Monitoring Well-to-Well Communication to Reduce Environmental Impacts

Djuna Gulliver – NETL-RIC

FWP-1022415

Project Overview

2021	2022	2023	2024	2025	Total Project Value
$150k	$350k	$500k	$600k	$150k	(2021 – 2024) $1,750 k

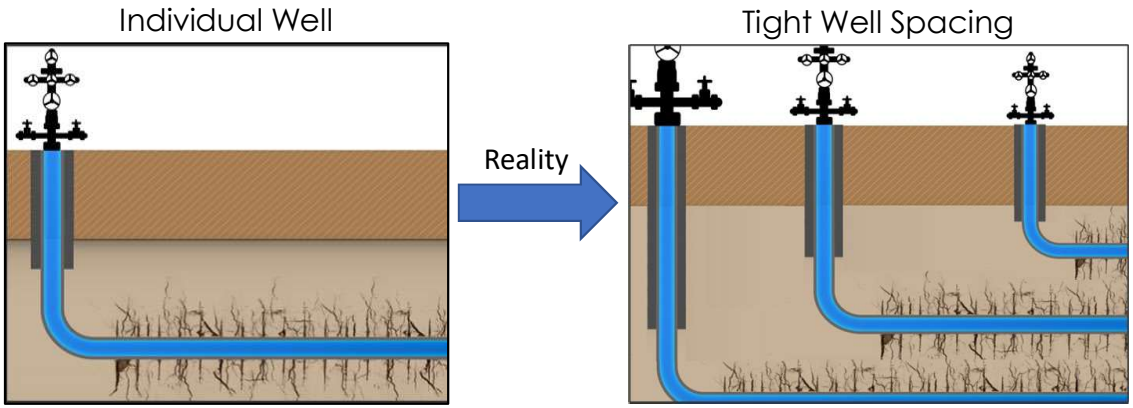
This task will identify/develop/test methods that visualize well-to-well communication. Methods will include application for both new infrastructure and existing infrastructure.

1. Identify new chemical and microbiological tracers
2. Use strain signatures to prevent well to well interactions.

Task Team Members

- PIs: Djuna Gulliver (NETL-RIC) and Richard Hammack (NETL-RIC)
- Other Key Personnel: Kara Tinker (LRST), Samuel Flett (ORISE), Justin Mackey (LRST), Ge Jin, Xiaoyu (Rosie) Zhu (CSM)
- Previous Key Personnel: Burt Thomas (NETL-RIC), James Gardiner (NETL-TDC)

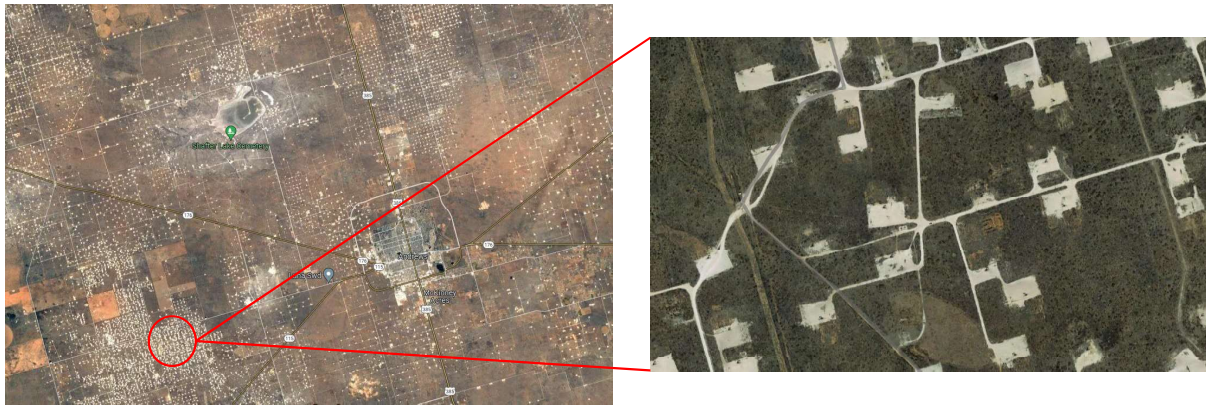
Technology Background



Research Question: What chemical, microbiological, and geomechanical signatures can be used to identify migrating fluids

Approach: The project will: 1) identify new chemical and microbiological tracers and 2) use strain signatures to prevent well to well interactions.

End Product: More complete utilization of existing wells/improved strategies for well use conversion or retirement.



Briny water spews high into the air from a former oil well in Crane County on January 4, 2022.

Project Scope

Identifier	Type[1]	Expected Completion Date	Description (What, How, Who, Where)
25.A	Go/No-Go	03/31/2022	Preliminary method to demonstrating well-to-well communication is identified using geochemical/microbiological signals.
25.B	Go/No-Go	03/31/2022	Review current practices for frac hit detection and mitigation through conversation with industry and review of NETL external projects.
25.C	Project	03/31/2022	Determine if the use of deployable FO probes to warn of frac hits can be incorporated in normal industry operations.
25.D	Go/No-Go	03/31/2022	Obtain three letters of support from relevant operators/agencies/institutions
25.E	Major	03/31/2023	Field deployment and evaluation of new well communication detection method.
25.F	Major	03/31/2023	Determine if the impending frac hit warning provided by FO strain data is early enough to prevent the actual frac hit.
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25.I	Major	03/31/2025	Develop guidance on well-to-well communication mitigation/management strategies.

