

Monitoring Well-to-Well Communication to Reduce Environmental Impacts



Djuna Gulliver – NETL-RIC

FWP-1022415



U.S. DEPARTMENT OF
ENERGY

11/10/2022

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Project Overview

2021 \$150k	2022 \$350k	2023 \$500k	2024 \$600k	2025 \$150k	Total Project Value (2021 – 2024) \$1,750 k
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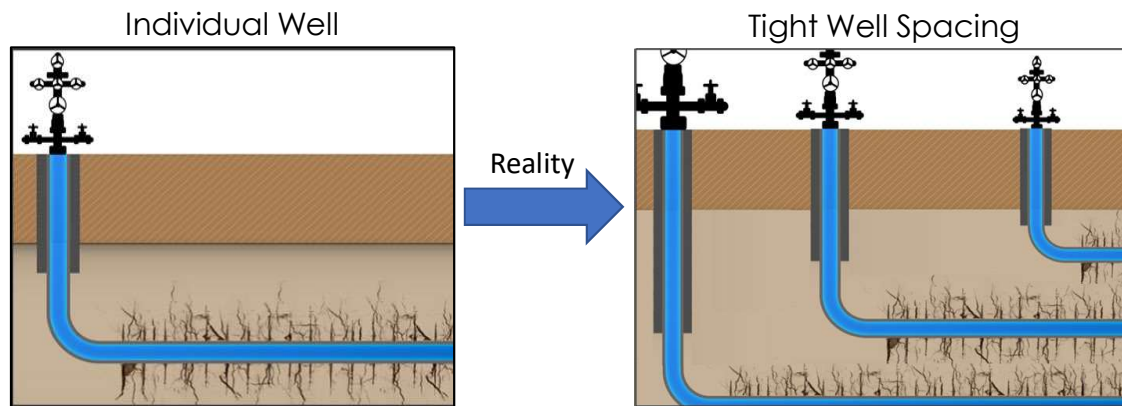
This task will identify/develop/test methods that visualize well-to-well communication. Methods will include application for both new infrastructure and existing infrastructure.

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

Task Team Members

- Pls: 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.
25.G	Project	03/31/2024	Demonstration of new method as a visualization tool of short-term and long-term well-to-well communication.
25.H	Major	03/31/2024	Complete field testing of FO strain methods for the early detection of impending frac hits at a site provided by an industry collaborator.
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

