



EERCSM



U N I V E R S I T Y O F
NORTH DAKOTA[®]



Critical Challenges. Practical Solutions.



Energy & Environmental Research Center (EERC)

CCUS Landscape 2023

ND House Energy Committee
ND House Agriculture Committee
ND Senate Energy Committee
ND Senate Agriculture Committee
January 13, 2023

John Harju
Vice President for Strategic Partnerships

PCOR PARTNERSHIP

2003–2005 – PCOR Partnership: Characterization

2005–2008 – PCOR Partnership: Field Validation

2007–2019 – PCOR Partnership: Commercial Demonstration

2019–2024 – PCOR Partnership Initiative: Commercial Deployment



U.S. DEPARTMENT OF
ENERGY



NATIONAL
ENERGY
TECHNOLOGY
LABORATORY



Institute of Northern Engineering
University of Alaska Fairbanks



UNIVERSITY
OF WYOMING

School of
Energy Resources

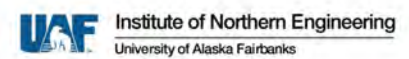
Image credit – EERC

0 500 1,000
kilometers

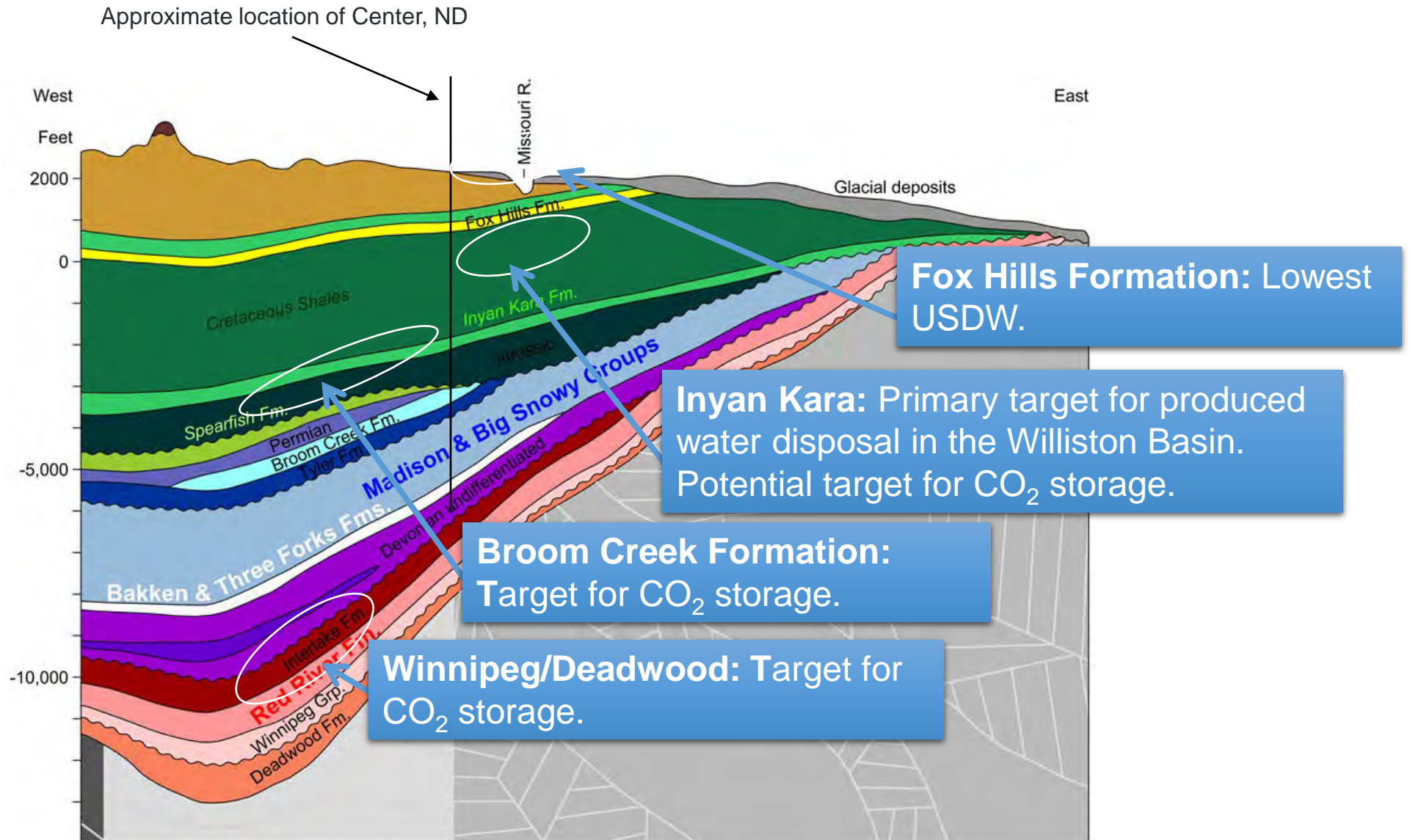




PARTNERSHIP MEMBERS



WILLISTON BASIN SALINE STORAGE OPPORTUNITIES



SAMPLING PUBLIC-PRIVATE PARTNERSHIP PROJECTS THAT THE EERC HAS PARTNERED ON WITH INDUSTRY TO ENABLE CCUS (SINCE 2003)*



* Does not include direct contract work to support commercial CCUS project development and implementation without a publicly funded component.

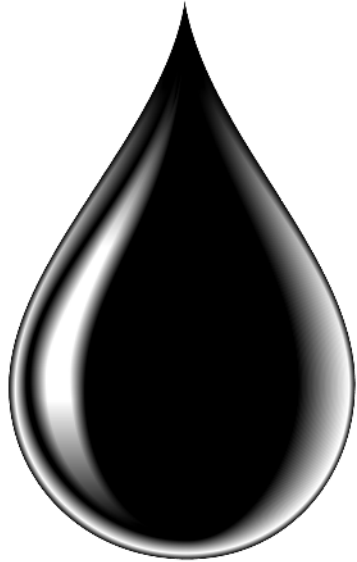
EERC BAKKEN EOR RESEARCH (2012-2023)

Multiple projects focused on the use of CO₂, Ethane, NGL, Methane in the Bakken.

