Critical Challenges. Practical Solutions.

Energy & Environmental Research Center (EERC)

Minnesota Senate Energy Committee

February 6, 2023

Charles Gorecki
CEO

OUR FACILITIES

254,000 SQ. FT. OF FACILITIES

OUR VISION

TO LEAD THE WORLD IN
DEVELOPING SOLUTIONS
TO ENERGY AND ENVIRONMENTAL
CHALLENGES.

CO_2 CAN BE MANAGED


Image Credit – EERC


Image Credit – EERC

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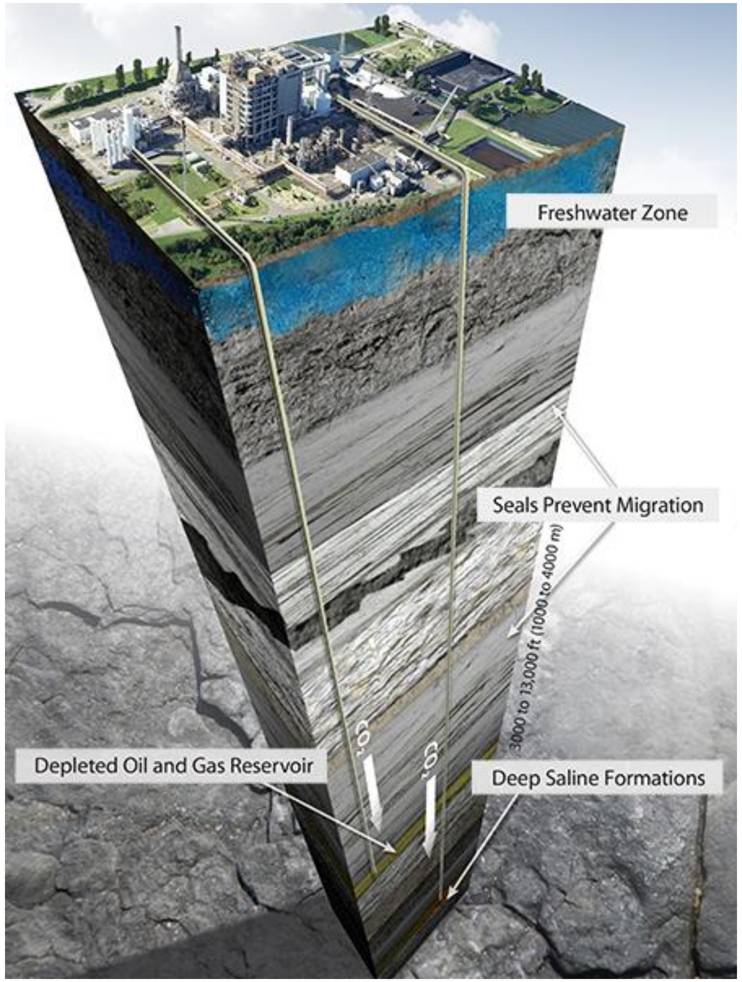
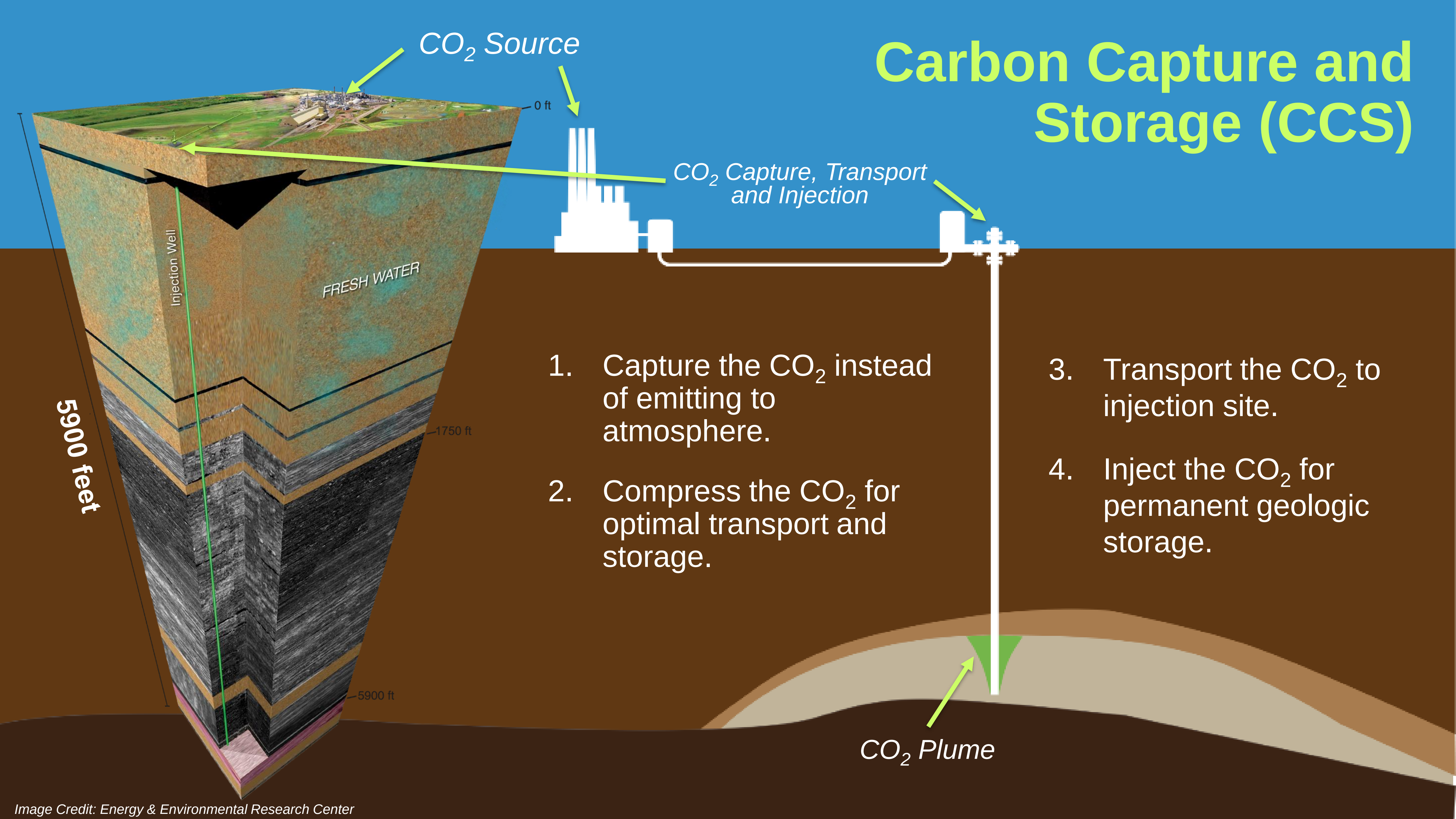
Image Credit – NACCO Industries