Technical Approach

Sample during fluid migration from new well

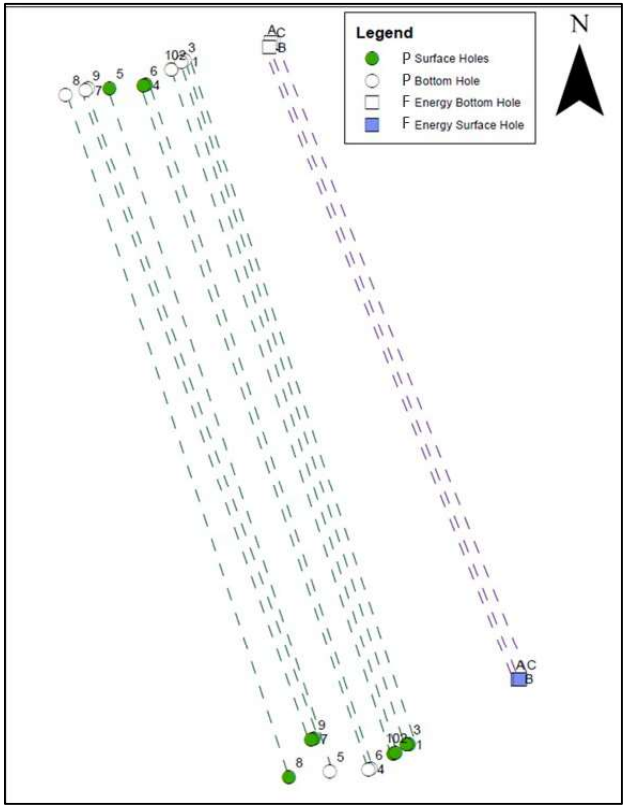
- **Assess signal from archived data**
  - Detection of well-to-well communication in 2018 and 2019 sampling
- **Sample impacted wells during a scheduled operation**

Onsite sampling

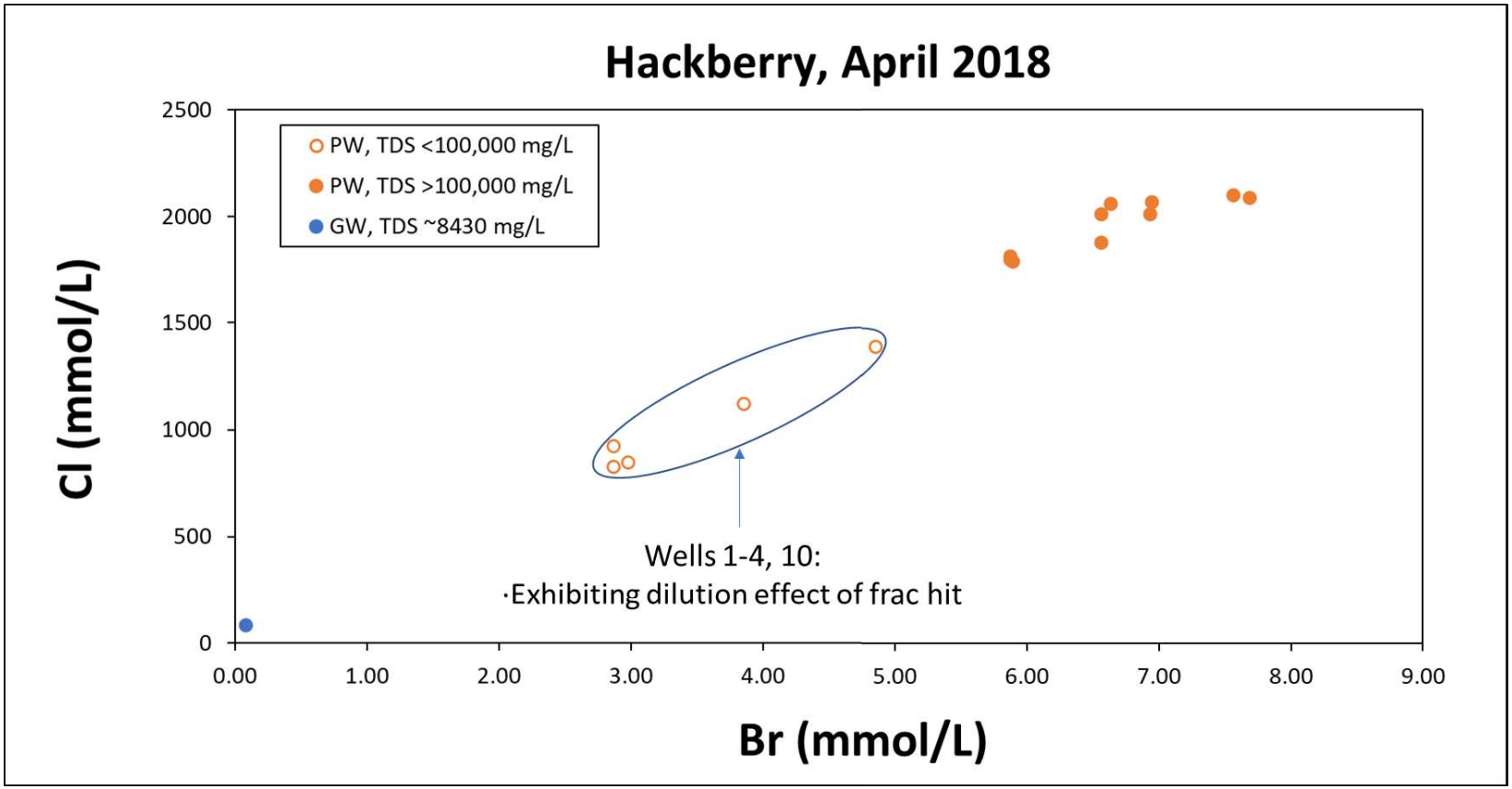
- **Observe systems**
- **Take onsite measurements**
- **Prep samples onsite**
  - Geochemistry
  - Taxonomy
  - Metagenomics

