

BEFORE THE INDUSTRIAL COMMISSION  
OF THE STATE OF NORTH DAKOTA

CASE NO. 29029  
ORDER NO. 31583

CORRECTED ORDER  
October 14, 2022

IN THE MATTER OF A HEARING CALLED ON A MOTION OF THE COMMISSION TO CONSIDER THE APPLICATION OF MINNKOTA POWER COOPERATIVE, INC. REQUESTING CONSIDERATION FOR THE GEOLOGIC STORAGE OF CARBON DIOXIDE IN THE BROOM CREEK FORMATION FROM THE MILTON R. YOUNG STATION LOCATED IN SECTIONS 35 AND 36, T.142N., R.84W., SECTIONS 19, 20, 21, 22, 26, 27, 28, 29, 30, 31, 32, 33, 34 AND 35, T.142N., R.83W., SECTIONS 1, 2, 12 AND 13, T.141 N., R.84W., SECTIONS 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20 AND 21, T.141N., R.83 W., OLIVER COUNTY, ND PURSUANT TO NDAC SECTION 43-05-01.

ORDER OF THE COMMISSION

THE COMMISSION FINDS:

- (1) This cause came on for hearing at 9:00 a.m. on the 2nd day of November, 2021.
- (2) Minnkota Power Cooperative, Inc. (Minnkota) made application to the Commission for an order authorizing geologic storage of carbon dioxide from the Milton R. Young Station in the amalgamated storage reservoir pore space of the Broom Creek Formation, in portions of Sections 35 and 36, Township 142 North, Range 84 West, Sections 19, 20, 21, 22, 26, 27, 28, 29, 30, 31, 32, 33, 34, and 35, Township 142 North, Range 83 West, Sections 1, 2, 12, and 13, Township 141 North, Range 84 West, Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, and 21, Township 141 North, Range 83 West, Oliver County, North Dakota, pursuant to North Dakota Administrative Code (NDAC) Section 43-05-01, and such other relief as is appropriate.

(3) Minnkota submitted an application for a Storage Facility Permit and necessary attachments pursuant to NDAC Section 43-05-01-05 and all other provisions of NDAC Chapter 43-05-01 as necessary.

(4) Case Nos. 29029, 29030, 29031, 29032, 29033, and 29034 were combined for the purposes of hearing.

(5) Case No. 29030, also on today's docket, is an application filed with the Commission by Minnkota for an order of the Commission determining the amalgamation of storage reservoir pore space, pursuant to a Geologic Storage Agreement for use of pore space falling within portions of Sections 35 and 36, Township 142 North, Range 84 West, Sections 19, 20, 21, 22, 26, 27, 28, 29, 30, 31, 32, 33, 34, and 35, Township 142 North, Range 83 West, Sections 1, 2, 12, and 13, Township 141 North, Range 84 West, Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, and 21, Township 141 North, Range 83 West, Oliver County, North Dakota in the Broom Creek Formation, has been signed, ratified, or approved by owners of interest owning at least sixty percent of the pore space interest within said lands pursuant to North Dakota Century Code (NDCC) Section 38-22-10.

(6) Case No. 29031, also on today's docket, is a motion of the Commission to determine the amount of financial responsibility for the geologic storage of carbon dioxide from the Milton R. Young Station located in portions of Sections 35 and 36, Township 142 North, Range 84 West, Sections 19, 20, 21, 22, 26, 27, 28, 29, 30, 31, 32, 33, 34, and 35, Township 142 North, Range 83 West, Sections 1, 2, 12, and 13, Township 141 North, Range 84 West, Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, and 21, Township 141 North, Range 83 West, Oliver County, North Dakota in the Broom Creek Formation, pursuant to NDAC Section 43-05-01-09.1.

(7) Case No. 29032, also on today's docket, is an application by Minnkota for an order authorizing geologic storage of carbon dioxide from the Milton R. Young Station in the amalgamated pore space of the Deadwood Formation in portions of Sections 35 and 36, Township 142 North, Range 84 West, Sections 19, 20, 21, 22, 26, 27, 28, 29, 30, 31, 32, 33, 34, and 35, Township 142 North, Range 83 West, Sections 1, 2, 12, and 13, Township 141 North, Range 84 West, Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, and 21, Township 141 North, Range 83 West, Oliver County, North Dakota, pursuant to NDAC Chapter 43-05-01.

(8) Case No. 29033, also on today's docket, is an application filed with the Commission by Minnkota for an order of the Commission determining the amalgamation of storage reservoir pore space, pursuant to a Geologic Storage Agreement for use of pore space falling within portions of Sections 35 and 36, Township 142 North, Range 84 West, Sections 19, 20, 21, 22, 26, 27, 28, 29, 30, 31, 32, 33, 34, and 35, Township 142 North, Range 83 West, Sections 1, 2, 12, and 13, Township 141 North, Range 84 West, Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, and 21, Township 141 North, Range 83 West, Oliver County, North Dakota in the Deadwood Formation, has been signed, ratified, or approved by owners of interest owning at least sixty percent of the pore space interest within said lands pursuant to NDCC Section 38-22-10.

(9) Case No. 29034, also on today's docket, is a motion of the Commission to determine the amount of financial responsibility for the geologic storage of carbon dioxide from the Milton R. Young Station located in portions Sections 35 and 36, Township 142 North, Range 84 West, Sections 19, 20, 21, 22, 26, 27, 28, 29, 30, 31, 32, 33, 34, and 35, Township 142 North, Range 83 West, Sections 1, 2, 12, and 13, Township 141 North, Range 84 West, Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, and 21, Township 141 North, Range 83 West, Oliver County, North Dakota in the Deadwood Formation, pursuant to NDAC Section 43-05-01-09.1.

(10) Commission staff requested to take administrative notice of the well files and geophysical logs of all wells within or nearby the area of review, to which Minnkota had no objection.

(11) The record in these matters was left open to receive additional information from Minnkota. Such information was received on November 16, December 8, and December 10, 2021, and the record was closed.

(12) Pursuant to NDCC Section 38-22-06 and NDAC Section 43-05-01-08: The notice of filing of the application and petition and the time and place of hearing thereof was given, and that at least 45 days prior to the hearing, Minnkota, as the applicant, did give notice of the time and place of said hearing and the Commission has accepted the notice as adequate, and that the applicant did, at least 45 days prior to the hearing, file with the Commission engineering, geological and other technical exhibits to be used and which were used at said hearing, and that the notice so given did specify that such material was filed with the Commission; that due public notice having been given, as required by law, the Commission has jurisdiction of this cause and the subject matter.

(13) The Commission gave at least a thirty-day public notice and comment period for the draft storage facility permit and issued all notices using methods required to all entities under NDCC Section 38-22-06 and NDAC Section 43-05-01-08. Publication was made September 29, 2021, and the comment period for written comments ended at 5:00 PM CDT November 1, 2021. The hearing was open to the public to appear and provide comments.

(14) The Commission received a letter from the State Historical Society of North Dakota on October 22, 2021 indicating it reviewed the application of Minnkota and recommends a Class III (pedestrian survey) in the project area for the proposed monitoring well and its access road, specifically in the N/2 SE/4 of Section 34, Township 142 North, Range 83 West, Oliver County, North Dakota. Minnkota agrees to take the activity of performing a Class III pedestrian survey and State Historic Preservation Office issuance of a determination of effect, prior to commencing construction on the well pad, as a condition precedent of the drilling permit for the NRDT-1 monitoring well.

(15) The Commission received a letter from the Dakota Resource Council (DRC) on November 1, 2021 indicating concern with the safety of this project. DRC states there should be more robust regulation around carbon storage that will ensure that blow outs and leakage cannot occur. DRC is concerned with Appendix E of the filed application indicating loss of mechanical integrity injection wells-tubing/packer leak being classified as serious and likely to occur. DRC states if this were to occur, it could greatly affect both the natural and human environment and if this were a chronic problem, it could potentially derail the entire project and waste millions in

taxpayer dollars. DRC is concerned that if the leakage were large enough, it could poison the surrounding air and ecosystem and greatly harm the health of people within the area.

DRC states research shows the injection of carbon dioxide has the potential for causing small scale earthquakes that can rupture the seal of carbon storage. DRC notes that two Stanford scientists recently concluded that while injection from CCS is unlikely to trigger large earthquakes, even small earthquakes from the injection process can break the seal of a carbon dioxide repository. DRC states the injection process of carbon dioxide storage is incredibly risky and the geologic report for this permit and top scientists agree with these findings. DRC states this is likely why there are no internationally recognized standards for monitoring and verifying that carbon dioxide sinks will remain underground.

