CarbonSAFE Phase III: Sweetwater Carbon Storage Hub

Center for Economic Geology Research
School of Energy Resources, University of Wyoming
Frontier Carbon Solutions

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2024 FECM/NETL CM Research Project Review Meeting
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Acknowledgment

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DISCLAIMER

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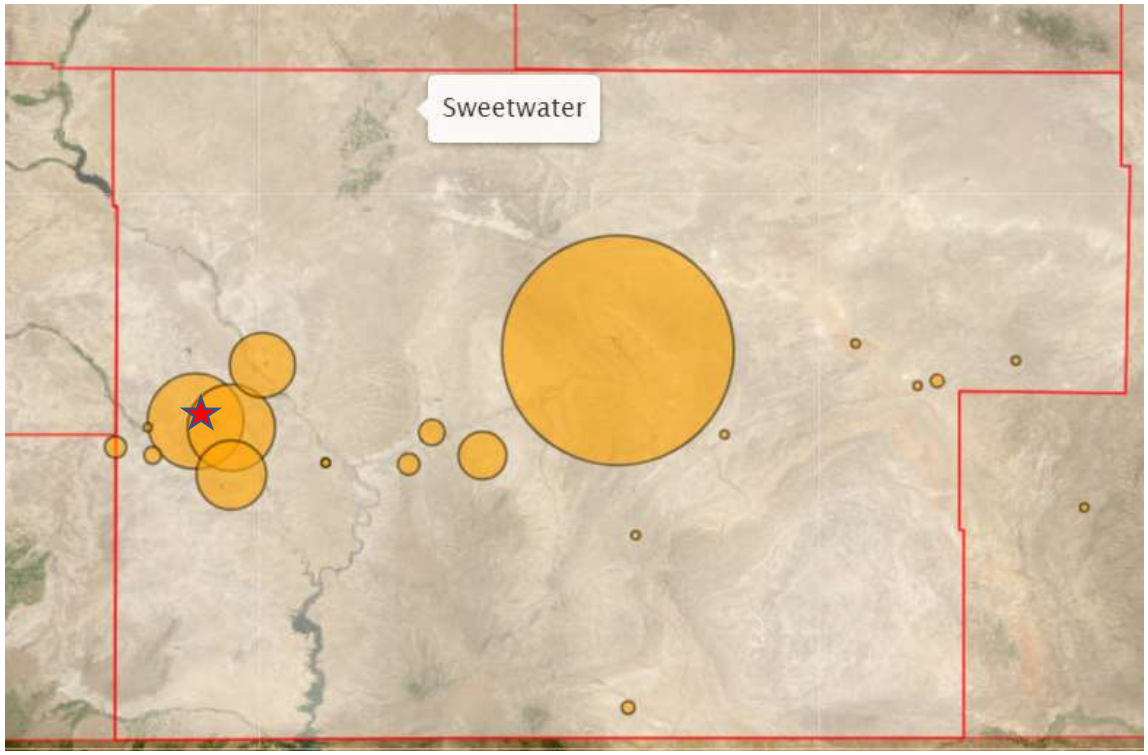
FRONTIER CARBON SOLUTIONS

Project Background

CO_2 Sources: Greater Green River Basin

Sweetwater County: total CO_2e in 2022 = 17,574,630

Emission Source and Type	Metric Tons CO_2e
Power Generation	
Jim Bridger Power Station	11,115,560
Trona Production	
American Soda LLC	1,025,302
Genesis Alkali Granger	6,376
Genesis Alkali Westvaco	1,984,817
Granger Gas Plant	52,323
Sisecam Wyoming LLC	843,706
Tata Chemicals (Soda Ash) Partners	1,607,575
Fertilizer Production	
P4 Production, LLC	166,049
Simplot Phosphates	447,012
Natural Gas Production and Transportation	
MountainWest Pipeline	89,150
Northwest Pipeline	20,764
Echo Springs Compressor Station	14,485
Blacks Fork Gas Plant	112,718
CIG Station	48,617
Vermillion Gas Plant	30,697
Wamsutter Compressor Station	9,479



