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11. Post-Injection Site Care and Site Closure Plan

This Post-Injection Site Care and Site Closure (PISC) plan describes the activities that ADM will perform to meet the requirements of 40 CFR 146.93. ADM will monitor groundwater quality and track the position of the carbon dioxide plume and pressure front for 10 years after the cessation of injection. ADM will not cease post-injection monitoring in accordance with the approved PISC Plan until site closure has been authorized by the Director pursuant to 40 CFR 146.93(b)(3). Following authorization for site closure, ADM will plug all monitoring wells, restore the site to its original condition, and submit a Site Closure report and associated documentation.

11.1 Pressure differential and position of the CO2 plume and pressure front

Figure 11.1-1 represents the predicted extent of the AoR pressure front at the end of operation, 5-years post-injection and at the end of the 10-year PISC timeframe. This map is a summary of the AoR delineation modeling results submitted in Section 4 of this CCS#3 application in 2022 per 40 CFR 146.84. At the onset of the post-injection period it is expected that the CO_2 plume will continue to expand to a small degree as the system reaches pressure equilibrium, with a maximum CO_2 plume occurring approximately 5-years post-injection. The size of the pressure front, defined by the shrinking cone of influence as reservoir pressures decline, will decrease. As shown in Figure 11.1-1, the AoR is contracting toward the injection well locations prior to the end of the 10-year PISC timeframe. Based on modeling forecasts, the pressure-induced cone of influence (the pressure change that defines the permit AoR) is projected to dissipate to less than 1% of its maximum size by 2088.

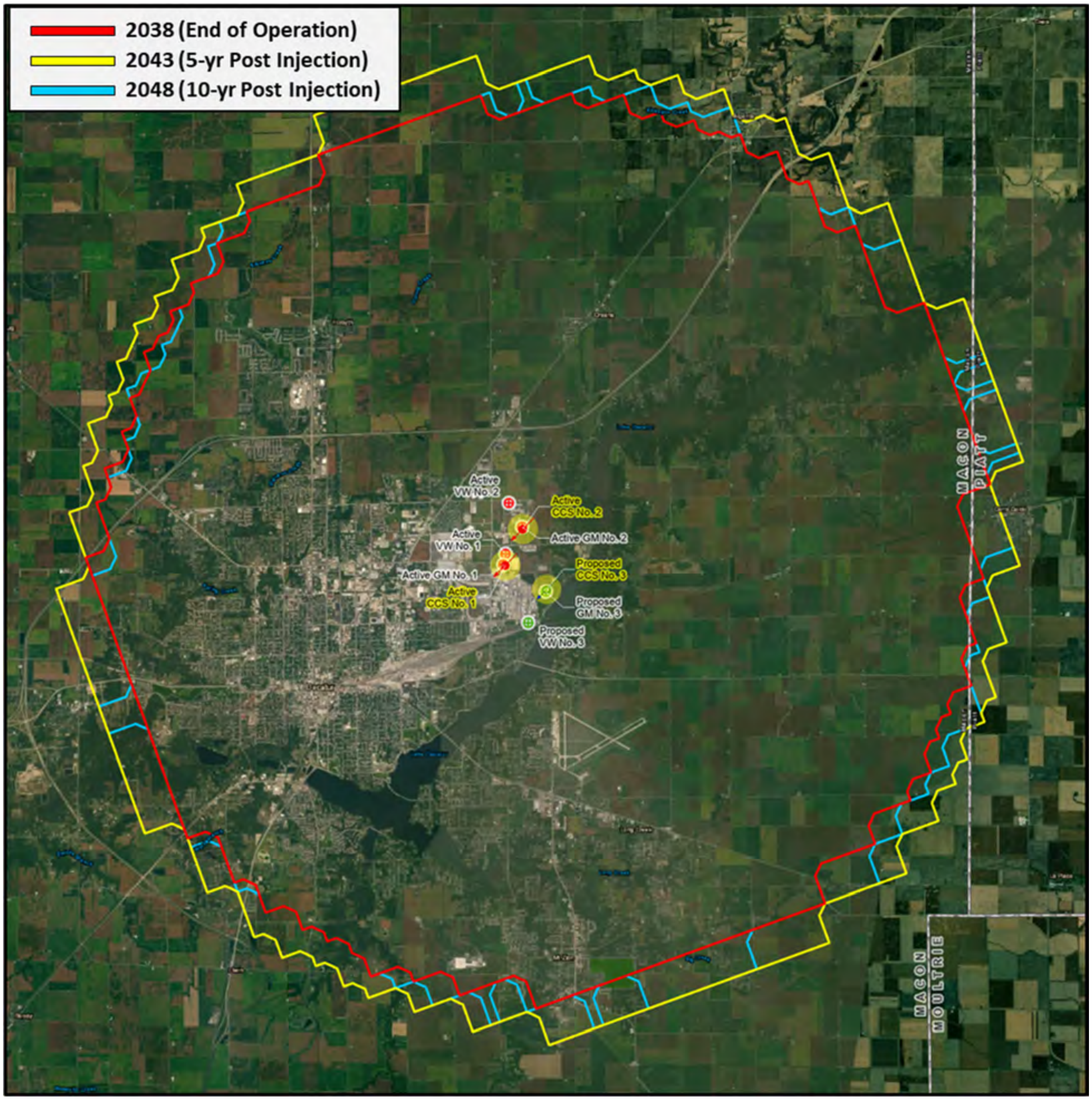

Figure 11.1-1. Modeled Extent of CO_2 Plume (End of Operation, 5-Years and 10-Years Post-Injection)

Similarly, Figure 11.1-2 is a summary of modeling results presented in Section 4 of this document. It depicts the modeled extent of the plume boundary at the end of operation, the end of the 10-year PISC timeframe and for comparison purposes also shows the minimal changes that occur at 50-years post injection as compared with the end of the PISC period. Based on modeling results, no significant post-operational plume drift is expected and the plume is predicted to reach its near-maximum size by the end of the 10-year PISC period.