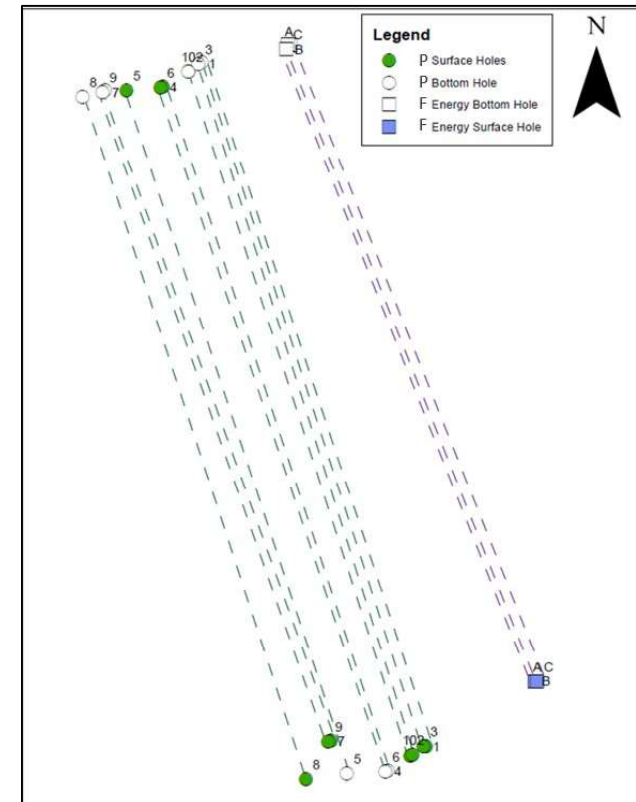
Onsite sampling

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

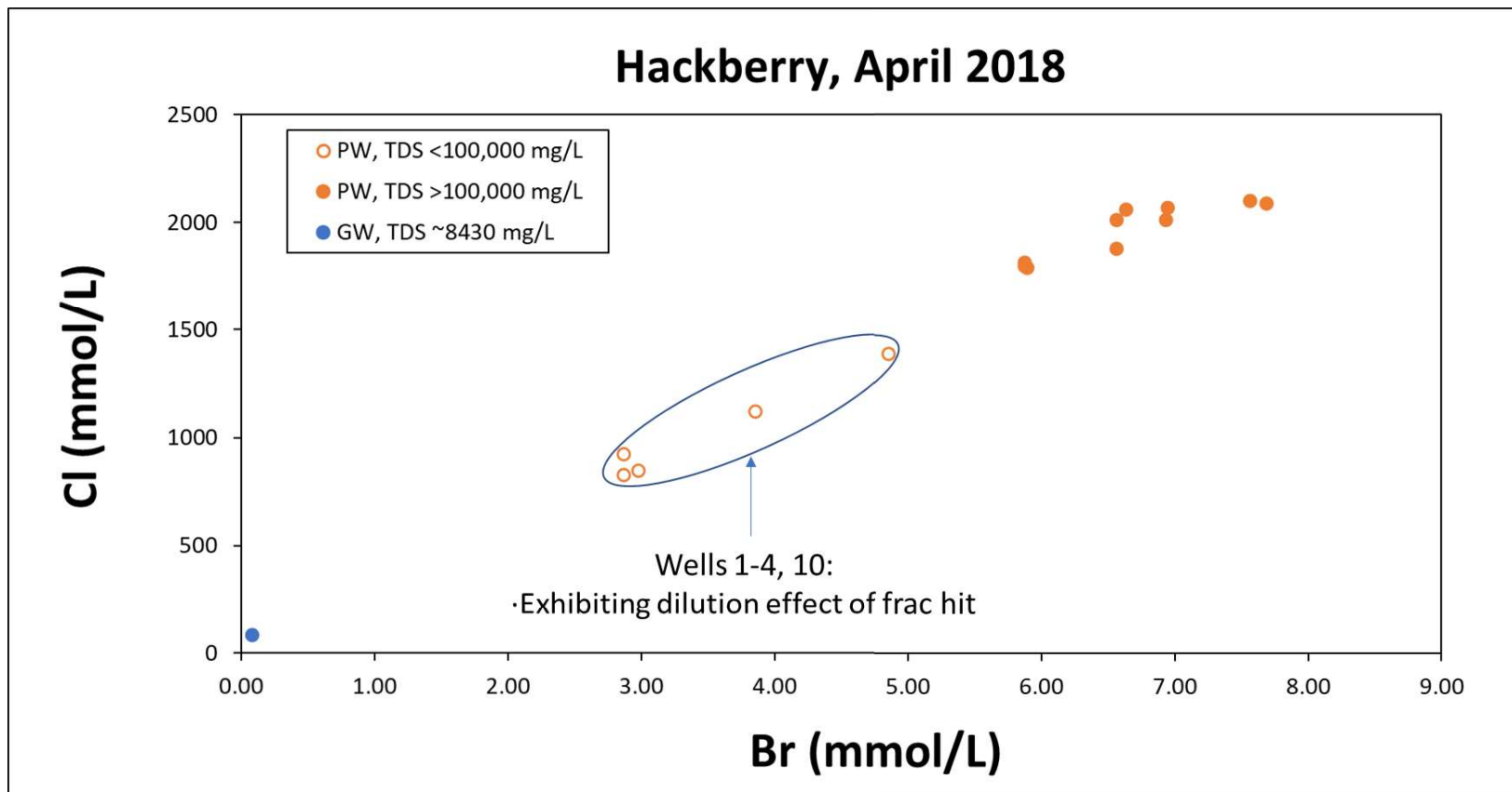


Field Site

- 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*

