CLASS VI PERMIT
TESTING AND MONITORING PLAN

40 CFR §146.82(a)(15) and 40 CFR §146.90

Caliche Beaumont Sequestration Project
Beaumont, Jefferson County, Texas

Claimed as PBI

[redacted]

Issued: 23 April 2024

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Beaumont, Jefferson County, Texas

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1.0 FACILITY INFORMATION AND INTRODUCTION

Facility/Project Name:	Caliche Beaumont Sequestration Project
Facility/Project Contact:	W. Graham Payne, Director of Energy Transition CDP II CO2 Sequestration, LLC ("Caliche") 919 Milam Street, Suite 2425 Houston TX, 77002 (832) 500-7590 / Claimed as PBI [redacted]
Well Locations:	Beaumont, Jefferson County, Texas Injection Well Nos. 1, 2, and 3
SIC Code(s):	4923
Entity Type:	Private
Indian Lands:	No

Well ID	Latitude	Longitude
Injection Well 1	Claimed as PBI [redacted]	[redacted]
Injection Well 2	Claimed as PBI [redacted]	[redacted]
Injection Well 3	Claimed as PBI [redacted]	[redacted]

This Testing and Monitoring Plan (T&M Plan) describes how Caliche plans to monitor the Caliche Beaumont Sequestration Project Site, pursuant to 40 CFR §146.90 and the California Air Resources Board (CARB) Low-Carbon Fuel Standard (LCFS) Protocol under Subsections C.2.5 and C.4. This plan also meets the requirements of the Monitoring, Measurement, and Verification Plan required under CARB LCFS Subsection C.4.3.2.

In addition to demonstrating that the injection wells are operating as permitted, the carbon dioxide (CO_2(sc)) plume and pressure front are moving as predicted, and that there is no endangerment to Underground Sources of Drinking Water (USDWs), the testing and monitoring data may be used to validate and adjust the geological models used to predict the distribution of the CO_2(sc) within the target storage reservoir to support Area of Review (AoR) reevaluations and a non-endangerment demonstration. Additionally, this T&M Plan includes components that can be utilized to detect and quantify CO_2 leakage from the target storage reservoir to the USDW and atmosphere, if necessary.

Caliche plans to perform the following T&M Plan components:

- CO_2 stream analysis with sufficient frequency to yield data representative of its chemical and physical characteristics;
- Installation and use, except during well workovers, of continuous recording devices to monitor injection pressure, rate, and volume; the pressure on the annulus between the tubing and the long string casing; and the annulus fluid volume added;

- Corrosion monitoring of the well materials for loss of mass, thickness, cracking, pitting, and other signs of corrosion, which must be performed on a quarterly basis to ensure that the well components meet the minimum standards for material strength and performance set forth in 40 CFR §146.86(b) by analyzing coupons of well construction materials placed in contact with the CO_2 stream;
- Periodic monitoring of the groundwater quality and geochemical changes above the Upper Confining System that may be a result of CO_2 movement through the confining zone or additional identified zones including:
  - The location and number of monitoring wells based on specific information about the geologic sequestration project, including injection rate and volume, geology, the presence of artificial penetrations, and other factors; and
  - The monitoring frequency and spatial distribution of monitoring wells based on baseline geochemical data that has been collected under 40 CFR §146.82(a)(6) and on any modeling results in the AoR evaluation required by 40 CFR §146.84(c);
- A demonstration of external mechanical integrity pursuant to §146.89(c) at least once per year until the injection well is plugged; and, if required by the UIC Program Director, a casing inspection log pursuant to requirements at §146.89(d);
- A pressure fall-off test at least once every five years;
- Testing and monitoring to track the extent of the CO_2 plume and the presence or absence of elevated pressure (e.g., the pressure front) by using direct methods in the injection zone(s) and indirect methods; and/or
- Surface air monitoring and/or soil gas monitoring to detect movement of CO_2 that could endanger the USDW.

Caliche will periodically review the T&M Plan to incorporate monitoring data collected under this T&M Plan, operational data collected under the Operating Plan (*Module A* - Section 7.0) and §146.88, and the most recent area of review reevaluation performed under the AoR and Corrective Action Plan (*Module B*) and §146.84(e) at least once every five years. Based on this review, Caliche will submit an amended testing and monitoring plan or demonstrate to the Director that no amendment to the testing and monitoring plan is needed. Any amendments to the T&M Plan must be approved by the UIC Program Director, will be incorporated into the Class VI permit, and are subject to the permit modification requirements at 40 CFR §144.39 or §144.41, as appropriate. Amended plans or demonstrations will be submitted to the UIC Program Director i) within one year of an area of review reevaluation; ii) following any significant changes to the facility, such as addition of monitoring wells or newly permitted injection wells within the area of review, on a schedule determined by the UIC Program Director; or iii) when required by the UIC Program Director.

Caliche has developed a Quality Assurance and Surveillance Plan (QASP), attached hereto as **Appendix E.1.A**.

Results of the T&M activities described below may trigger action according to the Emergency and Remedial Response Plan (ERRP; see *Module E.4 – ERRP*).

2.0 OVERALL STRATEGY AND APPROACH FOR TESTING AND MONITORING

2.1 T&M Plan Overview at the Caliche Beaumont Sequestration Project Site

This T&M Plan for the Caliche Beaumont Sequestration Project is designed to monitor the CO_2(sc) plume and pressure front migration within the Upper Frio Sand injection zone, verify containment of the CO_2 and brine within the storage complex, and quantify any CO_2 leakage from the injection zone, while considering site-specific features which are described below. The data collected in accordance with this T&M Plan also may be used to calibrate and verify the results from the CO_2(sc) plume and pressure front models presented in *Module B – Area of Review and Corrective Action Plan*, including computational model forecasts which may be crucial in determining the placement and selection of some of the monitoring locations and technologies. As a result, the spatial distribution of the monitoring network for Caliche Beaumont Sequestration Project includes various surface and subsurface media, spread over the extent of the modeled AOR at the minimum. To demonstrate compliance to the USEPA Class VI Rules, and CARB LCFS requirements, the monitoring components for Caliche Beaumont Sequestration Project may be installed in various depths within the Caliche Beaumont Sequestration Project Site including:

- Injection Zone (Upper Frio Sand Formation): The target injection zone within the Upper Frio Formation is the porous portions comprised of permeable sand layers interbedded by clay/shale layers. Within the Caliche AoR, site characterization efforts identified approximately Claimed as PBI [redacted]t of net Upper Frio Sands which are overlain by approximately Claimed as PBI [redacted] of the shale-rich Anahuac Formation (i.e., primary Upper Confining Unit). The injection zone within the AoR is generally encountered between Claimed as PBI [redacted]. The performance of the Upper Frio Sand injection zone in accepting injection fluids has been known and well-studied as there are several brine injection wells screened within the Upper Frio Formation in the vicinity of the Caliche Beaumont Sequestration Project Site.

- First Transmissive Zone Above the Confining Zone (Lower Oakville Formation): Overlying the primary Upper Confining Zone (i.e., Anahuac Formation), the Oakville Formation consists primarily of sand-rich layers and is generally encountered between Claimed as PBI [redacted] Additionally, the Lower Oakville is observed to consist of low permeability shales which will act as a secondary confining unit to vertical migration in addition to the Anahuac Formation. The Upper and Middle Oakville Formation (i.e., Jasper aquifer) constitutes a buffer aquifer to contain any fluid leaks through the primary Upper Confining Zone.

- Lowermost USDW (Lissie Formation): Together the Pleistocene and Holocene strata, encountered at the Caliche Beaumont Sequestration Project Site generally between Claimed as PBI [redacted] comprise the Chicot aquifer system with the base of the Lower Chicot (lowermost USDW) expected to occur within the Lissie Formation Claimed as PBI [redacted]). In the vicinity of the Caliche Beaumont Sequestration Project Site, the Upper Chicot aquifer appears to be the most used aquifer for domestic and shallow groundwater monitoring purposes with the majority of the wells screened between Claimed as PBI [redacted]. There are no water wells constructed within the upper portion of the Lower Chicot aquifer within the Caliche AoR.

- Near-Surface (Undifferentiated Formations): The vadose zone is anticipated to be relatively shallow (less than Claimed as PBI [redacted] thick) at the site and primarily made of clayey materials based on construction reports for wells near the site.

A summary of the testing and monitoring locations is provided on attached **Figure E.1.1**. Additionally, the data obtained from implementing the T&M Plan may be used to inform and improve operational decisions on the quantity, quality, and rate of CO_2 injected while ensuring containment within the storage complex. This T&M Plan is designed to confirm compatibility between the CO_2 stream and injection infrastructures (e.g., pipelines, pumps, and injection wells) and ensure integrity of the injection infrastructures during the life of the Caliche Beaumont Sequestration Project.

This T&M Plan is also designed to monitor and coordinate response actions identified in the Emergency and Remedial Response Plan (see *Module E.4 - ERRP*) associated with risks related to the injection and sequestration of CO_2 in the Upper Frio Sand. Those risks include the potential for: i) injection or monitoring (verification) well integrity failure; ii) injection well monitoring equipment failure (e.g., shut-off valve or pressure gauge, etc.); iii) fluid (e.g., formation brine) or CO_2 leakage to a USDW or the surface; iv) natural disaster (e.g., earthquake, tornado, lightning strike); or v) induced or natural seismic event. Although these risks are anticipated to affect the project primarily during the injection and post-injection phases of the Caliche Beaumont Sequestration Project, pre-injection testing of various media may be conducted to establish baseline conditions or trends.

Several site-specific features and risk profiles identified during the site characterization were considered in the design of this T&M Plan, such as regional and local structural features, artificial penetrations, nearby communities with potential environmental justice (EJ) concerns, and local use of USDWs near the site, as further described below.

- **Artificial Penetrations (APs):** As discussed in *Module B – Area of Review and Corrective Action Plan*, a total of 44 APs were identified to penetrate the Upper Frio Sand injection zone within the Caliche AoR. Review of available historical well records for the 44 wells penetrating the storage complex within the AoR identified 33 wells that appear to be sufficiently constructed and/or plugged and abandoned (P&A'd) to eliminate the AP's potential to convey CO_2 or other fluids from the storage reservoir to the overlying USDW. Three wells were identified as potentially having insufficient construction or P&A specifications and seven wells with insufficient well records to confirm the well construction and/or P&A specifications. As these wells present a potential risk of leakage, Caliche plans to conduct further investigation to the extent practicable to confirm their well integrity, at which time Caliche may determine if the wells warrant corrective action, if any. In addition to implementing any necessary corrective actions to mitigate or eliminate risk factors associated with select APs, this T&M Plan also is designed to ensure early detection of possible CO_2 for formation fluid leaks associated with these APs and to confirm the effectiveness of any corrective actions. Additionally, a few brine injection wells were located near Caliche Beaumont Sequestration Project Site with their target formation also consisting of the Upper Frio Sand. However, the pressures from those active brine injection wells are expected to push the plume away from them as well as any nearby APs to the brine injections wells.

- **Faults and Fractures:** Site characterization found that local domal radial and normal growth and antithetic faults are present at the Caliche Beaumont Sequestration Project Site; however, only the large normal growth fault (Fault A) extends through the AoR (see *Module A – Section 2.2 Local Geology*). Local Fault A, located in the southern portion of the Caliche AoR, extends radially from Spindletop salt dome from northeast to southwest and generally consists of an elevation offset of approximately [redacted]. AoR model predictions suggest that the CO_2(sc) plume may migrate toward Fault A; however, as discussed in *Module A – Section 2.2 Local Geology*, several lines of evidence (LOEs) suggest that Fault A is a non-transmissive, self-sealed fault, including the following:

- *Ductile Nature of Confining System Shales:* The shales of the Upper Confining System (Lower Oakville, Anahuac, and Upper Frio) are ductile and therefore deform plastically by bending or smearing.
- *Low Sand-Shale Ratio:* The sand-shale ratio of the faulted geologic section indicates a substantial amount of impermeable shale (Claimed as PBI [redacted]) is present in the Upper Confining System (Lower Oakville, Anahuac, and Upper Frio containment layers) and in the Lower Confining Unit (Frio-Hackberry shale).
- *High Clay Smear Potential (CSP):* Low sand-shale ratios (i.e., greater impermeable shales) result in a high CSP as more shale-to-shale and shale-sand juxtaposition is found along the fault plane.
- Claimed as PBI [redacted]
- *Structural Trapping Capacity:* Most petroleum system traps along the Gulf Coast are due to growth faults, including Fault A, as evidenced by the 19 of 44 artificial penetrations within the Caliche AoR being located near and along the northeast-southwest trending Fault A.
- *Differential Formation Pressure Gradients:* Higher formation pressure gradients measured in the Miocene-aged Flemming Group versus the Oligocene-aged Frio Formation confirm the vertical sealing nature of local growth faults in the area.

Although these results point to a low risk of vertical CO_2 or formation fluid migration within the AoR, this T&M Plan includes additional monitoring components to verify that leakage does not occur through the fault.

- **Regional and Local Seismicity:** As discussed in the site characterization, natural and induced seismicity are not expected within the vicinity of the Caliche Beaumont Sequestration Project Site. Additionally, the computational modeling for this Caliche Beaumont Sequestration Project does not anticipate that injection pressures for the Caliche Beaumont Sequestration Project will be high enough to induce any seismic events (i.e., injection pressures are below the 80% fracture gradient and fault reactivation pressures). Regardless, this T&M Plan includes seismic monitoring as required by USEPA Class VI rules.
- **Groundwater Resource Use:** Within the AoR, the Upper Chicot aquifer appears to be used for domestic and shallow groundwater monitoring purposes with shallow wells screened between Claimed as PBI [redacted]. At the Caliche Beaumont Sequestration Project Site, the base of the lowermost USDW was estimated to be approximately Claimed as PBI [redacted], which corresponds to the upper hydrogeologic unit of the Lower Chicot aquifer. This estimate is consistent with other reports and well records in the vicinity of the site.
  As discussed in *Module A – Section 2.3 Hydrogeology*, available data confirm that groundwater within the Evangeline and Jasper aquifers have TDS concentrations greater than 10,000 mg/L. As a result, these aquifers are not considered to be USDWs; and therefore, are buffer aquifers to limit the vertical migration of formation brine or CO_2 in the event of a leak from the storage complex.

  For the Caliche Beaumont Sequestration Project Site, Caliche plans to construct monitoring wells to monitor the lowermost USDW (Lower Chicot aquifer (Lissie Formation) within the AoR), as further discussed below.

- **Environmental Justice (EJ) Considerations:** Results of the EJ review identified residential and commercial areas primarily to the northern and northwester portions of the Caliche Beaumont Sequestration Project Site. The communities in those areas appear to be at high risk due to cumulative impacts of environmental burden. Therefore, the T&M Plan includes additional monitoring considerations to ensure that Caliche does not exacerbate the burden on those identified communities during the life of the Caliche Beaumont Sequestration Project. For example, USDW monitoring wells and soil gas monitoring points have been positioned near local communities and/or water wells to provide early leak detection.
- **Local and Regional Stratigraphy:** The review of the regional and local geology described in the site characterization (*Module A – Section 2.1 Regional Geology and 2.2 Local Geology*) reveals that the storage complex is located near two salt domes located Claimed as PBI [redacted] the Caliche Beaumont Sequestration Project Site, influencing the dip of the local stratigraphy to dip upwards toward the northwest and northeast. It is expected for the CO_2 plume to follow the local stratigraphy as it migrates upward and along the Upper Frio confining unit due to the buoyancy effect. Additionally, some brine injection wells identified near the Caliche Beaumont Sequestration Project Site are influencing the migration of the CO_2(sc) plume during the life of the Caliche Beaumont Sequestration Project (i.e., pushing the plume toward the west) (see *Module B – AoR and Corrective Action Plan*). Therefore, the in-zone (IZ) monitoring wells to track CO_2(sc) plume and pressure front have been strategically places within the AoR to maximize the chances of detecting any changes in geochemical and physical properties (e.g., temperature and pressure) of the fluids in the injection zone.
- **Other Local Infrastructures**: Other infrastructures near the Caliche Beaumont Sequestration Project Site also are considered in the design of this T&M Plan. Infrastructures such as underground pipelines, oil and gas production pads, and other facilities emitting large amounts of CO_2 or other gases located near the AoR can introduce additional complexity to the data collected due to their emissions or leaks. Moreover, their relative location to the injection wells may introduce another layer of risks to the Caliche Beaumont Sequestration Project in the event of a leak or natural disasters. Therefore, the location of monitoring components, such as ambient air and soil gas monitoring, are carefully chosen to produce a reliable dataset for this Caliche Beaumont Sequestration Project that will inform Caliche of any potential issues related to the Caliche Beaumont Sequestration Project, either due to natural or anthropogenic sources.

The testing and monitoring program includes controls and mitigations of brine and CO_2 leak in the following categories:

1. CO_2(sc) stream analysis
2. Continuous recording of operational parameters: injection rate, volume, pressure, temperature, and internal mechanical integrity
3. Corrosion monitoring and leak detection
4. Pressure fall-off testing
5. Above confining zone monitoring
6. Transient pressure falloff test
7. CO_2(sc) plume and pressure front tracking

8. Surface and near-surface monitoring
9. Seismic monitoring

This T&M Plan will be reviewed at least once every five years and any amendments, if necessary, will be submitted to the UIC Program Director and CARB Executive Officer for review and approval prior to implementation, in accordance with 40 CFR §146.90(j) and CARB LCFS Subsection 4.1.16.

Pertinent to the CARB LCFS requirements, if no changes to the T&M Plan are needed by the time of the review period, a demonstration of its appropriateness will be submitted to the UIC Program Director and CARB Executive Officer in accordance with CARB LCFS Subsection 4.1.16. Amended plans or demonstrations will be submitted to the UIC Program Director i) within one year of an AoR reevaluation; ii) following any significant changes to the facility, such as addition of monitoring wells or newly permitted injection wells within the area of review, on a schedule determined by the UIC Program Director; or iii) when required by the UIC Program Director.

The number and locations of the project monitoring components are determined based on: i) potential leakage pathway scenarios through preferential pathways and USDW endangerment, ii) the size of the computationally modeled pressure front and CO_2(sc) plume extents, iii) migration pattern of the CO_2 plume and pressure front, iv) geological structures such as formation dips and faults, v) the total number of proposed CO_2 injection wells (three) for this Caliche Beaumont Sequestration Project, vi) existing wells perforated within the target injection zone, with appropriate well construction specifications, vii) any revisions to the site computational model and delineated AoR associated with AoR reevaluations, and viii) the injection rate and volume. The modeled CO_2(sc) plume extends primarily toward the west due to formation dips and injection wells perforated within the Upper Frio Sand, and the modeled pressure front follows a radial pattern around the three proposed injection wells. A summary of the placement and installation timing of each monitoring component is presented below.

2.1.1 Injection Zone Monitoring

The IZ monitoring wells were placed to detect movement of the CO_2(sc) plume and/or formation brine, and pressure front using direct and indirect measurement methods as further discussed below in Section 9.0.

Caliche proposes a phased approach for installation of new IZ monitoring wells to allow for their placement or timing of drilling to be revised as necessary based on the drilling program schedule and monitoring results, new information about the Caliche Beaumont Sequestration Project (e.g., change APs within the AoR), and revision of the site computational model. The proposed location and timing of IZ monitoring wells are described below (see attached **Figure E.1.2**):

- *IZ Monitoring Well Frio-1:* Located to monitor the pressure front and CO_2(sc) plume between Injection Well Nos. 1 and 2 which are expected to have the highest induced formation pressures due to CO_2 injection. Caliche plans to drill and monitor this well prior to the start of CO_2 injection.
- *IZ Monitoring Well Frio-2:* Located near Fault A, southeast of Injection Well No. 2, within southeastern-most extent of the Caliche-leased Beaumont Acreage. Caliche plans to drill and monitor this well within one year of the start of injection operations.
- *IZ Monitoring Well Frio-3:* Located near Fault A, southwest of Injection Well No. 3, within southwestern-most extent of the Caliche-leased Beaumont Acreage. Caliche plans to drill and monitor this well within one year of the start of injection operations.

- *IZ Monitoring Well Frio-4:* Located at the northern-most extent of the Caliche-leased Beaumont Acreage. This well is anticipated to be located outside the maximum CO_2(sc) plume extent and may serve as a sentinel well to monitor the CO_2(sc) plume and pressure front extent as it migrates towards the local communities to the north. Caliche plans to drill and monitor this well within five years of the start of injection operations.

Note that the current proposed number of IZ monitoring wells may be revised during the life of the project and additional monitoring wells may be installed, if necessary.

2.1.2 Primary Upper Confining Zone Monitoring

Note that the primary Upper Confining Zone (Anahuac Formation) is not anticipated to be monitored during the life of the Caliche Beaumont Sequestration Project. However, pressure and temperature data may be collected during drilling and installation of the injection wells and IZ monitoring wells.

2.1.3 First Transmissive Zone Above Confining Zone Monitoring

The first transmissive zone above the confining zone (ACZ) monitoring wells were placed to detect any upward movement of the CO_2 or formation brine above the primary Upper Confining Unit or via Fault A, using direct and indirect measurement methods as further discussed below in Section 6.1.

Caliche proposes a phased approach for installation of new ACZ monitoring wells to allow for their placement and/or timing of drilling to be revised as necessary based on monitoring results, new information about the Caliche Beaumont Sequestration Project (e.g., change in artificial penetrations within the AoR), natural or anthropogenic seismic events (e.g., earthquake), and revision of the site computational model. The proposed location and timing of ACZ monitoring wells are described below (see **Figure E.1.3**):

- *ACZ Monitoring Wells Oakville-1 through Oakville-4:* Located adjacent to their respective IZ Monitoring Wells, Frio-1 through Frio-4. Caliche plans to drill and monitor these wells concurrently with their associated IZ monitoring wells.

Note that the proposed number of ACZ monitoring wells may be revised during the life of the project and additional monitoring wells may be installed, if necessary.

2.1.4 Lowermost USDW Monitoring

In addition to the site-specific considerations mentioned above, the locations of the lowermost USDW (Chicot aquifer) monitoring network are based on the location of the existing water wells and nearby residential communities. The lowermost USDW monitoring wells were placed to detect any vertical migration of CO_2 or formation brine which can endanger the USDW in case of leakage, using direct and indirect measurement methods discussed further below in Section 6.2.

