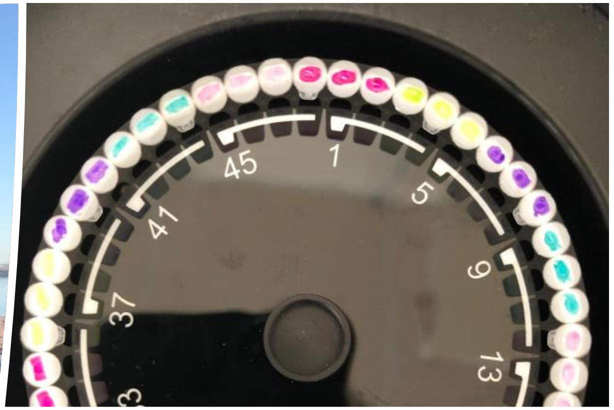
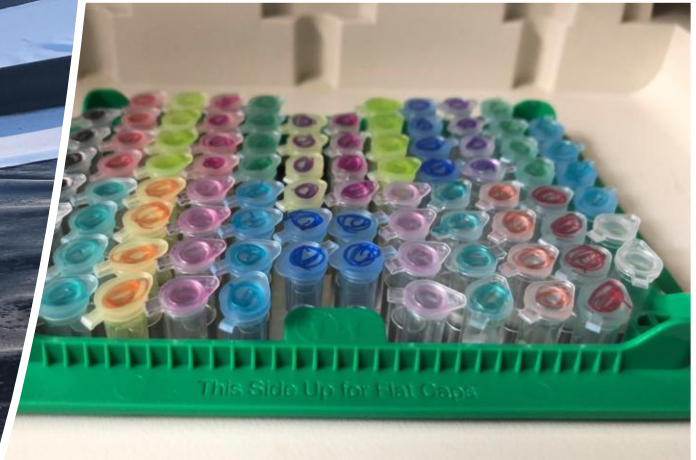
Task 25: Monitoring Aging Infrastructure and Well-to-Well Communication to Reduce Environmental Impacts

Kara Tinker - Leidos

FWP-1022415





Task 25: Monitoring Aging Infrastructure and Well-to-Well Communication to Reduce Environmental Impacts

NATIONAL ENERGY TECHNOLOGY LABORATORY

2021 $150k	2022 $195k	2023 $160k	2024 $200k	2025 $150k	Total Project Value (2021 – 2024) $855 k

- **Characterizing the Impacts of Oilfield Produced Water on Aging Well Infrastructure**

  Task Team Members: Djuna Gulliver, Justin Mackey, Daniel Bain

- **Monitoring Well-to-Well Communication to Reduce Environmental Impacts**

  Task Team Members: Djuna Gulliver, Kara Tinker, Sierra McDermott, Samuel Flett

Identifier	Type[1]	Expected Completion Date	Description
25.E	Major	03/31/2023	**Completed:** Field deployment and evaluation of new well communication detection method.
25.I	Major	03/31/2025	Develop guidance on well-to-well communication mitigation/management strategies.

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Characterizing the Impacts of Oilfield Produced Water on Aging Well Infrastructure

NATIONAL ENERGY TECHNOLOGY LABORATORY

- **Objective:** Characterize the impact produced water has on aging infrastructure in:
  - oil producing (Permian)
  - gas producing (Marcellus) basins

- Low carbon steel production tubing passivates (covers with corrosion precipitates) within weeks to months of exposure to well fluids.
  - Passivation slows the corrosion rate of steel. However, this steel is continuously exposed to produced water (PW) through the well's lifetime.

- **Question:** Can we see passivation or breakdown of passivation in short time-frame?

	Duration (days)	Biotic	Abiotic
Marcellus Shale(GAS) Formation Water	14 days	Aged steel coupon , 30 C, 1,200 PSI	Aged steel coupon , 30 C, 1,200 PSI
Permian Basin (OIL) (Wolfcamp) Formation Water	14 days	Aged steel coupon , 30 C, 1,200 PSI	Aged steel coupon , 30 C, 1,200 PSI

Analysis:

- Post reaction photomicrographs and surface roughness measurements were taken using the Olympus DSX100 optical microscope.
- Changes is fluid chemistry measured at PAL.

Aged Casing Reactor Experiment Results

	Units	B	Ba	Ca	Fe	K	Li	Mg	Mn	Na	P	Sr	Cl	SO_4	Br	pH
Marcellus-Unreacted	mg/L	14.1	4790	18200	134.7	251.3	80.6	1782	5.8	33800	3.2	3751	129122	1075	1892	5.48
Marcellus-Abiotic	mg/L	13.2	5095	19860	111.2	294.1	87.5	1852	14.9	32752	2.4	3912	118605	1087	1062	5.12
Marcellus-Biotic	mg/L	12.2	4807	18740	110.4	276.1	82.5	1731	16.6	31362	2.3	3704	123267	1077	1008	5.13
Permian-Unreacted	mg/L	42.9	1.97	2771	48.97	568.6	32.3	392.8	0.9	37130	2.9	605.5	72318	434.8	653.9	6.01
Permian-Abiotic	mg/L	34.9	1.84	2483	8.93	557.6	27.7	367.5	10.5	30592	0.7	403.2	70159	446.1	622.3	6.49
Permian-Biotic	mg/L	34.6	2.03	2634	9.17	582.4	29.6	396.6	9.7	32682	0.8	423.7	73749	462.3	663.4	6.60

Marcellus and Permian regions have unique geochemistry and microbiology profiles

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Post Reaction: Decrease in Fe and P and an increase in Mn

	Units	B	Ba	Ca	Fe	K	Li	Mg	Mn	Na	P	Sr	Cl	SO_4	Br	pH
Marcellus-Unreacted	mg/L	14.1	4790	18200	134.7	251.3	80.6	1782	5.8	33800	3.2	3751	129122	1075	1892	5.48
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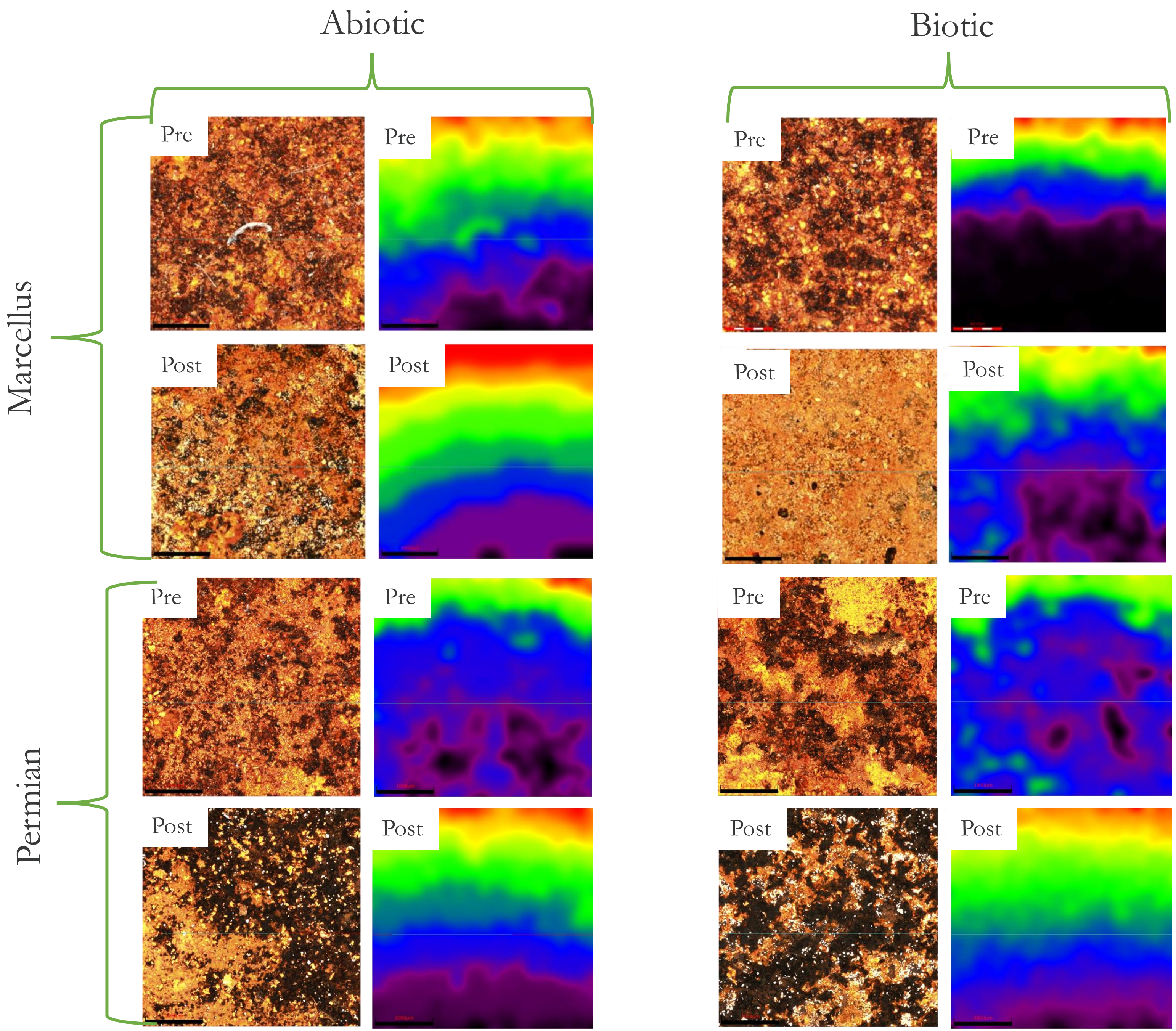
- Aqueous chemistry of the reacted fluids show a decrease in iron (Fe) and phosphorus (P) and increase in manganese (Mn), post reaction
- The reduction of Fe and P in the reacted fluid suggest Fe mineralization is occurring onto the surface of the steel, these Fe precipitates are incorporating P during precipitation.