★ SCS Hub

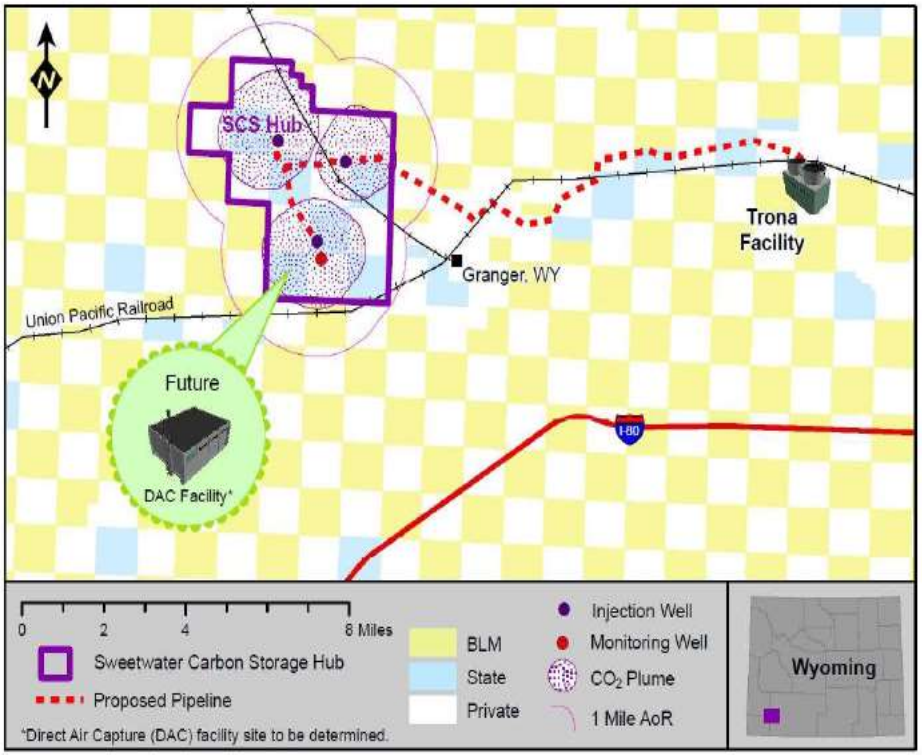
Sweetwater Carbon Storage Hub

- The SCS Hub will sequester CO_2 from two sources:
  (1) Trona (soda ash) mining and processing facilities
  (2) Direct Air Capture (DAC)

- Soda ash is the second largest mining industry in Wyoming behind coal. The ***entire*** U.S. trona industry is located within 10 miles of the SCS Hub, a critical national industry that supplies 90% of the world's soda ash.

- The U.S. (Wyoming) trona industry emits between 5 to 7 metric tons (MT) of CO_2 per year. The SCS Hub aims to provide enough CO_2 storage capacity ***to decarbonize this industry***.

- The SCS Hub will also support the scale-up of DAC by serving as a site host and sink for Project Bison, ***one of the largest DAC facilities*** planned for development within the U.S.



The Project Team

This Project is led by a team comprised of researchers from SER's Center for Economic Geology Research (CEGR) and Frontier Carbon Solutions (FCS), the owner and operator of the SCS Hub. The success of the SCS Hub will work to legitimize efforts for large-scale carbon sequestration in Southwestern Wyoming. This is the Team's principal focus.

The University of Wyoming is a research institution with significant facilities and equipment and has developed lab facilities specifically for CCUS research. UW has significant experience in all parts of a complete CarbonSAFE project. Wyoming's Flagship and Land-grant University leads the Wyoming CarbonSAFE Phase III project near Gillette, Wyoming (in the opposite corner of the state), which constructed the first wells in Wyoming that meet UIC Class VI construction standards. UW will lead Project Management, science and CBP.

Frontier Carbon Solutions (FCS), a Dallas, Texas-based, is founded in 2021 to offer safe and permanent carbon storage services for industrial emitters across the Mountain West. Specializing in the development of carbon capture infrastructure, geologic carbon storage hub, and carbon marketing. FCS's experience in well construction, contracting, and strategic selection of highly regarded industry experts and companies will help Phase III advance its objectives to develop a storage hub.

Project Overview

Objective

This project will develop one of the region's first net negative carbon storage hubs – the SCS Hub. The SCS Hub will capture and store carbon from the nation's largest trona mines and the largest proposed DAC facility in the Rocky Mountains.

There are four main objectives for this project that will advance commercialization:

1) Build three Underground Injection Control (UIC) Class VI injection wells, with attendant site characterization and science goals

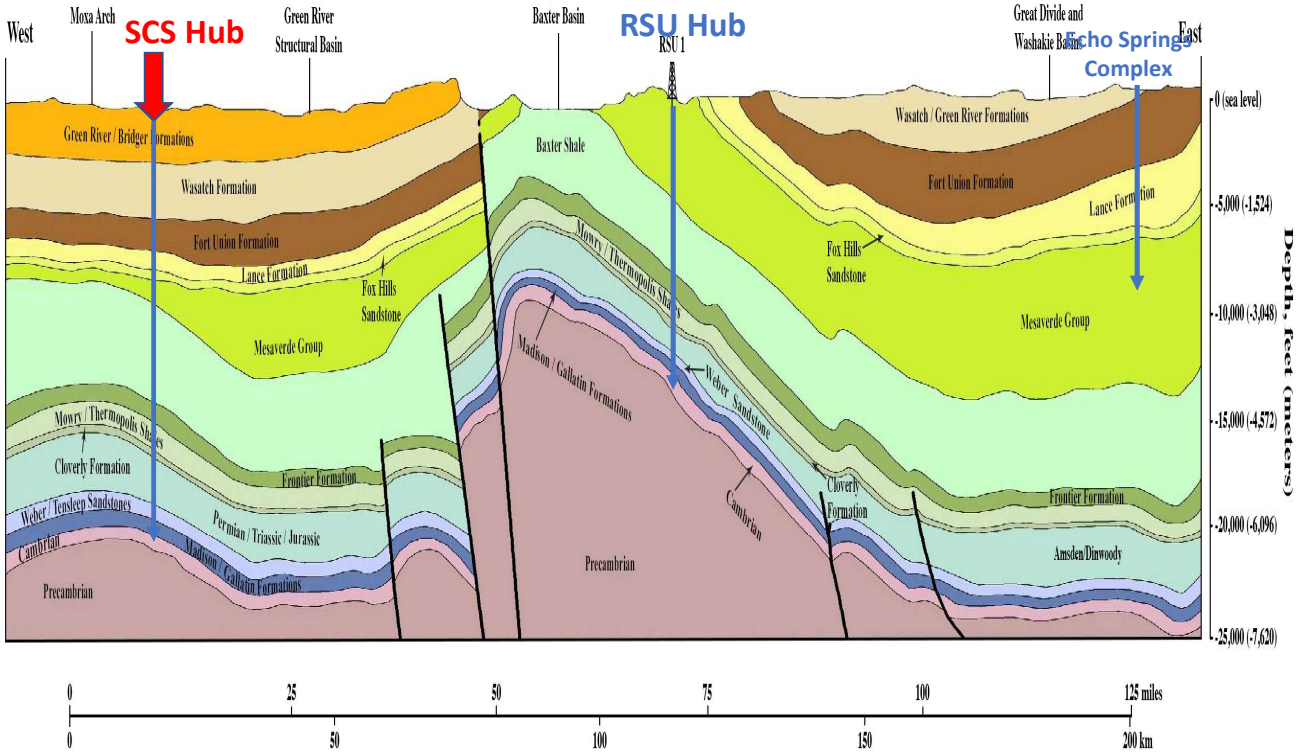
2) Complete capture & transport studies for two CO_2 sources (trona & DAC) and the pipelines to connect these sources to the storage hub.