Caliche proposes a phased approach for installation of new lowermost USDW monitoring wells to allow for their placement and/or timing of drilling to be revised as necessary based on monitoring results, new information about the Caliche Beaumont Sequestration Project (e.g., change in artificial penetrations within the AOR), natural or anthropogenic seismic events (e.g., earthquake), change in land use and groundwater use nearby the Caliche Beaumont Sequestration Project Site, and revision of the site computational model. The proposed location and timing of injection zone monitoring wells are described below (see **Figure E.1.4**):

- *USDW Monitoring Well Chicot-1:* Located adjacent to IZ and ACZ Monitoring Wells Frio-1 and Oakville-1, respectively, to monitor for potential impacts to the USDW within the AoR with the highest expected induced formation pressures due to CO_2 injection at Injection Well Nos. 1 and 2. Caliche plans to drill and monitor this well prior to the start of CO_2 injection.
- *USDW Monitoring Well Chicot-2:* Located adjacent to IZ and ACZ Monitoring Wells Frio-2 and Oakville-2, respectively, to monitor for potential impacts to the USDW within the AoR due to CO_2 injection at Injection Well No. 2 and/or potential vertical migration at Fault A. Caliche plans to drill and monitor this well concurrently with its associated IZ and ACZ monitoring wells.
- *USDW Monitoring Well Chicot-3:* Located adjacent to IZ and ACZ Monitoring Wells Frio-3 and Oakville-3, respectively, to monitor for potential impacts to the USDW within the AoR due to CO_2 injection at Injection Well No. 3 and/or potential vertical migration at Fault A. Caliche plans to drill and monitor this well prior to the start of CO_2 injection.
- *USDW Monitoring Well Chicot-4:* Located at the northeastern corner of the leased Beaumont Acreage near existing P&A'd well Claimed as PBI (located approximately 0.75-mile southeast of IZ and ACZ Monitoring Wells, Frio-4 and Oakville-4, respectively) to monitor for potential impacts to the USDW within the AoR closest to the northeastern residential area. Caliche plans to drill and monitor this well prior to the start of CO_2 injection.

Note that the proposed number of USDW monitoring wells may be revised during the life of the project and additional monitoring wells may be installed, if necessary.

2.1.5 Surface and Near-Surface Monitoring

In addition to the site-specific considerations mentioned above, the locations of the surface and near-surface monitoring network are based on the location of i) existing underground (e.g., pipelines) and above-ground infrastructure (e.g., large greenhouse gas emitting facilities), which can obscure the analysis of the data to detect a potential CO_2 leak to the atmosphere, and ii) existing artificial penetrations that penetrate the Upper Frio Sand injection zone. The surface and near-surface monitoring network is placed to detect any vertical migration of CO_2 to the atmosphere from wellbores, faults, and other migration pathways, using direct and indirect measurement methods discussed further below in Section 10.0.

Caliche proposes to install these monitoring components prior to the start of injection operations to allow for the collection of pre-injection monitoring data to characterize baseline conditions within the AoR. Locations may be adjusted or removed based on monitoring results, new information about the Caliche Beaumont Sequestration Project (e.g., change in APs within the AoR), change in land use near the Caliche Beaumont Sequestration Project Site, and revision of the site computational model.

2.1.5.1 Surface Monitoring (Atmospheric)

To monitor the atmospheric conditions to identify a potential CO_2 leak, LICOR® eddy covariance (EC) towers outfitted with a CO_2 analyzer may be used. CO_2 detectors may be used to measure ambient CO_2 in the atmosphere while the EC towers continuously measure flux changes of key air quality and meteorological parameters. The proposed locations and timing of atmospheric monitoring components are described below (**Figure E.1.5**):

- Discrete atmospheric monitoring may be conducted at several locations throughout the AoR (e.g., at IZ, ACZ, and USDW monitoring wells and soil gas probe sites) utilizing portable CO_2 analyzers (e.g., handheld infrared landfill gas meters). The monitoring will be conducted before, during, and after the start of CO_2 injection operations.
- A total of three EC towers may be placed adjacent to the three injection well locations (1 tower per injection well) to collect data from the area covering the highest induced formation pressures as a result of the CO_2 injection operations.

Note that additional methods for monitoring may be used (e.g., flux accumulation chamber), if necessary. The proposed number and location of EC towers may be revised during the life of the project.

2.1.5.2 Surface Monitoring (Ecosystem Stress)

One component of surface monitoring consists of an ecosystem (i.e., vegetative) stress evaluation during the life of the Caliche Beaumont Sequestration Project. The primary technology Caliche proposes to use to identify any vegetative stress potentially resulting from a CO_2 leak is satellite imagery. High resolution and publicly available imaging platforms will be evaluated from satellites which collect data within the Caliche Beaumont Sequestration Project Site. In addition, a ground-based vegetative survey will be conducted prior to the start of injection operations to characterize baseline vegetative conditions. Ecosystem stress will be evaluated within the AoR extent plus three reference areas of equal area (see **Figures E.1.6 and E.1.7**).

2.1.5.3 Near-Surface Monitoring (Soil Gas)

The near-surface monitoring network will consist of soil gas probes installed at various locations throughout the modeled AoR. The proposed locations of soil gas probes are described below (**Figure E.1.8**):

- Soil gas probes may be installed at the injection and monitoring wells and around select deep APs that penetrate the Upper Frio Sand injection zone within the modeled AoR. To date, 44 wells have been identified to penetrate the Upper Frio Sand injection zone within the AoR as discussed in *Module B – AoR and Corrective Action Plan*; however, only 30 of these wells require further investigation to determine if corrective action including subsequent monitoring is needed. Caliche plans to drill and monitor these soil gas probes prior to the start of CO_2 injection to collect baseline soil gas data across the Caliche AoR extent.
- Additional soil gas probes may be installed within the leased Beaumont Acreage near residential neighborhoods and may be drilled and monitored prior to the start of CO_2 injection.

Note that the proposed number and location of near-surface monitoring locations (i.e., soil gas stations) may be revised during the life of the project and additional monitoring locations may be installed, if necessary.

2.2 Quality Assurance Procedures

All T&M activities will be conducted in accordance with the QASP, pursuant to 40 CFR §146.90(k), found at **Appendix E.1.A** and CARB LCFS Subsection C.4.1(a)(13)(D).

2.3 Reporting Procedures

Caliche will report the results of all T&M activities to the USEPA and CARB in compliance with the requirements under 40 CFR §146.91 and LCFS requirements. **Table E.1.1** below is an overview of the T&M Plan, including the objectives, and the monitoring and reporting frequencies, for each monitoring activity.

For this project, Caliche proposes to collect T&M Plan during the baseline, injection, and post-injection phases of the Caliche Beaumont Sequestration Project. Data collected during the injection and post-injection phases will be compared to baseline conditions and/or trends to determine if any significant deviation from initial conditions or trends occur, which may indicate potential CO_2 or formation brine leakage from the Upper Frio Sand injection zone. Baseline conditions and/or trends will be established from measurements collected before CO_2 injection using probability and/or statistical methods in agreement with standard engineering practices and in compliance USEPA and CARB requirements. In the event that the data collected in accordance with this T&M Plan during the CO_2 injection and post-injection phases are interpreted to be inconsistent with established baselines and/or model predictions, additional testing, monitoring and/or evaluation may be triggered, and USEPA UIC Program Directors and CARB LCFS Executive Officers may be notified in accordance with the permit requirements.

Table E.1.1. Summary of Monitoring Method by Location and Project Stage.

Monitoring Location / Parameter	Monitoring Program	Monitoring Frequency			Reporting Frequency	
		Baseline (1 yr.)	Injection	Post Injection	USEPA	CARB LCFS
CO_2 Stream Analysis (40 CFR §146.90(a) & (CARB LCFS Subsection C.4.1(b)(2)))						
Chemical and Physical Composition of CO_2 Stream	Compositional analysis of the injected CO_2 stream (from each source and composite)	Once prior injection of each CO_2 source	Quarterly	None	Semiannually	Quarterly or annually
Continuous Recording of Operational Procedures [40 CFR §146.88(e)(1), §146.89(b), and §146.90(b)] & LCFS Protocol Subsections C.4.3.1.2 and C4.3.1.3]						
Injection Parameter Monitoring	Pressure and temperature gauge, mass flow meter with alarms for measurements outside of the normal operating conditions	Continuous monitoring prior injection	Continuous monitoring.	None	Semiannually	Quarterly or annually
Annulus Pressure Monitoring	Annulus pressure gauge			Year 1 - 2: Continuous Year 3 - 100: None		
	Annular Fluid Volume Measurements			None		
Corrosion Monitoring [40 CFR §146.90(c) & LCFS Protocol Subsection C.4.3.1.4]						
Coupon Testing	Flow-through corrosion coupon using injection well construction materials	Once prior injection	Quarterly and as new sources added to stream	None	Semiannually	Annually
First Transmissive Zone Above Confining Zone (Oakville Formation) Monitoring - [40 CFR §146.90(d) & LCFS Protocol Subsection C.2.5(b)(2)) & C.4.1.4]						

Monitoring Location / Parameter	Monitoring Program	Monitoring Frequency			Reporting Frequency	
		Baseline (1 yr.)	Injection	Post Injection	USEPA	CARB LCFS
Oakville Formation (Jasper aquifer)	Temperature, Pressure	Continuously	Continuously	Continuously until P&A	Semiannually	Annually
	Pulsed Neutron Logging	Once prior injection	As needed	As needed until P&A		
	Water analysis (geochemical and/or isotopic)	Quarterly	Claimed as PBI [redacted]	Year 1 - 15: Annually Year 16 - 100: As needed until P&A		
Lowermost USDW (Lissie Formation) Monitoring [40 CFR §146.90(d) & (LCFS Protocol Subsection C.2.5(b)(2)) & C.4.1.4]						
Lissie Formation (Lower Chicot Aquifer)	Water analysis (geochemical and/or isotopic)	Every 2 months	Claimed as PBI [redacted]	Year 1 - 15: Annually Year 16 - 100: As needed	Semiannually	Annually
Mechanical Integrity Testing [40 CFR §146.89(c) and §146.90 & LCFS Protocol Subsection C.4.2]						
Well Integrity (Injection wells)	Annulus Pressure Tests, Radioactive Tracer Survey, Temperature Survey	Once prior injection	Annually; after all well workover operations that change well configuration; and as needed	Year 1 - 2: Annually; prior to well P&A Year 3 - 100: None	Within 30 days of results	Annually
Pressure Falloff Test [40 CFR §146.90(f) & LCFS Protocol Subsections C.4.3.1.5]						
Reservoir transmissivity and pressure.	Pressure Falloff Test, Static and Flowing Bottomhole Pressures	Once prior injection	Every 5 year	Once prior to well P&A	Semiannually	Within 30 days of test
CO_2 Pressure and Plume Front (Frio Formation) [40 CFR §146.90(g)]						
Frio Sands	Direct Monitoring: Temperature, Pressure	Continuously	Continuously	Monitoring well: Continuous until P&A Injection well: Year 1 - 2	Semiannually	Quarterly or annually
	Direct Monitoring: Fluid analysis (geochemical and/or isotopic)	Quarterly	Claimed as PBI [redacted]	Monitoring wells only: Year 1 - 15: Annually Year 16 - 100: As needed until P&A		
	Indirect Monitoring: Pulsed Neutron Logging, Fiber Optic (Repeat Seismic survey)	Once prior injection (1 Event)	Claimed as PBI [redacted]	Monitoring wells only: Year 8 & 15 (2 Events) Year 16 - 100: As needed until P&A		
Atmospheric Monitoring [40 CFR §146.90(h); CARB LCFS Protocol Subsections C.2.5(c)(d) and C.4.3.2.2(d)(e)]						
Atmosphere	Continuous Measurement (Eddy Covariance Tower): Atmospheric composition (select compounds), meteorological conditions, Soil conditions and	Continuously	Continuously	Year 1 - 15: Continuously Year 16 - 100: As needed	Semiannually	Annually

Monitoring Location / Parameter	Monitoring Program	Monitoring Frequency			Reporting Frequency	
		Baseline (1 yr.)	Injection	Post Injection	USEPA	CARB LCFS
	Net radiation across surface					
	Intermittent Measurement (Ground Survey): Ambient air composition (select compounds)	Every 2 months; twice per day per event	Claimed as PBI [redacted]	Year 1 - 15: Annually Year 16 - 100: As needed		
Ecosystem Stress Monitoring [40 CFR §146.90(h); CARB LCFS Protocol Subsections C.2.5(c)(d) and C.4.3.2.2(f)]						
Ecosystem Stress	Satellite Imagery	Once prior injection (3 year retrospective from end of baseline)	Annually	Year 1 - 14: As needed Year 15: Once	Semiannually	Annually
	Ground-based vegetation survey	Once prior injection	As needed	As needed		
Soil Gas Monitoring [40 CFR §146.90(h); CARB LCFS Protocol Subsections C.2.5(c)(d) and C.4.3.2.2(g)]						
Soil Gas	Soil gas analysis: molecular and isotopic composition	Every 2 months; twice per day per event (geochemical) Twice (isotopic)	Claimed as PBI [redacted]	Year 1 - 15: Annually Year 16 - 100: Once every 5 years or as needed	Semiannually	Annually
Seismicity Monitoring [CARB LCFS Protocol Subsection C.4.3.2.3]						
Induced micro-seismicity	Fiber Optic (strain to measure micro-seismicity) (Injection and Monitoring Wells)	Continuously	Continuously	As needed until P&A	Semiannually	Within 30 days of >2.7 magnitude earthquake
	USGS's National Earthquake Information Center and Advanced National Seismic System, or equivalent.	Once prior injection for years before injection (3-year retrospective from end of baseline)	Continuously	As needed	Semiannually	Within 30 days of significant earthquake

3.0 CO_2 STREAM ANALYSIS

Caliche plans to analyze the CO_2 stream during injection operations to yield data representative of its chemical and physical characteristics and to meet the requirements of 40 CFR §146.90(a) and CARB LCFS Subsections C.4.3.1.1 and C.4.1(a)(1). One or more baseline samples of the CO_2 stream may be tested and evaluated prior to starting injection operations at the Caliche Beaumont Sequestration Project Site.

3.1 Sampling location and frequency

Measurements of the pressure, temperature, and flow volumes of the injected CO_2 will be collected continuously at the surface before injection into the wellhead. Sampling will be performed upstream or downstream of the surface fluid gauges (e.g., pressure, temperature, flowmeter). Sampling procedures described in this T&M Plan are designed to ensure the samples are representative of the chemical and physical characteristics of the injected CO_2 stream.

In addition to collecting baseline samples prior to injection operations, the frequency of CO_2 sampling will be conducted on a quarterly basis by the following dates each year as shown in **Table E.1.2** below.

Table E.1.2. Monitoring of CO_2 Stream.

Target Parameter	Monitoring Phase	Proposed Monitoring Location(s)	Spatial Coverage	Frequency/Duration
CO_2 Stream	Baseline	Each CO_2 source (pre-composite or pre-mixing)	Not applicable	Once
	Injection	<u>Pre-composite</u>: Once or as process changes at individual sources, additional sources are included in the injection stream, and anomalous results detected in post-composite. <u>Post-composite</u>: Quarterly and as process changes at sources and additional sources are included in the injection stream.	Not applicable	Claimed as PBI <u>Pre-composite:</u> Once, as needed <u>Post-composite:</u> Quarterly, as needed
	Post-Injection	None	Not applicable	None

The sampling and analysis of the CO_2 stream may be conducted when known significant changes to the injected CO_2 stream occur (i.e., the CO_2 source and/or additions/deletions to the existing stream changes). Sampling may also be conducted to verify the chemical and physical properties of the modified stream, if necessary (e.g., density measurements at the mass flow meter greater than normal variability and not correlated to thermal variations). This will determine if there are any unknown changes to the stream that need to be accounted and tested to update and compare to the baseline conditions. Additional sampling may be performed as requested by the UIC Program Director or CARB Executive Officer.

The proposed sample frequency is sufficient to characterize the injected CO_2 stream and account for any potential changes to representative data that may occur, as the CO_2 sources to the Caliche Beaumont Sequestration Project are existing facilities with established processes and not expected to vary significantly.

3.2 Analytical Parameters

Caliche plans to analyze the CO_2 stream(s) for constituents identified in **Table E.1.3** below.

Table E.1.3. Summary of Potential Analytical Parameters for CO_2 Stream(s).

Claimed as PBI

[redacted]

Notes:
1. An equivalent method may be employed with the prior approval of the UIC Program Director or CARB Executive Officer, such as ASTM Standards.
2. International Society of Beverage Technologists (ISBT) Carbon Dioxide Guidelines MBAA TQ vol. 39, no. 1, 2002, pp. 32-35 as cited in ISO/TR 27921:2020(en). Carbon dioxide capture, transportation, and geological storage — Cross Cutting Issues — CO_2 stream composition.

3.3 Sampling Methods

Sample collection may be performed from the sample port located between the last compression stage and the CO_2 injection wellhead and will follow protocols to ensure the sample is representative of the injected CO_2 stream. The sample port will be installed with the ability to purge and collect samples into a container in accordance with the laboratory specifications and will be sealed and sent to a certified laboratory.

Sampling methods and equipment will meet the standards provided in the attached QASP.

3.4 Analytical Laboratory Methods

Samples will be analyzed by third-party laboratories accredited by USEPA using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and/or photo ionization. Detection limits will be dependent on equipment utilized for sample analysis by the selected qualified vendor(s). However, all third-party vendors will meet the minimum standards provided in the QASP (**Appendix E.1.A**).

The sample chain-of-custody procedures will be dependent on the select laboratories as they will assume the custody of the samples. The procedures will document and track the sample transfer to laboratory, to the analyst, to testing, to storage, to disposal (at a minimum). A sample chain of custody procedures is contained in the QASP (**Appendix E.1.A**).

4.0 CONTINUOUS RECORDING OF OPERATIONAL PARAMETERS

Caliche plans to install and use continuous recording devices to monitor injection pressures, injection rates (mass flow), and volumes; the pressure on the annulus between the tubing and the long string casing; the annulus fluid volume added; and the temperature of the CO_2 stream, as required by 40 CFR §146.88(e)(1), §146.89(b), and §146.90(b), and CARB LCFS Subsections C.4.1(a)(2), C.4.3.1.2, and C.4.3.1.3.

Injection rates and pressures will be monitored such that they do not exceed the values set by the permit application (see *Module A – Section 7.0 Operating Plan*). All aspects of the injection process will be monitored, recorded, and if necessary, shut down in the event the normal operating range is exceeded. Surface pressures and temperatures will be measured continuously. The injected volume will be determined from a mass flow meter for each well that will be installed on the injection supply line.

4.1 Monitoring Location and Frequency

Caliche plans to perform the activities identified in **Table E.1.4** below to monitor operational parameters and verify internal mechanical integrity of the injection wells. All monitoring may take place at the locations and frequencies shown below. Operational procedures monitoring will cease upon plugging and abandonment of the injections wells two years following the cessation of injection operations, per CARB LCFS requirements (CARB, 2018, p. 101).

Table E.1.4. Sampling Devices, Locations, and Frequencies for Continuous Operational Monitoring.

Parameter	Device(s)	Location	Min. Sampling[1] Frequency	Min. Recording[2] Frequency
Injection Pressure (surface)	Pressure Gauge	Wellhead/Flowline	1 minute	30 minutes
Injection Pressure (downhole)	Quartz Pressure Gauge	Near Perforations	1 minute	30 minutes
Injection Rate	Mass Flow Meter/Computer	Flowline	1 minute	30 minutes
Injection Volume	Mass Flow Meter/Computer	Flowline	1 minute	30 minutes
Annulus pressure	Pressure Gauge	Wellhead	1 minute	30 minutes
Annulus fluid volume	Fluid Level Measure	Annulus Tank	1 minute	Daily
CO_2 stream temperature	Mass Flow Meter/Computer	Wellhead/Flowline	1 minute	30 minutes
Downhole Temperature	Temperature Gauge	Near Perforations	1 minute	30 minutes

Parameter	Device(s)	Location	Min. Sampling[1] Frequency	Min. Recording[2] Frequency
If Deployed on Injection Well				
Changes in *Rayleigh* scattering resulting from distributed strain indicative of wave arrival	DAS optical fiber	Installed on outside of casing	As designed for acoustic survey	As designed for acoustic survey
Changes in *Rayleigh* scattering indicative of temperature change	DAS optical fiber	Installed on outside of casing	Hourly	Daily

[1] 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.

[2] 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. Note a data archiver may be used to reduce data stream size for long term storage.

Continuously recorded injection parameters will be reviewed and interpreted on a regular basis, to evaluate the injection stream parameters against permit requirements. Trend analysis may also help evaluate the performance (e.g., drift) of the instruments, suggesting the need for maintenance or calibration.

Basic calibration standards, precision, formulas, conversion factors, and tolerances for measuring devices and analysis are included in the QASP (see **Appendix E.1.A**) but will be dependent on specific qualified vendor selection. Calibrations will be per manufacturers specifications and frequency.

4.2 Monitoring Details

For parameters that are required to be continuously monitored, such as injection pressure, injection rate, injection volume, annular pressure, annulus fluid volume, and CO_2 stream temperature, they may be monitored and recorded using a Supervisory Control and Data Acquisition (SCADA) distributed control system (DCS) or similar, if applicable. Results of the monitoring activities will be submitted to USEPA and CARB LCFS in a semi-annual report for each of the following parameters:

- Monthly average, maximum, and minimum values for injection pressure, flow rate, and volume, per 40 CFR §146.91(a)(2) and CARB LCFS Subsection C.4.3.1.2.
- Monthly average, maximum, and minimum values for annulus pressure, in compliance with 40 CFR §146.91(a)(2) and CARB LCFS Subsection C.4.3.1.3.
- A description of any event that exceeds operating parameters for annular pressure or injection pressure specified in the permit, in compliance with 40 CFR §146.91(a)(3).
- A description of any event that triggers a shut-off device required pursuant to 40 CFR §146.88(e) and the response taken.

- The monthly volume and/or mass of the CO_2 stream injected over the reporting period and volume injected cumulatively over the life of the project, per 40 CFR §146.91(a)(5) and CARB LCFS Subsection C.4.3.1.2.
- Monthly annulus fluid volume added or gained per 40 CFR §146.91(a)(6).

4.2.1 Injection Rate, Volume, and Pressure Monitoring

Injection rates, volumes, and pressures at Injection Well Nos. 1, 2, and 3 will be set and limited to safe operating conditions specified in *Module A –Section 7.0 Operating Plan* (see **Tables E.1.5 through E.1.7**, respectively). All gauges, pressure sensing devices, and recording devices will be tested and calibrated as specified by the manufacturer. Test and calibration records will be maintained at the facility. All instruments will be housed in weatherproof enclosures, where appropriate, to limit damage from outside elements and events. The flow meters and pressure gauges will continuously record data that will be sent to a distributive control system.

Table E.1.5. Proposed Operational Procedures: Injection Well No. 1.

Claimed as PBI

[redacted]

Table E.1.6. Proposed Operational Procedures: Injection Well No. 2.

Claimed as PBI

[redacted]

Table E.1.7. Proposed Operational Procedures: Injection Well No. 3.

Claimed as PBI

[redacted]

Downhole flowing pressures into the reservoir will be monitored by a gauge installed near the perforations in the injection wells. Gauges will be referenced to ground level at each well. Downhole pressure monitoring will protect the injection zone against over-injection as the CO_2 becomes denser. If a retrievable gauge is used, pressure gauge(s) will be periodically calibrated according to manufacturer's instructions and corrected for drift.

If permanent unretrievable downhole gauges are used, those gauges will be calibrated by comparison to a wireline deployed gauge run to the same depth in concert with mechanical integrity testing (MIT) events. Static gradient stops will be made with the wireline deployed gauge to verify fluid column density for pressure to depth corrections. Downhole pressure gauge data will provide real-time information for verification of model predictions and AoR reevaluations.

4.2.2 Annulus System Monitoring

The purpose of the annulus system is to maintain a positive pressure on the tubing by the casing annulus of at least 100 psi in excess of the tubing pressure. This will prevent fluid movement from the tubing out into the casing, which will prevent contamination of shallower zones including the USDW in the event of well casing or injection tubing failure.

