NORTH DAKOTA CARBONSAFE PHASE III: SITE CHARACTERIZATION AND PERMITTING OF GEOLOGIC STORAGE OF CARBON DIOXIDE

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National Energy Technology Laboratory
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626 Cochrans Mill Road
PO Box 10940, MS 921-107
Pittsburgh, PA 15236-0940

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Prepared by:

Katherine K. Anagnost
Wesley D. Peck

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Shannon R. Mikula
Minnkota Power Cooperative, Inc.
5301 32nd Avenue South
Grand Forks, ND 58201-3312

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EXECUTIVE SUMMARY

The Energy & Environmental Research Center (EERC), in partnership with Minnkota Power Cooperative Inc. (Minnkota), SLB, and Computer Modelling Group Ltd. (CMG), supported wide-scale deployment of carbon capture and storage (CCS) as part of the U.S. Department of Energy (DOE) National Energy Technology Laboratory **Carbon** **S**torage **A**ssurance **F**acility **E**nterprise (CarbonSAFE) Initiative Phase III. This phase included the acquisition, analysis, and development of information to fully characterize two storage complexes to demonstrate viable storage resources for commercial volumes of CO_2 (defined by DOE as a minimum of 50 million tonnes [MMt] of CO_2 within a 30-year period) (National Energy Technology Laboratory, 2024). Phase III also involved the preparation, submission, and approval of North Dakota underground injection control (UIC) Class VI storage facility permits (SFPs)—required precursors to applications for Class VI injection well permits.

The presumed viability of commercial-scale CCS, situated adjacent to Minnkota's Milton R. Young Station (MRYS), is validated by Minnkota's continued pursuit of Project Tundra—an initiative to build the world's largest lignite-based CCS project in central North Dakota (www.projecttundrand.com). Project Tundra comprises two scopes of work, Tundra Capture (installation of postcombustion CO_2 capture at MRYS) and Tundra SGS (secure geologic storage). The efforts of North Dakota CarbonSAFE Phase III, Site Characterization and Permitting, supported Tundra SGS.

Extensive site-specific characterization activities included a successful multimeasurement geophysical approach and drilling a stratigraphic test well (J-ROC 1, subsequently renamed Liberty-1) adjacent to MRYS. Core collection and analyses, downhole testing and fluid sampling, and geophysical logging were performed on J-ROC 1 and on a nearby stratigraphic test well (known as J-LOC 1), which was drilled, cored, and tested under a complementary project funded by the North Dakota Lignite Research Program. The injection tests performed on J-LOC 1 positively impacted the CarbonSAFE project, resulting in fewer proposed injection wells and significant construction, operations, and monitoring cost savings. The characterization data collected and analyses performed were integrated into geologic models, and successive numerical simulations were run to determine CO_2 plume extent and subsurface pressure buildup associated with the planned CO_2 injection rate of nearly 4 MMt per year. The latter doubles the CarbonSAFE Initiative goal with an estimated 100 MMt of CO_2 stored in 20 years. Application of the U.S. Environmental Protection Agency's (EPA's) method for estimating the Class VI Rule area of review (AOR) to the overpressurized Broom Creek Formation inspired an alternative method of calculation, called risk-based AOR delineation. This peer-reviewed method was applied for the first time during the storage facility-permitting process.

The two SFP applications submitted in 2021 successfully resulted in North Dakota Industrial Commission (NDIC) orders in 2022 authorizing the creation of the storage facility areas and amalgamation of pore space as well as establishing financial responsibility requirements. After

approval of the SFPs, Minnkota filed in 2022 applications for permits to reenter the J-ROC 1 well and to drill two new wells—all with the intended purpose to become Class VI injection wells. To establish eligibility under the Internal Revenue Code for Section 45Q tax incentives, a monitoring, reporting, and verification (MRV) plan was prepared and submitted by Minnkota to EPA in 2022, resulting in the first such plan approved in North Dakota.

Also in 2022, under the National Environmental Policy Act (NEPA), Minnkota prepared and submitted an environmental information volume (EIV) describing the proposed CCS project and associated potential environmental impacts. Based on the EIV, DOE determined that the proposed construction project required an environmental assessment, and Minnkota submitted the first draft in 2023 and a revised draft in 2024. Both submissions were followed by a public comment period. Subsequently, DOE issued a finding of no significant impact (FONSI) on September 13, 2024.

A successful outreach program, strongly based in the production, presentation, and dissemination of informational material, fostered an environment to aid stakeholders in making informed decisions regarding the planned project. Opportunities for public input were provided at various steps along the way, including at county planning and zoning meetings, before and during the SFP administrative hearing, and during environmental assessment public comment periods. In addition, land/pore space owners and mineral owners had various points of contact, including granting access rights, securing pore space leasing, and mineral owner notifications.

Based upon the successful storage facility permitting issued by NDIC, approval of the MRV plan by EPA, and receipt of a FONSI under the NEPA, Minnkota is continuing its pursuit of Project Tundra. In December 2023, the Office of Clean Energy Demonstrations under its Carbon Capture Demonstrations Projects Program announced funding for the capture system (Office of Clean Energy Demonstrations, 2023) and a proposal for CarbonSAFE Phase IV: Construction funding was submitted in March 2024 for the storage project. A go/no-go decision to proceed with construction and operations in the Broom Creek Formation is anticipated in 2024.

References

National Energy Technology Laboratory, CarbonSafe Initiative, https://netl.doe.gov/carbon-management/carbon-storage/carbonsafe (accessed August 2024).

Office of Clean Energy Demonstrations, 2023, OCED selects three projects in CA, ND, and TX to reduce harmful carbon pollution, create new economic opportunities, and advance carbon reducing technologies, December, www.energy.gov/oced/articles/oced-selects-three-projects-ca-nd-and-tx-reduce-harmful-carbon-pollution-create-new (accessed August 2024).

NORTH DAKOTA CARBONSAFE PHASE III: SITE CHARACTERIZATION AND PERMITTING OF GEOLOGIC STORAGE OF CARBON DIOXIDE

I. INTRODUCTION

The Energy & Environmental Research Center (EERC) partnered with Minnkota Power Cooperative Inc. (Minnkota), SLB, and Computer Modelling Group Ltd. (CMG) to conduct commercial-scale site characterization and permitting of two deep saline reservoirs in North Dakota for the geologic storage of anthropogenic carbon dioxide (CO_2) emissions. This effort is part of the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) **Carbon S**torage **A**ssurance **F**acility **E**nterprise (CarbonSAFE) Initiative.

The CarbonSAFE Initiative began in 2016 with the goal of addressing the key gaps on the critical path toward carbon capture and storage (CCS) deployment. The CarbonSAFE vision is to understand the development of a CCS complex (the target reservoir and respective upper and lower confining formations) from the pre-feasibility study until the point of injection. The phases of project progress comprising CarbonSAFE are I) Integrated CCS Pre-Feasibility, II) Storage Complex Feasibility, III) Site Characterization and Permitting, and IV) Construction (Figure 1).

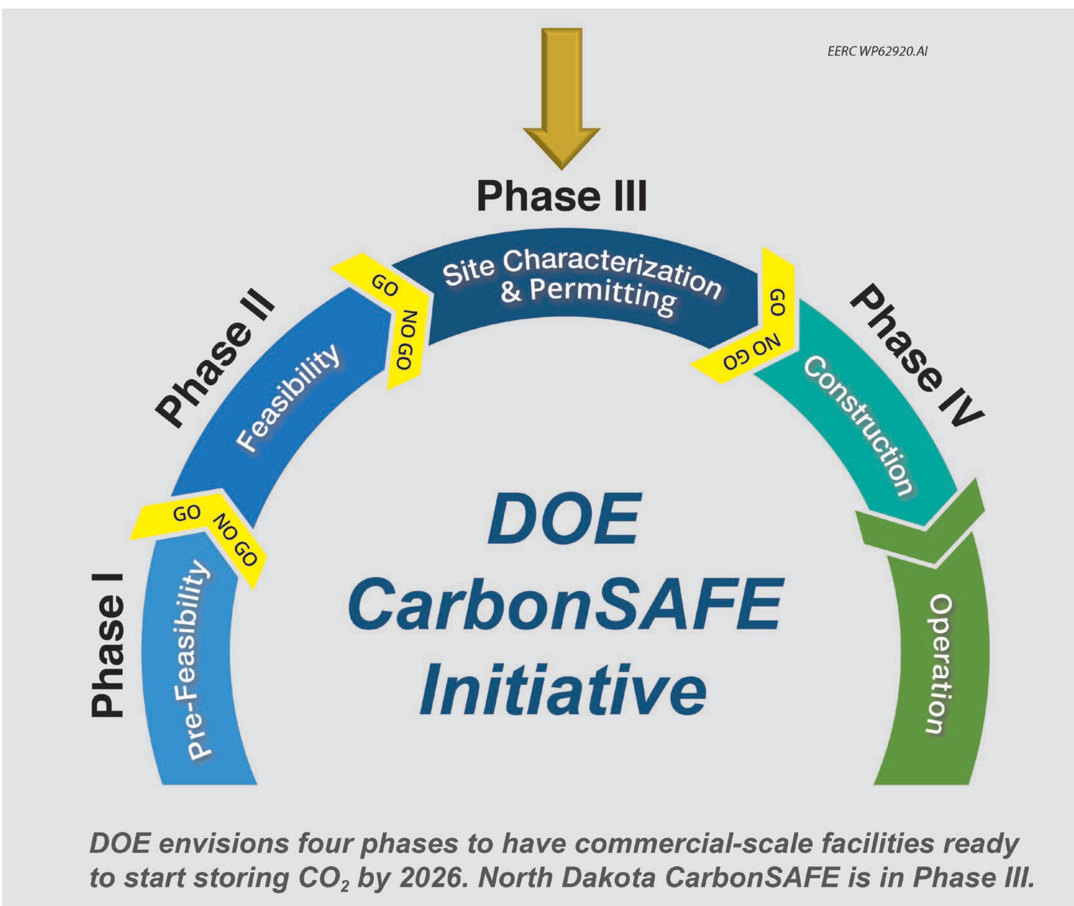

Figure 1. The four phases of DOE's CarbonSAFE Initiative.

Building on the knowledge, successful partnerships, and extensive characterization work of the Plains CO_2 Reduction (PCOR) Partnership, also sponsored under DOE's Carbon Storage Program, the EERC bypassed CarbonSAFE Phase I (Pre-Feasibility), and went on to successfully complete Phase II, establishing the technical, economic, and social feasibility of developing commercial-scale CO_2 geologic storage complexes in central North Dakota. The stacked storage complexes (in the Broom Creek and Deadwood Formations) located near Minnkota's Milton R. Young Station (MRYS) were determined capable to safely, permanently, and potentially economically store over 50+ million tonnes (MMt) of CO_2 within 30 years.

CarbonSAFE Phase III began in 2020, and as detailed in the following pages, the project successfully demonstrated the a) acquisition and analysis of geologic information needed to fully characterize stacked storage complexes to demonstrate storage resources for commercial volumes of CO_2; b) approval of storage facility permits (SFPs) for two storage reservoirs pursuant to North Dakota's underground injection control (UIC) Class VI program; c) approval of a monitoring, reporting, and verification (MRV) plan to the U.S. Environmental Protection Agency (EPA); d) preparation and submission of an environmental information volume and environmental assessment (EA) under the National Environmental Policy Act (NEPA), including receipt of a finding of no significant impact (FONSI); and e) the importance of community outreach and stakeholder support.

II. OVERVIEW OF MINNKOTA'S TUNDRA SGS (SECURE GEOLOGIC STORAGE) PROJECT

Minnkota is a regional generation and transmission cooperative headquartered in Grand Forks, North Dakota, providing wholesale power to 11 member–owner rural electric distribution cooperatives in eastern North Dakota and northwestern Minnesota. Minnkota is also affiliated with the Northern Municipal Power Agency (NMPA), which serves the electric needs of 12 municipalities in the same geographic region as the Minnkota member–owners. Minnkota serves as the operating agent of NMPA. Figure 2 provides a map showing the Minnkota and NMPA service territory.

Minnkota's primary generating resource is the two-unit MRYS, a minemouth lignite coal-fired power plant with the capacity to produce over 700 MW. The mine that provides the lignite coal for MRYS is owned and operated by BNI Coal, Ltd. (BNI, a subsidiary of BNI Energy Inc.) and is adjacent to the MRYS facility. The lignite used as the fuel for electrical generation also serves as the primary source of the captured CO_2 that will be securely stored by Tundra SGS. The scope of work for the geologic storage (Tundra SGS) together with the installation of postcombustion CO_2 capture at MRYS[1] (Tundra Capture) are commonly referred to together as Project Tundra (Department of Mineral Resources, 2022a, b).

Minnkota's Tundra SGS approach comprises a stacked storage concept where two storage reservoirs (namely, the Broom Creek and the Deadwood Formations) identified at varying vertical

[1] Project partner Minnkota has received a front-end engineering and design (FEED) study award under DOE DE-FOA-0002058 and complementary funding from the North Dakota Industrial Commission (NDIC) Lignite Research Program (LRP), FY19-LXXXVIII-220.

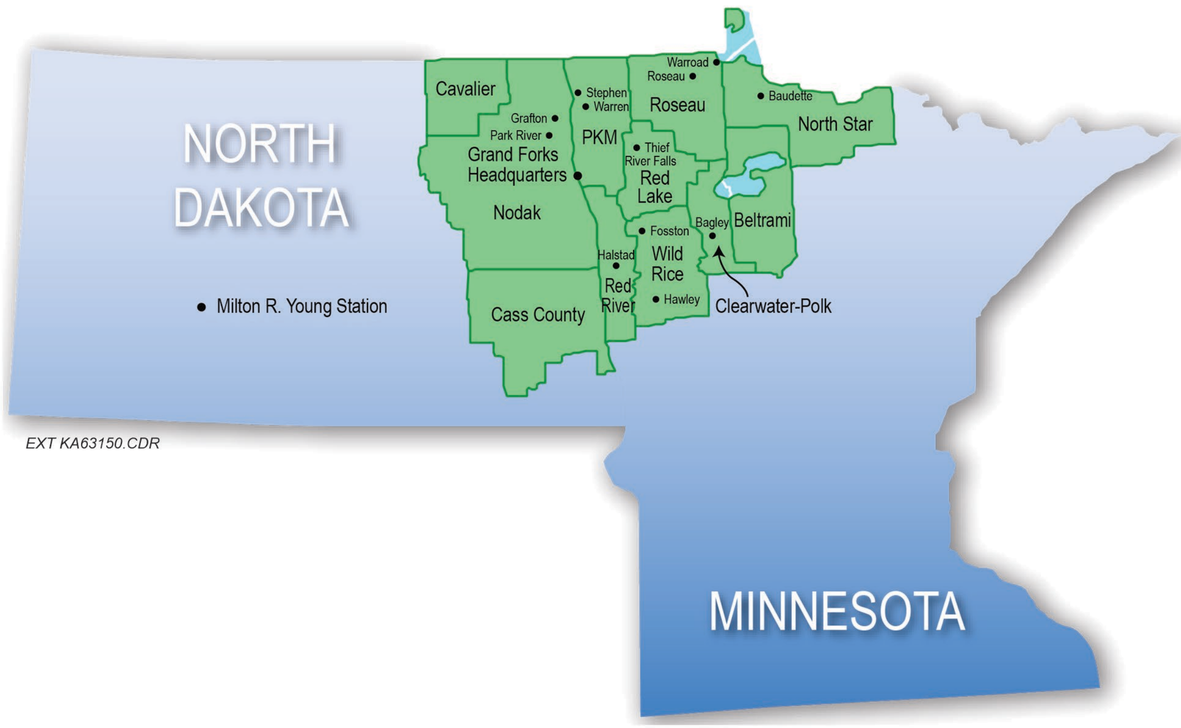

Figure 2. Map of the Minnkota and NMPA service territory (Department of Mineral Resources, 2022a, b).

depths can be accessed by a common wellsite. A key benefit of this development approach is to minimize the surface land use impact based on a smaller project area and a commensurate reduction of surface facilities needed for operation. This smaller area also resulted in fewer landowners involved in pore space-leasing activities and significant cost savings over the life of the project because of a smaller monitoring area.