Image Credit – EERC





Carbon Capture and Storage (CCS)
CO2 Source
0 ft
CO2 Capture, Transport and Injection
Injection Well
FRESH WATER
1750 ft
5900 feet
5900 ft
1. Capture the CO2 instead of emitting to atmosphere.
2. Compress the CO2 for optimal transport and storage.
3. Transport the CO2 to injection site.
4. Inject the CO2 for permanent geologic storage.
CO2 Plume
Image Credit: Energy & Environmental Research Center

CCUS Complements Renewables/Efficiency/etc.

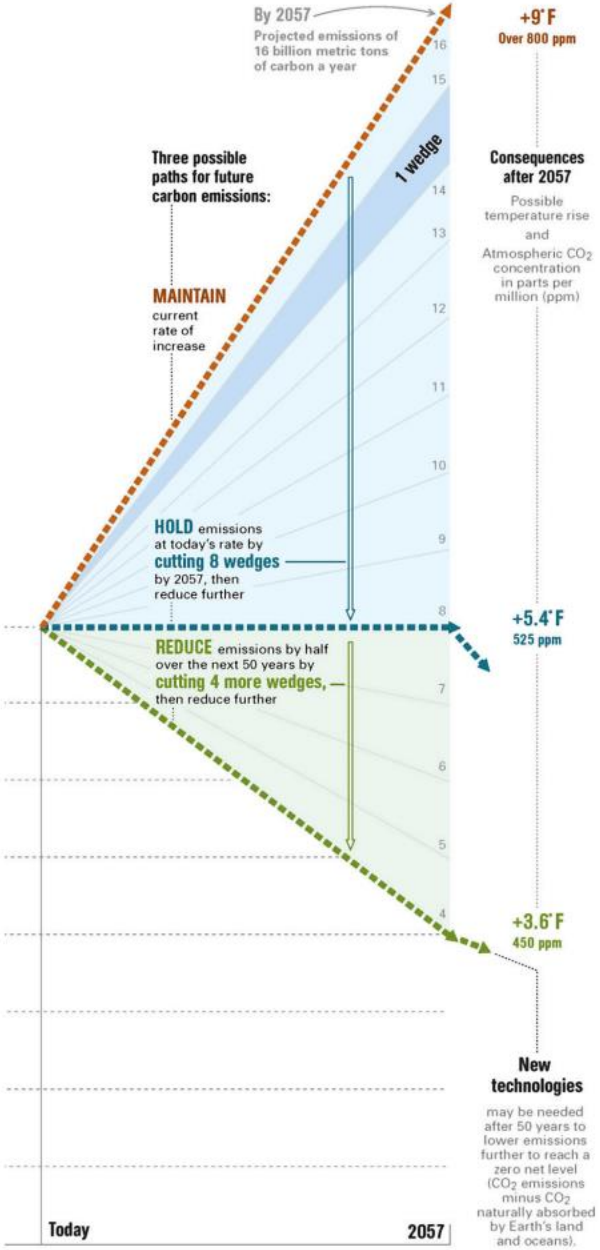
> "Without CCUS as part of the solution, meeting global climate goals will be practically impossible."

Dr. Fatih Birol
Executive Director, International Energy Agency

CCUS Complements Renewables/Efficiency/etc.

> "Carbon capture isn't a moon-shot solution, nor is it a silver bullet for decarbonization. It's a roll-up-your-sleeves solution to guiding our energy economy to a cleaner future."

Dr. Sally Benson
Former Deputy Director of Operations and Director of the Earth Sciences Division,
Lawrence Berkeley National Laboratory; Coordinating lead author, IPCC special report on CCS



ONE WEDGE AT A TIME

Each strategy listed below would, by 2057, reduce annual carbon emissions by a billion metric tons.

EFFICIENCY AND CONSERVATION

- Improve fuel economy of the two billion cars expected on the road by 2057 to 60 mpg from 30 mpg.
- Reduce miles traveled annually per car from 10,000 to 5,000.
- Increase efficiency in heating, cooling, lighting, and appliances by 25 percent.
- Improve coal-fired power plant efficiency to 60 percent from 40 percent.

CARBON CAPTURE AND STORAGE

- Introduce systems to capture CO_2 and store it underground at 800 large coal-fired plants or 1,600 natural-gas-fired plants.
- Use capture systems at coal-derived hydrogen plants producing fuel for a billion cars.
- Use capture systems in coal-derived synthetic fuel plants producing 30 million barrels a day.

LOW-CARBON FUELS

- Replace 1,400 large coal-fired power plants with natural-gas-fired plants.
- Displace coal by increasing production of nuclear power to three times today's capacity.

RENEWABLES AND BIOSTORAGE

- Increase wind-generated power to 25 times current capacity.
- Increase solar power to 700 times current capacity.
- Increase wind power to 50 times current capacity to make hydrogen for fuel-cell cars.
- Increase ethanol biofuel production to 50 times current capacity. About one-sixth of the world's cropland would be needed.
- Stop all deforestation.
- Expand conservation tillage to all cropland (normal plowing releases carbon by speeding decomposition of organic matter).