The integrity of the well's annulus system is achieved by monitoring of the annulus system at the wellhead. Annulus monitoring equipment used for the injection wells includes an annulus tank, an annulus pump (small volume/high pressure), well flow meters, pressure monitoring cells, and pressure control valves. Alternate annulus construction may use a pressurized nitrogen system to maintain a constant pressure on the annulus. The annulus pressure will be monitored continuously. Deviations from expected changes could indicate a potential loss of mechanical integrity in the well annulus system. Observed deviations will initiate a well shutdown and investigation to determine the root cause of the observed deviation.

Annulus brine tank fluid levels (and volumes) will be monitored for indications of system losses/gains and recorded daily.

5.0 CORROSION MONITORING

Per the requirements of 40 CFR §146.90(c) and CARB LCFS (CARB, 2018, p. 77), Caliche will monitor well materials during the operational period. This will be accomplished by using corrosion coupons of well construction materials, which will be monitored for loss of mass and thickness, and will be visually inspected for evidence of cracking, pitting, and other signs of corrosion. This testing will ensure that the well components meet the minimum standards for material strength and performance. The coupon monitoring program is described below.

5.1 Monitoring Location and Frequency

Coupon samples of the well construction materials (well casing, tubing, and any other well parts in contact with CO_2, such as the packer and wellhead) will be mounted in a tray located in the common flowline to the injection well, upstream of the flow distribution header. The tray of coupons will be in contact with the CO_2 stream during all injection operations. This will ensure that the tray location will provide representative exposure of the samples to the CO_2 composition, temperature, and pressures that will be seen at the wellhead and injection tubing. The holders and location of the system will be included in the pipeline design and will allow for continuation of injection during sample removal for testing.

The frequency of corrosion coupon collection and testing will be conducted on a quarterly basis per 40 CFR §146.90(c). Baseline measurements on all coupon samples may be made during one event prior to initiation of injection of CO_2. Commencing with the initiation of injection operations, the initial monitoring event will occur at the end of the first calendar quarter (even if less than 3 months). Subsequent monitoring will occur at the end of each calendar quarter. This equates to a schedule as follows:

- By March 31 – End of Calendar 1st Quarter
- By June 30 – End of Calendar 2nd Quarter
- By September 31 – End of Calendar 3rd Quarter
- By December 31 – End of Calendar 4th Quarter

The schedule may then repeat using this quarterly sample cycle for the lifetime of the injection operations. No monitoring will be conducted during post-injection phase of the project. Coupon compositions and details will be specified as part of conveyance pipeline and final well design.

5.2 Sample Description

Caliche is proposing that a corrosion coupon (weight loss) technique may be used for monitoring purposes, as it is the best known and simplest of all corrosion monitoring techniques (the alternative is to use flow line loops). The corrosion monitoring system will be located downstream of all process compression/dehydration/pumping equipment (i.e., at the beginning of the flow distribution header to the injection well). This will allow for monitoring at a single location for the injection well and at injection conditions (pressure/temperature). Corrosion coupons representative of the well construction materials (**Table E.1.8**), that are in contact with the injectate, will be inspected, photographed, and weighed prior to placement into the flowline to establish a baseline. This will be coupons of pristine (non-exposed) materials of the well construction materials. Prior to installation of the corrosion monitoring system, the following information will be recorded:

1) Coupon Serial Number;
2) Installation date;
3) Identification of the location of the system; and
4) Orientation of the coupon holder.

The coupon method involves exposing a specimen sample of material (the coupon) to a process environment for a given duration, then removing the specimen for analysis. The corrosion monitoring plan will be implemented following the initial installation of the test coupons in the flowline, as follows:

1) Consult maintenance schedule to determine when to remove test coupons from corrosion monitoring holders (coincident with end of calendar quarter);
2) Remove and inspect coupons on a calendar quarterly basis and quantitatively evaluate for corrosion according to American Society for Testing Materials (ASTM) Standard G1-03(2017)e1 or National Association of Corrosion Engineers (NACE) Standard RP0775-2005 Item No. 21017 standards guidelines;
3) Place coupons in proper receptacle for safe transport to measurement and weighing equipment;
4) Photograph each coupon as received. Visually inspect each corrosion coupon for any pitting, stress corrosion cracking or scale buildup. Analyze corrosion coupons by weighing each coupon (to the nearest 0.0001 gram) and measuring the length, the width, and the height of the coupon (to the nearest 0.0001 inch);

5) Record information for each coupon including the date of measurement, the coupon identity (coupon number and metal grade), and the coupon weight in grams, and include any observations of excessive weight loss or pitting, stress corrosion cracking, or scale buildup;
6) Determine if current the corrosion coupon can be returned to the monitoring test holder, if so, make a note of the coupon return; if not, make a note of the installation of a new coupon.

Table E.1.8. List of Equipment Coupons with Material of Construction.

Equipment Coupon	Material of Construction
Surface Piping	"as built" material in contact with CO_2
Wellhead	Chrome alloy, or "as built" trim material in contact with CO_2
Injection Tubing	Chrome alloy, or "as built" material in contact with CO_2
Packer	Chrome alloy (22Cr steel or better), or "as built" trim material in contact with CO_2

Samples will be collected by trained and authorized personnel and submitted to a third-party analytical laboratory for analysis. Results of the analysis will be compared to the pre-project baseline of the coupons. Basic details regarding the laboratory analysis are explained in the attached QASP; however, specific details will be provided and updated by the selected corrosion laboratory vendor. Results will be submitted through the GSDT semi-annual reporting portal. The UIC Program Director will independently assess the results of the corrosion monitoring program to assess the integrity of the injection wells.

5.3 Alternative Tests

In accordance with 40 CFR §146.90, Caliche may run a casing inspection log(s) to determine the presence, or absence, of corrosion in the protection (long string) casing whenever the tubing is pulled from the well, or at the request of the UIC Program Director. Proposed casing inspection logs may include multi-finger caliper, ultrasonic imaging, magnetic flux leakage, and electromagnetic imaging tools, as they are the industry standards for determining casing thickness and for identifying internal and external corrosion. The log(s) will be compared to those run during the initial construction of the well (40 CFR §146.87). Additional inspection logging programs may be implemented, should the coupons show undue corrosion in excess of the design-life criteria.

Alternative testing, other than those listed above, may be conducted with the written approval of the UIC Program Director. To obtain approval for alternative testing, ahead of any proposed testing, Caliche will submit a written request to the UIC Program Director setting forth the proposed test and all technical data supporting its use.

6.0 ABOVE CONFINING ZONE MONITORING

6.1 First Transmissive Zone Above the Confining Zone (Oakville Formation)

Caliche will conduct direct and indirect monitoring of the Lower Jasper aquifer of the Miocene-aged Lower Oakville Formation sandstones immediately above the Anahuac Formation and Lower Oakville shales (Upper Confining System). This will allow for early detection of any out-of-zone movement of either CO_2 or intraformational fluids above the Upper Confining System and out of the permitted sequestration complex. The Miocene-aged sandstones of the Oakville Formation are alternating saline aquifers and impermeable aquitards. The areal continuity of these sands is sufficient to provide monitoring and "first point" of leakage detection zones. The Oakville Sandstones will be monitored via four dedicated, above confining zone (ACZ) monitoring wells located within the leased Beaumont Acreage (see **Figure E.1.3**).

The wells will be engineered for continuous monitoring of the downhole pressure and temperature and set up for direct fluid geochemical sampling and testing. The downhole pressure/temperature gauge for the Oakville Sandstone will be referenced to ground level. Alternately, a "light" fluid column may allow monitoring and recording pressures at surface. The method is dependent on whether the monitoring wells can support a "light" fluid to surface. Native formation water from the monitored Oakville sandstone will be sampled initially upon well construction (including a quantification of dissolved native gases) for baseline characterization purposes. Downhole initial formation pressure and temperature will also be recorded for baseline establishment.

Changes in water composition are not expected to result from injection operations due to the depth and thickness of the Oakville Formation sandstones and the thick Upper Confining System above the Upper Frio Sand injection zone providing hydraulic and geochemical isolation between the first transmissive zone ACZ and the injection zone. However, the ACZ monitor wells will provide direct measurement, if the sequestered CO_2 or deeper formation brines ever vertically migrate upwards to the base of Oakville Formation.

Fluid sampling will be conducted in the ACZ monitoring wells during the baseline, injection, and post-injection phases. Should the Oakville ACZ monitoring wells begin to exhibit the presence of CO_2 (either by change in downhole pressure and temperature or by surface pressure and temperature changes or a change in water quality), an adaptive fluid sampling program will be initiated with more frequent monitoring events and the possible addition of a new ACZ monitoring well, if needed.

Field sampling work will be conducted by a qualified vendor and the selected analytical laboratory will be compliant with USEPA, Texas Commission on Environmental Quality (TCEQ), or alternative methods (e.g., ASTM Methods or Standard Methods) using standardized procedures.

6.1.1 Monitoring Location and Frequency

Per 40 CFR §146.90(d), the lower ACZ (the Oakville Formation) will be monitored utilizing direct and indirect methodologies. **Figure E.1.3** (attached) and **Table E.1.9** (below) show the planned monitoring methods, locations, and frequencies for direct and indirect monitoring of groundwater quality and geochemistry in the ACZ monitoring wells. The targeted monitoring zone is located at a depth of approximately Claimed as PBI [redacted]. Experienced water well drillers will be used to install the new ACZ monitoring wells within the Lower Jasper aquifer of the Oakville Formation in accordance with the well schematic provided in **Appendix E.1.B**. The ACZ monitoring wells will be located near the point of CO_2 injection, where the induced formation pressure in the reservoirs is expected to be the greatest during the injection and post-injection phases, as well as in proximity to the fault located south of the Caliche Beaumont Sequestration Project Site and to the residential neighborhoods to the north of the AoR.

Modeling shows that pressure monitoring is a more robust and more diagnostic leakage detection method in deep confined saline aquifers. Under typical low flow gradients in saline formations, a CO_2 pressure signal is unlikely to propagate far from the leakage point and would be chemically undetectable. Leakage of brine from one formation to another is also unlikely to be chemically diagnostic. If ambient methane or CO_2 is present in the system, CO_2 may not be chemically diagnostic either. Therefore, Caliche may prioritize measuring bottomhole pressure in the on-site ACZ monitoring wells, which will be continuously monitored, to support and provide context for the fluid analysis. If leakage trends are detected (such as significant changes in pressure and/or temperature), additional testing, logging, or geochemical measurements will be conducted to assess the change in signal (adaptive monitoring).

Table E.1.9. Monitoring of ACZ in Oakville Formation (Jasper Aquifer).

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Oakville Sandstone (Jasper aquifer)	Downhole Pressure and Temperature Monitoring	4 Oakville ACZ monitoring wells - downhole	Near the point of CO_2 injection, Fault A, and local residential neighborhoods	Continuously
	Pulsed Neutron Logging			Baseline log prior to CO_2 injection initiation Repeat surveys if anomaly is observed
	Fluid Sampling			Baseline: Quarterly Injection: Claimed as PBI [redacted]; as needed Post-Injection: Year 1 - 15: Annually Year 16 - 100: As needed until P&A

The goal of monitoring the ACZ is to detect the leakage or upward movement of either formation brine or CO_2 from the sequestration complex, should it occur. An initial geochemical description of the formation and CO_2 injectate fluids will be evaluated prior to injection operations for this interval.

Fluid sampling methods to be employed, include sampling standard operating procedures as adapted from EPA (2017) or as approved by the UIC Program Director and CARB Executive Officer. Sample containers will be new and of an appropriate material and size for the analyte. Sufficient volumes will be collected to complete all the specified analyses in **Table E.1.10** below. Appropriate preservation of each sample container will be completed upon sample collection (see QASP in **Appendix E.1.A**). The chain-of-custody will be documented using a standardized form from the analytical laboratory and will be retained and archived to allow tracking of sample status.

This will include any required duplicates collected and appropriate field and trip blanks included for quality assurance. Completing the field chain-of-custody form will be the responsibility of groundwater sampling personnel.

The frequency of fluid sampling of the ACZ will be conducted quarterly during the baseline phase, quarterly [redacted] or annually ([redacted] during the injection phase, and annually during the post-injection phase for 15 years. The initial monitoring event following the start of injection operations will occur at the end of the first calendar quarter (even if less than 3 months). Subsequent monitoring will occur at the end of each calendar quarter. This equates to a schedule as follows:

1. By March 31 – End of Calendar 1st Quarter
2. By June 30 – End of Calendar 2nd Quarter
3. By September 31 – End of Calendar 3rd Quarter
4. By December 31 – End of Calendar 4th Quarter

The schedule will then repeat using this cycle for the duration of injection and post-injection operations.

If a pressure anomaly is detected in an ACZ monitoring well, Caliche will investigate the anomaly. If it is determined that the anomaly appears to be real and related to project performance, this may trigger additional adaptive geochemical sampling of the IZ and ACZ fluids. The collected samples will be sealed, dated, and sent to an authorized third-party laboratory for analysis. The frequency of enhanced geochemical sampling may be conducted on an "as needed" basis if the pressure signal triggers additional testing.

If pressure and sample analyses confirm potential leakage into the strata overlying the Upper Confining System, then injection operations may cease and trigger the procedures set out in *Module E.4 - ERRP.* Sampling of USDW monitoring wells and near-surface soil gas probes may also be initiated as part of the response, to define the impact and reach of the potential leakage above the Upper Confining System.

6.1.2 Analytical Procedures

Pre-injection (baseline) phase fluid sampling and analysis is an integral part of the site characterization activities prior to start of the injection project. It provides a basis to assess data gathered during the injection and post-injection monitoring phases of the project when such a need is identified based on project performance / triggers. Pre-injection formation fluid samples will be collected from the Oakville Formation ACZ monitoring wells prior to injection operations for establishing baseline and protocols for leak detection. **Table E.1.10** below identifies the parameters to be monitored and the analytical methods that Caliche may use.

Table E.1.10. Summary of Potential Analytical Parameters for ACZ Fluid Monitoring.

[redacted]

Claimed as PBI

[redacted]

Notes:

1. AMS = accelerator mass spectrometry; CRDS = cavity ring down spectrometry; ICP-MS = inductively coupled plasma mass spectrometry; IRMS = isotope ratio mass spectrometry; MS = mass spectrometry; SM = standard method.
2. * = Analytical parameters to be included during the pre-injection phase, and only as needed during the injection and post-injection phases of the project.

The initial parameters identified in Table **E.1.10** may be revised to include additional components for testing, dependent on the baseline geochemical characterization. When the fluid samples are collected, they will be sent to a third-party laboratory for analysis using analytical methods accredited by the TCEQ or alternative (e.g., ASTM Methods or Standard Methods) using standardized procedures.

Pressure and temperature will be recorded continuously and monitored for major deviations from the initial formation baseline measurements. Evaluations of potential injection operations from local brine disposal wells also will be considered, as applicable, to the monitored interval within the Oakville Formation.

6.1.3 Sampling Methods

The sampling system used to sample and quantify dissolved gases and the aqueous phases in equilibrium with those gasses will be supplied by a third-party vendor (*such as:* Class VI Solutions (U-tube samplers), Schlumberger, Expro, or equivalent vendor using downhole PVT sampler or equivalent tool). Bottomhole samples are preferred; however, surface samples may be used for expediency.

The sampling protocol will be similar to the following:

1. Purge the casing volume to bring fresh fluids that have not reacted with casing and tubing to the sample point within the wellbore;
2. Deploy commercial downhole sampler on slickline to collect a fluid sample at pressure and then close to retain gas phases as sample is transported to the surface;
3. Conserve gas volumes as samples are stepped to atmospheric pressure for shipping and analysis;
4. Filter and preserve samples following protocols for brine sampling;
5. All sample containers will be labeled with durable labels and indelible markings;
6. A unique sample identification number and the sampling date will be recorded on each sample container; and
7. The sample container will be sealed and sent to an authorized third-party laboratory.

Repeat sampling and frequency to be determined based on results.

6.1.4 Analysis Procedures and Chain-of-Custody

Samples will be analyzed by a third-party laboratory accredited by the TCEQ or alternative (e.g., ASTM Methods or Standard Methods) using standardized procedures for gas, major, minor .and trace element compositions. Detection limits will be dependent on equipment used for the analytical methods by the selected qualified vendor and meet the minimum levels set forth in the QASP provided in **Appendix E.1.A**.

The sample chain-of-custody procedures will be dependent on vendor selection as they will assume custody of the samples. The procedures will document and track the sample transfer to laboratory, to the analyst, to testing, to storage, to disposal (at a minimum). An example of a sample chain-of-custody procedure is provided in the QASP **Appendix E.1.C**).

6.2 Lowermost Underground Source of Drinking Water (Lissie Formation)

6.2.1 Monitoring Location and Frequency

The primary goal of the USDW monitoring program is to confirm protection of groundwater that can potentially be used as a drinking water resource. For the Caliche Beaumont Sequestration Project, the lowermost USDW identified is the upper portion of the Lower hydrologic unit of the Chicot aquifer (Lower Chicot aquifer) within the Lissie Formation, with the base estimated to be located between Claimed as PBI [redacted] (see *Module A – Section 2.3 Hydrogeology*). The Evangeline and Jasper aquifers underlying the Chicot aquifer are known saline aquifers within the area (*Module A – Section 2.3 Hydrogeology*). There are no known existing or proposed WSWs or potable use of these aquifers; and therefore, no monitoring of the Evangeline or Jasper aquifers is proposed for this Caliche Beaumont Sequestration Project.

At the Caliche Beaumont Sequestration Project Site, it is anticipated that the areas with highest potential risk for vertical fluid migration will be in the vicinity of the injection wells due to the injection pressures; therefore, the siting of the four new USDW monitoring wells has taken into consideration the predicted zones of elevated induced pressures within the AoR. Other considerations for the locations of the four USDW monitoring wells are the size of the Claimed as PBI [redacted] AoR, the location and spatial density of APs that penetrate the Upper Frio Sand injection zone, Fault A located south of the Caliche Beaumont Sequestration Project Site, and the location of residential areas which use or may potentially use the USDW as a groundwater resource.

It is anticipated that the four USDW monitoring wells installed throughout the AOR will provide representative spatial trends and variable data to determine if impact within the USDW has occurred as a result of brine or CO_2 migration from the injection zone. Since no wells were identified to be screened within the Lower Chicot within the AOR which could be used for monitoring the lowermost USDW for this Caliche Beaumont Sequestration Project, Caliche plans to construct four new USDW monitoring wells to monitor the Lower Chicot aquifer during the baseline, injection, and post-injection phases of the Caliche Beaumont Sequestration Project, in accordance with applicable regulations and guidelines set forth by the USEPA UIC program for Class VI injection well sites (40 CFR §146.90(d); EPA, 2013a;b; EPA, 2016). Proposed locations of the new USDW monitoring wells are presented in **Figure E.1.4**. Experienced water well drillers will be used to install the new USDW monitoring wells within the upper portion of the Lower hydrologic unit of the Lower Chicot aquifer in accordance with the well schematic provided in **Appendix E.1.A**.

Groundwater samples will be collected from these wells for water quality testing during the baseline, injection, and post-injection phases of the Caliche Beaumont Sequestration Project. **Table E.1.11** below shows the planned monitoring methods, locations, and frequencies for groundwater quality and geochemical monitoring of the Lower Chicot aquifer.

Table E.1.11. Monitoring of USDW in Lissie Formation (Lower Chicot Aquifer).

Target Formation	Monitoring Phase	Proposed Monitoring Location(s)	Spatial Coverage	Frequency/Duration
Lissie Formation: Lower Chicot aquifer	Baseline	4 USDW Monitoring Wells	Over AoR	Every 2 months for at least 1 year
	Injection			Claimed as PBI [redacted]
	Post-Injection			Year 1 - 15: Annually Year 16 - 100: As needed

Fluid and dissolved gas samples will be collected and analyzed for geochemical and isotopic characterization after the installation and adequate development of the USDW monitoring wells (see **Table E.1.12** below). Additional samples will be collected every 2 months for at least one year prior to commencement of CO_2 injection activities and evaluated to establish baseline conditions within the USDW. As shown in **Table E.1.12**, during the injection phase, the USDW monitoring wells will be sampled for geochemical analysis and a subset of the isotopic analyses at a quarterly frequency during Years 1 and 2, then annually thereafter until the end of injection period (Claimed as PBI [redacted]). The initial monitoring event following the start of injection operations will occur at the end of the first calendar quarter (even if less than 3 months). Subsequent monitoring will occur at the end of each calendar quarter. This equates to a schedule as follows:

1. By March 31 – End of Calendar 1st Quarter
2. By June 30 – End of Calendar 2nd Quarter
3. By September 31 – End of Calendar 3rd Quarter
4. By December 31 – End of Calendar 4th Quarter

During the post-injection phase of Caliche Beaumont Sequestration Project, the USDW will be monitored annually for geochemical analysis and a subset of the isotopic characterization for the first 15 years.

If anomalous pressure, temperature, and/or geochemical changes are observed at the ACZ monitoring wells (i.e., Oakville-1 through Oakville-4), or there is any indication of leakage through the injection wells or nearby APs during the injection and post-injection phases of the project, additional fluid samples may be obtained for geochemical and/or isotopic analysis for comparison to pre-injection sample results.

6.2.2 Analytical Methods and Justification

Monitoring of the lowermost USDW (Lower Chicot aquifer) will be conducted by analyzing the groundwater for geochemical and isotopic analyses listed in **Table E.1.12** below. However, the analytical program proposed for this Caliche Beaumont Sequestration Project includes an array of analytical components, some of which may be prone to false-positive indications of CO_2 leakage, especially if evaluated independently from other monitoring components. These false positives often reflect the natural variability due to in situ biological and chemical processes in the groundwater geochemistry in space and time, which are unrelated to CO_2 injection and storage activities or brine migration from the target injection reservoir. As such, this USDW monitoring program has been designed to improve the ability to discern natural and anthropogenic sources of CO_2 or brine based on the geochemical and isotopic patterns observed before, during, and after the injection activities. A subset of the water quality parameters (e.g., isotopic composition and noble gases) is proposed for monitoring during the baseline phase of the project and will be included during injection and post-injection only as needed, as indicated on **Table E.1.12** below.

Table E.1.12. Summary of Potential Analytical Parameters for USDW Fluid Monitoring.

Claimed as PBI

[redacted]

Notes:

1. AMS = accelerator mass spectrometry; CRDS = cavity ring down spectrometry; ICP-MS = inductively coupled plasma mass spectrometry; IRMS = isotope ratio mass spectrometry; MS = mass spectrometry; SM = standard method.
2. * = Analytical parameters to be included during the pre-injection phase, and only as needed during the injection and post-injection phases of the project.

The USDW monitoring program for the Caliche Beaumont Sequestration Project will collect discrete groundwater samples every two months from the four USDW monitoring wells prior to the injection phase in order to establish baseline conditions (i.e., geochemical and isotopic trends, including seasonal variations, which characterize the natural or existing anthropogenic conditions in the Lower Chicot aquifer within the AoR, against which future groundwater data collected from the USDW during the injection and post-injection phases of Caliche Beaumont Sequestration Project will be compared. At the conclusion of baseline monitoring, the range of naturally occurring groundwater conditions during the baseline timeframe will be characterized, and protocols for CO_2 leakage detection during the injection phase (e.g., the initiation of adaptive sampling when certain threshold concentrations are exceeded) will be developed.