For permitting a UIC Class VI storage facility in North Dakota, there are no specific additional regulatory requirements for stacked storage beyond those that apply to any CCS project. Permitting is based on the single injection horizon; therefore, a permit is required for each individual storage complex in the stack (Belobraydic and others, 2021). Tundra SGS is broken into two phases and two SFP applications—Phase 1 involves initial injection operations into the Broom Creek Formation and, if additional storage capacity is needed, Phase 2 injection into the Deadwood Formation may be triggered.

Phase 1—Broom Creek Formation Construction and Operation—is to conduct CO_2 storage operations in the Broom Creek Formation (Figure 3) using two proposed wells, namely Liberty-1 (formerly J-ROC 1) and Unity-1. Upon construction and operation of the two injection wells and validation of the Phase 1 operation, the evaluation of additional capacity needs will be considered in the decision to proceed with Phase 2.

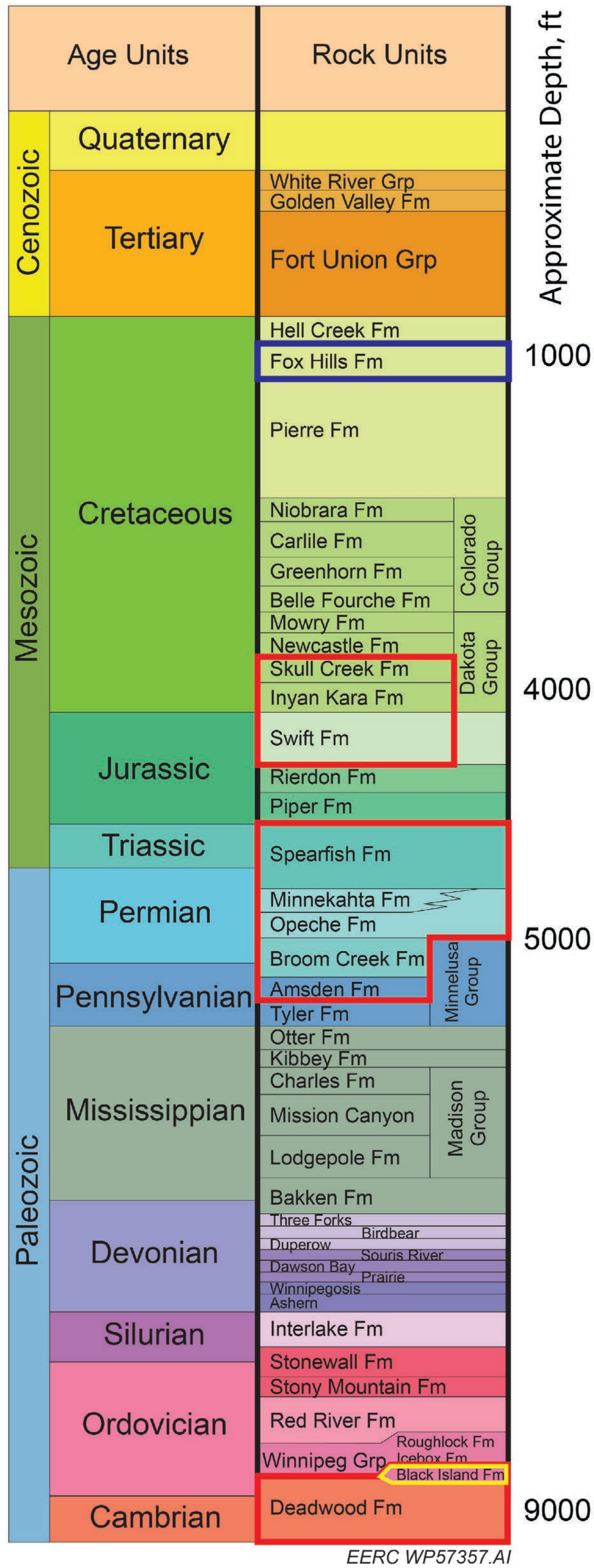

Figure 3. North Dakota stratigraphic column of Tundra SGS focus horizons (outlined in red).

Phase 2—Deadwood Formation Construction and Operation—would consist of one additional well (McCall-1) for injection of CO_2 into the Deadwood Formation (Figure 3). The Minnkota FP) applications (Department of Mineral Resources, 2022a, b) were based on currently available data, including regional and site-specific data derived from two stratigraphic test wells drilled by Minnkota in 2020, namely J-LOC 1 (NDIC Well File No. 37380) and J-ROC 1 (NDIC Well File No. 37672), and one stratigraphic test well drilled by the EERC in 2015, namely BNI 1 (NDIC Well File No. 34244), all located within 5 mi of the proposed injection site (Figure 4).

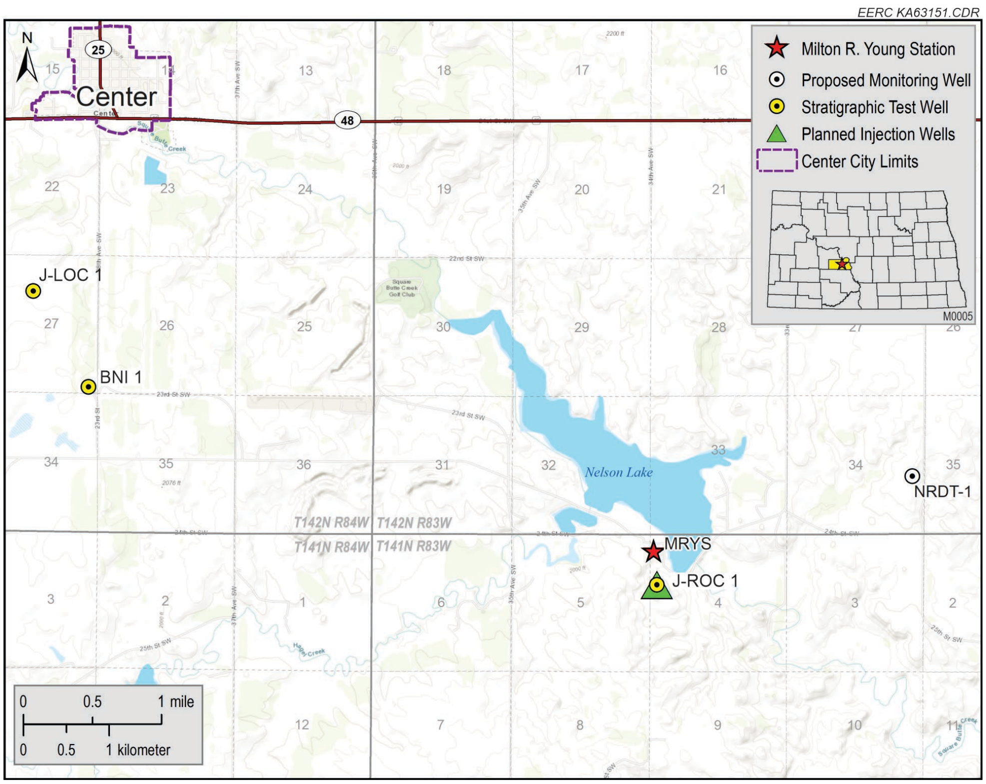

Figure 4. Topographic map of the Tundra SGS area showing stratigraphic test well locations and MRYS (Department of Mineral Resources, 2022a, b).

J-ROC 1, the stratigraphic test well now renamed Liberty-1, is proposed to be reentered and converted into a CO_2 injection well. The proposed Tundra SGS injection site is approximately 5.5 mi southeast of the town of Center, North Dakota, and will include up to three injection wells (McCall-1, Liberty-1, and Unity-1), one dedicated monitoring well for the lowest underground source of drinking water (USDW), and associated surface facility infrastructure that will accept CO_2 transported via a CO_2 flowline. In addition, NRDT-1 (NDIC Well File No. 40270), a deep reservoir-monitoring well is proposed to be installed approximately 2 mi northeast of the Tundra SGS injection site (Figure 5). All these surface facilities and underground equipment will be contained on Minnkota-owned property (Figure 6), and the injection site is within the MRYS fence line.

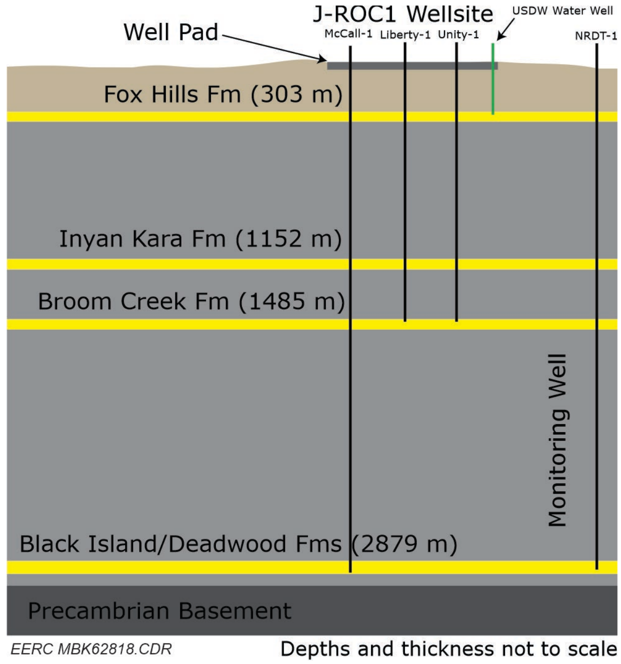

Figure 5. General well plan for Tundra SGS.

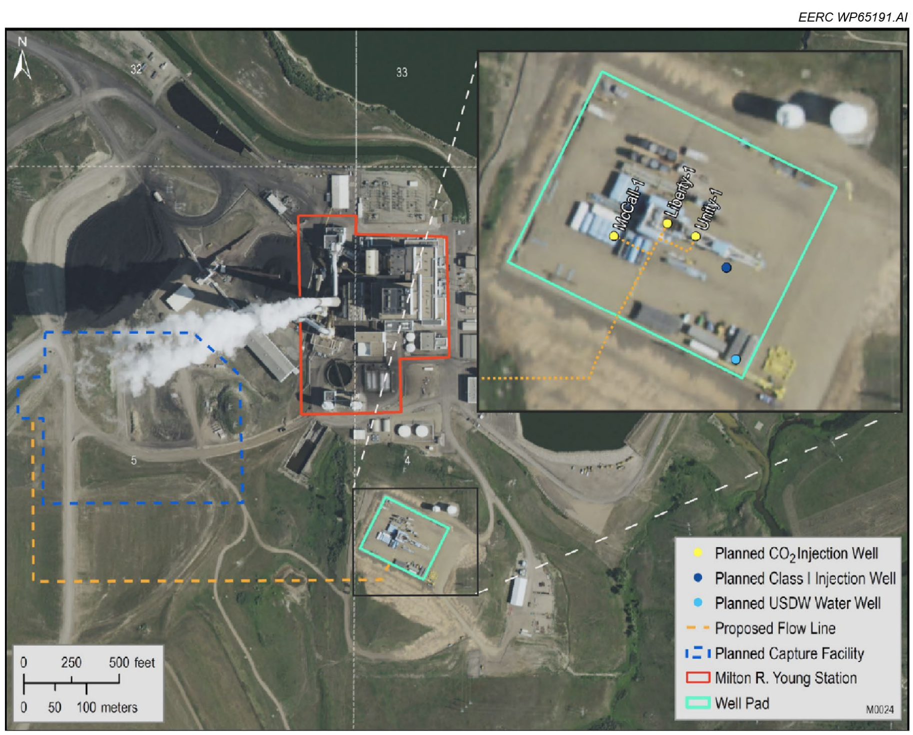

Figure 6. Aerial image showing the detailed spatial relationship between MRYS (red polygon), the planned capture facility (blue dashed polygon), the proposed flowline route (orange dashed line), and the well pad (aqua box) where the captured CO_2 will be injected. The three injection wells are shown on the inset map by yellow dots. Liberty-1 and Unity-1 will be used for Broom Creek Formation injection, while McCall-1 will be used for injection into the Deadwood Formation.

III. SITE CHARACTERIZATION

Ultimately, the goal of the site-specific characterization is to generate the data required to satisfy the UIC Class VI regulatory process, provide adequate information to project owners and their contractors to confidently design storage facilities, and provide assurance to other stakeholders of the security and efficiency of the developed site (Peck and others, 2019). Site-specific efforts to characterize the proposed storage complexes generated multiple datasets, including geophysical well logs, petrophysical data, fluid analyses, and three-dimensional (3D) seismic data. Table 1 provides a listing of key site characterization activities that will be described below.

Adherence to the NDIC Department of Mineral Resources Oil and Gas Division (DMR O&G) Class VI regulatory framework ensures that project partners have properly characterized the commercial-scale CO_2 storage site(s) within the selected storage complexes. Figures 7 and 8 depict the relationship between the major DMR O&G permitting requirements and the major characterization activities performed to address those requirements. Because the region near the CO_2 source, MRYS, presented only limited available data on the subsurface, significant investment in the acquisition of new data was made, e.g., geophysical surveys and stratigraphic test well drilling.

The following information describes in more detail key activities and findings related to the site-specific characterization activities in alignment with the flowchart in Figure 7.

Table 1. Key Characterization Activity Dates

Event/Milestone	Date
J-LOC 1 Well Spud*	5/14/2020
Two-Dimensional (2D) Seismic Survey Complete	8/31/2020
J-ROC 1 Well Spud	9/8/2020
3D Seismic Survey Complete	9/9/2020
2D Microgravity Survey Complete	11/2020
Injection Test (J-LOC 1) Complete*	12/21/2020
Controlled-Source Electromagnetic (CSEM) Survey Complete	4/9/2021
Drone-Based Magnetic Survey	6/19/2021
Fox Hills Monitoring Well Drilled	11/2021

* Non-CarbonSAFE North Dakota (CSND) funding.

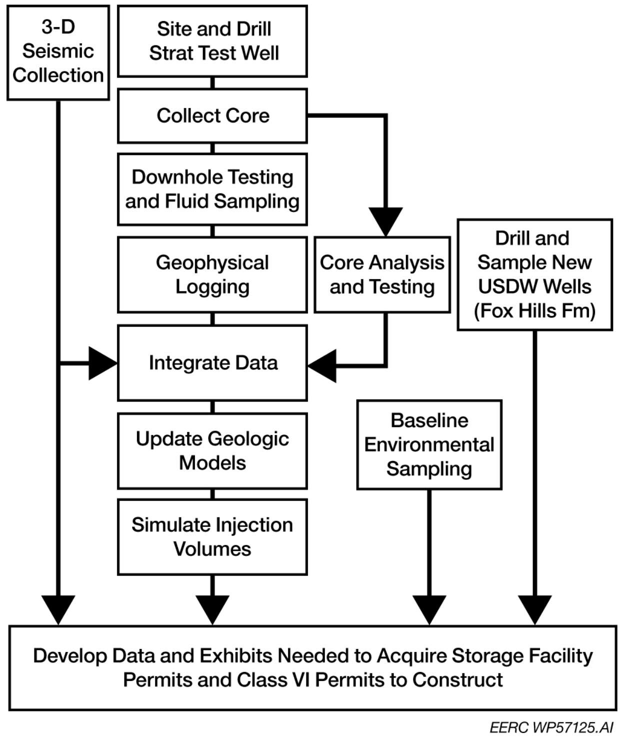

Figure 7. Relationship of major site development activities needed to acquire a North Dakota CO_2 SFP (Peck and others, 2019).

Major Proposed Characterization Activities

Major NDIC Permitting Requirements	Core	Logging	Downhole Testing	Lab Testing	Modeling	Simulation	Seismic Collection	Baseline Sampling	New Fox Hills Wells
Determine Plume Extent	X	X	X	X	X	X	X		
Determine Pore Space Amalgamation	X	X	X	X	X	X	X		
Geologic Properties of Injection and Confining Zones	X	X	X	X			X		
Regional Faulting Assessment	X						X		
Potential for Seismic Activity			X	X	X		X		
Geologic Maps and Cross Sections		X			X		X		X
Geomechanics of Confining Zone(s)		X	X	X	X				
Identify and Characterize Secondary Confining Zones		X	X		X		X		
Determine Area of Review		X	X	X	X	X	X		
Baseline Geochemical Data	X			X				X	X
Baseline Water and Soil Data				X				X	X

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Figure 8. Cross reference of major site development activities needed to acquire a North Dakota CO_2 SFP (Peck and others, 2019).