SOURCES: ROBERT H. SOCOLOW AND STEPHEN W. PACALA, PRINCETON UNIVERSITY (UPDATED REPORT); OAK RIDGE NATIONAL LABORATORY (GLOBAL CARBON EMISSIONS DATA). ICONS BY JONATHAN AVERY. GRAPHIC BY JUAN VELASCO, NGM ART

CRITICAL SUBSURFACE CHARACTERISTICS

- Depth
- Porosity/permeability
- Good cap rock
- Appropriate salinity
- No natural leakage pathways

Depth

- Below approximately 2600 ft, CO_2 becomes a supercritical fluid.
- CO_2 will behave like a liquid.
- High density of the CO_2 allows for more storage in a given volume.

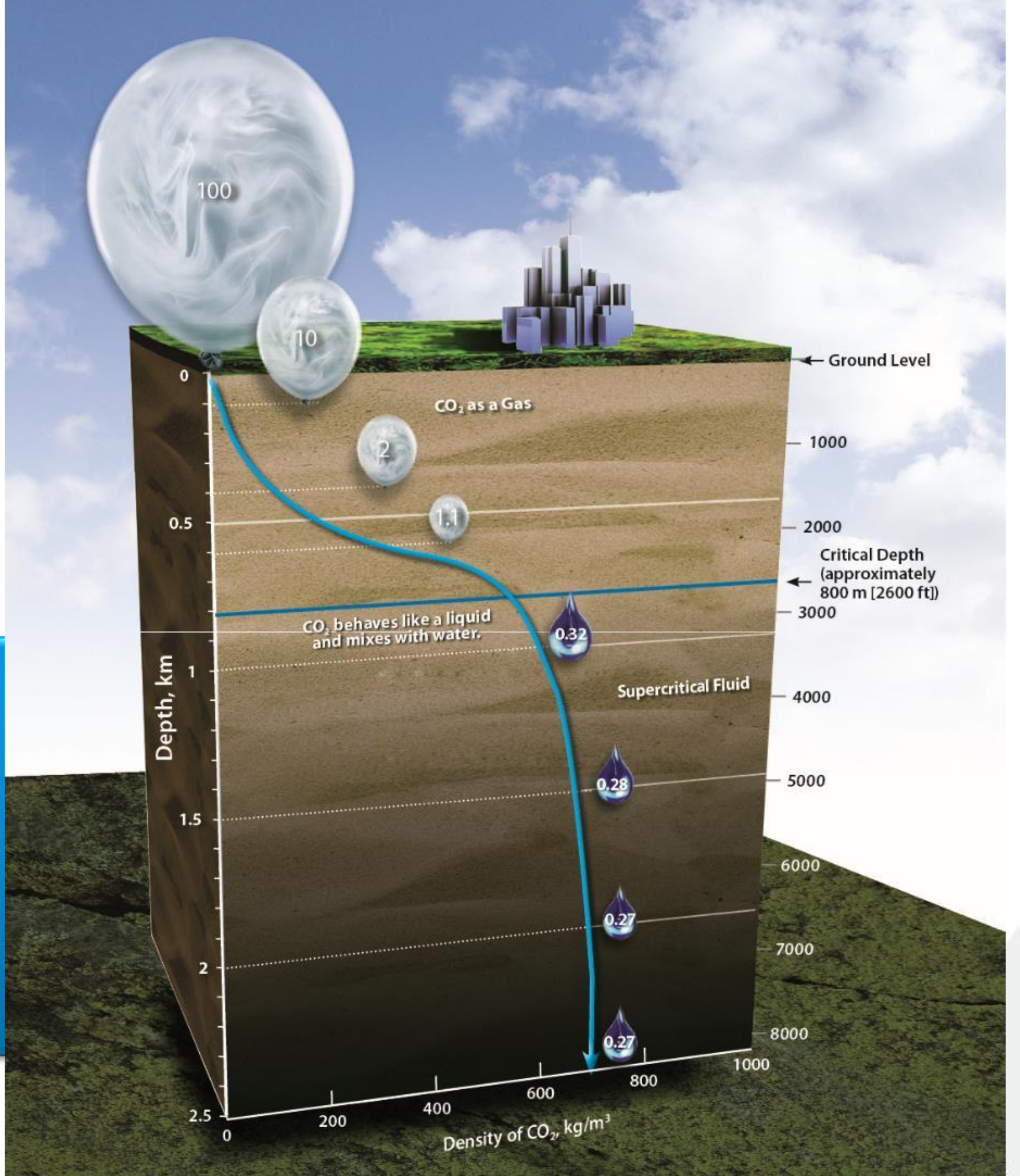


Image credit: EERC

PCOR PARTNERSHIP

2003–2005 – PCOR Partnership: Characterization

2005–2008 – PCOR Partnership: Field Validation

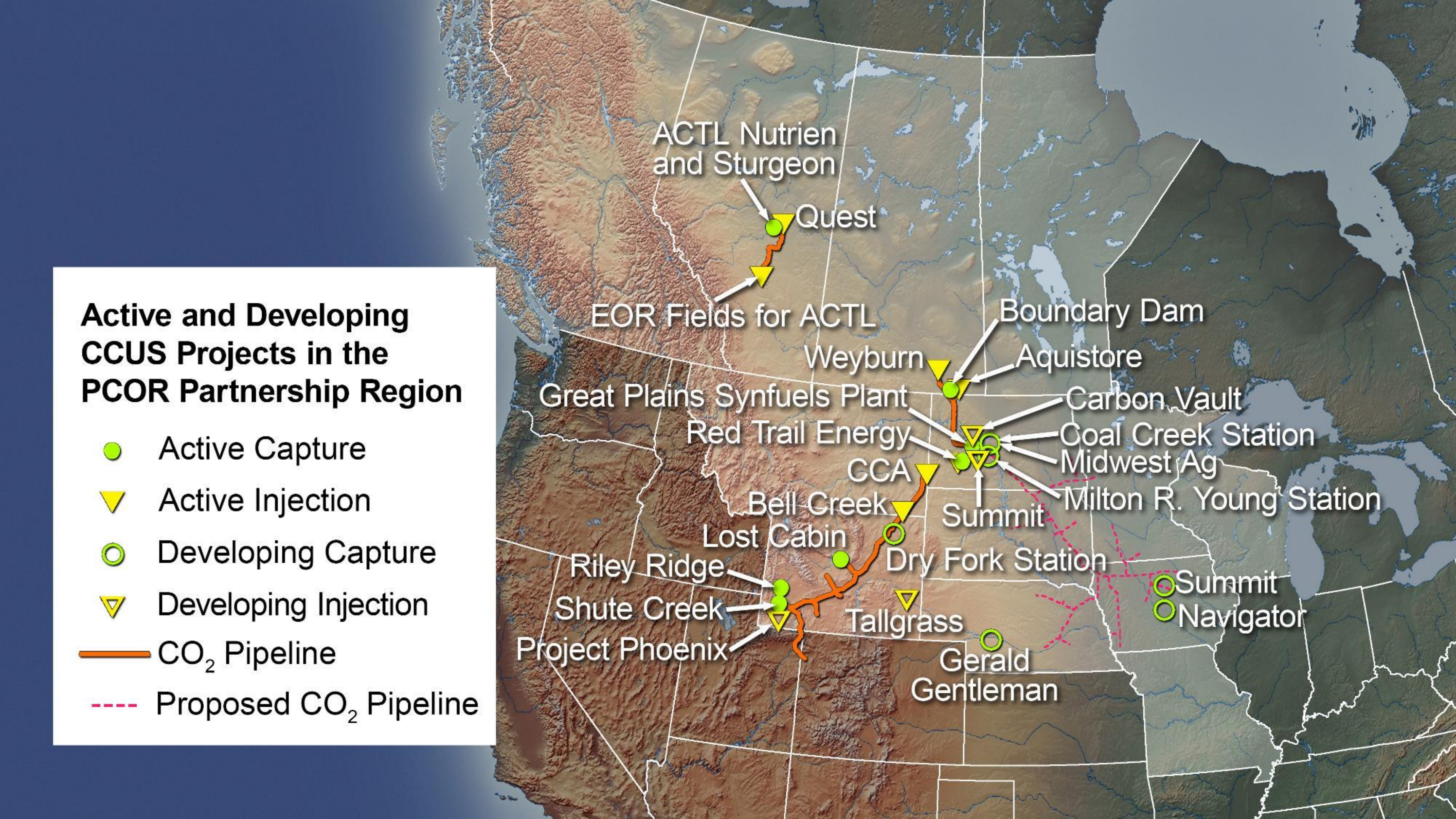
2007–2019 – PCOR Partnership: Commercial Demonstration