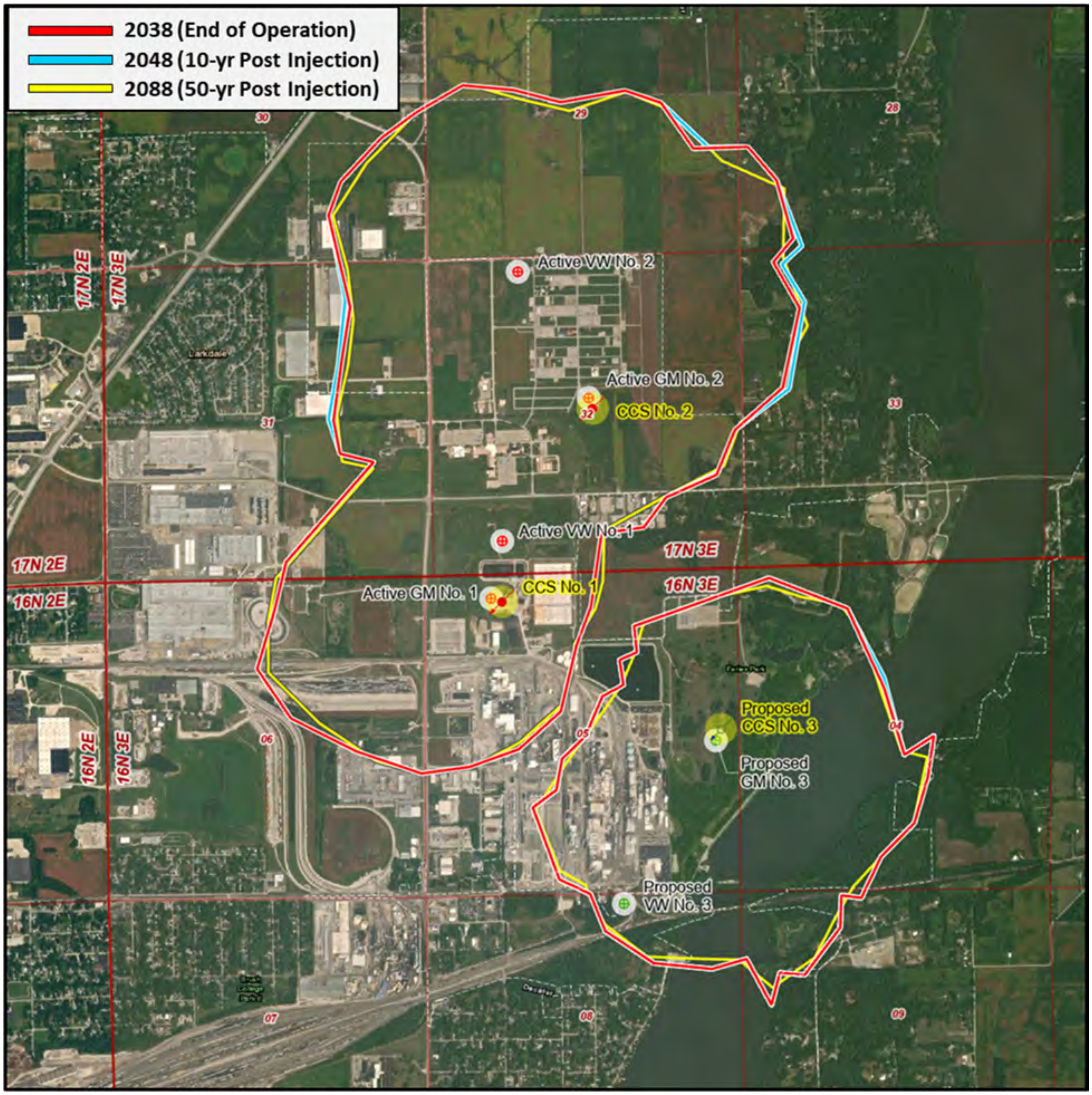

Figure 11.1-2. Modeled Extent of CO_2 Plume (End of Operation, 10-Years and 50-Years Post-Injection)

11.2 Post-injection phase monitoring plan

11.2.1 Groundwater Quality Monitoring

Tables 11.2.1-1 and 11.2.1-2 present the direct and indirect monitoring methods, locations, and frequencies for groundwater quality monitoring that are planned above the confining zone in the Quaternary and/or Pennsylvanian strata, in the St. Peter Formation, and for the Ironton-Galesville Sandstone. All of the existing and proposed monitoring wells are located on ADM property. Table I.3 identifies the parameters to be monitored and the analytical methods ADM will employ.

Fluid sampling will provide direct evidence regarding the presence or absence of CO2 and/or altered geochemistry that is associated with CO2 movement. Temperature monitoring will provide evidence to determine if fluid passing a monitored location has changed the original temperature of the monitored interval and pressure monitoring will provide evidence if sufficient fluid movement has occurred into a deep strata that has resulted in an induced pressure gradient at the monitored location.