Site-specific data were used to assess the suitability of the storage complex for safe and permanent storage of CO_2. Site-specific data were also used as inputs for geologic model construction, numerical simulations of CO_2 injection, geochemical simulation, and geomechanical analysis. The site-specific data improved the understanding of the subsurface and directly informed the selection of monitoring technologies, development of the timing and frequency of collecting monitoring data, and interpretation of monitoring data with respect to potential subsurface risks. Furthermore, these data guided and influenced the design and operation of site equipment and infrastructure.

A. Geophysical Exploration

Acquisition of data from geophysical surveys helps evaluate the rock layers below the surface, aid in development of more accurate computer models to simulate where the injected CO_2 may travel, evaluate the suitability of the storage complex(es) and placement of stratigraphic test wells, and ultimately map the movement of the CO_2 in future surveys. Considerations used in planning for geophysical exploration(s) included the permitting requirements and landowners involved. North Dakota's permitting requirements are found in North Dakota Administrative Code (NDAC) Chapter 38-08.1 and are administered by the same agency responsible for Class VI permitting—DMR O&G. After securing the necessary geophysical exploration permit, notification of the permitted activities and the owner/operator rights must be provided to the land operator and each nearby landowner. In addition, the county auditor must receive notification prior to commencement of exploration activities and the board of county commissioners has authorization to revoke the permit in certain conditions. Because the access and permitting processes involve local interaction (landowners/operators and county commissioners), these are prime opportunities to begin outreach and education efforts. Several fact sheets were developed for this purpose, and presentations were given to county commissioners (Appendixes A and B).

Seismic, CSEM and magnetotelluric (MT), and microgravity baseline monitoring surveys were collected to assess the commercial-scale geologic storage of CO_2 generated by MRYS (Figure 9). These are described in more detail below.

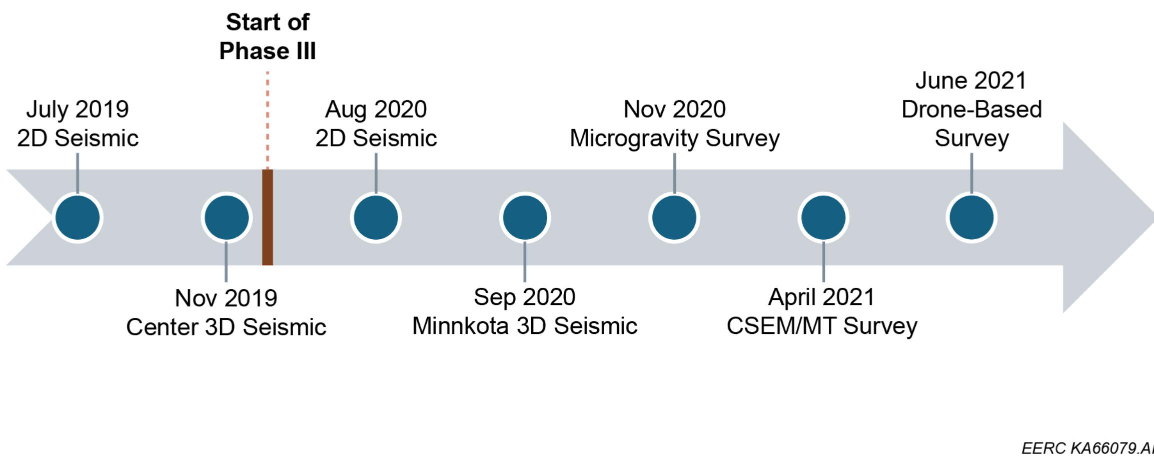

Figure 9. Timeline of key geophysical exploration events. The vertical line represents the start of the Phase III project.

1. Seismic

2D and 3D surface seismic surveys provide data for large tracts or volumes of the subsurface. When subsurface structure is gentle, 2D seismic lines can be used to produce vertical slice images of geologic structure and formation continuity. In more complex structural domains, 3D seismic surveys allow detailed geological analysis in any direction or orientation within the subsurface volume encompassed by the survey (Glazewski and others, 2017).

Building upon the seismic surveys conducted during CarbonSAFE Phase II, i.e., a 5-mi-long, 2D seismic source test and a 7-mi^2 Center 3D survey acquired in 2019, additional surveys and studies were conducted in Phase III to further characterize the geologic formations and help monitor the injected CO_2 over time to ensure containment. In August 2020, 22 linear miles of 2D seismic lines were acquired, and in September 2020, the 13-mi^2 Minnkota 3D seismic survey was acquired (Figure 10).

The 3D seismic data allowed for visualization of deep geologic formations at lateral spatial intervals as short as tens of feet. The 2D seismic data provided a means to connect the two 3D seismic datasets (Center 3D and Minnkota 3D surveys) and ensure consistent interpretation across the Tundra SGS area. The seismic data were used for assessment of the geologic structure, interpretation of interwell heterogeneity, and well placement. Data products generated from the interpretation and inversion of the 3D seismic data were used as inputs into the geologic model. Additionally, the geologic model that was informed by the seismic data was used to simulate migration of the CO_2 plume. These simulated CO_2 plumes were then used to inform the testing and monitoring plan.

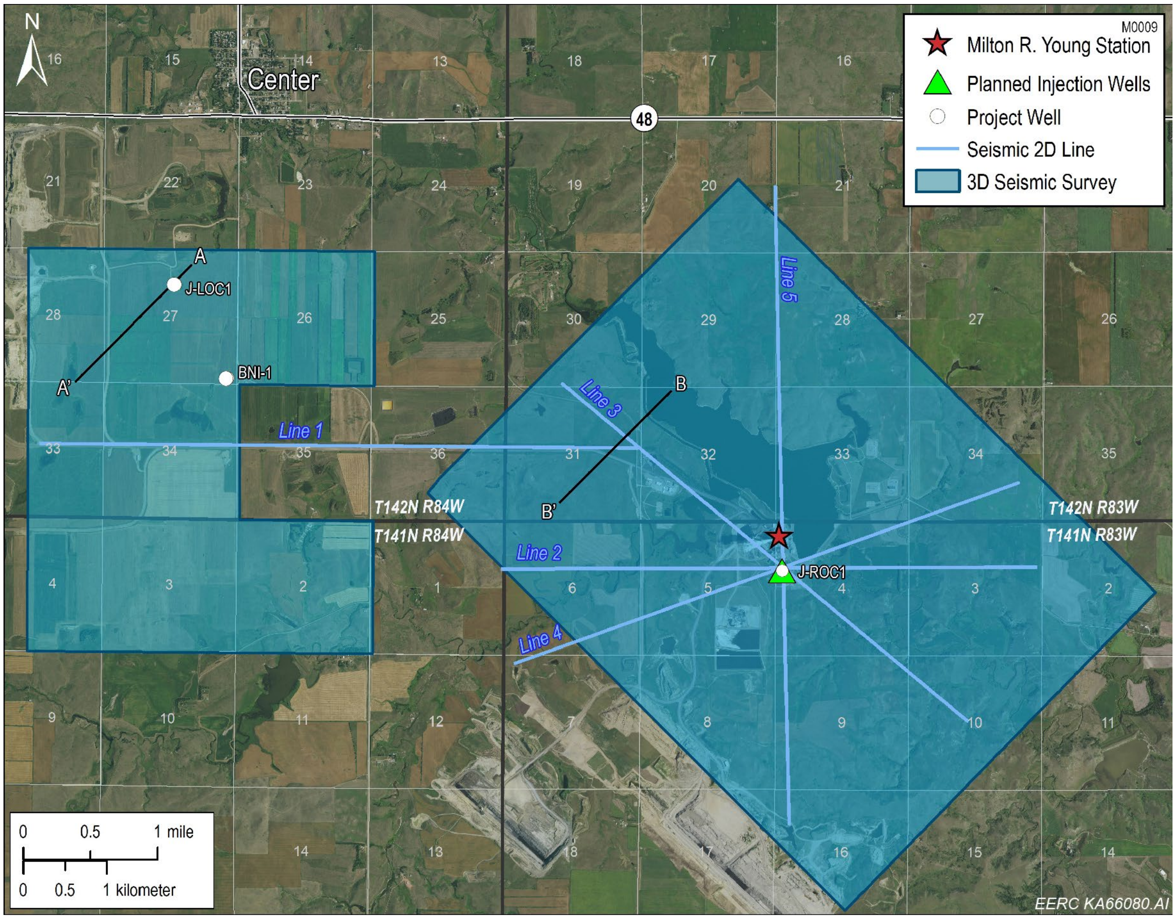

Figure 10. Map showing the Phase II 2D and Center 3D seismic surveys (left side) and the Phase III 2D and Minnkota 3D seismic surveys (right side).

Seismic data collected as part of site characterization efforts were used to reinforce structural correlation and thickness estimations of the storage reservoir. The combined structural correlation and analyses indicated that there should be few-to-no major reservoir stratigraphic discontinuities near the J-LOC 1 and J-ROC 1 wells. The Broom Creek Formation and Deadwood E member are estimated to pinch out 12.5 mi and ~24 mi, respectively, to the east of the J-ROC 1 site. Structure maps of the Broom Creek and Deadwood Formations showed no detectable features (e.g., folds, domes, or fault traps) within the Tundra SGS area.

2. 2D Microgravity Survey

In November 2020, a baseline microgravity survey was acquired. The goal of this survey was to assess whether microgravity would be an appropriate technique to monitor CO_2 stored at this site. Multiple sources of noise affect these data, including elastic hysteresis, meter tilt, barometric pressure changes, wind, and nearby industrial activities. Various field procedures and processing solutions were developed to address these noise issues and demonstrated the improvement in data quality, giving confidence in the modeling results and establishing microgravity as a potentially useful monitoring method at this site (Adams and others, 2021).

3. CSEM and MT Survey

In winter 2020–2021, electromagnetic testing was performed, including MT, which is passive and used only sun activity as the electromagnetic source, and a CSEM geophysical survey, which is active source with passive receivers. The CSEM was conducted to differentiate the type of rocks and fluids in the geologic layers below the surface near MRYS. The survey covered portions of 17 sections around MRYS, including the transmitter sites and a 300-ft-wide corridor 4–6 mi long to collect data. A feasibility study of the CSEM method, including one-dimensional (1D) and 3D modeling and a field noise test, was conducted to determine its effectiveness in monitoring CO_2 in the Broom Creek and Deadwood Formations. The study results demonstrated that the CSEM method could be a strong contributor to mapping the CO_2 movement and can be used for CO_2 storage monitoring in the study area (Barajas-Olalde and others, 2021).

4. Drone-Based Magnetic Survey

In June 2021, a field crew using a drone conducted a low-impact magnetic survey near MRYS to measure the natural magnetic field strength and potentially interpret structural features in the deep subsurface. Results of this survey were evaluated with those of the other geophysical surveys performed to estimate their efficacy to track CO_2 deep underground.

Studies for seismic, CSEM, and gravity methods were conducted to determine the effectiveness of these methods in monitoring CO_2 in the Broom Creek and Deadwood Formations. While all three methods can be used to monitor CO_2 injected into the Broom Creek Formation, only the seismic and CSEM methods proved applicable to monitoring CO_2 injected into the Deadwood Formation. Based on the positive results of those studies, baseline seismic, CSEM and MT, and microgravity data were acquired around MRYS and the associated coal mine. Overcoming data acquisition challenges associated with Nelson Lake in the study area, electrical infrastructure around the plant, noise from mine activities, complex near-surface conditions associated with reclaimed mine land, high wind speed, and extremely cold temperatures, data processing, modeling, and inversion of the baseline geophysical data demonstrated the importance of high-quality data for a CO_2 geophysical monitoring program.

B. Stratigraphic Test Wells

Wells provide the only means to physically sample and test (in situ) reservoir and seal formations. Factors that can impact well-drilling decisions include 1) sparseness or lack of existing wells within or near the storage reservoir and/or area of review (AOR), 2) significant uncertainty—based on the totality of existing site characterization data—regarding geologic sequence or structure within and near the storage reservoir and/or AOR, and 3) identified need for an infrastructure well (Wildgust and others, 2019). Because of the scarcity of offset wells near MRYS and insufficient existing data, the need for one or more test wells was identified during Phase II (Peck and others, 2019).

North Dakota issues stratigraphic test well permits to test the viability of and gain additional information about a subsurface formation (Department of Mineral Resources, 2024). In addition, the county issues a conditional use permit, after a public hearing held before the planning and zoning commission. Because the access and permitting processes involve local interaction (landowners/operators and county commissioners) and the sight of a drilling rig in coal country is eye-catching, outreach and education efforts are recommended prior to well drilling. For this purpose, a fact sheet about drilling and a site sign, adjustable to show drilling progress, were developed (Appendix B).

Minnkota drilled two stratigraphic test wells in 2020, with the primary objective to extract physical core and petrophysical log data for the two storage complexes. The data collected provided important information for guiding the design and operation of site equipment and infrastructure and contributed to an accurate representation of the subsurface via geologic models of injection and containment intervals at the Tundra SGS site.

J-LOC 1 (NDIC Well File No. 37380): Minnkota submitted a drilling permit application to DMR O&G on January 29, 2020, and the permit to drill was authorized on February 10, 2020. Under a separate but complementary project funded by the NDIC LRP, the stratigraphic test well was spudded on May 14, 2020' drilled to the Precambrian (10,470 ft) on June 10, 2020; reentered December 2, 2020 to perform injection testing; completed to Class VI standards (NDCC § 43-05-01-11) on December 17, 2020; and temporarily abandoned (Department of Mineral Resources, 2024). J-LOC 1 is located 1.55 mi southwest of the city of Center, North Dakota (Figure 4). The injection testing program was conducted under a separate but complementary project to the DOE CarbonSAFE program to gain information for the Class VI SFP permit application and for use in Minnkota's Project Tundra initiative.

J-ROC 1/Liberty-1 (NDIC Well File No. 37672): Minnkota submitted a drilling permit application to DMR O&G on August 14, 2020, and the permit to drill was authorized on August 25, 2020. Under the DOE CarbonSAFE program, J-ROC 1 was spudded on September 8, 2020; drilled to the Precambrian (9871 ft); and drilling was completed on October 18, 2020 (Figure 11). The well was successfully plugged and abandoned (P&A) in accordance with NDAC § 43-02-03-34 on October 26, 2020. A permit to reenter the well was approved March 11, 2022, with plans to convert to a Class VI injection well. J-ROC 1 was renamed Liberty-1 on March 22, 2022. The well permit was renewed in 2023 and 2024. Liberty-1 (sink) is located adjacent to MRYS (source), making the location and operations unusual compared to most oil and gas wells (Figure 4). An extensive coring, logging, and wireline testing program was conducted under the DOE CarbonSAFE program to gain information for the Class VI SFP permit application and for use in Minnkota's Project Tundra initiative. Table 2 provides a listing of key dates associated with the J-ROC 1/Liberty-1 well.

Figure 11. Drilling rig at J-ROC 1 test well.

Table 2. Key Dates Associated with the J-ROC 1/ Liberty-1 Well

Event/Milestone	Date
Application for Permit to Drill (APD) Submitted	8/14/2020
APD Approved	8/25/2020
Well Spud	9/8/2020
Drilling Completed	10/18/2020
P&A	10/26/2020
APD Approved for Reentry	3/11/2022
APDs Approved for McCall and Unity	3/11/2022
Sundry Form for Well Name Change	3/18/2022
Sundry Form for Permit Renewal	2/28/2023
Sundry Form for Permit Renewal	3/8/2024

C. Characterization of Geologic Core Samples

In addition to precisely targeted geologic data acquired during well-logging activities, test wells enable acquisition of core, drill cuttings, and fluid samples (Wildgust and others, 2019). Core samples provide essential information about the geologic properties of the reservoir rock and upper and lower confining zones, such as porosity, permeability, and rock composition. Understanding these properties helps to determine the feasibility of storing CO_2 in the subsurface and estimating the storage capacity.