Field Site

- **Sampled in April 2018 and October 2019**
- **F Energy: Fracturing adjacent wells 4/13-5/6/2018**
- **Well communication detected in P Wells 1-4, 10 in April 2018**
  - ***Wells 1-3, 10 closest to F frac operations***
  - ***Well 4 shows effects, but Well 6 does not***

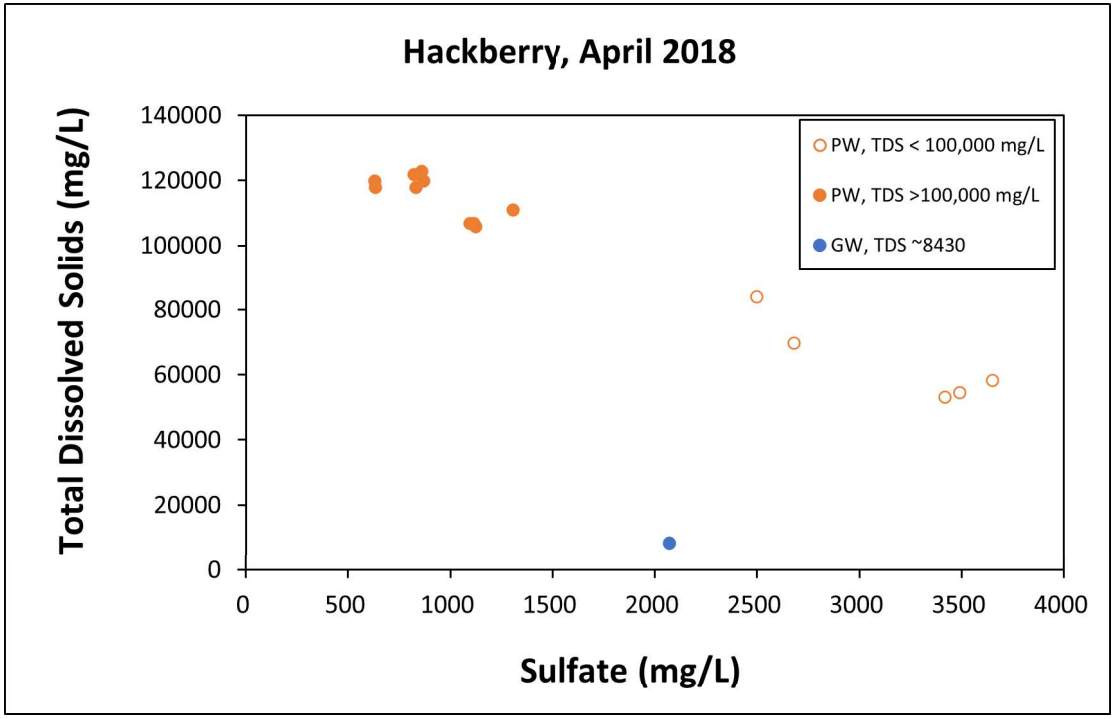


Chloride vs. Bromide



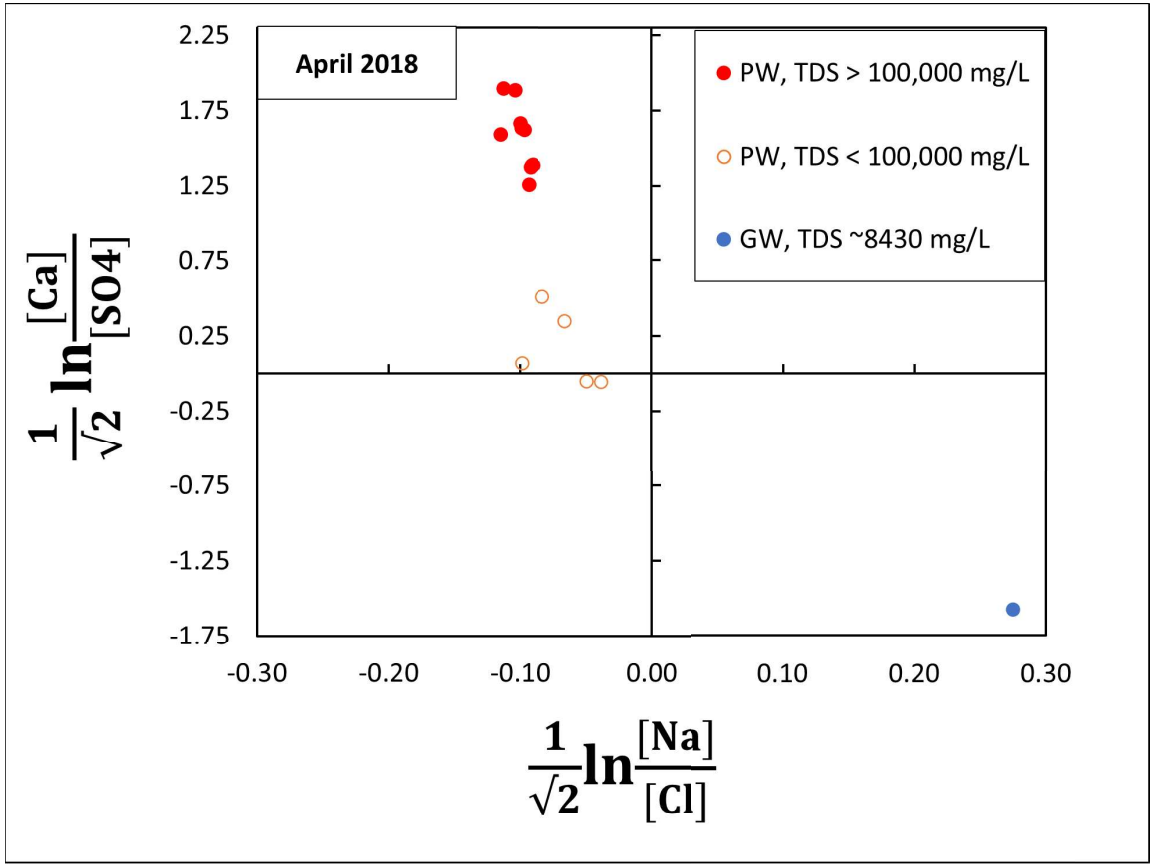
TDS vs. Sulfate

- **Decrease in TDS, increase in sulfate solubility → kinetic phenomena**
  - **<u>Sulfate increase related to:</u>**
  - ***Surfactants and other additives in HFF***
  - ***Reaction/dissolution of reservoir sulfur materials***