An anomalous detection of CO_2 above background levels in the USDW *"does not necessarily demonstrate that USDWs have been endangered, but it may indicate that a leakage pathway or conduit exists"* (EPA, 2013b). Therefore, if it is determined that a departure between observed and baseline parameter patterns appears to be related to a potential CO_2 leak from the target reservoir, additional testing of the USDW may be conducted.

During all phases of the Caliche Beaumont Sequestration Project, groundwater geochemical and isotopic analysis results provided by the certified laboratories will be evaluated by experienced geochemistry personnel. These data will be compared with previous measurements and baseline conditions to look for trends or changes in chemical or isotopic composition. Groundwater results will be evaluated within the context of other monitoring components for this project, such as pressure, temperature, and other environmental data (e.g., ACZ, soil gas) to determine whether a CO_2 has occurred.

If the evaluation of the USDW monitoring results confirm that fluids or gases from the injection zone may be leaking into the lowermost USDW, the source of the potential leak will be investigated, and appropriate corrective actions, if any, will be taken to protect the drinking water resources within the AoR per 40 CFR §146.94 (a) (see *Module E.4 – ERRP* for details).

The elements of this USDW monitoring program may be modified throughout the baseline, injection, and post-injection operational phases of the project, as needed, and with approval of the UIC Program Director, as more data and information become available for the Caliche Beaumont Sequestration Project Site.

6.2.3 Sampling Methods

Groundwater sampling will be conducted in general accordance with operating procedures set forth in USEPA Method SESDPROC-301-R4 (EPA, 2023a). Groundwater samples will be collected into appropriate laboratory-supplied, method-specific sample containers, properly preserved (as needed), and shipped within 48 hours of collection for laboratory analysis. Groundwater samples for the analysis of cations will be field-filtered utilizing a 0.45 µm flow-through filter cartridge and preserved using appropriate techniques. Prior to sample collection, filters will be purged with a minimum of 100 mL of well water (or more if required by the filter manufacturer). All sample containers will be labeled with durable labels and indelible markings, and a unique sample identification number and sampling date will be recorded on the sample containers.

6.2.4 Analysis Procedures and Chain of Custody

Groundwater samples will be submitted for various geochemical and isotopic analyses by a third-party laboratory accredited by the TCEQ or alternative (e.g., ASTM Methods or Standard Methods) using standardized procedures. Detection limits will be dependent on equipment utilized for the analytical methods by the selected qualified laboratories and meet the minimum levels set forth in the QASP (see **Appendix E.1.A**).

The sample chain-of-custody procedures will be dependent on field sampling vendor selection as they will assume custody of the samples. The procedures will document and track the sample transfer to laboratory, to the analyst, to testing, to storage, to disposal (at a minimum). A sample chain-of custody procedure is contained in the attached QASP (**Appendix E.1.A**). Sample chain-of-custodies will include any required duplicates collected and appropriate field and/or trip blanks included for quality assurance.

The initial parameters identified in **Table E.1.12** may be revised and include additional components for testing dependent on the initial geochemical and isotopic evaluation.

7.0 MECHANICAL INTEGRITY TESTING

To verify external mechanical integrity in the injection wells, Caliche will conduct at least one of the tests presented in **Table E.1.13** below, prior to the start of injection operations, and then annually during the injection and post-injection phases, as required by 40 CFR §146.89(c) and §146.90 and CARB LCFS (CARB, 2018, pp. 79-82). Per CARB LCFS requirements, the first MIT during the injection phase will be conducted within three months after injection has commenced (CARB, 2018, p. 80). A demonstration of mechanical integrity will be made at least once a year during injection operations. A report will be submitted within 30 days after each MIT.

7.1 Location and Frequency

The integrity of the long-string casing, the injection tubing, and the annular seal shall be tested by means of an approved pressure test. The integrity of the bottom-hole cement may be tested by means of a temperature survey or an approved tracer survey. Alternatively, a noise log may be run in in the well to demonstrate containment within the permitted injection zones. Pulsed neutron logging may be run to verify the mechanical integrity of the near-well area behind the casing of the well.

Table E.1.13. Mechanical Integrity Testing – Injection Well.

Test Description	Location
Temperature Survey or Tracer Survey	Injection Well – downhole, through tubing string
Pulsed Neutron Log	Injection Well – downhole, through tubing string
Annulus Pressure Test	Injection Wellhead - surface

MITs will be run after the initial construction of the well, prior to the initiation of injection operations. During injection operations, an MIT will be performed on an annual basis, within 45 days of the anniversary of the preceding year's test. Caliche will notify the UIC Program Director and CARB Executive Officer ahead of testing if required under 40 CFR §146.87(f). This schedule will be repeated through the duration of injection operations and prior to plugging operations. Should the well require a workover, an MIT will also be performed prior to placing the well back into service and a report will be submitted within 30 days after the well workover pursuant to 40 CFR §146.91(b)(2).

7.2 Testing Details

Prior to running an MIT, the wellbore may be displaced with water or brine. In either case, the well will be allowed to thermally stabilize prior to all testing operations. It is recommended that the well be shut-in for 36 hours to allow temperature effects to dissipate (EPA, 2013, p. 21). The external MIT logs will be run in the injection well.

7.2.1 Radioactive Tracer Survey

A Radioactive Tracer Survey (RTS) may be run as an alternative to a differential temperature survey (DTS; further discussed below in Section 7.2.2). The tool consists of a gamma ray detector above an ejector port and one or two gamma ray detectors below the ejector port. To run the RTS, the wellbore annulus will need to be flushed with brine. Therefore, the test will be conducted using brine to convey the radioactive tracer material down the well. The tool will continuously record the gamma ray API units during tracer fluid injection. The upper detector will be recorded in Track 1 at a scale of 0 to 100 or 150 API units, and the lower detector(s) will be recorded in Tracks 2 and 3 at a higher (less sensitive) scale, typically 0 to 1,000 API units.

Prior to testing, an initial gamma ray baseline log will be recorded from at least 100 feet above the injection tubing packer to the total depth of the well. The initial gamma ray survey can be made under low flow conditions or static well conditions.

For depth correlation, a concurrent casing collar locator log will be run on the wireline tool string. Two, 5-minute time drive, statistical checks will be run prior to the ejection of tracer fluid. One of the statistical checks will be run in the Upper Frio shale containment layer immediately above the uppermost perforation in the well. The second check will be run at the depth of the Upper Frio Sand injection zone. The baseline log and the statistical checks will be used to determine the baseline background radiation prior to the ejection of the tracer fluid.

Brine injection will be initiated or increased during testing operations. During the survey, brine injection rates will be set at the rate at which the fluid will be under laminar flow conditions, while remaining within the maximum permitted operating parameters anticipated for the well. The volume of the tracer fluid slug will be sufficient to cause a gamma curve deflection on the order of 25x background reading as the ejected slug passes the lower detector(s). This would typically be a full-scale deflection.

A constant injection (moving) survey will be run from above the packer down to the perforations to check for leaks between those two points. This survey will consist of ejecting a tracer slug above the packer, verifying the tracer slug ejection, dropping the tool down through the slug, and logging up through the slug to above where the slug was first ejected. Then, the tool will be successively dropped down through the slug again and logging will continue upward to above where the slug was encountered on the previous pass. This process will be repeated a minimum of two times, until the slug flows out into the formation. If necessary, the injection rate may be adjusted to accomplish this test.

A stationary survey will be run approximately 20 feet or less above the top of the perforated interval to check for upward fluid migration outside of the cemented casing. The flow during the stationary survey will be at sufficient rates to approximate the normal operating conditions anticipated for the well. The stationary survey procedure consists of setting the tool and logging on time drive, ejecting a slug, verifying the ejection, and waiting an appropriate amount of time to allow the slug to exit the wellbore and return through channels outside of the pipe, if present. The time spent at the station will vary but should be at least twice the time estimated to detect the tracer fluid if channeling exists, or 15 minutes, whichever is greater. If tracer fluid is detected channeling outside of the pipe at any time during the stationary survey, the survey may be stopped, and the movement of the tracer fluid will be documented by logging up on depth drive, until the tracer exits the channel. The stationary survey will be repeated at least once.

Additional stationary or moving surveys may be required, depending upon well construction, test results, or to investigate known problem conditions. At least two repeatable logs of every tracer survey, moving and stationery, should be run. On completion of the tracer surveys, a final background gamma log will be run for comparison with the initial background log. In general, the test procedure will be as follows:

1) Attach radioactive tracer tools, including the casing collar locator (CCL), the gamma ray detectors, and the ejector modules to the wireline. Lower the tools into wellbore to the deepest attainable depth (top of solids fill). Record the depth of solids fill in the well, if any. Correlate the tools to depth with the injection packer and any other cased-hole log(s) that are run in the well.

2) A baseline gamma log will be run from the deepest attainable depth to approximately 100 feet above the packer. Statistical tool checks will be conducted 10 feet above the set depth of the injection packer and approximately 15 feet above the top perforation. *Specific depths will be identified and updated after injection well completion.*

3) With the tool set a minimum of 100 feet above the packer, start injecting brine fluid at approximately 50 gallons per minute (gpm) or the defined acceptable rate. Eject a slug of tracer material and verify ejection.

4) Lower the tool through the slug and log up through the slug. Repeat the slug-tracking sequence, following the slug down the tubing and into the Injection Zone until the slug has been dissipated.

   Note: It is desired to achieve a minimum of three or more passes below the injection packer before the radioactive slug exits the perforations. Adjust or reduce injection rate, if needed, to achieve this objective.

5) Repeat Steps 3 and 4.

6) Position the RTS tool's lower detector approximately 15 feet above the top perforation. Initiate and maintain injection at approximately 250 gpm or the defined acceptable rate.

7) Eject a slug of tracer material and record on time drive for a minimum of 15 minutes to determine if upward flow around the casing occurs.

8) Repeat Step 7.

9) Cease pumping, lower the tool to the deepest attainable depth, and run a repeat baseline gamma ray log to verify that the radiation level has returned to baseline background radiation levels.

10) Dump the remaining radioactive tracer material from the tool and pump the remaining test fluid to flush the tracer material from the wellbore.

11) Retrieve the wireline tools from the wellbore and rig down wireline unit.

A successful pressure test will “PASS” if the radioactive iodine material stays within the Injection zone(s) and therefore within the sequestration complex.

7.2.2 Differential Temperature Survey (DTS)

A baseline DTS will be run in the well after allowing the well a period of time to reach approximate static conditions. The temperature log will be one of the approved logs for detecting fluid movement outside of the well pipe. A baseline survey will be run during completion operations, which will provide an initial baseline temperature curve for future comparisons. The log will include both an absolute temperature curve and a differential temperature curve. The well should be shut-in for at least 36 hours to allow temperature stabilization of the well prior to running the temperature survey (EPA, 2013, p. 21).

If a distributed temperature sensing fiber is run in the injection well, the fiber will be used for the temperature testing; otherwise, a wireline truck will be used.

If wireline operations are conducted, the temperature will be logged from the surface down to the total depth of the well. Recommended line speed for the logging operations is 30 to 40 feet per minute. A correlation log(s) will be presented in Track 1 and the two temperature curves will be presented in Tracks 2 and 3. The temperature log tracks will be scaled to approximately 20° F per track. The differential curve will be scaled in a manner appropriate to the logging equipment design but will be sensitive enough to readily indicate temperature anomalies. In general, the procedure for wireline operations will be as follows (also see *Module D – Pre-Operational Testing Plan*):

1) Attach a temperature probe and CCL to the wireline.
2) After a minimum of 36 hours of well static conditions, begin the temperature survey. The tools will be lowered into the well at 30 to 40 feet/minute, recording the temperature in wellbore. The temperature survey will be run to the deepest attainable depth (top of solids fill) in the wellbore. The wireline may be flagged, if needed, to assist in depth correlation.
3) Following completion of the survey, the wireline tools will be retrieved from the wellbore.

A temperature log run will be considered successful if there are no unexplained temperature anomalies observed outside of the permitted injection zone.

If temperature anomalies are observed outside of the permitted zone, additional logging may be conducted to determine whether a loss of mechanical integrity or loss of containment has occurred. Depending on the nature of the suspected movement, radioactive tracer, noise, oxygen activation, or other logs approved by the UIC Program Director may be required to further define the nature of the fluid movement or to diagnose a potential leak.

7.2.3 Pulsed Neutron Logging

Pulsed neutron logging may be run to verify the mechanical integrity of the near-wellbore area behind the casing in the injection well. A baseline survey will be run during completion operations (with the well in completion configuration) and will provide an initial baseline log for future comparisons. Should the downhole well completion change at any time, a new baseline log will be run. The pulsed neutron survey may be run from the top of the Upper Frio "Green" Sand interval below a depth of approximately [redacted] down to the total depth of the well and will be run in gas-sigma-hydrogen mode. The sigma measurement is used to determine porosity, differentiate between saline water and CO_2, and calculate formation saturation in the injection zone. Caliche will run the pulsed neutron log annually for the first two years, and then every 5 years after that throughout injection operations. The UIC Program Director may require more frequent monitoring to further define the nature of potential fluid movement along the casing-borehole wall or to diagnose potential leaks.

7.2.4 Annulus Pressure Test

In conjunction with annual MIT, an annulus pressure test (APT) of the casing by the tubing annulus will be made. Pressures will be recorded on a time-drive recorder for at least 60 minutes in duration and the chart or digital printout of times and pressures will be certified as true and accurate. The pressure scale on the chart will be low enough to readily show a five percent change from the starting pressure. In general, the test procedure will be as follows:

1. Connect a high-resolution pressure transducer to the annulus and increase the annulus pressure to at least 200 psig over the permitted maximum tubing/injection pressure. Conduct the APT by holding annular pressure a minimum of 100 psi above the well's maximum permitted surface injection pressure for a minimum of 60 minutes.
2. At the conclusion of the APT, the annular pressure will be lowered to the well's normal, safe differential pressure value and pressure recording equipment will be removed from the well system.

A successful pressure test will "PASS" if the pressure holds to +/-5 percent of the starting pressure. If the test is unable to hold pressure for the selected time period, the test will be considered a "FAIL." The test will then be repeated and if the well continues to "FAIL," the construction of the well may have lost mechanical integrity. Additional tests at progressively lower pressures may be run to identify the pressure at which the annulus can hold a differential. Continuous monitoring of the annulus system will be reviewed to identify any evidence of a potential leak and assist in diagnosing potential issues with the annulus.

8.0 PRESSURE FALLOFF TESTING

Caliche will perform pressure falloff tests during the injection phase, to meet the requirements of 40 CFR §146.90(f) and CARB LCFS Subsections C.2.3.1(i)(1), C.4.1(a)(8), and C.4.3.1.5. Pressure falloff testing will be conducted upon the completion of the injection well to characterize the baseline formation properties and to determine the near-well reservoir conditions that may impact the injection of CO_2.

8.1 Location and Frequency

As discussed in *Module D – Pre-Operational Testing Plan*, Caliche will perform an initial (baseline) pressure falloff test in the injection well using either formation brine or municipal water mixed with a clay stabilizer (to avert clay swelling) prior to authorization to inject. This will provide the baseline characterization of the transmissibility of fluid into the Upper Frio Sand injection zone. The pressure falloff test will be repeated using CO_2 within the first 60 days of initiation of injection operations. This will allow for a comparison to the baseline fluid-to-fluid test with the changes in the injection fluid from brine water to CO_2.

A pressure falloff test will then be performed at Claimed as PBI [redacted] (within +/-45 days of the anniversary of the previous test) for the lifetime of injection operations. Periodic testing is expected to provide insight into the performance of the storage complex and potentially aid in assessing the dimensions of the expanding CO_2 plume, based on the expected lateral change from supercritical CO_2 near the wellbore and native formation brine beyond the plume. The UIC Program Director or CARB Executive Officer may request more frequent testing, which will be dependent on test results or other variables. A final pressure falloff test will be run after the cessation of injection into the injection well prior to well P&A.

8.2 Testing Details

Testing procedures will follow the methodology detailed in "*EPA Region 6 UIC Pressure Falloff*

Testing Guideline-Third Revision (August 8, 2002)"[1]. Bottomhole pressure measurements near the injection well perforations are preferred due to phase changes within the column of CO_2 in the tubing. A surface pressure gauge may also serve as a monitoring tool for tracking the progress of the falloff test.

The pressure gauge can be either installed as part of the completion or deployed via a wireline truck. If a wireline truck-deployed gauge is used, the wireline should be corrosion resistant, and the deployed gauges should consist of a surface read-out gauge with a memory backup. Examples of standard gauge specifications are presented below in **Table E.1.14**.

Table E.1.14. Wireline Pressure Gauge Specification Examples.

Pressure Gauge	Property	Value
Surface Readout Pressure Gauge	Range Resolution	0 – 10, 000 psi/356 °F +/-0.01 psi/0.01 °F
	Accuracy	+/-0.03% of full scale +/-3 psi/+/-0.1 °F
	Manufacturer's Recommended Calibration Frequency	Minimum Annual
Memory Pressure Gauge	Range Resolution	0 – 10, 000 psi/356 °F +/-0.01 psi/0.01 °F
	Accuracy	+/-0.03% of full scale +/-3 psi/+/-0.1 °F
	Manufacturer's Recommended Calibration Frequency	Minimum Annual

The general testing procedure is as follows and presumes that a wireline truck-deployed unit is used for the testing. Note that a dedicated downhole monitoring gauge may be used if it can provide data of sufficient quality.

1. Mobilize the wireline unit to the injection well and rig up on the wellhead.
2. Rig up a wireline lubricator that contains a calibrated downhole surface-readout pressure gauge (SRO) and that has a memory gauge installed in the tool string as a backup to the adapter above the crown valve. Each gauge should have an operating range of 0 to 10,000 psi. Reference the elevation of gauge to both Kelly bushing reference (KBR) elevation and elevation above ground level.
3. Open the crown valve, record the surface injection pressure. While maintaining a constant rate of injection, run the wireline with the SRO down the well to just above the shallowest perforations in the completion. Steady rates of injection should be maintained for at least 24 hours ahead of the planned shut-in of the injection well. Any offset injection well(s) should be either shut-in ahead of the testing or should maintain a constant rate of injection for the entire duration of the testing. This will minimize cross-well interference effects.

[1] https://www.epa.gov/sites/default/files/2015-07/documents/guideline.pdf

4. With the SRO positioned just above the perforations, monitor the bottom-hole injection pressure response for ±1 hour to allow the gauge to stabilize to wellbore temperature and pressure conditions. Ensure that the injection rate and pressure are stable.
5. Cease injection as rapidly as possible (controlled quick shut-in). Starting with the valve closest to the wellhead, close the control valve and the manual flowline valve at the well site (so that wellbore storage effect in early time is minimized, the order of closing is important). Conduct the pressure falloff test for approximately 24 hours, or until bottomhole pressures have stabilized.
6. Lock out all valves on the injection annulus pressure system to ensure that the annulus pressure cannot be changed during the falloff test period. Ensure that the valves located on the flow line to the injection well are closed and locked out to prevent flow to the well during the falloff test period.
7. After 24 hours, download the pressure data and make a preliminary field analysis of the falloff test data using computer-aided transient test software to estimate if, or when, radial flow conditions might be reached. If sufficient data acquisition is confirmed, end the falloff test. If additional data is required, extend the falloff test until radial flow conditions are confirmed. After the confirmation of sufficient data acquisition, end the falloff test.
8. Pull the SRO tool up the well by 1,000 feet and stop to allow the gauge to stabilize (5 minutes each stop). Record stabilized temperature and pressure. Repeat the process to collect stabilized pressure data (5-minute stops) at 1,000-foot intervals and in the lubricator.

In performing a falloff test analysis, a series of plots and calculations will be prepared to QA/QC the test, to identify flow regimes, and to determine well completion and reservoir parameters. It will also be used to compare formation characteristics, such as transmissivity and skin factor of the near wellbore, for changes over time. Skin effects due to drilling and completion (possible damage from perforation) will be assessed for the well's injectivity and for potential well cleanouts in the future. These tests can also measure drops in pressure due to potential damage/leakage over time. With CO_2 injection, it is anticipated that drops in pressure may indicate multiple fluid phases. The analysis will be designed to consider all parameters.

8.3 Analysis and Reporting

In order to make the proper assessment, multi-phase flow conditions will be considered. Results of the pressure falloff test may trigger a reevaluation of the AoR. Testing methods, results, and interpretation will be submitted electronically within 30 days of the test per 40 CFR §146.91(e) and §146.91(b)(3), and to the CARB Executive Officer within 30 days of the test (per CARB LCFS Subsection C.4.3.1.5(d)).

Each submission will include the following.

1. Location, test name and the date and time of the shut-in period;
2. Bottom hole pressure and temperature depths;
3. Records of gauges;
4. Raw test data in a tabular format (if required by the UIC Program Director);
5. Measured injection rates and pressure data from the test well and any off-set wells completed in the same zone and including data prior to the shut-in period;

6. Pressure gauge information (make, model, manufacturer, etc.);
7. Diagnostic curves of test results, noting any flow regimes;
8. Description of quantitative analysis of pressure-test results, type of software used and any multi-phase effects;
9. Calculated parameter values such as transmissivity, permeability, and skin factor;
10. Analysis and comparison of calculated parameter values to previous testing values;
11. Identification of data gaps if any exist; and
12. Identified necessary changes to the project and the TMP to ensure continued protection of USDWs.

Testing procedures, testing equipment, tolerances and specifications, and calibration details are included in the attached QASP (**Appendix E.1.A**).

9.0 CO_2 PLUME AND PRESSURE FRONT TRACKING

As shown below in **Tables E.1.15 and E.1.16**, respectively, Caliche will employ both direct and indirect methods to track the geometry and extent of the CO_2 plume with time and the areal distribution in pressures within and above the sequestration complex to meet the requirements of 40 CFR §146.90(g). Caliche plans to have four deep IZ monitoring wells (Frio-1 through Frio-4), including at least one updip of injection, to monitor the injection zone at the Caliche Beaumont Sequestration Project Site (see **Figure E.1.2**). Experienced drillers will be used to install the new IZ monitoring wells within the Upper Frio Sand injection zone in accordance with the well schematic provided in **Appendix E.1.B**. The IZ monitoring wells will also provide direct measurement for the sequestered plume, when or if the sequestered CO_2 plume reaches the monitoring well location. As discussed above in Section 6.0, four ACZ and four USDW monitoring wells will be monitored as well for evidence of changes in the CO_2 plume and pressure front indicating a potential leak.