J-ROC 1/Liberty-1 Well

J-ROC 1 was drilled to a depth of 9871 ft, reaching the Precambrian basement rock. Data collection activities in J-ROC 1 included coring of the two storage reservoirs (i.e., the Broom Creek and Deadwood Formations) as well as the overlying and underlying sealing formations. A total of 1207 ft of 4-inch whole core was collected in J-ROC 1, with 380 ft of Broom Creek storage complex (Opeche–Picard – Broom Creek – Amsden) and 555 ft of Deadwood complex (Icebox – Deadwood – Precambrian). The main goal of this well was to obtain cores from the potential CO_2 injection reservoirs. Coring was a success, with most cores recovering close to 100%. The collected core was processed by the drilling/coring company and sent to the EERC for laboratory analyses.

At J-ROC 1, the Broom Creek Formation is made up of 81 ft of sandstone, 77 ft of dolostone, and 58 ft of dolomitic sandstone and is located at a depth of 4740 ft. At J-ROC 1, the Deadwood C-sand member is made up of 50 ft of sandstone and is located at a depth of 9548 ft. The Deadwood E member and Black Island Formation are made up of 69 ft of sandstone and 19 ft of dolostone and limestone at J-ROC 1 and are located at a depth of 9283 ft.

J-LOC 1 Well

At J-LOC 1, 306 ft of core was collected from the Broom Creek Formation comprising 202 ft of sandstone, 33 ft of carbonates, and 71 ft of anhydrite. Nearly 500 ft of core was collected in the Black Island and Deadwood storage reservoirs comprising 255 ft of sandstone, 31 ft of dolostone, and 200 ft of carbonates.

The cores collected from both J-ROC 1 and J-LOC 1 were analyzed to characterize the lithologies of the storage complexes and correlated to well log data. Core analysis also included porosity and permeability measurements, x-ray diffraction (XRD), x-ray fluorescence (XRF), relative permeability testing, thin-section analysis, capillary entry pressure measurements, and triaxial geomechanics testing. The results were used to inform geologic modeling, predictive simulation inputs and assumptions, geochemical modeling, and geomechanical modeling.

The knowledge gained from these site-specific core data analyses and well logs collected from the stratigraphic test wellbores were used to determine Broom Creek and Deadwood Formation lithologies in legacy wellbores throughout the area for which no core data were collected. Lithologies assigned to each wellbore were then used to generate the lithofacies properties of the injection zones. Offset wells with porosity logs were used to inform petrophysical property distributions in addition to the core data. The various datasets derived from site-specific information showed good agreement with the offset well data available near the J-LOC 1 site.

D. Well-Logging and Downhole Testing

The downhole sampling and measurement program focused on the proposed storage complexes (i.e., the Opeche–Picard, Broom Creek, and Amsden Formations and the Black Island and Deadwood Formations). The acquired well logs (from stratigraphic test wells) were used to pick formation top depths, interpret lithology, estimate petrophysical properties, and determine a time–depth shift for the seismic data. Regional formation top depths from wellbores around the proposed storage site were added to these existing site-specific data to understand the geologic extent, depth, and thickness of the subsurface geologic strata. Lateral structure trends from the acquired seismic data were used to reinforce interpolation of the formation tops to create structural surfaces which served as inputs for geologic model construction.

Openhole wireline geophysical well logs were acquired in J-ROC 1 along the entire open section of the wellbore. The logging suite included caliper, gamma ray (GR), density, porosity, dipole sonic, resistivity, combinable magnetic resonance (CMR) spectroscopy, and fracture finder or image log. The acquired well logs were used to pick formation top depths and interpret lithology and petrophysical properties and create synthetic seismic traces for tying depth to time. The site-specific formation top depths were added to the existing data of 109 wellbores within the 5500-mi^2-area covered by the Broom Creek Formation model and 13 wellbores within a 56-mi radius of the study area in the Deadwood Formation model to understand the geologic extent, depth, and thickness of the subsurface geologic strata. The formation top depths were interpolated to create structural surfaces which served as inputs for geologic model construction.

1. Geophysical Well Logs

Openhole and cased-hole wireline logs were collected in the J-ROC 1 surface section. The openhole logs were run after drilling the surface section to 2000 ft MD (measured depth). The cased-hole logs were run after drilling was completed in the Precambrian at 9871 ft. A suite of openhole wireline logs was also collected in the long-string section. The logging suite included the following:

- Caliper
- GR, density, porosity (neutron, density), and resistivity
- Sonic
- CMR log
- Spectral GR
- Formation microimager (FMI) log

2. Downhole Testing and Sampling/MDT Saturn Probe: Formation Pressure, Temperature, and Fluid Sampling

The proposed downhole testing and sampling plan called for fluid sampling in the Inyan Kara, Broom Creek, and Deadwood Formations as well as formation pressure testing and stress testing in the proposed storage horizons and respective cap rocks. Based on hole conditions, the drilling team was unable to acquire fluid samples and formation pressure tests from the Broom Creek and Deadwood Formations. Stress testing was not attempted after the MDT (modular formation dynamics tester) Saturn Probe became stuck in transition between the Inyan Kara Formation fluid sample and the Opeche Formation pressure test.

Formation pressure testing was successful in the Inyan Kara Formation. Formation pressure testing with the MDT tool allowed for calculation of a formation pressure gradient. The MDT tool also collects a temperature reading after each formation pressure test. These measurements were used to derive an Inyan Kara Formation temperature gradient. A fluid sample collected from 3845 ft was analyzed by Minnesota Valley Testing Laboratories, a state-certified lab, and confirmed by the EERC. The sample measured 27,900 mg/L total dissolved solids (TDS) in the Inyan Kara.

The proposed downhole testing and sampling plan for J-ROC 1 was previously completed under a separate project on the nearby J-LOC 1 well. Because these datasets were successfully collected from J-LOC 1, the unsuccessful testing and sampling on J-ROC 1 did not impact the ability to successfully complete the Class VI permit applications.

3. Seismic Data and Well Logs

Well logs and core analysis techniques can be used to develop a detailed understanding of near-wellbore geologic features and properties to support assessments of capacity, injectivity, and seal effectiveness. However, correlation and interpretation between wells may be challenging, since discrete samples represent an extremely small portion of the subsurface and may not be representative of the storage formation. By pairing well-based measurements (which can be regarded as 1D) with geophysical investigations such as surface-based 2D and 3D seismic surveys, extensive information regarding spatial variations in subsurface geology between and beyond wells can be ascertained (Glazewski and others, 2017).

The 3D seismic data coupled with the J-LOC 1 and J-ROC 1 well logs were used to interpret surfaces for the formations of interest within the survey area. These surfaces were converted to depth using the time-to-depth relationship derived from the J-LOC 1 and J-ROC 1 sonic logs. The depth-converted surfaces for the storage reservoir and upper and lower confining zones were used as inputs for the geologic model. These surfaces captured detailed information about the structure and varying thickness of the formations between wells. Interpretation of the 3D seismic data suggested there are no major stratigraphic pinch-outs or structural features with associated spill points in the Tundra SGS area. No structural features, faults, or discontinuities were observed in the seismic data that would cause a concern about seal integrity in the strata above the Broom Creek Formation extending to the deepest USDW, the Fox Hills Formation.

E. Injection Test

In December 2020, under a separate but complementary project, formation well testing was performed in J-LOC 1 specifically to characterize the injectivity of the Broom Creek and Deadwood Formations and gain information for the SFP applications. Injectivity testing is not specifically required under the North Dakota Class VI program; however, it is an option that can be used to verify hydrogeologic characteristics of the injection zone prior to injection well operation (NDAC § 43-05-01-11.2). Based on the timing (i.e., performed on a stratigraphic test well and not prior to injection well operation) and the high cost of the testing, it may seem an irregular choice. However, as described below, the tests yielded exceptionally high permeability results for the Broom Creek Formation and high permeability results for the Deadwood Formation. These permeability results increased storage capacity assessments and, in turn, resulted in a reduction in the number of necessary injection sites by half. Therefore, the costly injectivity testing proved to be cost-saving by resulting in a smaller project area, reducing the number of landowners involved in pore space leasing, consolidating surface facilities and CO_2 distribution systems, creating a smaller monitoring area, and minimizing environmental risks and impacts (Belobraydic and Smith, 2022).

The well testing in J-LOC 1 consisted of a step rate test (SRT), extended injection test, and pressure falloff test. The SRT provided fracturing pressure which, in turn, was used to establish maximum bottomhole injection pressure. The constant rate injection test and pressure falloff yielded kh (rock permeability-thickness), an important value in predicting CO_2 injection pressure and assisted in developing the reservoir model for the future CO_2 injection. The most important outcome of this operation is the successful recording and recovery of the downhole gauge information and recording surface pressures as a backup. In the Broom Creek Formation, the well was perforated from 4912 to 4922 ft with 4 shots per foot (spf) and 90° phasing. To record the bottomhole pressure, a tandem downhole memory gauge was installed at a depth of 4862 and 4868 ft. The well test data were interpreted by GeothermEx, a SLB Company.

Water blended with potassium chloride (KCl) was injected into the potential CO_2 storage reservoir, and a 12-hour extended injection rate test was performed at a constant rate of 5 barrels per minute (bpm) followed by a 24-hour pressure falloff test. The interpretation of the pressure falloff data showed a permeability of 4485 mD, with reservoir pressure of 2410 psi. No lateral boundary was observed from the pressure falloff test within the radius of investigation of 24,804 ft. Broom Creek Formation well testing is summarized in Table 3.

Table 3. J-LOC 1 Broom Creek Formation Test Summary

Parameters	Value	Unit
Reservoir Pressure	2410	psi
Permeability	4485	mD
Radius of Investigation	24,804	ft
Type of Boundary	Infinite acting	
Fracture Opening Pressure	3424	psi

In the Deadwood Formation, the well was perforated, and to record the bottomhole pressure, a downhole memory gauge was installed at a depth of 9855 ft. The well test data were interpreted by GeothermEx. The SRT was performed with a total of ten injection rates. The initial injection rate was 2.00 bpm, and the final injection rate was 10.5 bpm. From the SRT evaluation, no definitive analysis can be concluded from this test, but injection at the higher rate was below fracture opening pressure.

Water blended with KCl was injected into the potential CO_2 storage reservoir, and a 12-hour extended injection rate was performed at a constant rate of 4.5 bpm followed by a 24-hour pressure falloff test. Pressure falloff data interpretation showed a permeability of 1621 mD, with reservoir pressure of 4521 psi. There was no lateral boundary observed from the pressure falloff test within the radius of investigation of 9183 ft. Deadwood Formation well testing is summarized in Table 4.

Table 4. J-LOC 1 Deadwood Formation Test Summary

Parameters	Value	Unit
Reservoir Pressure	4521	psi
Permeability	1621	mD
Radius of Investigation	9183	ft
Type of Boundary	Infinite acting	

F. Modeling and Simulation

Geologic models provide a means to aggregate, interpret, and evaluate multiple datasets in context with one another. Models also provide a means to evaluate the performance of physical geologic systems under various operating scenarios, yielding key design criteria. Assessing storage site viability is supported by acquiring the site characterization data needed to build a representative model of the site geology and surrounding environment. The geologic model is then used to conduct predictive dynamic simulations and support risk assessments that provide an optimal understanding of three critical factors: CO_2 storage resource, CO_2 injectivity, and CO_2 containment (Glazewski and others, 2017).

From planning through postclosure, each phase of a CO_2 storage project requires an understanding of dynamic behavior of the target reservoir and the injected CO_2. A preponderance of this understanding comes from dynamic simulation of the planned or actual CO_2 injection. Successful dynamic simulations hinge on the development of an accurate static geologic model. A well-informed geologic model will include components that accurately integrate information about geologic structure, stratigraphy, petrophysical properties (e.g., porosity, permeability, etc.), faults, and other physical features. Constructing static models and using simulation to understand specific dynamic elements is critical to determining the long-term viability of any geologic storage project (National Energy Technology Laboratory, 2017b).

The EERC created a geologic model based on site characterization data, including seismic, core data, and well logs (Figure 12). Well log data were used to pick formation tops, interpret lithology, estimate petrophysical properties, and determine a time–depth shift for seismic data in the lower confining zones, the upper confining zones, and the injection formations. Geostatistics were used to distribute petrophysical properties throughout the confining zones. Seismic data were used to reinforce interpolation of the formation tops to create structural surfaces and to distribute lithologies and geologic properties in the model.

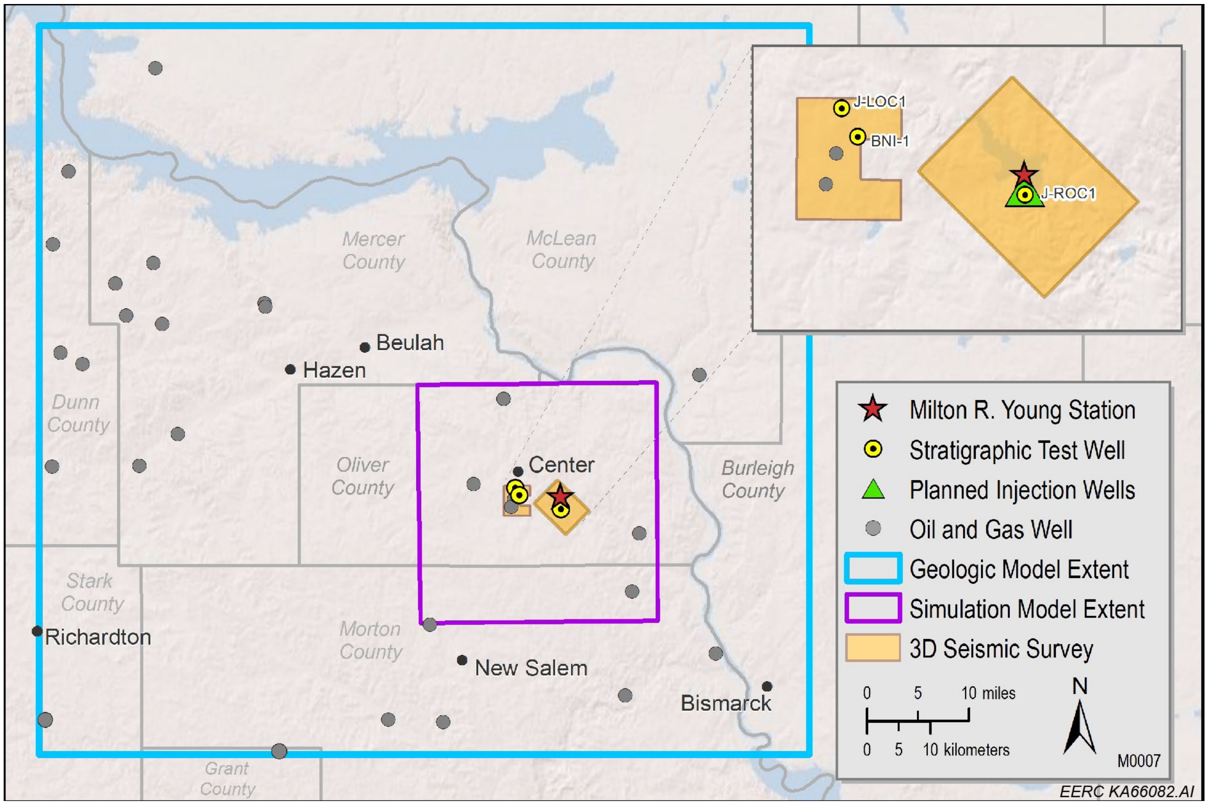

Figure 12. Map showing the 3D seismic surveys in relation to the extent of the regional geologic model, distribution of well control points, and extent of the simulation model.