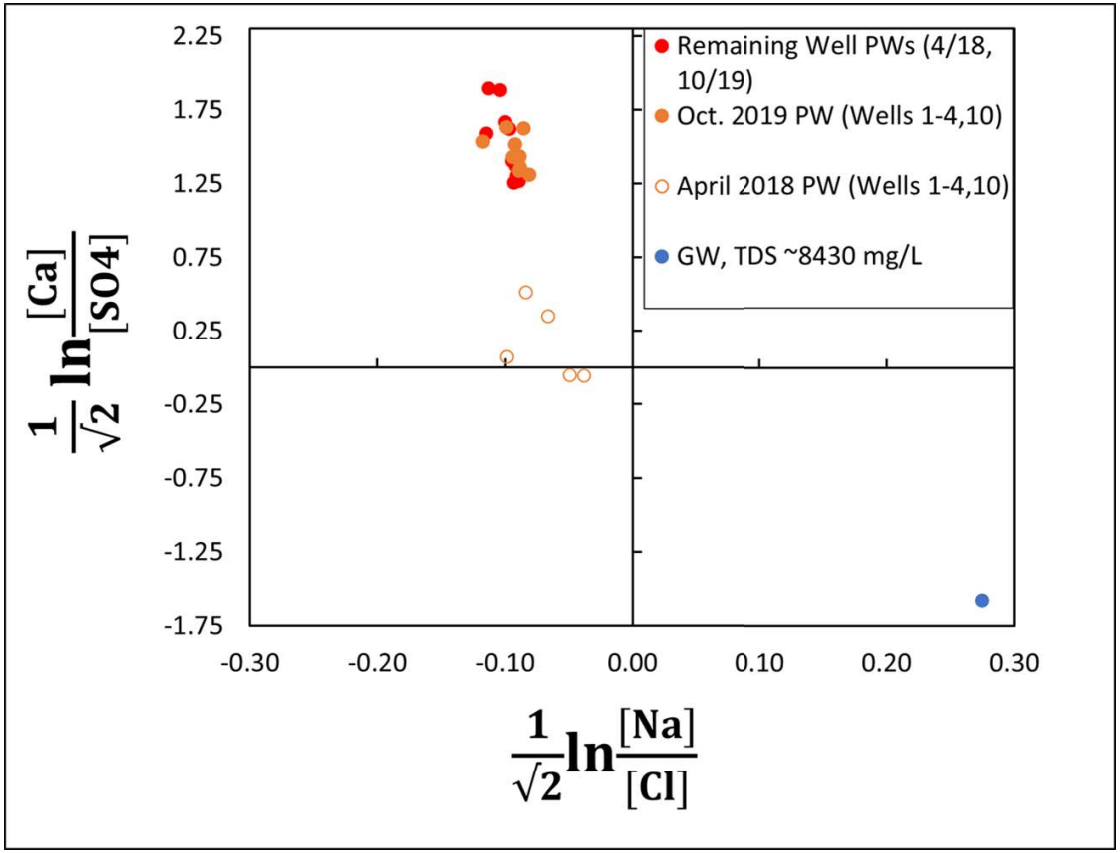
Isometric Log-Ratios

- Isometric log-ratios used to remove possible spurious correlations
- April 2018 Wells 1-4, 10 (<100,000 mg/L) still plot in unique location