DRC recommends that there is an internationally recognized system of monitoring and steps that are taken to ensure every risk in the geologic report is classified as unlikely before this permit is approved.

(16) Minnkota testified the tubing could leak based on experience, and such an event would be serious and impact the project economically because they would have to stop injection to replace the tubing or patch the casing. Minnkota testified that with this risk scenario, there is no loss of containment. Minnkota testified that there are controls in place listed along with the risk assessment, and that the risk likelihood is without the controls in place. The radius of influence from a large carbon dioxide release from the wellhead was analyzed by Minnkota. The release would be limited to approximately 2,153 feet at a concentration of 5,000 ppm with conservative wind factors, and occupied dwellings would not fall within this radius.

Minnkota testified for an earthquake to occur, there would need to be a fault present and have indicated there are no faults present within the storage reservoir or upper or lower confining zones. Minnkota testified that the reservoirs and their associated injection pressures do not pose a risk for inducing movement in the identified underlying Precambrian basement fault to create a small or large earthquake. Minnkota testified microseismic events caused by injection created fractures will not be created due to the regulatory bottom hole pressure constraint of 90% of fracture pressure. Minnkota testified it uses the fracture pressure gradient of the injection formation and were unable to get the upper confining zone to break down to get a fracture pressure at 8000 psi, but that the injection reservoir broke down at significantly lower pressures.

(17) The Commission has rules and regulations in place to safeguard against tubing leaks or blowouts. NDAC Section 43-05-01-11(10) requires all tubing strings must meet the standards contained in subsection 6. All tubing must be new tubing or reconditioned tubing of a quality equivalent to new tubing and that has been pressure-tested. For new tubing, the pressure test conducted at the manufacturing mill or fabrication plant may be used to fulfill this requirement.

NDAC Section 43-05-01-11(11) requires all wellhead components, including the casinghead and tubing head, valves, and fittings, must be made of steel having operating pressure ratings sufficient to exceed the maximum injection pressures computed at the wellhead and to withstand the corrosive nature of carbon dioxide. Each flow line connected to the wellhead must be equipped with a manually operated positive shutoff valve located on or near the wellhead.

NDAC Section 43-05-01-11(12) requires all packers, packer elements, or similar equipment critical to the containment of carbon dioxide must be of a quality to withstand exposure to carbon dioxide.

NDAC Section 43-05-01-11(14) requires all newly drilled wells must establish internal and external mechanical integrity as specified by the Commission and demonstrate continued mechanical integrity through periodic testing as determined by the Commission. All other wells to be used as injection wells must demonstrate mechanical integrity as specified by the Commission prior to use for injection and be tested on an ongoing basis as determined by the Commission. NDAC Section 43-05-01-11(17) requires all injection wells must be equipped with shutoff systems designed to alert the operator and shut-in wells when necessary.

(18) The Commission has rules and regulations in place requiring the operator to demonstrate seismicity will not interfere with containment and prohibiting fracturing of the injection zone. NDAC Section 43-05-01-05(1)(b)(2)(m) requires the applicant must provide information on the seismic history, including the presence and depth of seismic sources and a determination that the seismicity would not interfere with containment.

NDAC Section 43-05-01-11.3(1) requires, except during stimulation, the storage operator shall ensure that injection pressure does not exceed ninety percent of the fracture pressure of the injection zone so as to ensure that the injection does not initiate new fractures or propagate existing fractures in the injection zone. Injection pressure must never initiate fractures in the confining zone or cause the movement of injection or formation fluids that endanger an underground source of drinking water. All stimulation programs are subject to the Commission's approval as part of the storage facility permit application and incorporated into the permit.

(19) The Commission received a letter from CCUS Consultant Geoscientist, Daniel R. Zebrowski (Zebrowski) on October 29, 2021 stating Minnkota's permit application does not comply with NDCC Chapter 38-22 and NDAC Chapter 43-05-01 and that there is potential for leakage of the carbon dioxide from the injection formation. Zebrowski states that failure of the carbon dioxide storage facility could allow for contamination of the near surface freshwater aquifers and surface water features. Additionally, that technical data presented by Minnkota to the North Dakota Industrial Commission reveal incomplete evaluation of geologic data, engineering data, and 2D and 3D geophysical data to properly assess and characterize the confinement formations, injection formation, and lower confinement formations as described in their permit application.

Zebrowski references the seismic data collected by Minnkota and states they have failed to display any geophysical maps constructed and calibrated with existing well data for subsurface formations. Zebrowski states it is imperative the Commission reviews such geophysical data, interpretations, and maps to fully understand the geological setting across the storage facility area and the proposed injection site location to ensure the cap rock and containment formations do not have faults which breach both and would allow for carbon dioxide to escape and contaminate freshwater aquifers.

Zebrowski states Minnkota failed to display any 2D or 3D seismic data from the surface to the basement within the storage facility and area of review in support of their carbon dioxide storage

permit application. Zebrowski questions why Minnkota completed required work and then did not display final products in support of the storage facility permit application, and why no 3D seismic lines which directly tie the proposed injection well were depicted to the Commission in support of the carbon dioxide storage application. Zebrowski states four 2D seismic lines were acquired and processed which directly tie the proposed injection well yet none of this data is utilized in support of the carbon dioxide storage facility permit application and depicted for the Commission. Zebrowski states that additional 2D seismic legacy data is available within the storage facility area.

Zebrowski states Minnkota has displayed partial lines (200'-300' of data out of over 9,000' of data) from two different 3D seismic impedance volumes which only depict the Broom Creek Formation and failed to depict the lower Piper, Opeche, and Spearfish Formations. Zebrowski states utilizing the limited amount of impedance 3D seismic data presented in support of the carbon dioxide storage facility permit application allows for one to interpret several faults within the Broom Creek Formation. Zebrowski states the applicant states an evaluation has been completed from the Broom Creek Formation to freshwater aquifers, and that 3D seismic data and interpretations displayed to the Commission are incomplete and lack technical merit for the Commission to make a reasonable evaluation of the carbon dioxide storage container integrity. Zebrowski states one can clearly depict near vertical faults within the Broom Creek Formation utilizing the applicant's 3D seismic data.

Zebrowski states the applicant directly accepts a much higher degree of risk for carbon dioxide storage facility failure of the cap rock and injection formations by withholding critical scientific data and the Commission should not allow the State of North Dakota to accept additional risk of a carbon dioxide storage facility containment failure.

Zebrowski includes images of Figure 2-8 from Minnkota's application. Zebrowski provided edited images from Minnkota's application, captioned Figure 2-8, Figure 2-8(a), and Figure 2-8(b). On Figure 2-8 Zebrowski asks where are formation tie in points? On Figure 2-8(a), Zebrowski states Opeche/Piper and Broom Creek 3D seismic structure and isopach maps are not presented, and that they should have been included in support of the carbon dioxide storage permit application. Zebrowski states this data is required to effectively evaluate the storage facility area and integrity. Zebrowski claims that without this data, the North Dakota Industrial Commission will be making a carbon dioxide storage facility permit decision based solely on subsurface well control data, and thus why acquire 2D and 3D seismic data? On Figure 2-8(b) Zebrowski states that Opeche/Piper cap-rock data is missing and that interpretation of the limited 3D impedance lines depicts several near vertical faults within the Broom Creek Formation, and such faults are typical for the Williston Basin. Zebrowski states the faults interpreted may also breach the cap rock formation and asks why 3D seismic data above and below the Broom Creek Formation have been removed? Zebrowski states that deliberately covering up 3D seismic data from a permit application leads to suspicion of the applicant's interpretations of the data.

Zebrowski states the applicant projects a direct well tie via synthetic seismogram on Figure 2-8 (west 3D seismic survey), and that no formation tops are displayed on the synthetic trace from the well log data for the J-LOC #1. Zebrowski asks where is the top and base of the Broom Creek Formation displayed on the synthetic seismogram? Zebrowski states that it could be asked from the amount of data displayed, if this is the Broom Creek Formation? Zebrowski states that

the applicant has not proven the seismic data displayed is the top and base of the Broom Creek Formation. Zebrowski states that seismic frequencies of the synthetic trace are much higher than the actual 3D seismic data displayed and are not an exact seismic tie and can lead to mis-ties of both 2D and 3D seismic data.