Simulated CO_2 injection studies were conducted to determine the wellhead and downhole pressure response resulting from injection and disposition of injected CO_2 within the targeted injection formations. Reservoir conditions observed from the stratigraphic test wells were used to characterize and establish initial conditions. In the Broom Creek Formation, the target injection rate of 4.0 MMt for the first 15 years and 3.5 MMt per year for the last 5 years were consistently achievable over the 20 years of injection. A total of 77.5 MMt of CO_2 was injected into the Broom Creek Formation with two wells at the end of 20 years of simulated injection with the injected volume of 41.1 and 36.4 MMt for the Unity-1 and J-ROC1 wells, respectively. In the Black Island and Deadwood Formations, the resulting average injection rate of CO_2 injected over the 20 years of simulated injection was 1.17 MMt per year, with cumulative CO_2 injection at approximately 23.4 MMt over the 20 years of injection. Injection in the Broom Creek Formation exceeds the CarbonSAFE goal of 50 MMt of CO_2 injected within 30 years. The Broom Creek and Deadwood Formations combined (77.5 MMt + 23.4 MMt) amount to double the CarbonSAFE injection goal.

Results of the injection studies were then used to determine Tundra SGS's AOR pursuant to North Dakota's geologic CO_2 storage regulations. As defined at NDAC § 43-05-01 and as required for each SFP, the AOR "means the region surrounding the geologic sequestration project where underground sources of drinking water may be endangered by the injection activity." The AOR encompasses the region overlying the injected free-phase CO_2 and the region overlying the extent of formation fluid pressure increase sufficient to drive formation fluids (e.g., brine) into USDWs, assuming pathways for this migration (e.g., abandoned wells or fractures) are present. The minimum fluid pressure increase in the reservoir that results in a sustained flow of brine upward into an overlying drinking water aquifer is referred to as the "critical threshold pressure increase" and resultant pressure as the "critical threshold pressure."

1. Broom Creek AOR

Based on the reservoir pressure obtained from J-LOC 1, critical threshold pressure for the Broom Creek Formation exists prior to injection, i.e., the Broom Creek is overpressured. Overpressured formations have pore pressures higher than the hydrostatic pressure expected for a horizon at a specific depth. The implication of an overpressured formation is that reservoir fluids already have the potential to reach the lowermost USDW (i.e., Fox Hills Formation) in an open wellbore, even prior to planned CO_2 injection, resulting in an infinite AOR based on EPA definition.

Consequently, applying EPA (2013) methods to the Broom Creek Formation essentially results in an infinite AOR, which makes regulatory compliance infeasible. Applying the risk-based AOR (Burton-Kelly and others, 2021) essentially collapses to the areal extent of the CO_2 plume in the storage reservoir because the pressure buildup in the storage reservoir beyond the CO_2 plume is insufficient to drive formation fluids up a hypothetical leaky wellbore into the USDW. In addition, no indications of communication between the Broom Creek Formation and overlying Inyan Kara Formation were observed in the geologic model, and nothing in fluid samples indicated communication to USDWs. The predicted extent of the CO_2 plume from beginning to end of life of the project, at the time that the CO_2 plume ceases to migrate into adjacent cells of the geologic model, was used to define the AOR in this case. The minimum AOR is a 1-mi buffer extent beyond the storage facility area boundary (NDAC § 43-05-01) (Figure 13).

Risk-Based AOR Delineation

Several researchers recognized the need for alternative methods for estimating the AOR for locations that are already overpressurized relative to overlying aquifers. An alternative, Burton-Kelly and others (2021) proposed a risk-based reinterpretation of the EPA framework that would allow for a reduction in the AOR while ensuring protection of drinking water resources. An important distinction between EPA Methods 1 and 2, which both calculate a critical pressure threshold and the risk-based AOR approach, is that the risk-based approach 1) calculates and maps the potential incremental flow of formation fluids from the storage reservoir to the USDW that could occur and then 2) delineates the areal extent beyond which no significant leakage would occur. Therefore, the region beyond which no significant leakage would occur does not present an endangerment to the USDW; hence, the region inside of this areal extent is the risk-based AOR.

2. Deadwood AOR

Based on the reservoir pressure obtained from J-LOC 1, coupled with numeric simulations, the critical threshold pressure for this storage complex will be reached in the Black Island and Deadwood Formations during injection. The AOR shown in Figure 13 is the extent of the critical threshold pressure as determined using EPA (2013) methodology.

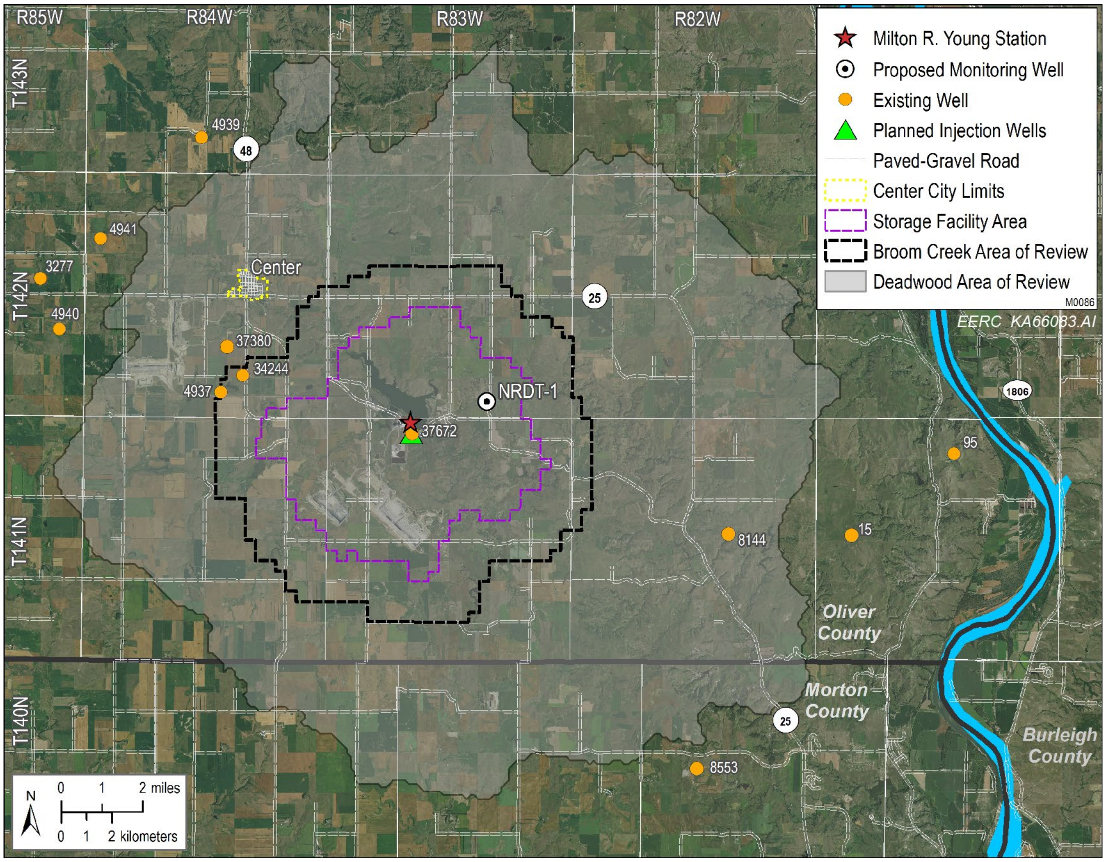

Figure 13. Map showing shared storage facility area for both the Broom Creek and Deadwood Formations and associated storage complexes.

The proposed horizontal boundaries of the storage reservoirs, including an adequate buffer area, are defined by the simulated migration of the CO_2 plume, using the actual rate of injection from the start until the end of injection. In establishing the definite boundaries of the storage facility area, Minnkota considered the characteristics and external factors influencing the operating life of the project, the opportunity for phased development of stacked storage facilities, and the coordinated operation of Broom Creek and Deadwood Formation storage facilities, if needed. The horizontal storage reservoir boundary is proposed using a 20-year injection period and was benchmarked off the maximum design life of the carbon capture equipment.

G. Near-Surface Characterization (Baseline Environmental Sampling)

The characterization of the near-surface environment informs the development of monitoring protocols that comply with North Dakota SFP requirements. The results generated help establish the required baseline monitoring of near-surface conditions and inform development of the required long-term monitoring program. The primary objective of the Tundra SGS sampling program is to establish baseline concentrations and seasonal variations in groundwater and soil gas chemistries (Figure 14). Near-surface sampling comprises 1) sampling of shallow groundwater

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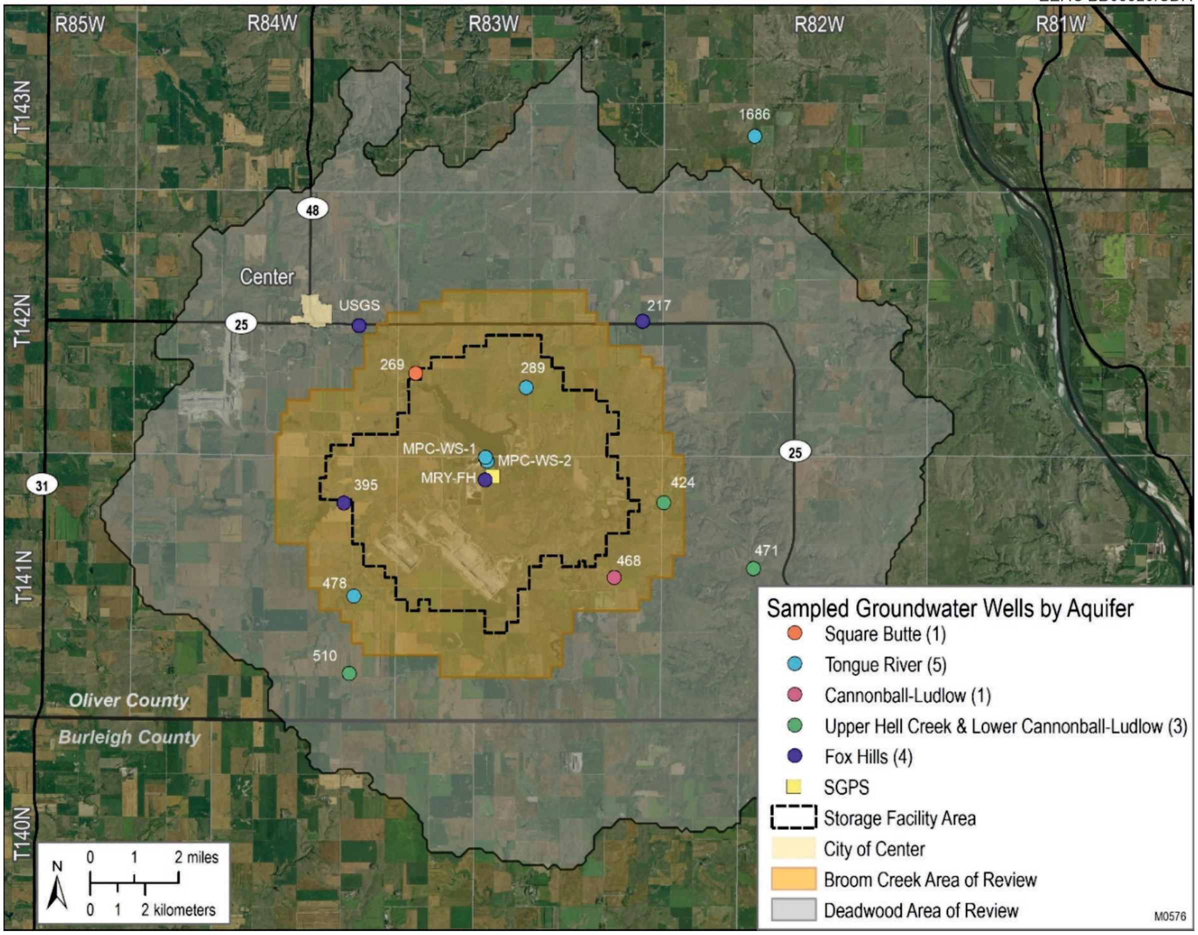

Figure 14. Groundwater samples collected by aquifer and soil gas profile station (SGPS) (Botnen and Crossland, 2022).

aquifers (<1010-ft depth in the study area) and 2) sampling of soil gas in the shallow vadose zone (<15-ft depth). Detailed analyses (both field and laboratory) were conducted on all samples. To capture seasonal variations in both environments, sampling events started in January 2021 and occurred approximately quarterly, ending in May 2023 (Figure 15) (Botnen and Crossland, 2023).

Sampling and chemical analysis of these zones provide reference concentrations of chemical constituents, including CO_2, and are used as part of a comprehensive subsurface-to-surface monitoring program. Long-term monitoring programs are conducted to comply with permitting requirements, provide a defensible source of data to show that near-surface environments are not adversely impacted by CO_2 injection, and/or provide timely identification of anomalies that could be indicative of an out-of-zone migration event should they occur (Botnen and Crossland, 2023).

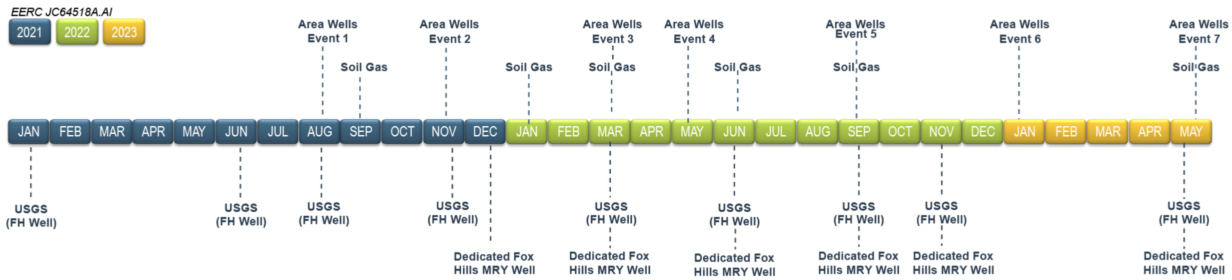

Figure 15. Timeline of baseline sampling activities (Botnen and Crossland, 2023).

Results for the groundwater portion of this baseline monitoring program indicated that while constituent concentrations vary by well and location, they remain consistent throughout the year, showing little to no seasonal variation. Results for key groundwater potential leakage indicators (pH, SpC [specific conductance], alkalinity, TDS) remain stable through all sample events.

The Minnkota Fox Hills well (USDW water well, Figure 5) installation was completed, and the well was sampled to establish a baseline, in December 2021.

Soil gas samples were collected in September 2021, January 2022, March 2022, June 2022, September 2022, and May 2023 to establish concentrations and measure potential seasonal variability. Results indicated that CO_2 concentrations generally increase with depth, along with a corresponding drop in O_2, and isotopic signatures show little variation. Natural seasonal variation was apparent in soil gas concentrations; however, all fell into what would be expected environmental ratios (Botnen and Crossland, 2023).

H. Storage Resource Management System (SRMS)

The Tundra SGS project is the first successfully permitted carbon storage facility in the United States where the primary source of CO_2 emissions is lignite coal used as fuel for electrical generation. Many factors converged to create the environment conducive to scaling up from feasibility to commercial viability, including foundational and ongoing work of the PCOR Partnership Program, North Dakota's regulatory primacy for UIC Class VI permitting, and Minnkota—a progressive leader in the development of next-generation energy technologies.

Figure 16 is a graphical representation of the Society of Petroleum Engineers (SPE) storage resources classification system. The system defines the major storage resource classes: Stored, Capacity, Contingent Storage Resources, and Prospective Storage Resources as well as Inaccessible Storage Resources. The "Range of Uncertainty" on the horizontal axis reflects a range of storable quantities, while the vertical axis represents the "Chance of Commerciality," which is the chance that the project will be developed and reach commercial storage status.