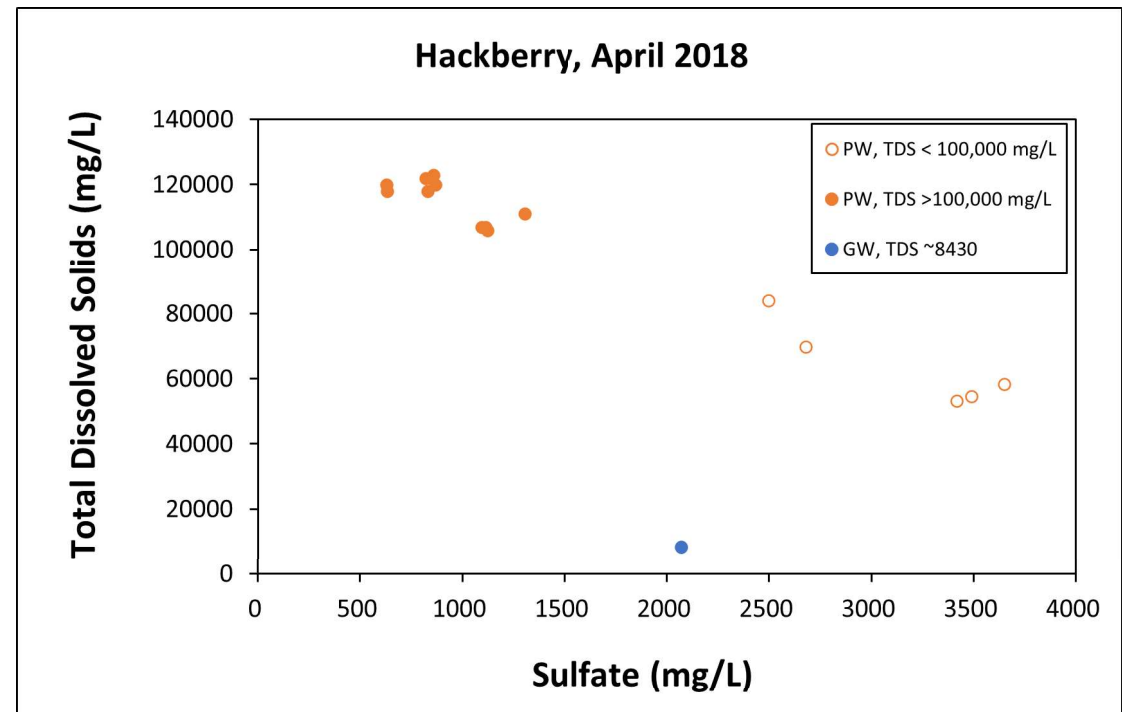


Chloride vs. Bromide



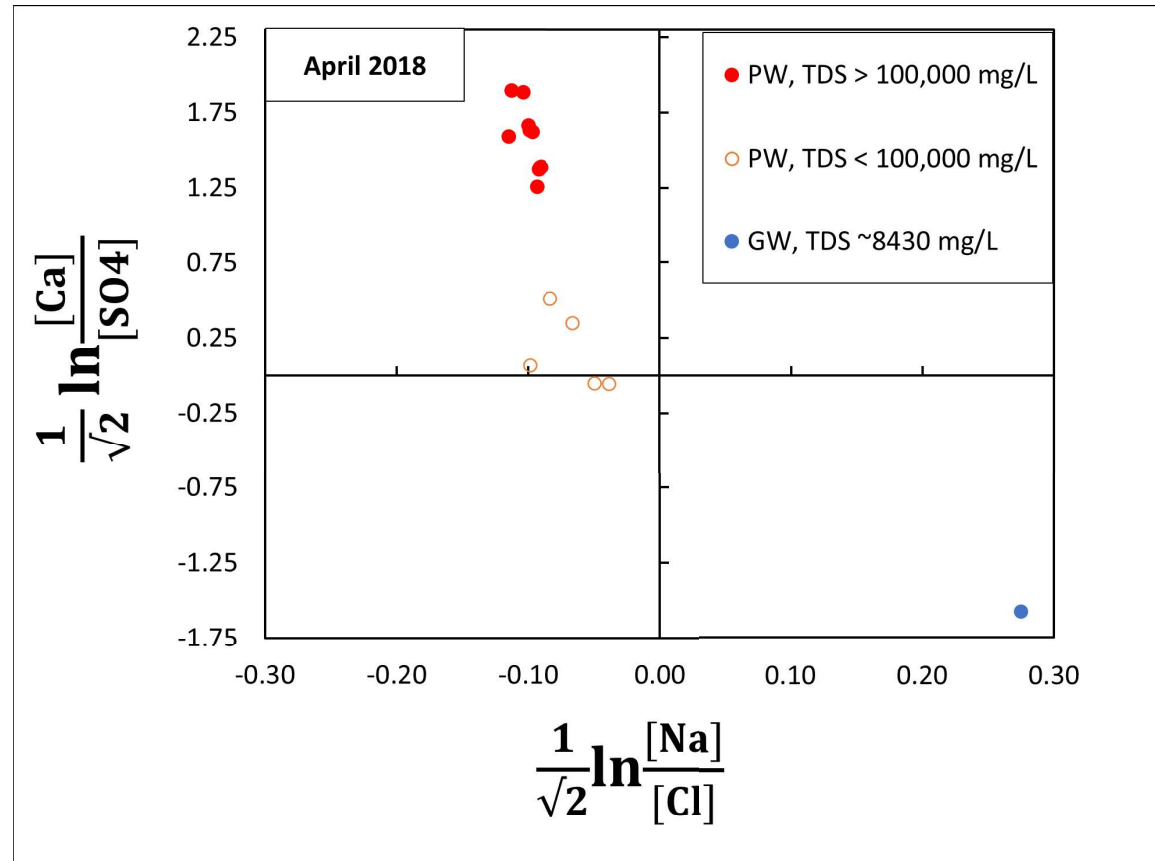
TDS vs. Sulfate

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



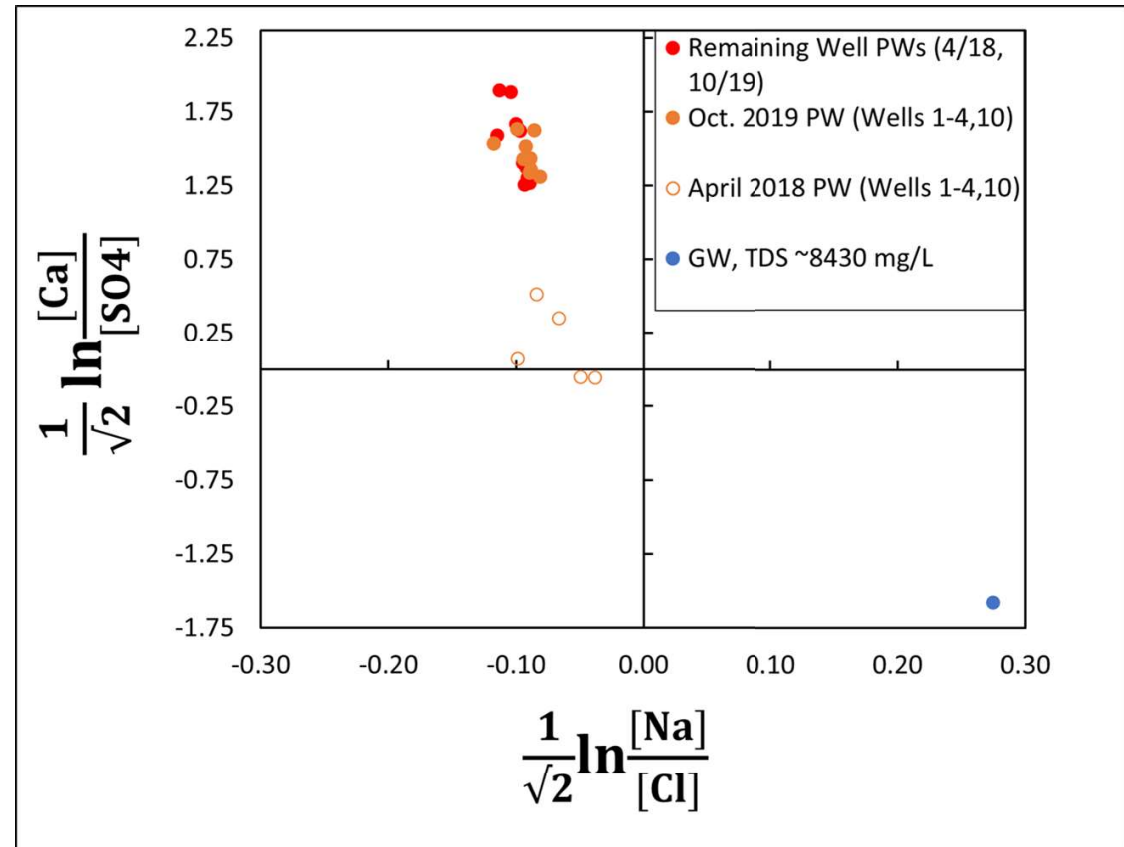
Isometric Log-Ratios