Table 11.2.1-1. Post-Injection Phase Direct Groundwater Monitoring Above Confining Zone

Target Formation	Monitoring Activity	Monitoring Location	Frequency: Year1	Frequency: Years 2-3	Frequency: Years 4-9	Frequency: Year 10
Sensitive, Confidential, or Privileged Information [redacted]	Fluid Sampling	Sensitive, Confidential, or Privileged I [redacted]	Annual	Annual	Annual	Annual
	Distributed Temperature Sensing (DTS)	[redacted]	Monthly	None	None	None
[redacted]	Fluid Sampling	[redacted]	Annual	Annual	Annual	Annual
	Pressure/Temperature Monitoring	[redacted]	Monthly	Monthly	None	None
	DTS	[redacted]	Monthly	None	None	None
[redacted]	Fluid Sampling	[redacted]	Annual	Annual	Annual	Annual
	Pressure/Temperature Monitoring	[redacted]	Monthly	Monthly	Annual	Annual
	DTS	[redacted]	Monthly	None	None	None

Table 11.2.1-2. Post-Injection Phase Indirect Groundwater Monitoring Above Confining Zone

Target Formation	Monitoring Activity	Monitoring Location	Frequency to Year 10
Sensitive, Confidential, or Privileged Information [redacted]	Pulse-Neutron/RST Logging	Sensitive, Confidential, or Privileged Information [redacted]	Years 1,3,5,7, and 10
	Pulse-Neutron/RST Logging		Years 1,3,5,7, and 10
	Pulse-Neutron/RST Logging		Years 1,3,5,7 ,and 10

Table 11.2.1-3. Summary of Analytical and Field Parameters for Groundwater Samples (1)

Parameters	Analytical Methods
Quaternary/Pennsylvanian	
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES EPA Method 6010B
Anions: Br, Cl, F, NO_3, and SO_4	Ion Chromatography EPA Method 300.0
Dissolved CO_2	Coulometric titration, ASTM D513-11
Total Dissolved Solids	Gravimetry; APHA 2540C
Alkalinity	APHA 2320B
pH (field)	EPA 150.1
Specific conductance (field)	APHA 2510
Temperature (field)	Thermocouple
St. Peter	
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES EPA Method 6010B
Anions:	Ion Chromatography

Br, Cl, F, NO_3, and SO_4	EPA Method 300.0
Dissolved CO_2	Coulometric titration, ASTM D513-11
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry
Total Dissolved Solids	Gravimetry; APHA 2540C
Water Density (field)	Oscillating body method
Alkalinity	APHA 2320B
pH (field)	EPA 150.1
Specific conductance (field)	APHA 2510
Temperature (field)	Thermocouple
Parameters	**Analytical Methods**
Ironton-Galesville	
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES EPA Method 6010B
Anions: Br, Cl, F, NO_3, and SO_4	Ion Chromatography EPA Method 300.0
Dissolved CO_2	Coulometric titration, ASTM D513-11
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry
Total Dissolved Solids	Gravimetry; APHA 2540C
Water Density (field)	Oscillating body method
Alkalinity	APHA 2320B
pH (field)	EPA 150.1
Specific conductance (field)	APHA 2510
Temperature (field)	Thermocouple

Note 1: ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography - pyrolysis. An equivalent method may be employed with prior approval of the Director.

Sampling will be performed as described in section B.2 of the QASP; this section of the QASP describes the groundwater sampling methods to be employed, including sampling SOPs (section B.2.a/b), and sample preservation (section B.2.g).

- Sample handling and custody will be performed as described in section B.3 of the QASP.
- Quality control will be ensured using the methods described in section B.5 of the QASP.

11.2.2 Carbon Dioxide Plume and Pressure Front Tracking

ADM will employ direct and indirect methods to track the extent of the carbon dioxide plume and the presence or absence of elevated pressure within the injection formation as specified. Table 11.2.2-1 presents the direct and indirect methods that ADM will use to monitor the CO_2 plume evolution in the injection zone, including the activities, locations, and frequencies ADM will employ. ADM will conduct fluid sampling and analysis to detect changes in groundwater in order to directly monitor the presence or absence of the carbon dioxide plume at a monitored location. Arrival time of the plume and concentrations detected will be compared to simulations to validate the model projections. The parameters to be analyzed as part of fluid sampling in the Mt. Simon (and associated analytical methods) are presented in Table 11.2.2-2. Sufficient changes in chemical constituents will be analyzed to determine if they provide evidence of plume location. Indirect plume monitoring will be employed using pulsed neutron capture/reservoir saturation tool (RST) logs to monitor CO_2 saturation and these data will be integrated with 3D surface seismic surveys as practical to determine if changing density results in sufficient seismic signatures to track plume movement in the subsurface. Quality assurance procedures for seismic monitoring methods are presented in Section B.9 of the QASP.

Table 11.2.2-1. Post-Injection Phase Plume Monitoring (1,2)

Target Formation	Monitoring Activity	Monitoring Location	Frequency to Year 10
Direct Plume Monitoring			
Sensitive, Confidential, or Privileged Information	Fluid Sampling	Sensitive, Confidential, or Privileged Information	Annual
Indirect Plume Monitoring			
Sensitive, Confidential, or Privileged Information	Pulse-Neutron/RST Logging		Years 1,3,5,7 ,and 10
	3D Seismic Survey		Year 1 and Year 10

Table 11.2.2-2. Summary of analytical and field parameters for fluid sampling in the Mt. Simon

Parameters	Analytical Methods (1)
Water Density (field)	Oscillating body method
Alkalinity	APHA 2320B
pH (field)	EPA 150.1
Specific conductance (field)	APHA 2510
Temperature (field)	Thermocouple
Mt. Simon	
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES EPA Method 6010B
Anions: Br, Cl, F, NO_3, and SO_4	Ion Chromatography EPA Method 300.0
Dissolved CO_2	Coulometric titration, ASTM D513-11
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry
Total Dissolved Solids	Gravimetry; APHA 2540C
Water Density (field)	Oscillating body method
Alkalinity	APHA 2320B
pH (field)	EPA 150.1
Specific conductance (field)	APHA 2510
Temperature (field)	Thermocouple

Note 1: ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography - pyrolysis. An equivalent method may be employed with the prior approval of the Director.