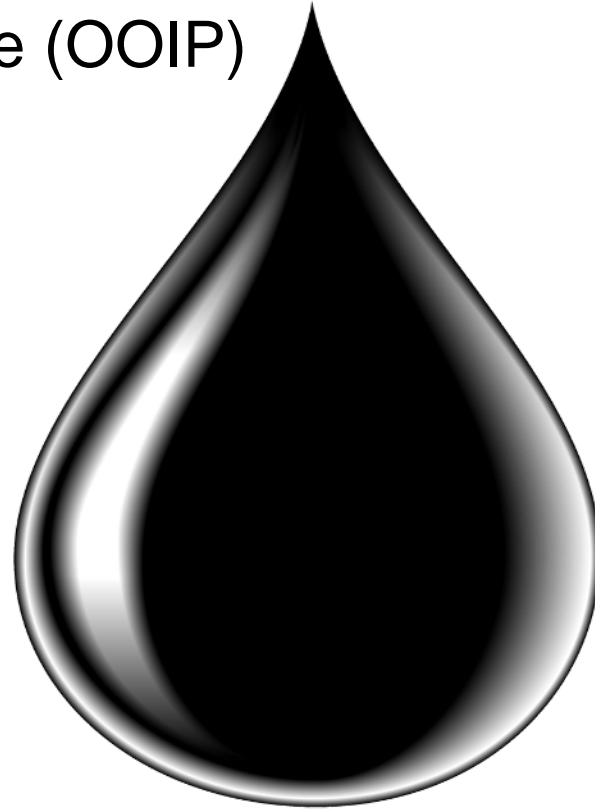


BAKKEN EOR SIZE OF THE PRIZE

Original Oil in Place (OOIP)
Estimates



300 Bbbl
(Flannery and Kraus, 2006)



900 Bbbl
(Continental Resources, 2011)

Technically Recoverable
Reserve Estimates
(Primary Recovery)



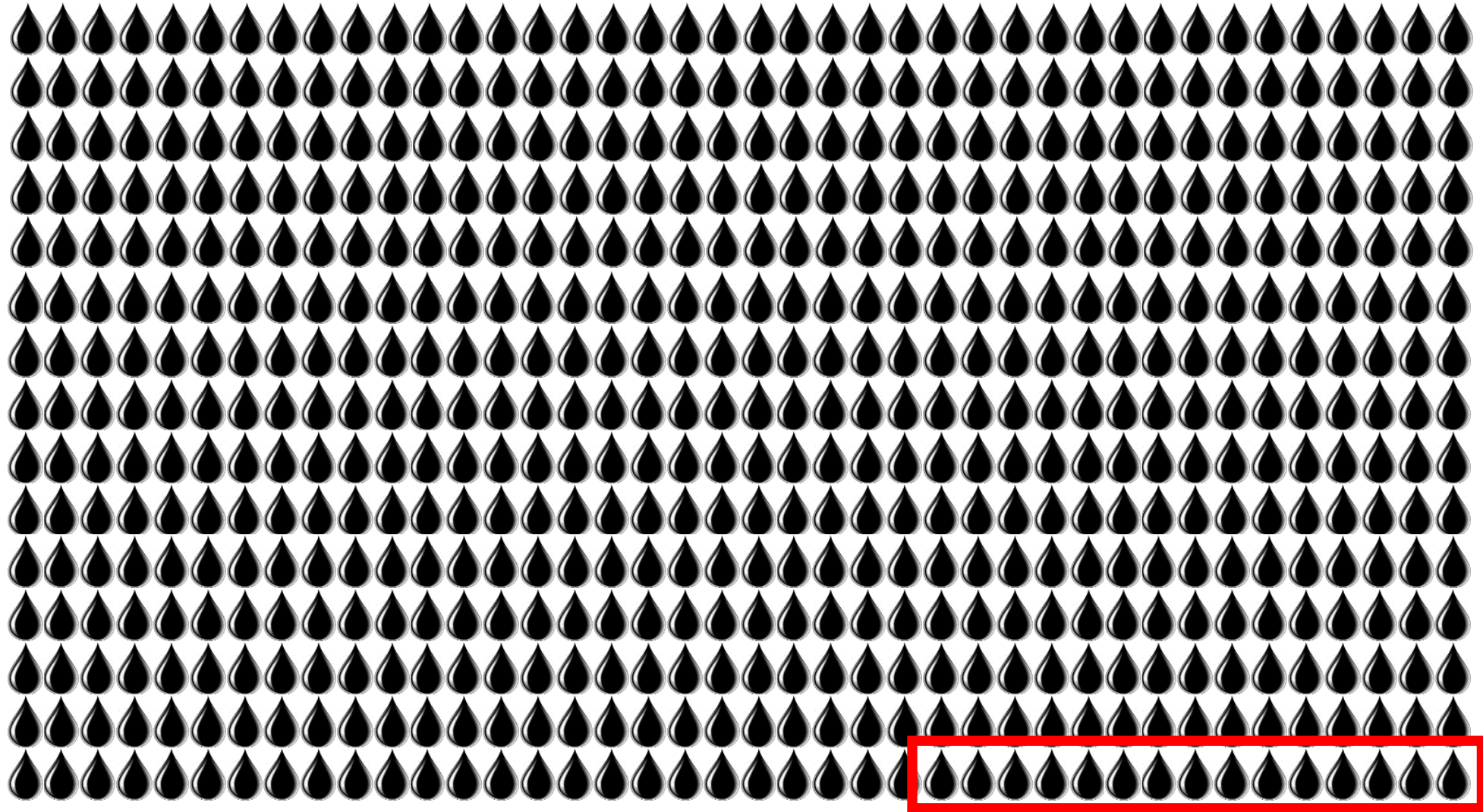
7.4 Bbbl
(USGS, 2013)



24 Bbbl
(Continental Resource, 2011)

Business as usual gets
about 15 billion barrels.

LEAVES A LOT OF BAKKEN OIL TO CHASE!



