Monitoring, Verification, and Accounting (MVA) Strategy for a North Dakota Carbon Capture and Storage Project Integrated with Ethanol Production: <u>Developing and Demonstrating Sustainable Monitoring Techniques</u>

AAPG CCUS
Carbon Capture, Utilization, and Storage Conference

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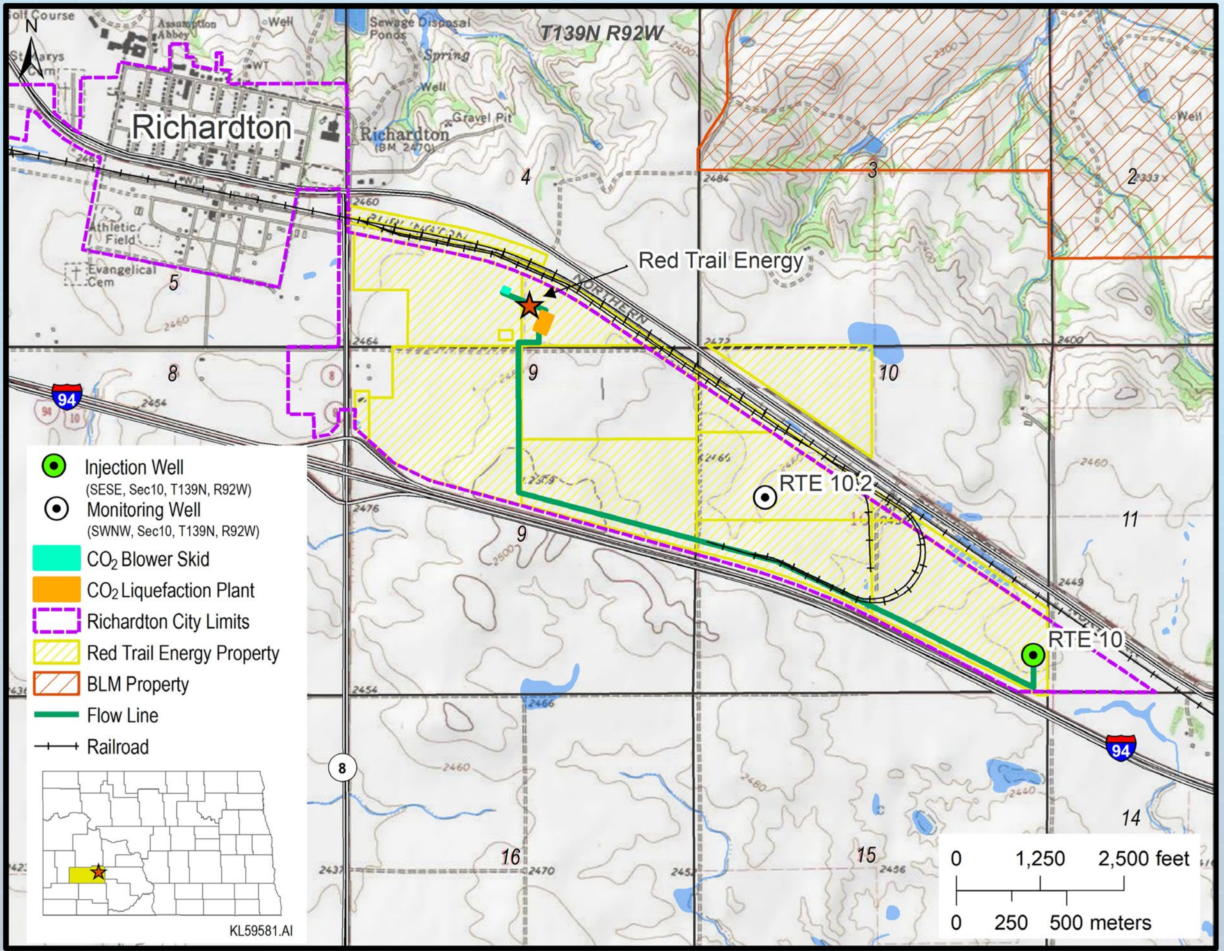
RED TRAIL ENERGY (RTE) CCS PROJECT OVERVIEW

An Emerging Field for Petroleum Geologists



Red Trail Energy NDIC Storage Facility Permit

Facility	64-million-gallon dry mill ethanol production plant	
Tonnage	180,000 tonnes per annum	
Injector Design	One CO_2 injector into single storage reservoir	
Regulatory Status	NDIC	Class VI permit approved Permit to Inject approved
Other	Support from US DOE, NDIC Renewable Energy Program, DOE-funded EERC-PCOR for storage site development and novel sustainable monitoring	

PCOR PARTNERSHIP INITIATIVE

- Accelerate CCUS deployment through field testing and development of ***<u>sustainable</u>*** monitoring techniques at an operating geologic CO_2 storage site.
- Leverage field deployment through the RTE partnership and in collaboration with the Research Institute of Innovative Technology for the Earth (RITE) team including Class VI Solutions and Barry Freifeld.
- DOE, the North Dakota Industrial Commission (NDIC) Renewable Energy Program, and the DOE-funded EERC PCOR Partnership have provided funding support for storage site development and demonstration of novel sustainable monitoring techniques.

