Underground Injection Control – Class VI Permit Application for Mockingbird Carbon Storage Project Injection Wells No. 01, No. 02, No. 03, and No. 04

SECTION 7 – POST-INJECTION SITE CARE AND SITE CLOSURE PLAN

Mockingbird Carbon Storage Project
Allen Parish, Louisiana
ExxonMobil Low Carbon Solutions Onshore Storage, LLC
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7.1 Introduction

The Post-Injection Site Care (PISC) and Site Closure Plan for the Mockingbird Carbon Storage (CS) (Mockingbird) Project Injection Wells (INJ) No. 01, No. 02, No. 03, and No. 04 was prepared to meet the requirements of Louisiana Administrative Code, Title 43 (LAC43): XVII **§3633**. ExxonMobil Low Carbon Solutions Onshore Storage, LLC (ExxonMobil) is undertaking the project in Allen Parish, Louisiana, to sequester up to approximately [redacted]

The PISC Plan describes the activities that will occur once injection operations have ceased, and the project moves into maintaining a non-endangerment condition for underground sources of drinking water (USDWs). The Site Closure Plan will be implemented once ExxonMobil demonstrates to the Commissioner of Conservation (Commissioner) that no additional monitoring is required to demonstrate protection of USDWs, and that the testing and monitoring system can be dismantled. ExxonMobil's strategy for PISC monitoring is based on the same systems and processes as described in *Section 5 – Testing and Monitoring Plan*.

The major monitoring elements include continued measurements of the CO_2 plume and pressure front location and monitoring the USDW and groundwater above the upper confining zone (UCZ). The data collected from this activity will be used to confirm compliance with the water-quality objectives for the project, and generate information needed to support the final non-endangerment demonstration and subsequent site closure. The end of the project will occur when the closure activities have been documented and approved by the Commissioner.

7.2 Objectives

The PISC and Site Closure Plan has been developed to meet the following objectives as outlined in LAC43: XVII **§3633**:

- Describe the pressure differential between pre-injection and predicted post-injection pressures in the injection zones, as well as the predicted positions of the CO_2 plume and associated pressure front at site closure.
- Describe the post-injection monitoring locations, methods, and proposed frequencies to demonstrate non-endangerment to the USDW over the time frame of the PISC.
- Identify the pre-closure, plugging, and site-restoration steps to achieve approval for site closure.
- Outline the documentation and recordkeeping practices that will provide the information for decision-making purposes.

ExxonMobil will not cease post-injection monitoring until the non-endangerment demonstration pursuant to LAC43: XVII **§3633.A.2.c** has been approved by the Commissioner. Pursuant to LAC43: XVII **§3633.A.2.a**, the default PISC monitoring time frame is 50 years after cessation of

injection. ExxonMobil will monitor groundwater quality and track the position of the CO_2 plume and pressure front for 50 years after cessation of injection, unless a lesser period is approved by the Commissioner in accordance with LAC43: XVII **§3633.A.3**. Once the non-endangerment demonstration has been approved, ExxonMobil will plug the monitoring wells, restore each well pad to the surface owner's agreed-upon condition, and submit a Site Closure Report to the Commissioner.

7.3 Calculation of Pre- and Post-Injection Pressure Differentials

As described in LAC43: XVII **§3633.A.1.b.i**, the Class VI non-endangerment demonstration will establish that pressure has declined to a level that no longer poses potential endangerment of USDWs. For the purposes of this section, ExxonMobil evaluated the pressure differentials by comparing the pre-operating pressure with the post-injection pressure differentials predicted by the plume model.