3) Prepare commercial plans to guide future work and eventual operations, such as risk assessment and mitigation plans, a Storage Field Development Plan, a Community Benefits Plan.

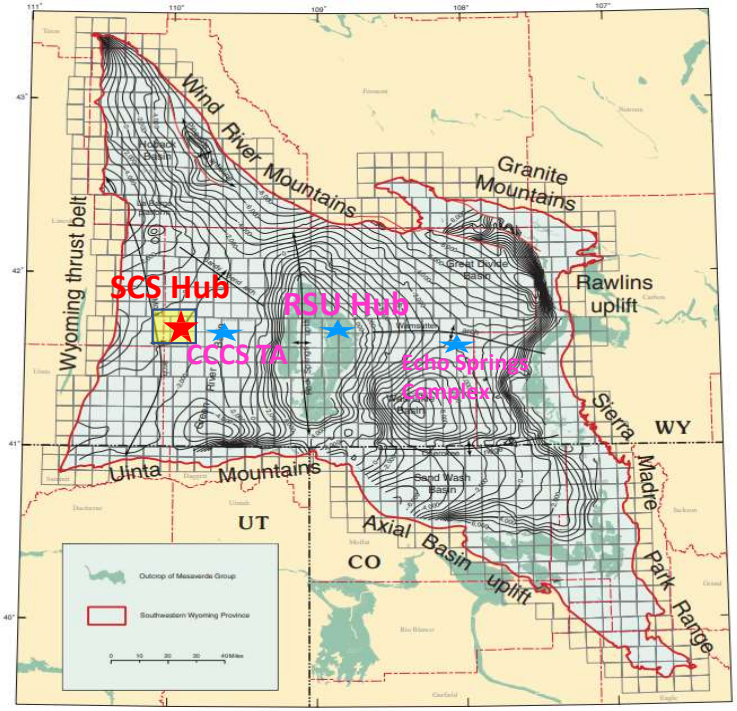
4) Complete a National Environmental Policy Act (NEPA) analyses.

Project Background

Stylized W-E Geologic Cross Section through study site and adjacent basins



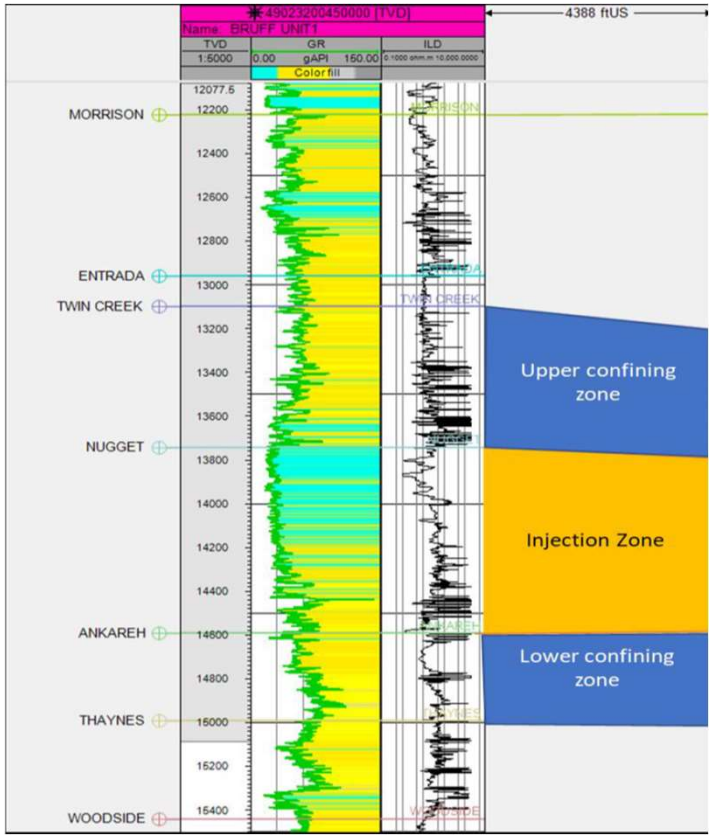
The Greater Green River Basin occupies ~20,000 mi² of the Central Rocky Mountains and has proven CO_2 storage reservoirs with multiple formations potentially suitable for secure sequestration.



Leverage and synergy with Multiple CCS projects in the GGRB.