RTE NORTH DAKOTA STORAGE FACILITY PERMIT (SFP)

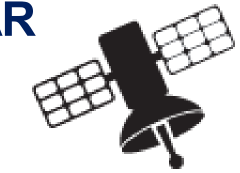
Monitoring Type	RTE Monitoring Program	Target Structure/Project Area
Analysis of Injected CO_2	Compositional and isotopic analysis of the injected CO_2 stream	Wellhead
CO_2 Flow Line	DTS/DAS and distributed strain sensing (DSS)	Capture facility to the wellsite
Continuous Recording of Injection Pressure, Rate, and Volume	Surface pressure/temperature gauges and a flowmeter installed at the wellhead with shutoff alarms	Surface-to-reservoir (injection well)
Well Annulus Pressure Between Tubing and Casing	Annular pressure gauge for continuous monitoring	Surface-to-reservoir (injection well)
Near-Surface Monitoring	Groundwater wells in the AoR, dedicated Fox Hills monitoring wells, and soil gas sampling and analyses	Near-surface environment, USDWs
Direct Reservoir Monitoring	Wireline logging, external downhole pressure and temperature gauges, and DTS/DAS fiber optic cable	Storage reservoir and primary sealing formation
Indirect Reservoir Monitoring	Time-lapse geophysical surveys, gravity surveys, inSAR and passive seismic measurements.	Entire storage complex
Internal and external mechanical integrity	Tubing-casing annulus pressure testing (internal) DTS/DAS fiber optic cable, ultrasonic imager tool (USIT) (external)	Well infrastructure
Corrosion Monitoring	Flow-through corrosion coupon test system for periodic corrosion monitoring.	Well infrastructure

Red Trail Energy NDIC SFP

- Supplemental U.S. Department of Energy (DOE)–Plains CO_2 Reduction (PCOR) Partnership monitoring activities integrated with RTE's SFP.
- SFP ensures safe storage and compliance.
- SFP requires a periodic testing and monitoring plan.

NOVEL SUSTAINABLE MONITORING

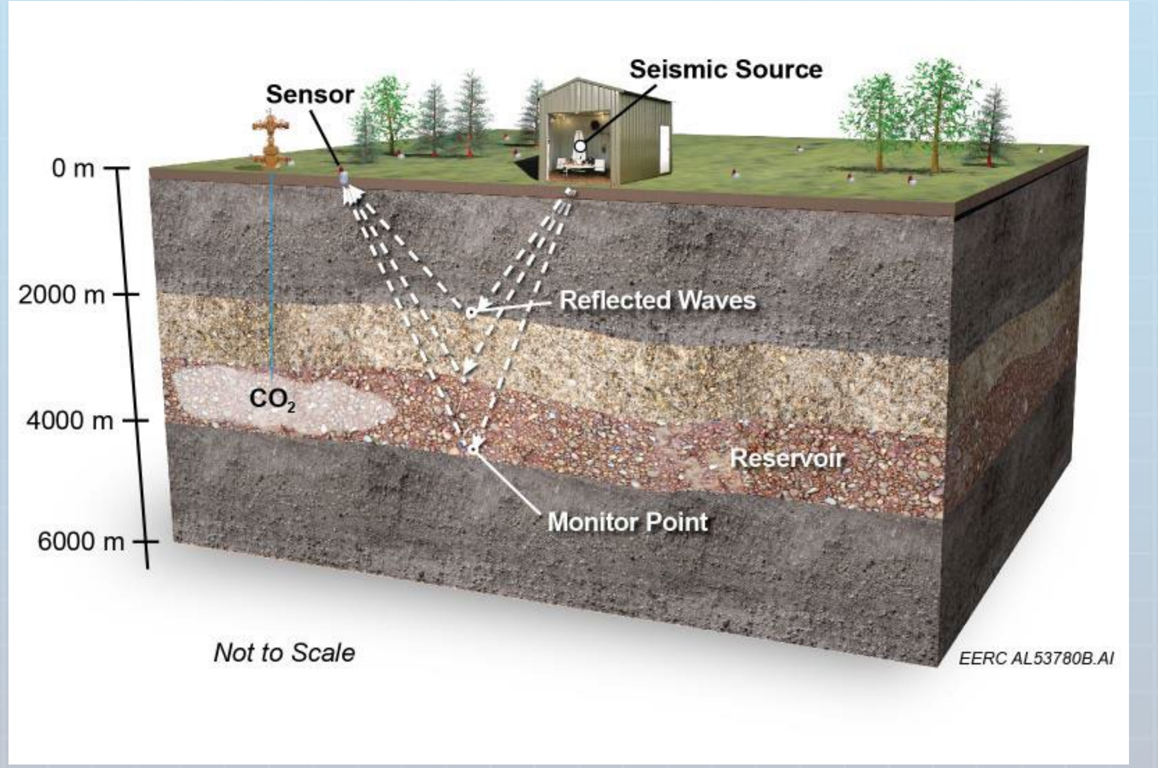
inSAR



- Analyze historical inSAR
- Surface expression of injection operations
- Reflective monuments for improved surface signal *(if needed)*

SASSA

- Autonomous equipment for recording, surface orbital vibrator (SOV), and passive noise
- Parameter testing to optimize autonomous sourcing