- Post reaction photomicrographs, surface roughness measurements and aqueous chemistry all suggest **breakdown passivation did not occur** in either batch reactor scenario (Permian or Marcellus; biotic or abiotic).
- Surface roughness measurements showed minor accumulation of iron oxy-hydroxides, but otherwise no significant changes to surface roughness or pitting.
- Iron precipitate color differed between formation but not between abiotic/biotic samples

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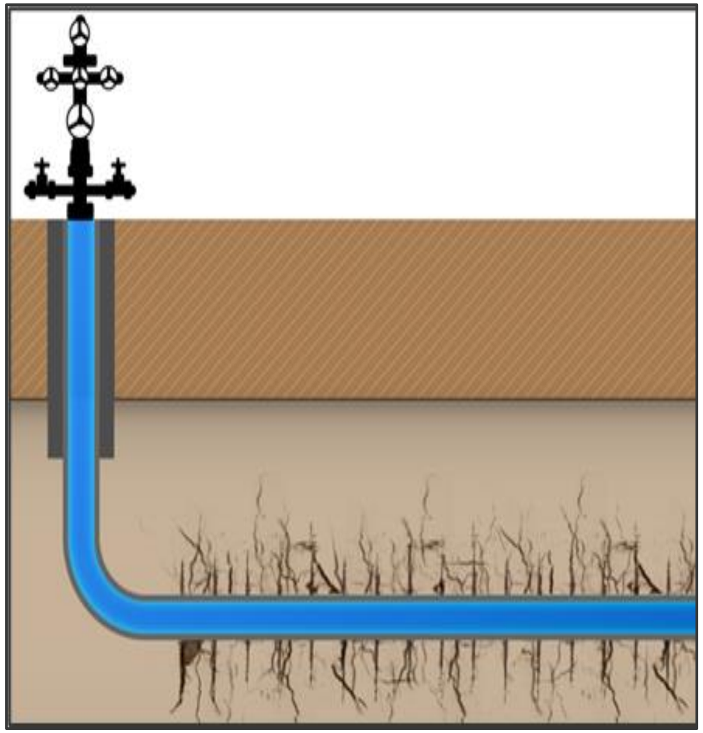
Technology Background

Research Question:

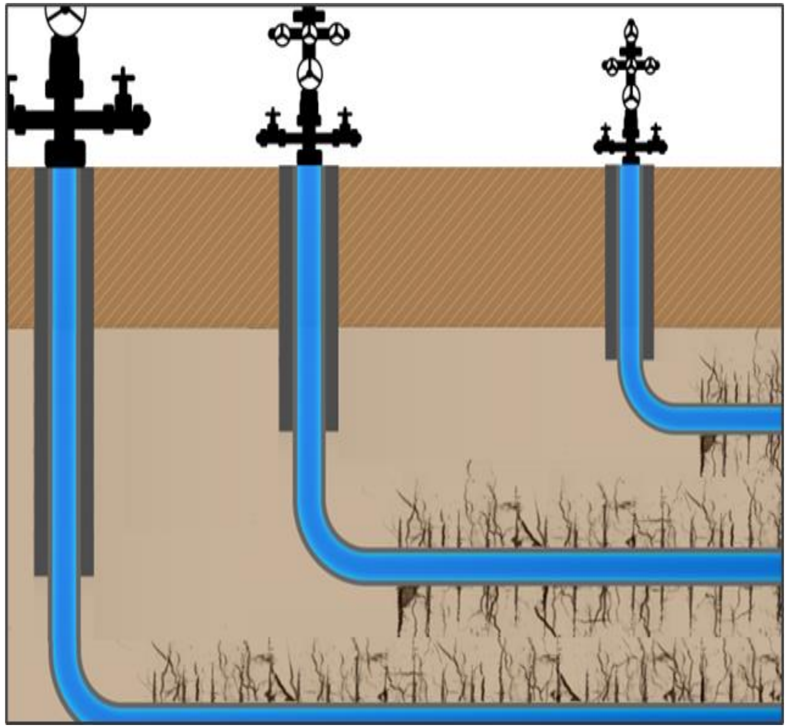
What chemical and microbiological signatures can be used to identify migrating fluids?