Targeted Stacked Storage Reservoirs

Priority Storage Reservoir: Nugget Sandstone



Targeted Stacked Aquifers

Stratigraphic Section

Age	Formation		Depth below surface (ft)	Thickness
Neogene	Browns Park FM, Qa		0	2000
Paleogene	Bridger FM		2,000	700
	Green River FM		2,700	~1200
	Knight/Wasatch Formation		3,800	~1000
	Almy/ Hoback FM		4,800	~2200
Cretaceous	Almond FM		7,184	410
	Ericson Sandstone			
	Adaville Formation		7,594	~100
	Hilliard/Baxter Shale		7,694	3546
	Frontier FM	O&G Res	11,240	248
	Aspen/Mowry Shale		11,488	~250
	Bear River FM		11,538	362
	Dakota Sandstone	USDW	11,900	318
Jurassic	Morrison FM		12,218	~300
	Sundance FM		12,518	583
	Twin Creek LST (member)	Confining	13,101	631
	Nugget Sandstone	Injection	13,732	705
Triassic	Ankareh FM	Confining	14,437	550
	Thaynes Limestone		14,987	406
	Woodside Shale	Confining	15,393	~600
	Dinwoody FM		16,002	~100
Permian	Phosphoria FM	Confining	16,102	368
Carboniferous	Tensleep/Weber Sandstone	Injection	16,470	586
	Amsden FM	Confining	17,056	244
	Darwin Sandstone		17,300	246
	Madison Limestone	Injection	17,546	778
Devonian	Three Forks Shale		18,324	778
	Jefferson Limestone		18,412	88
Ordovician	Bighorn Dolomite		18,755	343

USDW

Nugget Sandstone

Weber Sandstone

Madison Limestone

(from Bruff Unit 1)

Nugget Sandstone

- Nugget is late Triassic to Early Jurassic in age
- The Nugget (Navajo equivalent) developed in the largest dune field in Earth's history
- Dunes are transverse dunes with dominant wind direction about 45 deg E of N and dunes perpendicular to that (45 deg W of N)
- Dune facies have the best porosity and permeability
  - The best reservoir qualities are expected in avalanche deposits, followed by grainfall deposits, and poor qualities in the toe ripples
- Interdunes have the worst reservoir properties
  - Interpreted to form in interdunal lakes or during episodic flooding events
  - Dunes are stabilized in the presence of water and many dune fields show evidence of episodic flooding

Depositional Processes Creating Dune Architecture

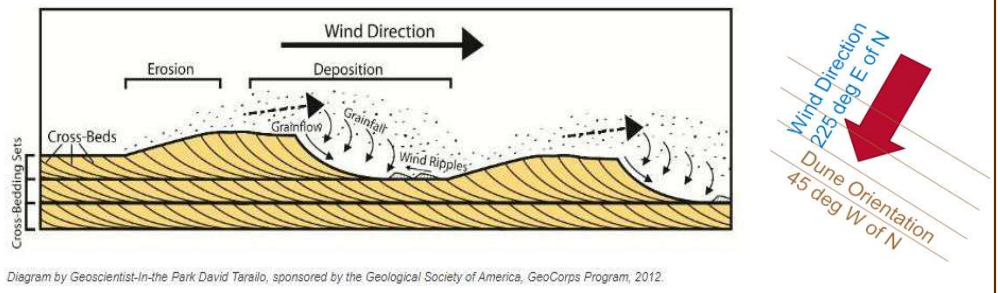
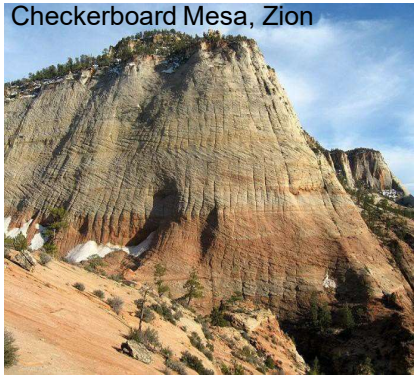


Diagram by Geoscientist-In-the Park David Tarailo, sponsored by the Geological Society of America, GeoCorps Program, 2012.