Table 11.2.2-3 presents the direct and indirect methods that ADM will use to monitor the pressure front, including the activities, locations, and frequencies ADM will employ. ADM will deploy pressure/temperature monitors and distributed temperature sensors to directly monitor the position of the pressure front. Passive seismic monitoring using a combination of borehole and surface seismic stations to detect local events over M1.0 within the AoR will also be performed.

Table 11.2.2-3. Post-Injection Phase Pressure Front Monitoring

Target Formation	Monitoring Activity	Monitoring Location	Frequency: Year 1	Frequency: Years 2-3	Frequency: Years 4-9	Frequency: Year 10
Direct Pressure-front Monitoring						
[redacted]	Pressure/Temperature Monitoring	[redacted]	Monthly	Monthly	Monthly	Monthly
			Monthly	Monthly	Annual	Annual
	DTS		Monthly	None	None	None
Other Monitoring						
[redacted]	Passive Seismic		Continuous**; processed monthly	Continuous**; processed monthly	Continuous**; processed monthly	Continuous**; processed monthly

**Continuous recording of passive seismic data is processed on a monthly basis to determine if seismic events over M1.0 occurred within the AoR. The passive seismic monitoring system at borehole and surface seismic stations is owned and operated by USGS.

11.3 Alternative PISC timeframe

ADM will conduct post-injection monitoring for 10 years following the cessation of injection operations in CCS#3, consistent with the demonstrated and approved alternative timeframe pursuant to 40 CFR 146.93(c)(1), for CCS#1 and CCS#2. ADM requests a 10-year alternative post-injection care time period for CCS#3 based on the computational modeling conducted to delineate the AoR; predictions of plume migration, pressure decline, and carbon dioxide trapping; site-specific geology; well construction; and the distance between the injection zone and the nearest USDWs. Modeling results are summarized in previous portions of this section and described in more detail in Section 4 of this application. Site specific conditions that satisfy the alternative timeframe requirements listed in § 146.93(c)(1) and (2) are described in the following paragraphs. Note that the specific section for each criterion in the CFR is listed in square brackets, [ ].

- [§146.93(c)(1)(i)] The results of computational modeling of the project (Section 4 of this application) show that the sequestered CO_2 will not migrate above the Mt. Simon Sandstone.

- [§146.93(c)(1)(ii)] The modeling demonstrates that formation fluids will not be forced into any USDWs; and/or the timeframe for pressure decline to pre-injection pressures. Consistent with the map presented in Figure 11.1-1, Figure 11.3-1 presents the modeled bottomhole pressures projected over time at the CCS#1, CCS#2 and CCS#3 locations. Pressure values are normalized to a depth of 6,000' SSTVD. Figure 11.3-1 illustrates that bottomhole pressures are projected to decline significantly over the first several years post-injection. At the end of the 10-year PISC timeframe, more than 90% of the pressure decline that will occur is observed in the wells. Pressure rise in the injection zone has dissipated significantly by the end of the 10-year PISC period.