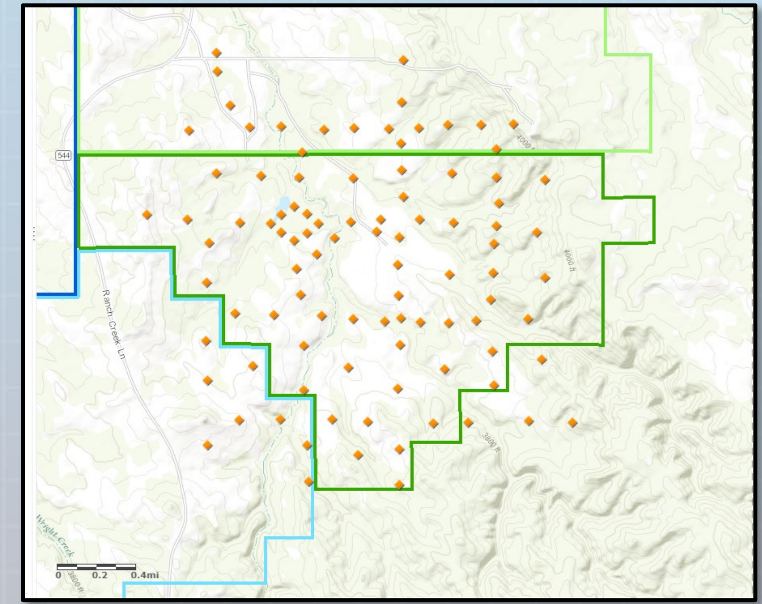


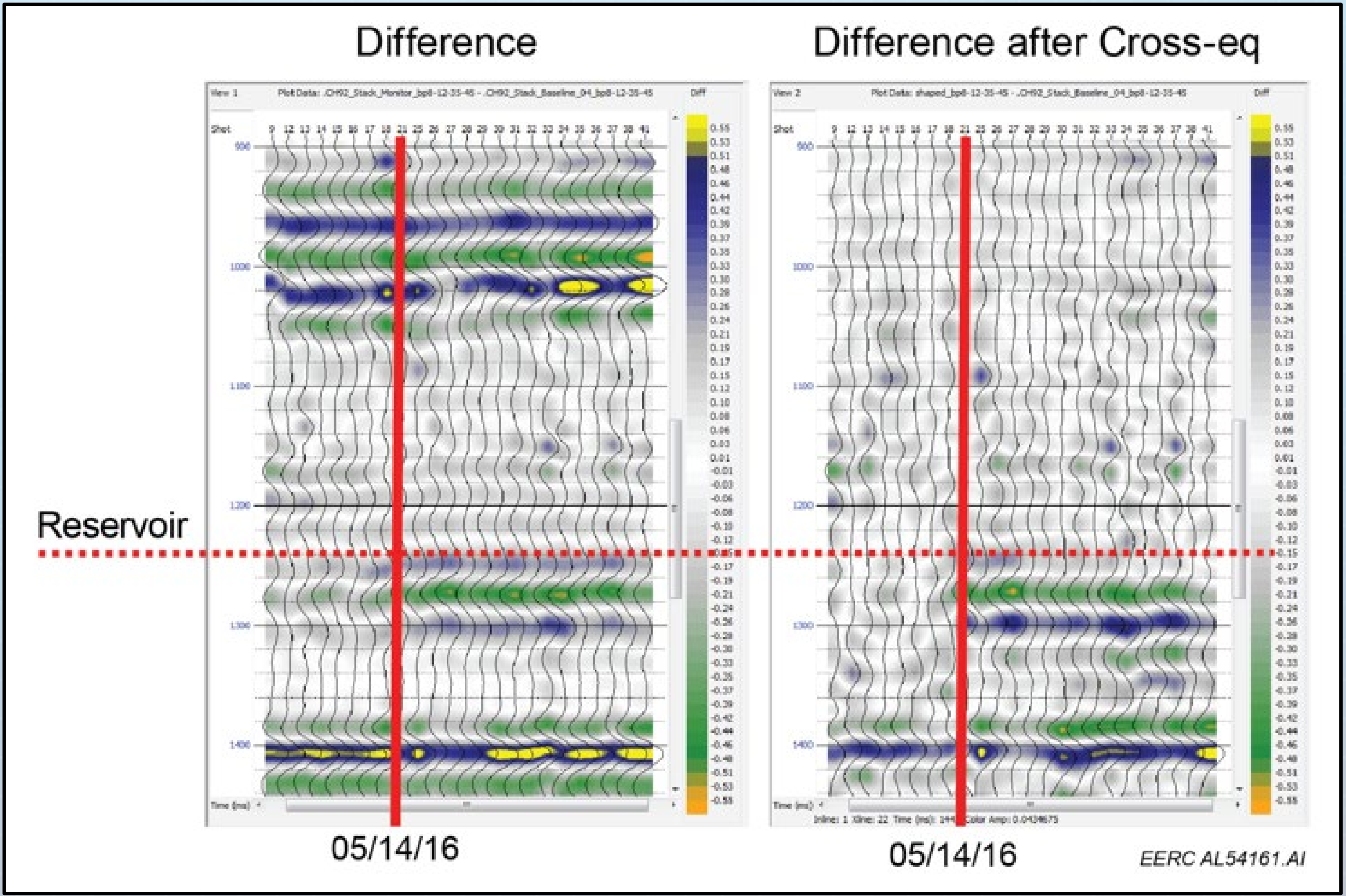
- Permanent fiber installed in the dedicated injection well, deep monitoring well, CO_2 flowline, and select groundwater-monitoring wells is capable of real-time distributed temperature sensing (DTS), distributed acoustic sensing (DAS), and distributed strain sensing (DSS) measurement and monitoring
- The project team will integrate these data and investigate training methods with ML/AI for predictive decision making.

SCALABLE AUTOMATED SPARSE SEISMIC ARRAY (SASSA)

SASSA

- Monitoring of strategically located subsurface discrete locations for understanding plume extents.
- Single-fold weekly reflection changes indicate change in CO_2 saturation.
- Integrate with dynamic reservoir simulations.