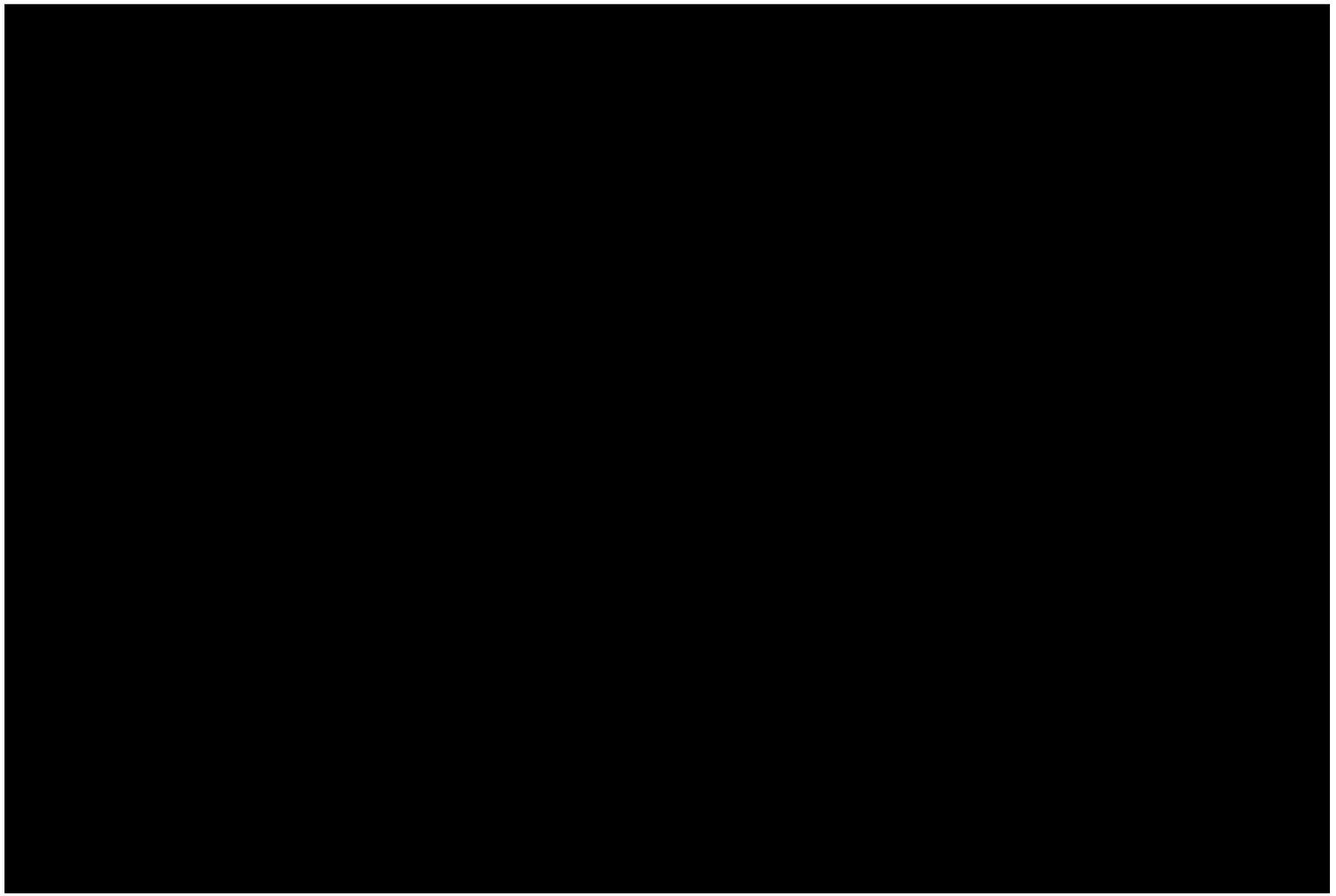
The predicted pressure differential between pre-injection and the modeled post-injection pressures are favorable, showing a steep and continuous decline in pressure toward pre-operational baseline conditions. The primary mechanisms responsible for the anticipated pressure decay rates are the injection sequencing plan, the geological conditions of the injection zones (e.g., net sand thickness, permeability, porosity) and confining zones, and the projected CO_2 storage volume for the Mockingbird Project site.

A staged injection sequence is planned for the proposed injection wells to optimize the storage of CO_2 in the injection intervals. *Section 3 – Area of Review and Corrective Action Plan* and *Section 4 – Well Construction Plan and Operating Conditions* provide detailed discussions of the injection sequencing strategy. Figure 7-1 summarizes the injection sequence schedule for the proposed injection period. The actual injection period will depend on the issuance of the permits for each injection well.

Figure 7-1 – [redacted]

Table 7-1 provides the model-predicted average pressure differential and the change in injection pressures in each injection interval over time pursuant to LAC43: XVII **§3633.A.1.b.i**.

Table 7-1 – Average Pressure Differential (psi) by Year for the Proposed Injection Wells



7.4 Predicted Position of the CO_2 Plume and Pressure Front at Site Closure

Pursuant to LAC43: XVII **§3633.A.1.b.ii**, the area of review (AOR) was delineated using computational modeling that accounts for all phases of CO_2 (supercritical, dissolved, etc.) under proposed operational conditions. The AOR consists of both the CO_2 plume and the extent of the pressure front. The following discussion provides the predicted evolution of both the CO_2 plume and pressure front throughout the course of the 50-year PISC time frame.

