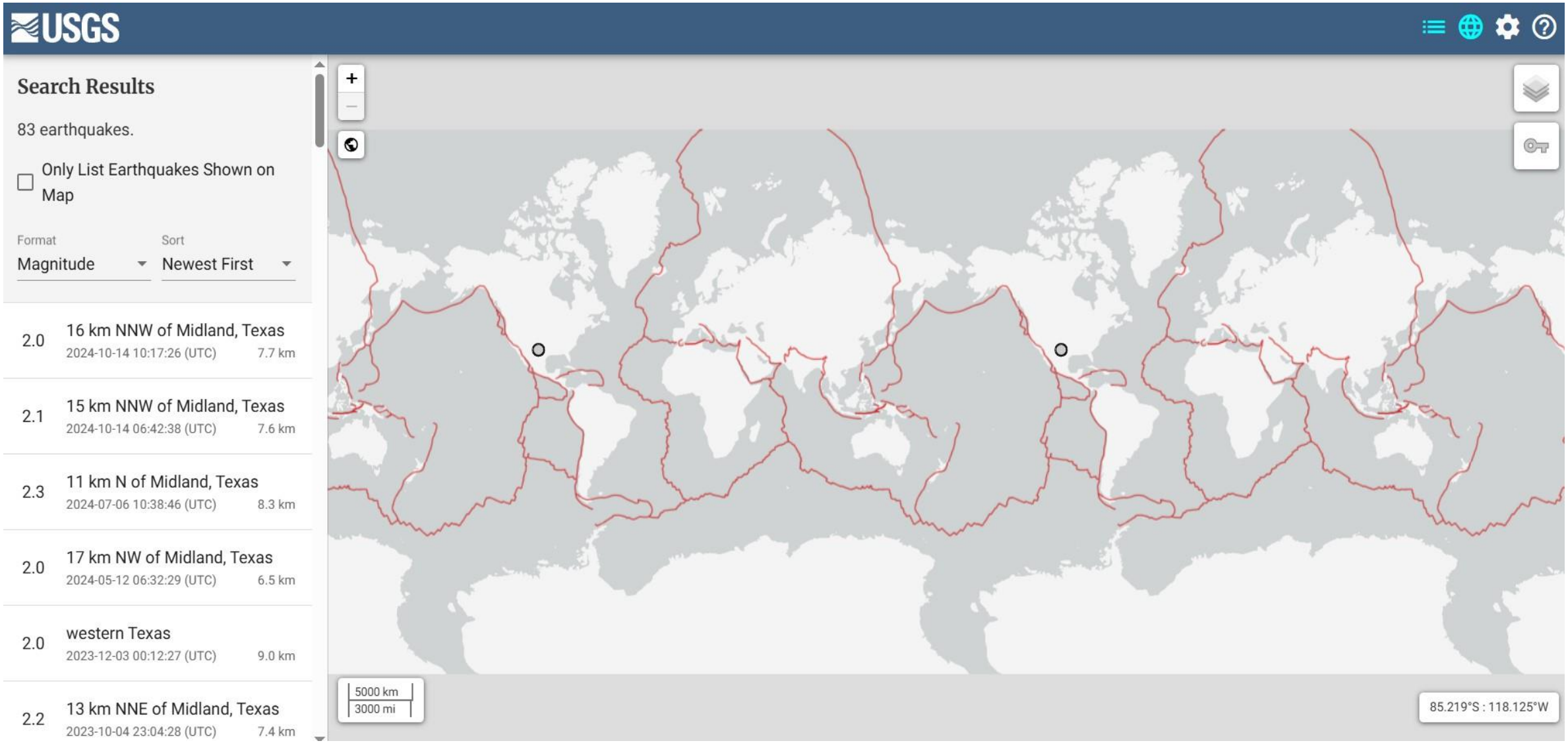
Maximum

Review Status

- (•) Any
- ( ) Automatic
- ( ) Reviewed

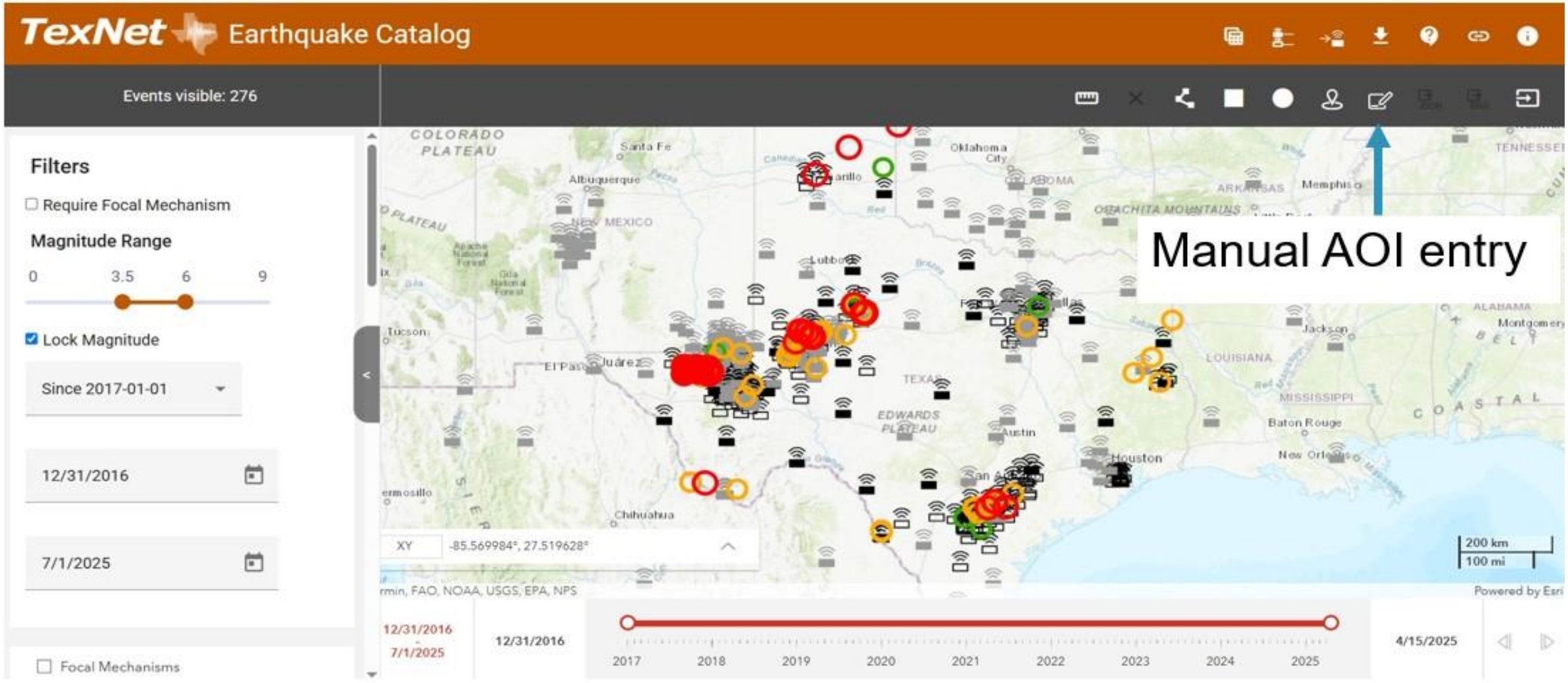
+ Event Type

Area of Interest (AOI) Map (5 of 8)



Area of Interest (AOI) Map (6 of 8)

https://catalog.texnet.beg.utexas.edu/



Area of Interest (AOI) Map (7 of 8)

