POST-INJECTION SITE CARE AND SITE CLOSURE PLAN
40 CFR 146.93(a)

Brown 4 Geologic Sequestration Project

Facility Information

Facility name: Brown 4 Geologic Sequestration Project
Lambda-Brown 4-1 & Lambda-Brown 4-2

Facility contact: [redacted]

Well location: Lambda-Brown 4-1: Brown, Manistee County, Michigan
44.3361397, -86.1393888, NAD 27

Lambda-Brown 4-2: Brown, Manistee County, Michigan
44.3418411, -86.1342111, NAD 27

This Post-Injection Site Care (PISC) and Site Closure plan for the Brown 4 Geologic Sequestration Project (GSP) describes the activities to be performed by Lambda to meet the requirements of 40 CFR 146.93. Lambda will monitor ground water quality and track the position of the CO_2 plume and pressure front for five years post injection. Lambda may not cease post-injection monitoring until a demonstration of non-endangerment of USDWs has been approved by the UIC Program Director pursuant to 40 CFR 146.93(b)(3). Following approval for site closure, Lambda will plug all wells in the AoR, restore the site to its original condition, and submit a site closure report and associated documentation.

Pre- and Post-Injection Pressure Differential [40 CFR 146.93(a)(2)(i)]

Based on the modeling of the pressure front as part of the AoR delineation, pressure at the injection well and within the reef is expected to remain stable in perpetuity. Additional information on the projected post-injection pressure declines and differentials is presented in the permit application and the AoR and Corrective Action Plan.

The final reservoir pressure will be 2,428 psig, equal to the original reservoir pressure. At the commencement of injection operations, the reservoir pressure will be approximately 9 psig. Given that the reservoir is a closed system, Lambda does not expect the reservoir or bottom hole injection pressure to experience a drop-off greater than 2 percent.

Discussion

The Brown 4 reservoir will be operated such that the pressure will not exceed the initial pressure at the time of discovery. This operating strategy was developed to ensure the competency of the seal and the confinement of the injectate.

The maximum pressure differential between the injection wellbore and the depleted Brown 4 storage reservoir exists prior to the commencement of CO_2 injection. Over time, the injection pressure differential will shrink until, at the time of project abandonment, the reservoir pressure will be at the initial conditions of the reservoir. Figure 1 shows the pressure of the Brown 4 reservoir over time from computational modeling. The modeling predicts negligible change in static reservoir pressure between 5 and 100 years post-injection, indicating system stabilization.

Figure 1: Plot showing the average reservoir pressure and CO_2 injection vs time

Predicted Position of the CO_2 Plume and Associated Pressure Front at Site Closure [40 CFR 146.93(a)(2)(ii)]

The predicted position of the CO_2 plume and pressure front at the end of the PISC timeframe will extend to the edge of the reef boundary. The maximum extent of both the plume and pressure

front is represented on the map in Figure 2. This map is based on the final AoR delineation modeling results submitted pursuant to 40 CFR 146.84.