Table E.1.15. Direct Pressure Front and CO_2 Plume Monitoring.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Pressure Front Monitoring				
Injection Zone - Upper Frio Green, Yellow, and/or Gold Sands	Pressure and Temperature	3 injection wells and 4 IZ monitoring wells	Injection well field and AoR, including updip of injection well	Continuous
CO_2 Plume Monitoring				
Injection Zone - Upper Frio Green, Yellow, and/or Gold Sands	Fluid Sampling	4 IZ monitoring wells - downhole	Near the point of CO_2 injection, Fault A, and local residential neighborhoods	<u>Baseline:</u> Quarterly <u>Injection:</u> Claimed as PBI [redacted] <u>Post-Injection:</u> Year 1 - 15: Annually Year 16 - 100: As needed until P&A

Table E.1.16. Indirect Pressure Front and CO_2 Plume Monitoring.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Pressure Front Monitoring				
Electrical, gravity, or seismic technologies may be used, if needed.				
CO_2 Plume Monitoring				
Injection Zone - Upper Frio Green, Yellow, and/or Gold Sands	Pulsed Neutron	4 IZ monitoring wells	AoR, including updip of injection well	Baseline: 1 Event Injection: Claimed as PBI [redacted] Post-Injection: Year 8 & 15 (2 events); Year 16 - 100: As needed

9.1 Pressure Front Monitoring

As discussed above, direct pressure monitoring in the Upper Frio Sand injection zone will be used to measure the induced pressure increase with time in the sequestration complex. Pressure monitoring using down-hole pressure/temperature gauges, will be conducted in the injection wells and offset IZ and ACZ monitoring wells. Gauges will be referenced to ground level at each well. These monitoring points will be used to evaluate the pressure buildup with time within the injection well field. Real-time, continuous pressure and temperature monitoring will be performed in each well.

Measured data will be used to evaluate the rate and magnitude of pressure decay with distance away from the injection well field and therefore the performance of the injection zone to ensure that the project is operating as permitted. Measured data will form the basis for the 5-year AoR reevaluations and Testing and Monitoring Plan reassessments. Therefore, measured pressures at the injection well and the IZ / ACZ monitoring wells will be compared to model predictions to determine if actual data deviate from baseline measurements and modeled predictions. Significant departures of actual pressure data above model predictions will be used to trigger an adaptive reassessment of the AoR. This is in addition to the minimum 5-year reassessment time frame specified for periodic review. The Testing and Monitoring Plan is also reevaluated every 5 years and may require modifications which will be based upon site-specific data collected after injection commences. In addition to the assessment of the AoR, real-time data from the overlying monitoring will also be reevaluated to ensure continued containment of the injected CO_2 within the sequestration complex.

The locations of the Caliche injection and IZ / ACZ monitoring wells are shown in **Figure E.1.1**. The anticipated CO_2 plume geometry and pressure front of the AoR with time are presented in *Module B - Area of Review and Corrective Action Plan.* The predicted maximum extent of the AoR is also projected in **Figure E.1.1**.

The downhole pressure and temperature data will be transmitted to the distributed control system for evaluation and storage. A data archiver may be used to permanently store data sets for later recovery.

9.2 CO_2 Plume Front Monitoring

9.2.1 Direct Monitoring Details

As discussed above, direct monitoring in the IZ monitoring wells will be used to detect and define the dimensions of the CO_2 plume during well operations (see **Figure E.1.2** for the locations of the four IZ monitor wells). The IZ monitor wells are optimally located within areas of high anticipated induced pressure buildup, within the direct plume path of the sequestered CO_2, near Fault A, and near residential neighborhoods. Real-time, continuous pressure monitoring and routine fluid sampling will be performed. The potential parameters to be analyzed as part of fluid sampling in the Upper Frio Sand injection zone and associated analytical methods are presented below in **Table E.1.17**.

Quality assurance procedures for these methods are presented in the attached QASP (**Appendix E.1.A**).

The direct monitoring program may be enhanced with the addition of tracers to the injected CO_2. This will entail the continuous introduction of a reservoir and CO_2 compatible chemical tracer into the injected CO_2 at the wellhead or flow line. The tracer will be foreign to the system and monitoring for its presence may be conducted in samples taken from shallow and deep monitoring wells. The tracer materials will be inert, non-flammable, non-toxic, and classed as non-dangerous goods. Analysis of the resulting tracer concentrations in samples enables flow characteristics to be determined so that mitigation can be carried out to reduce or stop the leakage from occurring.

The provenance of the CO_2 also can be determined, which may provide insight on how the tracer arrived at a particular sampling point, whether it be within the injection zone or at some other location. Hydraulic pump systems are typically used. In the case of electric pumps, these can be integrated into the control DCS system to change speed of tracer addition with changing flow rates of the CO_2 into the disposal well. A sampling frequency from observation/monitoring wells to meet project requirements will follow the water sampling plan. Note that sampling frequency is not as critical when using continuous injection of tracer into the CO_2 as a constant concentration will be present and a tracer pulse cannot be missed. Analysis involves sample conditioning and measurement of tracer presence typically using gas chromatography coupled with mass spectrometry. In general, the presence of the gas tracers in samples down to 1 part per trillion (ppt) levels can be measured. Analyzed samples may include IZ, ACZ, and lowermost USDW monitoring wells.

Additionally, IZ monitoring wells may also have a transmitter gauge at the surface to continuously record tubing pressures. Experience from previously implemented CCS projects indicates that CO_2 will rapidly evacuate the wellbore fluids in a monitoring well that is open to an injection zone, which will result in increased wellhead pressures due to the lighter column of gas replacing the displaced brine fluid column.

Table E.1.17. Summary of Potential Analytical Parameters for IZ Fluid Monitoring.

Claimed as PBI

[redacted]

Notes:

1. AMS = accelerator mass spectrometry; CRDS = cavity ring down spectrometry; ICP-MS = inductively coupled plasma mass spectrometry; IRMS = isotope ratio mass spectrometry; MS = mass spectrometry; SM = standard method.
2. * = Analytical parameters to be included during the pre-injection phase, and only as needed during the injection and post-injection phases of the project.

9.2.2 Indirect Monitoring Details

Indirect plume monitoring in the Upper Frio Sand injection zone will include pulsed neutron capture logging to monitor the lateral and vertical saturation of CO_2 in the injection wells and deep IZ monitoring wells. The tool incorporates a pulsed neutron generator and a dual-detector spectrometry system to measure elemental concentrations, including carbon and oxygen (O), and the formation neutron-capture cross section (sigma) during a single trip in the well. The sigma measurement is used to determine porosity and differentiates between saline water and other fluids to calculate formation saturations. Where formation water is fresh or of unknown salinity, saturation is determined from the C/O ratio measurement, which is salinity independent.

Caliche is also considering the use of certain time-lapse seismic techniques for indirect monitoring. The displacement of brine by injected CO_2 within sedimentary strata at similar project depths is well documented to produce a strong negative change in acoustic impedance (Vasco et al., 2019). This change in impedance can be detected by many time-lapse seismic methods. Leading-edge techniques for time-lapse imaging of CO_2 plumes include time-lapse vertical seismic profiling (Daley and Korneev, 2006; Gupta et al., 2020), azimuthal vertical seismic profiling (Gordon et al., 2016), sparse array walk-away surveys or scalable, automated, semipermanent seismic array “SASSA” (Roach et al., 2015; Burnison et al., 2016; Livers, 2017; Adams et al., 2020).

Permanent seismic monitoring techniques are robust and documented in monitoring plume growth and less invasive from a surface footprint (Harvey et al., 2021). Caliche is anticipating deployment of an autonomous, real-time permanent source and receiver array within and beyond the dimensions of the CO_2 plume. The system will use one or more permanent surface sources and an autonomous 6-component receiver array with the receivers emplaced underground. The receivers will be to monitor ray paths that will allow for dense sampling over time. System flexibility allows for sensors and/or source geometry to be optimally redeployed further away from the injection wells as the plume gets larger. Baseline and subsequent time-lapse surveys will be processed using a technique that will resolve the differences between the surveys, which will be mapped to show the change in plume extent over time.

In addition, the use of DAS fiber, if deployed, will allow a very wide aperture of the acoustic array and will include surveillance of strata above the sequestered CO_2 plume. This will provide further assurance that no out-of-zone migration is occurring within the monitored area.

10.0 SURFACE AND NEAR-SURFACE MONITORING PLAN

Pursuant to 40 CFR §146.90(h), the UIC Program Director may require surface air monitoring and/or soil gas monitoring to detect movement of CO_2 that could endanger a USDW (EPA, 2013a;13b; 2016). Caliche plans to conduct voluntary monitoring of the surface and near-surface for potential CO_2 leakage via preferential pathways and conduits from the injection zone to meet CARB LCFS Protocol Subsection C.4.1(a)(11). However, unless required by the UIC Program Director, Caliche may choose to revise or discontinue this monitoring at any time.

The primary objective of the surface and near-surface monitoring program is to confirm containment of CO_2 within the deep sequestration complex in order to: 1) demonstrate no endangerment to public health or the environment, 2) confirm conformance with the proposed injection plan, and 3) validate calculations for quantifying total sequestered CO_2 in the Caliche Beaumont Sequestration Project sequestration complex. The goal of the near-surface monitoring program is to provide for early detection of anomalous conditions indicative of potential leakage of CO_2 or of brine migration.

Accordingly, the proposed surface and near-surface program includes the following elements: i) determine baseline physical and chemical conditions and natural background variability at the surface above the storage complex, ii) detect changes in conditions that might be indicative of an environmental impact and therefore warrant further investigation, iii) attribute those changes to either natural variability or actual anthropogenic impacts, and iv) if needed, assist in the quantification of the potential CO_2 leak.

The proposed surface and near-surface monitoring program consists of three key monitoring components during the baseline and/or operational phases of the Caliche Beaumont Sequestration Project: 1) atmospheric monitoring, 2) ecosystem stress monitoring, and/or 3) soil gas monitoring. These monitoring components will allow for early detection of potentially anomalous levels of CO_2 and other gases at the surface and/or near-surface in the vicinity of the Caliche Beaumont Sequestration Project Site. These three surface and near-surface monitoring components are discussed further below.

10.1 Atmospheric Monitoring

Atmospheric monitoring may be used to identify CO_2 concentrations above ambient background levels and help determine locations of potential CO_2 leaks (NETL, 2009). Per Standard 40 CFR §146.90(h) and LCFS Protocol Subsections C.2.5(c)&(d) and C.4.3.2.2(d)&(e), continuous and intermittent atmospheric monitoring at the surface above the storage complex during the baseline and operational phases of the project will be conducted to i) define the baseline physical and chemical atmospheric conditions at the surface above the storage complex, ii) characterize natural background variability, including seasonal and diurnal trends, and iii) detect potential atmospheric CO_2 leakage and/or potential movement of CO_2 that may endanger the USDW at the Caliche Beaumont Sequestration Project Site, the Chicot aquifer.

Continuous air monitoring may be conducted utilizing eddy covariance flux measurement techniques via an advanced, stationary LI-COR® air quality and weather observation tower, equipped with eddy covariance (EC) and bio meteorological detectors. Intermittent atmospheric monitoring may be conducted at additional locations throughout the AoR utilizing a portable, handheld Landtec® infrared detector to supplement the continuous EC system monitoring data.

10.1.1 Monitoring Location and Frequency

The advanced LI-COR® EC system can generally cover an area of up to 1,500- to 3,000-foot radius for a single tower with sensors set to a height of approximately 30 feet depending on meteorological conditions, thermal stability, and height of sensors above the vegetation (Burba, 2022). Therefore, it is anticipated that up to three EC towers may be deployed to provide site-wide monitoring of the AoR (see **Figure E.1.5**). The EC towers will collect data on a continuous basis during the baseline phase (minimum of 1 year), the estimated [redacted] injection phase, and up to 15 years during the post-injection phase.

Intermittent ground-surface gas concentrations will be manually collected every two months during the baseline phase, quarterly or annually during the injection phase, and annually for 15 years during the post-injection phase, by a qualified vendor. Intermittent atmospheric monitoring will be conducted at locations of proposed injection wells, monitoring wells, soil gas monitoring sites, and deep artificial penetrations.

During the post-injection site care phase, supplemental continuous and/or intermittent atmospheric monitoring may be considered as part of a post-injection site care leak detection strategy, based upon final approval of the demonstration of plume stability.

The atmospheric monitoring approach is summarized below in **Table E.1.18**.

Table E.1.18. Monitoring of Atmospheric Conditions.

Target Location	Monitoring Phase	Proposed Monitoring Location(s)	Spatial Coverage	Frequency/Duration
Continuous Atmospheric Measurements	Baseline	3 EC Towers downwind of injection wells	Over AoR	Continuously
	Injection			Claimed as PBI [redacted]
	Post-Injection			Year 1 - 15: Continuously Year 16 - 100: As needed
Intermittent Atmospheric Measurements	Baseline	• 3 proposed injection wells • 4 monitoring well clusters • 30 soil gas monitoring clusters • <10 deep artificial penetrations	Over AoR	Every 2 month; twice per event
	Injection			Claimed as PBI [redacted]
	Post-Injection			Year 1 - 15: Annually Year 16 - 100: As needed

10.1.2 Analytical Instrumentation and Procedures

As further described below, LI-COR® EC systems are a low-impact, non-invasive technology that include precision, high-speed instruments capable of analyzing various near-surface and surface parameters (e.g., total gas concentrations, ambient CO_2 concentrations). The high-frequency data collected by the EC system are used to facilitate automated calculations of the net gas exchange (flux) between the ecosystem and the atmosphere. The EC tower may be fitted with the following instrumentation to analyze total gas concentrations, meteorological conditions, and soil conditions:

Claimed as PBI [redacted]

The raw data from the EC system will be processed utilizing EddyPro® software and the on-site SmartFlux® System to derive representative real-time flux data for the site. Tovi® Software will then be utilized to post-process the EC flux data, which will provide consistent, reproducible, and transparent data collection.

The Landtec® portable, handheld GEM2000 landfill gas analyzer is a simple, direct measurement technology that is capable of analyzing for ambient CO_2, CH_4, and O_2 concentrations (as percent volume) in the atmosphere and requires no data processing or post-processing. The portable gas analyzer will be calibrated regularly to a gas standard according to manufacturer specifications per the attached QASP.

Local ambient air CO_2 concentrations can vary spatially and temporally depending on factors including vegetation, changes in soil respiration, and the presence of other industrial processes (NETL, 2009). In addition, global atmospheric CO_2 concentrations are projected to rise an additional 9% over the next 16 years, from ~400 ppm presently to ~450 ppm in 2040 (NASA, 2022). To better identify false-positive CO_2 detections, the presence of natural (e.g., soil and vegetation) and anthropogenic (e.g., industrial processes) sources of CO_2 in the vicinity of the site will need to be well understood during the life of the project (NETL, 2009). A routine inventory of i) potential anthropogenic CO_2 sources unrelated to CO_2 leakage from the target reservoir (e.g., nearby industrial facilities, pipelines), and ii) oil and gas-related production or injection wells, and an assessment of nearby land use classifications and recent development activities will be conducted on an annual basis within a 4-mile radius of the proposed injection wells. As discussed below in Section 10.3, natural near-surface sources of CO_2 (e.g., microbial respiration, carbonate dissolution) will be characterized during baseline soil gas monitoring and may be further assessed at any point during the operational phase of the project, if needed.

Continuous and intermittent atmospheric monitoring data collected during the operational phase will be utilized to detect potential anomalous changes in surface conditions, which may be identified as an exceedance of a leakage detection threshold – to be defined after baseline background variability has been assessed (and with consideration of projected global increases in atmospheric CO_2 concentrations over time). If continuous and/or intermittent atmospheric monitoring data indicate a statistically significant departure between observed and baseline/ seasonal parameter patterns in the surface air conditions, the anomaly may be further evaluated by one or more of the following responses: 1) detailed inspection and calibration of the EC towers and instrumentation; 2) detailed evaluation of potential effects of recent changes, if any, to the land use, vegetative conditions, local CO_2 sources, artificial penetrations, CCS-related operations, etc.; 3) supplemental testing of the atmosphere, targeting injection wells, monitoring wells, and other potential point sources; 4) testing of the soil gas to determine the presence of natural and/or anthropogenic CO_2; and 5) if needed, attribution of the CO_2 detection to either natural variability or an anthropogenic source. If it is determined that the anomaly appears to be related to a potential CO_2 leak from the target reservoir, additional testing of the USDW and/or the ACZ wells may be conducted. If further testing confirms potential leakage into the strata overlying the Confining Zone, then injection operations will cease and will trigger the procedures set out in *Module E.4 - ERRP.*

The elements of the atmospheric monitoring program may be modified throughout the baseline and operational phases of the Caliche Beaumont Sequestration Project, as needed, as more data and information become available for the Site.

10.2 Ecosystem Stress Monitoring

Per UIC Program Site Characterization Guidance Subsection 2.3.11 and LCFS Protocol Subsections C.2.5(c)(3) and C.2.5(d)(1)(A), site characteristics including vegetation type and density in and around the storage complex should be defined during the baseline phase of the Caliche Beaumont Sequestration Project to establish the background vegetative conditions at the surface. Additionally, per LCFS Protocol Subsection C.4.3.2.2(f), ecosystem stress monitoring must be conducted in the form of annual vegetation surveys to measure potential stress resulting from elevated CO_2 in soil.

As further discussed below, seasonal composite satellite images may be assessed retrospectively for three years prior to the end of baseline, annually during injection operation and as needed during the post-injection phase. These evaluations will assess key metrics (e.g., biomass and vegetation health/stress) pre-injection and provide a mechanism for potential CO_2 release detection once the injection phase commences. To capture vegetation type and diversity metrics, a limited ground-based vegetation survey will be conducted during baseline to serve as a reference point if a future anomaly occurs, requiring ground-based verification. In addition to this temporal comparison of vegetative conditions, a spatial comparison will be conducted using surrounding pre-selected reference areas to account for other anomalous factors that may impact vegetation conditions within each assessment year.

10.2.1 Technology Selection

Satellite imagery may be used to evaluate vegetative conditions at the surface of the storage complex and its surrounding reference areas. This technology provides a mature, common, and frequently updated source of information for evaluating surface conditions. Satellite data may be acquired from high-resolution and publicly available imaging platforms including Landsat 8 and 9 where data will be provided by the National Aeronautics and Space Administration (NASA) and the United Stated Geological Survey (USGS), and Sentinel-2 provided where data will be obtained from the European Space Agency (ESA). Qualitative and quantitative assessments of satellite imagery and derived indices will be performed to assess key vegetative health metrics such as plant biomass and health/stress. Qualitative assessments will consist of analyzing and comparing standard three-color composite images (e.g., natural color and false color) temporally, to baseline conditions, and spatially, to reference areas. Indices such as the Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI) will be utilized as quantitative indicators of vegetation conditions.

10.2.2 Reference Areas

Three reference areas surrounding the AoR will be used to compare vegetative conditions spatially (see **Figures E.1.6 and E.1.7**). These areas are representative of conditions outside the AoR and will thus serve as a comparison to vegetation not overlying the projected CO_2 plume. Three distinct reference areas, as opposed to one, were defined to enable statistically robust comparisons to be made between surrounding areas and the AoR and examine trends as a function of distance. Each reference area was selected based on characteristics that allow for direct comparisons to the AoR including size, USEPA-defined Level III and Level IV Ecoregion designations, and land use characteristics. Each reference area will have a surface area approximately equal to the AoR (i.e., approximately [redacted]). Reference areas will capture similar Ecoregions including the Level III region (the Western Gulf Coastal Plain) and Level IV region (the Northen Humid Gulf Coastal Prairies) (see **Figure E.1.7**). Finally, reference areas will capture similar land use characteristics as that of the AoR where land is primarily agricultural and/or undeveloped with few residential parcel properties (see **Figure E.1.6**).

10.2.3 Monitoring Frequency and Assessment Methodology

Monitoring and assessment of ecological stress through vegetative conditions will take place at the AoR and the surrounding reference areas during the baseline and injection phases of the Caliche Beaumont Sequestration Project. A ground-based vegetation survey, satellite imagery, and imagery data processing products will measure vegetative conditions through key metrics pre-injection and be capable of detecting any anomalous changes to vegetation during injection.

A baseline analysis will consist of one focused ground-based vegetation survey during the peak growing season of spring, focusing on the key metric of primary plant diversity and type. The survey will be conducted utilizing a "quadrant"-like approach, where similar vegetation and terrain areas will be characterized by their primary vegetation types in the AoR and surrounding reference areas, pending appropriate land access agreements. Additionally, as part of the baseline analysis, satellite imagery assessments will be conducted for three years of data retrospectively from the end of the baseline phase to capture both seasonal and annual variations of pre-injection vegetative conditions. During the operational phase, a similar satellite imagery analysis will take place on an annual basis. After injection activities, satellite imagery analyses will be conducted as needed and at Year 15 to support plume stability discussion. A summary of the monitoring frequency is included below in **Table E.1.19**.

Table E.1.19. Monitoring of Ecosystem Stress.

Target Parameters	Monitoring Phase	Proposed Monitoring Location(s)	Spatial Coverage	Frequency/Duration
Satellite Imagery	Baseline	Not applicable	Over AoR + 3 Reference Areas	Once prior to injection (3 year retrospective from end of baseline)
	Injection			Claimed as PBI [redacted]
	Post-Injection			Year 1 - 14: As needed Year 15: Once
Ground-based vegetation survey	Baseline	Not applicable	Over AoR + 3 Reference Areas	Once prior injection
	Injection			Claimed as PBI [redacted]
	Post-Injection			Year 1 – 100: As needed

All available images will be processed into quarterly composite images, representative of each season. From these composite images, a variety of post-processing techniques will be used to develop various indices that can be used to quantify key vegetation-related attributes such as plant biomass and health/stress. Standard 3-color composite images (e.g., true color, false color) will support a qualitative analysis of vegetative conditions where significant anomalies in vegetation can be initially and quickly screened. Additionally, quantitative metrics will be calculated for satellite-derived images using standard algorithms developed by NASA, USGS, and ESA. NDVI, as well as a variety of other standard indices, will be used to quantify vegetation by greenness which provides information on plant density, biomass, and health.

Operation phase imagery and derived indices will be compared temporally to the three-year baseline satellite data, and spatially to surrounding reference areas in that same year. Since vegetative stress signals due to a CO_2 release have various potential confounding factors (e.g., droughts, floods, freezes, plant diseases, insect infestations, agricultural crop rotations, etc.), characterizing an anomaly attributed to injection will follow a tiered approach. As this tiered approach progresses, characterization of potential anomalies become more granular. If in an early tier no anomaly is detected, progression to the second and third tiers is not necessary. However, if moving through all three tiers is necessary and the anomaly cannot be attributed to a confounding (i.e., not injection-related) factor, further field verification may be conducted to assess the vegetative state of the AoR. The tiered "Anomaly Characterization" approach is further described below.

1) Anomaly Characterization Tier 1
   - Qualitative assessment of standard 3-color composite images from current year to baseline conditions and surrounding reference areas.
   - Quantitative analysis of key satellite-derived indices such as NDVI and EVI from current assessment year to baseline conditions and surrounding reference areas.
2) Anomaly Characterization Tier 2 (if anomaly is detected in Tier 1 analysis)
   - Statistically evaluate ancillary data (e.g., climate indices, weather, local flux measurements) from various sources (e.g., local EC tower, the National Oceanic and Atmospheric Administration (NOAA), United States Department of Agriculture (USDA), United States Army Corp of Engineers (USACE), the National Weather Service, and United States Fish and Wildlife Service (USFWS)) to potentially attribute anomaly source to a non-injection related process.
   - Conduct an initial site area characterization analysis to determine if any confounding factors not well-characterized by the available ancillary data have presented in the current assessment year. Confounding factors may include a unique crop rotation, significant land use changes, other anthropogenic factors, etc.
3) Anomaly Characterization Tier 3 (if anomaly in Tier 2 cannot be attributed to an ancillary source)
   - Retrospective analysis of the AoR and surrounding reference areas beyond that of the baseline assessment (e.g., 10-yr retrospective).
   - If Tier 1 anomalies are within range of historical variability (i.e., 10^{th}-90^{th} percentile), anomalies will not be attributed to CO_2 release.