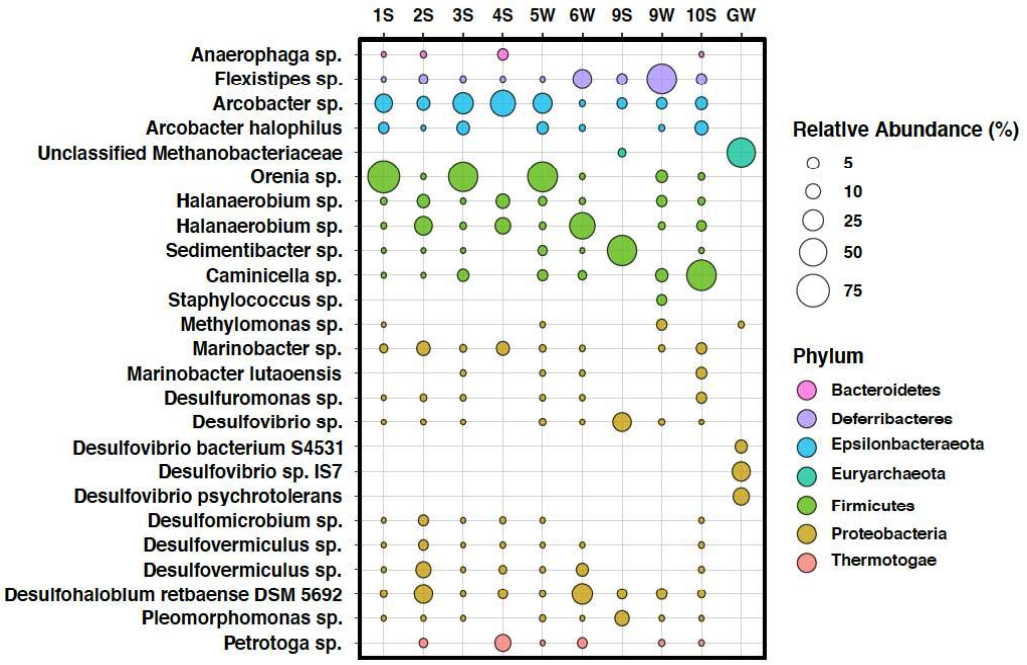
Isometric Log-Ratios

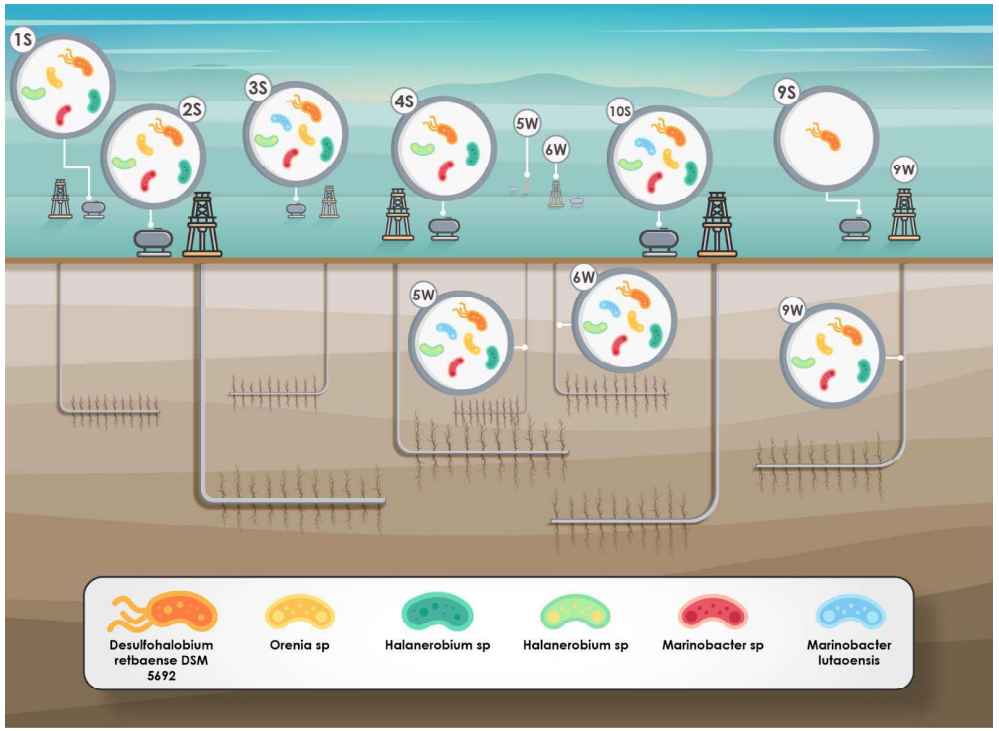
- **Isometric log-ratios used to remove possible spurious correlations**
- **April 2018 Wells 1-4, 10 (<100,000 mg/L) still plot in unique location**
- **October 2019 Wells 1-4, 10 plot with all other sampled wells**
- ***No evidence of fluid migration 1.5 years later***



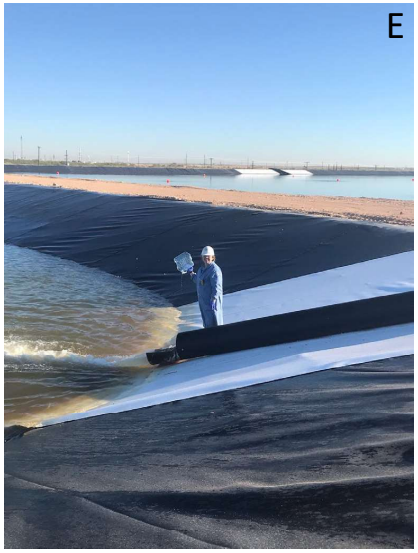
Microbiology

- **The microbial community and functional potential of the Midland Basin reveal a community dominated by both thiosulfate and sulfate-reducing microorganisms**

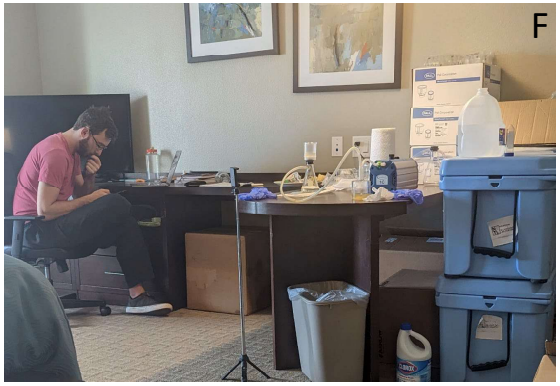




EY22 Field Sampling



- Field sampled time-series of well communication 12 wells over the course of 3 weeks
- Sampled two source fluids, treated produced water and groundwater
- Wells were shut off one by one over course of three weeks except for 4 of the most downgradient



Plans for Future Testing

- **EY21 – Complete technology transfer from archived datasets**
  - Tinker, K., Lipus, D., Gardiner, J., Thomas, B., Stuckman, M., Gulliver, D., 2022. "The Microbial Community and Functional Potential in the Midland Basin Reveal a Community Dominated by Both Thiosulfate and Sulfate-Reducing Microorganisms". Microbiology Spectrum
- **EY22 – Field sampling scheduled during expected impact (2-3 weeks)**
  - Zipper-frac three wells
  - Sample fracture fluid, groundwater, and treated produced water
  - Sample downgradient production wells at increasing distance
- **EY23 – Analysis of EY22 samples, field sampling of impacted wells 1 year after new drill**
- **EY24 – Integrate geochemical signals (25.1) with fiber optic strain (25.2)**
- **EY25 – Technology Transfer**