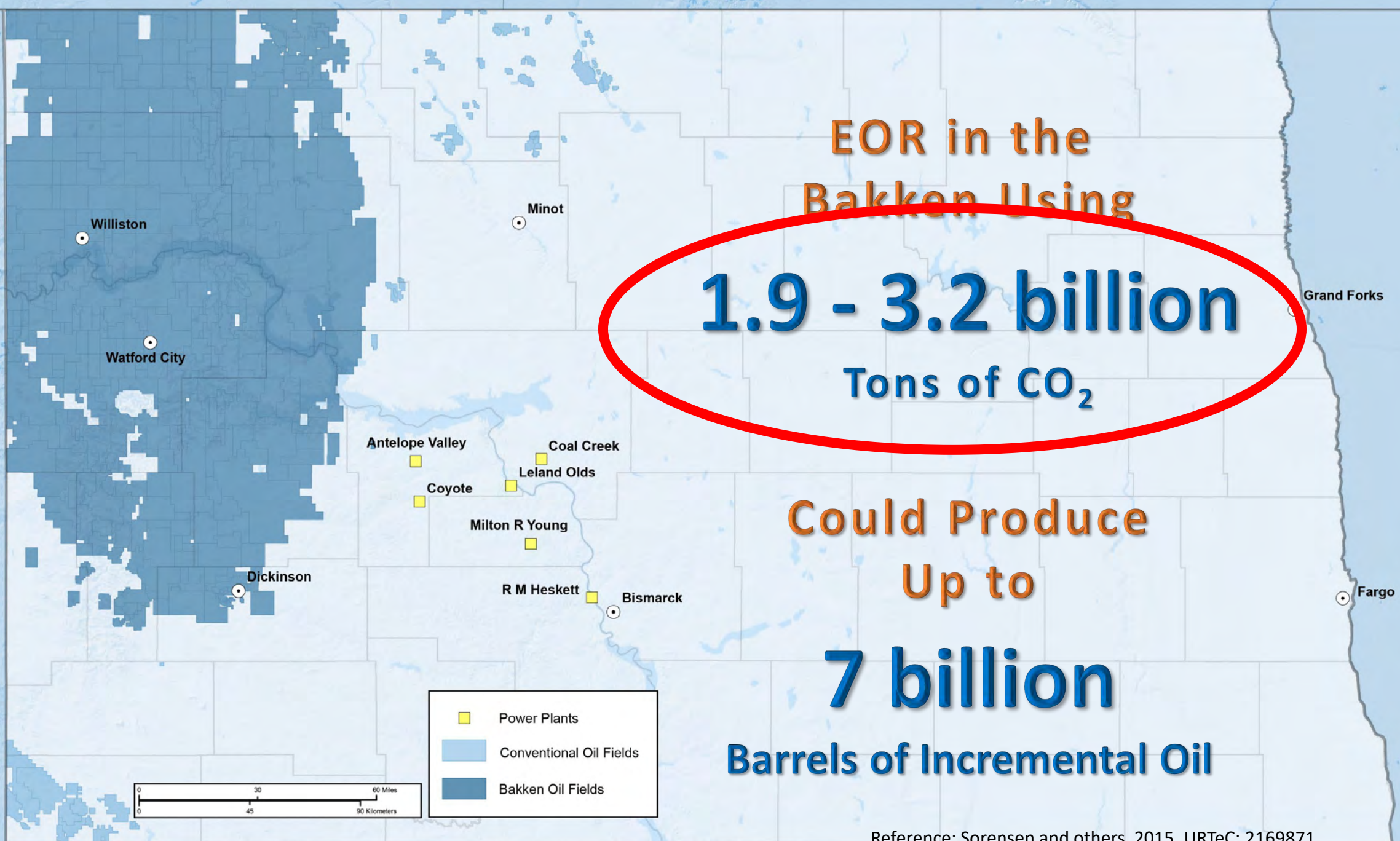
EOR in the
Bakken Using

1.9 - 3.2 billion
Tons of CO₂

Could Produce
Up to

7 billion
Barrels of Incremental Oil

Reference: Sorensen and others, 2015, URTeC: 2169871.



Liberty East Nesson EOR Project

Recap & Implications for Bakken Well EUR's

January 10, 2023



Liberty East Nesson EOR Project

GOAL / OBJECTIVES

- **The primary goal:**
 - to demonstrate the economic viability of enhanced oil recovery from the Bakken Petroleum System by using produced rich gas in combination with water and surfactants.
- **The objectives:**
 - increase reservoir pressure above MMP to promote gas EOR response
 - lower surface injection pressure requirements and improve injected gas conformance in the reservoir via co-injection with water
 - use a surfactant to enhance oil recovery through rock wettability alteration and interfacial tension reduction

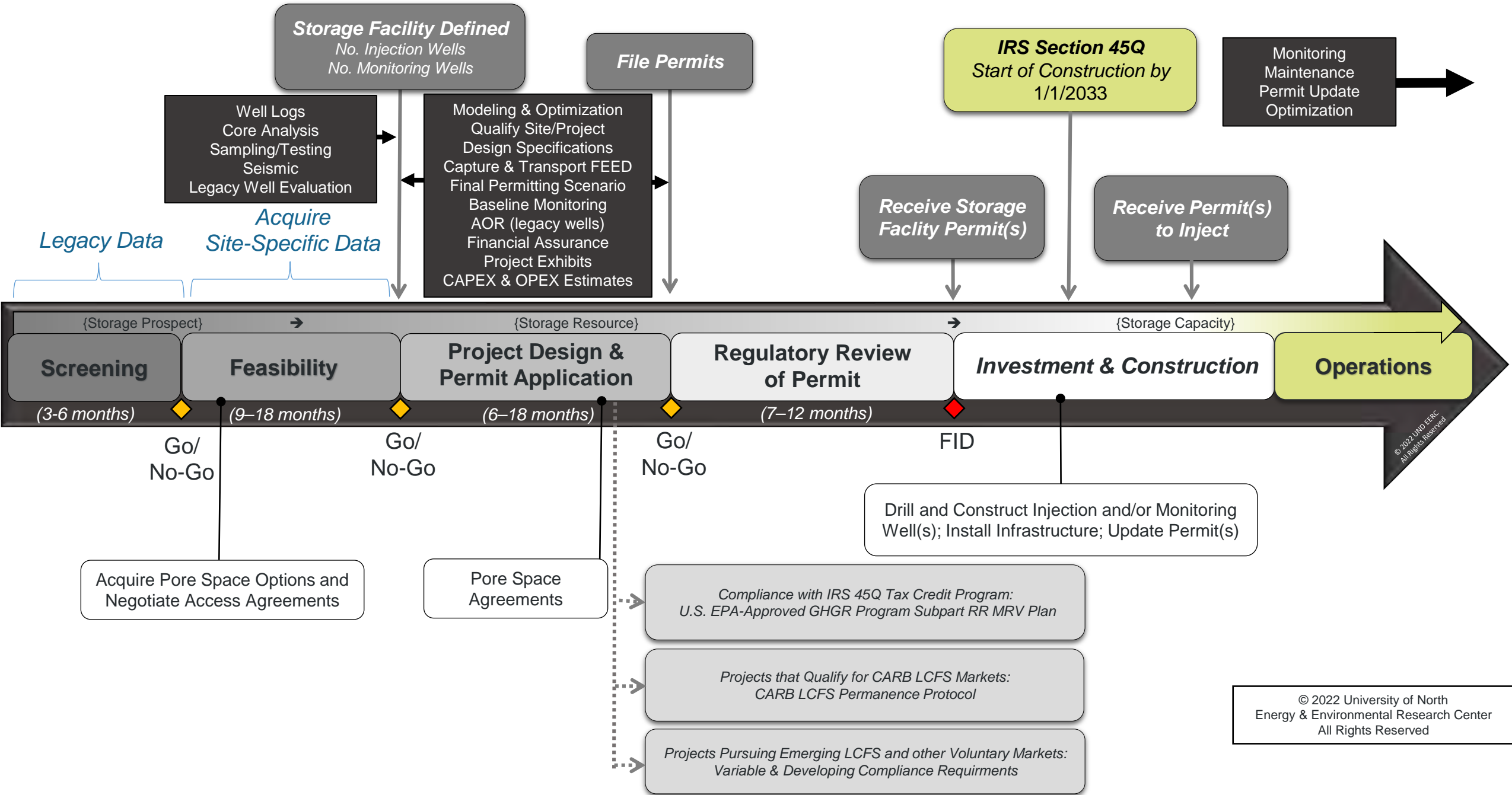


LIBERTY EAST NESSON EOR PILOT SUMMARY

Implications for Bakken Well EUR's:

- The use of water and gas in this Bakken HuffnPuff process increases oil recovery with less gas and lower injection pressures than that required in other HuffnPuff schemes.
- This process of gas and water injection implemented at scale (repeated cycles on multiple wells in a DSU) **could yield 30-50% incremental EUR's**, similar to that reported by EOG in the Eagle Ford.
- Future applications should focus on increased gas and water rates and volumes to demonstrate increases in recovery to clearly economic scale as indicated in process simulations and supported by pilot results.
- While this process used Bakken produced gas, the results have positive implications for use of CO2 in Carbon Capture Utilization & Sequestration (CCUS) applications.