If further verification is required (i.e., all three tiers were assessed and no anomaly source was defined), then a ground-based site survey may be conducted to verify and validate the influence of CCS activities, if any, to this anomaly, pending appropriate land access agreements. Baseline limited vegetation survey data may be referenced to compare vegetation type and diversity metrics to the current assessment year.

The elements of the ecosystem stress monitoring program may be modified throughout the baseline and operational phases of the Caliche Beaumont Sequestration Project, as needed, as more data and information become available for the site.

10.3 Soil Gas Monitoring

Soil gas data can be used to quantify the bulk chemical composition of gases in the near-surface and discern the source(s) of detected CO_2 to either natural or anthropogenic sources (NETL, 2009). Per Standard 40 CFR §146.90(h), the *"Director may require surface air monitoring and/or soil gas monitoring to detect movement of carbon dioxide that could endanger a USDW,"* and the *"design of Class VI surface air and/or soil gas monitoring must be based on potential risks to USDWs within the area of review." "The monitoring frequency and spatial distribution of surface air monitoring and/or soil gas monitoring must be decided using baseline data, and the monitoring plan must describe how the proposed monitoring will yield useful information on the area of review delineation and/or compliance with standards under 40 CFR §144.12."* CARB LCFS Protocol Subsections C.2.5(c)&(d)&(e) and C.4.3.2.2(g) state that the requirement for continuous and/or intermittent soil gas monitoring is contingent upon one or more of the following conditions:

1) Results of the site-specific risk assessment, pursuant to LCFS Protocol Subsection C.2.2, and/or computational modeling, pursuant to LCFS Protocol Subsection C.2.4.1, indicate that *"[a]ny property of the storage complex, groundwater, overburden, or surface projection of the storage complex"* may *"potentially be impacted by injection operations"* (CARB, 2018).
2) Results of baseline or subsequent *"deep subsurface or atmospheric monitoring suggests that atmospheric carbon dioxide leakage may occur or has occurred,"* (CARB, 2018) or that *"movement of the carbon dioxide could endanger a USDW"* (40 CFR §146.90(h)).

At this site, it is anticipated that soil gas monitoring will provide additional characterization of near-surface variability due natural and anthropogenic sources during the baseline of the Caliche Beaumont Sequestration Project, due to the following site-specific conditions:

1) The Caliche Beaumont Sequestration Project Site has a nearby fault (Fault A) at seismic resolution across the Upper Confining System and Upper Frio Sand injection zone.
2) Deep APs (e.g., oil and gas production or injection wells) within the AoR.
3) The presence of active industrial facilities within various levels of emissions of greenhouse gases.

Several natural processes in the near surface (e.g., biologic respiration, microbial oxidation of methane) can contribute to significant temporal variability in CO_2 concentrations. Background soil CO_2 concentrations and isotopic compositions are largely *"dependent on exchange with the atmosphere, organic matter decay, uptake by plants, root respiration, deep degassing, release from groundwater due to depressurization, and microbial activities (Oldenburg and Lewicki, 2004)"* (EPA, 2013b). Therefore, some component of soil gas monitoring during the baseline phase of the project is useful to i) define the baseline molecular and isotopic compositions of the shallow soil gas, and ii) characterize natural background variability, including seasonal and diurnal trends. The results of the baseline soil gas monitoring may then be used for future reference and comparison to operational and post-operational soil gas monitoring to assist in the detection, validation, and quantification of potential CO_2 leakage. To this end, a limited intermittent soil gas monitoring program may be conducted during baseline utilizing permanent soil gas probes as an active [whole air] sample collection method.

10.3.1 Monitoring Location and Frequency

Permanent subsurface soil gas probes may be installed at up to 40 representative locations throughout the surface projection of the AoR. The baseline soil gas monitoring network will depend on appropriate land access agreements, and may include, at a minimum:

- three probe sites in the vicinity of each injection well site (9 soil gas probes total),
- three probe sites in the vicinity of each deep subsurface monitoring well cluster (12 soil gas probes total)
- three probe sites in the vicinity of select APs which penetrates the injection zone within the Beaumont Lease Area (6 soil gas probes total)
- Three probe sites towards the western portion of the Beaumont Lease Area (3 soil gas probes),
- 10 probe sites throughout the Beaumont Lease Area in order to increase the variability of the soil gas characterization throughout the Caliche AoR.

Caliche may install one or more probes within the ecosystem stress monitoring reference areas, if needed, as more data and information become available for the site during the baseline and injection phases of the project. It is anticipated that the baseline soil gas monitoring network will be utilized during the injection phase as well, as needed.

Soil gas samples may be collected manually from the soil gas probe sites every two months during the approximately 1-year baseline phase, quarterly or annually during the [redacted] injection phase and annually or every 5 years during the post-injection phase. During the post-injection site care phase, supplemental soil gas monitoring may be considered as part of a post-injection site care leak detection strategy, based upon final approval of the demonstration of plume stability. A summary of the monitoring frequency is shown in **Table E.1.20** below.

Table E.1.20. Monitoring of Near-Surface Soil Gas.

Target Formation	Monitoring Phase	Proposed Monitoring Location(s)	Spatial Coverage	Frequency/Duration
Near-Surface (Soil Gas)	Baseline	• 30 probes in the vicinity of injection wells, monitoring wells, and select APs within the Beaumont Lease Area • 10 probes installed throughout the Beaumont Lease Area	Over AoR	Every 2 months and twice per event for at least 1 year
	Injection	• 30 probes in the vicinity of injection wells, monitoring wells, and select APs within the Beaumont Lease Area	Over AoR	[redacted]
	Post-Injection	• 10 probes in the vicinity of injection wells, monitoring wells, and select APs within the Beaumont Lease Area	Over AoR	Year–1 - 15: Annually– Year –6 - 100: Every 5 years or as needed

10.3.2 Soil Gas Probe Construction Procedures

Soil gas probe sites may be installed to a depth of approximately [redacted] below ground level, dependent upon the depth to shallow groundwater and presence of low-permeability (e.g., clay) zones, utilizing traditional direct-push or hand-auger drilling technologies and equipment (see **Exhibit E.1.1** below).

Exhibit E.1.1. Schematic of Installation of Soil Gas Probe.

Claimed as PBI

[redacted]

During borehole advancement, a continuous soil core will be collected and logged in accordance with Unified Soil Classification System (USCS) guidelines to determine soil type. Additionally, soil samples will be collected in general accordance with USEPA Method LSASDPROC-300-R5 (EPA, 2023b) for the laboratory analysis of pH, electrical conductivity, sodium adsorption ratio, total organic carbon (TOC), and soil moisture, in accordance with the methods specified in **Table E.1.21** below. **Table E.1.21** identifies the parameters to be monitored and the analytical methods Caliche will use for the soil samples.

Soil gas probes will be constructed in general accordance with operating procedures set forth in USEPA Method LSASDPROC-307-R5 (EPA, 2023c), and will consist of stainless-steel vapor implant points attached securely to 1/8th-inch Nylaflow® tubing and lowered to the bottom of the borehole. A sand pack using U.S. mesh interval 20/40 sand will be installed to approximately 6-inches above the vapor implant point. The remainder of the borehole will be backfilled with granular bentonite to the ground surface and hydrated to create an annular seal. The upper 1-foot of tubing will be encased within 1-inch diameter, schedule 40 polyvinyl chloride (PVC) pipe at the surface. The tubing will be threaded through a drilled, tight-fitting PVC slip cap and sealed from atmospheric air utilizing a stainless-steal Swagelok® capping fitting. The tubing at the surface will be concealed within a 6-inch steel, flush mount manway, individually installed with a concrete pad, for protection and easy accessibility. Detailed soil gas probe location and construction information will be recorded at each site.

10.3.3 Soil Gas Sampling and Testing Methods

Soil gas sampling will be conducted in general accordance with operating procedures set forth in USEPA Method LSASDPROC-307-R5 (EPA, 2023c). During sample collection, a vacuum will be applied to the tubing on the surface to first purge the full length of the tubing, and second collect a soil gas sample in a 0.3-L IsoBag® Gas Bag using 60 mL gas-tight syringes, equipped with a 3-way valves. During soil gas sampling, a leakage test will be conducted by releasing helium gas as a tracer gas within a shroud over each soil gas sampling site.

Soil gas samples will be submitted for the laboratory analysis of various geochemical methods, including natural tracers (isotopes of C). **Table E.1.21** identifies the parameters to be monitored and the analytical methods Caliche will use for the soil gas samples.

Table E.1.21. Summary of Potential Soil and Soil Gas Analysis Parameters.

Claimed as PBI [redacted]

Note:

1. * = Analytical parameters to be included during the pre-injection phase, and only as needed during the injection and post-injection phases of the project.

Claimed as PBI [redacted]

An anomalous detection of CO_2 above background levels in soil gas "does not necessarily demonstrate that USDWs have been endangered, but it may indicate that a leakage pathway or conduit exists" (EPA, 2013b). Therefore, if it is determined that a statistically significant departure between observed and baseline/ seasonal parameter patterns appears to be related to a potential

CO_2 leak from the target reservoir, additional testing of the atmosphere, USDW, and/or the Oakville Formation may be conducted. If further testing confirms potential leakage into the strata overlying the Upper Confining Zone, then injection operations will cease and will trigger the procedures set out in *Module E.4 - ERRP.*

The elements of the soil gas monitoring program may be modified throughout the baseline and operational phases of the project, as needed, as more data and information become available for the Site.

10.3.4 Analysis Procedures and Chain of Custody

Soil and soil gas samples will be collected into the appropriate lab-supplied, method-specific sample containers, properly preserved (as needed), and shipped within 48 hours of collection for analysis by third party laboratories accredited by the TCEQ or alternative (e.g., ASTM Methods or Standard Methods) using standardized procedures. Detection limits will be dependent on equipment facilitated for the analytical methods by the selected qualified vendor and meet the minimum levels set forth in **Appendix E.1.A**.

The sample chain-of-custody procedures will be dependent on Vendor selection as they will assume custody of the samples. The procedures will document and track the sample transfer to laboratory, to the analyst, to testing, to storage, and to disposal (at a minimum). A sample chain of custody procedures is contained in the attached QASP (**Appendix E.1.A**).

The initial parameters identified in **Table E.1.21** may be revised and include additional components for testing dependent on the initial geochemical evaluation.

11.0 SEISMICITY MONITORING

The seismicity monitoring program for the Caliche Beaumont Sequestration Project will help to identify and characterize the presence or absence of any induced micro-seismic activity associated with all wells and/or near any structural discontinuities (e.g., faults, or fractures) in the subsurface. For this end, continuous seismicity monitoring will be conducted during the baseline, injection, and post-injection phases of the project in accordance with LCFS Protocol Subsection C.4.3.2.3, although the risk of natural and CO_2 injection-induced seismicity is low at the site as described in *Module A - Section 2.6 Seismicity Risk* and *Module B – Area of Review and Corrective Action Plan*, respectively. If, at any time, Caliche determines that seismic monitoring is no longer necessary, Caliche may cease such monitoring.

To continuously monitor for induced seismicity during baseline and injection operations, Caliche plans to install a network of DAS fiber downhole one or more injection and/or IZ monitoring wells. This downhole tool will allow a very wide aperture of the acoustic array which will assist with surveillance of earthquake events with a wide range of Richter magnitude (Lellouch et al., 2021). However, Caliche will focus its evaluation of the data for risk of earthquake of magnitude 2.7 or greater within a radius of one mile of each injection well. Additionally, Caliche will continuously monitor during baseline and injection operations the local and regional earthquake data centers (i.e., Bureau of Economic Geology (Bureau) at The University of Texas and U.S. Geological Survey's National Earthquake Information Center, respectively). A summary of the seismicity monitoring program is presented below in **Table E.1.22**.

Table E.1.22. Seismicity Monitoring of Deep Subsurface (Anahuac and Upper Frio Formations).

Target Formation	Monitoring Phase	Proposed Monitoring Location(s)	Spatial Coverage	Frequency/Duration
Anahuac and Frio Formations: DAS Fiber	Baseline	One or more injection and/or Frio-level monitoring wells	Over AoR	Continuously
	Injection			Claimed as PBI [redacted]
	Post-Injection			Year 1 - 100: As needed until P&A
Anahuac and Frio Formations: Local and regional Earthquake Information Centers	Baseline	Various seismometers in Texas	Local and regional	Continuously
	Injection			Claimed as PBI [redacted]
	Post-Injection			Year 1 - 100: As needed

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APPENDICES

Appendix E.1.A Testing and Monitoring Plan QASP

Appendix E.1.B Proposed Completion Well Schematics

Appendix E.1.C Example of Chain of Custody

APPENDIX E.1.A

Testing and Monitoring Plan QASP

CLASS VI INJECTION WELL TESTING AND MONITORING PLAN

APPENDIX E.1.A
QUALITY ASSURANCE AND SURVEILLANCE PLAN

40 CFR §146.90(k)

Caliche Beaumont Sequestration Project
Beaumont, Jefferson County, Texas

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APPENDIX E.1.A
QUALITY ASSURANCE AND SURVEILLANCE PLAN

Caliche Beaumont Sequestration Project
Beaumont, Jefferson County, Texas

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EXHIBIT

Exhibit E.1.A.1. Organizational Chart

APPROVAL SHEET

This Quality Assurance and Surveillance Plan (QASP) is hereby approved for use during operations for the Caliche Sequestration Project. The signatures below denote the approval of this document and intend to abide by the procedures outlined within it.

Signature [Name] [Title]	Date
Signature [Name] [Title]	Date
Signature [Name] [Title]	Date
Signature [Name] [Title]	Date

DISTRIBUTION LIST

The following project participants will receive the completed Quality Assurance and Surveillance Plan (QASP) and all future updates for the duration of the project.

Name
Title
Business Address
Email
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A. PROJECT MANAGEMENT

A.1. Project/Task Organization

A.1.a/b. Key Individuals and Responsibilities

The Caliche Beaumont Sequestration Project is led by CDP II CO2 Sequestration, LLC ("Caliche") and will include participation from designated internal staff and subcontractors to perform and the following monitoring responsibilities as follows:

i. Sampling and analysis of the carbon dioxide injectate stream at a quarterly frequency during injection operations per 40 CFR §146.90(a) and the Carbon Capture and Sequestration (CCS) Protocol under the California Air Resources Board (CARB) Low-Carbon Fuel Standard (LCFS) Subsection C.4.1(a)(1).
ii. Continuous monitoring of injection parameters (injection pressure, rate, temperature, mass flow, pressure on the annulus, and annulus fluid volume) per 40 CFR §146.88(1), §146.89(b), and §146.90(b); and CARB LCFS Protocol Subsections C.4.1(a)(2) and C.4.3.1.2.
iii. Corrosion monitoring of injection well materials on a quarterly basis as new sources are added to the injectate stream per 40 CFR §146.90(c) and CARB LCFS Subsection C.4.3.1.4.
iv. Monitoring of ground water quality and geochemical changes above the confining zone and within the lowermost underground source of drinking water (USDW), at a site-specific frequency per 40 CFR §146.90(d) and LCFS Subsection C.4.1(a)(4).
v. Mechanical Integrity Testing (MIT), at least once per year or after well workover operations that change the well configuration(s) per 40 CFR §146.89(c) and §146.90, and LCFS Subsection C.4.1(a)(3).
vi. Pressure fall-off testing, once prior to injection and at least once every five years thereafter per 40 CFR §146.90(f), and CARB LCFS Subsections C.2.3.1(i)(1), C.4.1(a)(8), and C.4.3.1.5.
vii. Testing and monitoring to track the extent and pressure of the carbon dioxide plume per 40 CFR §146.90(g), and CARB LCFS Subsections C.4.1(a)(9) and C.4.3.2.1.
viii. Continuous and intermittent surface air composition and intermittent soil gas monitoring per 40 CFR §146.90(h), and CARB LCFS Subsections C.4.1(a)(11) and C.4.3.2.2.
ix. Ecosystem stress monitoring vias satellite imagery or ground-based vegetation surveys per 40 CFR §146.90(h), and CARB LCFS Subsections C.4.1(a)(11) and C.4.3.2.2(f).
x. Soil gas monitoring for molecular and isotopic composition at a site-specific frequency per 40 CFR §146.90(h) and CARB LCFS Subsections C.2.5(c)&(d)&(e) and C.4.3.2.2(g).
xi. Seismicity monitoring via continuous measurement at a site-specific frequency per CARB LCFS Subsection C.4.3.2.3.

A.1.c. Independence from Project QA Manager and Data Gathering

The majority of the analytical samples and continuous monitoring data gathered and cataloged as part of the quality assurance and surveillance plan (QASP) and testing and monitoring (T&M) plans will be analyzed, processed, or witnessed by unbiased third parties independent and outside of the Caliche management structure.

A.1.d. QA Project Plan Responsibility

Caliche is responsible for developing, maintaining, following, and distributing an USEPA and CARB approved QASP. The QASP will be reviewed/updated a minimum of once every five years or when changes are warranted based on operations or monitoring equipment/methods in accordance with 40 CFR §146.90(j) and CARB LCFS Subsection 4.1.16.

A.1.e. Organizational Chart for Key Project Personnel

Exhibit E.1.A.1 shown below outlines the organization structure of the Caliche Project Site. Caliche will provide the Underground Injection Control (UIC) Program Director and CARB Executive Officer with a contact list of individuals fulfilling these roles.

Exhibit E.1.A.1. Organizational Chart.

Claimed as PBI

[redacted]

A.2. Problem Definition/Background

A.2.a. Reasoning

This QASP was developed to support the T&M plan included in the Class VI permit application provided by Caliche for the geological sequestration of the carbon dioxide produced from industrial and commercial facilities located in the vicinity of the Project site in Jefferson County, Texas. The T&M plan was also developed in accordance with the USEPA Class VI Rule regulations, the CARB LCFS Protocols, and includes available best practices learned from other similar CO_2 injection and sequestration projects.

Additionally, the T&M plan and QASP were designed to assist in the quantification of carbon dioxide sequestered at the Site to satisfy the requirements 40 CFR §98 Subpart RR – Geologic Sequestration of Carbon Dioxide. The Monitoring, Report and Verification program for the Caliche Sequestration Site is to demonstrate that injection activities are and will remain protective of human health and the environment prior to, during, and following project operations. This QASP was developed to support the goal of the Monitoring, Reporting and Verification (MRV) program and to ensure the quality standards of the Testing and Monitoring program meet the requirements of the U.S. Environmental Protection Agency's (USEPA) Underground Injection Control (UIC) program for Class VI wells and the California CCS LCFS protocol. The MRV program will be developed based on careful evaluation of site-specific data and publicly available from permitted USEPA Class II saltwater disposal (SWD) wells in the vicinity of the project area. Information used to develop the MRV/QASP/T&M was collected and evaluated to confidently determine that the injection zone (Upper Frio Formation) is capable of accepting and retaining the injected CO_2 stream.

The Caliche MRV plan will contain operational monitoring, verification, and environmental monitoring components. Operational monitoring will be used to ensure that all procedures associated with fluid injections are conducted in a safe manner. Operational monitoring is outlined in Section A.1.a/b and includes continuous monitoring of injection parameters (pressure, rate, temperature, mass flow, pressure on the annulus, and annulus fluid volume). Additional monitoring parameters include continuous seismic strain measurements and monitoring of nearby USGS seismographs. The verification component will provide information to evaluate if leakage of CO_2 through the confining unit. This includes pulse neutron logging, pressure, and temperature monitoring. The atmospheric and environmental monitoring components will determine if the injectate is being released into the shallow subsurface or biosphere. This monitoring includes pulse neutron logging, ground water, surface air, soil gas, and ecosystem stress monitoring.

A.2.b. Reasons for Initiating the Project

The purpose of the Caliche Sequestration Project is to permanently sequester carbon dioxide within the upper Frio Formation in a manner that will protect human health and the environment, protect the underground source of drinking water (USDW), and mitigate any leakage of CO_2 to the atmosphere. As a result, the T&M plan and QASP are designed to comply with the Class VI Rule and CARB LCFS protocols and document data collection that will validate or update the predictions made during subsurface characterization and modeling. The data collected in accordance with the prepared T&M plan and QASP will be used to ensure that injectate fluids will remain permanently in the Injection zone and be isolated from USDWs, near-surface geologic units, ground surface, and the atmosphere.

A.2.c. Regulatory Information, Applicable Criteria, Action Limits

The Class VI Rule (40 CFR §146 Subpart H) and CARB LCFS Protocols require owners/operators of Class VI injection well(s) to conduct various monitoring and quality control activities during the lifetime of the project to ensure that each injection well maintains mechanical integrity, that fluid migration and the extent of pressure elevation are within the limits described in the permit application, and that underground sources of drinking water (USDWs) are not endangered. Monitoring activities include Mechanical Integrity Tests (MITs), injection well testing/monitoring during operations, monitoring of groundwater quality above the Confining zone, tracking of the

CO_2 plume and associated pressure front, atmospheric, soil gas, ecosystem stress and seismic monitoring.

A.3. Project/Task Description

A.3.a/b. Summary of Work to be Performed

Table E.1.A.1 shown below lists the testing and monitoring activities, locations, methods, analytical methods, vendors and purposes. Refer to the Testing and Monitoring Plan (see *Module E.1*) for monitoring and reporting frequencies.

Table E.1.A.1. Summary of Testing and Monitoring.