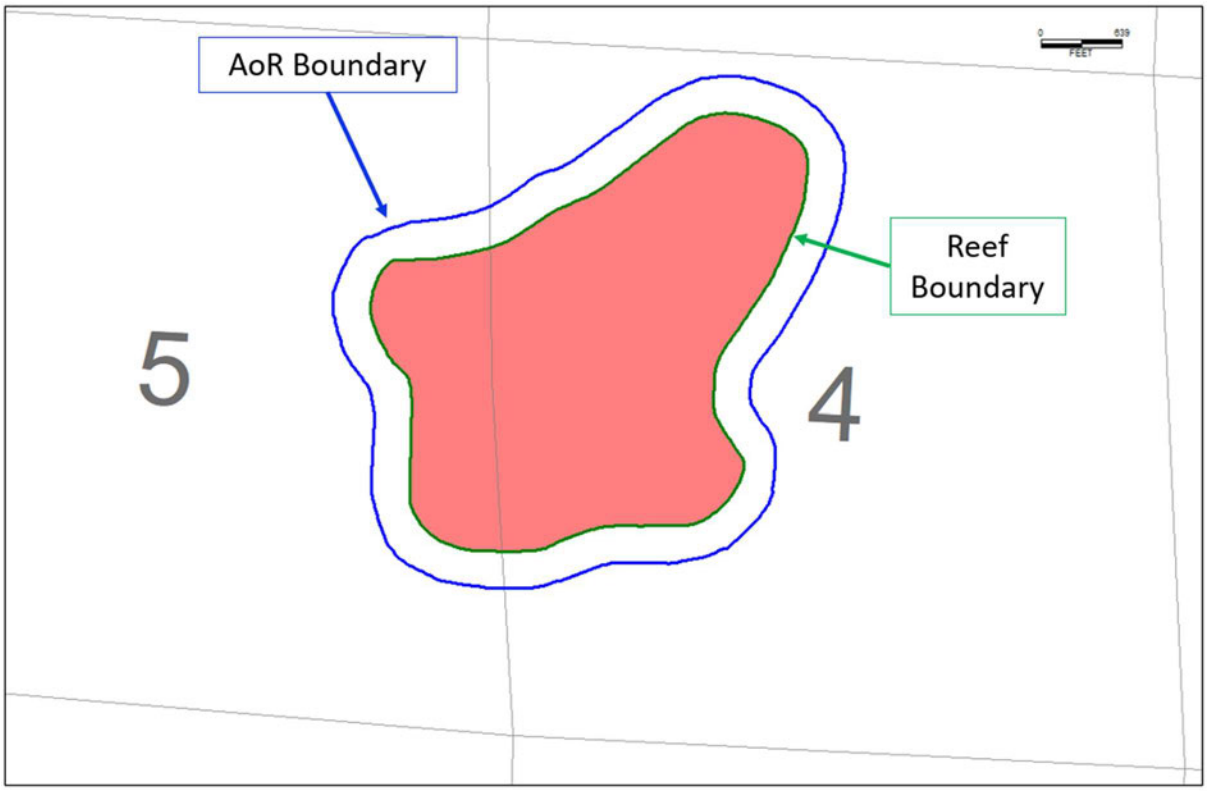

Figure 2: Map of the predicted position of the CO_2 plume and pressure front at site closure – 5 years post-injection.

Post-Injection Monitoring Plan [40 CFR 146.93(b)(1)]

The Testing and Monitoring Plan outlines the monitoring methodologies to be used for the injection zone, above the injection zone, and within the USDW and will meet the requirements of 40 CFR 146.93(b)(1). The results of all post-injection phase testing and monitoring will be submitted annually, within one year, as described in the "Schedule for Submitting Post-Injection Monitoring Results," below.

To verify confinement within the storage reservoir over the proposed 5-year PISC period, the most effective method is to ensure sustained pressure stabilization. Lambda will conduct continuous pressure monitoring in the sequestration zone through the injection wells. Additionally, Lambda will monitor for stabilized pressure and the absence of CO_2 above the injection zone using monitoring wells completed in the first permeable layer above the confining zone. If post-injection reservoir pressure decreases or deviates significantly from computational modeling results, Lambda will evaluate the possibility of leakage.

Groundwater samples will be collected and tested on an annual basis throughout the five years of PISC in both the USDW and the Bass Island Dolomite to assess for possible CO_2 leakage.

Monitoring Above the Confining Zone

Table 1 presents the monitoring methods, locations, and frequencies for monitoring above the confining zone. Table 2 identifies the parameters to be monitored and the analytical methods Lambda will employ. Figure 3 displays the locations of the monitoring well. Table 3 outlines the recording frequencies for continuous pressure monitoring in the monitoring wells.

Table 1. Monitoring of above the confining zone.

Target Formation	Monitoring Activity	Monitoring Location(s)	Device	Spatial Coverage or Depth	Frequency (Post-Injection)
Glacial Drift (USDW)	Fluid Sampling	Shallow Water Monitoring Wells	Pump	Expected depth < 250' MD/TVD	Annual
Bass Island Dolomite	Fluid Sampling	Viol 1-4 & Viol 3-4	Swab	3,010' – 3,025' MD/TVD	Annual
	External MIT	Viol 1-4 & Viol 3-4	Temperature, Noise, or Oxygen Activation Log	3,010' – 3,025' MD/TVD	Annual
	Pressure	Viol 1-4 & Viol 3-4	Pressure Gauge	3,010' – 3,025' MD/TVD	Continuous
	Temperature	Viol 1-4 & Viol 3-4	Temperature Sensor	3,010' – 3,025' MD/TVD	Continuous

Table 2. Summary of analytical and field parameters for ground water samples.