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



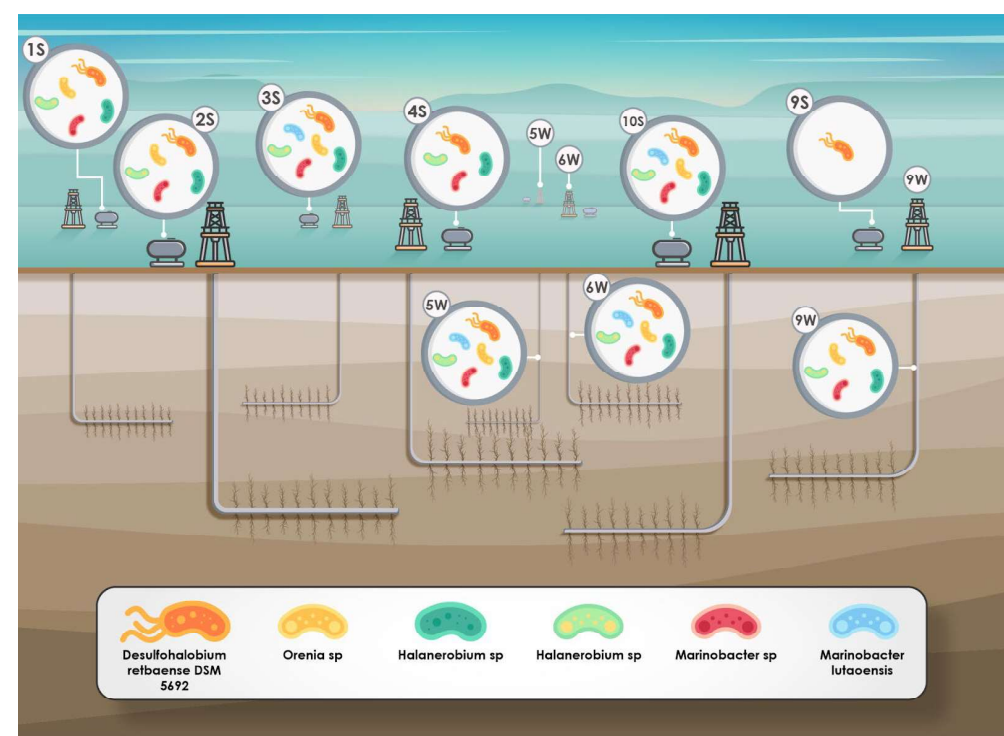
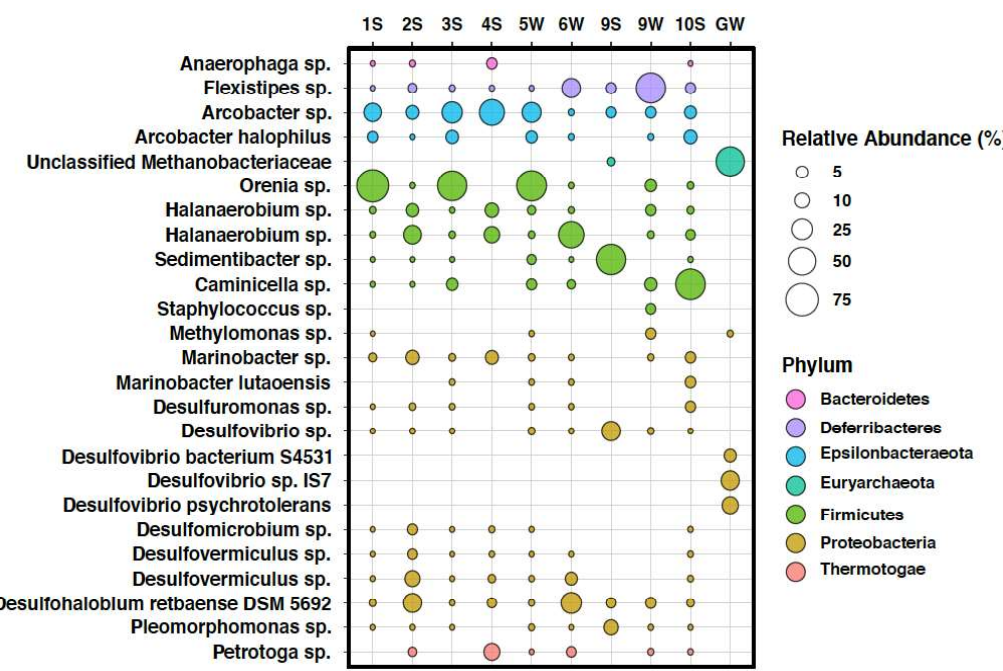
Isometric Log-Ratios

- 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