Individual Well



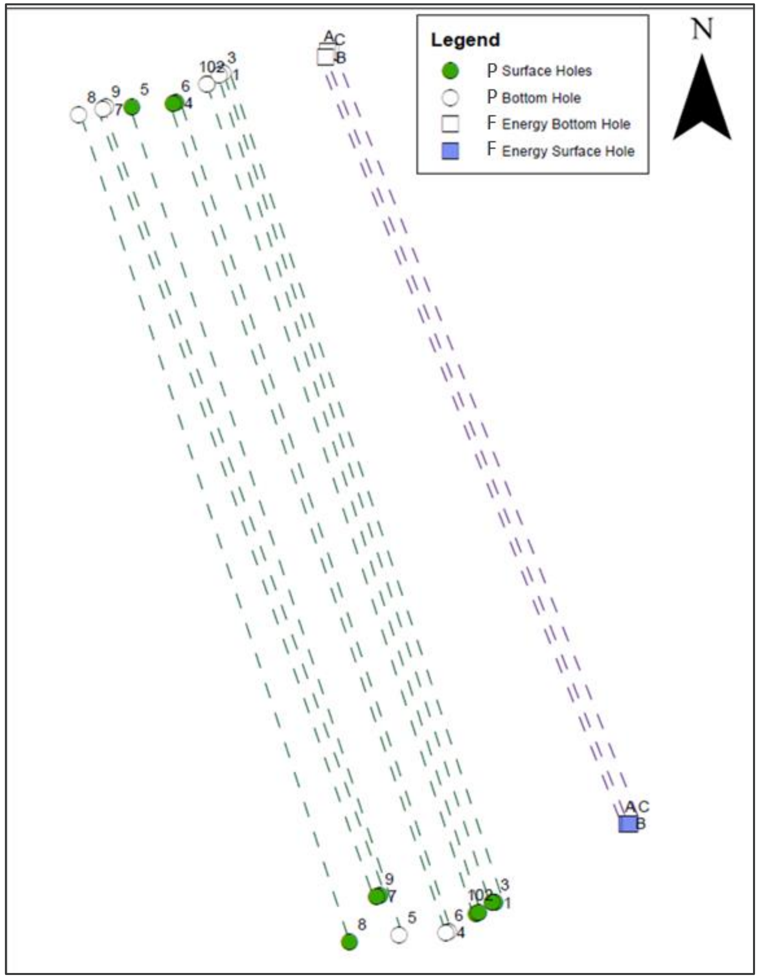
Reality

Tight Well Spacing



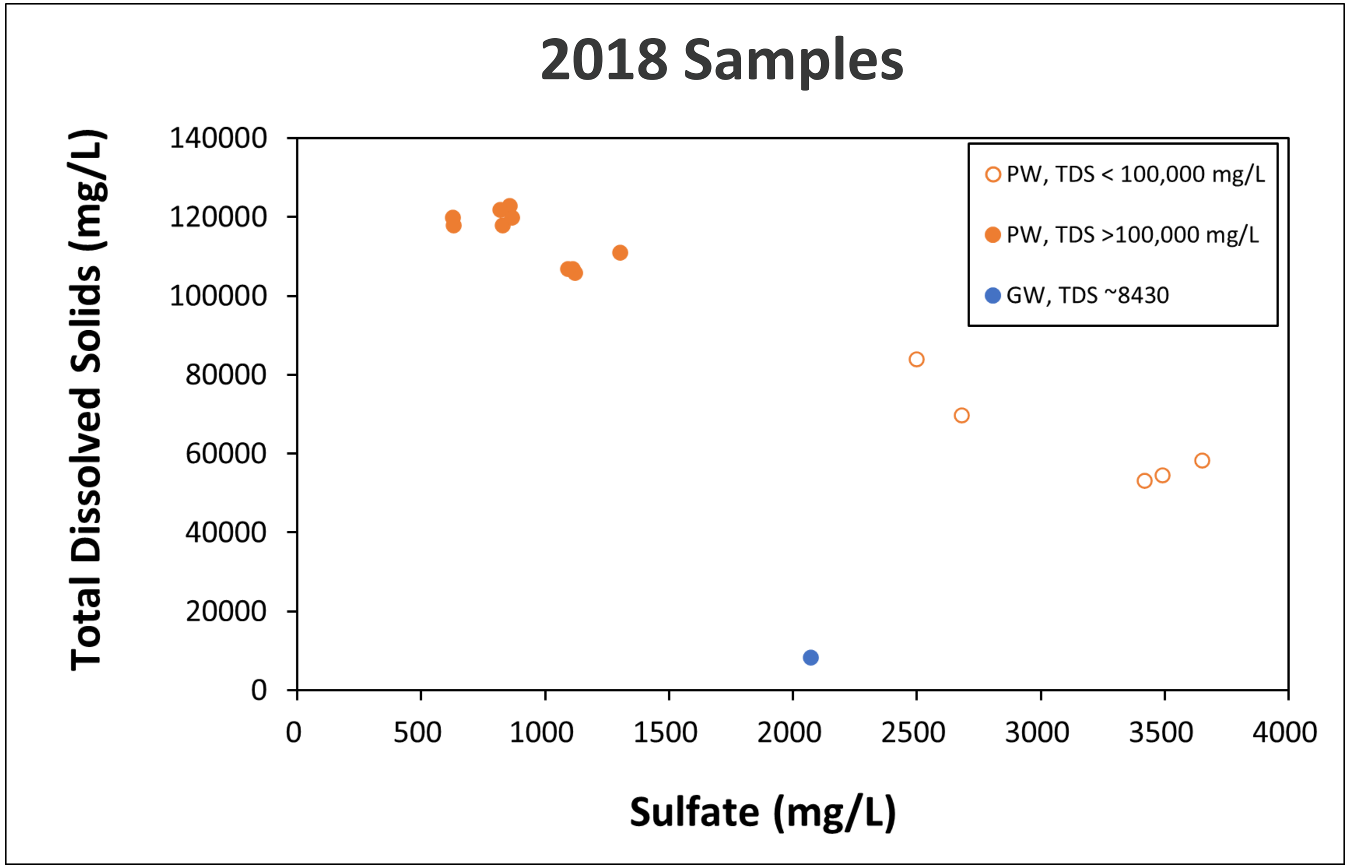
2018 Field Site

- Sampled in April 2018
- 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*

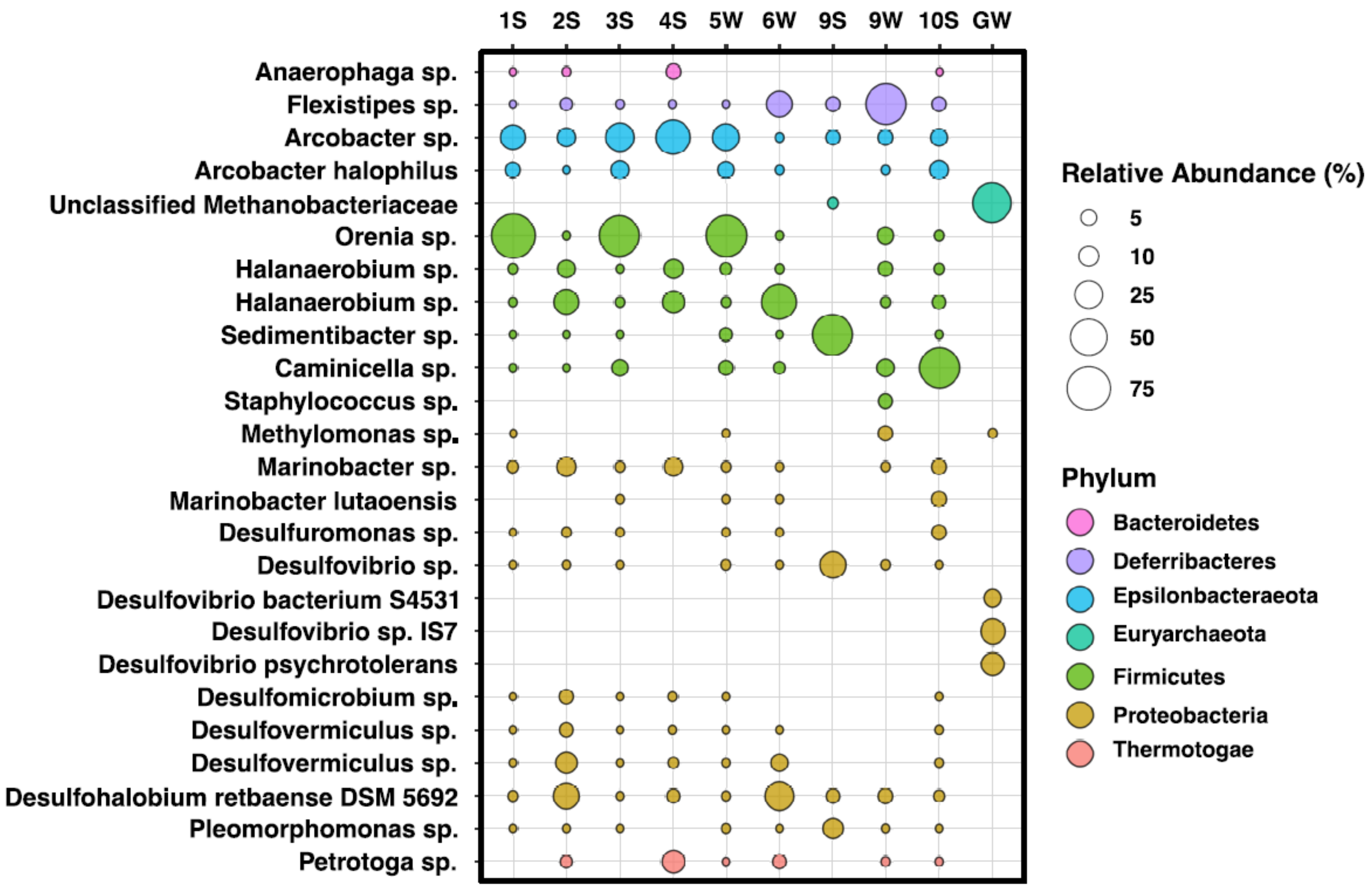


2018 TDS vs. Sulfate Separation by frac hit status

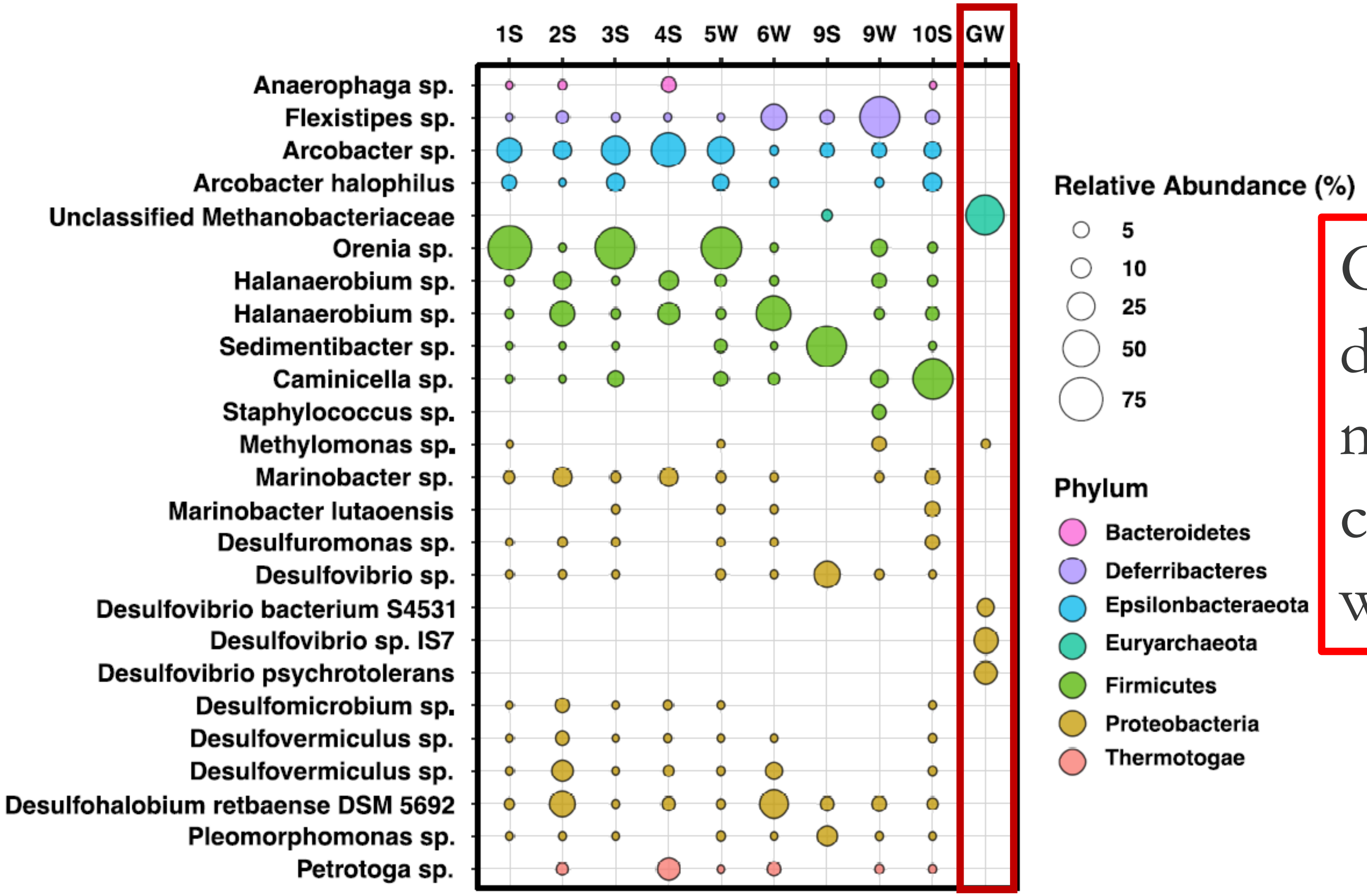
- Decrease in TDS, increase in sulfate solubility → kinetic phenomena
  - DO in range of 1.8 – 2.9 mg/L Avg of 2.4
  - Sulfate increase related to:
  - *Surfactants and other additives in HFF*
  - *Reaction/dissolution of reservoir sulfur materials*