Zebrowski states no 3D seismic data and synthetic seismogram ties from the J-ROC1 #1 wellbore are depicted in the permit application; data quality at the J-ROC1 #1 is probably poor which does not allow for a direct synthetic seismogram tie of the 3D seismic data; and well log data from the J-ROC1 #1 and J-LOC #1 depict different stratigraphy at the top of the Broom Creek Formation and asks if the Broom Creek Formation is displayed in Figure 2-8.

Zebrowski states the permit application indicates additional seismic surveys within the area of review to monitor the carbon dioxide plume for this potential carbon dioxide storage facility site. Zebrowski asks why budget money if there is no intention to display data, interpretation, and results.

Zebrowski references a report, "North Dakota Integrated Carbon Storage Complex Feasibility Study" and states there are no geophysical maps or 3D seismic lines in it. Zebrowski includes Figure A-5 from the report and states they are displayed to inform the Commission of how some data can be interpreted differently and what is stated may not necessarily be correct. Zebrowski states the figure is captioned "Map view of seismic amplitude time slice through the Broom Creek Formation with interpreted geobodies. High amplitude values (blue) caused by thin bed tuning indicate the blue amplitude are interdunal carbonates." Zebrowski states the caption is incorrect and does not indicate the blue amplitude are interdunal carbonates. Zebrowski states thin bed tuning relates to the ability of seismic data to resolve the top and base of a seismic event. Zebrowski states as the thickness between the top and base decrease the seismic character will not be able to resolve top and base thickness. Zebrowski states one must have an existing well (none depicted in figure) with a sonic log and porosity logs directly tied to each seismic event to justify that statement. Zebrowski states a more reasonable interpretation is the positive amplitude events (blue) depicted are a shale/siltstone within the Broom Creek Formation and the amplitude scale varies within the formation which makes it appear there are three separate geologic features, when it is one formation or geologic feature. Zebrowski states the fourth blue amplitude created in Figure A-5 is not defined as an interdunal carbonate.

Zebrowski includes Figure B-10 and B-10(a) from the same report. Zebrowski references Figure B-10(a) and states a partial interpretation of the same time slice clearly depicts a fault with a NE to SW orientation adjacent to the Flemmer-1 wellbore. Zebrowski states the features within the orange boundaries appear to be additional faults and are not a channel feature as stated. Zebrowski states channel feature can usually be distinguished by a contrast from the outer edges (overbank-channel area) of a channel, not from the middle as has been suggested while viewing time slice data. Zebrowski asks, "How can the middle of a channel contrast (same rock-stratigraphy)?" Zebrowski states one can see stripping effects (acquisition footprint) within this 3D seismic data set.

Zebrowski includes Figure B-11, from an uncited source, stating it depicts a combination of 3D vertical seismic line with an associated time slice. Zebrowski states the figure was included to demonstrate to the Commission one can identify both faults and channels utilizing existing 3D seismic data. Zebrowski notes the channel displayed on the time slice is recognized by the

overbank-channel contrast, and that both positive and negative amplitudes are demonstrated in this example. Zebrowski states, “The faults have zero amplitudes (white) depicted, are in the middle of a fault.”

Zebrowski states the Department of Energy (DOE) has utilized time slice data for past carbon dioxide projects. Zebrowski references an article published by DOE in 2013 “Time-lapse surface seismic inversion with thin bed resolution for monitoring carbon dioxide sequestration: A case study from Cranfield, Mississippi” depicting several time slices. Zebrowski includes Figure #3 from the article and states it depicts four time slices of the Tuscaloosa injection zone across the entire 3D seismic survey. Zebrowski states the first time slice is pre-injection of carbon dioxide, the second post injection of carbon dioxide. Zebrowski states one can easily recognize the difference in the seismic data from carbon dioxide as stated in the article. Zebrowski adds one can easily recognize at least one major fault within the area of review, trending in a NW to SE orientation. Zebrowski includes Figure #4(a) from the article and states it depicts a portion of the inline from the 3D seismic survey. Zebrowski states the inline extends the entire length of the 3D seismic survey and notes the fault can clearly be recognized on inline 1102. Zebrowski includes Figure #5 as a comparison of the amount of 3D seismic data the applicant has given the Commission to evaluate this carbon dioxide storage facility permit. Zebrowski states only the Tuscaloosa (injection zone) Formation is depicted in Figure #5.

Zebrowski states review of the post-acquisition 3D seismic survey plot located on the North Dakota government website demonstrate the CarbonSafe 3D (Permit # 960299) did not undershoot the nearby lake correctly. Zebrowski states one can assume the 3D seismic data quality around the injection well is probably poor as there is a lake adjacent to the proposed carbon dioxide injection well and within the storage facility area. Zebrowski states without proper undershooting (acquisition) of the lake a large data gap at the surface will be observed on the 3D seismic data volume. Zebrowski states the applicant failed to demonstrate an accurate subsurface tie of a synthetic seismogram to the eastern 3D seismic data survey. Zebrowski includes Figure #7 and states it depicts similar large surface data gaps on the seismic line displayed.

Zebrowski includes Figure #6 and states it depicts one of the 3D impedance lines (Figure 2-8 (B-B')) taken from the applicant's storage facility permit application with a similar scale for appearance and comparison to Figure #5. Zebrowski states it is impossible for the Commission to evaluate the cap rock and injection formations integrity of the storage facility area from this limited amount of data. Zebrowski states the applicant depicts less than 3% of the actual data of one strike line from the 3D seismic survey, and that 97% of the seismic line depicted in Figure 2-8 is missing.

Zebrowski references Figure #7 and includes Figure #7a, and states it depicts a Gulf Oil Company seismic line over Little Knife Field located in the Williston Basin which has been published several times. Zebrowski references Figure #7 and states it depicts the entire 2D seismic line. Zebrowski references Figure #7a and states it demonstrates the same amount of seismic data Minnkota depicts in the storage facility permit application. Zebrowski states the applicant has denied the Commission the opportunity to review and evaluate 2D and 3D seismic data acquired and processed specifically for this carbon dioxide storage facility permit application.



Zebrowski states the applicant should display several strike lines, dip lines, and arbitrary lines from the 3D seismic volumes which display normal migrated (black and white wiggle trace filled) seismic data from surface to well below the Precambrian in support of this carbon dioxide storage facility permit application. Zebrowski states several lines should directly tie the proposed injection and monitor wells, and that the applicant could also display several time slices of the 3D volume from 1.00 seconds to 1.40 seconds “(20 msec intervals)” wherein the Commission can have confidence the cap rock and injection formations are free of any faults which might breach the formations and allow carbon dioxide to escape and contaminate freshwater aquifers.

Zebrowski states all 2D seismic data could also be displayed from surface to below the Precambrian with the carbon dioxide storage facility permit application. Zebrowski believes by including critical geophysical data requested above, the Commission and public would have a higher degree of confidence of carbon dioxide containment in the proposed carbon dioxide storage facility area.

Zebrowski states the applicant has utilized DOE funds to characterize the proposed Tundra (CarbonSAFE III) carbon dioxide storage facility area and area of review. Zebrowski states all data (including all geologic well data, 2D and 3D geophysical data, reports, simulations, etc.) are public record and can be obtained by any United States citizen. Zebrowski states the applicant can easily display all data to the Commission and the public.

Zebrowski supplies Figure #8 and states the applicant has failed to address the linear geologic surface feature which is within the 3D seismic survey outline, proposed carbon dioxide storage facility area and the area of review, approximately 1.2 miles from the proposed carbon dioxide injection well. Zebrowski states linear geologic surface features are usually associated with subsurface faults. Zebrowski states several linear geologic surface features are depicted on the North Dakota State Government website ([nd.gov/gis/apps/HubExplorerV2/](http://nd.gov/gis/apps/HubExplorerV2/)) within the area of review. Zebrowski states the applicant has stated no faults are present within the storage facility area and area of review. Zebrowski states a linear geologic surface feature could have a large subsurface fault(s) which potentially fault freshwater aquifers and extend several thousand feet below the surface. Zebrowski states an evaluation of the freshwater aquifers sample data indicate faulting is possible.

Zebrowski supplies Figure #9 and states it depicts existing 2D seismic data over the proposed storage facility area which has not been depicted in this carbon dioxide storage facility permit application. Zebrowski states several long regional 2D seismic lines were probably licensed for the evaluation of this storage facility permit at the inception of this carbon dioxide sequestration project. Zebrowski states Figure #9 also depicts the approximate location of the storage facility area and 3D seismic survey locations along with the location of the linear geologic surface feature. Zebrowski states the existing 2D seismic data would be extremely important to assist the Commission in determining the vertical and horizontal extent of the Broom Creek storage facility area. Zebrowski states the applicant could also depict the full migrated 2D seismic lines previously licensed to the Commission for review.