Activity	Location(s)	Method[1]	Analytical Technique[1]	Lab/Custody	Purpose
Carbon dioxide stream analysis	Flowline	High-pressure vessel	ISBT[2] methods	TBD	Monitor CO_2 stream(s) quality
CO_2 stream temperature	Wellhead / Flowline	Mass Flow Meter/Computer	Direct continuous measurement	Not applicable	Monitor CO_2 stream temperature at the surface
Injection rate/volume	Flowline	Mass Flow Meter/Computer	Direct continuous measurement	Not applicable	Monitor injection rate/volume
Injection Pressure (surface)	Wellhead / Flowline	Pressure Gauge	Direct continuous measurement	Not applicable	Monitor injection pressure at surface
Injection Pressure (downhole)	Near Perforations	Quartz Pressure Gauge	Direct continuous measurement	Not applicable	Monitor downhole injection pressure
Annulus pressure	Wellhead	Pressure Gauge	Direct continuous measurement	Not applicable	Monitor annulus pressure for potential well integrity detection
Annulus fluid volume	Annulus Tank	Fluid Level Measure	Direct continuous measurement	Not applicable	Monitor annulus fluid level for potential well integrity detection
Downhole Temperature	Near Perforations	Temperature Gauge	Direct continuous measurement	Not applicable	Monitor downhole CO_2 stream temperature

Activity	Location(s)	Method[1]	Analytical Technique[1]	Lab/Custody	Purpose
Corrosion monitoring	Flowline – Before Flow distribution header	Weight loss in holder, and observation	ASTM G1-03 and/or NACE Standard RP0775-2005 Item No. 21017	TBD	Monitor corrosion of surface and downhole piping/tubing
Distributed Temperature Sensing (DTS) fiber optics[3]	Injection wells	Fiber optic cable	Direct continuous measurement	Not applicable	Monitor wellbore integrity
Mechanical integrity (casing / cement)	Injection wells	Various, as discussed in T&M plan.	40 CFR §146.87 (a)(4), 40 CFR §146.89 (c)(2) and applicable CARB LCFS requirements	TBD	Monitor wellbore integrity and detect potential leakage through casing
Pressure fall-off testing	Injection wells	USEPA Region 6 UIC Pressure Fall-off Testing Guideline – Third Revision (August 8, 2002)	USEPA Region 6 UIC Pressure Fall-off Testing Guideline – Third Revision (August 8, 2002)	TBD	Monitor wellbore integrity and assess formation injectivity
In-zone pressure monitoring – Frio Formation	Injection wells and IZ monitoring wells	Downhole pressure gauge	Direct continuous measurement	TBD	Monitor in-zone pressure for plume tracking
In-zone temperature monitoring – Frio Formation	Injection wells and IZ monitoring wells	Downhole temperature gauge	Direct continuous measurement	TBD	Monitor in-zone temperature for plume tracking
In-zone pressure monitoring – Frio Formation[3]	TBD	Electrical, gravity, or seismic technologies	Provided by vendor	TBD	Monitor in-zone pressure for plume tracking
Pulsed Neutron Logging – Sequestration Complex	IZ monitoring wells	Wireline formation evaluation logging	Provided by vendor	TBD	Monitor CO_2 migration within the sequestration complex
In-zone fluid monitoring – Frio Formation	IZ monitoring wells	Downhole PVT sampler or equivalent tool	Various for geochemical and isotopic analyses	TBD	Monitor CO_2 migration within the injection zone

Activity	Location(s)	Method[1]	Analytical Technique[1]	Lab/Custody	Purpose
Time-laps Seismic - Sequestration Complex	IZ monitoring wells	Time-lapse Vertical Seismic Profiles (VSP) or other method	Provided by vendor	TBD	Track CO_2 plume size and monitor changes within sequestration complex
Above-Confining Zone pressure monitoring (ACZ) – Oakville Sand	ACZ monitoring wells	Downhole pressure gauge	Direct continuous measurement	Not applicable	Monitor ACZ pressure for verifying plume containment
Above-Confining Zone temperature monitoring (ACZ) – Oakville Sand	ACZ monitoring wells	Downhole temperature gauge	Direct continuous measurement	Not applicable	Monitor ACZ temperature for verifying plume containment
Above-Confining Zone fluid monitoring (ACZ) – Oakville Sand	ACZ monitoring wells	Downhole PVT sampler or equivalent tool	Various for geochemical and isotopic analyses	Not applicable	Monitor ACZ fluid for verifying plume containment
USDW fluid monitoring – Lissie Formation	USDW monitoring wells	Downhole pumps for surface sample collections	Various for geochemical and isotopic analyses	TBD	Monitor changes to identify potential CO_2 leaks and discern the source(s) of detected CO_2
Atmospheric monitoring	3 Eddy Covariance (EC) Towers	Surface air sampling and net CO_2 flux calculation	Direct measurement	Not applicable	Monitor environmental atmospheric changes
Atmospheric monitoring	Various throughout AoR	Handheld portable landfill gas meter	Direct measurement	Not applicable	Monitor environmental atmospheric changes
Ecosystem Stress monitoring	AoR and Reference Areas	Vegetation surveys	Satellite imagery analysis	Not applicable	Monitor vegetation changes
Ecosystem Stress monitoring	AoR and Reference Areas	Vegetation surveys	Ground based survey	BGE	Assess and monitor vegetation changes

Activity	Location(s)	Method[1]	Analytical Technique[1]	Lab/Custody	Purpose
Soil Gas monitoring	Up to 40 discrete soil gas probes	Soil gas sampling	Standard laboratory analyses (gas chromatography and mass spectrometry)	Istotech Laboratories and Beta Analytics	Monitor vadose zone to confirm containment of CO_2
Soil Characterization	Up to 40 discrete locations	Soil Sampling	Standard laboratory analyses	ALS Houston	Establish site soil characteristics
Seismicity monitoring	AoR	Various seismometers in Texas	Not applicable	Not applicable	Monitor seismic events of magnitude greater than 2.7
Seismicity monitoring	AoR	Downhole Fiber Optic Cables or equivalent	Provided by vendor	Not applicable	Monitor earthquake events of magnitude greater than 2.7

Notes:
1. An equivalent method may be employed with the prior approval of the UIC Program Director or CARB Executive Officer, such as ASTM Standards.
2. ISBT = International Society of Beverage Technologists.
3. If deployed or used.

Table E.1.A.2 shows instrument types, data collection location for each monitoring location.

Table E.1.A.2. Instrumentation Summary.

Monitoring Location	Instrument Type	Monitoring Target (Formation or Other)	Data Collection Location(s)	Explanation
CO_2 Facility	High-pressure vessel	Surface/flowline	Tap on flowline	Monitor injectate quality
	Flow meter	Surface/flowline	Flowline	Monitor injectate rate/volume
Injection Wells	Wellhead Pressure / temperature gauge (on tubing)	Wellhead)	Wellhead tap	Monitor injection conditions; safety and compliance
	Annulus Pressure gauge	Wellhead	Wellhead tap	Monitor injection conditions; safety and compliance
	Downhole pressure/ temperature gauge	Injection Zones (Frio Sands)	Perforations	Monitor downhole conditions; safety and compliance

Monitoring Location	Instrument Type	Monitoring Target (Formation or Other)	Data Collection Location(s)	Explanation
	Weight loss coupons in holder	Surface/flowline	ASTM G1-03 and/or NACE Standard RP0775-2005 Item No 21017	Monitor corrosion
	Distributed Temperature Sensing (DTS) fiber optic cable[1]	Whole formation section down to Confining Zone	Dedicated server (VSP array)	Monitor wellbore integrity
	Various	Whole formation section	40 CFR §146.87 (a)(4) and 40 CFR §146.89 (c)(2)	Monitor wellbore integrity
	Wireline cement evaluation logging	Whole formation section	Casing	Monitor wellbore integrity
	USEPA Region 6 UIC Pressure Falloff Testing Guideline – Third Revision (August 8, 2002)	Injection Zones (Frio Sands)	USEPA Region 6 UIC Pressure Falloff Testing Guideline – Third Revision (August 8, 2002)	Monitor wellbore integrity and assess formation injectivity
	Wireline formation evaluation logging tools	Whole formation section	Open Hole	Track formation property changes
	Distributed Acoustic Sensing (DAS) fiber optic cable[1]	Whole formation section	Dedicated server (VSP array)	CO_2 plume tracking and well integrity
	Fiber optic cables	Whole formation section	Whole well casing	Monitor earthquake events of magnitude greater than 2.7
In Zone (IZ) Monitoring Wells – Frio Formation	Pressure/temperature gauge (on tubing)	Injection Zones (Frio Sands)	Wellhead	Safety and compliance
	Downhole pressure/temperature gauge	Injection Zones (Frio Sands)	Perforations	Monitor downhole conditions of pressure/temperature in the Injection Zone
	Downhole PVT sampler or equivalent tool	Injection Zones (Frio Sands)	Perforations	Monitor CO_2 migration within the injection zone
	Fiber optic cables	Whole formation section	Whole well casing	Monitor earthquake events of magnitude greater than 2.7

Monitoring Location	Instrument Type	Monitoring Target (Formation or Other)	Data Collection Location(s)	Explanation
Above Confining Zone (ACZ) Monitoring Wells - Oakville Formation	Pressure / temperature gauge (on tubing)	First transmissive zone above the confining zone (Oakville Sand)	Wellhead	Safety and compliance
	Downhole pressure/temperature gauge	First transmissive zone above the confining zone (Oakville Sand)	Perforations	Monitor ACZ temperature for verifying plume containment
	Downhole PVT sampler or equivalent tool	Injection Zones (Frio Sands)	Perforations	Monitor ACZ fluid for verifying plume containment
USDW Monitoring Wells	Downhole bladder pump, or equivalent	Lower Chicot Aquifer (Lissie Formation)	Perforations within screened interval or wellhead tap	Identify potential CO_2 leaks and discern the source(s) of detected CO_2
VSP stations or other method	Time-lapse VSP or other time-lapse method	Reservoir – Plume Tracking	Surface and/or in wellbore	Monitor CO_2 plume migration and reservoir integrity

Notes:
1. If deployed or used.

A.3.c. Geographic Locations

The injection wells will be located near Beaumont, Texas within the Hillebrandt Bayou watershed (**Figure E.4.1** - Emergency and Remedial Response Plan). The location of the monitoring components for the Caliche Sequestration Project are shown in **Figure E.1.1** of the T&M Plan (see *Module E.1*) and includes monitoring well clusters, soil gas probe clusters/stations, and atmospheric monitoring towers at various locations within the Area of Review (AoR).

In-Zone (IZ) monitoring will occur with the upper Frio Formation near the Caliche injection wells, near the northern boundary of the AoR and near the fault located south of the project area. The primary goal of monitoring the injection zone is to track the migration of the CO_2 and pressure front at the Site. Above confining zone (ACZ) monitoring will occur within the Oakville Sandstone near the Caliche injection wells, near the northern boundary of the AoR and near the fault located south of the project area. The goal of monitoring the unit directly above the Confining Zone is to detect the leakage or upward movement of either formation brine or carbon dioxide from the sequestration complex early before it reaches the USDW, should it occur. Additionally, USDW monitoring will occur within the Lissie Formation (Lower Chicot Aquifer) near the Caliche injection wells, near the northern boundary of the AoR by the environmental justice (EJ) communities and near the fault located south of the project area. The primary goal of the USDW monitoring program is to confirm protection of groundwater that can potentially be used as a drinking water resource by ensuring that any geochemical changes observed within the USDW falls within the established baseline conditions prior injection. An initial geochemical description of the fluids will be evaluated prior to injection operations for this interval.

Continuous and intermittent atmospheric monitoring will be conducted at the Project surface, above the storage complex during the baseline, operational, and post injection phases of the project as required. Continuous air monitoring will be conducted utilizing Eddy Covariance (EC) flux measurement techniques via an advanced, stationary LI-COR® air quality and weather observation tower, equipped with eddy covariance (EC) and bio meteorological detectors. Intermittent atmospheric monitoring will be conducted at additional locations throughout the AoR utilizing a portable, handheld Landtec® infrared detector to supplement the continuous EC system monitoring data.

Ecosystem monitoring will be conducted at the Site via baseline ground vegetation surveys to characterized including vegetation type and density in and around the storage complex and assess potential stress which may result from elevated carbon dioxide in soil. Additionally, seasonal composite satellite images will be assessed retrospectively for three years prior to the end of baseline, annually during operation, and once at Year 15 during the post-injection site care (PISC) period to support plume stability discussion. Satellite data will be acquired from high-resolution and publicly available imaging platforms including Landsat 8 and 9 where data will be provided by the National Aeronautics and Space Administration (NASA) and the United Stated Geological Survey (USGS), and Sentinel-2 provided where data will be obtained from the European Space Agency (ESA).

Permanent subsurface soil gas probes will be installed at up to 40 representative locations (i.e., 10 clusters of 3 soil gas probes and 10 individual soil probes) throughout the surface above the projected of the AoR. Soil gas monitoring will be conducted during baseline phase to assess near surface molecular and isotopic composition and characterize the natural background variability at the Site, as several natural processes in the near surface can contribute to significant temporal variability in carbon dioxide concentrations. The location of the soil gas monitoring network will include soil gas probes in the vicinity of i) each injection well, ii) deep monitoring wells, iii) select artificial penetrations (APs) which penetrate the injection zone, and iv) the western portion of the Caliche-leased Beaumont Acreage. Additional soil gas probes will be installed through the Caliche-leased Beaumont Acreage to increase spatial variability of the soil gas characterization through the Caliche AoR.

A.3.d. Resource and Time Constraints

No resource or time constraints have been identified for the Caliche Beaumont Sequestration Project based on the proposed monitoring described above and detailed in the T&M Plan beyond the project funding and schedule.

A.4.Quality Objectives and Criteria

A.4.a. Performance/Measurement Criteria

The objective of this QASP is to develop and document monitoring and quality assurance procedures for surface, near-surface, and subsurface testing and monitoring, field sampling, laboratory analyses, and reporting. Monitoring results will be reported in accordance with USEPA permit requirements to track the migration of CO_2 plume and elevated pressure within the storage complex, and ensure that the project meets the non-endangerment of the USDW goals, and ensure that CO_2 leakage to the atmosphere does occur during the project life. Groundwater monitoring will be conducted at the Caliche Beaumont Sequestration Project Site during the baseline, injection and post-injection phases of the project. Fluid samples from the injection zone (Upper Frio Formation) using In-Zone (IZ) monitoring wells will be collected to assess the isotopic and geochemical changes due to CO_2 injection activities. Additionally, monitoring the lowest USDW (Lower Chicot Aquifer) and ACZ (Oakville Formation) will verify that CO_2 sequestration does not impact the groundwater resource. **Tables E.1.A.3, 4,** and **5** outline the analytical and field parameters for the IZ, ACZ, and USDW monitoring wells at the Site, respectively.

Table E.1.A.3. Summary of Analytical Parameters for Fluid Samples in the Frio Formation (IZ Monitoring Wells).

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Notes:

1. AMS = accelerator mass spectrometry; CRDS = cavity ring down spectrometry; ICP-MS = inductively coupled plasma mass spectrometry; IRMS = isotope ratio mass spectrometry; MS = mass spectrometry; SM = standard method.
2. * = Analytical parameters to be included during the pre-injection phase, and only as needed during the injection and post-injection phases of the project.
3. An equivalent method may be employed with the prior approval of the UIC Program Director and CARB Executive Officer.
4. Detection limits and precision (laboratory control limits) are typical for these analytical methods.

Table E.1.A.4. Summary of Analytical Parameters for Fluid Samples in the Oakville Formation (ACZ Monitoring Wells).

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Notes:

1. AMS = accelerator mass spectrometry; CRDS = cavity ring down spectrometry; ICP-MS = inductively coupled plasma mass spectrometry; IRMS = isotope ratio mass spectrometry; MS = mass spectrometry; SM = standard method.
2. * = Analytical parameters to be included during the pre-injection phase, and only as needed during the injection and post-injection phases of the project.
3. An equivalent method may be employed with the prior approval of the UIC Program Director and CARB Executive Officer.
4. Detection limits and precision (laboratory control limits) are typical for these analytical methods.

Table E.1.A.5. Summary of Analytical Parameters for Fluid Samples in the Lissie Formation (USDW Monitoring Wells).

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Notes:

1. AMS = accelerator mass spectrometry; CRDS = cavity ring down spectrometry; ICP-MS = inductively coupled plasma mass spectrometry; IRMS = isotope ratio mass spectrometry; MS = mass spectrometry; SM = standard method.
2. * = Analytical parameters to be included during the pre-injection phase, and only as needed during the injection and post-injection phases of the project.
3. An equivalent method may be employed with the prior approval of the UIC Program Director and CARB Executive Officer.
4. Detection limits and precision (laboratory control limits) are typical for these analytical methods.

Atmospheric, ecosystem stress, and soil gas monitoring will be conducted during the pre-injection, injection and post-injection phases of the project. Additionally, soil samples will be collected during the installation of the soil gas probes. Field parameters for continuous surface air testing are presented on **Table E.1.A.6**. **Table E.1.A.7** includes the analytical and field parameters for soil and soil gas samples.

Table E.1.A.6. Summary of Analytical Parameters for Continuous Surface Testing.

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Table E.1.A.7. Summary of Analytical Parameters for Soil and Soil Gas.

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Notes:

1. AMS = accelerator mass spectrometry; CRDS = cavity ring down spectrometry; ICP-MS = inductively coupled plasma mass spectrometry; IRMS = isotope ratio mass spectrometry; MS = mass spectrometry; SM = standard method.
2. * = Analytical parameters to be included during the pre-injection phase, and only as needed during the injection and post-injection phases of the project.
3. An equivalent method may be employed with the prior approval of the UIC Program Director and CARB Executive Officer.
4. Detection limits and precision (laboratory control limits) are typical for these analytical methods.

Table E.1.A.8 shows a summary of the field parameters which will be measured during the collected of fluid samples from the USWD, ACZ and IZ monitoring wells.

Table E.1.A.8. Summary of Field Parameters for Fluid Sampling.

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Quality objectives for satellite imagery data used to evaluate ecosystem stress monitoring are met by i) standard imagery source reliability by accredited agencies such as the United States Geological Survey (USGS) and the European Space Agency (ESA), and ii) imagery processing product reliability tailored to these sources (Dwyer et al., 2018; Vermote et al., 2016; IDB Project, 2022).

Table E.1.A.9 shows the summary of the analytical parameters monitored for the CO_2 stream during the project.

Table E.1.A.9. Summary of Analytical Parameters for CO_2 Stream at the Surface.

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Notes:

1. An equivalent method may be employed with the prior approval of the UIC Program Director and CARB Executive Officer.
2. Detection limits and precision (laboratory control limits) are typical for these analytical methods.

Table E.1.A.10 shows the summary of the analytical parameters monitored for corrosion coupons for this project.

Table E.1.A.10. Summary of Analytical Parameters for Corrosion Coupons.

Claimed as PBI

[redacted]

Table E.1.A.11 shows the summary of the analytical parameters monitored for field gauges for this project.

Table E.1.A.11. Summary of Measurement Parameters for Field Gauges.

Claimed as PBI

[redacted]

Table E.1.A.12 provides a summary of the actionable testing and monitoring outputs.

Table E.1.A.12. Actionable Testing and Monitoring Outputs.

Claimed as PBI

[redacted]

Notes:

1. These data limits are to be determined during well engineering design, after assessment of available instruments.
2. The methodology for anomaly detection and attribution will be developed after data collection to identify natural and spatial variation and comparison to fluid compositions to identify a leakage signal.
3. Actual mismatch between modeled and observed In Zone pressure response and plume tracking depends on recalibration of the model with new data, followed by a forward model to determine any unacceptable outcomes, result from the production of pressure and plume evolution.
4. If deployed.

Note that the tables above may be periodically updated/revised as Caliche finalizes its selection of vendors/equipment for this project.

A.4.b. Precision

The precision tolerances for the analytical and field parameters for this project are provided in **Tables E.1.A.3 through 11** above.

Precision tolerances gauges and meters will be updated after the equipment specifications and contractors are finalized, as changes in equipment availability/precision may occur during the permitting process. Generalized specifications for continuous injection monitoring parameters are presented below in **Tables E.1.A.13**.

Table E.1.A.13. Pressure and Temperature - Downhole Gauge Specifications.

Claimed as PBI

[redacted]

Table E.1.A.14. Pressure Field Gauge (Injection Tubing Pressure).

Claimed as PBI

[redacted]

Table E.1.A.15. Pressure Field Gauge (Annulus Pressure).

Claimed as PBI

[redacted]

Table E.1.A.16. Temperature Field Gauge (Injection Tubing Temperature).

Claimed as PBI

[redacted]

Table E.1.A.17. Mass Flow Rate Field Gauge (CO_2 Mass Flow Rate).

Claimed as PBI

[redacted]

Table E.1.A.18. Representative Logging Tool Specifications.

Claimed as PBI

[redacted]

A.4.c. Bias

Analytical bias will be the responsibility of the analytical laboratories based on their standard operating procedures and industry standard analytical methodologies. Additionally, analytical laboratories will conduct accuracy tests in accordance with their standard operating procedures. These tests may include the percent recovery on laboratory control samples or matrix spike analysis.

No bias is reasonably expected for mechanical field instruments. However, logging equipment, gauges, and meters will be calibrated and/or tested by the responsible vendors prior use or deployment.

A.4.d. Representativeness

Monitoring data representativeness expresses the degree to which data accurately and precisely represents environmental conditions. The groundwater, surface air, soil gas, and soil sampling networks for the Caliche Sequestration Project have been developed to provide data representative of site conditions.

Representativeness for groundwater samples will be assessed using an ion balance approach where an error of less than 10% is considered representative. A mass balance approach may be applied where the ion balance error is greater than 10%.

A.4.e. Completeness

Completeness is the measure of the amount of valid data obtained from continuous or discrete field measurements, field sensors, and analytical results compared to the amount of valid data that could expect to be collected under optimal operations conditions. A data completeness threshold of 90% is acceptable for this project to meet the monitoring needs of the QASP and T&M plan.

A.4.f. Comparability

Data comparability is the degree to which one dataset can be compared to another similar dataset. Datasets collected as part of this project will be expected to be comparable to datasets collected at a later time due to the programmatic methods (e.g., QA/QC requirements, standardized methods, etc.) employed under the project quality assurance program.

Historical (pre-baseline) or external project data will be evaluated against the quality assurance protocols established in this QASP.

A.4.g. Sensitivity

The sensitivity of specific field measurements/sensors and analytical methods will be finalized following selection of equipment, subcontractors, and approval of the Draft T&M plan. However, typical sensitivity requirements (e.g., detection/quantitation ranges) for the instruments, analytical and field methods are presented in **Tables E.1.A.3 through 10** and **13 through 18** above.

A.5. Special Training/Certifications

A.5.a. Specialized Training and Certifications

No specialized certifications are required for personnel conducting groundwater, surface air, soil gas, or soil sampling. Field sampling will be conducted by trained and qualified personnel according to the procedures approved by the UIC permit and Caliche.

Geophysical and wireline logging equipment (e.g., DAS optical fiber and pulse neutron equipment) will be installed and operated by qualified specialty contractors and interpreted in accordance with industry standard guidance and practice.

A.5.b/c. Training Provider and Responsibility

All necessary training will be provided by Caliche and/or its contractors. Vendors and contractors will provide documentation of their training to Caliche upon request.

A.6. Documentation and Records

A.6.a. Report Format and Package Information

Caliche will report the results of all T&M activities to the USEPA and CARB in compliance with the requirements under 40 CFR §146.91 and LCFS requirements. During the injection phase, Caliche will provide at the minimum semi-annual reports to the USEPA Program Director and quarterly/annual reports to the CARB Executive Officer containing all required monitoring and testing data as specified in **Table E.1.1** of the T&M plan or the final UIC permit. During the post-injection phase of the project, reports will be provided to USEPA Program Director and CARB Executive Officer as specified in the *Post-Injection Site Care and Site Closure Plan in Module E.3*. Data will be provided in electronic or other formats as required by the UIC program.

A.6.b. Other Project Documents, Records, and Electronic Files

Other documents, records, and electronic files such as monitoring results, well integrity tests, or other required ancillary data will be provided to the USEPA Program Director and CARB Executive Officer upon request.

A.6.c/d. Data Storage and Duration

Caliche or a formally designated contractor/consultant will maintain and store all required project data as required.

A.6.e. QASP Distribution Responsibility

Caliche is responsible for distributing the most current approved copy of the QASP to the distribution list included in the introductory section of this plan.

B. DATA GENERATION AND ACQUISITION

B.1. Sampling Process Design

Sampling process design discussed in this section includes samples which require the collection of physical media including injectate fluids, corrosion coupon, groundwater, and soil gas. Monitoring activities which do not include physical sample collection are not relevant to this section, including: geophysical logging, seismic monitoring, pressure/temperature monitoring, atmospheric monitoring, and ecosystem stress monitoring via satellite imagery. Sampling process design for intermittent atmospheric monitoring is discussed in the T&M plan in *Module E.1*.