2018 Microbiology



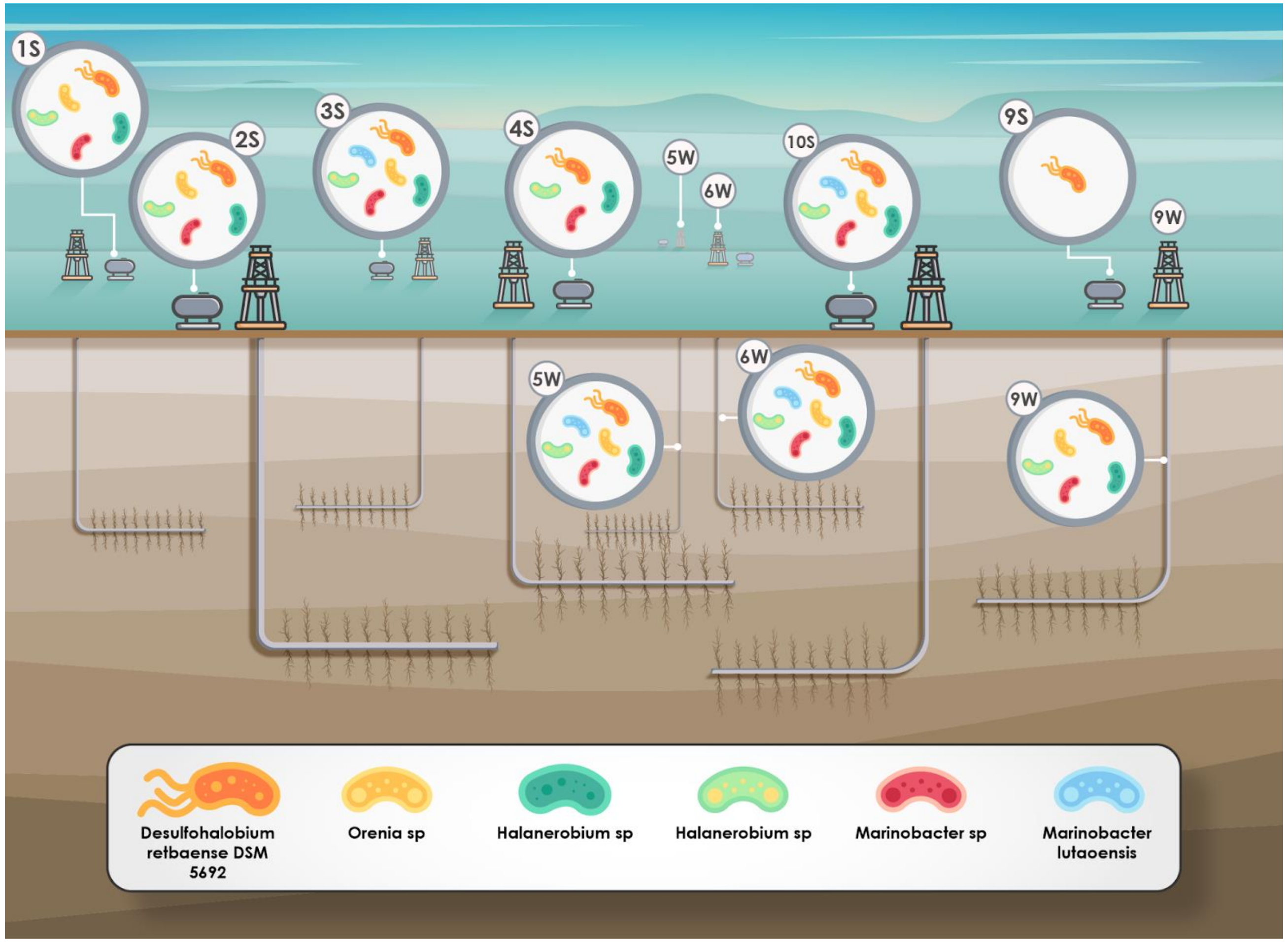
2018 Microbiology



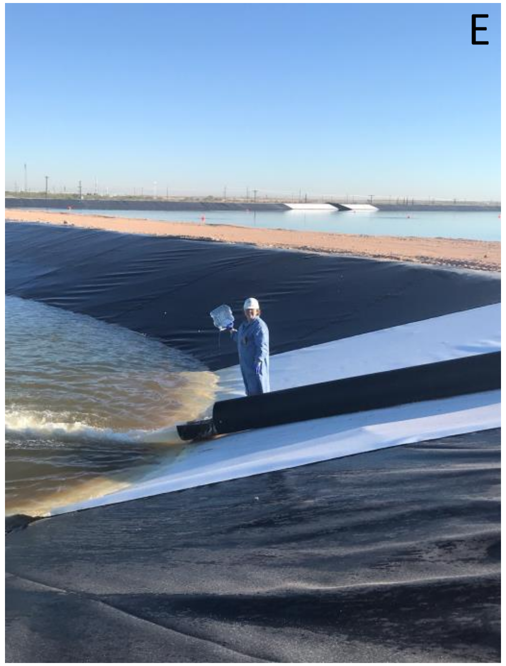
Groundwater has 1) less diversity and 2) unique microbial taxa when compared to the sampled wells

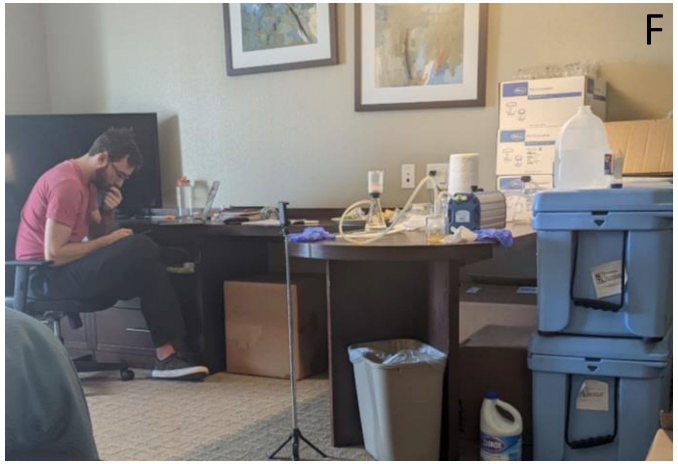
2018 Microbiology

Fracture fluid → Leaching of sulfate from reservoir → Increase of sulfate reducers → H_2S production