2019–2024 – **PCOR Partnership Initiative:** Commercial Deployment

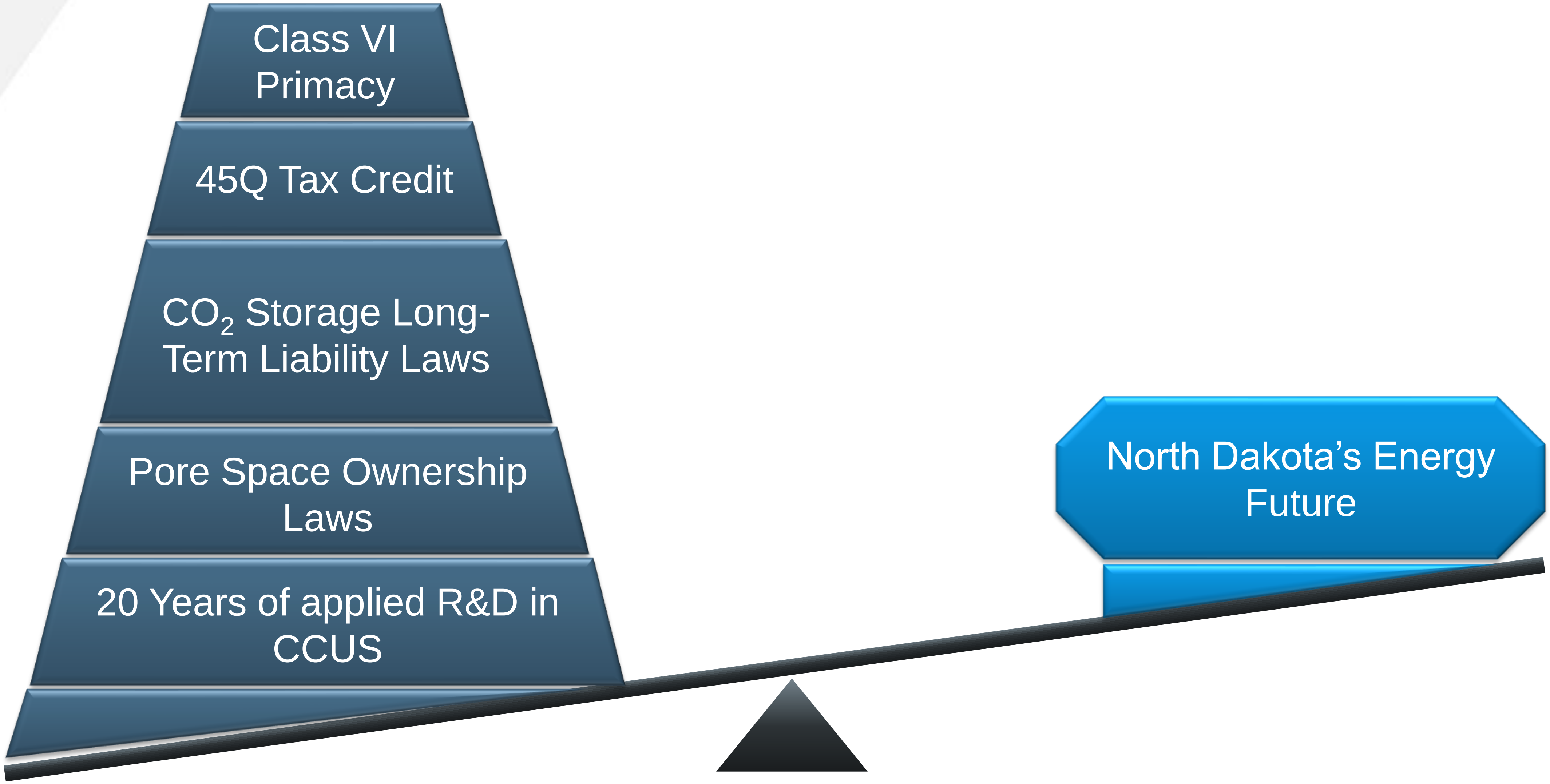
Image credit – EERC

MAJOR STATIONARY SOURCES OF CO_2

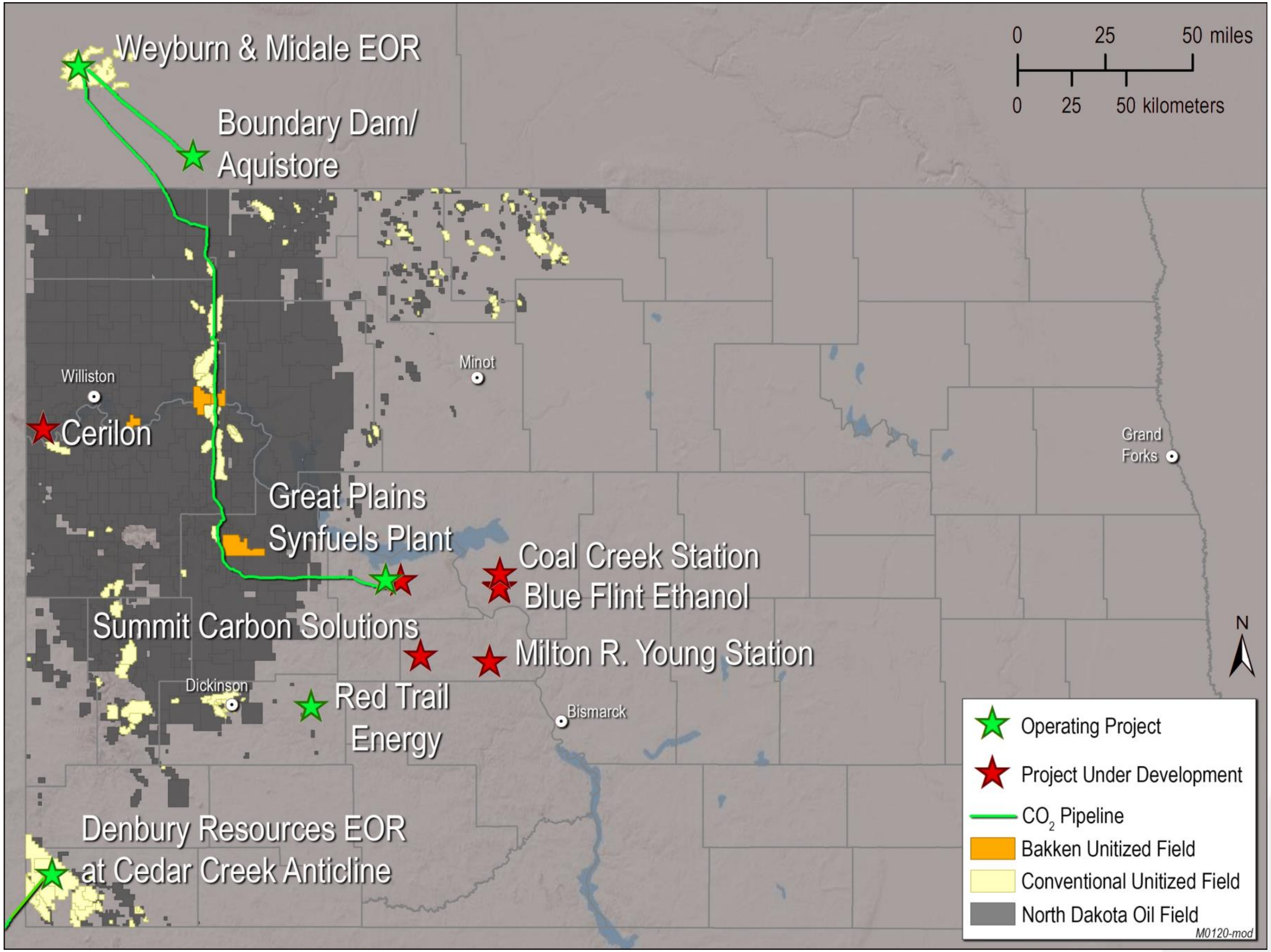
CO_2 SINKS IN NORTH AMERICA


Active and Developing CCUS Projects in the PCOR Partnership Region
Active Capture
Active Injection
Developing Capture
Developing Injection
CO_2 Pipeline
Proposed CO_2 Pipeline
ACTL Nutrien and Sturgeon
Quest
EOR Fields for ACTL
Boundary Dam
Weyburn
Aquistore
Great Plains Synfuels Plant
Carbon Vault
Red Trail Energy
Coal Creek Station
Midwest Ag
CCA
Milton R. Young Station
Bell Creek
Summit
Lost Cabin
Dry Fork Station
Riley Ridge
Summit
Navigator
Shute Creek
Tallgrass
Project Phoenix
Gerald Gentleman