Parameters	Analytical Methods
Glacial Drift (USDW)	
Cations: Metals	ICP EPA Method 6010
Anions: Chloride	Standard Method 4500E
Specific Conductivity (µS/cm)	ASTM Std Method 2510
pH (S.U.)	ASTM Std Method 4500
Temperature	Field Test
Dissolved Carbon Dioxide	EPA Method RSK 175
Water Density (Sp Gravity)	ASTM Method D5057
Total Dissolved Solids (TDS) –	ASTM Method 2540
Bass Island Dolomite	
Cations: Metals	ICP EPA Method 6010
Anions: Chloride	Standard Method 4500E
Specific Conductivity (µS/cm)	ASTM Std Method 2510
pH (S.U.)	ASTM Std Method 4500
Temperature	Field Test
Dissolved Carbon Dioxide	EPA Method RSK 175
Water Density (Sp Gravity)	ASTM Method D5057

Table 3. Sampling and recording frequencies for continuous monitoring.

Parameter	Device(s)	Location	Min. Sampling Frequency	Min. Recording Frequency
Pressure	DH Pressure Gauge	Viol 1-4 and Viol 3-4	10 sec	5 min
Temperature	DH Temp. Gauge		10 sec	5 min

Notes:

- *Sampling frequency refers to how often the monitoring device obtains data from the well for a particular parameter. For example, a recording device might sample a pressure transducer monitoring injection pressure once every two seconds and save this value in memory.*
- *Recording frequency refers to how often the sampled information gets recorded to digital format (such as a computer hard drive). For example, the data from the injection pressure transducer might be recorded to a hard drive once every minute.*

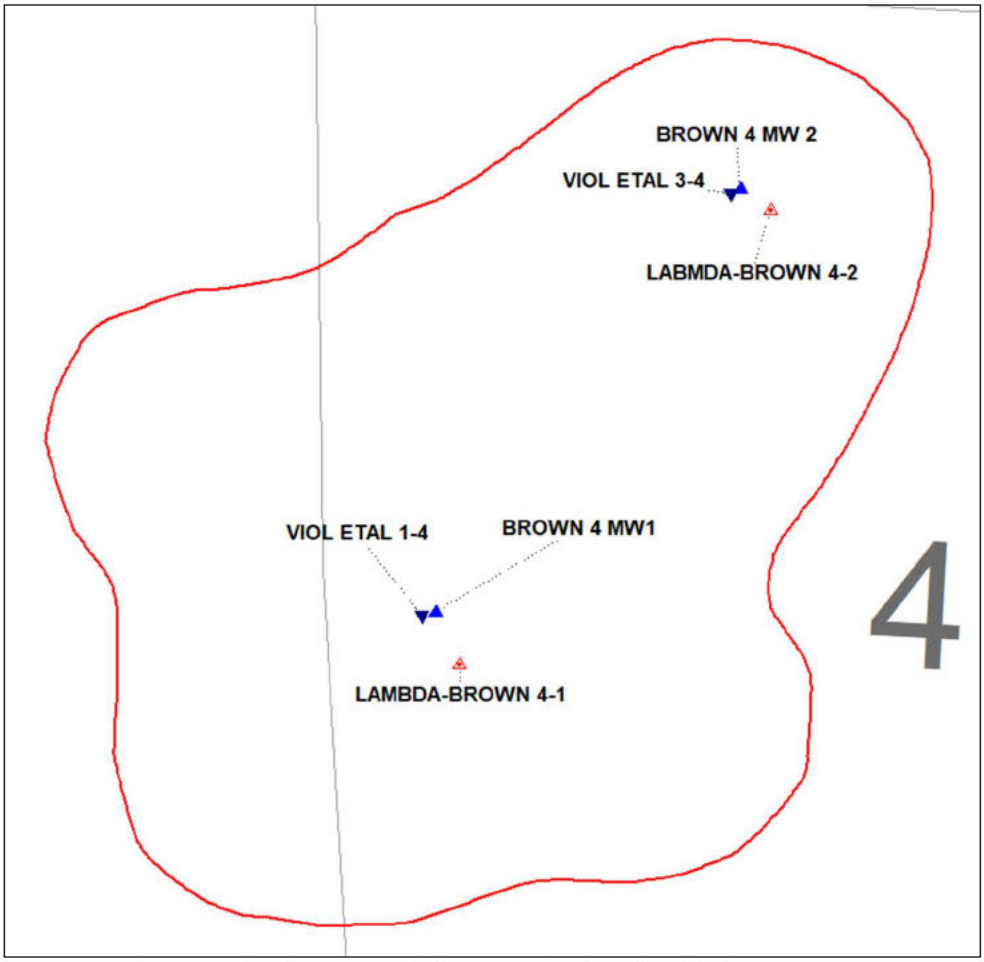

Figure 3: Map showing the location of the AoR (red outline), the two CO_2 injection wells (Lambda-Brown 4-1 and 4-2), the two above zone monitoring wells (Viol 1-4 and 3-4), and the two USDW monitoring wells (Brown 4 MW1 and MW2).