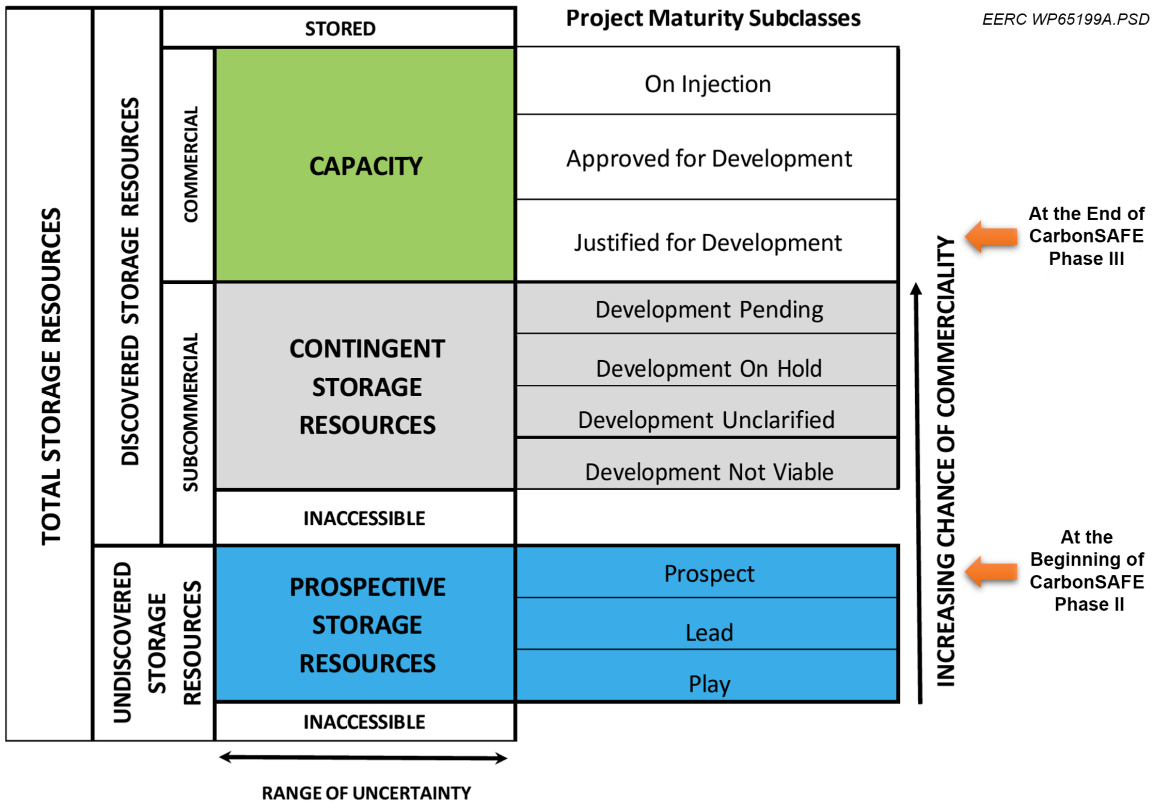

Figure 16. Maturation of project Tundra SGS as reflected on the SRMS resources classification framework (Society of Petroleum Engineers, 2017).

From the beginning of CarbonSAFE Phase II activities at this site in 2017 to the end of CarbonSAFE Phase III in 2024, the storage resource status for this project has progressed from Prospective – Prospect to Capacity – Justified for Development (Figure 16). Support for the current project status is provided by the following definition:

> **Capacity – Justified for Development:** Implementation of the development project is justified on the basis of reasonable forecast commercial conditions at the time of reporting, and there are reasonable expectations that all necessary approvals/contracts will be obtained.

IV. UIC CLASS VI PERMITTING

The North Dakota Class VI permitting program consists of two main parts: the SFP application (and resulting NDIC Orders) and the well permit for CO_2 injection. Table 5 shows key dates associated with both program parts.

Table 5. Key Dates Associated with SFP and Class VI Applications

Event/Milestone	Date
Draft SFP Applications Submitted	5/28/2021
Final SFP Applications Submitted	9/13/2021
Fact Sheet and Draft SFP Issued	9/23/2021
CSND SFP Hearing	11/2/2021
Hearing Supplemental Filings Submitted	11/16/2021
NDIC Orders Issued (SFP Approval)	1/21/2022
Amalgamation Effective	2/1/2022
Well Permit Applications Submitted	3/11/2022
Deep Monitoring Well Application Submitted*	10/2023

* Well is currently on "Confidential" status.

A. SFP Application

1. SFP Application Components

Minnkota prepared its SFP applications and supporting documentation to demonstrate that:

1) The proposed Tundra SGS site comprises injection zones of sufficient areal extent, thickness, porosity, and permeability to safely receive the planned injection volume and rates of CO_2 over 20 years.

2) The confining and secondary confining zones are free of transmissive faults and fractures and of sufficient areal extent and integrity to vertically contain the injected CO_2 at the proposed pressures and volumes without initiating or propagating fractures in the reservoir or confining zones.

These findings are supported by the available regional data and site-specific geologic data gathered from CSND Phases II and III characterization, including coring, logging, sampling, and testing the subsurface characteristics in the stratigraphic test wells.

Minnkota developed comprehensive construction and operations, testing and monitoring, injection well-plugging, and postinjection site care (PISC) and site closure plans as well as an emergency and remedial response plan to protect USDWs. To ensure that sufficient funds are available to undertake these actions, Minnkota has also developed a financial responsibility plan.

The entire SFP applications are available online as follows:

- TUNDRA SGS – CARBON DIOXIDE GEOLOGIC STORAGE FACILITY PERMIT – Broom Creek Formation; DMR-O&G Case No. 29029: www.dmr.nd.gov/dmr/sites/www/files/documents/Oil%20and%20Gas/Class%20VI/Minnkota/BC/C29029.pdf

- TUNDRA SGS – CARBON DIOXIDE GEOLOGIC STORAGE FACILITY PERMIT – Deadwood Formation; DMR-O&G Case No. 29032: www.dmr.nd.gov/dmr/sites/www/files/documents/Oil%20and%20Gas/Class%20VI/Minnkota/DW/C29032.pdf

The Minnkota SFP applications include the following five sections: 1) pore space access, 2) geologic exhibits, 3) AOR exhibits, 4) supporting permit plans, and 5) injection well and storage operations plus appendixes (Table 6). These five sections should be presented in this order as it comports with the general order of presentations that are typically made during the testimony provided at the administrative hearing, which is part of the regulatory process required for approval of the SFP application (Anagnost and others, 2022).

Table 6. Tundra SGS SFP Application Sections and Contents

SFP Section No.	SFP Section Name	Contents
PS	Permit Application Summary	• Project Overview
1	Pore Space Access	• Storage Reservoir Pore Space • Persons Notified
2	Geologic Exhibits	• Overview of Project Area Geology • Data and Information Sources • Storage Reservoir • Confining Zones • Faults, Fractures, and Seismic Activity • Potential Mineral Zones
3	Area of Review (AOR)	• AOR Delineation • Corrective Action Evaluation • Reevaluation of AOR and Corrective Action Plan • Protection of USDWs
4	Supporting Plans	• Testing and Monitoring Plan • Emergency and Remedial Response Plan • Financial Assurance Demonstration Plan • Worker Safety Plan • Well Casing and Cementing Plan • Well Plug and Abandonment Program • PISC and Facility Closure Plan
5	Injection Well and Storage Operations	• Proposed Completion Procedure to Conduct Injection Operations • Proposed Completion Procedure for Broom Creek CO_2 Injectate Well • Logging and Testing Program • Blowout Preventer Equipment

Appendix A	Data, Processing, and Outcomes of CO_2 Storage Geomodeling and Simulations	Appendix B	Well and Well Formation Fluid-Sampling Laboratory Analysis
Appendix C	Near-Surface Monitoring Parameters and Baseline Data	Appendix D	Testing and Monitoring – Quality Control and Surveillance Plan
Appendix E	Risk Assessment Emergency Remedial and Response	Appendix F	Corrosion Control Matrix
Appendix G	Financial Assurance Demonstration Plan	Appendix H	Surface Use and Pore Space Lease
Appendix I	Storage Facility Permit Regulatory Compliance		

1.A. Pore Space Access

North Dakota law explicitly grants title of the pore space in all strata underlying the surface of lands and waters to the overlying surface estate, i.e., the surface owner owns the pore space (NDCC § 47-31-03). Furthermore, prior to initiating the storage of CO_2, the applicable North Dakota statute mandates that the storage operator obtain consent of landowners who own at least 60% of the pore space of the storage reservoir (NDCC § 38-22-08).

The statute also mandates a good faith effort be made to obtain consent from all pore space owners and that all nonconsenting pore space owners are or will be equitably compensated. North Dakota law grants NDIC the authority to require pore space owned by nonconsenting owners to be included in a storage facility and subject to geologic storage through pore space amalgamation. The concept of amalgamation is based upon the established pooling and unitization practices used to join various mineral interests (either voluntary or compulsory) in a specific reservoir to increase the ultimate recovery of oil and gas. Amalgamation of pore space is considered at the administrative hearing as part of the regulatory process required for consideration of the SFP application.

Within the hearing notification area (comprising the storage facility area and within an additional 0.5 mi of its outside boundary), Minnkota identified the owners of record (surface and mineral), pore space and mineral lessees of record, and operators of mineral extraction activities and notified each in advance of the SFP administrative hearing. Within the prescribed hearing notification area, Minnkota made a good faith effort to obtain consent from all surface/pore space owners of the approximately 18,900 acres (plus buffer), and successfully secured voluntary consent from over 97% of the landowners by acreage.

A "Geologic Storage Agreement and Surface Use and Pore Space Lease" was used to document consent, including associated terms such as compensation, amalgamation, damages, and other terms.

2. SFP Regulatory Process

After compilation of the foregoing information, amounting to over 1300 pages, along with modeling and simulation electronic files, Minnkota submitted two draft SFP applications (650 pages each), one for the Broom Creek Formation and one for the Deadwood Formation, on May 28, 2021. NDIC staff reviewed the applications and checked the information against regulatory requirements. This technical completeness review is iterative and followed by a consultative review by the North Dakota Department of Environmental Quality. Upon determination that the SFP application is complete, it is docketed, the hearing date is set, and required notifications are given.

At the hearing (Figure 17), expert testimony was given and DMR O&G staff asked questions and requested supplemental information, leaving the administrative hearing record open until the deadline for receipt. Once all the facts were gathered and carefully considered into findings, orders were issued and signed by NDIC (comprising the governor, attorney general, and agriculture commissioner).

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Figure 17. Photo of November 2, 2021, Tundra SGS SFP public hearing (courtesy of Minnkota, www.projecttundra.com/news).

For each Minnkota SFP application submitted, NDIC issued three orders on January 21, 2022—less than 8 months from the draft application submittals on May 28, 2021, and approximately 4 months from determination that the application was complete. The types and numbers of the orders are listed below.

a) Geologic Storage in Storage Reservoir

Orders authorizing geologic storage of CO_2 from MRYS in the amalgamated storage reservoir pore space of the Broom Creek Formation, creating the Minnkota Center MRYS Broom Creek Storage Facility No. 1 (Order No. 31583 is available online here: www.dmr.nd.gov/dmr/sites/www/files/documents/Oil%20and%20Gas/Class%20VI/Minnkota/BC/or31583.pdf), and in the Deadwood Formation, creating the Minnkota Center MRYS Deadwood Storage Facility No. 1 (Order No. 31586 is available online here: www.dmr.nd.gov/dmr/sites/www/files/documents/Oil%20and%20Gas/Class%20VI/Minnkota/DW/or31586.pdf).

b) Amalgamation of Storage Reservoir Pore Spacing

Orders determining the amalgamation of storage reservoir pore space, pursuant to a geologic storage agreement for use of pore space falling within the designated portions of Oliver County, North Dakota, in the Broom Creek (Order No. 31584 is available online here: www.dmr.nd.gov/dmr/sites/www/files/documents/Oil%20and%20Gas/Class%20VI/Minnkota/BC/or31584.pdf) and Deadwood (Order No. 31587 is available online here: www.dmr.nd.gov/dmr/sites/www/files/documents/Oil%20and%20Gas/Class%20VI/Minnkota/DW/or31587.pdf) Formations, have been signed, ratified, or approved by owners of interest owning at least 60% of the pore space interest within said lands. The amalgamation of pore space in the Minnkota Center MRYS Broom Creek Storage Facility No. 1 and the Minnkota Center MRYS Deadwood Storage Facility No. 1 is effective February 1, 2022.

c) Determination of Financial Responsibility

Orders determining the amount and adequacy of instruments of financial responsibility, required to be maintained by Minnkota for the geologic storage of CO_2 from MRYS in the amalgamated storage reservoir pore space located in portions of Oliver County, North Dakota, in the Broom Creek (Order No. 31585 is available online here: www.dmr.nd.gov/dmr/sites/www/files/documents/Oil%20and%20Gas/Class%20VI/Minnkota/BC/or31585.pdf) and Deadwood (Order No. 31588 is available online here: www.dmr.nd.gov/dmr/sites/www/files/documents/Oil%20and%20Gas/Class%20VI/Minnkota/DW/or31588.pdf) Formations. Financial responsibility is provided for the same wells and lands in the Minnkota Center MRYS Broom Creek Storage Facility No. 1 and the Minnkota Center MRYS Deadwood Storage Facility No. 1.

B. CLASS VI WELL INJECTION PERMITS

The final regulatory approval necessary prior to beginning injection operations at a storage facility is an approved permit for CO_2 injection. The permit application for Liberty-1 is a request for approval to convert and operate a temporarily abandoned stratigraphic test well after verification of construction to Class VI well integrity requirements as a CO_2 injection well. As of December 2023, Minnkota has filed three APDs—Liberty-1, Unity-1, and McCall-1—associated with the approved SFPs for both storage complexes. All three APDs were approved March 11, 2022, to begin drilling operations. The permitting process from stratigraphic characterization well through anticipated receipt of a permit to operate a CO_2 injection well is shown in Figure 18.

V. ADDITIONAL REGULATORY REQUIREMENTS

A. Greenhouse Gas Reporting Program

1. MRV Plan Development

EPA's Greenhouse Gas Reporting Program (GHGRP) collects key information regarding the supply, underground injection, and geologic sequestration of CO_2 in the United States. EPA developed guidelines and requirements for the reporting of CO_2 stored in geologic formations ("Geologic Sequestration of Carbon Dioxide: Subpart RR") as quoted below:

> "Under subpart RR of the Greenhouse Gas (GHG) Reporting Program, facilities that conduct geologic sequestration of carbon dioxide (CO_2) must report basic information on the amount of CO_2 received for injection; develop and implement an EPA-approved monitoring, reporting, and verification (MRV) plan; and report the amount of CO_2 sequestered using a mass balance approach and annual monitoring activities."

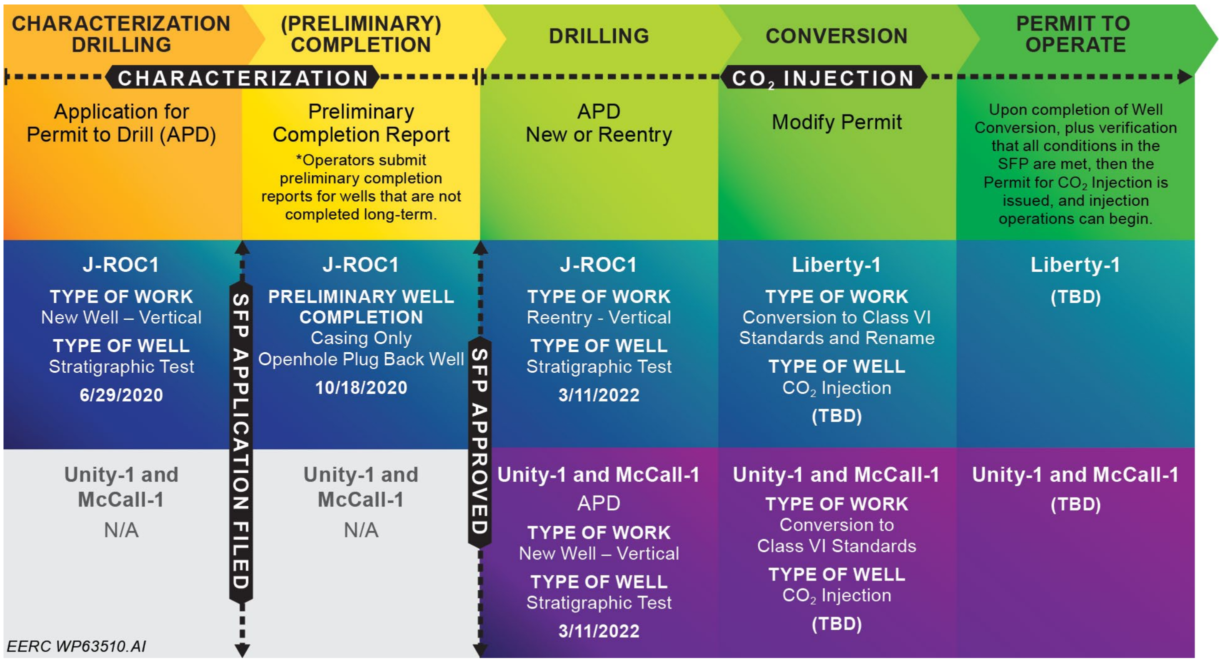

Figure 18. North Dakota well-permitting process in general (top row) and specific to Tundra SGS proposed injection wells (Anagnost and others, 2022).