North Dakota’s Leverage



NORTH DAKOTA CCUS ACTIVITY



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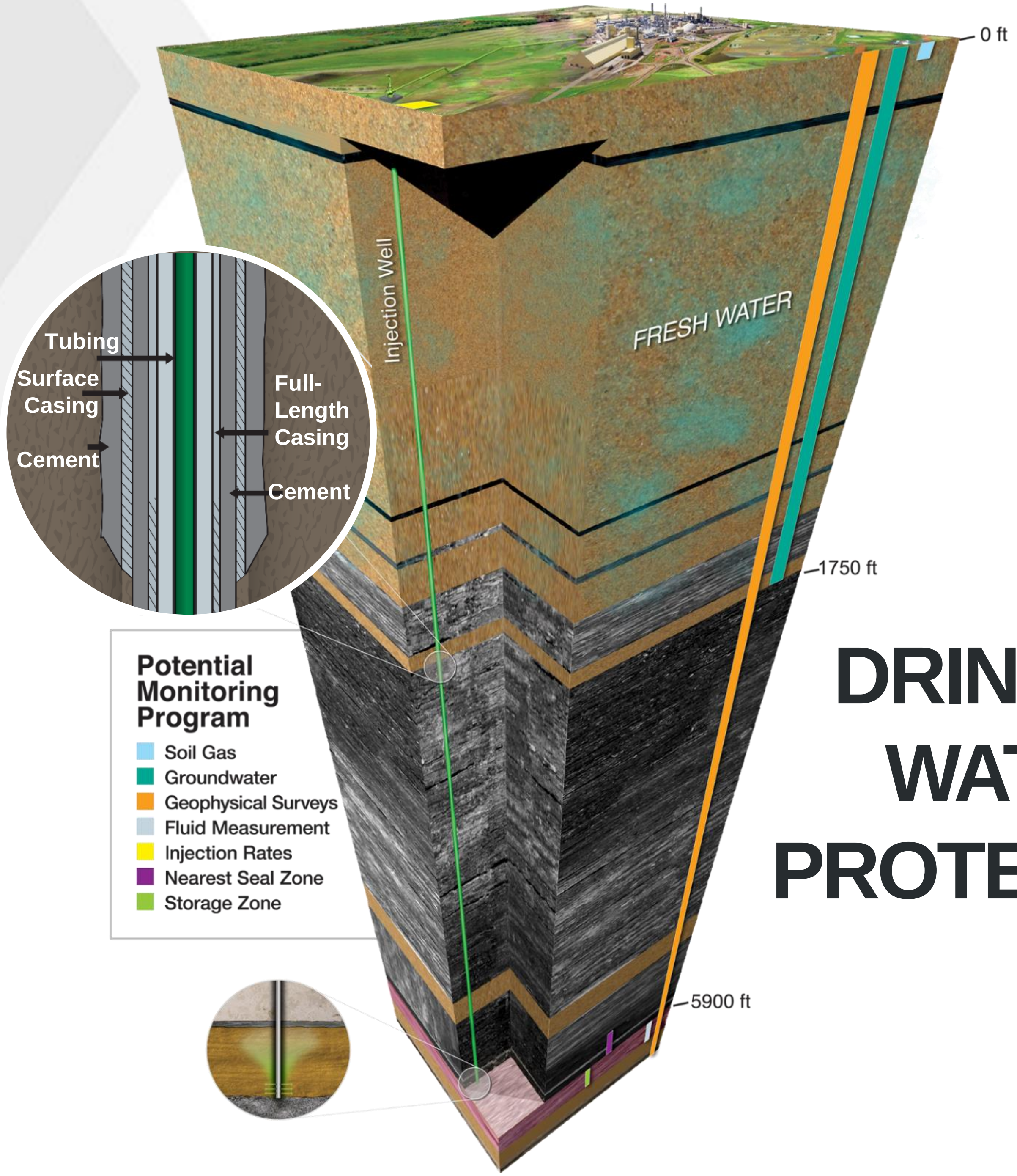
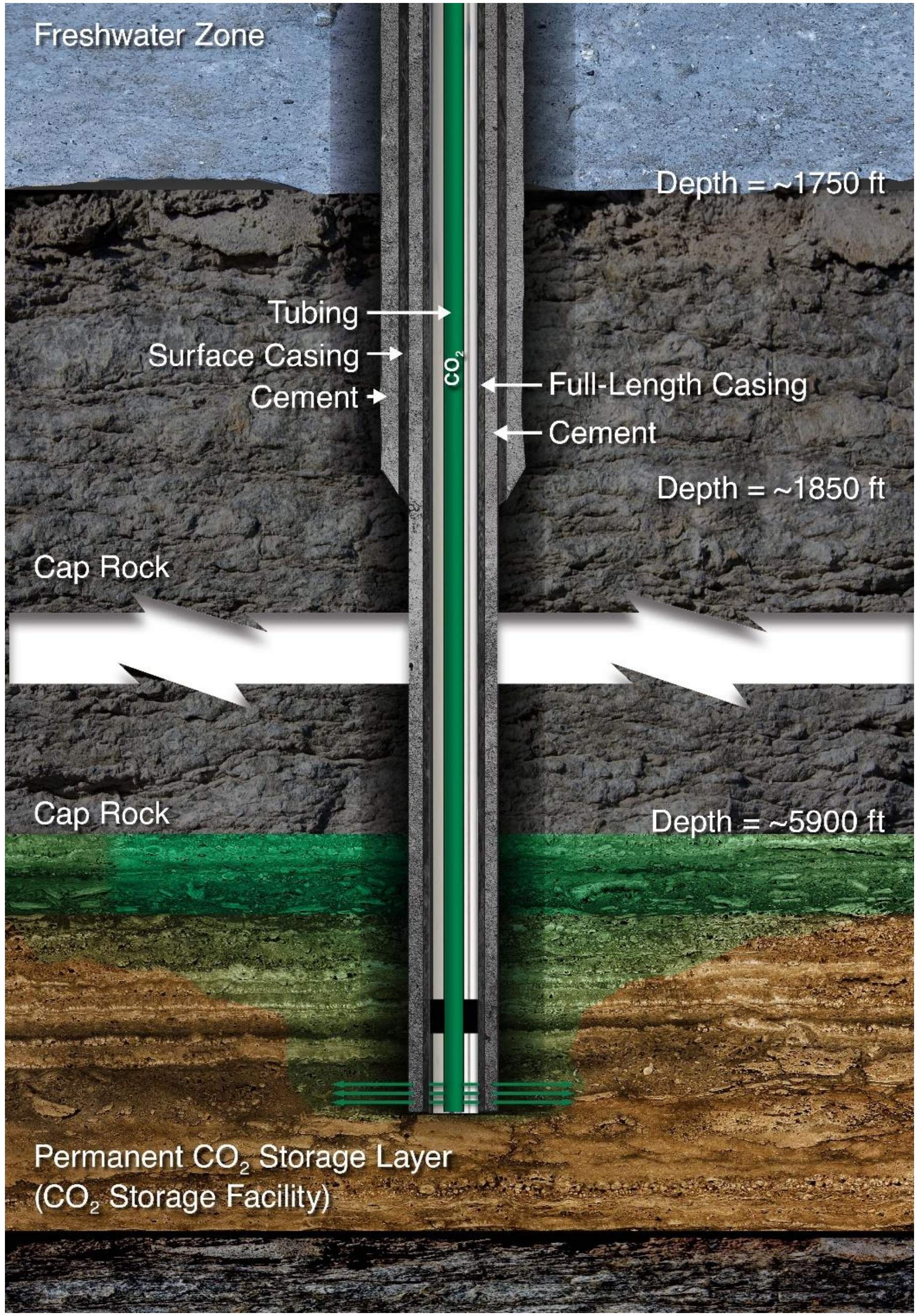
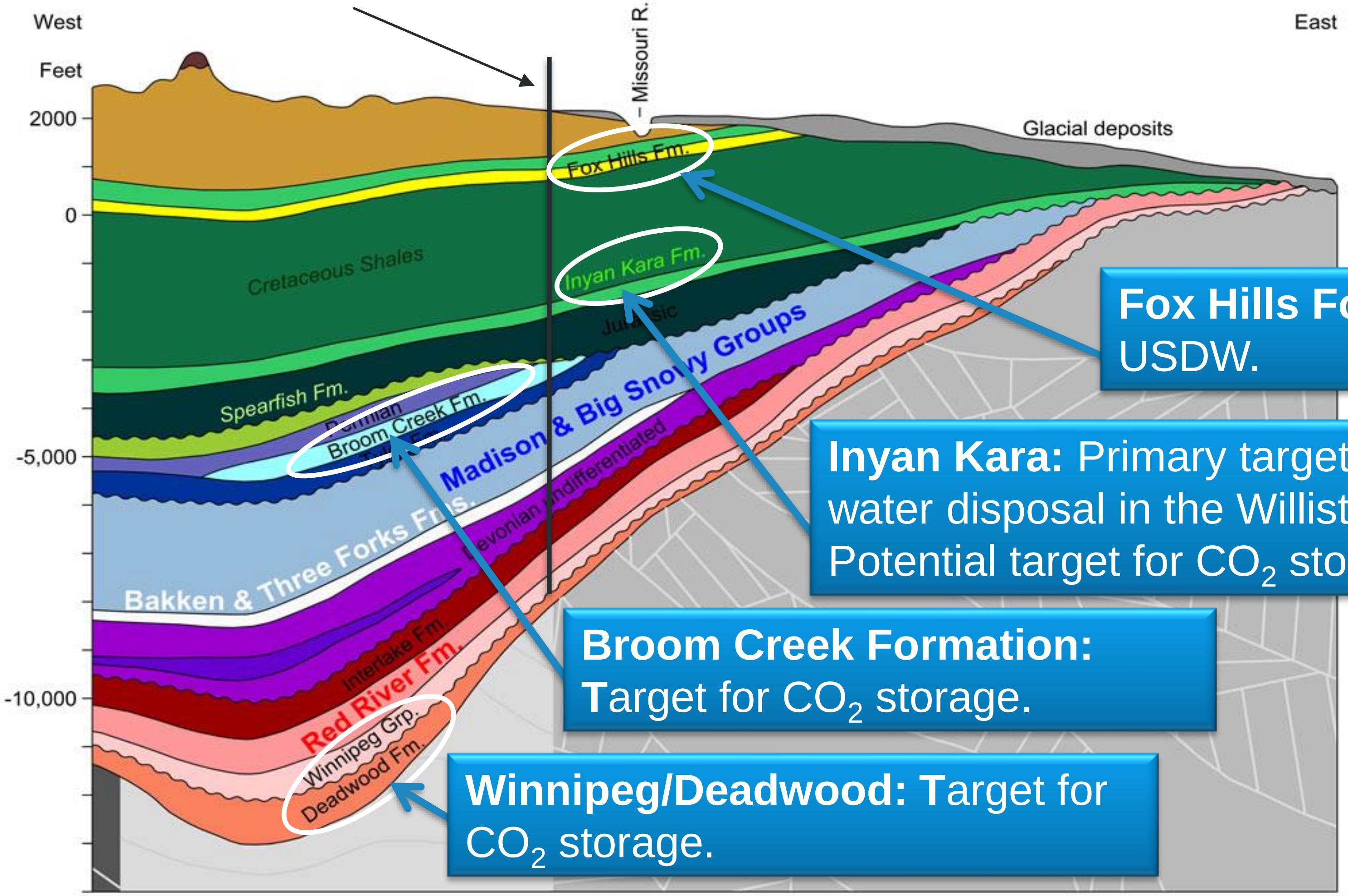