2022 Field Sampling



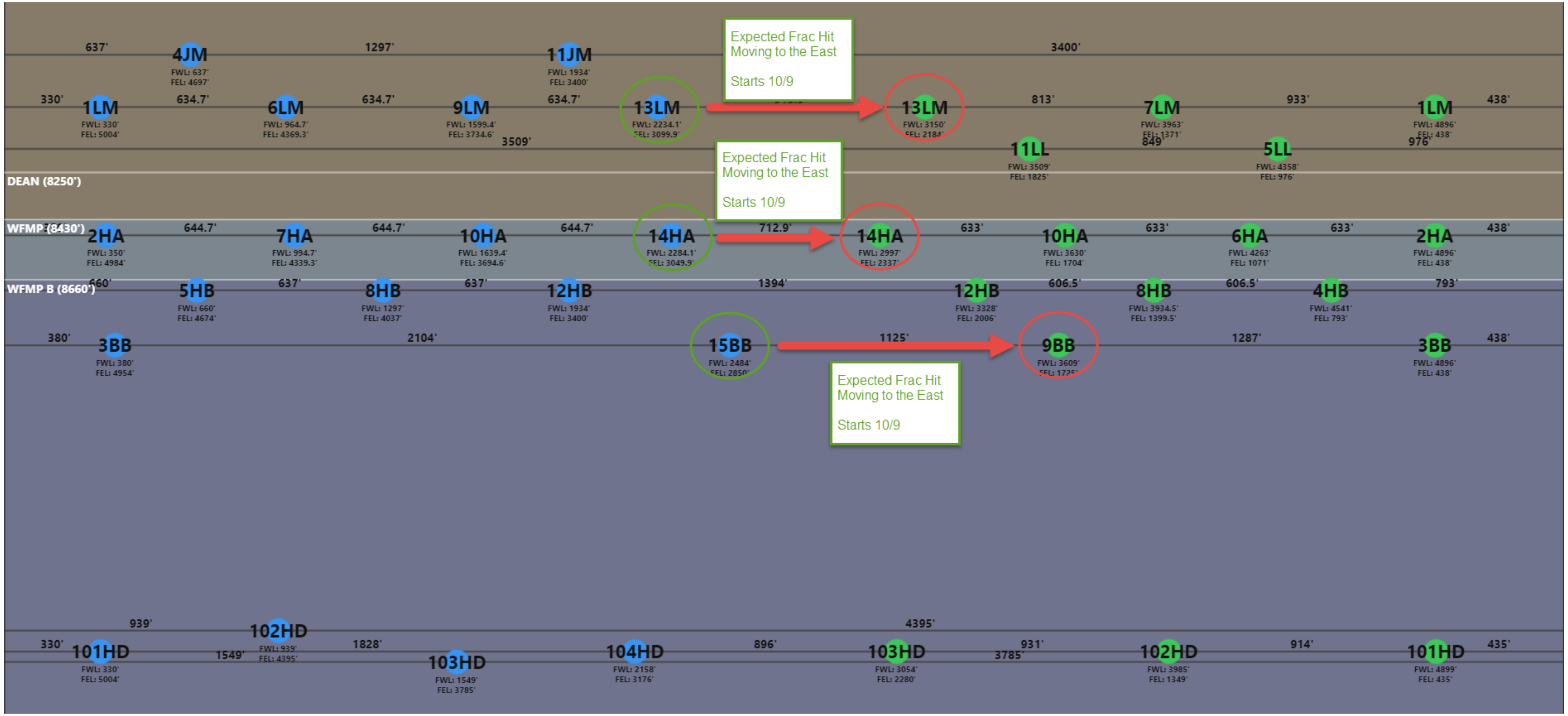


- Field sampled time-series of well communication 12 wells over the course of 3 weeks
- Sampled two source fluids, treated produced water and groundwater
- Wells were shut off one by one over course of three weeks except for 4 of the most downgradient

2022 Field Site

Geomicrobiology

NATIONAL ENERGY TECHNOLOGY LABORATORY



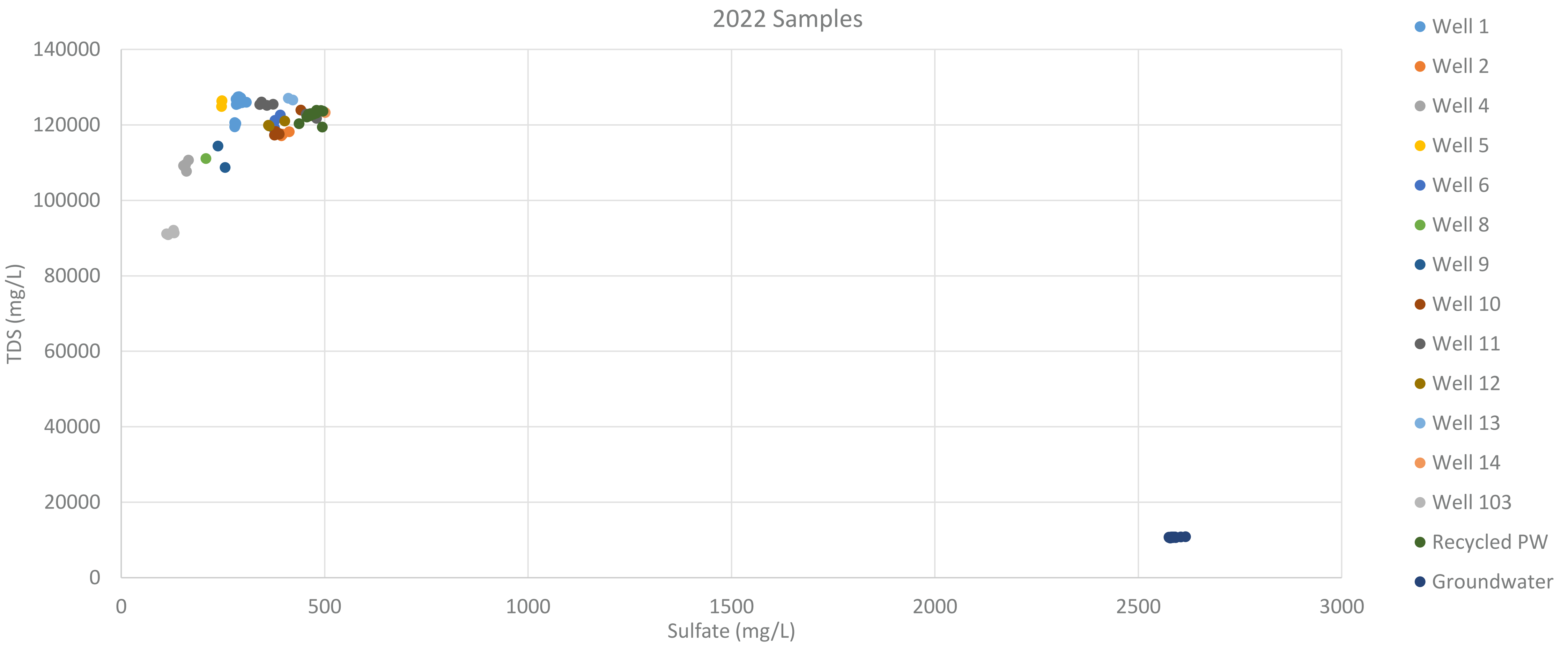
2022: Regularly sampled 15 sites at a well pad adjacent to an active hydraulic fracturing site throughout the month-long fracture event.

Collected a total of 78 samples, 8 field blanks, and 8 processing/hotel blanks.

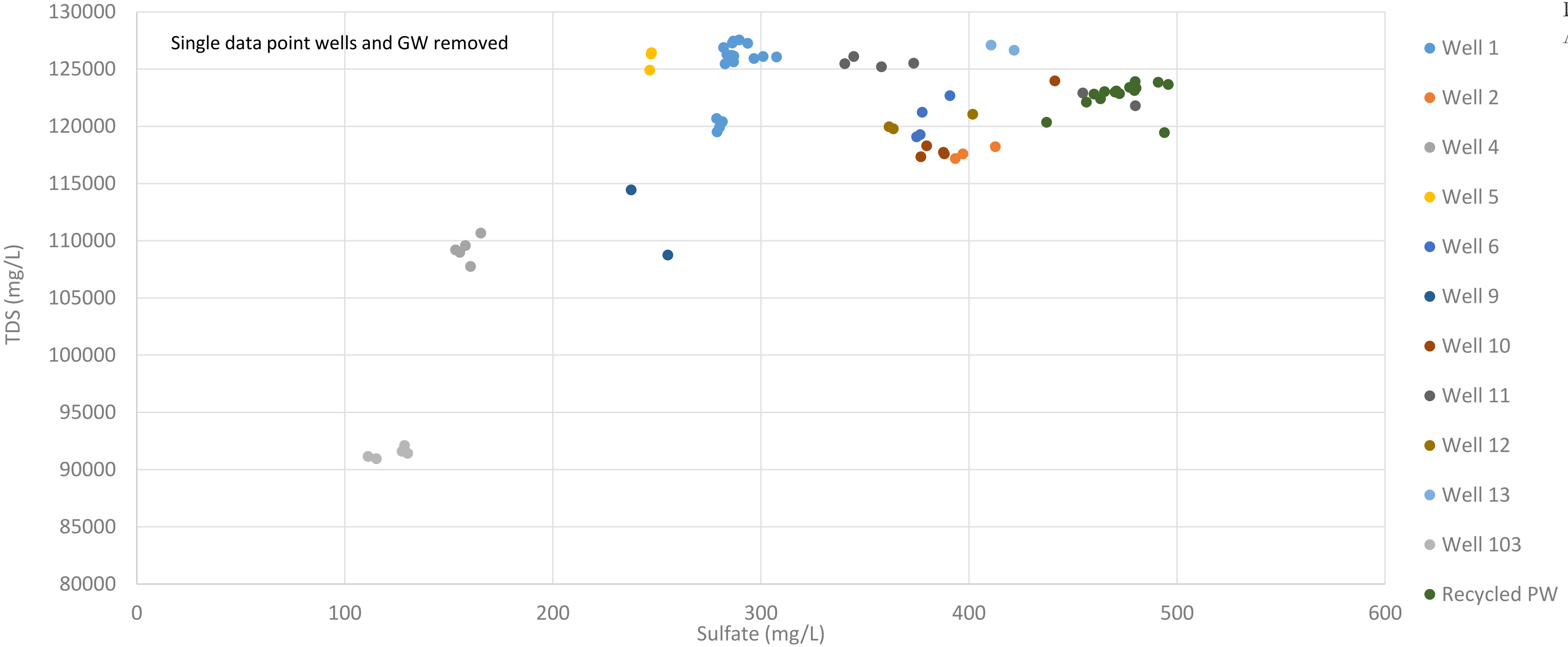
2022 Sampling Schedule

Frac start on 10/4/2022				Frac Ends						
	7-Oct Day 1	8-Oct Day 2	10-Oct Day 4	12-Oct Day 6	14-Oct Day 8	16-Oct Day 10	18-Oct Day 14	20-Oct Day 16	22-Oct Day 18	24-Oct Day 20
Recycled PW	x		x	x	x	x	x	x	x	x
Groundwater	x		x	x	x	x	x	x	x	x
1LM	x	x	x	x	x	x	x	x	x	x
2HA	Gas	Gas	Gas	x	Gas	Gas	Gas	x	Gas	Gas
3BB	Gas	Gas	Gas	Gas	Gas	Gas	Gas	Gas	Gas	Gas
4HB	N/A	N/A	N/A	N/A	x	N/A	x	x	x	x
5LL	N/A	N/A	N/A	N/A	N/A	x	x	Gas	Gas	x
6HA	x	x	Gas	x	x	Gas	Gas	Gas	Gas	Gas
8HB	Gas	x	Gas	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in
9BB	x	x	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in
10HA	x	Gas	x	x	x	x	Shut in	Shut in	Shut in	Shut in
11LL	x	x	x	x	x	x	Shut in	Shut in	Shut in	Shut in
12HB	x	x	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in
13LM	x	x	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in
14HA	x	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in
103HD	x	x	x	x	Shut in	Shut in	Shut in	Shut in	Shut in	Shut in