Paleographic Map

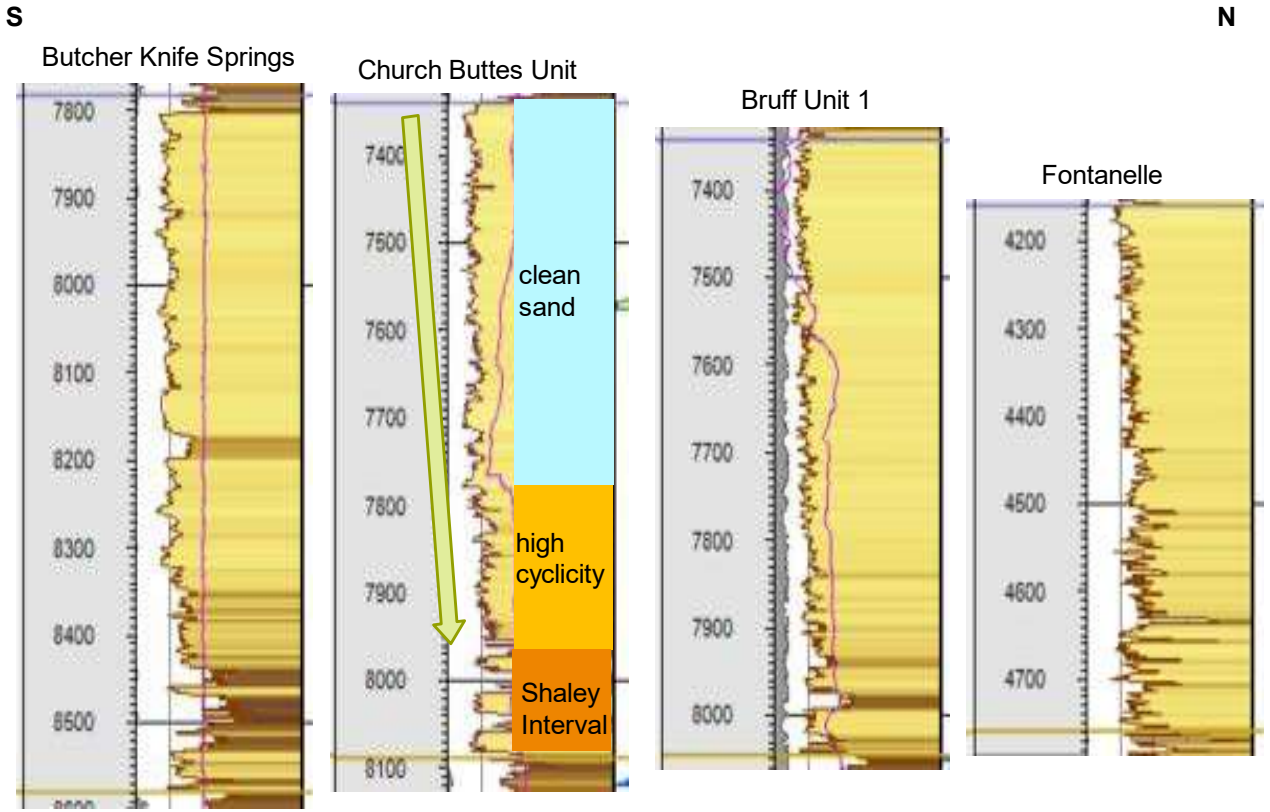
Truncated Cross Beds



Modified: Melissa Northcott, Hass &Cobb

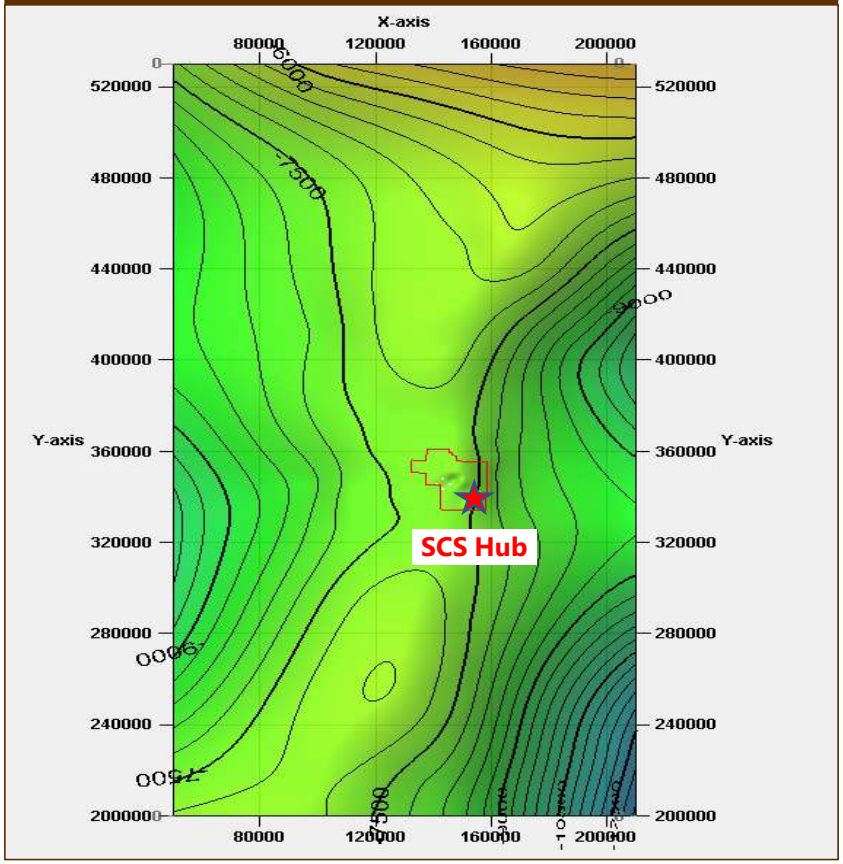
Nugget Sandstone

- The Nugget has a high degree of lateral variability
- However, Nugget often shows a pattern of cleaner sand at the upper section, high cyclicity sand near the middle, and shaley intervals alternating with blocky sands at the base