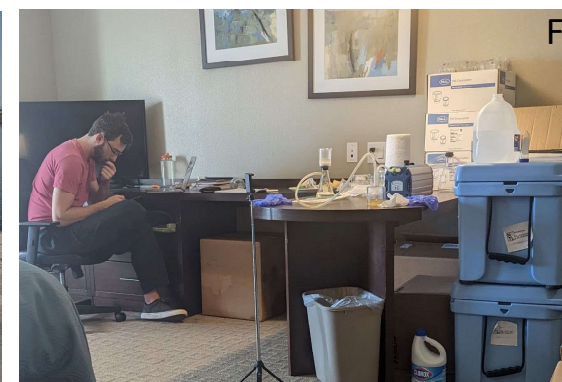
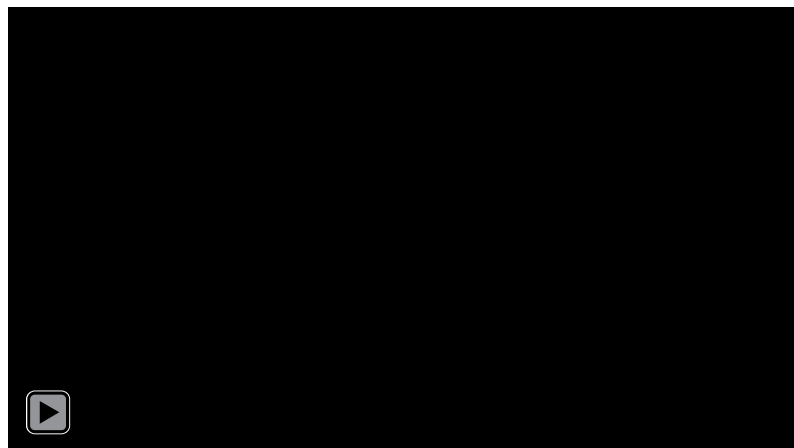
- The microbial community and functional potential of the Midland Basin reveal a community dominated by both thiosulfate and sulfate-reducing microorganisms