Figure 7-2 shows the extent of the AOR and its subcomponents [redacted] years from the start of injection ([redacted] from the cessation of injection). Based on the model, the CO_2 plume stabilization is predicted to occur [redacted]. Maximum pressure differentials occur during active injection phase (first 13 years) and dissipate rapidly post-injection, thereby reducing the potential for USDW endangerment. The CO_2 plume from the proposed injection wells is based on the maximum extent of any injection interval. [redacted]

Figure 7-2 – [redacted] during injection.

7.5 Post-Injection Site Care Monitoring Plan

Post-injection site care monitoring is required by LAC43: XVII **§3633.A.2** to demonstrate that the USDW is not endangered during the post-injection phase of the Mockingbird Project. Much like the operational phase, direct and indirect forms of monitoring will be used to track the evolution of the CO_2 plume and pressure front after cessation of CO_2 injection. The strategy for the PISC monitoring is to rely on a core set of monitoring locations that were established during the operational phase of the project.

The following core monitoring locations were assumed to be installed and monitored pursuant to the Testing and Monitoring Plan (*Section 5*) and found sufficient pursuant to the AOR reevaluation process:

[redacted]

Figure 7-2 illustrated the locations of these monitoring wells. If additional monitoring locations are added during the course of the injection operations under the direction of the Commissioner, this core set of monitoring wells will be updated to reflect the monitoring system in place at the close of the injection phase of the project.

In accordance with LAC43: XVII **§3633.A.2.a**, monitoring of the pressure front and CO_2 plume will occur for at least 50 years—unless an alternate duration approved by the Commissioner. ExxonMobil is proposing a schedule to submit PISC monitoring results annually and within 30 days of the anniversary date of injection cessation (LAC43: XVII **§3633.A.1.b.iv**).

The following discussion provides details on the elements of the PISC monitoring strategy outlined above.

7.5.1 PISC and Site Closure Plan Reviews and Amendments

As required by LAC43: XVII **§3633.A.1.c**, ExxonMobil will submit an amended PISC and Site Closure Plan or demonstrate that no amendment is needed upon cessation of injection. Amendments to the plan, or the demonstration that no revisions are necessary, will be based on monitoring data collected during injection and the most-recent AOR delineation.

During PISC monitoring, ExxonMobil will conduct periodic reviews to incorporate new monitoring data, changes to the site computational model that may warrant changes in PISC monitoring, and/or changes in the methodology proposed to demonstrate non-endangerment of the USDW. This approach will also support the use of new technologies that may be available in the future that facilitate a higher level of performance than the existing system. Pursuant to LAC43: XVII **§3615.C.2** and as described in *Section 4 – Well Construction Plan and Operating Conditions*,

ExxonMobil will reevaluate the AOR periodically by comparing model predictions with monitoring results.

Following an AOR reevaluation process, if the AOR and Corrective Action Plan is amended, ExxonMobil will review the PISC and Site Closure Plan to determine whether any updates are needed to ensure consistency across all plans. ExxonMobil may submit an amended PISC that describes how changes to the model affect predictions of pressure dissipation, plume migration rates, CO_2 trapping, and additional processes that need to be accounted for in the non-endangerment demonstration.

In accordance with LAC43: XVII **§3633.A.1.d**, ExxonMobil may—at any time during the life of the project—modify and resubmit the PISC and Site Closure Plan for the Commissioner's approval within 30 days of such changes.

7.5.2 Monitoring Above the UCZ and USDW

During the injection phase, periodic monitoring of groundwater quality for significant geochemical changes above the UCZ is required by LAC43: XVII **§3625.A.4** for the purpose of detecting potential leakage through the UCZ. In accordance with LAC43: XVII **§3633.A.2.a**, groundwater quality and geochemical characteristics will be monitored in the AZMI at proposed [redacted] and in the USDW at [redacted] during the post-injection period.

ExxonMobil's strategy for monitoring groundwater above the UCZ is a risk-based approach correlated to modeled CO_2 plume and injection-zone characteristics. By the time the PISC monitoring program is initiated, the risk-mitigating effects of the injection sequence plan, operating strategy, and corrective actions taken on artificial penetrations will likely have demonstrated protection of the USDW throughout the operational phase of the project. The list of analyses to be performed at these monitoring wells is summarized in Table 7-2, based on the same approach used for the operational phase of the project.