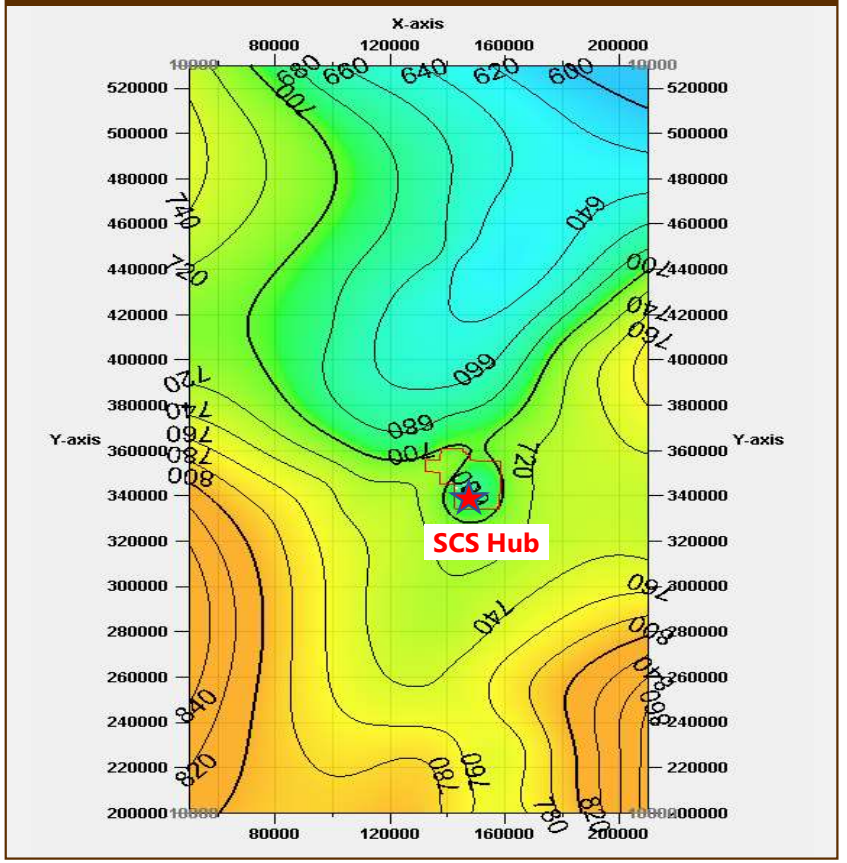


Project Background

Top Nugget Sandstone Structure



Nugget Isochore



Major Scientific and Site Characterization Challenges

SCS Hub-specific challenges to be studied as part of this Project include:

- Acquisition of data from storage reservoir depths of ~13,500 ft and over 17,500 ft from the Nugget and Madison, respectively
- Viability and capacity of the storage reservoir(s) and associated caprock
- Mapping the petrophysical property based on core, well log, and seismic data
- Formation fluid salinity and pressure
- Remediating active shallow oil and gas producing Corrective Action wells
- **Retrofitting legacy industrial facilities to accommodate carbon capture technology**
- **Economics of hub development**
- **Mitigating and accommodating cultural, environmental, and wildlife concerns**
- **Carbon management public outreach and education**

Scope of Work

The Scope of Work includes both *Technical* and non-technical aspects and is developed to meet or exceed CarbonSAFE program objectives and SCS Hub commercialization goals.

The *technical* scope of work includes:

(1) Completing site characterization of the SCS Hub

(2) Constructing three injection wells to meet research objectives and commercial injection goals

(3) Completing CO_2 capture engineering work for a trona mining and processing facility, and assessing carbon capture capacity with the Project Bison's DAC facility

(4) Completing a FEED assessment for in-field CO_2 pipelines

(5) Finalizing risk assessments and the MVA and mitigation strategies

(6) Drafting the Storage Field Development Plan.

Scope of Work

The Scope of Work includes both technical and *Non-technical* aspects and is developed to meet or exceed CarbonSAFE program objectives and SCS Hub commercialization goals.

The *non-technical* scope of work includes:

(1) Finalization of three Class VI permit applications and thereafter obtaining all Underground Injection Code Class VI permit(s) to construct in support of eventual commercial-scale operations

(2) Completing regulatory site access assessments, including but not limited to an EIV to determine and complete an EA or EIS under NEPA

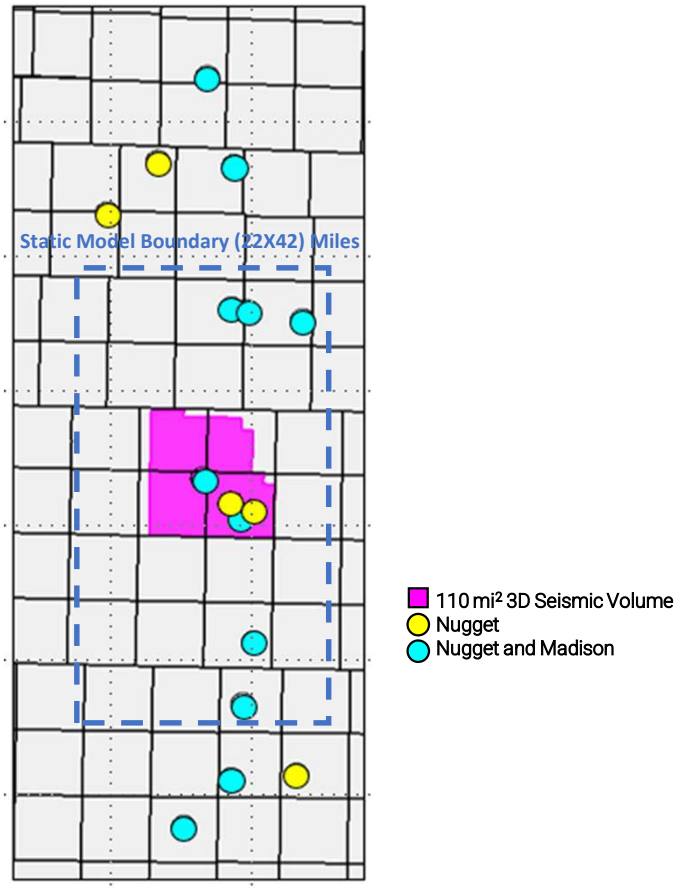
(3) Completing the Community Benefits Plan