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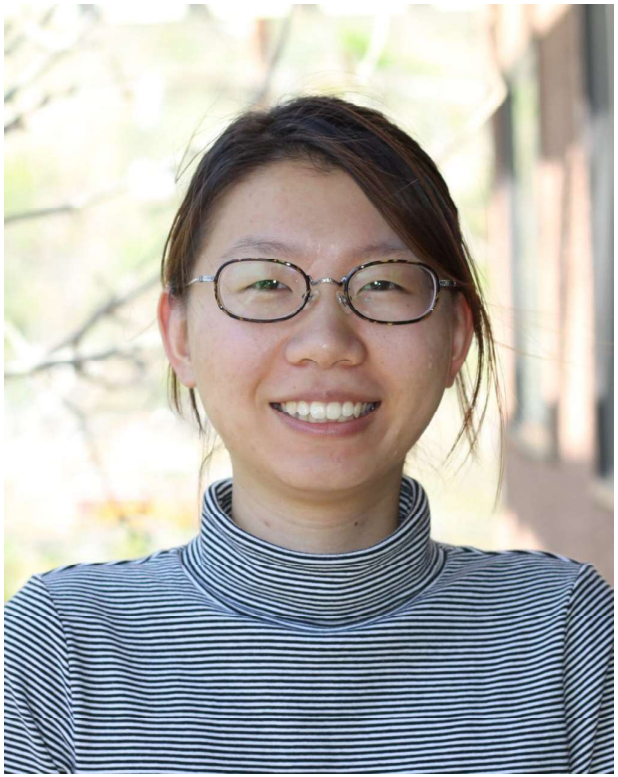
Using Fiber Optic Strain Signatures to Prevent Damaging Frac Hits

Research Team

Ge Jin



Xiaoyu (Rosie) Zhu

Using Fiber Optic Strain Signatures to Prevent Damaging Frac Hits

Objective – Provide Early Warning of Impending Frac Hit

- Approach
  - Deploy FO cable in well to be protected from frac hits
  - Analyze low-frequency DAS data from the fiber optic interrogator to recognize frac hit signatures
  - Report impending frac hit to frac crew
  - Frac crew will initiate frac hit mitigation strategy

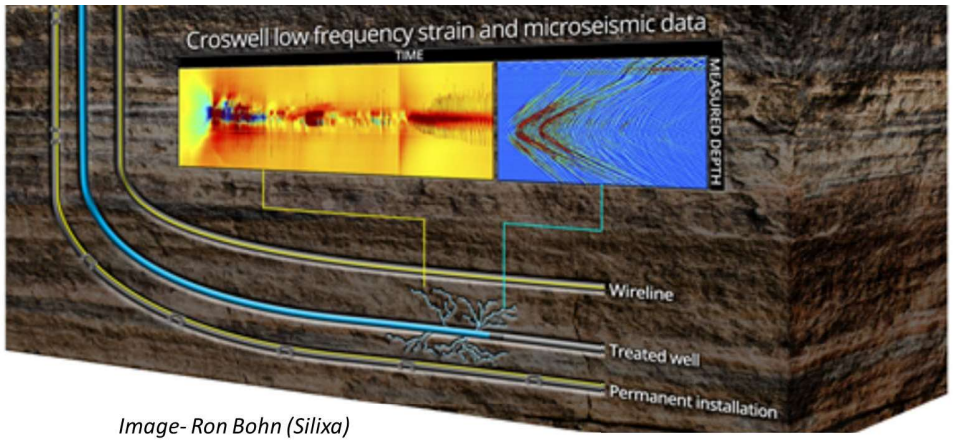
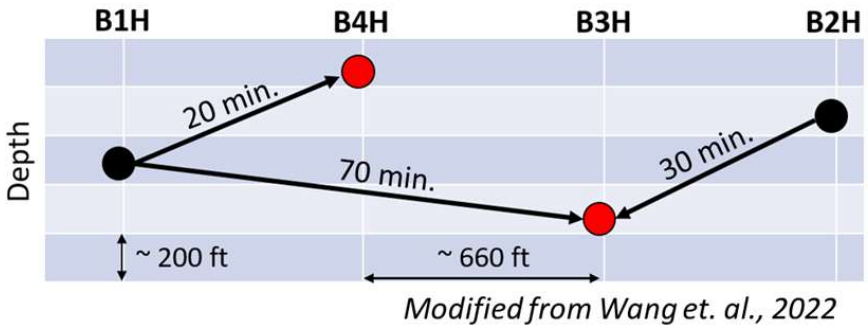