Table 7-3 provides a summary of indirect monitoring technologies to be used for monitoring the above-zone CO_2 plume and pressure front during the PISC phase of the project. This monitoring strategy is consistent with the details and rationale provided in *Section 5 – Testing and Monitoring Plan*. The results of the monitoring activities will be submitted in the annual report for the year in which they occur—and within 30 days of the anniversary date of injection cessation or through an alternate schedule agreed upon with the Commissioner.

Table 7-2 – Direct Above-Zone Monitoring and USDW Sampling and Analysis Program

Target Formation	Monitoring Activity	Monitoring Location(s)	Frequency[1]	Geochemical Analyses
USDW [redacted]	Water Level Gauging and Collection of Fluid Samples	[redacted]	[redacted]	[redacted]
First Laterally Continuous Permeable Formation Above the UCZ	Collection of Fluid Samples	[redacted]	[redacted]	[redacted]
	Pressure, Temperature	[redacted]	[redacted]	[redacted]
[redacted]				

Table 7-3 – Indirect Above-Zone Monitoring Program

Testing/Monitoring Activity	Frequency	Reporting Schedule	Comment
[redacted]			

*Monitor surveys No. 1 and 2 will occur earlier in the operational period (e.g., No. 1 in the initial years).

The analytical methods and quality assurance/quality control measures discussed in *Section 5 – Testing and Monitoring Plan* for collecting and analyzing fluid samples will apply to the data collection program of the PISC, as appropriate.

7.5.3 In-Zone CO_2 Plume and Pressure Front Tracking

ExxonMobil proposes to use direct and indirect methods to track the extent of the CO_2 plume and pressure front in the injection zone during the PISC period. Direct monitoring in the injection zone includes continuous pressure and temperature measurements for proposed [redacted] By the start of the PISC phase of the Mockingbird Project, the direct and indirect monitoring activities will have been used for approximately [redacted] years and will be a proven set of monitoring technologies for detection monitoring of CO_2 plume and brine crossflow potential.

Table 7-4 describes the proposed CO_2 and pressure plume tracking methods for the PISC Plan. The water quality and geochemical parameters to be analyzed are presented in Table 7-5, consistent with *Section 5*, which includes additional information on the monitoring methods described and how deviations would be identified.

Table 7-4 – Direct and Indirect In-Zone Monitoring Program for PISC

Monitoring Element	Strategy
Time Period	Immediately following and for up to 50 years from cessation of injection operations
Monitored Locations, Conditions, and Frequency	[redacted]
Planned Changes in Monitoring Techniques	None. The model-predicted rapid decrease in CO_2 plume movement and pressure significantly reduces the potential for USDW endangerment following injection and eliminates the need for additional monitoring.
Triggers	*Section 3 – AOR and Corrective Action Plan* provides a list of triggers for the AOR reevaluation process. Those triggers are applicable to the monitoring program.

Table 7-5 – USDW and AZMI Monitoring and Sampling Program During the PISC Phase

Monitoring Well	Frequency	Parameter/Analyte
[redacted]		

7.5.4 Submitting PISC Monitoring Results

In accordance with LAC43: XVII **§3633.A.1.b.iv**, ExxonMobil will submit PISC monitoring data to the Commissioner in annual reports within 30 days following the anniversary of the date that injection ceases. The annual reports will contain information and data generated during the reporting period, such as the following:

- A list of monitoring events performed during the reporting period and the associated dates
- A brief description of sampling/testing/analytical locations, elevations/depths, equipment, and procedures, indicating whether (and why) departures from the procedures specified in the PISC and Site Closure Plan occurred
- Changes to the monitoring program that took place during the reporting period (e.g., repair to monitoring wells, implementation of approved changes in the frequency of monitoring activities based on criteria established in the PISC and Site Closure Plan and on approval of the Commissioner)
- Synthesis and interpretation of the results that describe trends in parameter values (or lack of trends), alignment between actual and plume model predictions, the appearance of anomalous or unexpected results, and progress toward attaining the Louisiana Department of Energy and Natural Resources (LDENR) criteria for non-endangerment
- Map(s) and cross section(s) showing the AOR, monitoring locations, and interpreted extent of the separate-phase CO_2 plume and the pressure front
- Any recommended changes to the PISC and Site Closure Plan to continue protection of the USDWs

7.6 Demonstration of Non-Endangerment of the USDW

Prior to the approval of the site closure authorization and in accordance with LAC43: XVII **§3633.A.2.b** and **§3633.A.2.c**, ExxonMobil will provide documentation to assess the potential for the USDW to be at risk of endangerment from the CO_2 plume at the end of the PISC phase of the Mockingbird Project. The non-endangerment demonstration will be based on monitoring data and a demonstration that the structure of the confining zones, combined with the geochemical conditions of the subsurface, have effectively, permanently sequestered the stored CO_2. This information will be used to demonstrate that additional monitoring is not needed to protect the USDW and that the project has met the compliance obligations to receive authorization for site closure.