DRINKING WATER PROTECTION



WILLISTON BASIN SALINE STORAGE OPPORTUNITIES



Fox Hills Formation: Lowest USDW.

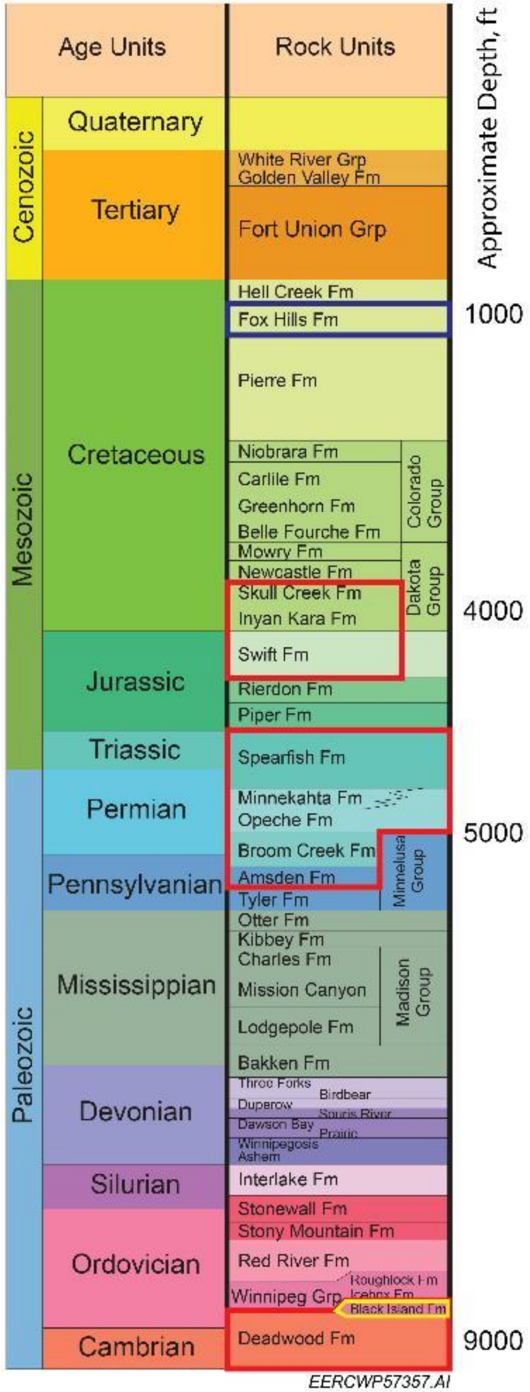
Inyan Kara: Primary target for produced water disposal in the Williston Basin. Potential target for CO_2 storage.

Broom Creek Formation: Target for CO_2 storage.

Winnipeg/Deadwood: Target for CO_2 storage.

WILLISTON BASIN GEOLOGY OFFERS MULTIPLE OPTIONS FOR CCS & CCUS

North Dakota Stratigraphic Column



Inyan Kara Fm – Saline Storage

Image Credit: Energy & Environmental Research Center

Broom Creek Fm – Saline Storage

Madison conventional reservoirs – EOR

Bakken & Three Forks unconventional reservoirs– EOR

Duperow conventional reservoirs – EOR

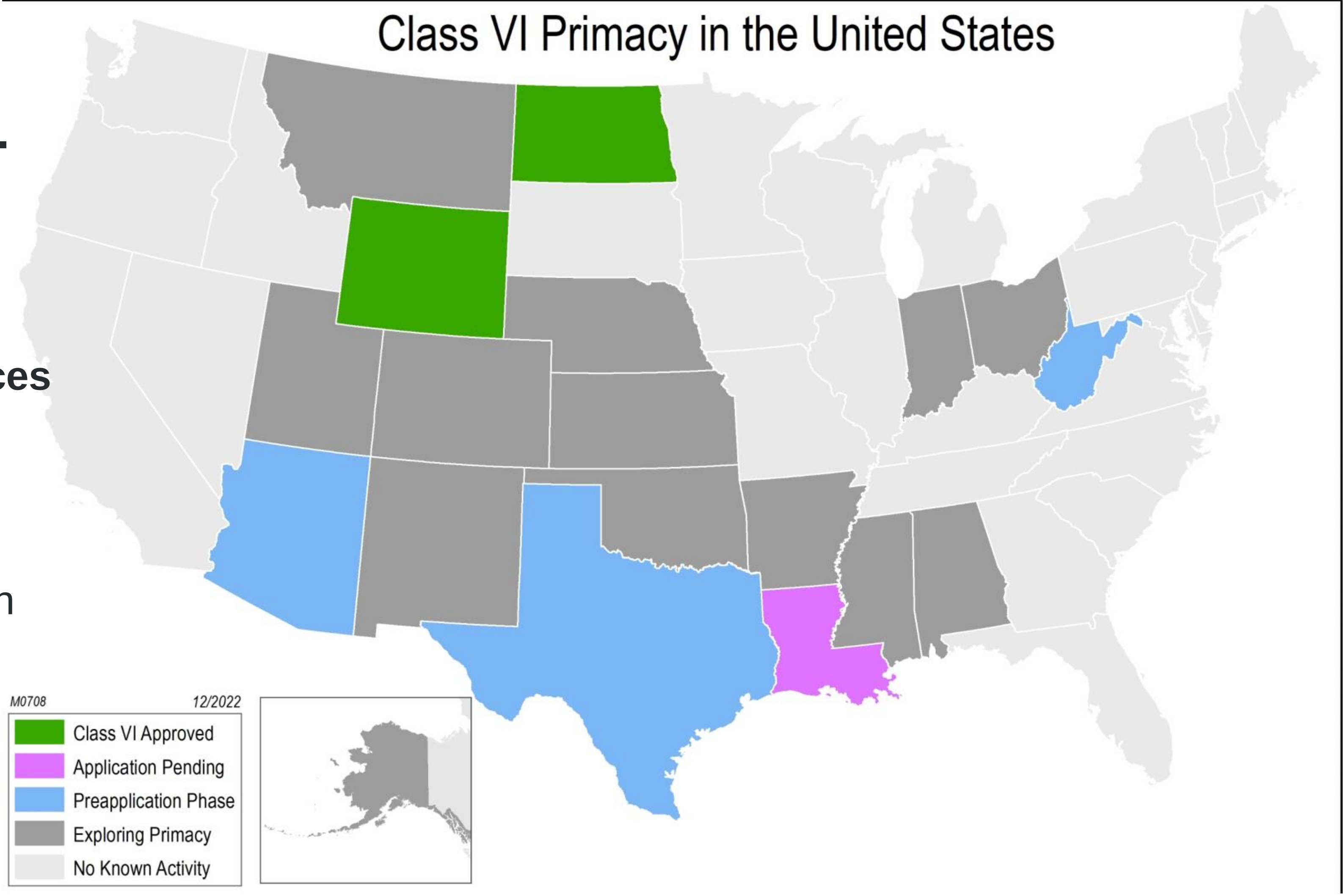
Red River conventional reservoirs – EOR

Deadwood Fm – Saline Storage

UNDERGROUND INJECTION CONTROL (UIC) Program

UIC Program Standards:

1) **Protection of underground sources of drinking water (USDW)**
2) Injection zone
3) Confining zones (upper and lower)
4) Area of review and corrective action
5) Wellbore integrity demonstration



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.