Current Activities

Regional Data

Regional Study Data Available

- Magenta polygon depicts 110-mi2 3D seismic footprint, increased from the original 9 mi2
- 16 Wells were studied to develop an EOD of the Moxa Arch to inform model construction in the project area
- 16 Well logs in the Nugget (13 through the full interval)
- 4 Well logs through the entire Madison interval
  - Nine regional well penetrations in the Madison, four of which have a Three Forks top (base of Madison)
  - Bruff 1 (the only well that ties seismic data) gets very close to the base of the Madison.
- Cores: 1 Nugget, 1 Weber
- Logs: 1,070 LAS files from 769 wells, most TD at the Cretaceous.
- Well Test: DST 5 Nugget, 2 Weber



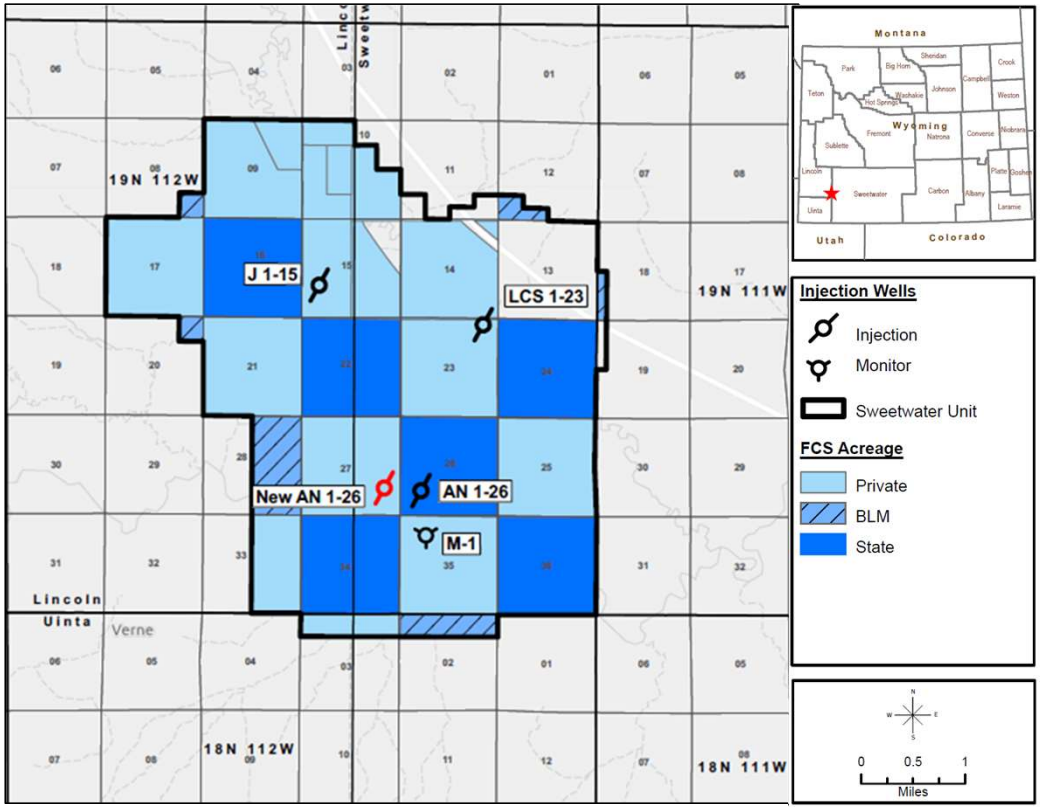
SCS Hub Class VI Permits to Construct

Key Points

- FCS received Wyoming's ***first*** three Class VI Permits to Construct in December 2023
- This will allow for drilling of Class VI wells under the CarbonSAFE program