Bell Creek Oil Field, MT – SASSA example

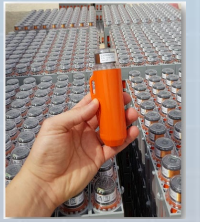
MONITORING OBJECTIVES

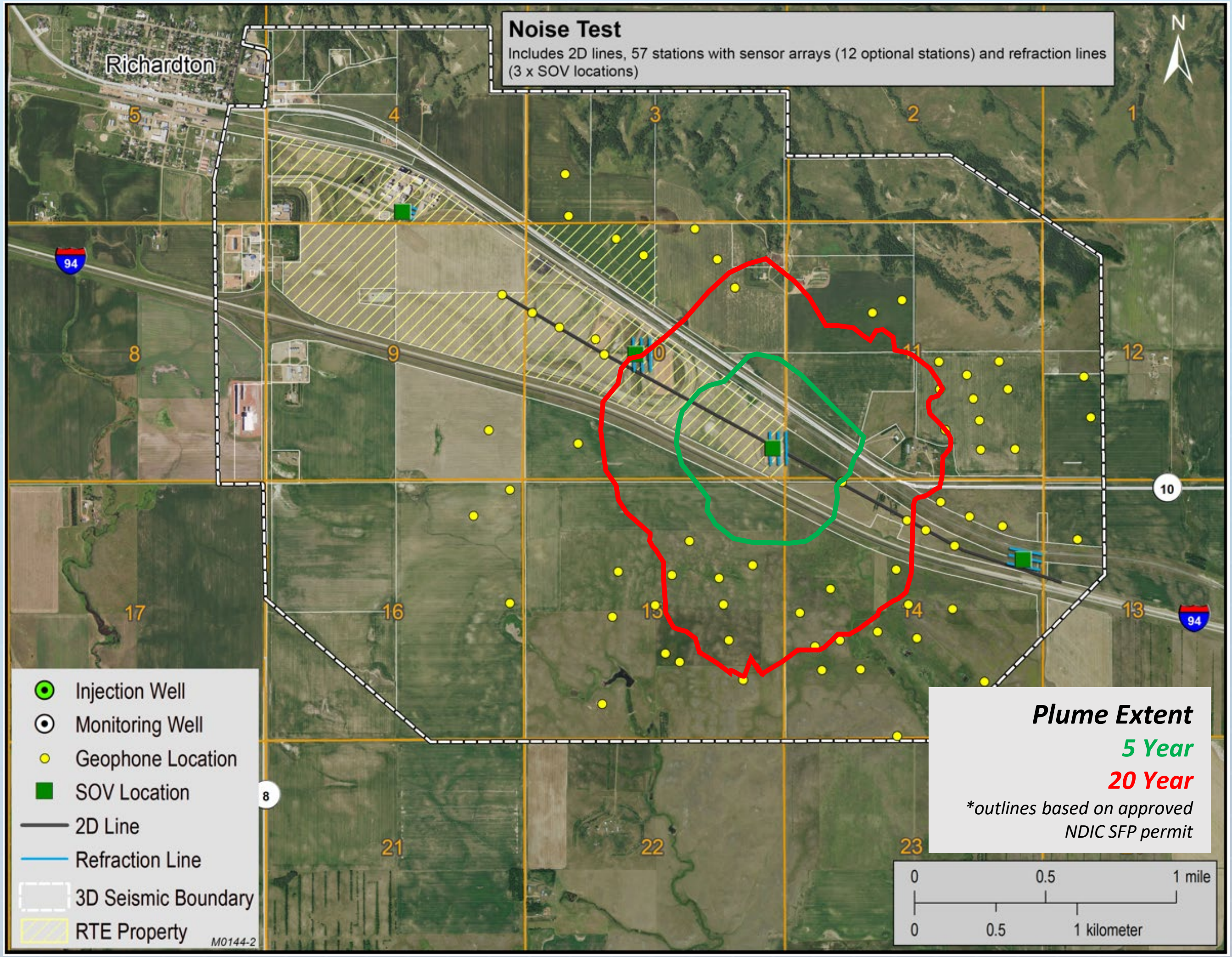
An Emerging Field for Petroleum Geologists

SASSA Planning – enhancing and optimizing cost-effective methods that reduce surface impact, lower HSE risk, and allow for safer storage

- Deployment of a sparse array of geophones at strategic locations for monitoring the injected CO_2 plume.
- RITE's SOV source will be recorded with the sparse array on a daily/weekly basis.

- 96 Zland 3C nodes to be deployed for noise characterization and SASSA baseline.
- 20 Geospace GSX-C nodes for demonstration of on demand remote harvesting.
- 750 Stryde nodes deployed in high-density arrays for noise characterization and monitoring phase of SASSA.