Facilities must submit and receive approval for an MRV plan before they can report data under Subpart RR. Once the plan is approved, facilities report basic information on CO_2 received for injection, data related to the amounts of CO_2 sequestered, and annual monitoring activities. The Minnkota MRV plan was approved April 5, 2022, making it the first MRV plan approved in North Dakota. The link to the approved plan is provided here: www.epa.gov/ghgreporting/tundra-sgs-llc. Key dates associated with Minnkota's MRV plan are listed in Table 7.

Table 7. Project Tundra MRV Plan Key Dates

Event/Milestone	Date
Initial MRV Submission to EPA	11/9/2021
Received MRV Revisions from EPA	12/13/2021
Resubmission to EPA	12/20/2021
Received Revisions from EPA	1/27/2022
Final Submission to EPA	3/2022
Acceptance of MRV	4/5/2022

2. *MRV Plans and 45Q Tax Credits*

Under 26 U.S. Code (USC) § 45Q, developers of CCS projects may qualify for credit equal to the sum of CO_2 volumes captured and permanently stored in the subsurface in the taxable year. With the acceptance the of MRV plan, Project Tundra is eligible for 45Q tax credits once CO_2 injection is initiated. Commercial project incentives were boosted on August 16, 2022, with passage of the Inflation Reduction Act. One of the substantial provisions is the creation of a "direct payment" option for electric cooperatives to use energy tax credits. Historically, cooperatives like Minnkota did not have direct access to those credits because of their not-for-profit status. Direct pay coupled with the increase from $50/ton to $85/ton for Section 45Q tax credits helped to improve the economics of CCS projects. Table 8 provides key information about the tax credit.

Table 8. Key Elements of the Section 45Q Credit

Equipment Placed in Service After 12/31/2022 and Construction Beginning Prior to 1/1/2033	
Credit Amount (per metric ton of CO_2)	Base credit of $17/Mt of CO_2, increased to $85 for facilities that pay prevailing wages during the construction phase and during the first 12 years of operation and meet registered apprenticeship requirements. Amounts adjusted for inflation after 2026.
Claim Period	12-year period once facility is placed in service, reduced to 5-year period if transferred.
Annual Capture Requirements	Power plants: Capture at least 18,750 Mt and a capture design capacity not less than 75% of baseline emissions.
Eligibility to Claim Credit	Entity who owns the capture equipment and physically or contractually ensures the disposal, utilization, or use as a tertiary injectant of the CO_2. Certain tax-exempt entities can claim the tax credit through "direct pay" and other entities are allowed a one-time transfer to another entity.

Source: Congressional Research Service (2023).

As of October 5, 2023, a total of 13 projects were reporting under Subpart RR, including 11 CO_2 enhanced oil recovery (EOR) projects and two dedicated storage projects (www.epa.gov/ghgreporting/subpart-rr-annual-monitoring-reports).

B. NEPA: Future CarbonSAFE Phase IV

As part of CarbonSAFE Phase III, Minnkota submitted an environmental information volume (EIV) for the future Phase IV: Construction project. An EIV includes a higher level of detail about the project and its impacts. DOE uses the EIV to determine the appropriate level of NEPA review for Phase IV—either an EA or an environmental impact statement (EIS). The NEPA document commenced when the determination was made and all parties have sufficient empirical data to support the analysis (Fayish, 2023). In October 2022, DOE determined that Project Tundra required an EA, and Minnkota engaged a third party (Burns & McDonnell) to assist in preparation.

The draft EA (DOE/EA-D2197) was published by DOE in August 2023 for public review, and DOE received numerous comments. Because of the increased level of public interest and number of comments received, DOE prepared a response document and reissued the draft EA (revised draft EA) in April 2024. The revised draft EA evaluated the resource areas DOE commonly addresses and identified no significant adverse impacts. An additional 30-day comment period was provided to allow comments on the edits to the draft EA and draft FONSI. DOE reviewed comments and responses and issued a FONSI for the proposed North Dakota CarbonSAFE: Project Tundra on September 13, 2024.

Table 9 shows key dates associated with Minnkota's EIV and EA filings. For more information about the draft EA, revised draft EA, and the FONSI that assess the potential environmental impacts of DOE providing cost-sharing financial assistance to Minnkota for North Dakota CarbonSAFE: Project Tundra (DOE/EA-2197), visit https://netl.doe.gov/node/6939.

Table 9. Key NEPA Dates

Event/Milestone	Date
Draft EIV Submitted to DOE	4/12/2022
Final EIV Submitted to DOE	9/1/2022
EA Determination by DOE	10/21/2022
Draft EA Published by DOE	8/19/2023
Public Comment Period Ends	9/19/2023
Revised Draft EA and Draft FONSI Published by DOE	4/13/2024
Public Comment Period Ends	5/13/2024
FONSI Issued	9/13/2024

VI. OUTREACH AND COMMUNITY BENEFITS PLAN

A. Outreach

Public outreach for the proposed CO_2 storage project addressed a wide variety of stakeholders and stakeholder groups through activities designed to inform, educate, and communicate with the local and regional audiences (Figure 19). The outreach goal is to foster an environment that helps stakeholders make informed decisions regarding their attitude toward the planned CCS project, with the aim of neutral-to-positive opinions on the project. Areas of focus included stakeholder engagement activities and production and dissemination of informational materials. Various stakeholder groups targeted for engagement included local and regional officials, landowners and residents, industry employees and stakeholders (e.g., electric cooperative members), and educators.

There are several key points for interacting with the public during the routine progression of each CCS project. These include announcing the test location and initiating site activities (e.g., seismic testing and drilling), applying for an injection permit, injection activities, and project closure (National Energy Technology Laboratory, 2017a). Appendix B, Table B-1, provides a listing of several high-visibility outreach interactions and associated engagement activities.

Figure 19. Mac McLennan (left), Minnkota President and CEO, explains to a landowner on May 5, 2021, how CO_2 will be safely and permanently stored in geologic formations (photo courtesy of Minnkota, www.projecttundrand.com).

B. Community Benefits Plan

DOE requires community benefits plans (CBPs) as part of all Bipartisan Infrastructure Law (BIL) and Inflation Reduction Act (IRA) funding opportunity announcements (FOAs) and loan applications. Although CarbonSAFE Phase III was not funded as part of BIL and IRA, future CarbonSAFE projects under FOA No. DE-FOA-0002711 will be. For this reason, a CBP was prepared as part of the Phase III activities.

CBPs are based on a set of four core interdependent policy priorities:

1. Engaging communities and labor.

2. Investing in America's workers through quality jobs.

3. Advancing diversity, equity, inclusion, and accessibility (DEIA) through recruitment and training.

4. Implementing the Justice 40 Initiative (J40), which directs 40% of the overall benefits of certain federal investments to flow to disadvantaged communities (DACs).

These key principles, when incorporated comprehensively into projects and executed upon, will help ensure broadly shared prosperity in the clean energy transition.

1. *Community and Labor Engagement*

The Phase IV project should engage stakeholder groups in the community most impacted by and vulnerable to project development, ensuring that their voices are heard and that their needs are addressed. This includes seeking input, conducting consultations, and incorporating feedback throughout the project life cycle. Minnkota's goals and planned actions for Phase IV are set forth in Table 10 (Crocker and others, 2023).

2. *Investing in Job Quality and a Skilled Workforce*

The Phase IV project should outline strategies for investment in the development and advancement of the local workforce. This may include job training programs, apprenticeships, and initiatives that enhance the skills and employability of individuals in the community. This plan can serve as a road map for identifying, measuring, meeting, and tracking goals. Minnkota's goals and planned actions for Phase IV are set forth in Table 11 (Crocker and others, 2023).

3. *Diversity, Equity, Inclusion, and Accessibility*

The Phase IV project should foster a welcoming and inclusive environment; support people from groups underrepresented in science, technology, engineering, and mathematics (STEM), construction and operations workforces, and other applicable workforces; advance equity; and encourage the inclusion of individuals from these groups in all phases of the project. This plan should also discuss activities to ensure equitable accessibility to economic opportunities created from the project. Minnkota's goals and planned actions for Phase IV are set forth in Table 12 (Crocker and others, 2023).

Table 10. Community and Labor Engagement Goals and Planned Actions

Category and Goal	Action	Steps Forward	
Understand Interaction with Underrepresented Communities and DACs	Gather metrics that demonstrate engagement and possible gaps.	Develop a tracking system to include metrics that demonstrate engagement on an annual basis.	Adapt goals as needed.
Increase Two-Way Communication and Engagement Efforts with Tribal Nations Within Service Area	Provide focused studies, concepts, and exposure regarding the energy industry to Native American students.	Support University of North Dakota (UND) Indigenous students/engineering programs which engage students at tribal colleges.	
	Engage with tribal colleges regarding project goals and initiatives.	Sponsor a Native American student in Energy Hawks Program.	
	Support internships and educational opportunities.	Provide internships for students from tribal community colleges.	
Utilize Two-Way Engagement to Consider Solutions and Accommodate Community Needs	Establish an advisory group representing stakeholders.	Receive and address ongoing feedback on engagement efforts to advise decisionmakers throughout the project's lifespan.	
Landowner Meetings	Meetings held at least biannually to discuss any impacts from the project to their interests. Individual meetings, ad hoc.		

Table 11. Investing in Job Quality and a Skilled Workforce Goals and Planned Actions

Category and Goal	Action	Steps Forward
Establish Safety and Health Committee to Provide Feedback and Recommendations	Establish metrics to measure the effectiveness of safety and health plans.	Meet every 3 months. These metrics will be used to identify areas for improvement and to recognize areas of success.
At Least 50% of Workers Participate in at Least One Training or Educational Program	Establish partnerships with local educational institutions.	Provide training and educational opportunities to workers.
Develop a Set of Success Metrics	Measure employee turnover, productivity, and engagement.	Regularly track and report progress against these metrics throughout the project.
Ensure that Workers Have the Right to Form/Join Unions	Develop a plan to support workers' collective bargaining rights.	Goal of achieving activities with or exposure to union opportunities.
Negotiation of Workforce and Community Agreements	Meet with impacted unions, establish workforce and community agreement, as needed.	

Table 12. DEIA Goals and Planned Actions

Category and Goal	Action	Steps Forward
Increase DEIA Awareness and Knowledge Among Employees	Identify diversity-focused training opportunities for all employees.	Two DEIA trainings. Training attendance will be tracked and reported, with the goal of 100% participation.
Improve Effectiveness of Leaders Internally in DEIA Work	Training: awareness of implicit biases, effective leadership, and participation in diverse teams; how DEIA supports success.	Internal presentations will be digitally archived and shared to build DEIA knowledge and resources at Minnkota.
Build Partnerships with Tribal Colleges or other Minority-Serving Institutions	Participate in one STEM-focused community outreach event.	Contact multiple potential partners and explore opportunities to increase engagement. Sponsor a recruiting booth for internships as well as regular employment.
Subtitle an Existing Outreach Video in Spanish and English, Post on the Web	Update existing materials (videos, web posts, etc.) with subtitling, and create new materials for the project.	Increase outreach material accessibility.
Increase Collaboration with Minority-, Woman-, and Veteran Owned Businesses	Build and maintain comprehensive list of minority-, woman-, and veteran-owned businesses.	Goal: 20% of project contracts awarded to listed businesses.

4. Justice40 Initiative

CBPs should contribute to the J40 goal of ensuring that at least 40% of the overall benefits of clean energy investments flow to DACs (Figure 20). This ensures that the benefits of clean energy development are shared equitably, addressing historical disparities, and promoting social and economic justice. Minnkota's goals and planned actions for Phase IV are set forth in Table 13 (Crocker and others, 2023).

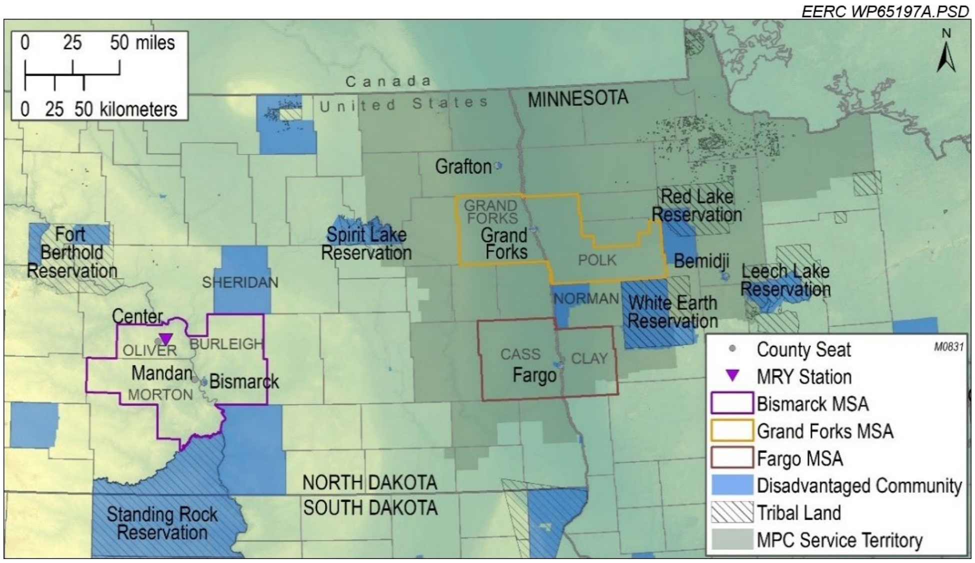

Figure 20. Map showing the Minnkota service territory and impacted DACs identified by the Energy Justice Mapping Tool, tribal lands, and metropolitan statistical areas (MSAs) (Crocker and others, 2023).

Table 13. J40 Workforce Goals and Planned Actions

Category and Goal	Action	Steps Forward
Assess/Mitigate Potential Increased Commute Times	Possible creation of a ride service.	Assess commute issues and community impact.
Decrease Energy Burden: Decrease Energy Poverty	Visit communities, highlight programs.	Document number of people contacted, number of new sign-ups.
Increase Energy Democracy: Existing Solar Projects	Document and distribute information regarding projects.	Completion and distribution of document.
Data Collection: High Non-Grid-Connected Heating	Gather information regarding heating in service territory.	Adjust J40 project and outreach activities as needed.
Increase Clean Energy Contracting with MBEs/DBEs*	Create database of territory MBE/DBE businesses.	Track MBE/DBE project engagement.
Increase Clean Energy Jobs, Pipeline, and Training	Make members of DACs aware of opportunities.	Track participants in job training, intern or apprenticeships, recruiting activities, number of jobs created/hired.
Education for Project Personnel	Attend one J40 training per year tracking who/when completed.	
Mitigate Increased Energy Burden	Track rates over project life, document increases and reasons to avoid project-related rate.	

* Minority-owned business enterprises (MBEs)/disadvantaged-owned business enterprises (DBEs).

VII. CO_2 SOURCE FEASIBILTY STUDY

From late 2019 through 2022, Minnkota executed a front-end engineering and design (FEED) study with Fluor's Econamine FG Plus[SM] (EFG+) technology (DE-FE0031845, https://netl.doe.gov/projects/project-information.aspx?p=fe0031845). As part of the FEED study, a steam-sourcing study was conducted that evaluated steam integration and natural gas auxiliary boiler options. Initially, a natural gas auxiliary boiler was selected during the pre-FEED study, as it presented lower technical risk and provided flexibility in plant operations; however, after detailed FEED design and cost estimating and after securing a commercial proposal for the natural gas supply, Minnkota elected to shift to steam extraction.