INDICATIVE TIMELINE TO IMPLEMENT CARBON CAPTURE AND GEOLOGIC CO₂ STORAGE IN ND



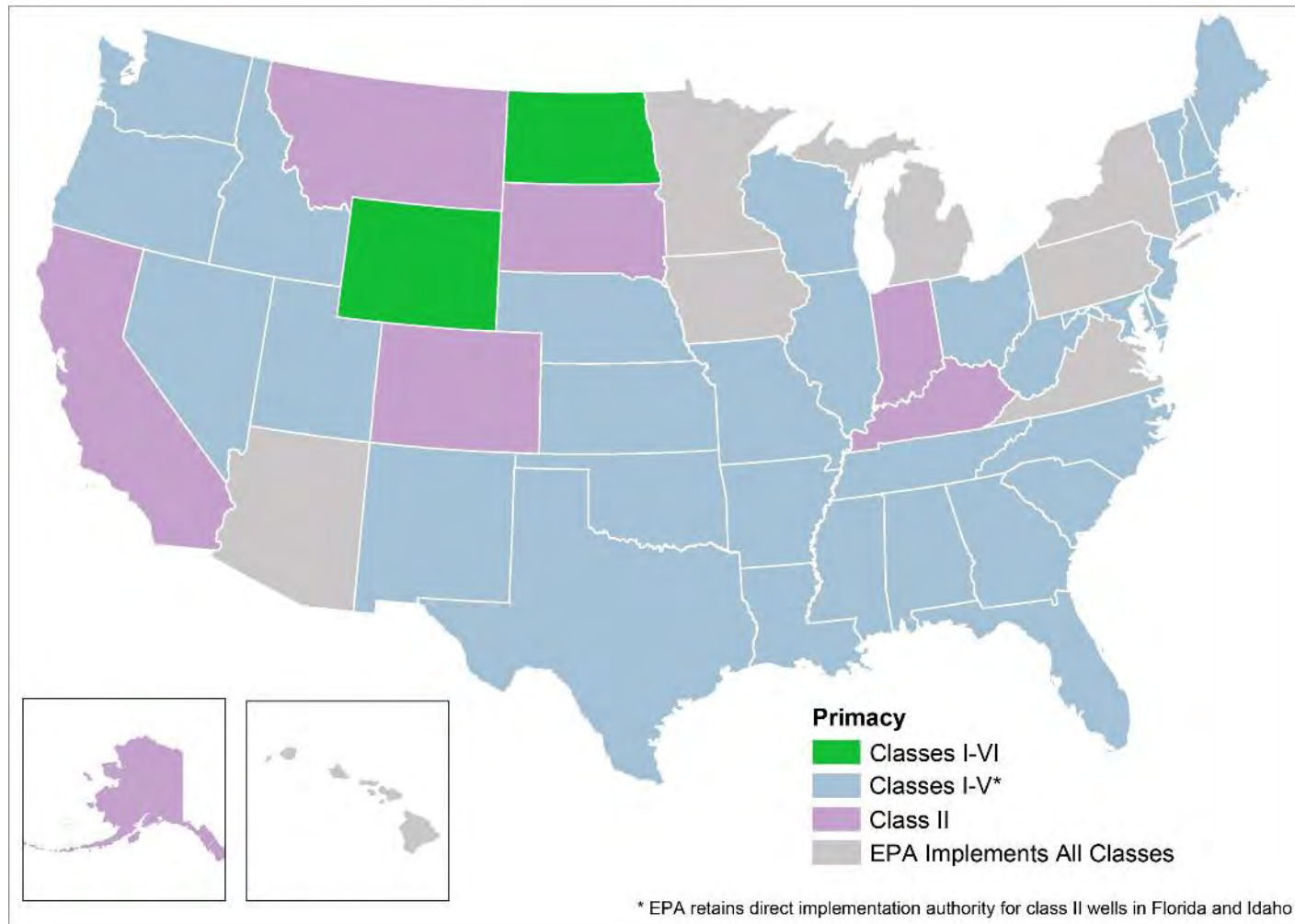
Inflation Reduction Act – 45Q Modifications

	Old	New
Commence Construction	January 1, 2026	January 1, 2033
DAC Facility	100,000 metric tons/year*	1,000 metric tons/year
Electric Generator	500,000 metric tons/year*	18,750 metric tons/year
All other facilities	100/000 metric tons/year*	12,500 metric tons/year
Saline Storage Credit	\$50/metric ton	\$85/metric ton (industry and power); \$180/metric ton (DAC)
EOR and Conversion Credit	\$35/metric ton	\$60/metric ton (industry and power); \$130/metric ton (DAC)

* Non-EOR Conversion facilities were previously 25,000 metric tons/year regardless of facility/source.

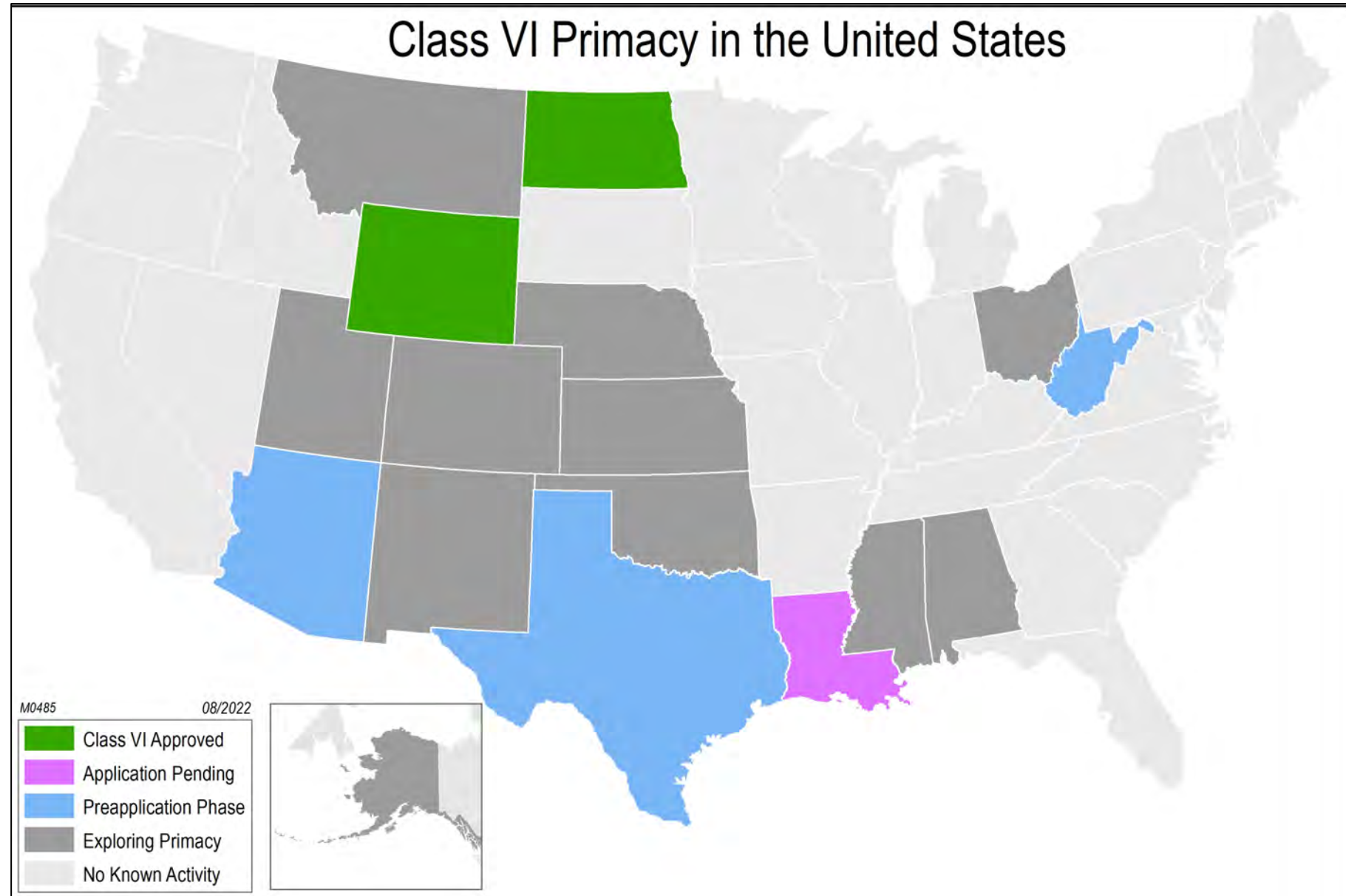
Notes: New Modifications allows up to 5 years for direct pay (up to 12 years certain entities)