Zebrowski states the applicant may have licensed an existing regional 2D seismic line (81087-3983) which is an east-west line located approximately 2,200’ south of the J-ROC1 #1 wellbore and within the storage facility area and the area of review. Zebrowski states this line

extends over five miles east and five miles west of the proposed carbon dioxide injection well. Zebrowski states the applicant has not mentioned or displayed this line in the carbon dioxide storage facility permit application. Zebrowski states this line is required to assist in characterization of the carbon dioxide storage facility area and the area of review in an east-west direction. Zebrowski states additional existing 2D seismic data may have also been licensed by the applicant within the storage facility area and area of review and are not depicted for this carbon dioxide storage facility permit application. Zebrowski states that if available from applicant, this data could be useful to fully evaluate the storage facility area and area of review for potential regional and localized faults.

Zebrowski includes Figure 2-14, a lithofacies distribution model from the applicant's permit application. Zebrowski also includes Figure 2-14(a) and states it is the same lithofacies distribution model with an interpretation of several faults within the carbon dioxide storage facility area. Zebrowski states one can clearly demonstrate some changes of lithology on the upthrown and downthrown sides of the faults within the modeled data. Zebrowski states the interpreted faults depict upthrown and downthrown portions of formations within the carbon dioxide storage facility area. Zebrowski states the applicant has stated 2D and 3D seismic data were utilized to construct this model. Zebrowski states seismic data utilized appear to confirm faults within the model data.

Zebrowski states pursuant to NDCC Chapter 38-22 (Carbon Dioxide Underground Storage) and NDAC Chapter 43-05-01 (Geologic Storage of Carbon Dioxide) the applicant has not presented all technical work required for the North Dakota Industrial Commission to make a comprehensive decision on the storage facility area and integrity from the carbon dioxide storage facility permit application. Zebrowski states the applicant has withheld vital geologic and geophysical data, incorrectly displayed geologic and geophysical data, or did not acquire geological and geophysical data required in the permit application which could reduce the risk of a carbon dioxide storage facility failure.

Zebrowski claims the applicant has failed to comply with NDCC Section 38-22-08(1):

- 1.) Applicant has failed to provide and depict all characterization interpretations and correct detailed seismic data and interpretations, geologic/geophysical maps, and cross sections for a comprehensive evaluation of the carbon dioxide storage facility permit application as required by the State of North Dakota and the Commission.
- 2.) Applicant has failed to acquire MDT, FMI, or QuantaGeo logs at the proposed injection wellbore (J-ROC1 #1) location or within the carbon dioxide storage facility area as required by the State of North Dakota and the Commission.
- 3.) Applicant has failed to address a linear geologic surface feature within the proposed storage facility area which usually indicate the presence of subsurface faults as required by the State of North Dakota and the Commission.

Zebrowski claims the applicant has failed to comply with NDCC Section 38-22-08(2):

- 1.) Applicant has not demonstrated the storage facility is suitable and feasible for carbon dioxide injection and storage by withholding critical geological/geophysical maps and both

2D and 3D seismic data (strike lines, dip lines, arbitrary lines, time slices, etc.) for interpretation and inspection by the State of North Dakota and the Commission. Strike lines, dip lines, arbitrary lines, and time slices of 3D seismic volumes can easily verify the presence of faults (storage containment failure) within the storage facility area. Zebrowski states figure #2-8(b) depicts several interpreted faults within the Broom Creek Formation from the existing 3D seismic data set.

2.) Applicant has failed to run MDT logs over the confinement formation and injection formation or any other formation at the proposed injection well location (J-ROC1 #1) or within the storage facility area. Zebrowski states the applicant does not have any Microfracture in situ stress tests from the J-ROC1 #1 wellbore and cannot determine formation pressures, high quality fluid samples, and permeability anisotropy within the storage facility area as required by the State of North Dakota. Applicant projects incomplete MDT data from a wellbore located over 4.5 miles (outside the proposed storage facility area) from the proposed carbon dioxide injection wellbore (J-ROC1 #1) wherein geologic conditions (depth, stratigraphy, structure, dip rates, pressure, etc.) have changed above the cap rock formations, within the cap rock formations, within the injection formation, and below the injection formation. Applicant has failed to demonstrate the storage facility is suitable and feasible for carbon dioxide injection and storage.

3.) Applicant failed to run an FMI or QuantaGeo log in the proposed injection wellbore (J-ROC1 #1) which can demonstrate faults and fractures above the cap rock formations, within the cap rock formations, within the injection formation and below the injection formations. Zebrowski states the applicant has failed to demonstrate the storage facility is suitable and feasible for carbon dioxide injection and storage.

Zebrowski claims the applicant has failed to comply with NDCC Section 38-22-08(8):

1.) Applicant has withheld detailed structure and isopach maps of the confining and injection formations constructed from existing 2D and 3D seismic data from the carbon dioxide storage facility permit application. This data can be directly calibrated to geological well data from the proposed injection well. Applicant has withheld 2D and 3D seismic data (lines, time slices, etc.) from the Commission and public. Applicant states no faults are present in the area of review area but do not provide any evidence to the Commission to support such statement. Figure 2-8(b) clearly depicts several interpreted faults within the storage facility area and contrast with the applicant's statement. Applicant could easily provide such evidence to support their statement by making several inlines, cross lines, and arbitrary lines from the migrated 3D seismic volume (surface to below Precambrian) to the Commission. Applicant could also display time-slices from above the cap rock formations through the injection formation at "20 msec." intervals utilizing the entire 3D seismic volumes. This data is required to confirm that carbon dioxide will not escape from the storage reservoir within the storage facility area. Zebrowski states the applicant has failed to confirm from all geologic, geophysical, and engineering data that carbon dioxide will not escape from the storage reservoir.

2.) Zebrowski reiterates that the applicant has failed to run MDT logs and an FMI or QuantaGeo log in the proposed injection wellbore (J-ROC1 #1).

Zebrowski claims the applicant has failed to comply with NDCC Section 38-22-06(10):

1.) Applicant's permit clearly has a higher degree of containment failure risk which will clearly endanger human health and endanger the environment (permanent contamination of freshwater aquifers and surface water ponds, lakes, and streams.) Zebrowski states faults are present within confinement and injection zones.

2.) Applicant has not addressed linear geologic surface features (which are usually associated with faults) within the carbon dioxide storage facility area and the area of review. Surface/near-surface fault(s) could extend downward through freshwater aquifers into deeper formations. Carbon dioxide could escape confinement and travel through a series of faults to freshwater aquifers and surface water (lakes, streams, etc.) If carbon dioxide escapes and makes its way to the surface it will collect in surface sink areas and could potentially kill all human and wildlife within surface sink areas.

Zebrowski claims the applicant has failed to comply with NDCC Section 38-22-08(11):

1.) At the present, the applicant's carbon dioxide storage permit application is not in the public interest as the risk of carbon dioxide storage facility containment failure clearly outweighs the removal of carbon dioxide from the atmosphere. Applicant has failed to provide and depict all characterization data, interpretations, and maps for a comprehensive evaluation by the State of North Dakota and the Commission of the carbon dioxide storage facility area and area of review.

Zebrowski claims the applicant has failed to comply with NDCC Section 38-22-08(12):

1.) Applicant has not demonstrated the storage reservoir has been defined. The vertical boundaries have not been determined directly over the proposed injection wellsite, storage facility area, and a substantial portion of the area of review (storage reservoir). Applicant has withheld critical geological/geophysical maps and both 2D and 3D seismic data for interpretation and inspection by the State of North Dakota and the Commission. Applicant has not provided accurate detailed structure maps and isopach maps of the cap-rock formations and injection formation which define the vertical and horizontal extent of the potential carbon dioxide reservoir. Applicant has not depicted any seismic data (2D or 3D) which depicts both the cap rock formation and the injection formation in this application. Applicant has only depicted maps constructed from existing well control for the horizontal and vertical boundaries of the storage reservoir. Applicant has not addressed interpreted faults depicted in figure 2-8(b). Applicant has not defined the horizontal and vertical boundaries of the storage reservoir utilizing all existing and required scientific data.

2.) Zebrowski reiterates that the applicant has failed to run MDT logs on the proposed injection wellbore (JROC1 #1) and without formation pressure data applicant cannot define the horizontal and vertical boundaries of the storage reservoir as required by the State of North Dakota.