Circular AOI

Center Latitude

32.1

Center Longitude

-102.1

Radius

9.08

Radius Units

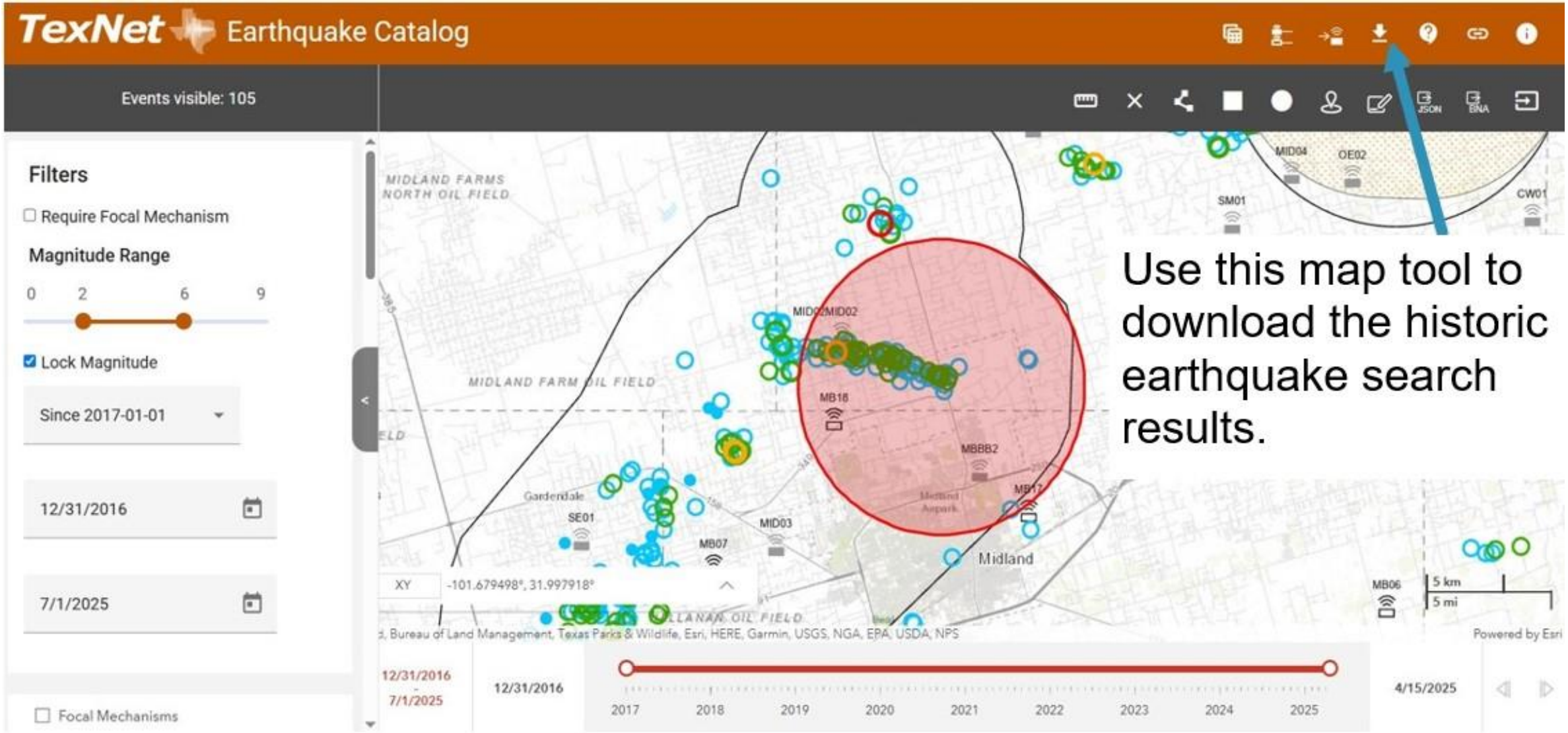
(•) Kilometers ( ) Miles

Geodesic

[x]

This setting controls whether the circle is drawn using real-world coordinates or projected map coordinates. For most scientific purposes, it should be left unchecked. For purposes related to regulation by the Railroad Commission of Texas (RRC), checking this box can improve agreement between maps used by RRC and the TexNet Earthquake Catalog.

Area of Interest (AOI) Map (8 of 8)



Geologic Information and Fault Hazard Analysis

Geologic Information

- Structure maps on top and bottom of injection interval,
- Isopach map of the injection interval, and
- Cross-sections oriented along strike and dip of the formation(s) proposed for injection.

Fault Hazard Analysis

- If a fault exists within the AOI, a fault hazard analysis may be required. The Stanford Center for Induced and Triggered Seismicity (SCITS) provides a free tool, Fault Slip Potential, to screen a fault's likelihood to slip, using data on the nature of the fault and nearby injection.
- Applicants are encouraged to submit any additional information that would assist evaluation of seismic hazard.

