Critical Challenges. Practical Solutions.

Energy & Environmental Research Center (EERC)

CARBON CAPTURE, UTILIZATION, AND SEQUESTRATION: OVERVIEW OF NORTH DAKOTA CCUS

John “Jocko” Evans Symposium

Butte, Montana

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CRITICAL CHALLENGES.
PRACTICAL SOLUTIONS.

The EERC is a leader in developing new technologies and practical solutions to critical energy challenges.

PLAINS CO_2 REDUCTION (PCOR) PARTNERSHIP

Led by the EERC. Funded by:

- U.S. Department of Energy (DOE)
  National Energy Technology Laboratory (NETL)
- North Dakota Industrial Commission (NDIC)
  Oil and Gas Research Program
- NDIC Lignite Research Program
- More than 240 public and private partners

Partnered with:

- University of Wyoming
- University of Alaska Fairbanks

Industrial Commission of North Dakota
Lignite Research, Development and Marketing Program

PCO2R Partnership — PARTNERSHIP MEMBERS

U.S. Department of Energy | National Energy Technology Laboratory

EERC — University of North Dakota

North Dakota Industrial Commission

UAF Institute of Northern Engineering — University of Alaska Fairbanks

University of Wyoming — School of Energy Resources

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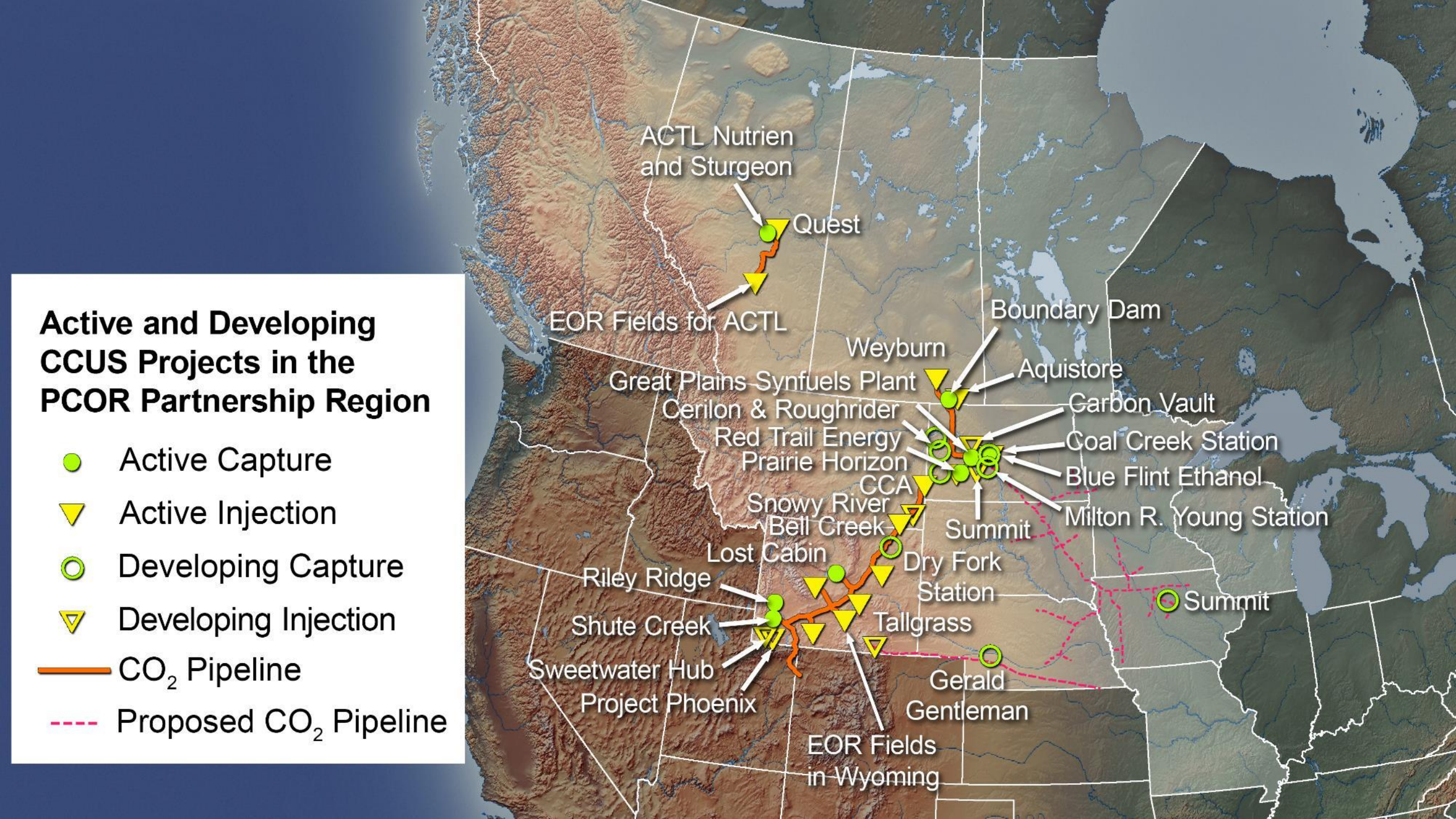
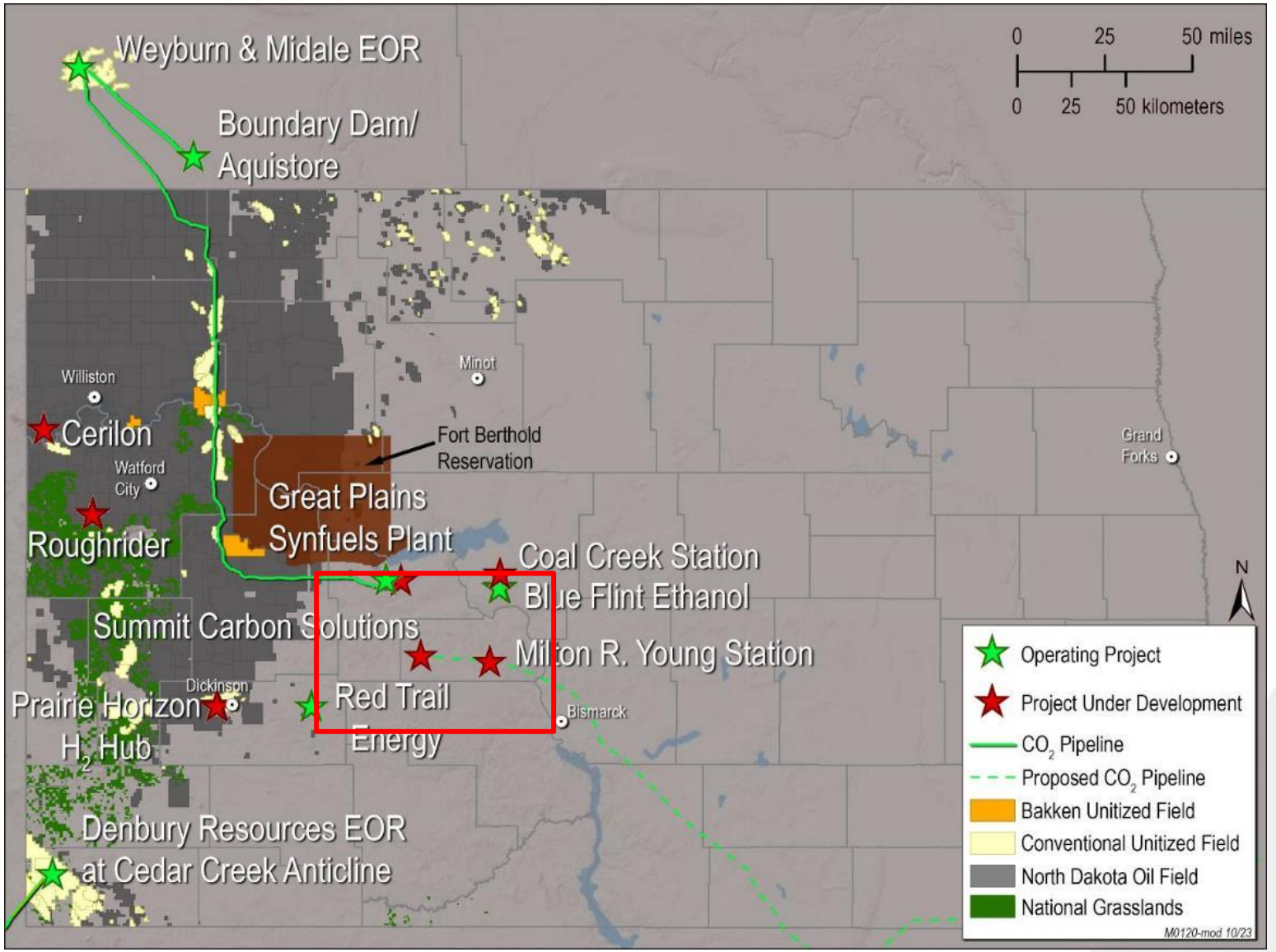