Zebrowski claims, "The applicant has failed to comply with NDAC Section 43-05-01(C-4) Geologic Exhibits i."

1.) Applicant has failed to depict accurate well log cross sections which depict the structural configuration of the storage reservoir. Zebrowski references Figure 2-12b and states it depicts two cartoon structure cross sections which are not accurate. The cross sections are not displayed relative to sea level and do not indicate true formation dips of the geologic conditions at the storage reservoir in a cross-section view. Regional well log structure maps (Figure 2-13) are depicted in subsea depths while both cross sections depicted in Figure 2-12b are in measured depth or true vertical depth, not subsea depth. Accurate structural cross sections could assist in identification of existing faults within the carbon dioxide storage facility area and area of review. Applicant has failed to comply with accurate structural cross sections as required by the State of North Dakota.

Zebrowski claims, “The applicant has failed to comply with NDAC Section 43-05-01(C-4) Geologic Exhibits j.”

1.) Zebrowski references Figure 2-8(b) and states it depicts several interpreted faults within the injection zone that appear to transect the confining zone. Zebrowski states additional 2D and 3D seismic data must be displayed to confirm the extent and orientation of faults within the carbon dioxide storage facility area and area of review. Zebrowski reiterates the applicant has failed to address a linear geologic surface feature approximately 1.2 miles from the proposed injection well. Zebrowski states this linear geologic surface feature is probably related to a large subsurface fault within the storage facility area and area of review. Zebrowski states the near surface freshwater aquifers could be faulted and that the faults could also extend several thousand feet below surface. Zebrowski reiterates the applicant has failed to run MDT logs at the proposed injection well location (J-ROC1 #1) or within the storage facility area. Zebrowski states the applicant projects incomplete MDT data from a wellbore located over 4.5 miles from the proposed carbon dioxide injection wellbore (J-ROC1 #1). Zebrowski reiterates the applicant has failed to run an FMI or QuantaGeo log in the proposed injection wellbore (J-ROC1 #1) which can demonstrate faults and fractures within the cap rock formations, injection formation, below the injection formation, and within the storage facility area. Zebrowski states the applicant has no log data within the storage facility area to determine if fractures or faults exist. Zebrowski states the applicant cannot definitively state no fractures or faults are present in the storage facility area without this data.

Zebrowski claims, “The applicant has failed to comply with NDAC Section 43-05-01(C-4) Geologic Exhibits k.” Zebrowski reiterates the applicant has not provided seismic data, addressed faults depicted in figure 2-8(b), and addressed linear geologic surface features. Zebrowski reiterates the applicant has failed to run MDT logs over formations at the J-ROC1 #1.

Zebrowski states, “The applicant has failed to comply with NDAC Section 43-05-01(C-4) Geologic Exhibits L.” Zebrowski reiterates the applicant has not run MDT logs and an FMI or QuantaGeo log in the J-ROC1 #1.

Zebrowski states he does not object to carbon dioxide sequestration and that his goal is to assist in evaluations from a public perspective and help reduce risk of potential carbon dioxide containment failures. Zebrowski states the applicant could easily remedy most of the deficiencies with additional time and completed work products suggested and required by the State of North Dakota. Zebrowski states the applicant could not receive a Class VI (UIC)

injection well permit from the EPA with incomplete data (No MDT, FMI or QuantaGeo log) as demonstrated in this carbon dioxide storage facility permit application.

Zebrowski, considering the evidence depicted within his letter, urges (on behalf of several surface owners within the carbon dioxide storage facility area) the North Dakota Industrial Commission to reject Minnkota Power Cooperative, Inc's storage facility permit (Case No. 29029) until such time the applicant fulfills all requirements set forth by the State of North Dakota in NDCC Chapter 38-22 (Carbon Dioxide Underground Storage) and NDAC Chapter 43-05-01 (Geologic Storage of Carbon Dioxide). Zebrowski states the applicant has burdened the State of North Dakota with additional containment failure risks with an incomplete application that does not comply with North Dakota State Law. Zebrowski states it would be extremely unfortunate if carbon dioxide injection begins and immediately escapes the Broom Creek Formation.

(20) Minnkota testified it believes it is in complete compliance with the statutes and regulations, and that comments made by Zebrowski stating the application does not comply with NDCC Chapter 38-22 and NDAC Chapter 43-05-01, are an opinion.

Minnkota testified that the seismic interpretation was completed from the Precambrian basement up through the Pierre Formation and that this interpretation included structural surfaces, including the reservoirs of interest and confining layers. Minnkota testified this was included in the model which was provided to the Commission as part of the application. Minnkota testified in the Deadwood permit application, time structure maps were included that were constructed and calibrated using existing well data, particularly Figure 2-55 and Figure 2-59.

Minnkota testified having seismic data and displaying seismic data is not a requirement of the regulations, and that no data was withheld. Minnkota testified no cross sections of the seismic data were included in the Broom Creek application because there were no relevant structural features identified. Minnkota testified in the Deadwood application that Figure 2-57 shows a 3D seismic line tied to the J-ROC1 #1 well. Minnkota testified that 2D seismic lines were collected as part of the project and permit application and did not display them within the application since the four 2D lines are within the 3D seismic survey outline. Minnkota testified 2D information was not included in the model, only the 3D data was. Minnkota testified that 2D legacy seismic data was typically collected with lesser parameters than modern standards and that it purchased 28 miles of 2D legacy seismic data in this area. Minnkota testified such legacy data was purchased as part of the CarbonSAFE phase 2 feasibility study, conducted by the Energy and Environmental Research Center (EERC) in 2016. The datasets were deemed to have insufficient data quality in review, leading to performing additional 2D and 3D data acquisitions.

Minnkota testified impedance volumes displayed are using smooth seismic horizons as a framework, but that the initial model uses square grid blocks which are not able to capture the smoothness of the structure. Minnkota testified the square grid blocks arranged in a vertical orientation leave remaining artifacts in the final inversion results which present themselves as vertical features, but that those features are only artifacts. Minnkota testified that acoustic impedance volumes are not useful in interpreting structure and attempting to draw conclusions or interpreting a fault from this dataset is not a sound method for geophysical interpretation.

Minnkota testified that the data necessary has been provided to address various rules related to presence of any leakage pathways, lateral continuity of the formation, upper confining zones, thickness, structure, and structural features that have the potential to serve as fluid communication pathways, and structural or stratigraphic pinch outs in the region with figures in the application. Minnkota testified it can supply additional data if the Commission finds additional information relevant. Minnkota testified the inversion was focused on the reservoir which was displayed to show data used for the geologic model and that there was not a good inversion match above and below the reservoir.

Minnkota testified that well logs from the J-LOC #1 and J-ROC1 #1 were used to calibrate well log data to seismic data for both 3D seismic data sets, and BNI #1 log data was used for the western seismic data set. Minnkota testified data quality from the J-ROC1 #1 well was sufficient to tie the well to the seismic data and used the east-west 2D seismic line acquired to tie the western 3D seismic data set to the eastern data set. Minnkota testified this confirmed the well tie for the western 3D survey to the J-LOC #1 well and is in agreement with the independent well tie of the eastern 3D survey to the J-ROC1 #1 well.

Minnkota testified data sets referenced in paragraph 5 of page 4 and pages 5-7 of Zebrowski's comments were not used in this application as they were not connected to this application or the location under consideration. Minnkota testified the data sets referenced in Zebrowski's comments are related to a different location in Mercer County and some data is from a different state. Minnkota testified several figures are from different formations, depositional environments, and structural regimes and are not relevant to the application.

Minnkota testified surface infrastructure and obstacles such as Nelson Lake were considered in the design of the 3D survey and appropriately addressed through source and receiver line placement, and that the 3D seismic data was sufficient for interpreting and tying well log data to the seismic data for interpretation of the formations of interest.

Minnkota testified the linear geologic surface features are glacial features and not relevant to the deep subsurface geology. Minnkota testified freshwater sample data indicating faulting is unsubstantiated and that no supporting information was provided by Zebrowski. Minnkota testified that it and EERC reviewed available baseline freshwater sample data in the region and collected samples.

Minnkota testified vertical features in Figure 2-14 from their application are modeling artifacts at the edges of the seismic horizons put into the model as well as gentle structure from the seismic data, and that the artifacts and structure were amplified in appearance by vertical exaggeration.

Minnkota testified the implied failure to comply with statutory and regulatory requirements are an opinion by Zebrowski, and that he does not have the authority to make those conclusions. Minnkota testified an FMI log was run in the J-ROC1 #1 well, and that MDT was unable to be acquired. Minnkota testified an MDT log is not a requirement for the storage facility permit application, but is required prior to injection and will be performed and submitted.