This demonstration will be in the form of a detailed report submitted to the Commissioner that synthesizes site- and project-specific information and demonstrates a current understanding of system behavior at the time of the non-endangerment demonstration. The following subsections outline the type of information to be presented in the non-endangerment demonstration report.

ExxonMobil will engage the Commissioner as soon as the available data are aligned with the criteria for site closure, which may ultimately be less than the default PISC duration of 50 years pursuant to LAC43: XVII **§3633.A.2.b** and **§3633.A.3**.

7.6.1 Introduction and Overview for Non-Endangerment Demonstration

A summary of relevant background information will be provided in the introduction section of the report, including the operational history of the injection project, the date of the non-

endangerment demonstration relative to the post-injection period outlined in this PISC and Site Closure Plan, and a general overview of how monitoring and modeling results will be used together to support a demonstration of USDW non-endangerment.

7.6.2 Summary of Existing Monitoring Data

The monitoring data collected throughout the project's life cycle will be summarized and used to describe how the UCZ functioned as a barrier to mitigate endangerment of the USDW, and how the CO_2 is effectively trapped in the injection zones. The non-endangerment demonstration will include a summary of previous monitoring data collected at the site, pursuant to the details in *Section 4 – Well Construction Plan and Operating Conditions* and *Section 5 – Testing and Monitoring Plan*, as well as the PISC and Site Closure Plan.

Data submittals will be in a format acceptable to the Commissioner (LAC43: XVII **§3629.A.3**) and include the following:

- An explanation of monitoring activities, including the dates of all monitoring events, and changes to the monitoring program over time
- An explanation of the monitoring infrastructure that has existed at the site
- A comparison with baseline data collected during the site characterization to assess trends in key parameters that support the proposal for site closure

7.6.3 Summary of Computational Modeling History

A series of data sources detailed in *Section 5 – Testing and Monitoring Plan* will be used to update the computational model at least once every 5 years—more frequently if warranted. The following measured data will be utilized to update the computational model to demonstrate non-endangerment:

- In-zone temperature and pressure data
- Injection rate and volume data
- CO_2 plume location based on indirect geophysical monitoring
- AZMI data regarding the performance of the UCZ

The procedure used to reevaluate the AOR will be based on the data collected between reevaluations and the well conditions at the time of reevaluation. The post-injection data will include historical injection rates, pressures, pressure falloff, and historical operational parameters of the four proposed injection wells. ExxonMobil will rely on a process of history matching the plume model results with the actual monitoring data. The measured data will be used as a calibration point for the plume model, and the input parameters adjusted to provide a reasonable match between the two data sets. Through this or a similar process, ExxonMobil will provide a validation of the model performance for the CO_2 plume and pressure front.

7.6.4 Evaluation of Reservoir Pressure

The non-endangerment demonstration will include an evaluation of the residual pressure and the potential for continued trends in pressure dissipation that might endanger USDWs in the future. Information will be provided to describe how the pressure and buoyancy effects on plume and pressure migration decayed over time, and how the residual levels comply with the requirements for non-endangerment. This evaluation will consider the most-recent AOR delineation/modeling results and pressure monitoring data. The same model that supported the delineation of the AOR or a similar model approved by the Commissioner will be used for this modeling, as it will be verified (or calibrated) by actual monitoring and operational data via AOR reevaluations.

7.6.5 Evaluation of the CO_2 Plume

The non-endangerment demonstration will include an evaluation of the gas-phase CO_2 plume and the dissolved-phase CO_2 plume, as appropriate. The evaluation of the potential CO_2 plumes will rely on monitoring data, including geochemical and geophysical analyses and the most recent AOR modeling results. Direct measurements of the temperature and pressure of CO_2 in the injection zone, as well as the results of geophysical measurements, will be used to confirm plume location and demonstrate plume migration rates.

7.6.6 Evaluation of Emergencies or Other Events

[redacted]

Any subsequent artificial penetrations discovered to have a potential to threaten the USDW will be remediated using the same procedures, so that no artificial penetrations of concern remain at the time of site closure.