Active and Developing CCUS Projects in the PCOR Partnership Region
Active Capture
Active Injection
Developing Capture
Developing Injection
CO_2 Pipeline
Proposed CO_2 Pipeline
ACTL Nutrien and Sturgeon
Quest
EOR Fields for ACTL
Boundary Dam
Weyburn
Aquistore
Great Plains Synfuels Plant
Cerilon & Roughrider
Carbon Vault
Red Trail Energy
Coal Creek Station
Prairie Horizon
Blue Flint Ethanol
CCA
Snowy River
Milton R. Young Station
Bell Creek
Summit
Lost Cabin
Dry Fork Station
Riley Ridge
Summit
Shute Creek
Tallgrass
Sweetwater Hub
Project Phoenix
Gerald Gentleman
EOR Fields in Wyoming

NORTH DAKOTA PROJECTS

- EERC has been involved in multiple CCUS projects.
  - Two Class VI projects are actively injecting.
  - Storage facility permits (SFPs):
    - Six approved SFPs
    - Three SFPs under review
  - 11 stratigraphic test wells
    - Over 8000 ft of core



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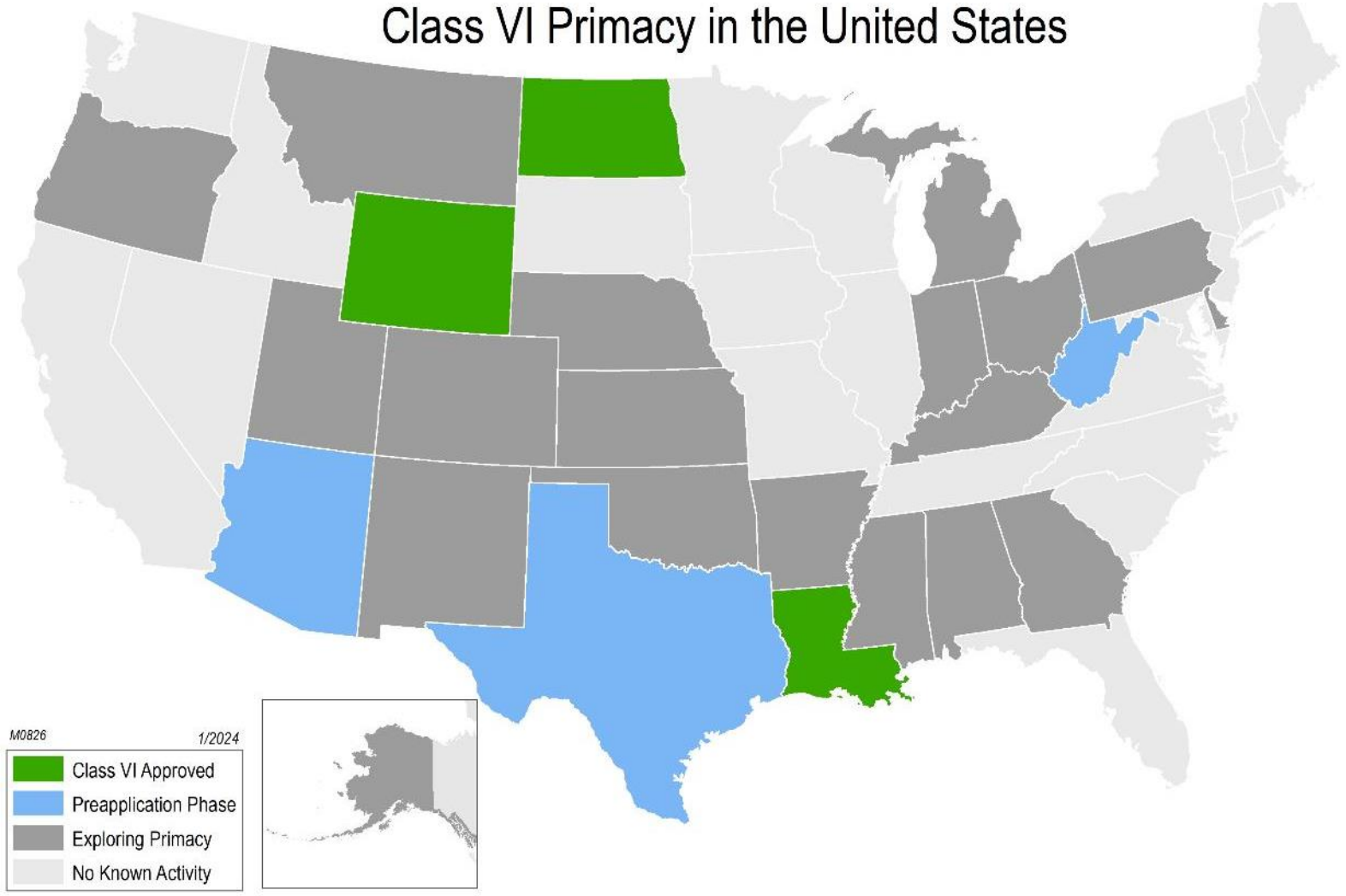
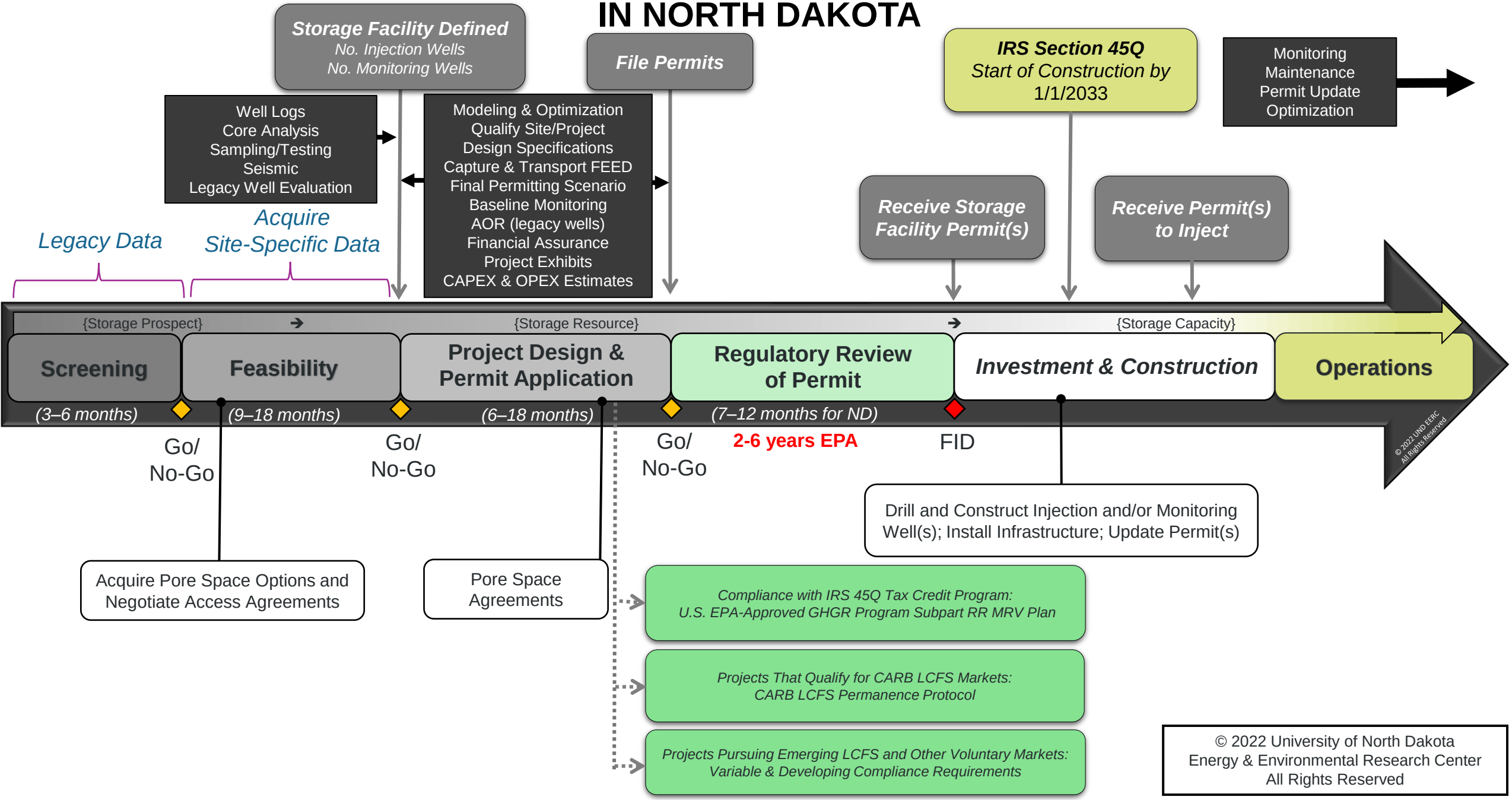
U.S. REGULATORY AUTHORITY