Underground Injection Control (UIC) Class VI Primacy



Class I	Class II	Class III	Class IV	Class V	Class VI
Hazardous and nonhazardous fluids (industrial and municipal wastes).	Brines and other fluids associated with oil and gas production, including CO ₂ EOR.	Fluids associated with solution mining of minerals.	Hazardous or radioactive wastes. This class is banned by EPA.	Nonhazardous fluids into or above a USDW and are typically shallow.	Injection of CO ₂ for long-term storage.

CURRENT CLASS VI PRIMACY ACTIVITY

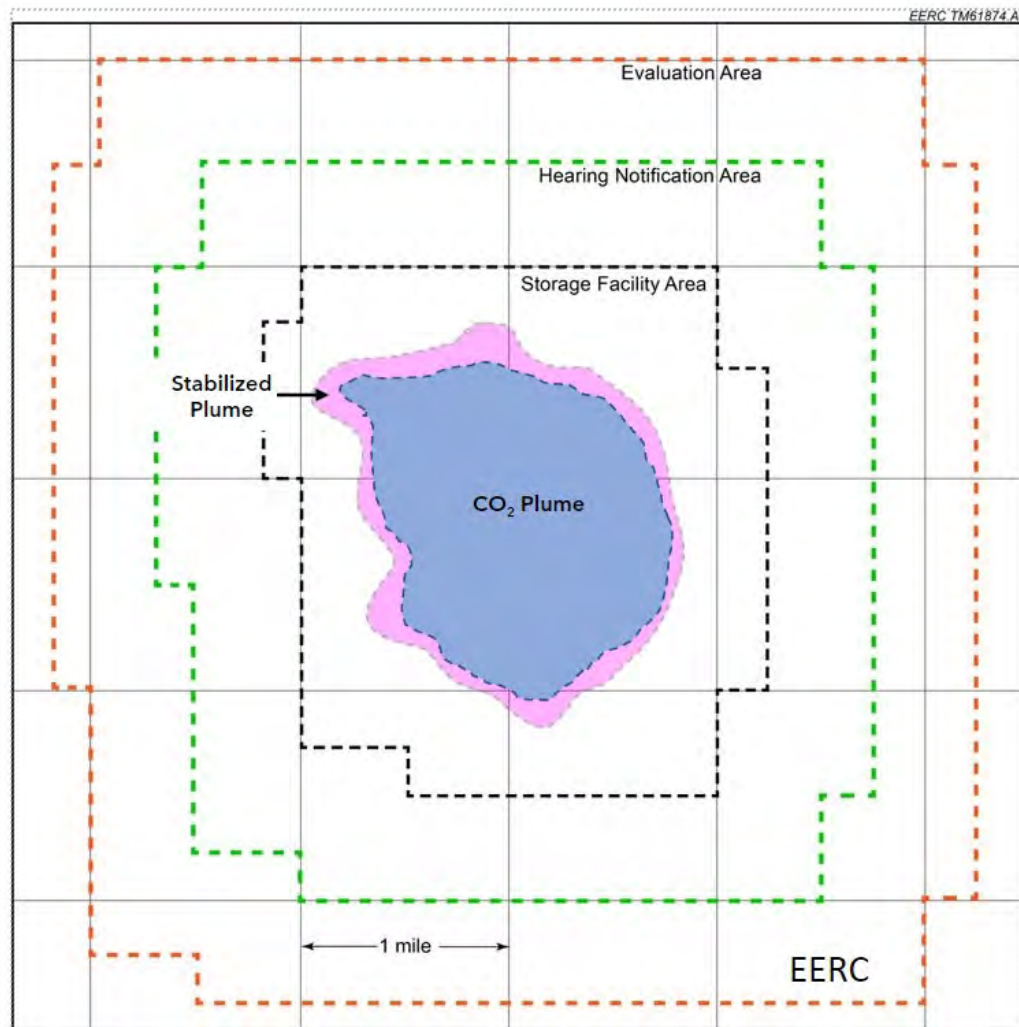


Regulatory Definitions

- **CO₂ Plume** – (NDCC Section 43-05-01.1 subsection 6.) “means the extent underground, in three dimensions, of an injected carbon dioxide stream.”
- **Stabilized Plume** – (NDCC 38-22-17 subsection 5d) “Shows that the carbon dioxide in the storage reservoir has become stable. Stored carbon dioxide is stable if it is essentially stationary or, if it is migrating or may migrate, that any migration will be unlikely to cross the storage reservoir boundary.”
- **Storage Facility Area** – (statutory mandate NDCC 38-22-08 subsection 12) “That the horizontal and vertical boundaries of the storage reservoir are defined. These boundaries must include buffer areas to ensure that the storage facility is operated safely and as contemplated.”
- **Hearing Notification area** – (NDCC 43-05-01-08) ½ mile from the storage facility area boundary.
- **Area of Review** – (NDCC Section 43-05-01-05) At least 1 mile outside of the storage facility area boundary
 - (NDCC 43-05-01-01 subsection 4) “means the region surrounding the geologic sequestration project where underground sources of drinking water may be endangered by the injection activity.”