2022 TDS vs. Sulfate

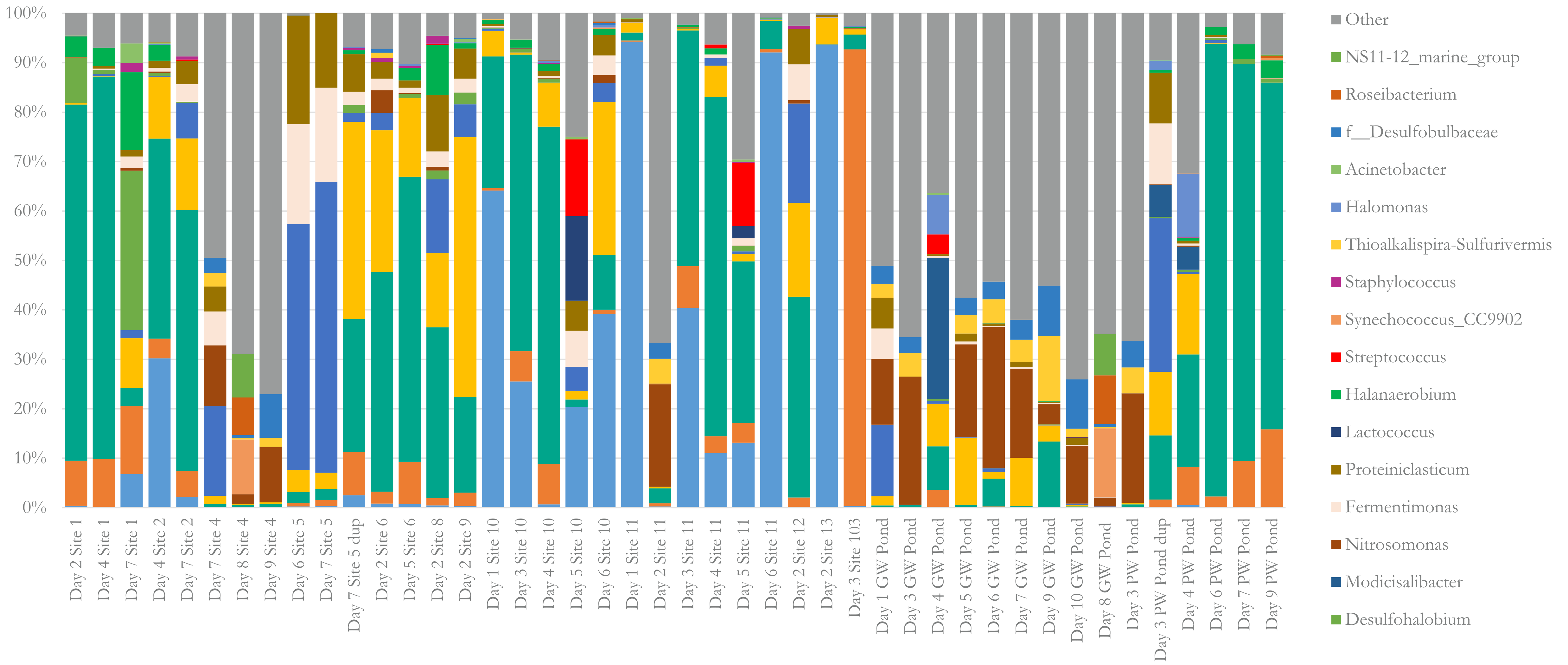


2022 TDS vs. Sulfate

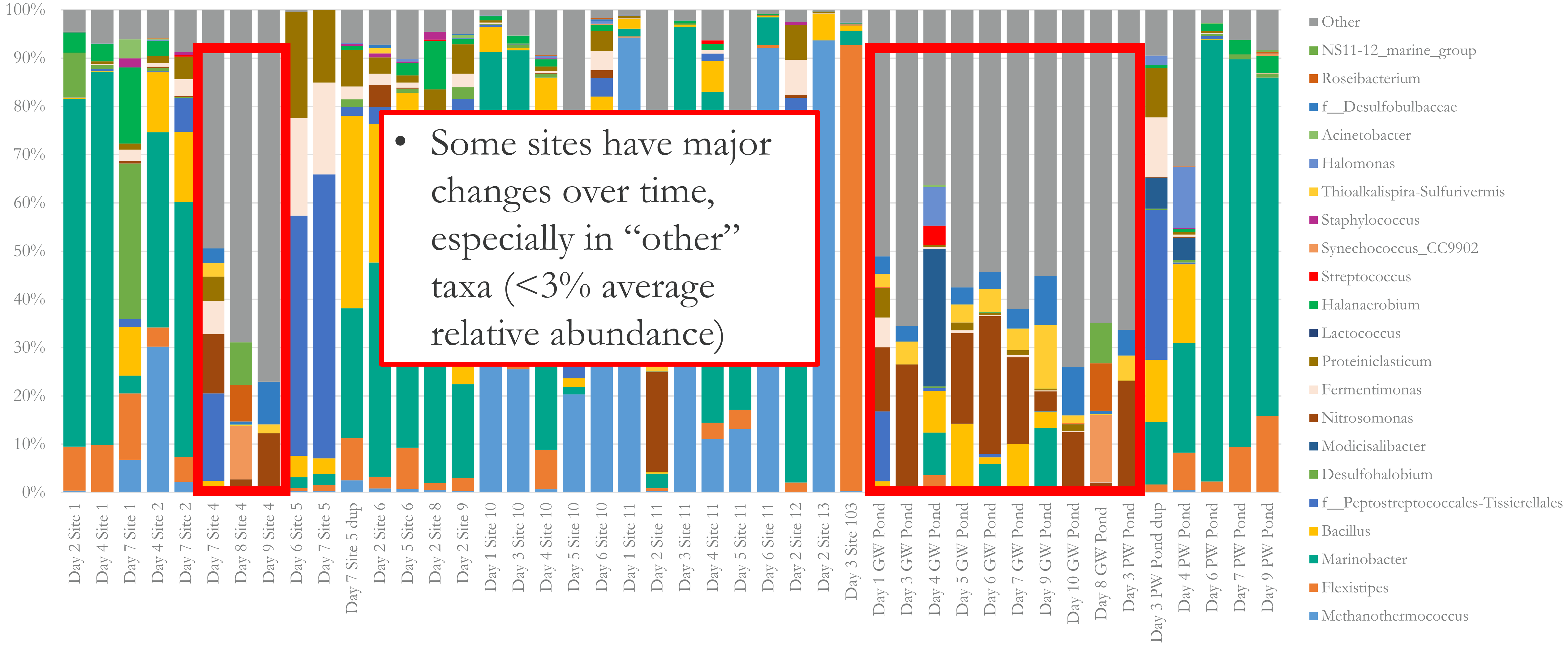


DO = 1.1 – 2.8 mg/L
Avg = 1.9 mg/L

2022: Preliminary Taxonomic Census

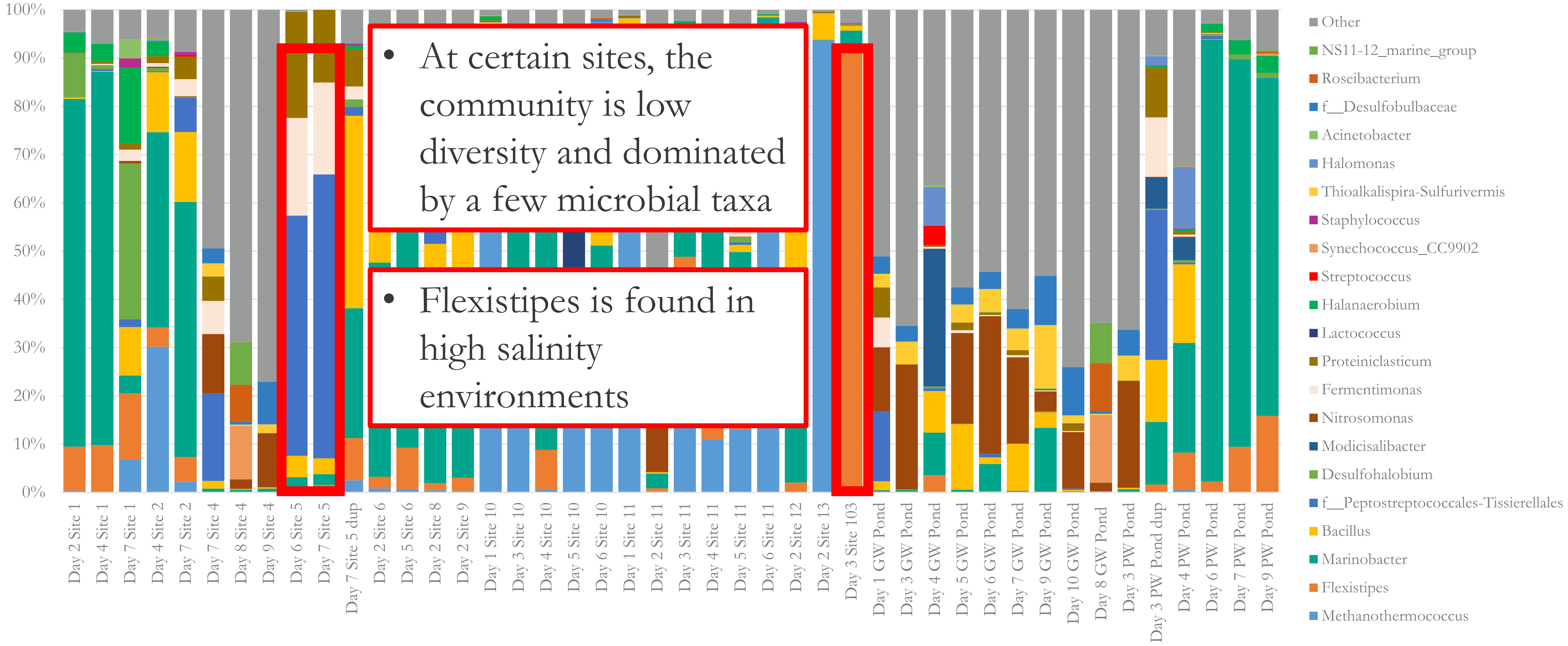


2022: Preliminary Taxonomic Census



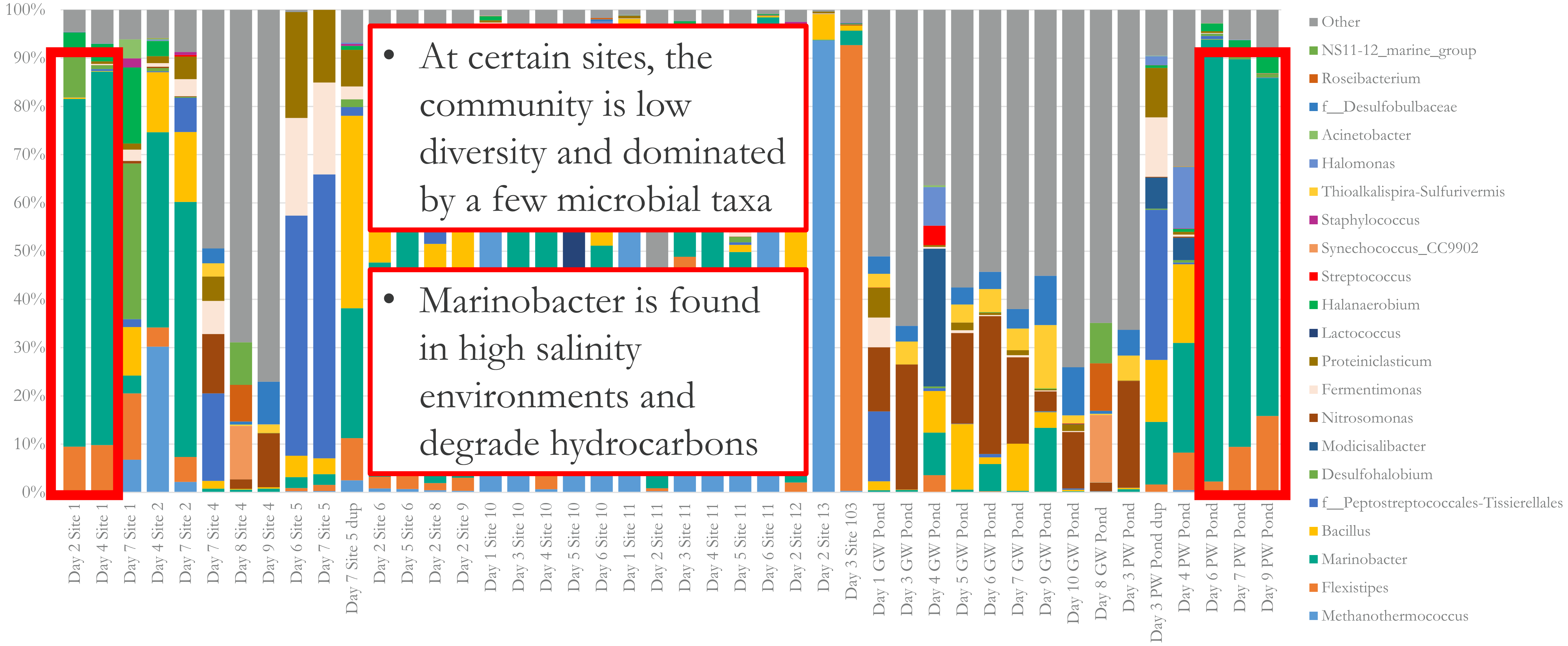