- U.S. Environmental Protection Agency (EPA)
  - 2010: Class VI Rule – geologic sequestration wells
- U.S. states awarded primary regulatory authority:
  - 2018 – North Dakota
  - 2020 – Wyoming
  - 2023 – Louisiana



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.

TIMELINE TO IMPLEMENT CARBON CAPTURE AND GEOLOGIC CO_2 STORAGE IN NORTH DAKOTA



U.S. INCENTIVES

Internal Revenue Code § 45Q Tax Credits*

- Qualifying projects beginning construction before January 1, 2033, can claim credits for 12 years after operations begin.
- Direct payment option for receiving the credit (restrictions apply).
- Transferability of all or a portion of the credit value to any third-party, tax-paying entity in exchange for cash value during 12-year credit window.
- Tax credit for CO_2 stored in a qualified EOR project ($60/tonne).
- Tax credit for CO_2 stored in a saline formation ($85/tonne).

West Coast LCFS+ Markets

- Credits trading up to $73/tonne (July 17, 2023)
- Stacked with 45Q

State Incentives

- State tax (e.g., no sales tax on capture-related infrastructure)

*Inflation Reduction Act of 2022

+Low-Carbon Fuel Standard

Image Credit – EERC

PREFEASIBILITY SITE-SCREENING WORKFLOW

STAGE 1

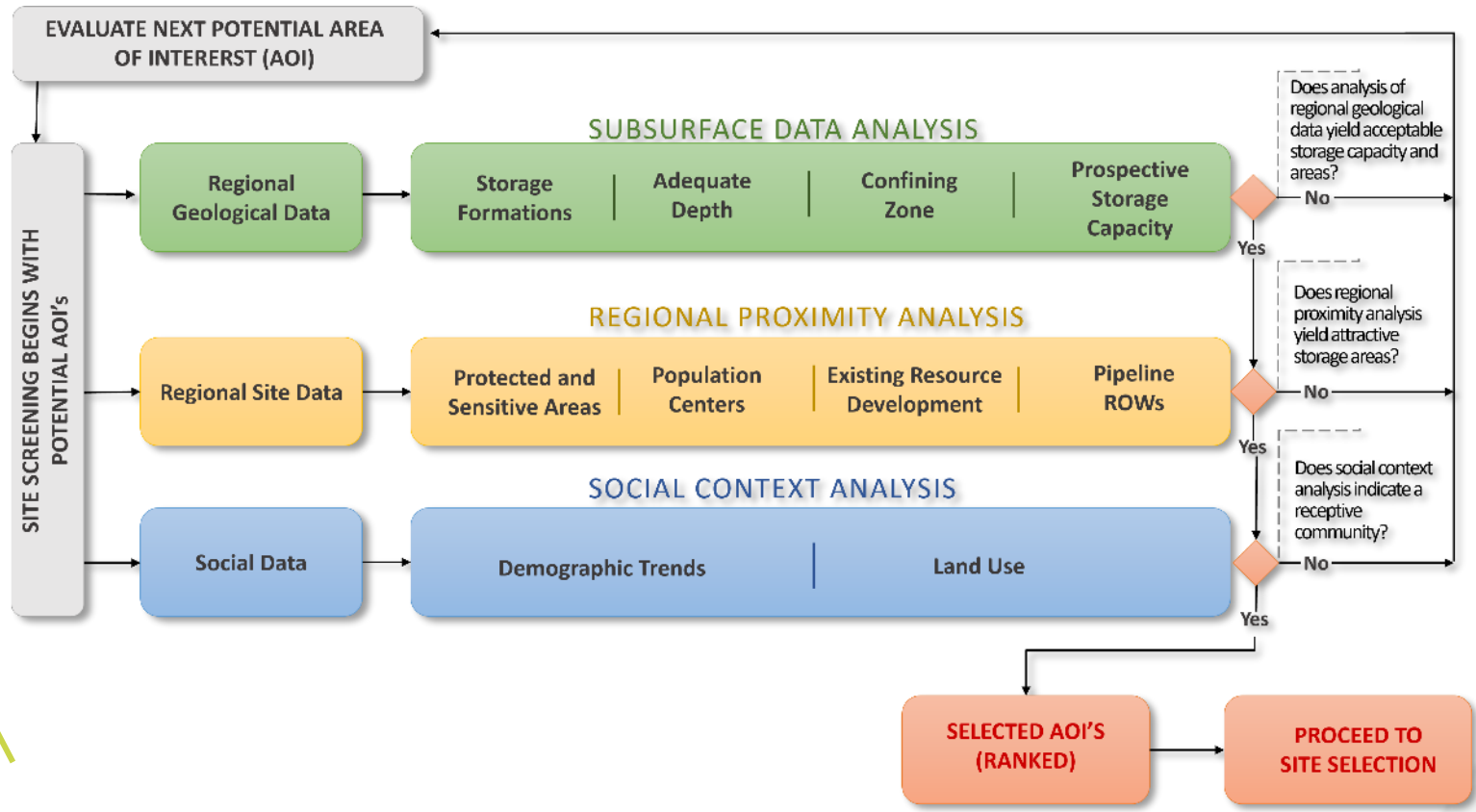
Site Screening and Ranking

- Screen potential sites and eliminate those that do not meet qualifying criteria.
- Perform static storage resource volume estimation for each site.
- Score and rank potential sites using surface and subsurface criteria.
- Generate a qualitative pros and cons list for each site.