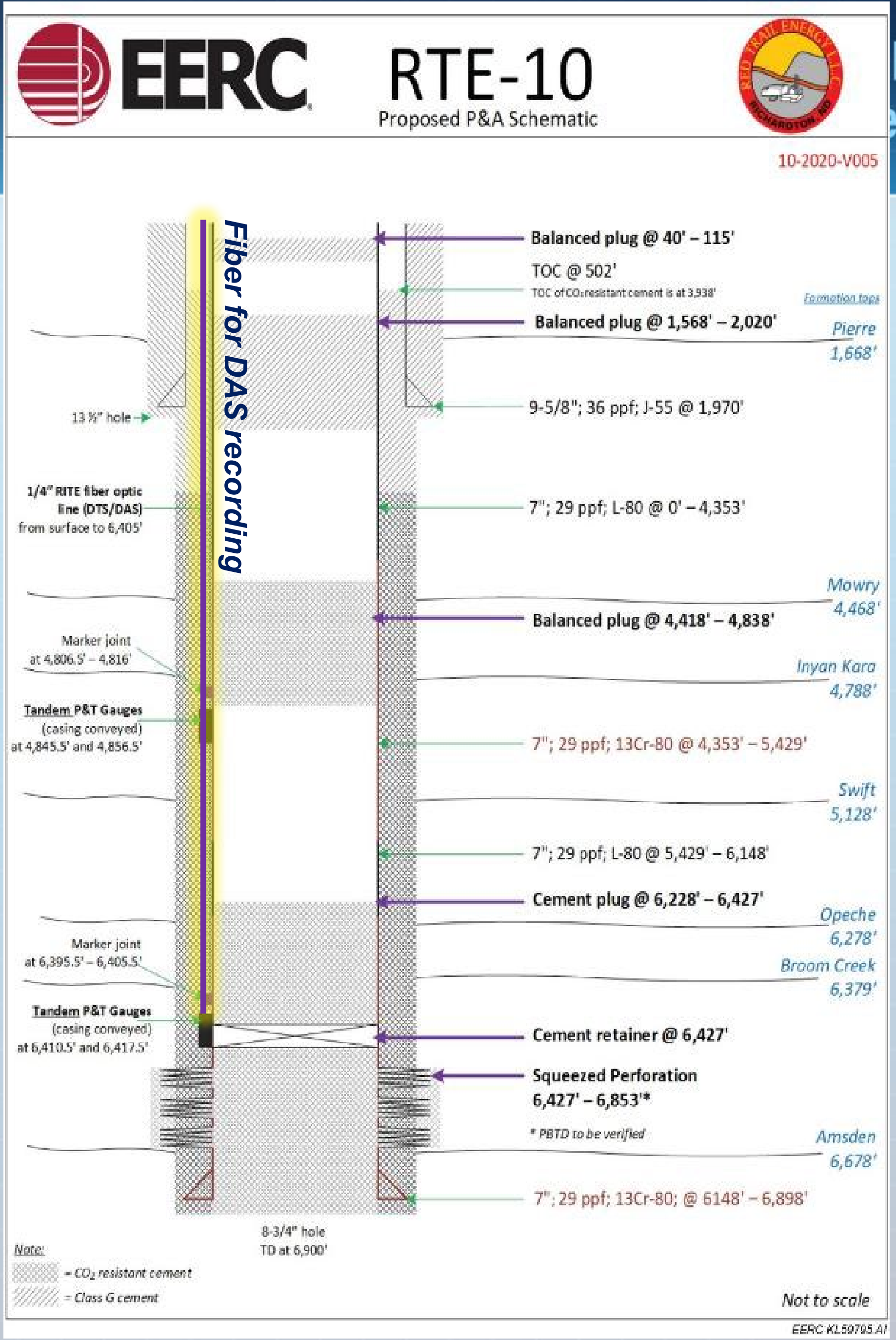


https://www.dmr.nd.gov/oilgas/seismic/permitfiles/970304.pdf

RITE FIBER DEPLOYMENT

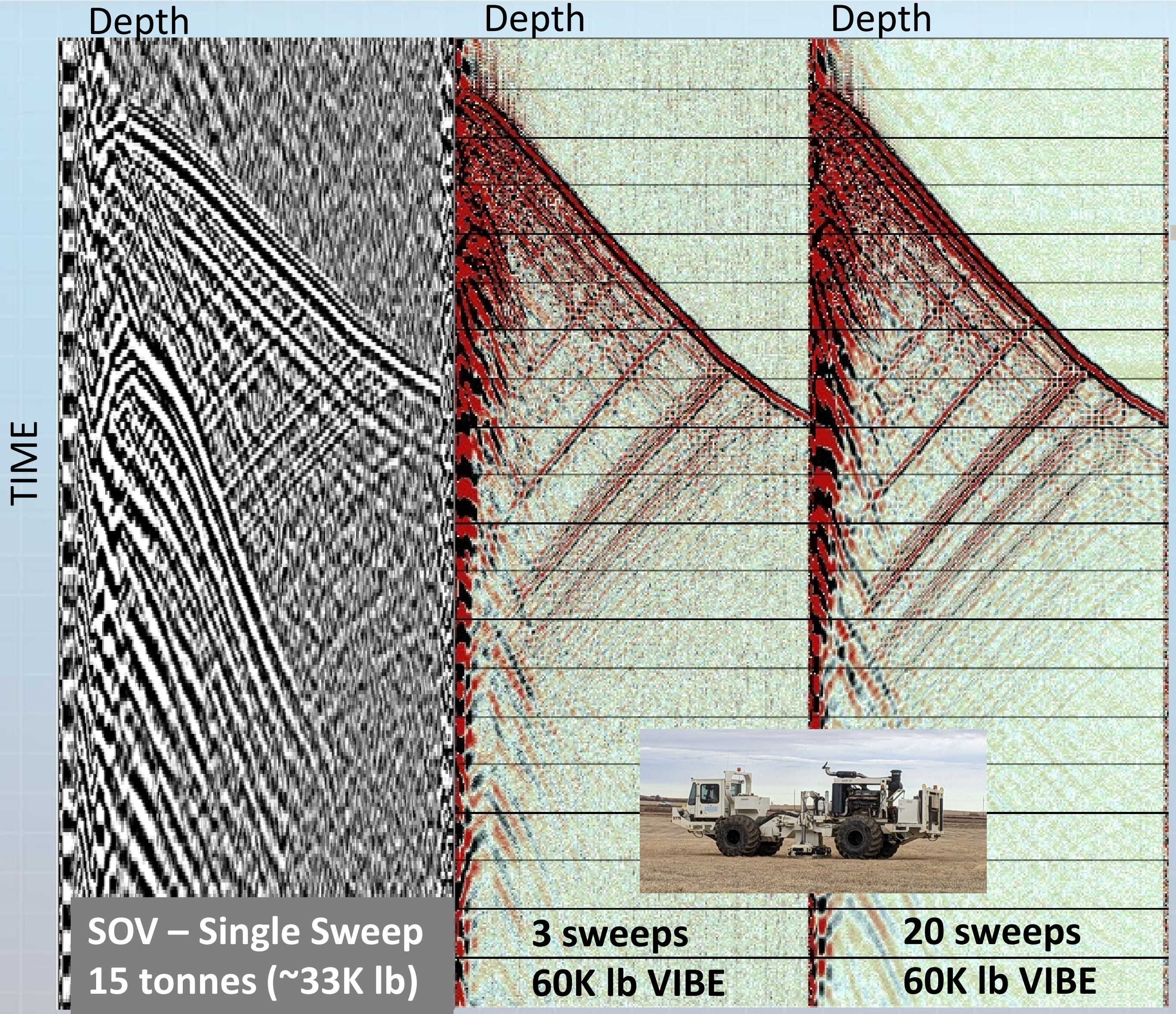
- Fiber permanently installed in injector and monitor wells.
- DTS will continuously monitor temperatures for wellbore integrity.
- ***DAS will record weekly SOV sourcing***.
- DSS will continuously measure and monitor stress changes related to reservoir changes and integrated with other pressure data.
- Record vibroseis for VSP (3D and walkaway).