Carbon Dioxide Plume and Pressure Front Tracking [40 CFR 146.93(a)(2)(iii)]

Lambda will employ the following methods to model the sustained integrity of the Brown 4 GSP to ensure continued CO_2 containment within the Brown 4 reef. The Lambda-Brown 4-1 and Lambda-Brown 4-2 injection wells will be utilized as monitoring wells during the PISC period. Table 4 presents the methods that Lambda will use to monitor the Brown 4 GSP, including the activities, locations, and frequencies to be employed.

- Pressure and temperature will be constantly monitored in the injection zone via downhole gauges. Pressure data will be used to verify GSP stabilization. A decrease in reservoir pressure during the PISC would indicate possible leakage from the GSP.
- An approved external MIT will be conducted annually on the monitor wells, 30 days prior to the anniversary of the site closure approval date. These tests will verify the absence of fluid is present above the confining zones.

Table 4. Post-injection phase monitoring.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Niagaran	Pressure	Lambda-Brown 4-1 & Lambda-Brown 4-2	~4,300' – 4,700' MD/TVD	Continuous
	Temperature			Continuous
	MIT: Temperature, Noise, or Oxygen Activation Log			Annual
	Reservoir Model			As Needed
Glacial Drift (USDW)	Fluid Sampling	Shallow Water Monitoring Wells	Expected depth < 250' MD/TVD	Annual
Bass Island Dolomite	Pressure	Viol 1-4 & Viol 3-4	3,010' – 3,025' MD/TVD	Continuous
	Temperature			Continuous
	Fluid Sampling			Annual

Schedule for Submitting Post-Injection Monitoring Results [40 CFR 146.93(a)(2)(iv)]

All post-injection site care monitoring data and results collected using the methods described above will be submitted to the UIC Director in reports on an annual basis. These reports will contain information and data generated during the reporting period, including well-based monitoring data, sample analysis, and updated site model results.

Alternative Post-Injection Site Care Timeframe [40 CFR 146.93(c)]

Lambda will conduct post-injection monitoring for five years following the cessation of injection operations. A demonstration that an alternative PISC timeframe is appropriate and ensures non-endangerment of USDWs is provided throughout the application, with locations referenced in Table 5. Lambda will conduct all the monitoring described under "Ground Water Quality Monitoring" and "CO_2 Plume and Pressure-Front Tracking" above and report the results as described in the "Schedule for Submitting Post-Injection Monitoring Results." Regardless of the alternative PISC timeframe, monitoring and reporting as described in the sections above will continue until Lambda 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 on which the demonstration was based changes or the actual behavior of the site varies significantly from modeled predictions as a result of an AoR reevaluation, Lambda may update this PISC and Site Closure Plan pursuant to 40 CFR 146.93(a)(4). Lambda 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.

Table 5. Demonstration of alternative post-injection site care timeframe

40 CFR 146.93 (a) (1)	Location in Application Referenced	Section / Page #
(i)	Area of Review and Corrective Assessment Plan	"Computational Modeling Results" - Predictions of System Behavior, pg 30-34
(ii)	Area of Review and Corrective Assessment Plan	"Computational Modeling Results" - Predictions of System Behavior, pg 30-34
(iii)	Area of Review and Corrective Assessment Plan	"Computational Modeling Results" - Predictions of System Behavior, pg 30-34
(iv)	Area of Review and Corrective Assessment Plan	"Computational Modeling Results" - Predictions of System Behavior, pg 34
(v)	Area of Review and Corrective Assessment Plan	"Computational Modeling Results" - Predictions of System Behavior, pg 35
(vi)	Application Narrative	"Site Characterization" – Geochemistry, pg 42-43
(vii)	Area of Review and Corrective Assessment Plan; Application Narrative	"Computational Modeling Results" – Boundary Conditions, pg 23-24; "Site Characterization" – Injection and Confining Zone Details, pg 30-32
(viii)	Application Narrative	"Site Characterization" – Maps and Cross Sections of AoR, pg 12-15
(ix)	N/A; *No P&A wells within the AoR.*	
(x)	Application Narrative	"Site Characterization" - Hydrologic and Hydrogeologic Information, pg 40

Non-Endangerment Demonstration Criteria

Prior to approval of the end of the post-injection phase, Lambda will submit a demonstration of non-endangerment of USDWs to the UIC Program Director, per 40 CFR 146.93(b)(2) and (3).