STAGE 2

Site Characterization

- Determine most suitable top-ranking site from Stage 1.
- Evaluate need for a feasibility screening for selected top-ranking site.
  - Drill stratigraphic test wells, acquire site characterization and seismic data, lab testing, modeling, and simulations.



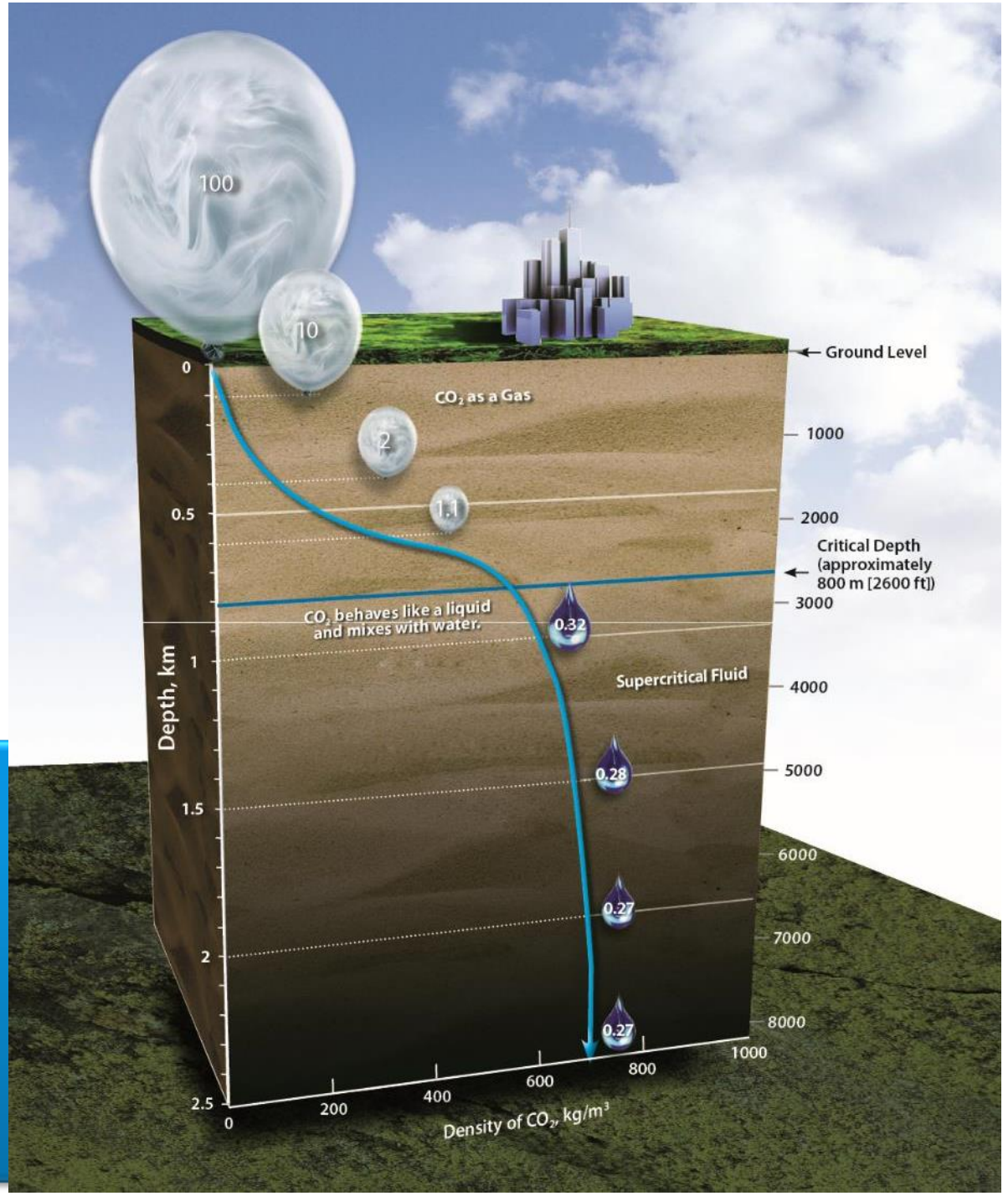
Critical Challenges. Practical Solutions.

SCREENING CRITERIA FOR GEOLOGIC CO_2 SEQUESTRATION

- Depth >2600 ft
- Porosity sufficient for desired stored CO_2 volume
- Permeability sufficient to receive injected CO_2 at the rate required
- Effective sealing formations
- Salinity greater than 10,000 mg/L TDS