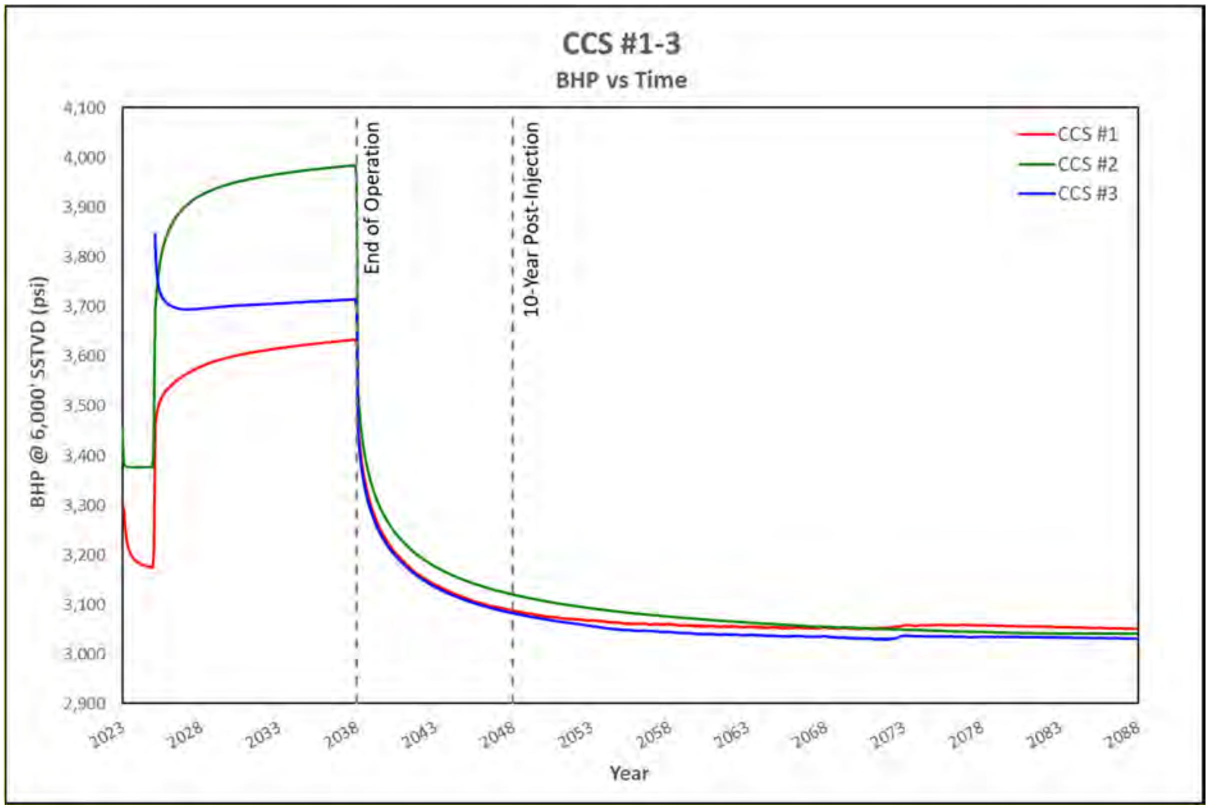

Figure 11.3-1. Modeled Extent of AOR Boundary (End of Operation, 5-Years and 10-Years Post-Injection)

- [§146.93(c)(1)(ii)] The hydrogeologic and seismic characterization for the project site indicates that the Eau Claire Formation, the primary seal above the Mt. Simon, does not contain any faults and has permeability sufficiently low to impede CO_2 migration to overlying formations.

- [§146.93(c)(1)(iii), the predicted rate of carbon dioxide plume migration within the injection zone and predicted time frame for cessation of migration is addressed in Section 4 of this application. Based on the modeled plume areas summarized in Figure 11.1-2, the equivalent plume radius (assuming circular areas and no initial plume) grows at an average of approximately 400 ft/year during the later portion of injection operations. During the initial ten years of post-injection equilibration, the rate of plume expansion reduces to an average of approximately 33 ft/year. Following the 10-year PISC timeframe, the rate of expansion continues to decrease and becomes negligible by 50 years post-injection.

- [146.93(c)(1)(iv-vi) addresses the description of processes that result in carbon dioxide trapping including immobilization by capillary trapping, dissolution and mineralization and the predicted rate of trapping, as well as the site-specific studies supporting these mechanisms. Section 3.11 addressed expected mineralogical reactions and associated studies associated with CO2 injection. The section concludes that it is not expected “that injection of CO2 into the proposed well would lead to drastic geochemical reactions within the reservoir and seal that compromise injectivity and long-term security”, and does not call for CO2 immobilization as a trapping mechanism. The alternative timeframe is well justified by modeled pressure decline. As indicated above and shown in Figure 11.3-1, at the end of the 10-year PISC timeframe, more than 90% of the pressure decline that will occur is observed in the wells. Pressure rise in the injection zone has dissipated significantly by the end of the 10-year PISC period.

- [§146.93(c)(1)(viii) and (ix)] Potential conduits for hypothetical CO_2 migration above the Mt. Simon are limited to the ADM injection and verification wells, all of which will be constructed, monitored, and plugged in a manner that will minimize the potential for any such migration and meet the requirements of 40 CFR Part 146. There are no other potential vertical pathways out of the Mt. Simon injection zone within the AoR at the end of the operating life and pressures at the injection wells are projected to have declined to within approximately 10% of the maximum pressure rise experienced during operations by the end of the 10-year PISC period.

- [§146.93(c)(1)(x)] The Mt. Simon Sandstone is nearly 7,000 feet below the lowermost USDW, and there are three confining formations (New Albany Shale, Maquoketa Formation, Eau Claire Formation) between the injection zone and the lowermost USDW. If, based on results of operational monitoring the EPA requires post-injection monitoring beyond the ten-year timeframe outlined in this plan, the operator will work with the Director to establish the monitoring activities, frequency, and duration of the PISC period.

Sections 3 and 4 present the information that satisfies the requirements set forth in §146.93(c)(2) regarding predictive models used, parameter determination including analyses, tests, and estimation techniques, model calibration, modeling assumptions, and modeling uncertainty. The same parameters, modeling techniques, and geologic characterization were presented to support approval of the CCS#2 alternative 10-year time period. In addition to historical injection, this application addresses additional CO_2 injection into all three wells (including the CCS#3 well) over a 12-year initial operating period.

ADM will conduct the monitoring described under “Groundwater Quality Monitoring” and “Carbon Dioxide Plume and Pressure Front Tracking” sections presented above and report the results as described under the “Schedule for Submitting Post-Injection Monitoring Results.” This will continue until ADM demonstrates, based on monitoring and other site-specific data, that no additional monitoring is needed to ensure that the project does not pose an endangerment to any USDWs, per the requirements at 40 CFR 146.93(b)(2) or (3).

If any of the information upon which this demonstration was based changes or the measured behavior of the system varies significantly from modeled predictions, e.g., as a result of an AoR reevaluation, ADM may update this PISC and Site Closure Plan pursuant to 40 CFR 146.93(a)(4). ADM will update the PISC and Site Closure Plan, within six months of ceasing injection or demonstrate that no update is needed and as necessary during the duration of the PISC timeframe.

11.4 Non-endangerment demonstration criteria

Prior to authorization of site closure, ADM will submit a demonstration of non-endangerment of USDWs to the Director, per 40 CFR 146.93(b)(2) or (3).