DTS, DAS, and DSS systems provide changes related to saturation and pressure and record strain and passive noise.



Red Trail Energy NDIC Storage Facility Permit

RITE SOV



- Four SOVs are installed and are contained in sheds for protection from weather and for noise reduction.
- Each SOV includes a geophone installed beneath foundation to capture source signature.
- Maximum ground force is 15 tonnes.

Frequent monitoring with SOVs and periodic indirect plume monitoring with vibroseis trucks.

INTERFEROMETRIC SYNTHETIC APERTURE RADAR (InSAR)

- Pressure development interpreted from ground deformation response at Bell Creek enhanced oil recovery.
- InSAR will provide satellite-based surface deformation deliverables:
  - *Historical analysis (reflective monuments, if necessary)*
  - Modeling surface deformation
  - Monthly reports and collaborative meetings for up to 2 years

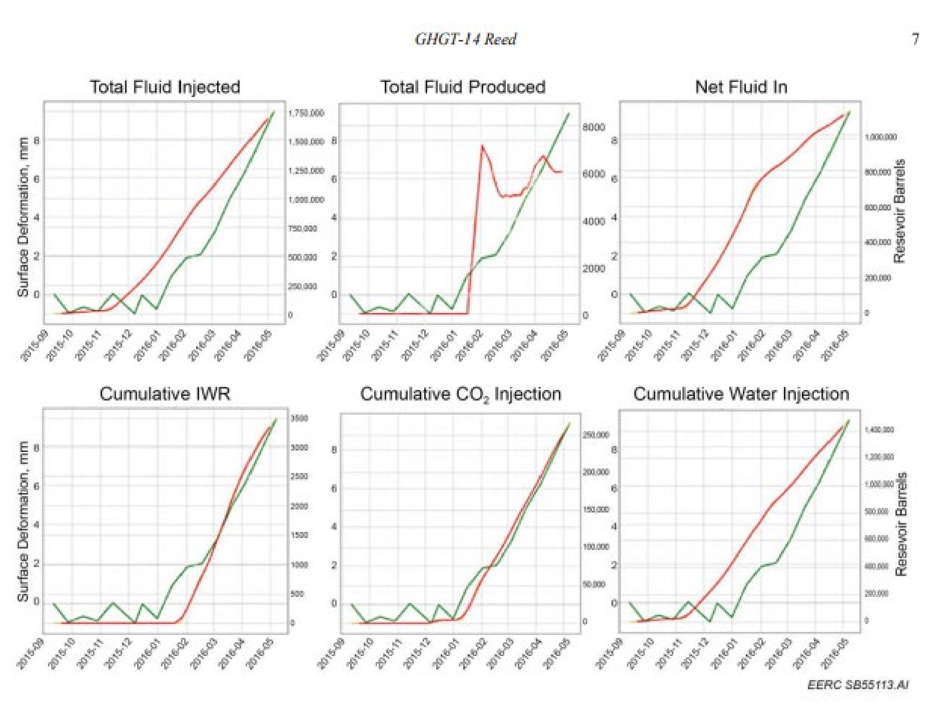
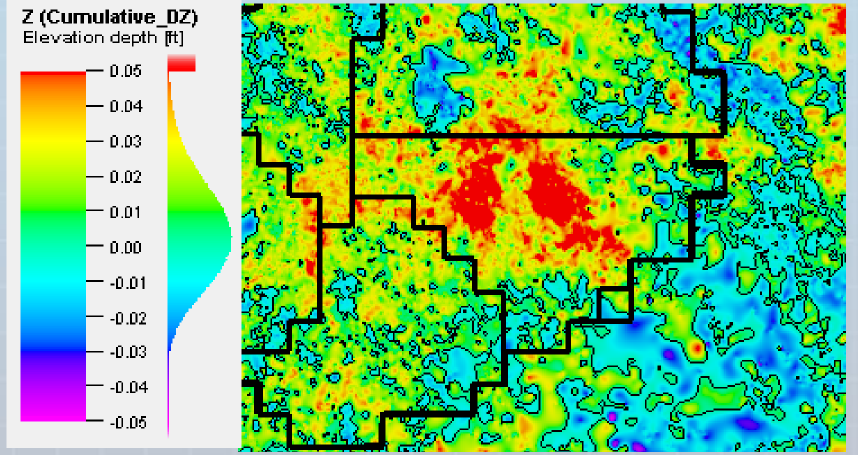
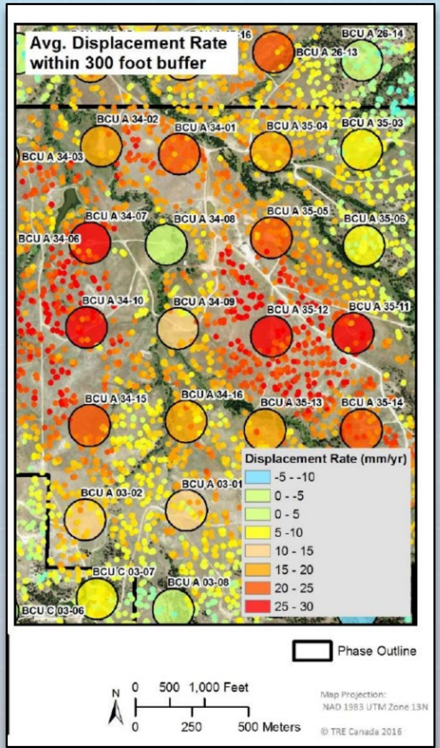