Lambda will issue a report to the UIC Program Director. This report will demonstrate USDW non-endangerment based on the evaluation of the site monitoring data used in conjunction with the project's computational model. The report will detail how the evaluation uses site-specific conditions to confirm and demonstrate non-endangerment. It will include all relevant monitoring data and interpretations upon which the demonstration is based, model documentation, all supporting data, and any other information necessary for the UIC Program Director to review the analysis. The report will include the following sections:

Introduction and Overview

A summary of relevant background information will be provided, 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 the demonstration of USDW non-endangerment.

Summary of Monitoring Data

A summary of all previous monitoring data collected at the site, pursuant to the Testing and Monitoring Plan of this permit and this PISC and Site Closure Plan, including data collected during the injection and post-injection phases of the project, will be submitted to help demonstrate non-endangerment. Data submittals will be in a format acceptable to the UIC Program 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. The data will be compared with baseline data collected during site characterization [40 CFR 146.82(a)(6) and 146.87(d)(3)].

Summary of Computational Modeling History

Computational modeling confirms that sequestered CO_2 will remain within the storage complex over a 100-year timeframe post injection. Lambda's conclusions are based on analytical reservoir simulation modeling showing no migration outside of the reservoir boundaries, indicating the seals are competent. A series of migration snapshots throughout the duration of the model timeframe is included in the AoR and Corrective Action document.

Both injection wells will have downhole, real-time pressure and temperature gauges that will capture and record data used to update the model. The updated model will be compared to previous iterations for analysis. If there are any major discrepancies between model iterations, injection will be ceased until issue is resolved.

Evaluation of Reservoir Pressure and CO_2 Plume

Because the CO_2 is trapped in an isolated and compartmentalized reef structure, plume migration outside of the reef boundary is non-existent. As such, pressure stabilization will be used for non-endangerment assessment. Real-time bottom-hole pressures will be collected via downhole pressure gauges and used to update the simulation model. Monitoring data will be reviewed to ensure that the reservoir pressure has stabilized post-injection. Computational modeling indicates that the pressure change over the post-injection timeframe is less than forty psi over 100 years. Computational modeling results, calibrated with monitoring data, will be used to support that the plume has stabilized, pressure change is negligible, and poses no risk for potential vertical migration. Computational modeling results calibrated with monitoring data from storage reservoir, USDW and above zone will be used to demonstrate:

- The lack of CO_2 leakage over the project timeframe;

- The accuracy of the model to predict and represent the storage reservoir; and
- The computational model confirmed containment within the AoR boundary.

Evaluation of Potential Conduits for Fluid Movement

All well penetrations within the AoR and the confining layer will be reviewed and assessed prior to PISC and site closure. A final determination will be made that no natural or artificial conduits will allow CO_2 migration from the storage reservoir.

Site Closure Plan

Lambda will conduct site closure activities to meet the requirements of 40 CFR 146.93(e) as described below. Lambda will submit a final Site Closure Plan and notify the permitting agency at least 120 days prior to its intent to close the site. Once the permitting agency has approved closure of the site, Lambda will plug the monitoring wells and submit a site closure report to the EPA. The activities, as described below, represent the planned activities based on information provided to EPA. The actual site closure plan may employ different methods and procedures. A final Site Closure Plan will be submitted to the UIC Program Director for approval with the notification of the intent to close the site.

Site Closure Report

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

- Verification of injector and monitor well plugging;
- Location of sealed injection wells on a plat of survey submitted to the local zoning authority;
- Notifications to state and local authorities as required at 40 CFR 146.93(f)(2);
- Records regarding the composition and volume of the injected CO_2; and
- Post-injection monitoring records.

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

- The property was used for CO_2 sequestration,
- The name of the local agency to which a plat of survey with injection well location was submitted;
- The volume of fluid injected;
- The formation 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 retained by the owner or operator for a period of ten years, following site closure. Additionally, the owner or operator will maintain the records collected during the post-injection period for a period of ten years after which these records will be delivered to the UIC Program Director.