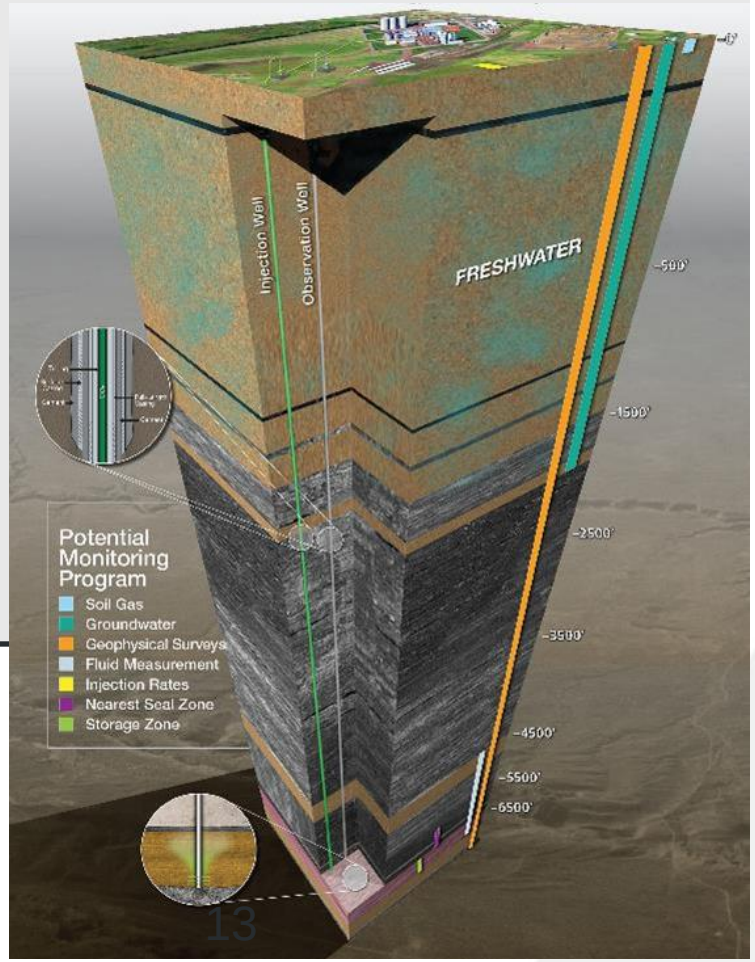
Depth

- Temperature and pressure conditions at depths greater than 2600 ft are effective in keeping CO_2 in the supercritical state:
  - Supercritical CO_2 has a density of liquid.
  - Does not have surface tension like liquid.
  - High density of supercritical CO_2 yields the most efficient use of subsurface storage space.



NORTH DAKOTA CO_2 SFP [CLASS VI] SECTIONS

- ❑ Pore Space Access
- ❑ Geologic Exhibits
- ❑ Geologic Model Construction and Numerical Simulation of CO_2 Injection
- ❑ Area of Review
- ☑ **Testing and Monitoring Plan**
- ❑ Postinjection Site Care and Facility Closure Plan
- ❑ Emergency and Remedial Response Plan
- ❑ Worker Safety Plan
- ☑ **Well Casing and Cementing Program**
- ☑ **Plugging Plan**
- ☑ **Injection Well and Storage Operations**
- ❑ Financial Assurance and Demonstration Plan
- ❑ Permit Appendixes



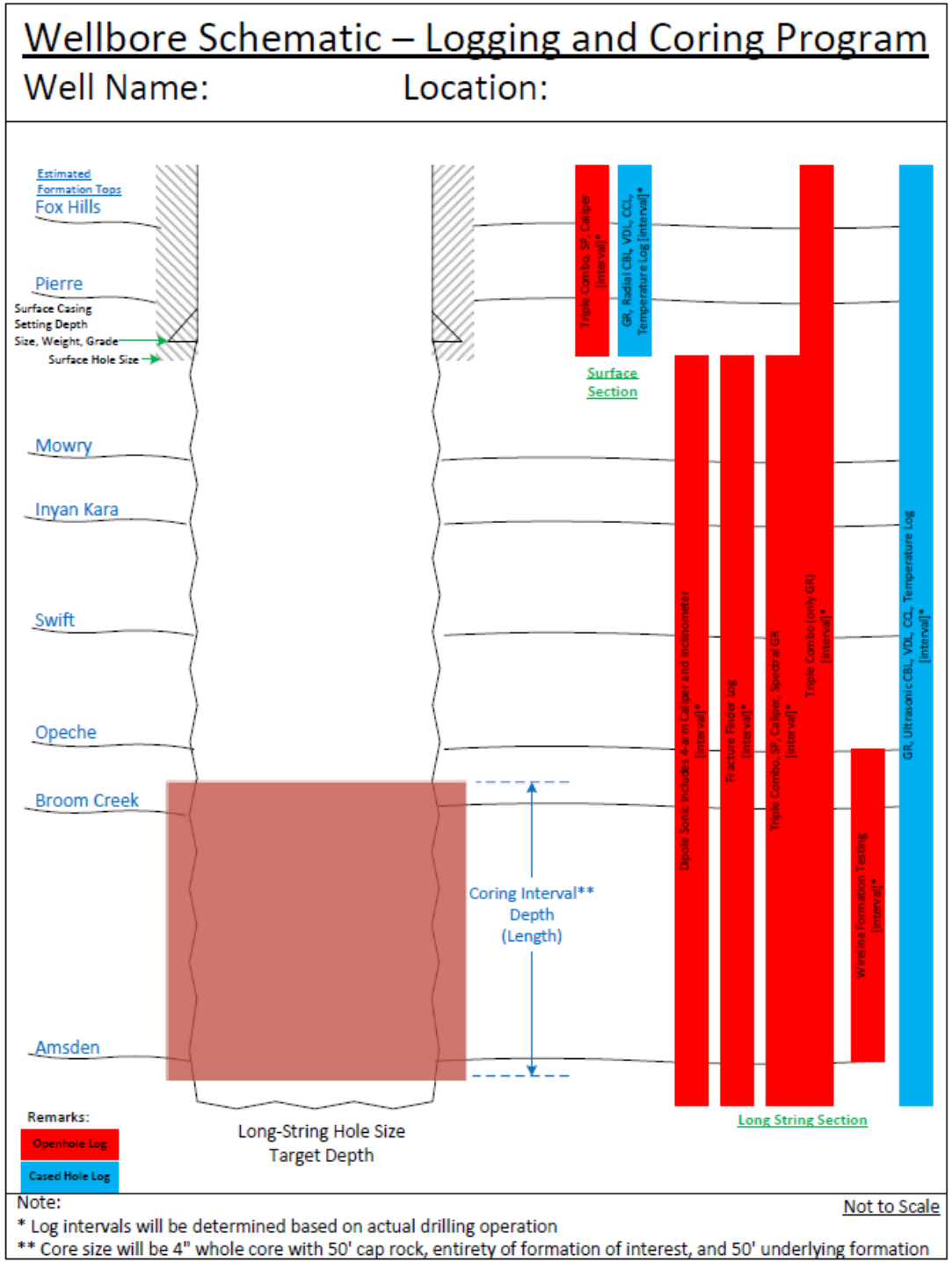
SFPs consist of 12 sections and are approximately 400+ pages in length.