(21) Pursuant to NDAC Section 43-05-01-05 (1)(b)(2)(j) the application is required to provide the location, orientation, and properties of known or suspected faults and fractures that

may transect the confining zone in the area of review, and a determination that they would not interfere with containment.

Pursuant to NDAC Section 43-05-01-05 (1)(b)(2)(k) the application must include data on the depth, areal extent, thickness, mineralogy, porosity, permeability, and capillary pressure of the injection and confining zone, including facies changes based on field data, which may include geologic cores, outcrop data, seismic surveys, well logs, and names and lithologic descriptions.

Pursuant to NDAC Section 43-05-01-05 (1)(b)(2)(l) the application is required to provide geomechanical information on fractures, stress, ductility, rock strength, and in situ fluid pressures within the confining zone. The confining zone must be free of transmissive faults or fractures and of sufficient areal extent and integrity to contain the injected carbon dioxide stream.

Pursuant to NDAC Section 43-05-01-05 (1)(b)(2)(o) the application is required to identify and characterize additional strata overlying the storage reservoir that will prevent vertical fluid movement, are free of transmissive faults or fractures, allow for pressure dissipation, and provide additional opportunities for monitoring, mitigation, and remediation. There are no requirements to include the 2D or 3D seismic lines in the application.

(22) The Commission believes Minnkota's testimony sufficiently addresses the appearance of vertical features in acoustic impedance volumes and in the geologic model cross section.

(23) The Commission notes "Linear Geologic Surface Features" on [nd.gov/gis/apps/HubExplorerV2](http://nd.gov/gis/apps/HubExplorerV2) are river channels and a glacial ice margin.

(24) Minnkota's application provides adequate data to show suitability of the Broom Creek Formation for geologic storage of carbon dioxide in the facility area.

(25) Minnkota's application provides adequate modeling of the storage reservoir for delineation of the facility area, and adequate monitoring to detect if carbon dioxide is migrating into properties outside of the facility area pursuant to NDAC Section 43-05-01-11.4. Vertical release of carbon dioxide is addressed by the application pursuant to NDAC Section 43-05-01-13, and lateral release of carbon dioxide from the facility area is addressed by the application pursuant to NDAC Section 43-05-01-05.

(26) The amalgamated storage reservoir pore space to be utilized is not hydrocarbon bearing as determined from test data included with the application. There has been no historic hydrocarbon exploration or production from formations below the Broom Creek Formation within the proposed facility area. Lignite coal is mined from the Sentinel Butte Formation above the proposed facility area. Coal seams exist in the Bullion Creek Formation. All coal seams present in the Fort Union Group above the facility area will not be impacted by this project as there are no current or future planned mining activities at the location of the wells. The lateral extent of the stabilized plume is large enough to prevent drilling for hydrocarbon exploration in interior sections within the facility area, under the Broom Creek Formation, without penetrating the stored carbon dioxide. While Minnkota does not foresee an operator drilling through the carbon dioxide plume, they acknowledge controls would need to be in place to consider it for any potential future exploration that would penetrate the storage reservoir.



(27) Minnkota's Milton R. Young Station is a two-unit mine-mouth lignite coal-fired power plant located in Oliver County, North Dakota, near the city of Center. The lignite used as fuel for electrical generation is the source of the carbon dioxide.

(28) Up to 4,300,000\* metric tons of carbon dioxide will be captured annually from the Milton R. Young Station. The captured carbon dioxide will be dehydrated, compressed, transported to a Class VI well by a flow line, and then injected. Up to 4,300,000\*\* metric tons of carbon dioxide will be injected into the Broom Creek Formation annually.

(29) The entire length of flow line to be utilized for carbon dioxide transportation from the capture facility to the wellhead falls within the facility area delineation and is under the jurisdiction of the Commission.

(30) Minnkota submitted supplemental information regarding the flow line. The information contained in the supplement is from a FEED study performed by Burns & McDonnell and materials and contractors have not been selected. When a final construction plan is issued, Minnkota will submit notice of intent a minimum of seven days prior to commencing construction in a form containing all required and requested information in accordance with NDAC Section 43-02-03-29.1. Maximum operating pressure is expected to be 1,690 psi.

(31) The flow line will be equipped with a DAS/DSS/DTS fiber optic cable to detect leaks.

(32) The projected composition of the carbon dioxide stream is greater than 99.9% carbon dioxide with trace quantities of water, nitrogen, argon, oxygen, sulfur dioxide, nitrogen dioxide, and nitric dioxide.

(33) The J-ROC1 #1 (File No. 37672) is a plugged back stratigraphic test well that was used for reservoir characterization, located 1,959 feet from the north line and 333 feet from the west line of Section 4, Township 141 North, Range 83 West, Oliver County, North Dakota. This well is to be drilled out, used to acquire additional test data, and be plugged back for conversion to a Class VI injection well.

(34) The proposed Unity #1 well will be tested, logged, and constructed to Class VI requirements, to be located 1,979 feet from the north line and 373 feet from the west line of Section 4, Township 141 North, Range 83 West, Oliver County, North Dakota.

(35) The proposed NRDT #1 well is to be located 2,148 feet from the south line and 691 feet from the east line of Section 34, Township 142 North, Range 83 West, Oliver County, North Dakota. This well is to be utilized as a direct method of monitoring the injection zone pursuant to NDAC Section 43-05-01-11.4.

(36) Minnkota created a geologic model based on site characterization as required by NDAC Section 43-05-01-05.1 to delineate the area of review. Data utilized included well log, seismic, and core data. Well log data was used to pick formation tops, interpret lithology,

\*Originally stated 4,000,000

\*\*Originally stated 4,000,000

estimate petrophysical properties, and determine a time-depth shift for seismic data in the Amsden Formation, the lower confining zone, the Opeche Formation, the upper confining zone, and the Broom Creek Formation, the injection formation. Geostatistics were used to distribute petrophysical properties throughout the confining zones. Seismic data was used to reinforce interpolation of the formation tops to create structural surfaces, and to distribute lithologies and geologic properties in the model. Based on the reservoir pressure obtained from the J-LOC #1 (Well No. 37380), critical threshold pressure for this storage facility exists in the Broom Creek Formation prior to injection. Critical threshold pressure has the same meaning as pressure front, defined in NDAC Section 43-05-01-01, for area of review delineation purposes. EPA's "UIC Program Class VI Well Area of Review Evaluation and Corrective Action Guidance" lists several methods to estimate an acceptable pressure increase for over-pressurized reservoirs, including a multiphase numerical model designed to model leakage through a single well bore, or through multiple well bores in the formation. Minnkota has used this method to determine cumulative leakage potential along a hypothetical leaky wellbore without injection occurring is estimated to be 0.011 cubic meters over 20 years. Incremental leakage with injection occurring was determined to be a maximum of 0.009 cubic meters over 20 years. A value of 1 cubic meter is the lowest meaningful value that can be produced by the ASLMA model as smaller values likely represent statistical noise. An actual leaky wellbore or transmissive conduit would likely communicate with the Inyan Kara Formation. Minnkota testified no indications of communication between the Broom Creek Formation and Inyan Kara Formation were observed, and that nothing in fluid samples indicated communication to USDWs. The predicted extent of the carbon dioxide plume from beginning to end of life of the project, at the time that the carbon dioxide plume ceases to migrate into adjacent cells of the geologic model, was used to define the area of review in this case. Pursuant to NDAC Section 43-05-01-05(1)(b)(2) the area of review was proposed as a one-mile buffer around the storage facility boundaries. Time lapse seismic surveys will be used for monitoring the extent of the carbon dioxide plume.