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**

Project Scope

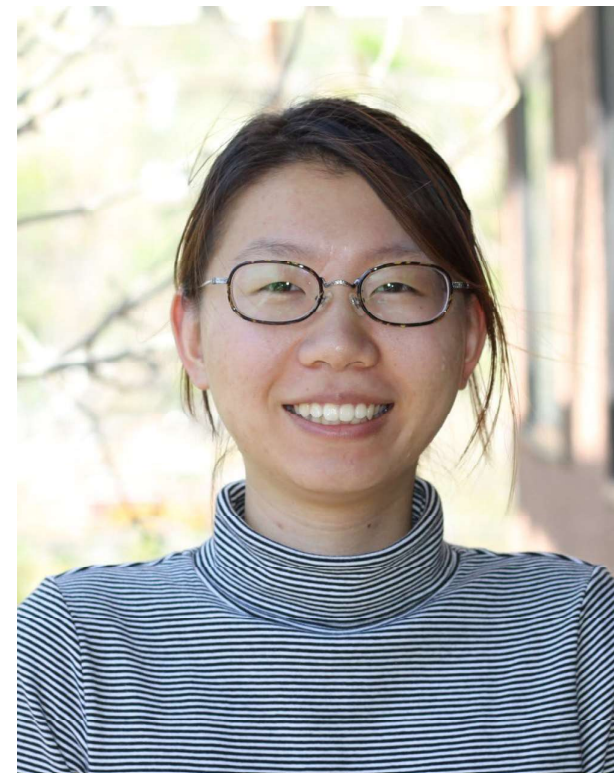
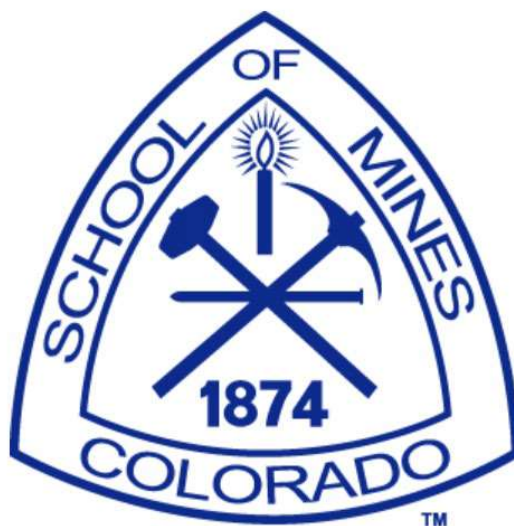
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Using Fiber Optic Strain Signatures to Prevent Damaging Frac Hits