EXAMPLE OF NORTH DAKOTA STORAGE FACILITY PROJECT BOUNDARIES

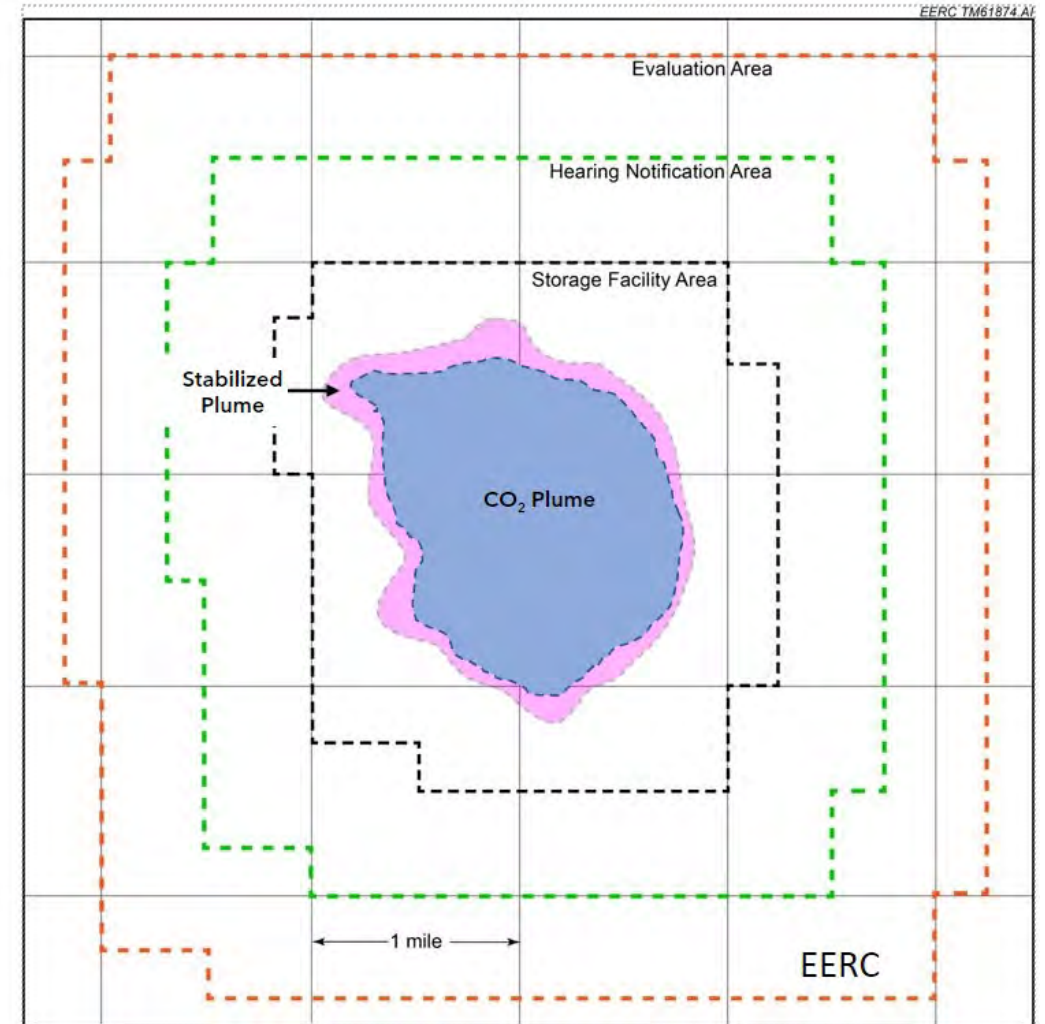
- **CO₂ Plume** – Computational simulation of the predicted CO₂ extent in the subsurface from start of injection to cessation of injection.
- **Stabilized Plume** – Post-injection plume migration and stabilization based on statutory definition (NDCC Section 38-22-17 subsection 5d).
- **Storage Facility Area** – Boundary must include a buffer area (statutory mandate NDCC 38-22-08 subsection 12) determined in consultation with the following:
 - Project developer
 - Project landman
 - Project developer's legal council
 - Technical Team
- **Hearing Notification area** – ½ mile from the storage facility area boundary.
- **Area of Review** – Not shown; calculated using computational simulations.
- **Evaluation Area** – 1-mile from the storage facility area boundary.



STORAGE FACILITY PROJECT BOUNDARIES

North Dakota UIC Class VI

- **CO₂ Plume** – Simulated boundary at end of injection.
- **Stabilized Plume** – Simulated boundary at postinjection stabilization.
- **Storage Facility Area** – Boundary + Buffer
[pore space lease and amalgamation area]
- **Hearing Notification Area** – ½ mile from the storage facility area boundary (mineral estate and surface estate).
- **Area of Review (AOR)** – Not shown; calculated with simulation.
- **Evaluation Area** – 1 mile from the storage facility area boundary (default minimum AOR).



ANCILLARY REGULATORY MECHANISMS FACILITATE INDUSTRIAL CCUS

Carbon dioxide storage facility administrative fund (\$0.01/ton): administer program.

Carbon dioxide storage facility trust fund (\$0.07/ton): post-injection compliance and long term liability.

Amalgamation of pore space (forced @ 60%)

Final decision issued within 12 months of the date a submitted carbon storage facility permit application is deemed complete.

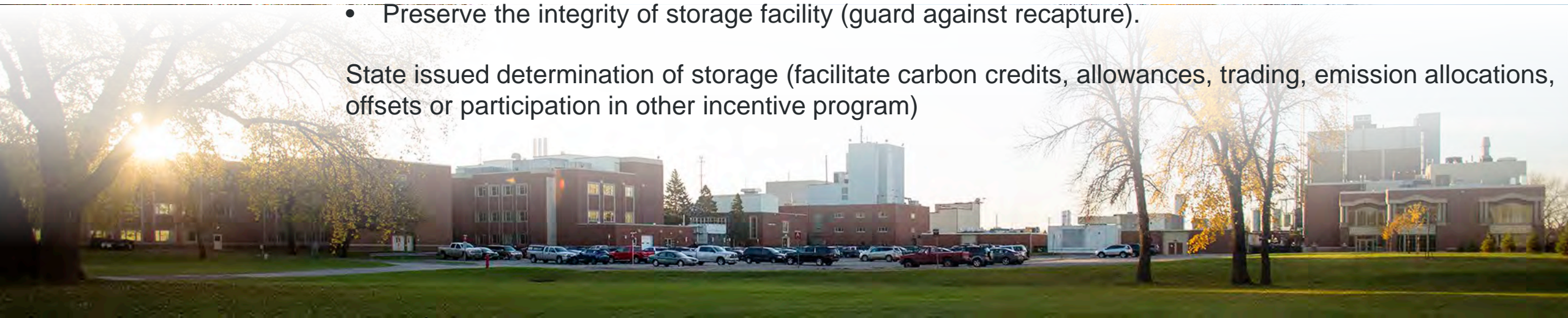
State issues certificate of project completion (all criteria met – at least 10 years postinjection)