To make the non-endangerment demonstration, ADM will issue a report to the Director. This report will make a demonstration of USDW non-endangerment based on the evaluation of the site monitoring data used in conjunction with the project computational model. The report will detail how the non-endangerment demonstration uses site-specific conditions to confirm and demonstrate non-endangerment. The report will include (or appropriately reference): all relevant monitoring data and interpretations upon which the non-endangerment demonstration is based, model documentation and all supporting data, and any other information necessary for the Director to review the analysis. The report will include the following components:

Summary of Existing Monitoring Data

A summary of all previous monitoring data collected at the site, pursuant to the Testing and Monitoring Plan (Section 9 of this application) and this PISC and Site Closure Plan, including data collected during the injection and PISC phases of the project, will be submitted to help demonstrate non-endangerment. Data submittals will be in a format acceptable to the Director [40 CFR 146.91(e)], and will include a narrative explanation of monitoring activities, including the dates of all monitoring events, changes to the monitoring program over time, and an explanation of all monitoring infrastructure that has existed at the site. Data will be compared with baseline data collected during site characterization [40 CFR 146.82(a)(6) and 146.87(d)(3)].

Comparison of Monitoring Data and Model Predictions and Model Documentation

The results of computational modeling used for AoR delineation and for demonstration of the alternative PISC timeframe will be compared to monitoring data collected during the operational and the PISC periods. The data will include the results of time-lapse temperature and pressure monitoring, groundwater quality analysis, passive seismic monitoring, and geophysical surveys (i.e. logging, operating-phase VSP, and 3D surface seismic surveys) used to update the computational model and to monitor the site. Data generated during the PISC period will be used to show that the computational model accurately represents the storage site and can be used as a proxy to determine the properties of the plume including the plume size. ADM will demonstrate that the accuracy of the model is sufficient by comparing the monitoring data obtained during the PISC period against the performance of the system as predicted by the model (i.e. plume location, rate of movement, and pressure decay). Statistical methods will be employed to correlate the data and confirm the capability of the model to accurately represent the storage site. The validation of the computational model with the significant set of monitoring data will be a significant element to support the non-endangerment demonstration. Justification that the conclusions of the model are meaningful will be presented based on the validation efforts. Further, the validation of the model over the areas, and at the points, where direct data collection has taken place will help to ensure confidence in the model for those areas where surface infrastructure preclude geophysical data collection and where direct observation wells cannot be placed.

Evaluation of Carbon Dioxide Plume

ADM will use a combination of time-lapse RST logs, time-lapse VSP surveys, and other seismic methods (2D or 3D surveys) to locate and track the extent of the CO_2 plume. Figures 11.4-1 through 11.4-3 present examples of how the data may be correlated against the model prediction. In Figure 11.4-1, a series of RST logs are compared against the model's predicted plume vertical extent at a specific point location at a specified time interval. If a good correlation between the two data sets can be established it will be used to provide validation of the model's ability to represent the storage system. Similarly, Figure 11.4-2 illustrates an example of how the time-lapse VSPs can be compared against the predicted spatial extent of the plume at a specified time interval. Limited 2D and 3D seismic surveys will be employed to attempt a determination of the plume location at specific times. The data produced by these activities will be compared against the model using statistical methods to validate the ability of the model to accurately represent the storage site. Figure 11.4-3 presents an example of how the data from time-lapse 3D seismic surveys may be correlated against model predictions.

Sensitive, Confidential, or Privileged Information

Figure 11.4-1. Comparison of the time-lapse RST logs against the predicted vertical extent of the plume at a specific time interval during the operational and PISC timeframes.

Sensitive, Confidential, or Privileged Information

[redacted]

Figure 11.4-2. Comparison of the time-lapse VSPs against the predicted spatial extent of the plume at specific time intervals during the operational and PISC timeframes.

Sensitive, Confidential, or Privileged Information

[redacted]

Figure 11.4-3. Comparison of the time-lapse surface 3D against the predicted spatial extent of the plume at specific time intervals during the operational and PISC timeframes.

<u>Evaluation of Mobilized Fluids</u>

In addition to carbon dioxide, mobilized fluids may pose a risk to USDWs. These include native fluids that are high in TDS and therefore may impair a USDW, and fluids containing mobilized drinking water contaminants (e.g., arsenic, mercury, hydrogen sulfide). The geochemical data collected from monitoring wells will be used to demonstrate that no mobilized fluids have moved above the confining formations that act as the seal or caprock. If no such fluids are detected during the PISC period, declining pressure gradients will be limited in potentially moving the fluids as pressures are coming to equilibrium by the end of the PISC; therefore, such fluids would not pose a risk to USDWs. In order to demonstrate non-endangerment, ADM will compare the operational and PISC period samples from layers above the injection zone, including the lowermost USDW, against the pre-injection baseline samples. This comparison will support a demonstration that no significant changes in the fluid properties of the overlying formations have occurred and that no mobilized formation fluids have moved through the sealing formation. This validation of seal integrity will help demonstrate that the injectate and/or mobilized fluids would not represent an endangerment to any USDWs. Additionally, RST logs will be used to monitor the concentrations of the reservoir fluids in the observation zone above the primary overlying Eau Claire Shale seal.

Evaluation of Reservoir Pressure

ADM will also support the demonstration of non-endangerment to USDWs by showing that, during the PISC period, the pressure within the Mt. Simon has rapidly decreased toward pre-injection static reservoir pressure values. Because the increased pressure during injection is the primary driving force for fluid movement that may endanger a USDW, the decay in the pressure differentials will provide strong justification that the injectate does not pose a risk to any USDWs.

ADM will monitor the downhole reservoir pressure at various locations and intervals using a combination of surface and downhole pressure gauges. The measured pressure at a specific depth interval will be compared against the pressure predicted by the computational model. Agreement between the actual and the predicted values will help validate the accuracy of the model and further demonstrate non-endangerment.