(37) The area proposed to be included within the storage facility is as follows:

TOWNSHIP 142 NORTH, RANGE 84 WEST

THE S/2 SE/4 OF SECTION 35, AND THE S/2 OF SECTION 36,

TOWNSHIP 142 NORTH, RANGE 83 WEST

ALL OF SECTIONS 28, 29, 31, 32, 33 AND 34, THE SE/4 SE/4 OF SECTION 19, THE SE/4 AND S/2 SW/4 OF SECTION 20, THE S/2 AND S/2 N/2 OF SECTION 21, THE SW/4 NW/4, W/2 SW/4, AND SE/4 SW/4 OF SECTION 22, THE SW/4 AND SW/4 SE/4 OF SECTION 26, THE W/2, SE/4, AND W/2 NE/4 OF SECTION 27, THE E/2, E/2 SW/4, AND SE/4 NW/4 OF SECTION 30, AND THE W/2, NE/4, AND W/2 SE/4 OF SECTION 35,

TOWNSHIP 141 NORTH, RANGE 84 WEST

ALL OF SECTIONS 1 AND 12, THE E/2, E/2 SW/4, AND E/2 E/2 NW/4 OF SECTION 2, AND THE NE/4, E/2 NW/4, AND NE/4 SE/4 OF SECTION 13,

TOWNSHIP 141 NORTH, RANGE 83 WEST

ALL OF SECTIONS 2, 3, 4, 5, 6, 7, 8, 9, 10, 16, 17 AND 18, THE W/2 SW/4 OF SECTION 1, THE W/2, NE/4, W/2 SE/4, AND NE/4 SE/4 OF SECTION 11, THE W/2 NW/4, NE/4 NW/4, AND NW/4 SW/4 OF SECTION 12, THE N/2 NW/4, SE/4 NW/4,

NW/4 NE/4, W/2 SW/4 NW/4, AND NE/4 SW/4 NW/4 OF SECTION 14, THE N/2 N/2, SE/4 NE/4, AND SW/4 NW/4 OF SECTION 15, THE N/2 N/2, SE/4 NW/4, AND SE/4 NE/4 OF SECTION 19, THE N/2 OF SECTION 20, AND THE W/2, W/2 NE/4, AND NW/4 SE/4 OF SECTION 21.

(38) The Broom Creek Formation, the upper confining Opeche Formation, and the lower confining Amsden Formation are laterally extensive through the area of review.

(39) Core analysis of the Broom Creek Formation shows sufficient permeability to be suitable for the desired injection rates and pressures without risk of creating fractures in the injection zone. Thin-section investigation shows the Broom Creek Formation's sandstone intervals are comprised primarily of quartz, with minor occurrences of feldspar, dolomite, and anhydrite as cement. Two distinct carbonate intervals are present consisting of dolostone, dolomite, quartz, feldspar, and clay. Anhydrite intervals are expressed as thin beds that separate different sand bodies and cement. Microfracture testing in the J-LOC #1 (Well No. 37380) well, near, but outside of the delineated facility area, at a depth of 5,045 feet determined the breakdown pressure of the formation to be 6,384 psi, with a fracture propagation pressure of 3,592 psi, and a fracture closure pressure of 3,203 psi. Microfracture testing in the BNI #1 (Well No. 34244) well, near, but outside of the delineated facility area, at a depth of 5,042 feet determined the breakdown pressure of the formation to be 7,089 psi, with a fracture propagation pressure of 3,586 psi, and a fracture closure pressure of 3,270 psi. Microfracture in situ tests were attempted in the J-ROC1 #1 (File No. 37672) well, but because of unstable wellbore conditions, the MDT stress tool run was not performed after a near-loss of the tool in the wellbore. Microfracture testing is proposed for the Broom Creek Formation within the facility area, to be submitted to the Commission for review prior to injection of carbon dioxide.

Core analysis of the overlying Opeche Formation shows sufficiently low permeability to stratigraphically trap carbon dioxide and displaced fluids. Thin-section investigation shows the Opeche Formation is comprised of intervals of silty mudstone, argillaceous siltstone, mudstone, and anhydrite. Microfracture testing in the J-LOC #1 (Well No. 37380) well, near, but outside of the delineated facility area, at depths of 4,888 and 4,889 feet observed no formation breakdown with a maximum of 8,162 psi and 8,151 psi applied, respectively. Microfracture testing was performed in the BNI #1 (Well No. 34244) well, near, but outside of the delineated facility area, at depths of 4,873 and 4,898 feet. The test at 4,873 feet observed no formation breakdown with a maximum of 7,561 psi applied. The test at 4,898 feet determined the breakdown pressure of the formation to be 5,897 psi, and a fracture closure pressure of 4,273 psi. Microfracture tests were attempted in the J-ROC1 #1 (File No. 37672) well, but because of unstable wellbore conditions, the MDT stress tool run was not performed after a near-loss of the tool in the wellbore. Microfracture testing is proposed for the Opeche Formation within the facility area, to be submitted to the Commission for review prior to injection of carbon dioxide.

Core analysis of the underlying Amsden Formation shows sufficiently low permeability to stratigraphically contain carbon dioxide and displaced fluids. Thin-section investigation shows the Amsden Formation is comprised of dolomite, sandy dolomite, shaly sandstone, and anhydrite.

(40) The in situ fluid of the Broom Creek Formation in this area is in excess of 10,000 parts per million of total dissolved solids.

(41) Investigation of wells within the area of review found no vertical penetrations of the confining or injection zones requiring corrective action. The area of review will be reevaluated at a period not to exceed five years from beginning of injection operations.

(42) The Fox Hills Formation is the deepest underground source of drinking water (USDW) within the area of review. Its base is situated at a depth of 1,225 feet at the location of the proposed injection wells, leaving approximately 3,515 feet between the base of the Fox Hills Formation and the top of the Broom Creek Formation.

(43) Fluid sampling of shallow USDWs has been performed to establish a geochemical baseline, with additional baseline sampling proposed for the Fox Hills Formation and other shallow wells under investigation. Future sampling is proposed in Minnkota's application pursuant to NDAC Section 43-05-01-11.4.

(44) Soil sampling is proposed pursuant to NDAC Section 43-05-01-11.4. A baseline of soil gas concentrations will be established and submitted to the Commission for review prior to injection operations. Soil gas profile stations will be located off of the well pads near the J-ROC1 #1 (Well No. 37672), near the Herbert Dresser #1-34 (Well No. 4937), and near the proposed NRDT-1 monitoring well.

(45) The top of the Inyan Kara Formation is at 3,665 feet, approximately 2,440 feet below the base of the Fox Hills Formation and it provides an additional zone of monitoring between the Fox Hills Formation and the Broom Creek Formation to detect vertical carbon dioxide or fluid movement.

(46) No known or suspected regional faults or fractures with transmissibility have been identified during the site-specific characterization. Formation imaging logs run showed the section of the Opeche Formation closest to the Broom Creek Formation to be dominant in anhydrite, compaction features, and corresponding tensional features. Compaction features are parallel to bedding and commonly filled with clay minerals, reducing porosity. The mid-region of the Opeche Formation contains electrically resistive features, possibly from anhydrite-filled fractures. One high angle thrust fault in the Precambrian was identified within the area of review that vertically terminates well below the injection and confining formations, creating no risk to containment.

(47) Fluid samples from the Inyan Kara Formation and Broom Creek Formation suggest that they are hydraulically isolated from each other, supporting that the confining formations above the Broom Creek Formation are not compromised by migration pathways.

(48) Geochemical simulation performed with the injection stream and data obtained from the confining and injection zones determined no observable change in injection rate or pressure. Conservatively high carbon dioxide exposure simulations to the cap rock determined that geochemical changes will be minor and will not cause substantive deterioration compromising confinement.

(49) Risk of induced seismicity is not a concern based on existing studies of major faults within the area of review, tectonic boundaries, and relatively stable geologic conditions surrounding the proposed injection site.

(50) The two injection wells and one monitoring well are proposed to be equipped with DTS fiber optic cables enabling continuously monitored external mechanical integrity.

(51) The approval of this application is in the public interest by promoting the policy stated in NDCC Section 38-22-01.

IT IS THEREFORE ORDERED:

(1) The creation of the Minnkota Center MRYS Broom Creek Storage Facility #1 in Oliver County, North Dakota, is hereby authorized and approved.

(2) Minnkota Power Cooperative, Inc., its assigns and successors, is hereby authorized to store carbon dioxide in the Broom Creek Formation in the Minnkota Center MRYS Broom Creek Storage Facility #1.