VIII. STORAGE FIELD DEVELOPMENT PLAN

In establishing the definite boundaries of the storage facility area, Minnkota considered the characteristics and external factors influencing the operating life of the project, the opportunity for phased development of stacked storage facilities, and the coordinated operation of Broom Creek and Deadwood Formation storage facilities. Minnkota defines the storage reservoir boundaries as the projected vertical and horizontal migration of the CO_2 plume from the start of injection until the end of injection. The storage reservoir boundary is identified based on the computational model output of the areal extent of the subsurface CO_2 volume at the end of the injection period (20 years), in which a CO_2 saturation is predicted to be greater than or equal to 5%. To identify the storage reservoir boundaries, reservoir simulation software was used to model the coupled hydrologic, chemical, and thermal processes and chemical interactions of CO_2 with the aqueous fluids and rock minerals. The storage reservoir extent is determined from the numerical model.

The Tundra SGS project is designed to securely store the injected CO_2 within the storage reservoirs. At MRYS, the captured CO_2 stream will be at least 99% purity, dehydrated, and compressed to about 1800 psi before entering the CO_2 flowline. Under these conditions, the CO_2 will be in a dense fluid phase, noncorrosive, and nonflammable. The approximately 0.25-mi flowline will be 16 in. in outer diameter and have a maximum design flow rate of 4.3 MMt/yr (224 MMscf/d).

Because of the short distance between the compressor and wellsite (0.25 mi), the CO_2 pressure is not anticipated to decrease significantly as the CO_2 travels the length of the flowline to the Tundra SGS site. The Broom Creek Formation injector wellhead pressure does not exceed 1600 psi. Surface injection pressure into the Deadwood Formation storage zone will be increased to 2800 psi using a booster pump downstream of the custody transfer metering station.

Postinjection monitoring will include a combination of groundwater monitoring, storage zone pressure monitoring, and geophysical monitoring of the Tundra SGS site. The monitoring locations, methods, and schedule are designed to show the position of the CO_2 plume and demonstrate that the CO_2 injected is within the storage reservoir and there is no endangerment to the USDWs. The proposed monitoring program includes one monitoring well, which covers each of the injection and above confining zones to verify that CO_2 has not migrated into that interval.

In addition, a groundwater well was completed at the Tundra SGS site in the Fox Hills Formation to monitor this lowermost federal USDW. Monitoring of the site will continue for a minimum of 10 years after injection has ceased.

IX. NEXT STEPS

Project Tundra is currently in the advanced engineering phase and focusing on financing efforts.

Mac McLennan, Minnkota President and CEO, has said, “Innovation is our path forward through the energy transition. Project Tundra has the potential to help pave the way toward a future where electric grid reliability and environmental stewardship go hand in hand.” A go/no-go decision to proceed with Phase 1, Construction and Operations in the Broom Creek Formation, is anticipated in 2024.

In June 2023, Minnkota announced that TC Energy, Mitsubishi Heavy Industries, and Kiewit joined the Project Tundra team. In July 2023, Minnkota received approval of a $150 million loan authorized by NDIC for Project Tundra. The funding is made available through the North Dakota Clean Sustainable Energy Authority and will be furnished by the Bank of North Dakota. In December 2023, DOE announced that it selected Project Tundra (Tundra Capture) as a recipient of BIL funding through its Carbon Capture Demonstration Projects Program in the Office of Clean Energy Demonstrations. In March 2024, Minnkota, through its subsidiary, DCC East Project LLC, submitted a proposal to the DOE Office of Fossil Energy and Carbon Management for North Dakota CarbonSAFE Phase IV: Construction.

DCC East Project LLC has stated that Tundra SGS a) is economically attractive, has a sound business case, and is publicly acceptable; b) has developed a comprehensive storage field development plan to optimize the defined capacity to safely store at least 50 MMt within 30 years; c) has access to a reliable CO_2 stream that can be readily transported to the storage site at a sufficient quantity and quality for commercial-scale CO_2 storage; and 4) has evaluated various engineering, subsurface drilling, materials procurement, and construction vendors to implement the project execution strategy.

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APPENDIX A

OVERVIEW OF REGULATORY CHARACTERIZATION

OVERVIEW OF REGULATORY CHARACTERIZATION

Among the factors to be used in evaluating potential storage sites is whether "the site can be permitted under all relevant federal, state, and local regulations" (Van Voorhees and others, 2021). As such, it is useful to identify and review the regulatory permits, requirements, and approvals that a geologic storage project must obtain. For the North Dakota CarbonSAFE (Carbon Storage Assurance Facility Enterprise) geologic storage projects, the key regulations and notifications are listed below.

Federal Requirements:

- **National Environmental Policy Act (NEPA) (40 Code of Federal Regulations [CFR] Parts 1500–1508)**
  - The NEPA was the first major environmental law in the United States (signed January 1, 1970) and requires federal agencies, like the U.S. Department of Energy (DOE), consider the environmental consequences of proposed actions and inform the public about their decision making (National Environmental Policy Act, 2024). NEPA applies whenever a proposed activity or action:
    - Is proposed on federal lands.
    - Requires passage across federal lands.
    - Is to be funded – either entirely or in part – by the federal government (e.g., DOE). Or
    - Affects the air or water quality that is regulated by federal law.
  - When any one of these four conditions is present, the federal agency with the greatest expertise, regulatory authority, and capacity to manage the NEPA process for the proposed project becomes the lead agency for that project (U.S. Fish and Wildlife Service, 2024).
    - **Greenhouse Gas Reporting Program (GHGRP), Subpart RR (40 CFR Part 98)**
  - Complementary to EPA's underground injection control (UIC) Class VI permit requirements, Subpart RR is administered under the Clean Air Act.
    - Facilities that conduct geologic sequestration including facilities that opt in to the monitoring and reporting requirements for this source category are required to:
      - Report on the amount of CO_2 received for injection.
      - Develop and implement an **EPA-approved monitoring, reporting, and verification (MRV) plan** that is best suited for each facility.
      - Report the amount of CO_2 geologically sequestered using a mass balance approach and annual monitoring activities.
    - All facilities that hold a UIC Class VI permit must report under Subpart RR.
    - Submit MRV plan, MRV plan extension request, or research and development (R&D) project exemption request within 180 days of receiving final UIC permit.
    - Starting in 2013 and each year thereafter, reports must be submitted to EPA by March 31 of each year.

- **Geologic Sequestration MRV Plan (40 CFR § 98.448)**
  - The Subpart RR mechanism used to monitor and report to EPA the amount stored is the MRV plan. This plan must be approved by EPA, thereby determining adequate security measures for the geologic storage of qualified carbon oxide to prevent escape into the atmosphere. EPA approval of the plan is also required prior to any tax credit claims under Section 45Q (see below).

- **Internal Revenue Code (IRC) Section 45Q Credit for Carbon Oxide Sequestration (26 U.S. Code § 45Q)**
  - This section of the Internal Revenue Service tax code provides a tax credit intended to incentivize investment in carbon capture and storage (CCS). The amount that a taxpayer may claim as a tax credit is computed per metric ton of qualified carbon oxide captured and stored. To claim a tax credit, the carbon oxide emissions must be measured at the point of capture as well as at the point of disposal, injection, or other use. To be eligible based on geological storage, the captured carbon oxide must be disposed of in "secure geological storage." According to IRC Section 45Q, secure geological storage includes "storage at deep saline formations" (Congressional Research Service, 2023).

- **Community Benefits Plan (CBP) (DE-FOA-0002711)**
  - The CBP process is a first-of-its-kind DOE effort to leverage the opportunity for significant climate and clean energy funding to encourage a more equitable, place-based approach to project development.
  - DOE requires CBPs as part of all Bipartisan Infrastructure Law (BIL) and Inflation Reduction Act (IRA) funding opportunity announcements (FOAs) and loan applications.
  - CBPs are based on a set of four core policy priorities:
    1. Engaging communities and labor.
    2. Investing in America's workers through quality jobs.
    3. Advancing diversity, equity, inclusion, and accessibility through recruitment and training.
    4. Implementing the Justice 40 Initiative, which directs 40% of the overall benefits of certain federal investments to flow to disadvantaged communities.
  - DOE views CBPs as the key to successful project implementation by reducing risks of opposition and delays, maximizing benefits, ensuring long-term success, and building durable support for implementation.

<u>State of North Dakota Permits</u>:

- **Geophysical Exploration Permits (North Dakota Century Code [NDCC] § 38-08.1-04; North Dakota Administrative Code [NDAC] § 43-02-12)**
  - Upon filing a complete application for permit to explore pursuant to NDCC § 38-08.1-04, the North Dakota Industrial Commission (NDIC) may issue to any person desiring to engage in geophysical exploration a "geophysical exploration permit." The permitting agent shall notify the operator of the land at least 7 days before the commencement of any geophysical exploration activity.

- **Department of Mineral Resources (DMR) Well-Drilling Permits (NDCC § 38-08-04; NDAC § 43-02-03-32)**
  – Stratigraphic test permits are issued to test the viability and gain additional information about a formation. According to NDAC § 43-02-03-32, Stratigraphic Test and Core Holes, stratigraphic test and core holes shall be permitted the same as oil and gas wells, although no setback from a drilling unit shall be required.

- **UIC Class VI Permits (NDCC § 38-22; NDAC § 43-05-01)**
  – NDAC § 43-05-01-05 Storage Facility Permit
  – NDAC § 43-05-01-10 Injection Well Permit, Class VI

- **Stormwater Discharge Permits (NDCC § 61-28-04; NDAC § 33.1-16)**
  – Application (Notice of Intent) to Obtain Coverage Under NDPDES (North Dakota Pollutant Discharge Elimination System) General Permit for Stormwater Discharges Associated with Industrial Activity
  – Procedures the department follows for issuing NDPDES permits (NDAC Ch. 33.1-16-01)
  – Standards of Quality for Waters of the State (NDAC Ch. 33.1-16-02.1)

Oliver County Permit and Notification:

- **Conditional Use Permits**: Conditional use permits grant an official exception which allows the property owner use of their land in a way not otherwise permitted within the particular zoning district. Applications will be reviewed by the land use administrator, followed by a public hearing before the planning and zoning commission, and final action will be made by the Oliver County Board of Commissioners.

- **Notification of Geophysical Exploration Permits**: NDIC shall immediately forward notice of the issuance of a permit to the board of county commissioners of the county in which the lands are located.

Landowner Notifications and Agreements:

- Notifications: published/mailed
- Land use: deed, lease agreement, easement
- Pore space use: lease agreement
- Property access agreement and field/crop damages

References

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APPENDIX B

OUTREACH MATERIALS AND ACTIVITIES

OUTREACH MATERIALS AND ACTIVITIES

Fact Sheets

Outreach Material for Geophysical Exploration
- Geophysical Survey near Milton R. Young Station (Activity FAQs), North Dakota CarbonSAFE (Carbon Storage Assurance Facility Enterprise (NDCS) No. 6 (7/20)
- Gravity and Magnetic Surveys near Young Station (Activity FAQs), NDCS No. 7 (7/20)
- Electromagnetic Geology Survey near Young Station (Activity FAQs), NDCS No. 12 (11/20)

Outreach Material – Miscellaneous
- North Dakota CarbonSAFE – Permanent CO_2 Storage in Central North Dakota (Fact Sheet), NDCS No. 9 (8/20)
- Groundwater Sampling near Center, North Dakota (Activity FAQs), NDCS No. 11 (10/21)
- Drone-Enabled Magnetic Survey near Young Station (Activity FAQs), NDCS No. 13 (5/21)

Outreach Material for Well Drilling
- Geologic Study in Central North Dakota (Activity FAQs), NDCS No. 9 (8/20)

Site Signage for Well Drilling

Figure B-1. Example sign displayed at the drilling site informing passersby about the type of project and progress.

Landowner Sampling Results

Groundwater- and soil gas-sampling results were mailed to landowners as a way to thank them for access and also to keep them engaged and provide positive interactions.

Outreach Advisory Board
An outreach advisory board comprising representatives from Minnkota Power Cooperative (MPC), the Lignite Energy Council (LEC), and the Energy & Environmental Research Center (EERC), was established in October 2020 and met in November and December 2020.

Virtual/In-Person Open House
December 16–17, 2020; Center

Landowner (closed) Meeting and Open House
May 5, 2021

Education
- LEC Teacher Seminar (June 15, 2021) (June 13, 2022) (June 13, 2023)
- North Dakota Petroleum Council (NDPC) Teacher Seminar (6/20/2023)

Exhibit Booths
- Booth at STEM (science, technology, engineering, and mathematics) Day at Bismarck Larks ballgame (August 7, 2021)
- Exhibit at LEC annual meeting (September 28 – October 1, 2021)
- Exhibit at Basin Electric Power Cooperative (BEPC) annual meeting (November 9–11, 2021)
- NDPC Cookfest in Killdeer (July 18, 2023)
- Booth at the Energy Progress & Innovation Conference (EPIC) in Bismarck (January 23–25, 2024)

Web page
- March 31, 2021 (go-live date)

Table B-1. Sampling of Key Outreach and Engagement Dates

Event/Milestone	Date
Oliver County Commission Meeting	6/6/2019
Oliver County Commission Meeting	9/5/2019
Oliver County Commission Meeting	1/9/2020
Oliver County Commission Meeting	2/6/2020
Community Open House (MPC/EERC)	12/16/2020
Project Web Page Launch (EERC website)	3/31/2021
Landowner Open House (MPC/EERC)	5/5/2021
LEC Teacher Seminar	6/15/2021
LEC Annual Meeting (booth)	9/28–10/1/2021
BEPC Annual Meeting (booth)	11/9–11/2021
Landowner Open House (MPC)	4/6/2022
LEC Teacher Seminar	6/13/2022
Landowner Open House (MPC)	10/13/2022
Oliver County Commission Meeting	5/4/2023
LEC Teacher Seminar	6/13/2023
NDPC Teacher Seminar	6/20/2023
Bakken Rocks Cookfest – Killdeer, ND	7/18/2023
Landowner Open House (MPC)	7/20/2023
EPIC (booth)	1/23–25/2024

APPENDIX C

ADDITIONAL REGULATORY INFORMATION

ADDITIONAL REGULATORY INFORMATION

National Environmental Policy Act (NEPA) CatEx
6/9/2020 signed by NEPA Compliance Officer
Tasks 1, 2, 4, 5, 6, 8
Site Characterization Phase of Minnkota Power Cooperative (Minnkota)/Project Tundra CO_2 Storage Complex
Categorical exclusion (CX) covers activities to be conducted within existing lab/office sites. Data compilation, analysis, computer modeling, and simulation conducted under these tasks. Also, document preparation and data dissemination and literature searches.

Regulatory Approvals for Geophysical Exploration

- **Federal: NEPA Approval**
  NEPA CatEx
  9/14/2020 signed by NEPA Compliance Officer
  Task 3.2
  Two-dimensional (2D) and three-dimensional (3D) Seismic, Controlled Source Electromagnetic (CSEM) Survey
  2D and 3D seismic surveys, CSEM survey, collect gravity and magnetic data

- **State: Department of Mineral Resources Oil & Gas Division (DMR O&G) Permit**
  Geophysical Exploration Permit 97-0298 (vibroseis – 2D) 8/14–8/31/2020
  Geophysical Exploration Permit 97-0299 (vibroseis – 3D) 8/31–9/9/2020
  Geophysical Exploration Permit 97-0301 (electromagnetic source – 2D) 12/14/2020–4/9/2021
  (Note: No permit is needed for microgravity study.)

- **County: Oliver County Notification**
  County Commission Meeting September 3, 2020: Judith Hintz, Auditor, presented a handout from Minnkota giving notice of an upcoming geophysical survey.

Regulatory Approvals for the Stratigraphic Test Well(s)

- **Federal: NEPA Approval**
  NEPA CatEx
  CX-021900
  6/24/2020 signed by NEPA Compliance Officer
  Subtask 3.1
  Drill Stratigraphic Test Well

- **State: DMR O&G Permits**
  J-ROC 1/Liberty-1 – NDIC Well File No. 37672; American Petroleum Institute (API) No. 33-065-00020
  (spud date: 9/8/2020)
  Unity-1 – NDIC Well File No. 38826; API No. 33-065-00022
  McCall-1 – NDIC Well File No. 38827; API No. 33-065-00023
  NRDT-1 – NDIC Well File No. 40270; API No. 33-065-00028