Evaluation of Passive Seismic Data

Finally, passive seismic monitoring will be used to help further demonstrate seal formation integrity. ADM will provide seismic monitoring data showing that no seismic events have occurred that would indicate fracturing or fault activation near or through the seal formation. This validation of seal integrity will provide further support for a demonstration that the CO_2 plume is no longer capable of posing endangerment to any USDWs. Figure 11.4-4 illustrates how these data could be presented. This figure shows a subset of locatable microseismic events occurring during part of the IBDP project operational period. This figure shows that a majority of the microseismic events measured occurred below the Eau Claire seal formation indicating that no fracturing or fault activation was possible within this formation. This provided additional verification of the Eau Claire formation integrity and indicates that to date the response to the imposed fluid pressures due to injection are confined to the vicinity of the injection zone and below.

Sensitive, Confidential, or Privileged Information

[redacted]

Figure 11.4-4. Visual representation showing the microseismic activity occurring during the injection and post-injection periods (figure provided by IBDP project)

11.5 Monitoring well plugging and site closure plan

ADM will conduct site closure activities to meet the requirements of 40 CFR 146.93(e), as described below. ADM will submit a final Site Closure Plan and notify the permitting agency at least 120 days prior of its intent to close the site. Once the permitting agency has authorized closure of the site, ADM will: plug the injection well(s), monitoring and verification well(s), and geophysical well(s); restore the site and move out all equipment; and submit a site closure report to the Director. The activities, as described below, present the planned activities consistent with the approved PISC for CCS#2. A final Site Closure Plan will be submitted to the Director for approval with the notification of the intent to close the site. Details regarding plugging of the CCS#3 injection well is included in Section 10.

11.5.1 Plugging the Verification Monitor Wells

A detailed verification well plugging procedure is provided below. All casing in these wells are designed to be cemented to surface and no casing will be retrieved at plugging.

<u>Type and Quantity of Plugging Materials, Depth Intervals</u>

The cements used for plugging will be tested in a lab prior to plug placement and both wet and dry samples will be collected during plugging for each plug to ensure quality of the plugs. All of the casing strings will be cut off at least 4 feet below the surface, below the plow line. A blanking plate with the required permit information will be welded to the top of the cutoff casing at the end of the plugging process.

Volume Calculations

Volumes will be calculated for each wellbore environment at the time of plugging based on desired plug diameter and length required. The methodology employed will be to:

1) Choose the following:
    a. Length of the cement plug desired.
    b. Desired setting depth of base of plug.
    c. Amount of spacer to be pumped ahead of the slurry.
2) Determine the following:
    a. Number of sacks of cement required.
    b. Volume of spacer to be pumped behind the slurry to balance the plug.
    c. Plug length before the pipe is withdrawn.
    d. Length of mud freefall in drill pipe.
    e. Displacement volume required to spot the plug.

Plugging Procedure

At the end of the serviceable life of a verification well, or when it is determined that plugging is appropriate, the well will be plugged and abandoned. In summary, the plugging procedure will consist of flushing the well with a kill weight brine fluid, conducting a final external MIT, removing all components of the completion system and then placing cement plugs along the entire length of the well. Prior to placing the cement plugs, the final MIT will consist of running casing inspection and temperature logs or suitable equivalents to confirm external mechanical integrity. If a loss of integrity is discovered, then a plan to repair using the cement squeeze method will be prepared and submitted to the agency for review and approval.

The following is an example of a detailed plugging procedure provided for VW#2 in the CCS#2 approved PISC, noting that all depths, cement volumes/sacks and other well-specific data are provided by example and will be modified to reflect actual well conditions. The same approved procedures are proposed for each of the VW wells at the site including proposed VW#3.

1. Move in workover unit with pump and tank.
2. Record bottom hole pressure using down hole instrumentation and calculate kill fluid density. Pressure test annulus as per historic annual mechanical integrity testing (MIT) requirements.
3. Fill both tubing strings with kill weight brine as calculated from bottomhole pressure measurement (expected approximately 9.5 ppg).
4. Nipple down well head and nipple up blow-out preventers (BOPs).
5. Remove completion equipment from well. If the packer cannot be removed from the well, modify plans to cut off tubing and plug through the packer.

6. Keep hole full with workover brine of sufficient density to maintain well control.
7. Log well with cement bond log (CBL), temperature, and casing inspection log or suitable equivalent techniques to confirm external mechanical integrity.
8. Pick up work string and trip in hole to PBTD.
9. Circulate two wellbore volumes to ensure that uniform density fluid is in the well.
10. The lower section of the well will be plugged using CO_2 resistant cement from TD at approximately 7,150 feet to approximately 800 feet above the top of the Eau Claire formation (to approximately 4,200 ft). This will be accomplished by placing plugs in 500-foot increments. Using a density of 15.9 ppg slurry with a yield of 1.11 cf/sk, approximately 347 sacks of cement will be required (to incorporate a safety factor, 416 sacks are assumed: 2,950 ft X .1305 cu ft/ft x 1.2 excess / 1.11 cf/sk = 416 sacks). Actual cement volume will depend upon actual weight of the casing within the plugged zone. This will require at least six plugs of 500 feet in length. No more than two plugs will be set before cement is allowed to set and plug depths will be verified by setting work string down onto the plug.
11. Pull approximately ten stands of tubing (~600 ft) out and shut down overnight to wait on cement curing.
12. After appropriate wait on cement period based on hole conditions, trip in hole and tag the plug. Resume plugging procedure as before and continue placing plugs until the last plug reaches the surface.
13. Nipple down BOPs.
14. Remove all well head components and cut off all casings below the plow line.
15. Finish filling well with cement from the surface if needed. Total of approximately 465 sacks total cement used in all remaining plugs above 4,200 feet (4200 ft X .1305 cu ft/ft /1.18 cu ft/sk = 465 sks). Cement calculations based on using Class A cement from 4200 ft back to surface with a density of 15.6 ppg and a yield of 1.18 cu ft /sk. Lay down all work string, etc. Clean cellar to where a plate can be welded with well name onto lowest casing string at least 4 feet below ground level, or as per permitting agency directive.
16. If required, install permanent marker back to surface on which all pertinent well information is inscribed.
17. Backfill cellar.
18. Rig down workover unit and move out all equipment. Haul off all workover fluids for proper disposal.
19. Reclaim surface to normal grade and reseed location.
20. Complete plugging forms and send in with charts and all lab information to the regulatory agency. Plugging report shall be certified as accurate by ADM and shall be submitted within 60 days after plugging is completed.