Fault Hazard Analysis May Be Required

https://cisr.beg.utexas.edu/fsp

CISR

Fault Slip Potential Software Download Portal

At the link below the current release of the FSP software and related information and tutorials can be downloaded. This software is provided at no cost and there is no warranty of its function or accuracy.

Background

Fault Slip Potential (FSP) is a free tool for deterministic and probabilistic screening of the rupture stability of existing faults in contact with a reservoir undergoing a pore pressure change, typically near injection wells. The tool can be used for screening of individual faults locally, or systems of faults regionally. The tool combines Mohr-Coulomb analysis with pore pressure modeling. FSP can use either an imported pressure model or semi-analytic pressure modeling of a uniform confined aquifer using constant, isotropic parameters and linear superposition of multiple wells. It can also be used to assess the rupture stability of faults in the natural state or as influenced by uniformly perturbed conditions. Faults are assumed to be in contact with the injection interval and out-of-zone effects and poroelasticity are not considered. FSP is best used in conjunction with a GIS tool such as ArcMap and a tutorial for that I/O process is provided.

FSP was developed and publicly released in 2017 through a partnership between ExxonMobil and the Stanford Center for Induced and Triggered Seismicity (https://scits.stanford.edu/). In 2023 the role of provision, maintenance and feature enhancement was transferred to The University of Texas Bureau of Economic Geology.

Download

Current Version: FSP 2.0, co-developed by Stanford and ExxonMobil. Information about changes to the software, new versions, and associated information will be posted here.

Sampling of recent CISR public presentations

CISR Research Portfolio

CISR Fault Maps

CISR/TXRRC Seismic Interpretation Collaboration

Fault Slip Potential (FSP) Analysis Tool

Geologic Characterization and Geomodeling

Pore Pressure Modeling

Injection Capacity and Hazard Analysis

Bureau of Economic Geology

Spacing Requirements and Permit Conditions

Spacing Requirements

Disposal Wells being permitted near seismically active areas should be spaced ≥ 0.62 mi (1 km) apart if injecting into the same disposal zone to reduce interference and mitigate seismic risk.

Permit Conditions

To ensure that disposal permits issued with a seismic event ≥ 2.0M in the AOI do not contribute to seismic activity, permit conditions may be applied for administrative approval, including:

- Lower permitted injection rate in accordance with seismicity review score,
- Lower injection pressure if disposal is into a formation with a low fracture gradient,
- Step-rate test(s),
- Bottom-hole pressure test(s),
- Daily recording of injection volumes and pressures, and
- Permitting conditions recommended by the RRC Seismologist.

Seismic Monitoring

Seismic Monitoring

Disposal well operators are encouraged to perform seismic monitoring. An operator may be permitted for a higher injection rate if an operator develops and implements an RRC-approved Seismic Monitoring Plan and an Earthquake Response Plan.

Seismic Monitoring Plan

The Seismic Monitoring Plan must contribute data to an existing public seismic network, for example The University of Texas, Bureau of Economic Geology's TexNet program. TexNet has specified seismic station requirements. Monitoring should contribute to the body of public knowledge to better resolve earthquake locations, especially depth. At a minimum, the Seismic Monitoring Plan must include:

- The method of monitoring,
- The location and type of instrumentation, and
- An archive of the data in a public seismic database.

Earthquake Response Plan

The Earthquake Response Plan must identify actions that will be taken to inspect for facility damage, mitigate risk by modifying operations, and establish thresholds for suspension of injection activity. At a minimum, the Earthquake Response Plan must include:

- Monitoring plan will be filed with the Commission before disposal activities begin.
- Operator will monitor TexNet and USGS catalogs.
- Response plan triggered when a 3.5M event is detected with a reported hypocenter location within the AOI.
- Operator will notify the Commission within 24 hours of an earthquake that triggers the response plan.
- Within 30 days of an earthquake trigger, the operator will file a report with the Commission documenting the event.

Appendix: Supporting Documentation

- 2017-11-30-Final Report-Texas Aquifer Exemption Project
- 2018-01-19-Final Report-East Texas Formation Pressure Project
- Seismicity Permian Basin Guidelines, February 8, 2019
- 2022-01-31_Seismic_Response_SOG_Final

Questions?