(3) The Minnkota Center MRYS Broom Creek Storage Facility #1 shall extend to and include the following lands in Oliver County, North Dakota:

TOWNSHIP 142 NORTH, RANGE 84 WEST  
THE S/2 SE/4 OF SECTION 35, AND THE S/2 OF SECTION 36,

TOWNSHIP 142 NORTH, RANGE 83 WEST  
ALL OF SECTIONS 28, 29, 31, 32, 33 AND 34, THE SE/4 SE/4 OF SECTION 19, THE SE/4 AND S/2 SW/4 OF SECTION 20, THE S/2 AND S/2 N/2 OF SECTION 21, THE SW/4 NW/4, W/2 SW/4, AND SE/4 SW/4 OF SECTION 22, THE SW/4 AND SW/4 SE/4 OF SECTION 26, THE W/2, SE/4, AND W/2 NE/4 OF SECTION 27, THE E/2, E/2 SW/4, AND SE/4 NW/4 OF SECTION 30, AND THE W/2, NE/4, AND W/2 SE/4 OF SECTION 35,

TOWNSHIP 141 NORTH, RANGE 84 WEST  
ALL OF SECTIONS 1 AND 12, THE E/2, E/2 SW/4, AND E/2 E/2 NW/4 OF SECTION 2, AND THE NE/4, E/2 NW/4, AND NE/4 SE/4 OF SECTION 13,

TOWNSHIP 141 NORTH, RANGE 83 WEST  
ALL OF SECTIONS 2, 3, 4, 5, 6, 7, 8, 9, 10, 16, 17 AND 18, THE W/2 SW/4 OF SECTION 1, THE W/2, NE/4, W/2 SE/4, AND NE/4 SE/4 OF SECTION 11, THE W/2 NW/4, NE/4 NW/4, AND NW/4 SW/4 OF SECTION 12, THE N/2 NW/4, SE/4 NW/4, NW/4 NE/4, W/2 SW/4 NW/4, AND NE/4 SW/4 NW/4 OF SECTION 14, THE N/2 N/2, SE/4 NE/4, AND SW/4 NW/4 OF SECTION 15, THE N/2 N/2, SE/4 NW/4, AND SE/4 NE/4 OF SECTION 19, THE N/2 OF SECTION 20, AND THE W/2, W/2 NE/4, AND NW/4 SE/4 OF SECTION 21.

(4) Injection into the Minnkota Center MRYS Broom Creek Storage Facility #1 shall not occur until Minnkota Power Cooperative, Inc. has met the financial responsibility demonstration pursuant to Order No. 31585 entered in Case No. 29031.

(5) This authorization does not convey authority to inject carbon dioxide into the Minnkota Center MRYS Broom Creek Storage Facility #1; approved permits to inject for the J-ROC1 #1 well (File No. 37672) and proposed Unity #1 shall be issued by the Commission prior to injection operations commencing.

(6) The authorization granted herein is conditioned on the operator receiving and complying with all provisions of the injection permit issued by the Oil and Gas Division of the Industrial Commission and complying with all provisions of NDAC Chapter 43-05-01 where applicable, and this order.

(7) Definitions.

“Area of review” in this case means an area encompassing a radius around the facility area of one mile.

“Cell” in this case means individual cell blocks of the geologic model; each cell is approximately 1000 feet by 1000 feet.

“Facility area” means the areal extent of the storage reservoir as defined in paragraph (3) above, that includes lands within the lateral boundary of the carbon dioxide plume from beginning of injection to the time the carbon dioxide plume ceases to migrate into adjacent geologic model cells.

“Storage facility” means the reservoir, underground equipment, and surface facilities and equipment used or proposed to be used in the geologic storage operation. It does not include pipelines used to transport carbon dioxide to the storage facility under NDCC Section 38-22-02.

(8) The storage facility operator shall comply with all conditions of this order, the permit to inject, and NDAC Chapter 43-05-01, where applicable. Any noncompliance constitutes a violation and is grounds for enforcement action, including but not limited to termination, revocation, or modification of this order pursuant to NDAC Section 43-05-01-12.

(9) In an administrative action, it shall not be a defense that it would have been necessary for the storage facility operator to halt or reduce the permitted activity in order to maintain compliance with this order, the permit to inject, and NDAC Chapter 43-05-01, where applicable.

(10) The storage facility operator shall take all reasonable steps to minimize or correct any adverse impact on the environment resulting from noncompliance with this order, the permit to inject, and NDAC Chapter 43-05-01, where applicable.

(11) The storage facility operator shall implement and maintain the provided emergency and remedial response plan pursuant to NDAC Section 43-05-01-13.

(12) The storage facility operator shall cease injection immediately, take all steps reasonably necessary to identify and characterize any release, implement the emergency and remedial response

plan approved by the Commission, and notify the Commission within 24 hours of carbon dioxide detected above the confining zone.

(13) The storage facility operator shall at all times properly operate and maintain all storage facilities which are installed or used by the storage facility operator to achieve compliance with the conditions of this order, the permit to inject, and NDAC Chapter 43-05-01, where applicable. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities or similar systems only when necessary to achieve compliance.

(14) This order may be modified, revoked and reissued, or terminated pursuant to NDAC Section 43-05-01-12. The filing of a request by the storage facility operator for an order modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any condition contained therein.

(15) The injection well permit or the permit to operate an injection well does not convey any property rights of any sort of any exclusive privilege.

(16) The storage facility operator shall furnish to the Director, within a time specified, any information which the Director may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this order, or to determine compliance thereof. The storage facility operator shall also furnish to the Director, upon request, copies of records required to be kept by this order, the permit to inject, and NDAC Chapter 43-05-01, where applicable.

(17) The storage facility operator shall allow the Director, or an authorized representative, upon presentation of credentials and other documents as may be required by law, to:

- (a) Enter upon the storage facility premises where records must be kept pursuant to this order and NDAC Chapter 43-05-01.
- (b) At reasonable times, have access to and copy any records that must be kept pursuant to this order and NDAC Chapter 43-05-01.
- (c) At reasonable times, inspect any facilities, equipment, including monitoring and control equipment, practices, or operations regulated or required pursuant to this order, the permit to inject, and NDAC Chapter 43-05-01.
- (d) At reasonable times, sample or monitor for the purposes of assuring compliance, any substances or parameters at any location.

(18) The storage facility operator shall maintain and comply with the proposed testing and monitoring plan pursuant to NDAC Section 43-05-01-11.4

(19) The storage facility operator shall comply with the reporting requirements provided in NDAC Section 43-05-01-18. The volume of carbon dioxide injected, the average injection rate, surface injection pressure, and down-hole temperature and pressure data shall be reported monthly

to the Director on or before the fifth day of the second succeeding month once injection commences regardless of the status of operations, until the injection well is properly plugged and abandoned.

(20) The storage facility operator must obtain an injection well permit under NDAC Section 43-05-01-10 and injection wells must meet the construction and completion requirements in NDAC Section 43-05-01-11.

(21) The storage facility operator shall notify the Director at least 48 hours in advance to witness a mechanical integrity test of the tubing-casing annulus in the injection well. The packer must be set within 100 feet of the upper most perforation and in the 13CR-80 casing, as an exception to NDAC Section 43-05-01-11. However, the packer must also be set within confining zone lithology, within carbon dioxide resistant cement, and not interfere down-hole monitoring equipment.

(22) The storage facility operator shall maintain and comply with the prepared plugging plan pursuant to NDAC Section 43-05-01-11.5.

(23) The storage facility operator shall establish mechanical integrity prior to commencing injection and maintain mechanical integrity pursuant to NDAC Section 43-05-01-11.1.

(24) The storage facility operator shall implement the worker safety plan pursuant to NDAC Section 43-05-01-13.

(25) The storage facility operator shall comply with leak detection and reporting requirements pursuant to NDAC Section 43-05-01-14.

(26) The storage facility operator shall implement the proposed corrosion monitoring and prevention program pursuant to NDAC Section 43-05-01-05.1.

(27) The storage facility operator shall maintain financial responsibility pursuant to NDAC Section 43-05-01-09.1.

(28) The storage facility operator shall maintain and comply with the proposed post-injection site care and facility closure plan pursuant to NDAC Section 43-05-01-19.

(29) The storage facility operator shall notify the Director within 24 hours of failure or malfunction of surface or bottom hole gauges in the J-ROC1 #1 (File No. 37672) or proposed Unity #1 injectors.

(30) The storage facility operator shall implement surface air and soil gas monitoring as proposed.

(31) This storage facility authorization and permit shall be reviewed at least once every five years from commencement of injection to determine whether it should be modified, revoked, or minor modification made, pursuant to NDAC Section 43-05-01-05.1(4).



(32) The storage facility operator shall pay fees pursuant to NDAC Section 43-05-01-17 annually, no more than thirty days after the receipt of 26 U.S. Code § 45Q tax credits, unless otherwise approved by the Director.

(33) This order shall remain in full force and effect until further order of the Commission.

Dated this 21st day of January, 2022.

INDUSTRIAL COMMISSION  
STATE OF NORTH DAKOTA

/s/ Doug Burgum, Governor

/s/ Wayne Stenehjem, Attorney General

/s/ Doug Goehring, Agriculture Commissioner