Note: 7,150 ft 5 ½” 17 #/ft (7150 ft X .1305 cu ft/ft = 933 cu ft) casing requires an estimated 933 cubic feet of cement to fill 14 plugs. An excess factor of 20% is to be used, as practical, for plugging the lowermost 3,000 ft of the wellbore to account for cement that might be lost to the formation, so total material used would be 423 sacks of EverCRETE CO_2 resistant cement (or equivalent) and 442 sack Class A/H cement.

Figure 11.5.1-1 presents an example well plugging schematic prepared for VW#2, which would be generally applicable to VW#3 noting that final plugging design will be dependent upon local geologic and other conditions at the time of plugging.

Figure 11.5.1-1. Generic Plugging Schematic – Verification Well Based on VW#2

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11.5.2 Plugging the Geophysical Well(s)

At the end of the serviceable life of the well, or when plugging is determined to be appropriate, the geophysical well(s) will be plugged and abandoned. The following is an example of a detailed plugging procedure provided for GM#2 in the CCS#2 approved PISC, noting that all depths, cement volumes/sacks and other well-specific data are provided by example and will be modified to reflect actual well conditions:

1. Notify the permitting agency at least 60 days prior to plugging the well.
2. Remove monitoring equipment from well bore. Well will contain fresh water or a mixture of fresh water and native St. Peter formation water.
3. Nipple down well head and connect cement pump truck to casing. Establish injection rate with fresh water. Mix and pump 247 sacks Class A cement (15.9 ppg). Slow injection rate to ½ bbl/min as cement starts to enter St. Peter perforations. Continue squeezing cement into formation until a squeeze pressure of 500 psi is obtained. Monitor static cement level in casing for 12 hours and fill with cement if needed to top out. Plan to have 50 sacks additional cement above calculated volume on location to top out if needed. (To incorporate a safety factor, 255 sacks are assumed: 3,450 ft X 0.0873 cu ft/ft /1.18 cu ft/sk = 255 sacks.)
4. After cement cures, cut off all well head components and cut off all casings at least 4 feet below ground surface (below the plow line).
5. Install permanent marker at surface, or as required by the permitting agency.
6. Reclaim surface to normal grade and reseed location.

Figure 11.5.2-1 presents a generalized GM#3 plugging schematic based on GM#2, noting that the specific depths, formation tops, etc., will be specific to the GM#3 location and conditions encountered at the time of plugging.

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Figure 11.5.2-1. Generic Plugging Schematic- Geophysical Monitoring Wells based on GM #2

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11.5.3 Planned Remedial/Site Restoration Activities

To restore the site to its pre-injection condition following site closure, ADM will be guided by the state rules for plugging of wells located on leased property under The Illinois Oil and Gas Act: Title 62: Mining Chapter I: Department of Natural Resources - Part 240, Section 240.1170 - Plugging Fluid Waste Disposal and Well Site Restoration.

The following steps will be taken:

1. The free liquid fraction of the plugging fluid waste will be removed from any pits and disposed of in accordance with state and federal regulations (e.g., injection or in above ground tanks or containers pending disposal) prior to restoration. The remaining plugging fluid wastes shall be disposed of by on-site burial.
2. All plugging pits shall be filled and leveled in a manner that allows the site to be returned to original use with no subsidence or leakage of fluids, and where applicable, with sufficient compaction to support farm machinery.
3. All drilling and production equipment, machinery, and equipment debris shall be removed from the site.
4. Casing shall be cut off at least four (4) feet below the surface of the ground, and a steel plate welded on the casing or a mushroomed cap of cement approximately one (1) foot in thickness shall be placed over the casing so that the top of the cap is at least three (3) feet below ground level.
5. Any drilling rat holes shall be filled with cement to no lower than four (4) feet and no higher than three (3) feet below ground level.
6. The well site and all excavations, holes and pits shall be filled and the surface leveled.

Site Closure Report

A site closure report will be prepared and submitted within 90 days following site closure, documenting the following:

- Plugging of the verification and geophysical wells (and the injection well if it has not previously been plugged) as specified at 40 CFR 146.92,
- Location of any sealed injection well on a plat of survey that has been submitted to the local zoning authority, with a copy of the plat provided to the Regional Administrator of EPA Region 5,
- Notifications to state and local authorities as required at 40 CFR 146.93(f)(2),
- Records regarding the nature, composition, and volume of the injected CO_2, and
- Post-injection monitoring records.

ADM will record a notation to the property deed on which the injection well was located that will indicate the following:

- That the property was used for carbon dioxide sequestration,
- The name of the local agency to which a plat of survey with injection well location was submitted, as well as the EPA Region Office to which is was submitted
- The volume of fluid injected,
- The formation(s) into which the fluid was injected, and
- The period over which the injection occurred.

The site closure report will be submitted to the permitting agency and maintained by the operator for a period of 10 years following site closure. Additionally, the operator will maintain the records collected during the PISC period for a period of 10 years after which these records will be delivered to the Director.

11.6 Quality Assurance and Surveillance Plan (QASP)

The Quality Assurance and Surveillance Plan is presented in Appendix C.