FORMATION EVALUATION, SAMPLING, AND TESTING

Table 1. Recommended Suite of Well Logs for UIC Class VI Wells

OH[1]/CH[2]	Surface Section Log
OH	Triple combo (resistivity, density, porosity, GR[3], caliper, and SP)
OH	Acoustic compression and shear (dipole sonic)
CH	CCL[4]-ultrasonic log–VDL[5]–GR–temperature log
OH/CH	**Long-String Section**
OH	Triple combo (resistivity, density, porosity, GR, caliper, and SP (if using conductive mud); GR run to surface (0')
OH	NMR
OH	Spectral GR
OH	Capture spectroscopy
OH	Dipole sonic log (compression and shear waves)
OH	Acoustic, electric, or optical borehole imaging
OH	Fluid sampling
OH	Formation pressure testing
OH	Stress testing
OH	Sidewall cores (as a backup option *if* whole core fails)
CH	CCL–ultrasonic log–VDL–GR–temperature log

[1] Openhole.
[2] Cased hole.
[3] Gamma ray.
[4] Casing-collar locator.
[5] Variable-density log: ultrasonic log for radial cement bond.



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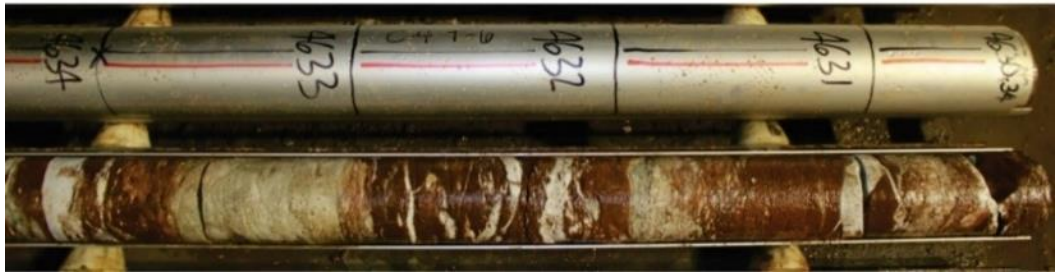
CORING