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

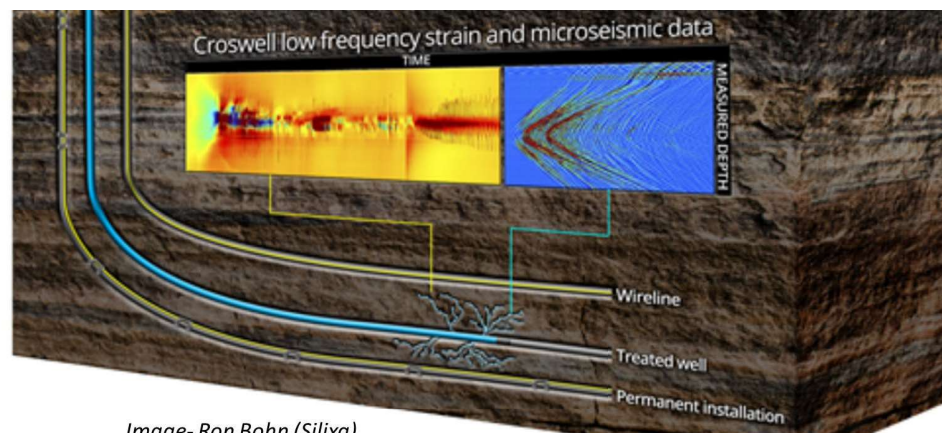
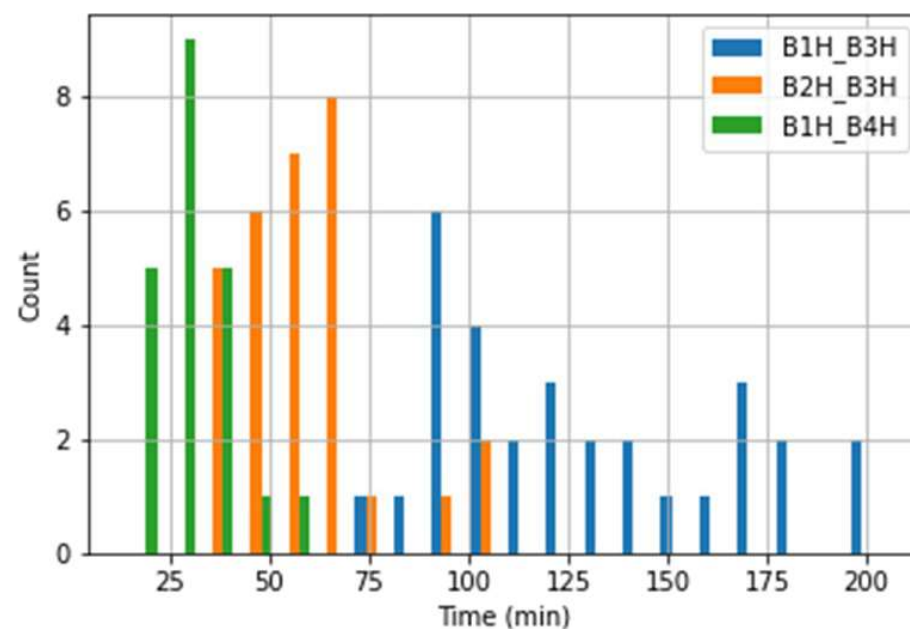
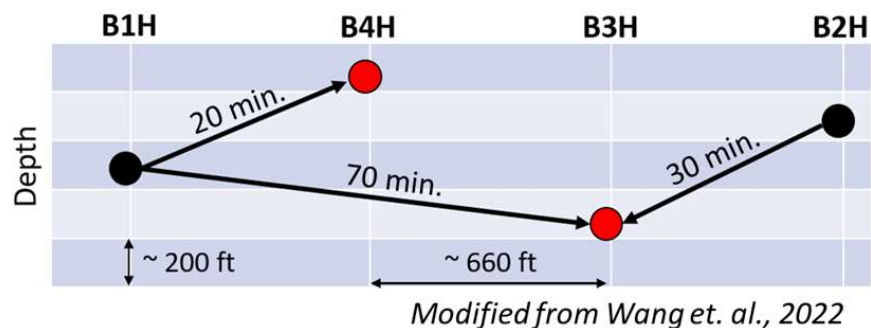


Image- Ron Bohn (Silixa)

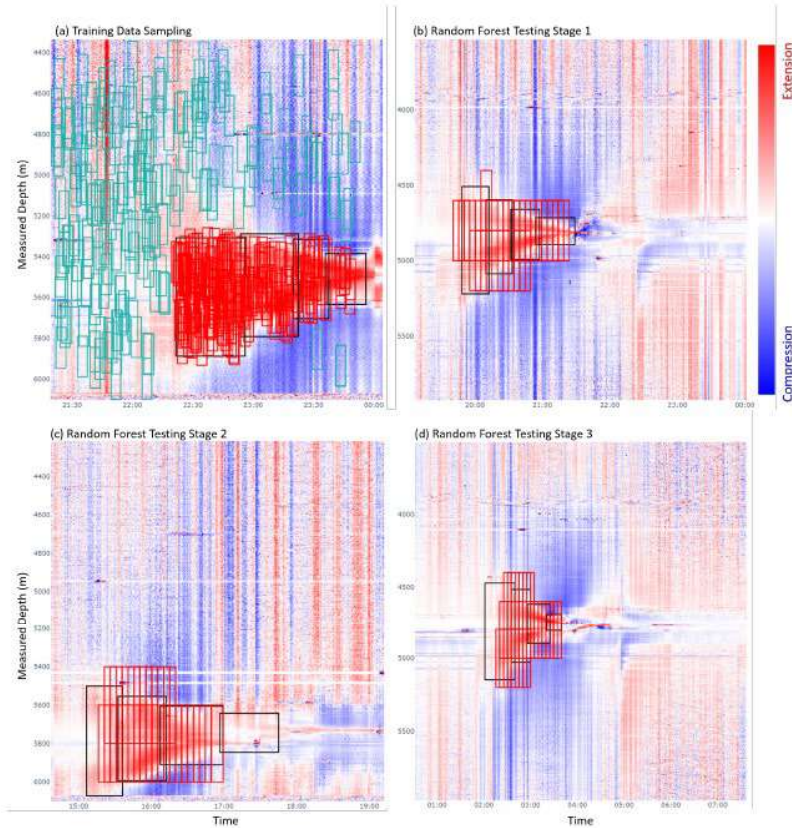
Using Fiber Optic Strain Signatures to Prevent Damaging Frac Hits