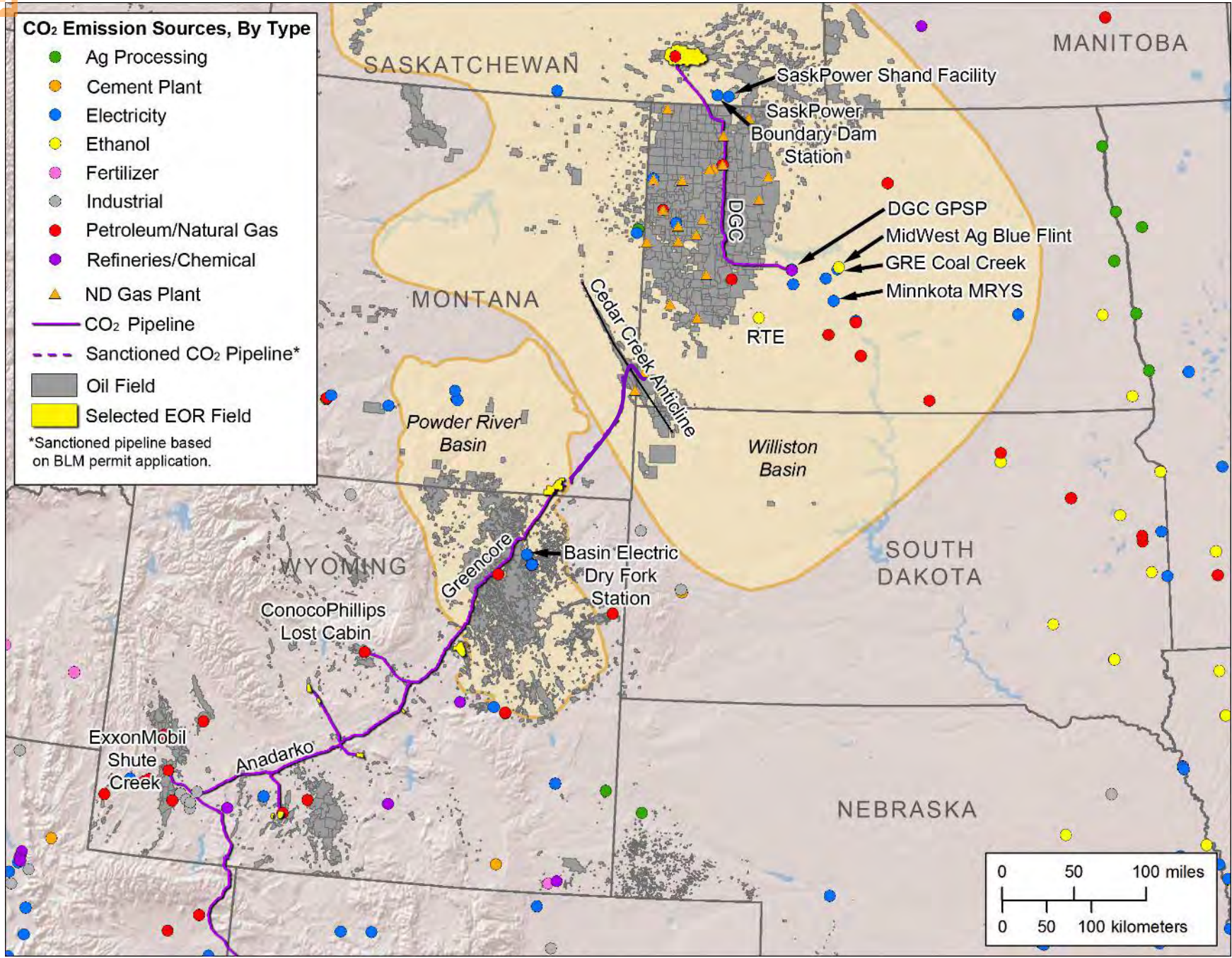
- Releases responsibility, regulatory requirements, and bonds
- Transfer of title and custody to storage facility and stored CO₂ to state
- State oversees/responsible for monitoring and managing the storage facility until such time as federal government assumes responsibility (assures site access/confidence)

State retains all authority to regulate future mineral and UIC activities

- Preserve the integrity of storage facility (guard against recapture).

State issued determination of storage (facilitate carbon credits, allowances, trading, emission allocations, offsets or participation in other incentive program)