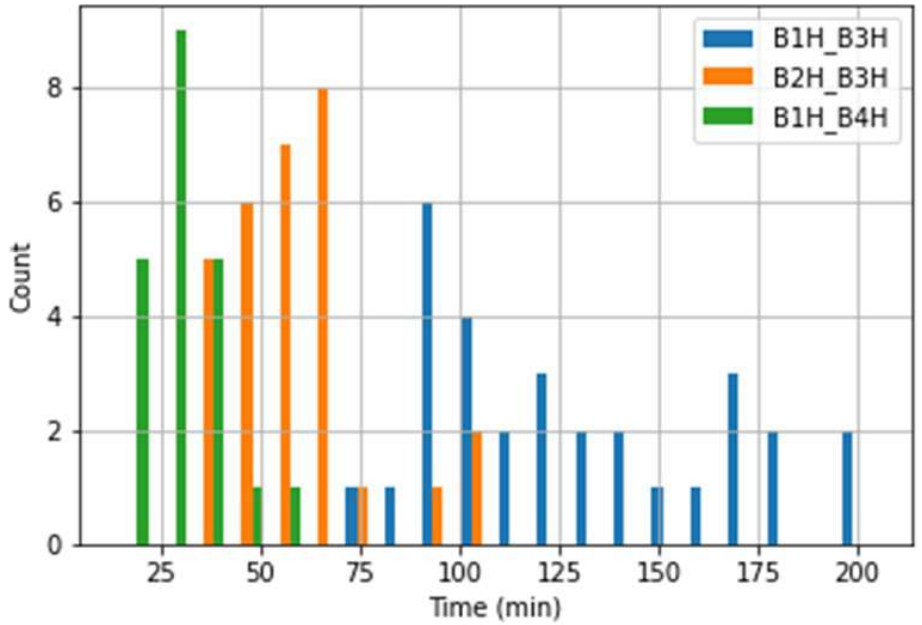
Image- Ron Bohn (Silixa)

Using Fiber Optic Strain Signatures to Prevent Damaging Frac Hits

Warning Time vs. Distance Between Wells (Data from HFTS II)

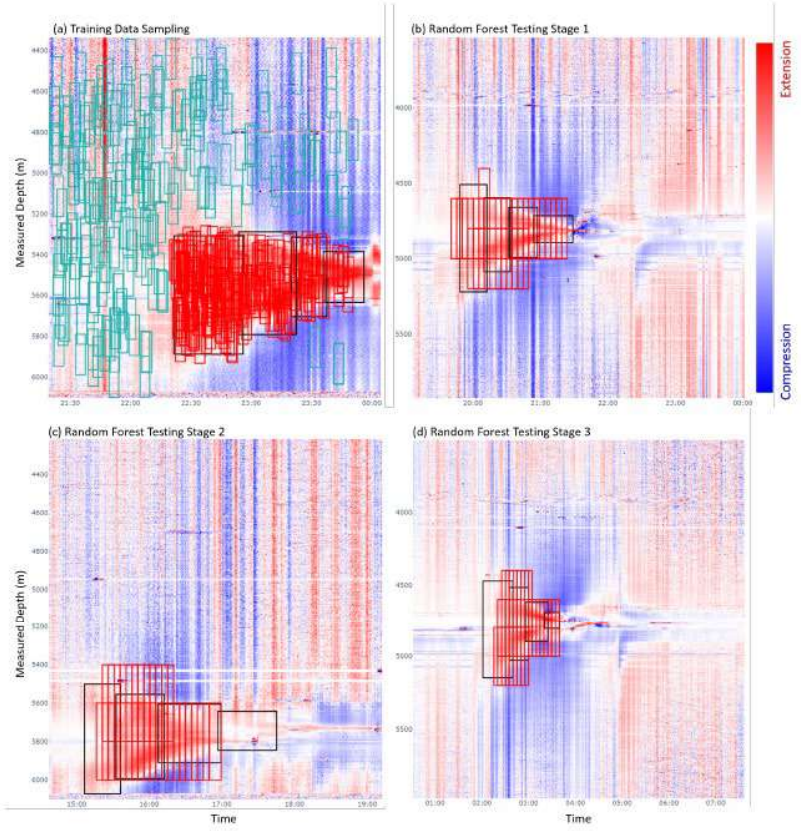


Modified from Wang et. al., 2022



Using Fiber Optic Strain Signatures to Prevent Damaging Frac Hits

Machine Learning Workflows for Recognizing Frac Hit Strain Signatures



$$Accuracy = \frac{Correct\ Predictions}{Total\ Predictions}$$

$$Precision = \frac{True\ Positives}{True\ Positives + False\ Positives}$$

Low-frequency DAS fracture-hit detection

Method	Accuracy	Frac-hit precision	Training time (s)	Predict time (s)
Random Forest	0.93	0.98	91.468	0.165
Bagging SVM	0.90	0.94	5833.670	5448.934
Neural Network	0.93	0.95	104.657	1.701