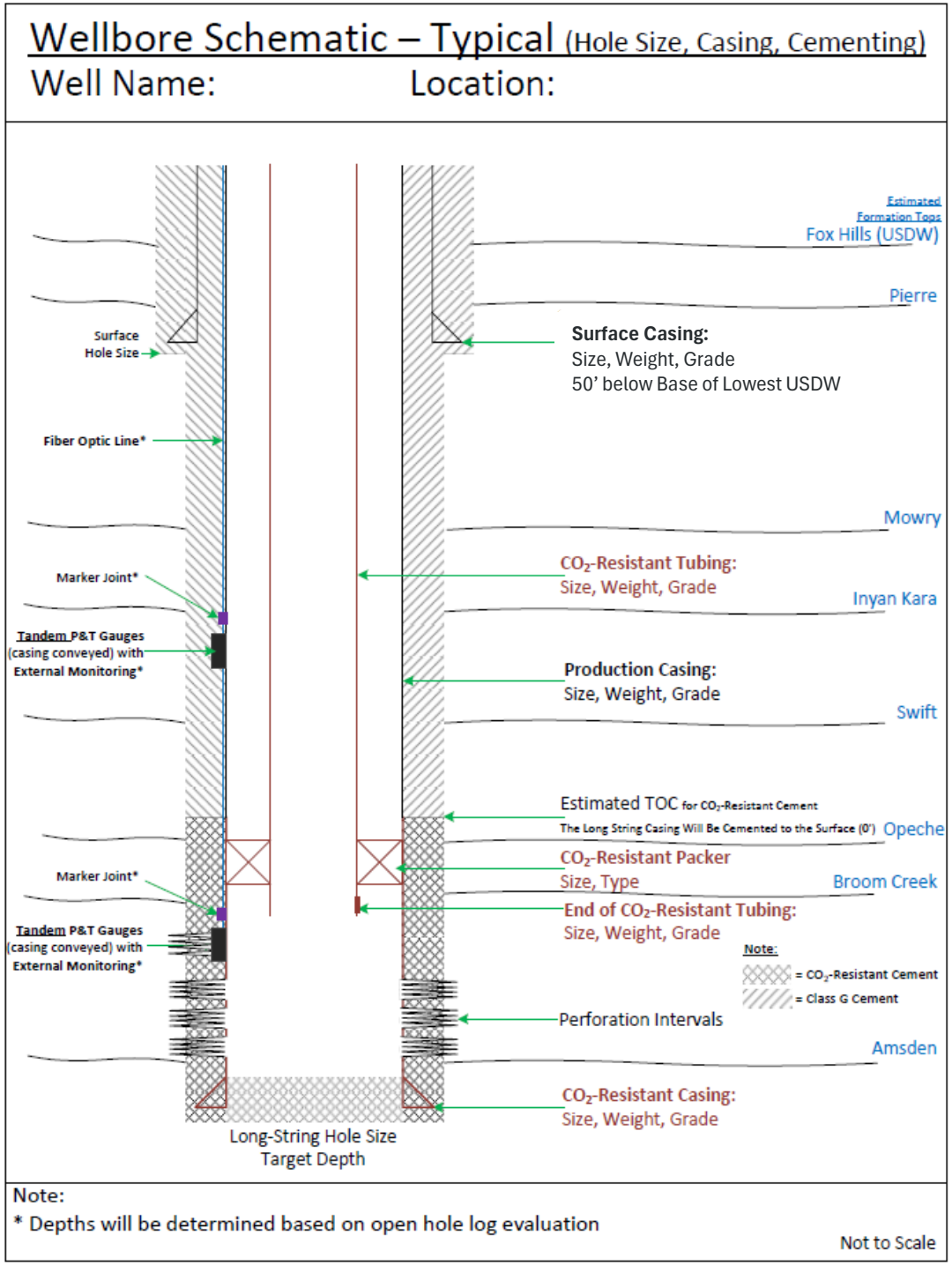


Core Testing and Interpretation

- Routine analyses to identify the bulk characteristics of the formations including:
  - Lithology, thickness, porosity, permeability, and mineralogy.
  - Geomechanical competency of the overlying and underlying sealing formations.

WELL CONSTRUCTION REQUIREMENT

- Compliance and transition to underground injection control (UIC) Class VI injection or monitoring well.
  - ❖ CO_2-resistant material for tubulars and cement
  - ❖ Cement to surface in every hole section
  - ❖ Logging, testing, and monitoring tools for wellbore integrity and injection
    - ➢ Fiber-optic distributed acoustic, and temperature sensing; downhole P/T gauges



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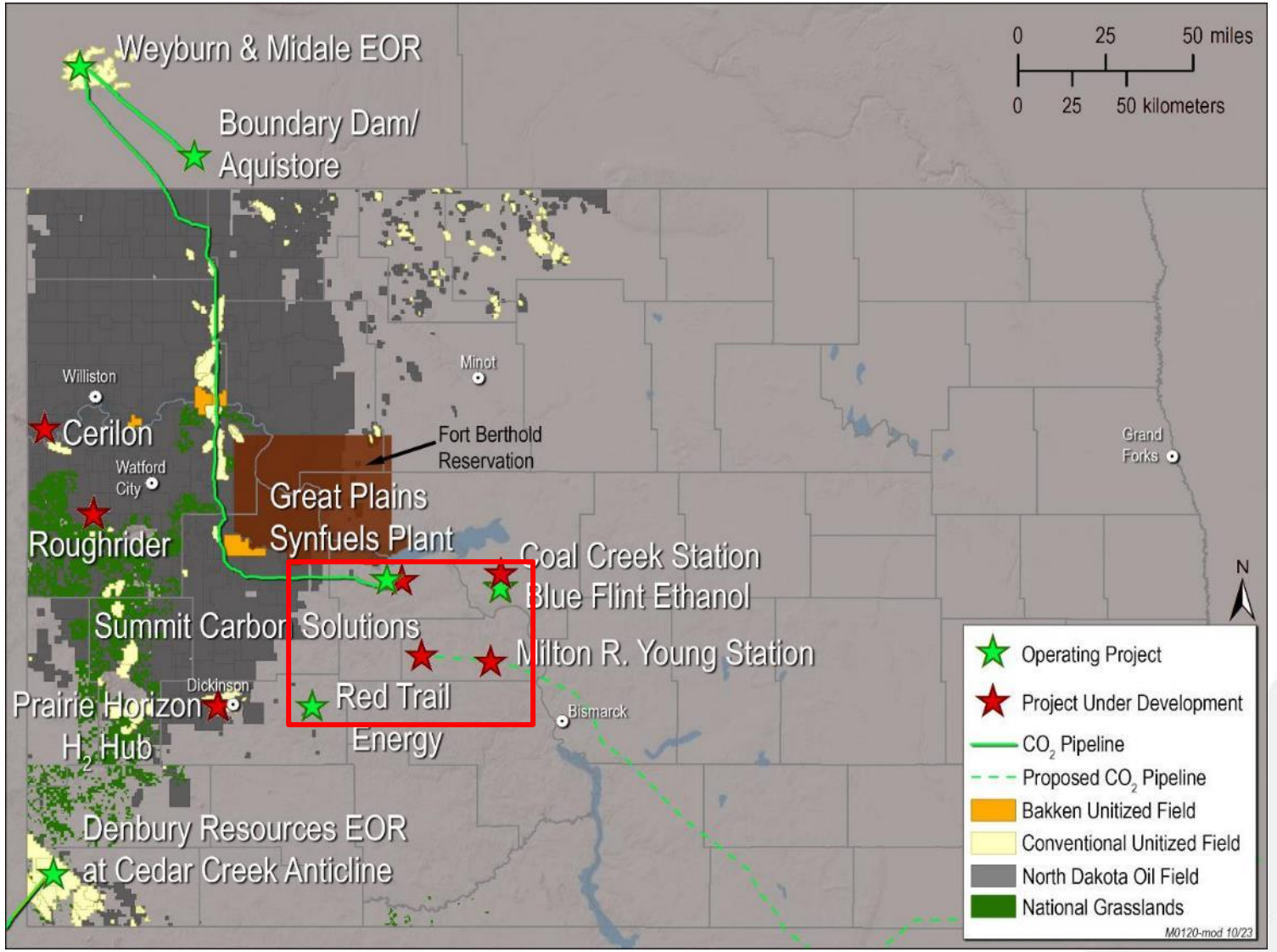

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THANK YOU!

Photo courtesy of John Oleksik, EERC

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THANK YOU

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