- Some sites have major changes over time, especially in “other” taxa (<3% average relative abundance)

2022: Preliminary Taxonomic Census



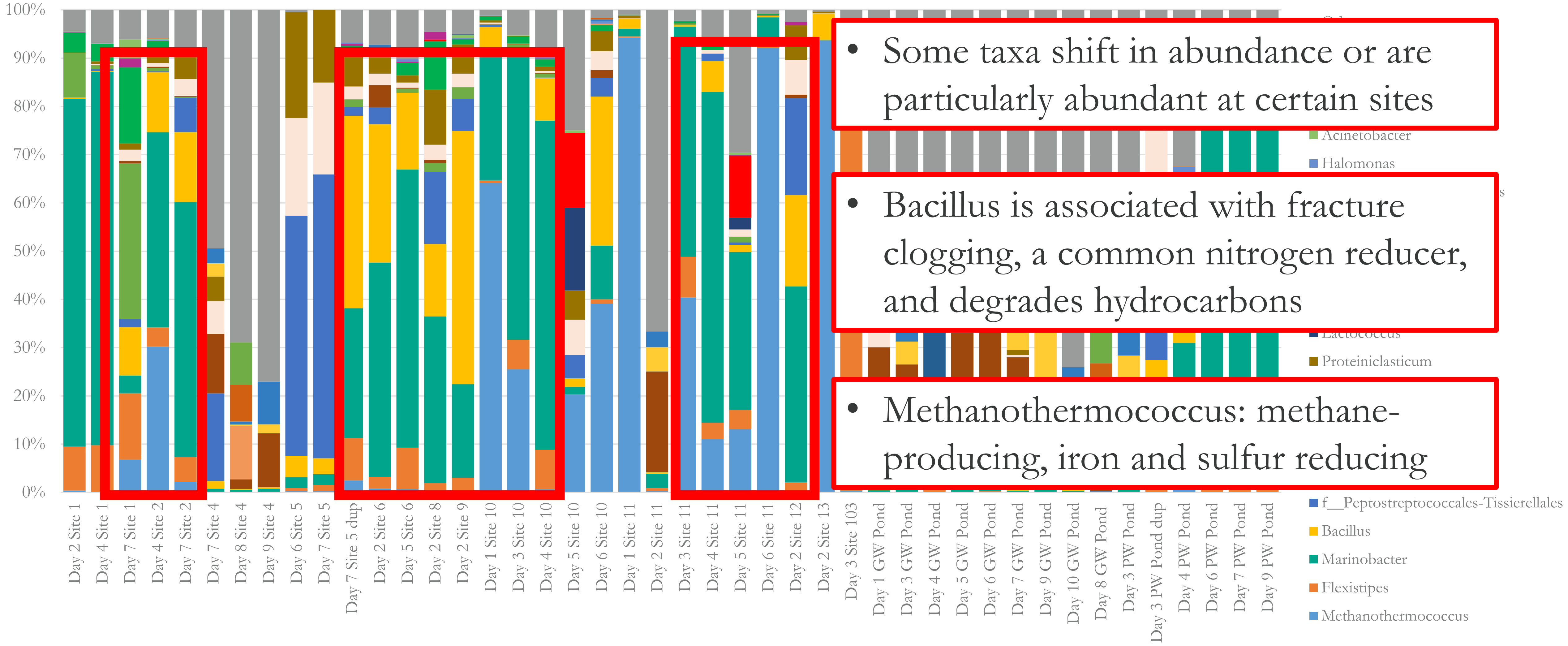
- At certain sites, the community is low diversity and dominated by a few microbial taxa
- Flexistipes is found in high salinity environments