Table 1: Summary of algorithm performance

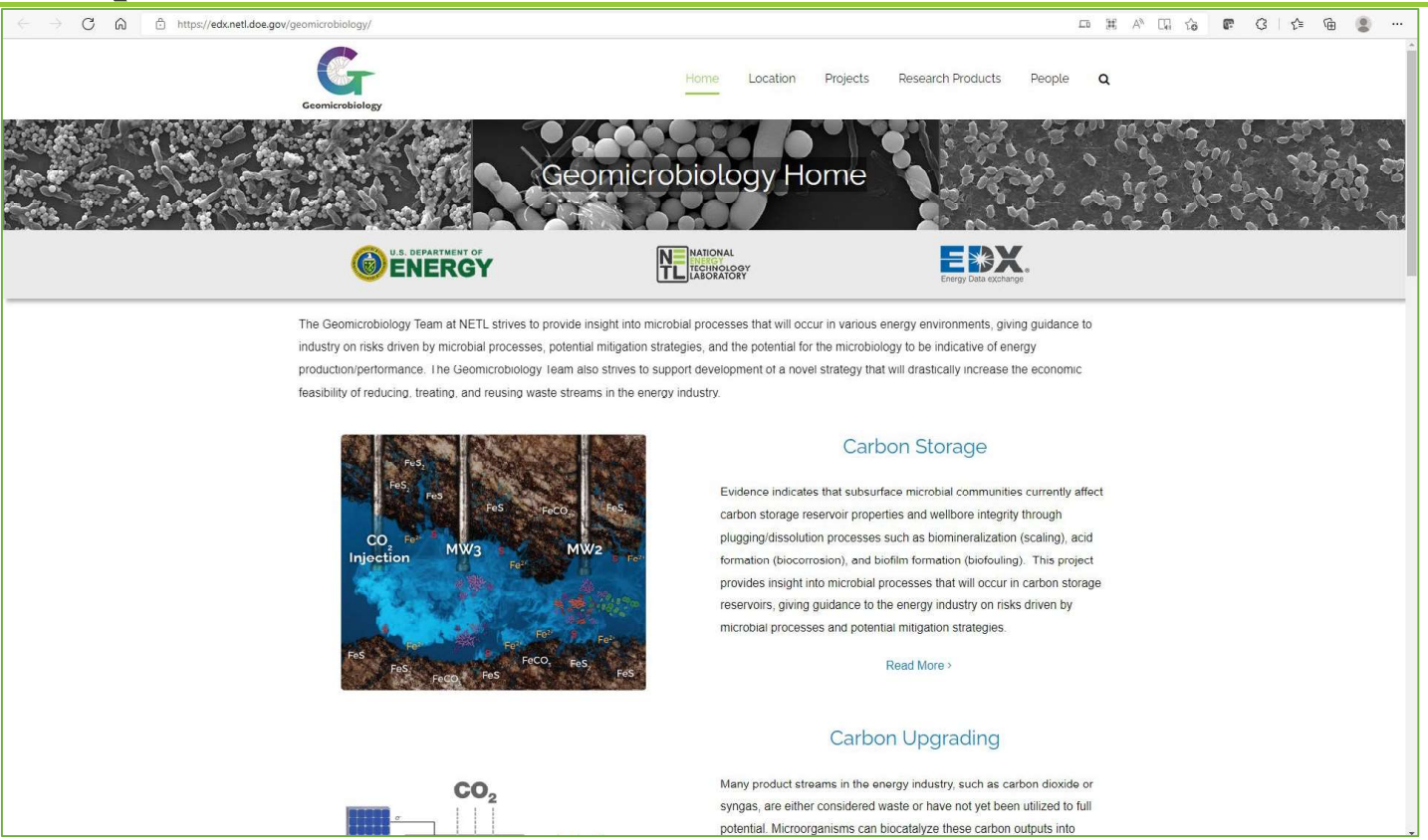
EY 21 Accomplishments

- Developed ML (Random Forest) method to scan FO strain data
  - Recognizes frac hit in 0.2 s
  - Provides > 20 min warning to completions engineer
  - Allows ample time to deploy frac mitigation strategies
  - Algorithm published on GitHub

Current Work

- Develop ML algorithm to predict time to frac hit
- Test algorithms on MSEEL II and HFTS I Phase III data

Questions



Website:
https://edx.netl.doe.gov/geomicrobiology/

Organization Chart

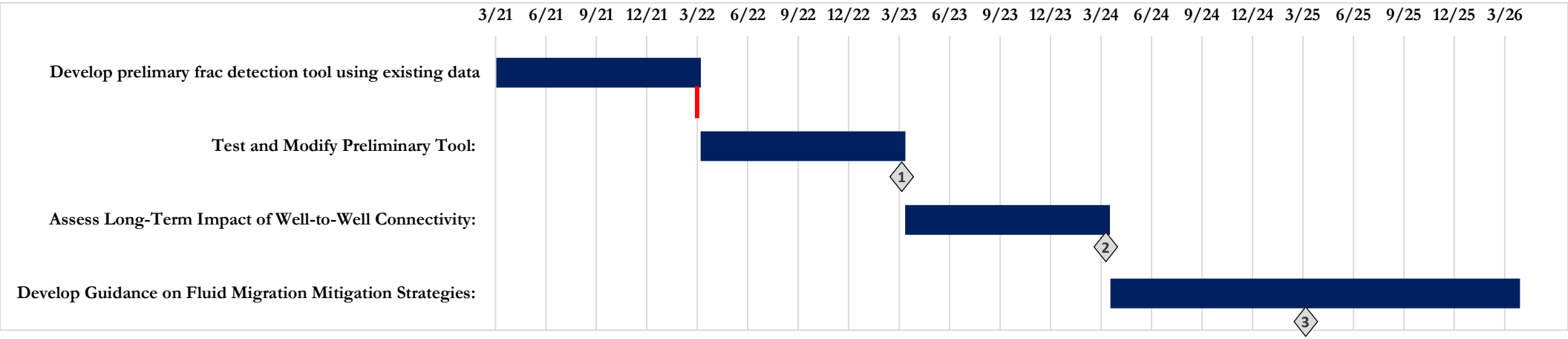
Task 25.1

- Djuna Gulliver, NETL-RIC (PI – Task 25.1)
- Kara Tinker, Leidos-NETL (Task 25.1)
- James Gardiner, NETL-TDC, formerly Battelle-NETL (Task 25.1)
- Samuel Flett, ORISE-RIC (Task 25.1)
- Justin Mackey, Leidos-NETL (Task 29)

Task 25.2

- Richard Hammack, NETL-RIC (PI – Task 25.2)
- Ge Jin, Colorado School of Mines (Task 25.2)
- Xiaoyu (Rosie) Zhu, Colorado School of Mines (Task 25.2)

Gantt Chart



Milestones

1. Field deployment and evaluation of new well communication detection method.(Q4, March 2023)
2. Demonstration of new method as a visualization tool of short-term and long-term well-to-well communication.(Q4, March 2024)
3. Develop guidance on well-to-well communication mitigation/management strategies.(Q4, March 2025)

Go / No-Go

1. Preliminary method to demonstrating well-to-well communication is identified using geochemical/microbiological signals.
2. Review current practices for frac hit detection and mitigation through conversation with industry and review of NETL external projects.
3. Obtain three letters of support from relevant operators/agencies/ institutions on developing methods of detecting well-to-well commuication