The data and evaluation methods specified pursuant to the requirements of *Section 5 – Testing and Monitoring Plan* as well as the PISC Plan provide the basis for demonstrating that no future endangerment of the USDW is likely to occur.

7.7 Site Closure Plan

ExxonMobil will conduct site closure activities to meet the requirements of LAC43: XVII **§3633.A.4** through **§3633.A.8** as described below. ExxonMobil will submit a final Site Closure Plan and notify the Commissioner at least 120 days prior to its intent to close the site. Once the Commissioner has approved closure of the site, ExxonMobil will plug all injection and monitoring wells and submit a site closure report to the LDENR. The planned activities, described below, are based on information provided to the LDENR. The actual Site Closure Plan may employ different methods and procedures.

Additionally, ExxonMobil will record a notation on the deed to the site that the land has been used to sequester CO_2. Site closure activities will also include removing all surface equipment and restoring the site to its prior land surface condition.

7.7.1 Pre-Closure

In accordance with LAC43: XVII **§3633.A.4**, a notice of intent to close the site will be submitted to the Commissioner at least 120 days prior to the commencement of closure operations. If any changes are made to the original PISC and Site Closure Plan, a revised plan will also be submitted. Relevant notifications and applications, such as plugging requests, will be submitted and approved by the appropriate agency prior to commencing such activities.

The site closure notice submitted to the Commissioner will include the following:

- Facility information, name, and location
- A list of contact personnel for allowing timely direct communication to resolve any pressing issues
- A projected closure date, no less than 120 days following the site closure notification submission—unless the Commissioner has approved a different period prior to that submission

7.7.2 Plugging Activities

Mockingbird INJ No. 01 through No. 04, [redacted] will be plugged as discussed in *Section 6 – Injection Well Plugging Plan*. After injection ceases and after the appropriate post-injection monitoring period is complete, the monitoring wells will be plugged and abandoned to meet the requirements of LAC43: XVII **§3631** and in compliance with applicable state requirements. The plugging procedure and materials will be designed to mitigate fluid movement and protect the USDW. Prior to plugging the wells, the necessary procedural revisions to address new information will be submitted to the Commissioner for review and approval. The final plugging plans will be submitted to the Commissioner no later than 60 days prior to the plugging of the wells.

Following receipt of the approved plugging plans, the wells below the lowermost USDW and above the UCZ will be logged and pressure-tested to ensure mechanical integrity. If a loss of mechanical integrity is discovered, it will be repaired prior to proceeding with plugging operations. The casing in these wells will be left in place and will not be retrieved at abandonment. A combination of bridge plugs and cement plugs will be set to plug the wells, and all casing strings will be cut at least 5 feet below ground level. A steel plate with the required permit information will be welded to the top of the casing to meet LDENR requirements.

7.7.3 Site Restoration

Once the injection and monitoring wells are plugged and abandoned, the surface equipment will be decommissioned and removed from the well site—and the site restored to a condition agreed upon with the surface owner.

7.7.4 Documentation of Site Closure

Within 90 days of site closure, a final report will be submitted to the Commissioner per the requirements of LAC43: XVII **§3633.A.6** and include the following:

- Documentation of appropriate injection and monitoring well plugging, including a copy of the survey plats (LAC43: XVII **§3633.A.6.a**)
- The survey plat, indicating the locations of the injection wells relative to permanently surveyed benchmarks and including the location of the monitoring wells
- Documentation of the well-plugging report, to be filed with the LDENR (LAC43: XVII **§3633.A.6.b**)
- Post-injection monitoring records, summarized
- Records of the nature, composition, and volume of the CO_2 stream for the injection period, summarized (LAC43: XVII **§3633.A.6.c**)

Pursuant to LAC43: XVII **§3633.A.7**, a record of notation in the Mockingbird Project facilities and infrastructure will be filed on the property deed to provide notice to landowners of the following:

- The land having been used to sequester CO_2
- The name of the state agency with which the survey plat was filed (LDENR) and the EPA Regional Office (Region 6) at which it was submitted
- The total volume of CO_2 injected, the injection zones into which it was injected, and the period over which injection occurred

As required by LAC43: XVII **§3633.A.8**, ExxonMobil will retain all records collected during the PISC period for 10 years following site closure. At the end of the retention period, ExxonMobil will deliver all records to the Commissioner for retention at a location designated by the Commissioner for that purpose.