Class VI Public Hearing

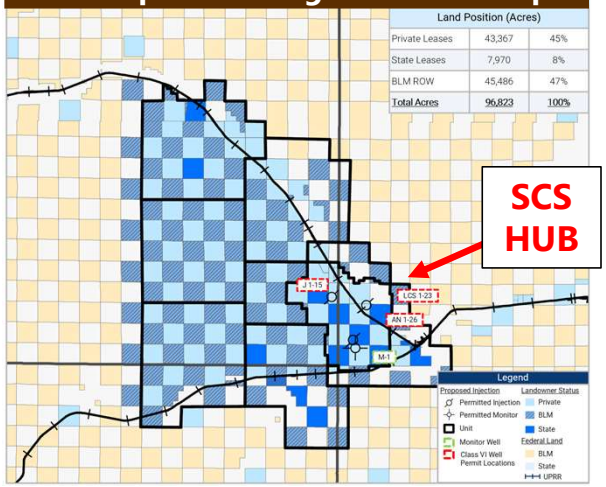
Proposed Sweetwater Hub Unit Boundary



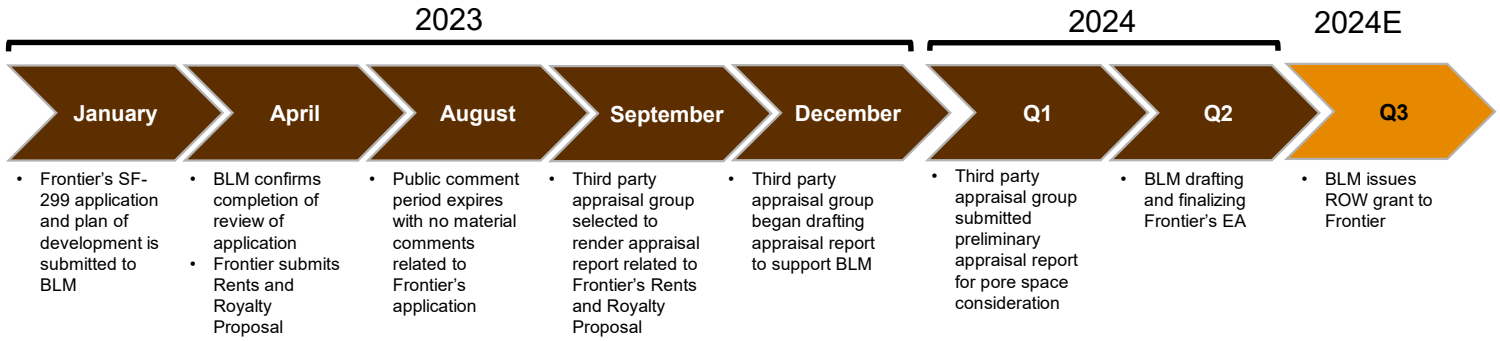
Land Overview

- Frontier has acquired ~51,230 acres of pore space from private landowners and the State of Wyoming
- Currently working to secure additional ~45,500 acres of pore space from the BLM covering federal lands; BLM SF-299 ROW application was submitted Jan 2023 and will likely ***be the first*** in Wyoming when completed
- SCS Hub Unitization application submitted June 28 for August WOGCC hearing. This meeting scheduled for August 13, and will ***be the first*** CCS unitization meeting in Wyoming
- Frontier currently has leased >88% of the pore space in the unit, well over the 80% statutory threshold required. Potential to have SF-299 ROW from BLM in August, providing Frontier about 93% of leased pore space in the unit.

Pore Space Acreage Position Map



Estimated BLM Application Process Timeline

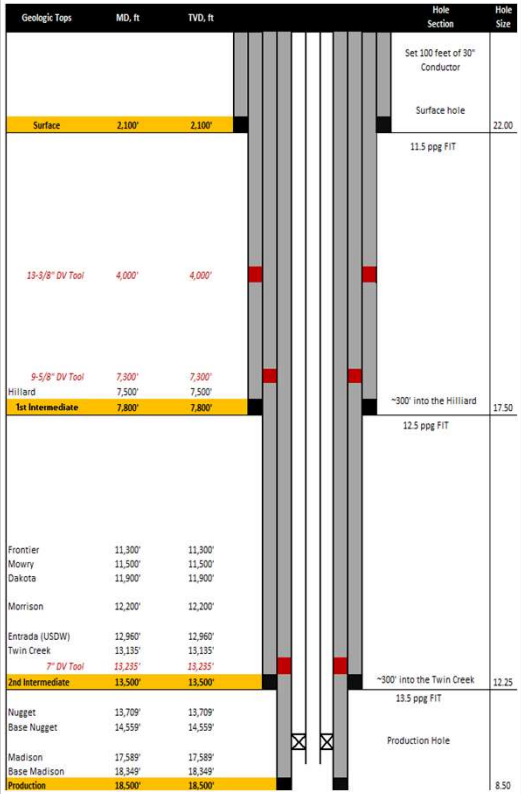


Injection and Monitor Well Engineering

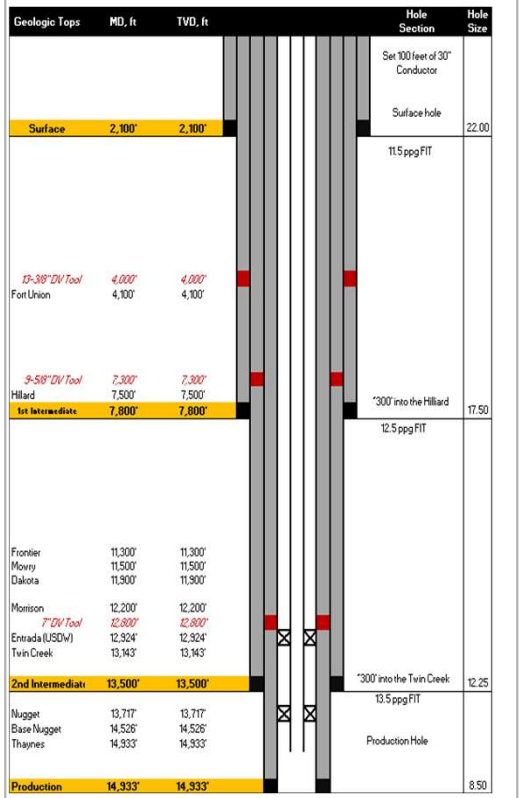
Key Points

- Acquired CR25 casing for the injection interval
  - Conservative approach vs. CR13
  - Many options were weighted relative to lead times
- DV tool will be used to ensure cement to surface
- Whole core and sidewall core will be gathered
- Fluid samples to be obtained via MDT

Nugget Injection Wellbore Diagram



Nugget Monitor Wellbore Diagram




Questions?
IRONHAND
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