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



Using Fiber Optic Strain Signatures to Prevent Damaging Frac Hits

Machine Learning Workflows for Recognizing Frac Hit Strain Signatures



$$Accuracy = \frac{\text{Correct Predictions}}{\text{Total Predictions}}$$
$$Precision = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$$

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

The screenshot shows the 'Geomicrobiology Home' page. At the top is a navigation bar with links: Home, Location, Projects, Research Products, and People. Below the navigation bar is a large banner image showing microscopic views of microbial communities. The banner text reads 'Geomicrobiology Home'. Below the banner are logos for the U.S. Department of Energy, NETL, and EDX. The main content area features a paragraph about the Geomicrobiology Team's mission, followed by two sections: 'Carbon Storage' and 'Carbon Upgrading'. The 'Carbon Storage' section includes a diagram of a subsurface reservoir with CO₂ injection and monitoring wells (MW2, MW3) and a 'Read More' link. The 'Carbon Upgrading' section includes a diagram of a CO₂ stream and a paragraph about its potential use.

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

Geomicrobiology

Home Location Projects Research Products People

Geomicrobiology Home

U.S. DEPARTMENT OF ENERGY

NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

EDX Energy Data Exchange

The Geomicrobiology Team at NETL strives to provide insight into microbial processes that will occur in various energy environments, giving guidance to industry on risks driven by microbial processes, potential mitigation strategies, and the potential for the microbiology to be indicative of energy production/performance. The Geomicrobiology Team also strives to support development of a novel strategy that will drastically increase the economic feasibility of reducing, treating, and reusing waste streams in the energy industry.

Carbon Storage

Evidence indicates that subsurface microbial communities currently affect carbon storage reservoir properties and wellbore integrity through plugging/dissolution processes such as biomineralization (scaling), acid formation (biocorrosion), and biofilm formation (biofouling). This project provides insight into microbial processes that will occur in carbon storage reservoirs, giving guidance to the energy industry on risks driven by microbial processes and potential mitigation strategies.

[Read More >](#)

Carbon Upgrading

Many product streams in the energy industry, such as carbon dioxide or syngas, are either considered waste or have not yet been utilized to full potential. Microorganisms can biocatalyze these carbon outputs into

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

Organization Chart

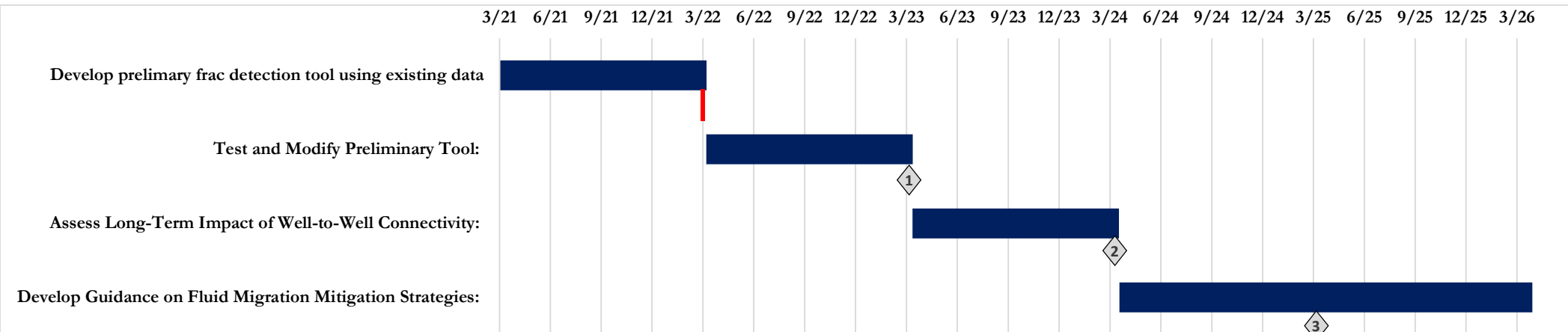
Task 25.1

- 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 communication