2022: Preliminary Taxonomic Census



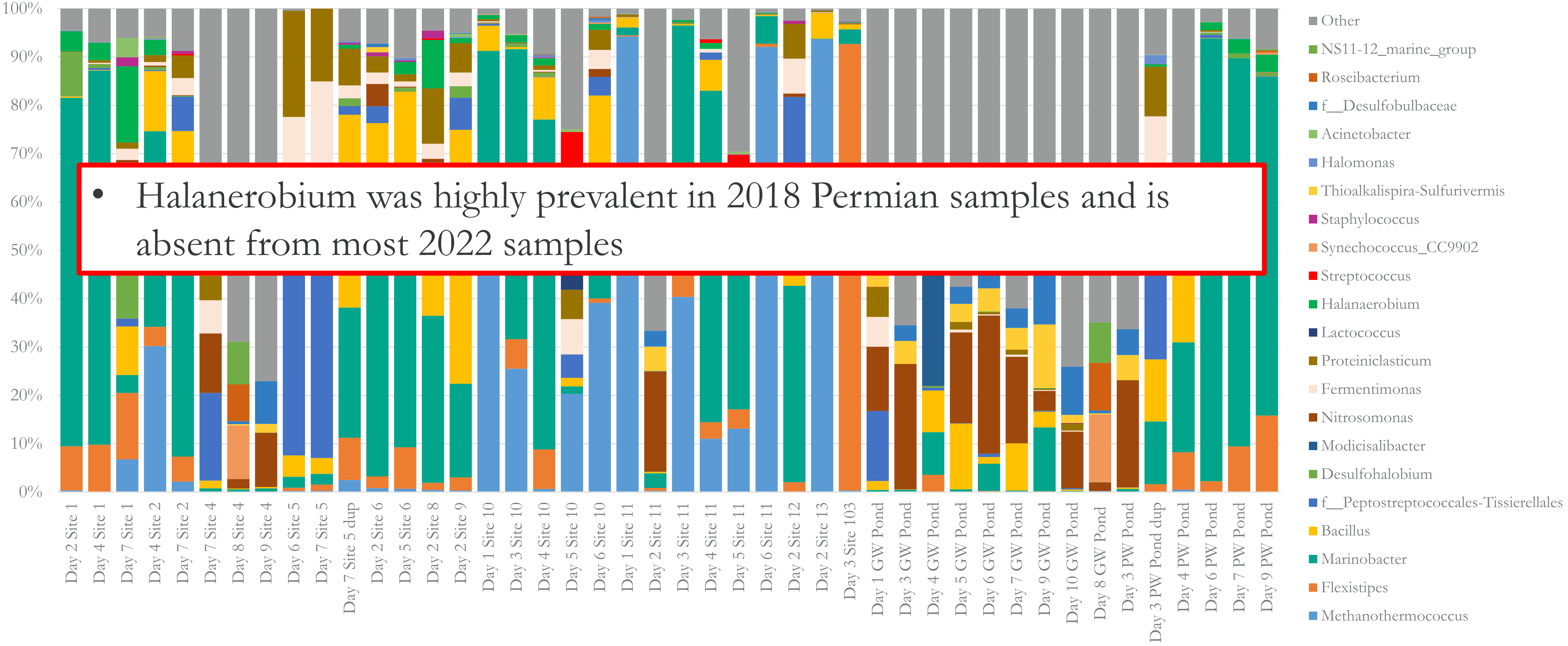
- At certain sites, the community is low diversity and dominated by a few microbial taxa
- Marinobacter is found in high salinity environments and degrade hydrocarbons

2022: Preliminary Taxonomic Census



- Some taxa shift in abundance or are particularly abundant at certain sites
- Bacillus is associated with fracture clogging, a common nitrogen reducer, and degrades hydrocarbons
- Methanothermococcus: methane-producing, iron and sulfur reducing

2022: Preliminary Taxonomic Census



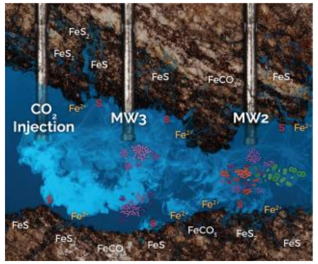
- Halanerobium was highly prevalent in 2018 Permian samples and is absent from most 2022 samples

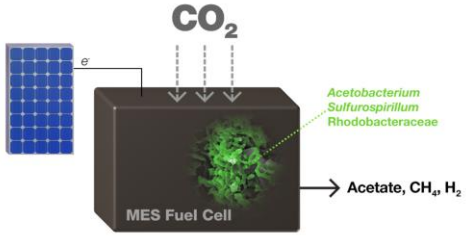
Future Work: EY24

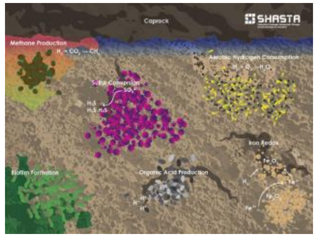
With a full dataset we can move beyond visual microbial trends to understand and measure well-to-well communication:

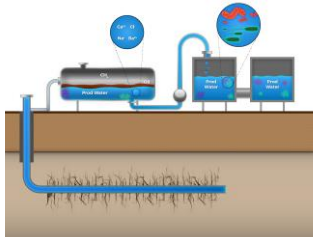
- Q: Does the number of cells increase/decrease when well-to-well communication occurs?
- Q: Do certain taxa appear/disappear when there is a nearby frac job?
- Q: Is the microbial community changing more quickly in impacted wells?
- Q: If we concurrently analyze microbial and geochemical data, can we measure correlative "signatures" that indicate a frac hit?

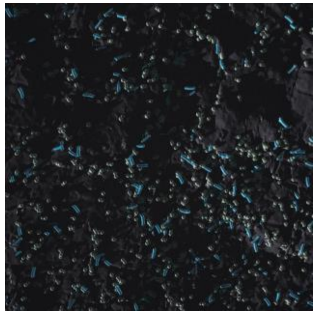
Questions?











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

E-mail: kara.tinker@gmail.com

Organization Chart

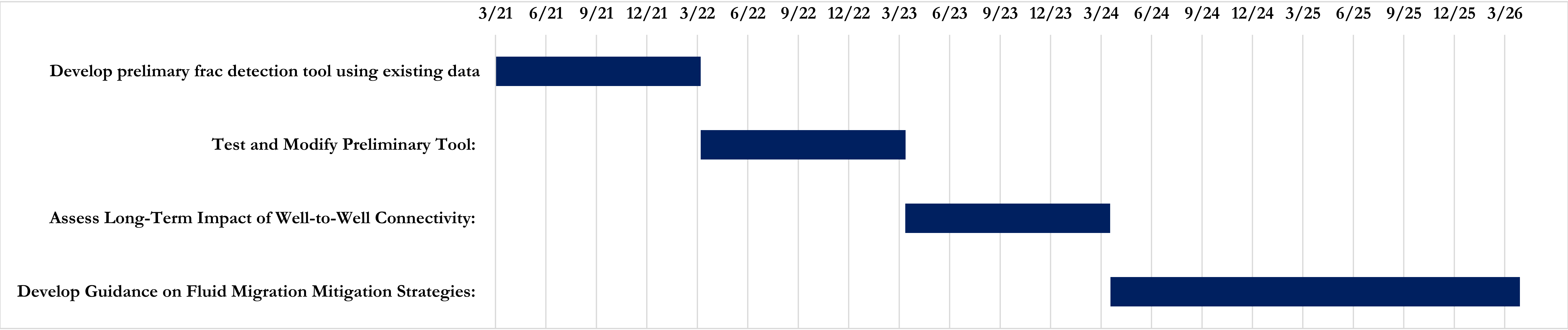
Task 25.E

- Djuna Gulliver, NETL-RIC (PI – Task 25.E)
- Justin Mackey, Leidos-NETL
- Daniel Bain, University of Pittsburgh

Task 25.I

- Djuna Gulliver, NETL-RIC (PI – Task 25.I)
- Kara Tinker, Leidos-NETL
- Sierra McDermott, Leidos-NETL
- Samuel Flett, Leidos-NETL

Gantt Chart



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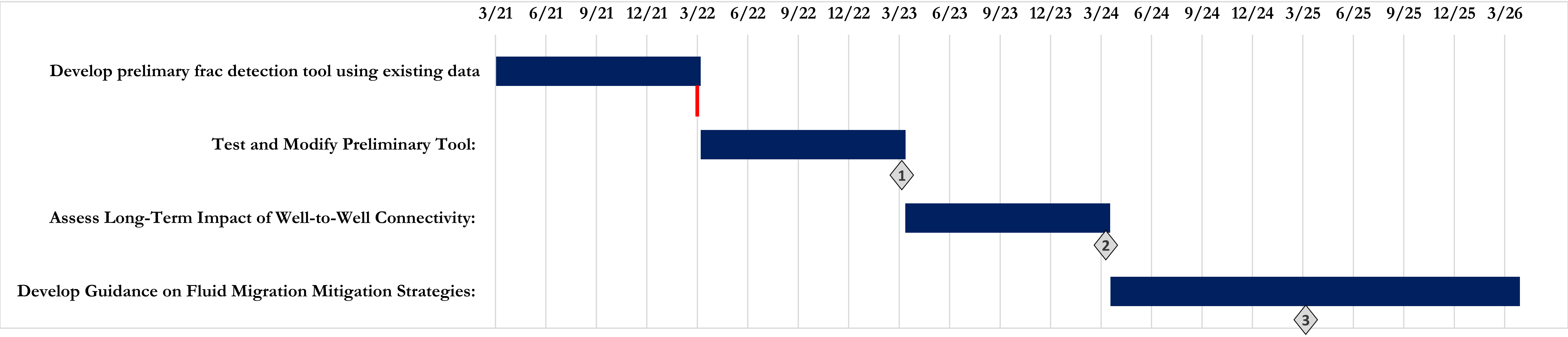
Develop prelimary frac detection tool using existing data
Test and Modify Preliminary Tool:
Assess Long-Term Impact of Well-to-Well Connectivity:
Develop Guidance on Fluid Migration Mitigation Strategies:

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