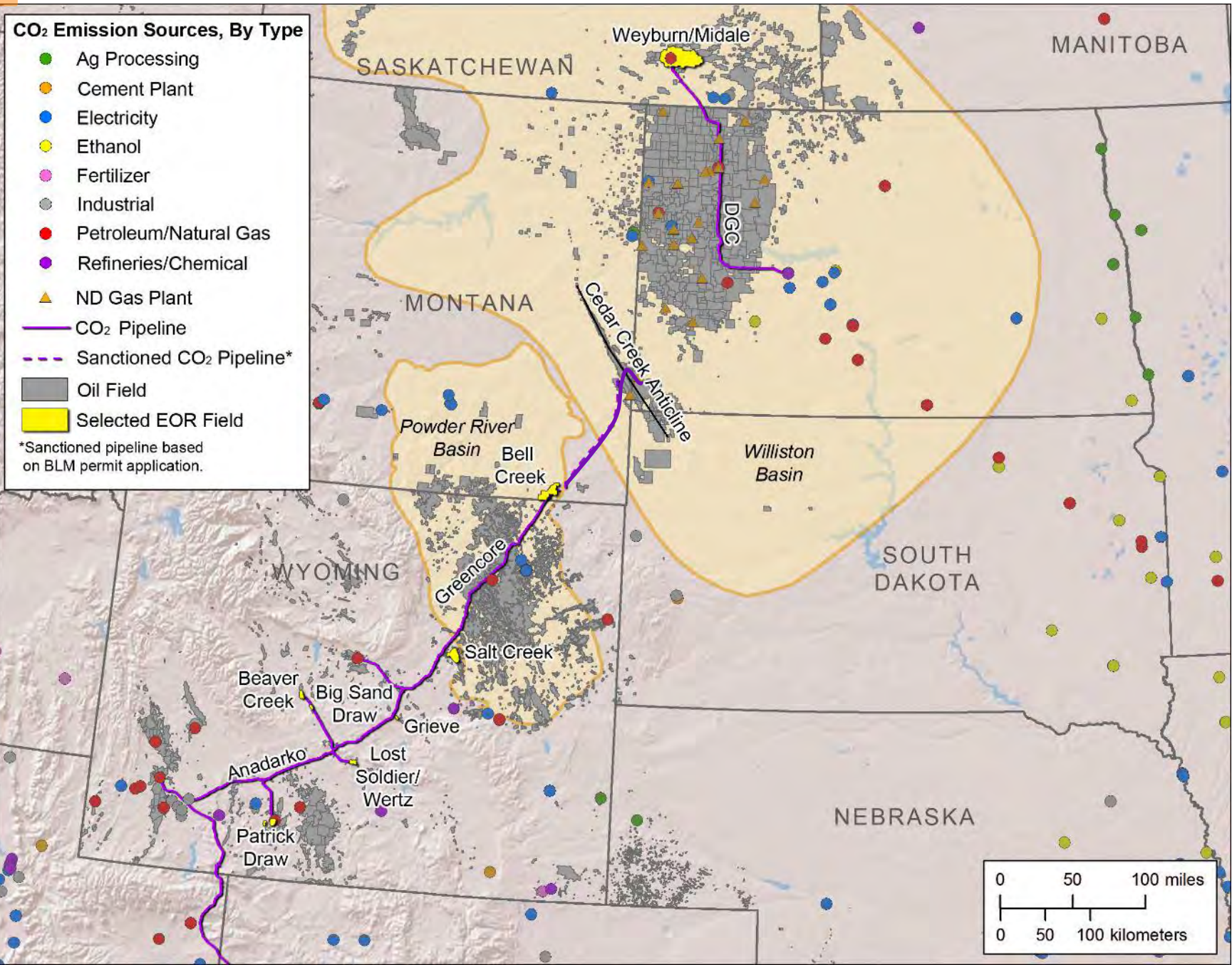
Commercial Industrial CCUS Projects

- Basin Electric Power Cooperative, Dakota Gasification Company Great Plains Synfuels (commercial)
- Basin Electric Power Cooperative Urea Process Liquefaction Plant (commercial)
- SaskPower Boundary Dam Carbon Capture Project (commercial)
- Exxon Mobil Shute Creek Natural Gas Processing (commercial)
- ConocoPhillips Lost Cabin Natural Gas Processing (commercial)
- Shell Quest CCS Facility* (commercial) – Alberta, Canada
- RTE Ethanol (commercial)
- Minnkota Tundra (feasibility – announced)
- Midwest Ag/Blue Flint (feasibility - announced)
- Rainbow - Coal Creek Station (feasibility - announced)
- SaskPower Shand (feasibility - announced)



CO₂ Emission Sources, By Type

- Ag Processing
 - Cement Plant
 - Electricity
 - Ethanol
 - Fertilizer
 - Industrial
 - Petroleum/Natural Gas
 - Refineries/Chemical
 - ▲ ND Gas Plant
 - CO₂ Pipeline
 - - - Sanctioned CO₂ Pipeline*
 - Oil Field
 - Selected EOR Field
- *Sanctioned pipeline based on BLM permit application.



CO₂ Transportation Network

DGC line (commercial)

- 205-mile 14" → 12"

Greencore Pipeline (commercial)

- 232-mile long 20"
- (725 MMscf/day)
- Anadarko CO₂ pipeline interconnect

Greencore Pipeline Expansion

- 105-mile expansion to Baker, MT 16"
- 17-mile lateral extension to Bowman County, ND 12"

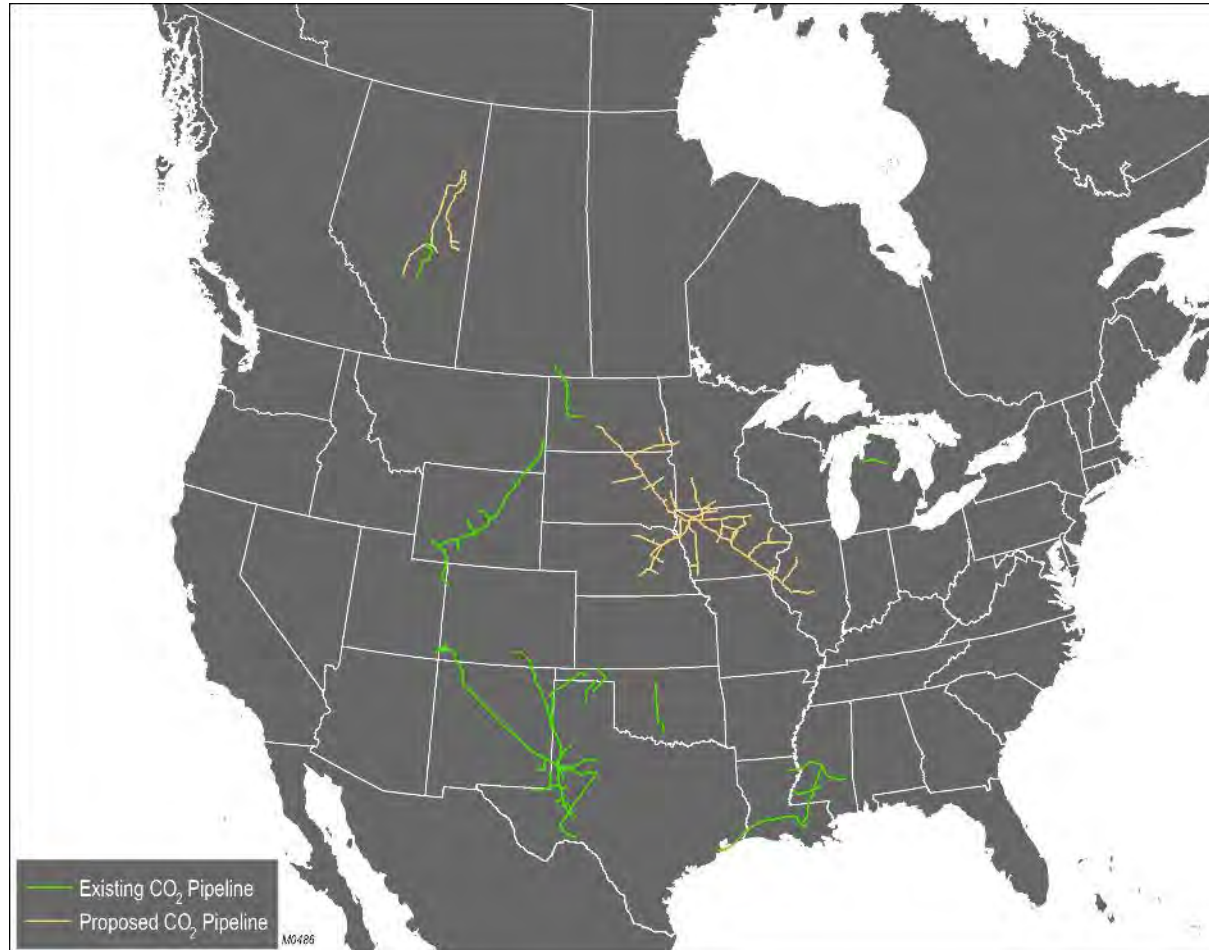
Summit Carbon Solutions (announced)

- ~2000-miles 4" to 24" (variable)

DGC Food-Grade Truck Facility (commercial)

CO₂ Transportation - Pipelines

- CO₂ pipelines have been operating safely in the United States for decades. Today, there are over 5,000 miles of pipelines delivering CO₂.



CO₂ Pipeline Safety Regulations

- Congress in the *Pipeline Safety Reauthorization Act of 1988* required the U.S. Department of Transportation to regulate CO₂ pipelines under federal pipeline safety regulations.
- The U.S. Department of Pipeline and Hazardous Materials Safety Administration (PHMSA) in 1989 expanded its federal pipeline safety regulations to cover CO₂ pipelines.
- Current PHMSA regulations at 49 CFR Part 195 prescribe hundreds of requirements on the construction, inspection, maintenance, monitoring and incident response for CO₂ pipelines.
- PHMSA inspects and enforces compliance on pipeline operators violating federal CO₂ pipeline safety requirements.
- Federal pipeline safety regulations require CO₂ pipeline operators to proactively inspect and perform preventive maintenance on their systems. Pipeline personnel monitor their systems 24/7 to ensure everything is running safely.



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A wide-angle photograph of a university campus at sunset. The sun is low on the horizon, casting a warm glow over the scene. In the foreground, there are large trees with yellowing leaves. In the background, there are several large, multi-story brick buildings and a parking lot filled with cars.

THANK YOU

Critical Challenges. Practical Solutions.