Fig. 7. Cumulative production and injection data for Bell Creek Phase 4 (red lines) compared to cumulative surface deformation (green lines).





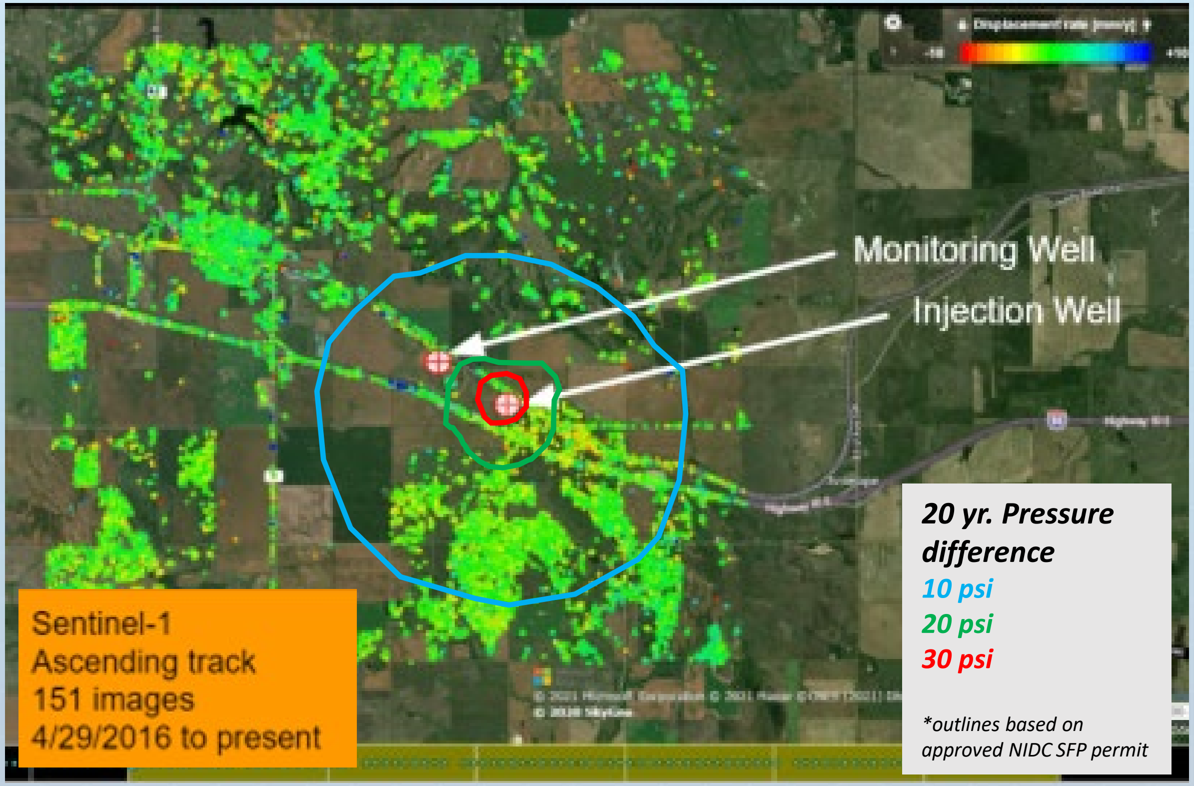
Reed et al., 2018

InSAR

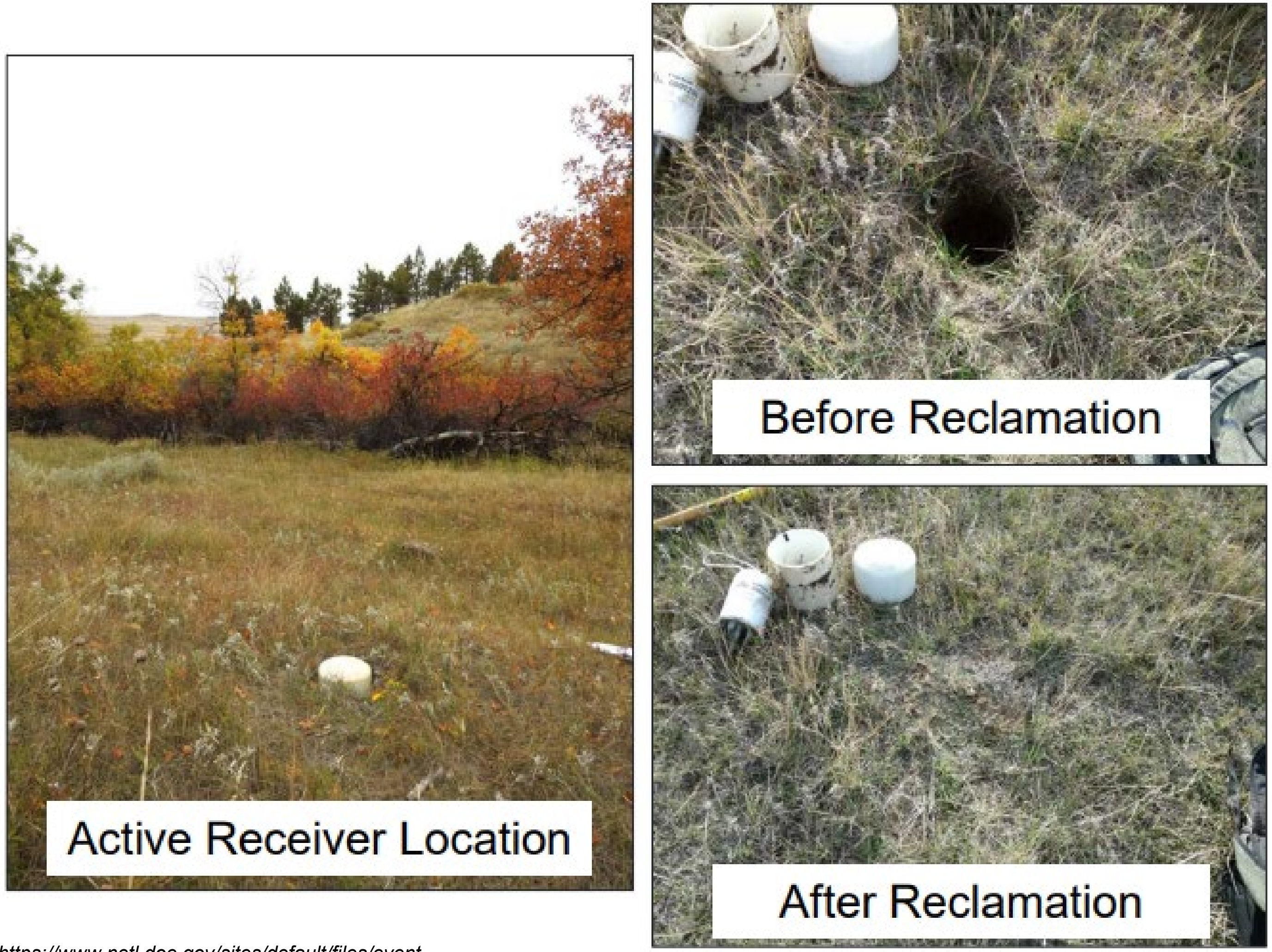
An Emerging Field for Petroleum Geologists

Initial InSAR Results with 20-year Pressure Overlay

- Public Sentinel data show limited natural reflectivity.
- Next steps:
    - Model deformation response
    - Characterize noise in other higher-resolution sources of SAR data
- Proceed with inSAR analysis for 2 years of injection operations.
- Calibrate ML training with pressure data, seismic, and other reservoir data to complement monitoring of plume extents.



RECLAMATION AT RTE SITE



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RECLAMATION AT RTE SITE

An Emerging Field for Petroleum Geologists

Fiber installed in flowline trench

- Trenched fiber DSS will be used to measure and monitor pressure changes.

- Fiber will monitor for potential temperature variations (DTS) to ensure the integrity of the flowline.

- The horizontal fiber will also be capable of DAS acquisition.

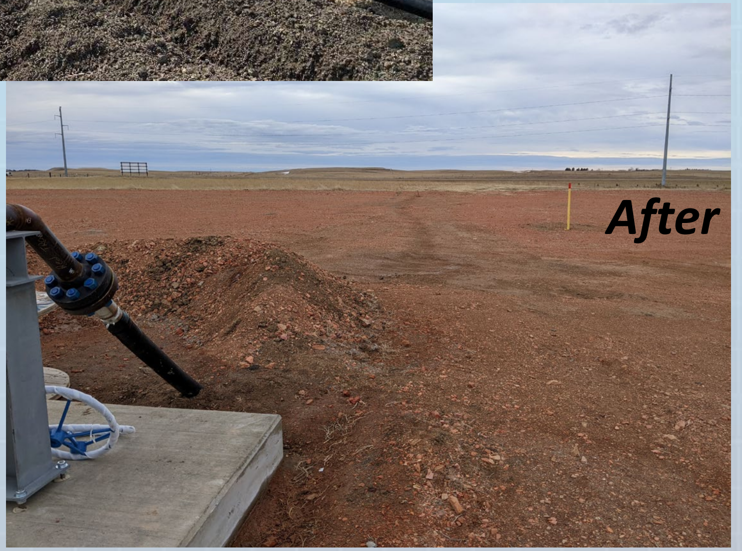

Image Credit: Barry Freifeld, Class VI Solutions

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SUSTAINABLE MONITORING

- Ensures safe storage and regulatory compliance.
- Requires robust risk-based monitoring plan to meets storage goals.
- Allows for adaptations to the monitoring plan.
- Progress low-impact CCS monitoring.

Be good stewards of the land...

ACKNOWLEDGMENT

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DISCLAIMER

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