Groundwater monitoring will be performed during the baseline (pre-injection) and injection phases of the project and will focus on a comprehensive set of analytical parameters to characterize the geochemical and isotopic conditions within the project area. Analytical parameters include constituents with USEPA primary or secondary drinking water standards, compounds which are known to be sensitive to CO_2, compounds which serve a quality control objective, constituents needed to discern the source of anomalous CO_2 detections or potential brine migration, and compounds which may be useful for geochemical modeling. **Table E.1.A.1** includes a summary of monitoring activities, and **Tables E.1.A.3, 4** and **5** include groundwater monitoring analytes for the IZ, ACZ and the lowermost USDW, respectively. Soil gas monitoring will be performed at shallow soil gas probes, and soil gas monitoring analytes are provided in **Table E.1.A.7**. CO_2 stream monitoring and corrosion coupon monitoring will be conducted using methods provided in **Tables E.1.A.9 and 10**, respectively.

The groundwater and soil gas analytical suites are adaptive for the Caliche Beaumont Sequestration Project as some parameters may be removed from the routine monitoring if determined to be stable after baseline conditions or natural trends are established. In the event that statistically significant geochemical changes are confirmed in groundwater samples, isotopic sampling may be re-initiated to verify baseline conditions.

Groundwater, soil gas, CO_2 stream and corrosion coupon samples will be analyzed by a third-party analytical laboratories certified by TCEQ or alternative (e.g., ASTM Methods or Standard Methods) using standardized procedures. Analytical methods used by the laboratory will be industry standard and developed by EPA/ASTM, or specialty methods which meet those quality assurance requirements.

If anomalous data changes are observed, or there is any indication of brine and/or CO_2 leakage or well integrity issues, additional samples may be obtained for geochemical and isotopic analysis and comparison to pre-injection sample results.

B.1.a. Design Strategy

B.1.a.1 CO_2 Stream Monitoring Strategy

The objective of analyzing the CO_2 injectate stream is to evaluate its potential interactions with formation matrices, fluids and other materials which may be in contact with the injectate including well/piping infrastructure. Characterization of the injectate supports any potential Resource Conservation and Recovery Act (RCRA), 42 U.S.C. §6901 et seq. (1976) waste designations. Furthermore, injectate monitoring may be beneficial to differentiate injectate from native reservoir fluids if unintended fluid migration is confirmed. Injectate sampling is included in **Table E.1.A.1** and will be conducted on a quarterly basis or whenever a new injectate source is added. Detailed monitoring frequency is provided in the T&M plan.

B.1.a.2 Corrosion Monitoring Strategy

Corrosion coupons will be analyzed quarterly to verify the mechanical integrity of any infrastructure and piping in contact with the CO_2 stream. Coupons will be placed directly into the injectate stream and will be collected and submitted to a qualified third-party analytical laboratory for analysis accordance with NACE Standard RP0775-2005 Item No. 21017 (or similar such as ASTM G1 – 03 (2017) to determine mass loss of the coupon via corrosion.

B.1.a.3 Shallow Groundwater Monitoring Strategy

Shallow or USDW groundwater monitoring will be performed in the Lissie Formation (upper portion of the Lower Chicot aquifer), which is anticipated to be lowermost USDW within the project area. Monitoring parameters are outlined in **Table E.1.A.5**. The primary purpose for monitoring the shallow groundwater is to confirm protection of groundwater that can potentially be used as a drinking water resource by evaluating any geochemical and/or isotopic changes outside the established baseline conditions or trends before injection activities begin.

As discussed in the T&M plan, it is anticipated that four USDW monitoring wells, placed in the vicinity of highest potential of vertical migrations (i.e., injection wells, artificial penetrations and fault) or sensitive receptors (i.e., residential areas) will be sufficient to meet the project objectives.

Shallow groundwater will be sampled in accordance with USEPA Method SESDPROC-301-R4 (EPA, 2023a) at frequencies detailed in the T&M plan (see *Module E.1*) for the pre-injection and injection phases, and in the Post-Injection Site Care and Site Closure plan (see *Module E.3*) for the post-injection phase. USDW groundwater samples will be submitted for various geochemical and isotopic analyses by a third-party laboratory accredited by the TCEQ or alternative (e.g., ASTM Methods or Standard Methods) using standardized procedures.

B.1.a.4 Deep Groundwater Monitoring Strategy

Deep groundwater monitoring will be performed in the Oakville Formation and Frio Formation using ACZ and IZ monitoring wells, respectively. Monitoring parameters for the IZ and ACZ monitoring wells are outlined in **Tables E.1.A.3** and **4**, respectively. The primary objective of monitoring Frio Formation and Oakville Formation is to track the migration of CO_2 plume within the Injection Zone, and any vertical migration of CO_2 to the first transmissive zone above the confining zone, respectively. Groundwater data collected after injection activities start will be compared to baseline conditions or trends established during the pre-injection phase.

As discussed in the T&M plan, it is anticipated that four ACZ and four IZ monitoring wells, placed in the vicinity of highest potential of vertical migrations (i.e., injection wells, artificial penetrations and fault), sensitive receptors (i.e., residential areas) and up dip from the CO_2 migration path will be sufficient to meet the project objectives.

The sampling system used to sample and quantify dissolved gases and the aqueous phases in equilibrium with those gasses will be supplied by a third-party vendor (*such as:* Class VI Solutions (U-tube samplers), Schlumberger, Expro, or equivalent vendor using downhole PVT sampler or equivalent tool). Bottomhole samples are preferred; however, surface samples may be used for expediency. The sampling frequencies for the Oakville and Frio Formations are detailed in the T&M plan (see *Module E.1*) for the pre-injection and injection phases, and in the Post-Injection Site Care and Site Closure plan (see *Module E.3*) for the post-injection phase. Deep groundwater samples will be submitted for various geochemical and isotopic analyses by a third-party laboratory accredited by the TCEQ or alternative (e.g., ASTM Methods or Standard Methods) using standardized procedures.

B.1.a.5 Soil Gas Monitoring Strategy

Soil gas monitoring will be conducted for parameters outlined in **Table E.1.A.7**. Monitoring soil gas can be used to quantify the bulk chemical composition of gases in the near-surface and discern the source(s) of detected CO_2 to either natural or anthropogenic sources (NETL, 2009).

As discussed in the T&M plan, several naturally-occurring processes in the near surface (e.g., biologic respiration, microbial oxidation of methane) can contribute to significant temporal variability in CO_2 concentrations. Therefore, the soil gas monitoring strategy for the Caliche Project was designed to i) define the baseline molecular and isotopic compositions of the shallow soil gas, and ii) characterize natural background variability, including seasonal and diurnal trends. Up to 40 soil gas probe locations will be installed throughout the project area in the vicinity of the injection wells, monitoring wells, artificial penetrations, faults, and other areas to increase the variability of the soil gas dataset. Additionally, soil samples will be collected in general accordance with USEPA Method LSASDPROC-300-R5 (EPA, 2023b) for parameters specified in **Table E.1.A.7** to characterize soil at the site.

Soil gas will be sampled in accordance with USEPA Method LSASDPROC-307-R5 (EPA, 2023c) at frequencies detailed in the T&M plan (see *Module E.1*) for the pre-injection and injection phases, and in the Post-Injection Site Care and Site Closure plan (see *Module E.3*) for the post-injection phase. Soil and soil gas samples will be submitted for various geochemical and isotopic analyses by a third-party laboratory accredited by the TCEQ or alternative (e.g., ASTM Methods or Standard Methods) using standardized procedures.

B.1.b. Type and Number of Samples/Test Runs

Type and number of samples will be finalized following approval of a draft permit by the UIC program director.

B.1.c. Site/Sampling Locations

Sites and sampling locations will be finalized following approval of a draft permit by the UIC program director.

B.1.d. Sampling Site Contingency

Contingency sampling locations will be finalized following approval of a draft permit by the UIC program director.

B.1.e. Activity Schedule

The sampling activity schedule will be finalized following approval of a draft permit by the UIC program director.

B.1.f. Critical/Informational Data

Detailed field information will be collected by field vendors during physical sample collection. Sample attributes will be recorded on field forms (paper or electronic) and chain of custody will be tracked on a form provided by the analytical laboratory. Critical sampling information includes sample date and time, media, sample containers, sample preservation (if applicable), personnel collecting the sample(s), location of sample, field instrument calibration data and field parameter values. Critical data in laboratory analytical reports will be provided by the analytical laboratory and will be provided in electronic format (PDF and tabular). Noncritical data which may not have quantitative criteria includes appearance, color, odor, texture, weather conditions during sample collection, and issues related to field equipment which were corrected prior to sample collection.

B.1.g. Sources of Variability

Sources of variability in analytical samples include natural variability in sample media, sample variability due to operational conditions, sample variability due to extreme weather events, changes in field instrument calibration, changes in analytical or sample collection methods throughout the life of the project, manual errors related to data management.

Multiple procedures will be in place to eliminate and/or minimize sources of variability including collection of a robust baseline dataset which captures natural variability, evaluating data on a regular basis and comparing recently collected data to existing data, conducting statistical analysis of data populations to confirm if new data represents the same distribution as existing data, maintenance and calibration of field instruments, ensuring that field staff have appropriate qualifications and training, data validation of laboratory analytical results, and implementing quality control checks on sample results.

B.2. Sampling Methods

B.2.a/b. Sampling SOPs

B.2.a/b.1 CO_2 Stream Sampling SOPs

Sample collection may be performed from the sample port located between the last compression stage and the CO_2 injection wellhead and will follow protocols to ensure the sample is representative of the injected CO_2 stream. The sample port will be installed with the ability to purge and collect samples into a container in accordance with the laboratory specifications and will be sealed and sent to a certified laboratory.

B.2.a/b.2 Corrosion Coupon Sampling SOPs

Corrosion monitoring via coupon sampling involves exposing a specimen sample of material (the coupon) to a process environment for a given duration, then removing the specimen for analysis. The corrosion monitoring will be conducted following the initial installation of the test coupons in the flowline, as follows:

1) Consult maintenance schedule to determine when to remove test coupons from corrosion monitoring holders (coincident with end of calendar quarter);
2) Remove and inspect coupons on a calendar quarterly basis and quantitatively evaluate for corrosion according to American Society for Testing Materials (ASTM) Standard G1-03(2017)e1 or National Association of Corrosion Engineers (NACE) Standard RP0775-2005 Item No. 21017 standards guidelines;
3) Place coupons in proper receptacle for safe transport to measurement and weighing equipment;
4) Photograph each coupon as received. Visually inspect each corrosion coupon for any pitting, stress corrosion cracking or scale buildup. Analyze corrosion coupons by weighing each coupon (to the nearest 0.0001 gram) and measuring the length, the width, and the height of the coupon (to the nearest 0.0001 inch);

5) Record information for each coupon including the date of measurement, the coupon identity (coupon number and metal grade), and the coupon weight in grams, and include any observations of excessive weight loss or pitting, stress corrosion cracking, or scale buildup;

6) Determine if current the corrosion coupon can be returned to the monitoring test holder, if so, make a note of the coupon return; if not, make a note of the installation of a new coupon.

B.2.a/b.3 Groundwater Sampling SOPs

Shallow groundwater samples will be collected using low flow sampling methods in accordance with USEPA's *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures* (1996) or with USEPA Method SESDPROC-301-R4 (EPA, 2023a). For deep groundwater zones, bottomhole samples will be collected equipment and SOPs provided by third-party vendor (*such as:* Class VI Solutions (U-tube samplers), Schlumberger, Expro, or equivalent vendor using downhole PVT sampler or equivalent tool). If permissible, field parameters will be monitored using a flow-through cell to verify stable parameters prior to sample collection. A static water level measurement will be collected using an electronic water level meter (e-tape) prior to disturbing the water column. Dedicated sampling pumps (e.g. bladder, piston, submersible pump) and or peristaltic pump tubing may be installed in each well to minimize cross contamination and reduce the need for decontamination between sampling locations.

Field water quality sensors associated with the flow through cell will be calibrated in accordance with manufacturer specifications at the beginning of each sampling day. Sample collection will be initiated when stabilization is confirmed as listed in **Table E.1.A.19**. Stabilization will be conformed for each parameter by three successive measurements collected every three to five minutes.

Table E.1.A.19. Water Quality Parameter Stabilization Criteria.

Claimed as PBI [redacted]

Samples will be placed directly into laboratory supplied containers and preserved/chilled in accordance with EPA Method and laboratory requirements. Dissolved fraction analytes will be field filtered through a 0.45 mm disposable field filter. Samples will be secured and shipped to the analytical laboratory under chain of custody procedures.

B.2.a/b.4 Soil Gas Sampling SOPs

Soil gas samples will be collected from soil vapor probes in accordance with USEPA Method EPA Method LSASDPROC-307-R5 (EPA, 2023c). A helium tracer enclosure will be placed over the soil gas probe to serve as a leak test tracer gas. A vacuum will be first applied to the soil gas probe tubing to purge the tubing and a soil gas sample will be collected in a 0.3-L IsoBag Gas Bag® using 60 mL gas-tight syringes equipped with a 3-way valves. Samples will be placed directly into laboratory supplied containers and preserved in accordance with EPA Method and laboratory requirements. Samples will be secured and shipped to the analytical laboratory under chain of custody procedures.

B.2.c. In-situ Monitoring

In situ monitoring of CO_2 stream, corrosion coupon, groundwater or soil gas chemical parameters is not currently planned.

B.2.d. Continuous Monitoring

Continuous chemical parameters of CO_2 stream, corrosion coupon groundwater or soil gas are not currently planned.

B.2.e. Sample Homogenization, Composition, Filtration

No corrosion coupon, groundwater, or soil gas sample homogenization or compositing is planned. However, composite CO_2 steam samples may be collected if CO_2 from multiple sources are delivered to the Caliche Beaumont Sequestration Project Site for injection. Sample filtration for dissolved fraction groundwater samples is discussed in Section B.2.a/b.

B.2.f. Sample Containers and Volumes

A summary of sample containers is presented in **Tables E.1.A.20, 21** and **22** below.

B.2.g. Sample Preservation

A summary of sample preservation is presented in **Tables E.1.A.20, 21** and **22** below.

B.2.h. Cleaning/Decontamination of Sampling Equipment

Decontamination of sampling equipment will be minimized via installation of dedicated sampling equipment. Any reusable equipment in contact with groundwater will be decontaminated with an industrial grade detergent (e.g., Liquinox® or Aquanox®) and rinsed with deionized or distilled water.

B.2.i. Support Facilities

Any specialized support facilities will be identified following issuance of a draft UIC permit and after analytical laboratories or vendors are selected.

B.2.j. Corrective Action, Personnel, and Documentation

Caliche personnel and their vendors are responsible for any corrective actions regarding field sampling equipment. Any major corrective actions which may result in a compromised sample will be documented in field notes.

B.3. Sample Handling and Custody

Sample handling and field custody will be managed in accordance with EPA approved analytical methods and any laboratory specific requirements which may apply. Sample custody will be tracked via chain of custody forms and cooler seals where applicable. Samples will be shipped to the selected laboratories within 24-48 hours after collection. Analysis of the samples will be completed within the holding times listed discussed in Section B.3.a below. An example of a laboratory chain of custody is provided in **Appendix E.1.C** of the T&M plan.

B.3.a. Maximum Hold Time/Time Before Retrieval

A summary of sample maximum holding time is presented in **Tables E.1.A.20, 21** and **22** below.

B.3.b. Sample Transportation

Sample transportation/shipping protocols will be finalized following selection of the analytical laboratories. However, it is anticipated that samples will be shipped to the selected laboratories within 24-48 hours after collection.

B.3.c. Sampling Documentation

Field sampling forms will document collection of each analytical sample by the field sampling personnel.

B.3.d. Sample Identification

Samples will be identified using waterproof labels and indelible ink, including sample date, time, media, sample name, and preservative. Additional details may be required by the laboratory, and these will be added to the sample label or chain of custody as necessary.

Table E.1.A.20. Summary of Sample Containers, Preservation Treatments, and Holding Times for CO_2 Gas Stream Analysis.

Claimed as PBI

[redacted]

Table E.1.A.21. Containers, Preservation Techniques and Holding Times for Groundwater Sample Parameters Collected in the Lowermost USDW.

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Table E.1.A.22. Containers, Preservation Techniques and Holding Times for Soil Gas and Soil Samples.

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

B.3.e. Sample Chain-of-Custody

All samples will be tracked on a chain of custody form provided by the analytical laboratory and filled out by the field sampling personnel. A copy of the chain of custody will accompany each sample shipment or delivery.

B.4. Analytical Methods

B.4.a. Analytical SOPs

All laboratory analyses of groundwater samples, soil gas, CO_2 stream, and corrosion coupon collected for the Caliche Beaumont Sequestration Project will be conducted in accordance with EPA-approved methodologies or standardized methods (see **Tables E.1.A.3-5, 7, 9, and 10**). Laboratory analyses will be completed in accordance with SOPs developed by the respective laboratories to be consistent with referenced methods. Upon request, Caliche can provide all SOPs implemented for specific parameters using appropriate standard methods after a contract with the selected laboratories is established. The laboratories will summarize the analytical results, associated QA/QC results, and the laboratory certifications in a laboratory report.

B.4.b. Equipment/Instrumentation Needed

Maintenance/calibration of laboratory equipment/instrumentation will be conducted by the laboratory. The laboratory will report results of continuing calibration and verification samples in each laboratory sample report.

B.4.c. Method Performance Criteria

Internal audits of field activities for collection of physical groundwater samples will be conducted by Caliche or contractor, as necessary, to verify that the protocols specified in this document are being followed and correct any deficiencies in the execution of the field procedures. These internal audits may include an evaluation of the field sampling records, instrument operation records and groundwater sample collection and handling.

Laboratory performance criteria will be designated once the third-party analytical laboratory is selected and contracted, based on their quality assurance and quality control specifications. The selected laboratory will be responsible for implementing their internal laboratory assessments and correct any deficiencies to ensure their compliance with the analytical method SOPs. Any performance criteria failure will be reported to Caliche as pertinent to the testing and monitoring program for the BRP.

B.4.d. Analytical Failure

Minor adjustments in field and laboratory procedures (e.g., change in sampling order, change in location of equipment blank, change in sample on which matrix spike and matrix spike duplicate analysis is performed) will be made at the discretion of the sampling contractors and laboratory personnel without prior approval from Caliche, and the modifications will be recorded in the field and laboratory reports. USEPA and CARB will be notified of the modifications made in the submittal of regular project reports.

If major modifications which could affect the project objectives are necessary, as determined by Caliche and/or contractors (e.g., change in sampling method for deep zone), Caliche will notify the USEPA UIC Director and CARB Executive Officer for approval before implementation.

Corrective actions to address any failure in meeting the performance criteria will be conducted by the selected laboratories in accordance with the respective analytical method SOPs.

B.4.e. Sample Disposal

The analytical laboratories will dispose of any remnant sample volume in accordance with applicable local/state/federal regulations. Each analytical laboratory will adhere to their own sample retention and disposal policies.

B.4.f. Laboratory Turnaround

Standard laboratory turnaround may vary depending on the laboratory and/or analytical parameter. Slight turnaround delays up to a total of one month are considered acceptable assuming that samples are prepared, analyzed, and extracted within analytical method specified holding times.

B.4.g. Method Validation for Nonstandard Methods

Nonstandard methods are not currently proposed for this project. Any nonstandard methods or deviations from standard methods would be submitted to the USEPA Program Director and CARB Executive Officer for approval prior to analysis.

B.5. Quality Control

Quality control standards discussed in this section apply to physical samples including groundwater and soil gas samples.

B.5.a. QC activities

In addition to the samples collected at the project monitoring locations, QC samples will be collected. General practices regarding the QC protocol for CO_2 stream, corrosion coupon, groundwater and soil gas sampling are summarized in the table below for each sampling zone (e.g., lowermost USDW, first transmissive zone above the injection zone, injection zone, and near surface) and described further below (see **Table E.1.A.23**). All QC samples will be preserved appropriately after collection and shipped to respective third-party laboratories under chain-of-custody control.

Table E.1.A.23. QA/QC Sampling Frequency.

QC Sample Type	Frequency
Field Duplicate	10% of the Primary Samples (minimum of 1 sample per field mobilization and sample zone)
Field Blank [1]	1 per sampling field mobilization
Equipment Blank [1]	1 per equipment or type of supplies, if non-dedicated equipment is used

Notes
1. QC sample collected for the lowermost USDW monitoring program only.

Field Duplicate

A field duplicate sample will be collected at a frequency of one duplicate sample for every 10 samples, or, 10% of the primary samples. General precautions for collecting duplicate samples will be followed while sampling, including but not limited to alternating sample containers between the primary and duplicate samples if multiple containers are used. The duplicate samples will be analyzed for the same analytical parameters as the primary samples.

Field Blank

A field blank will be collected at a frequency of at least one field blank per field mobilization for sampling the USDW monitoring wells. To collect the field blank sample, an open container of deionized water supplied by the laboratory will be placed near the monitoring well on the day of the field mobilization. At the end of the field mobilization, the water in the open container will be poured into a set of laboratory-supplied containers and immediately placed on ice for shipment to the laboratory under chain-of-custody control. Caliche anticipates collecting one field blank sample for each sampling event and the field blank sample will be analyzed for geochemical parameters only.

Equipment Blank

If more than one USDW monitoring well is constructed, sampled, and non-dedicated equipment is used to collect groundwater samples, one equipment blank sample will be collected from at least one equipment type (sample pump) or type of supply (tubing). To prepare an equipment blank, the same decontamination procedures employed between sampling locations will be followed and a sample of deionized water provided by the laboratory will be run through the sample pump or tubing and collected in an appropriate sample container. Caliche anticipates collecting one equipment blank sample for each sampling event, if applicable, and the equipment blank sample will be analyzed for geochemical parameters only.

B.5.b. Exceeding Control Limits

If an analytical sample exceeds laboratory control limits (charge balance error exceeds 10%), the data will be examined by calculated the ratio of laboratory measured total dissolved solids (TDS) to the calculated TDS (mass balance) per APHA Method (APHA, 1999). APHA Method identifies specific ion results which may typically exceed control limits, and these ions will be evaluated in comparison to other samples from the same sampling delivery group as well as compared to historical data. Suspect results may be requested for reanalysis if sufficient sample volume is available within the specified hold time.

B.5.c. Calculating Applicable QC Statistics

The following statistical analyses will be used to evaluate the accuracy of the sample analytical results. If any of these tests are not met, additional investigation will be conducted and corrective action will be taken, including re-analysis of questionable parameters.

Field Precision

Field precision objectives for target parameters are ±30% relative percent difference (RPD) between field duplicates and expressed by the following equation:

$$\text{RPD}(\%) = \frac{|X_1 - X_2|}{(X_1 + X_2)/2} \times 100$$

Where: RPD (%) = relative percent difference

X_1 = Original sample concentration

X_2 = Duplicate sample concentration

Charge Balance

The analytical results for the lowermost USDW will be evaluated to determine the accuracy of the analyses based on anion-cation charge balance calculations (APHA, 1999). All potable waters are expected to be electrically neutral, so the anion-cation charge balance calculated using the following formula below should yield zero percent, as the ion sums are calculated in milliequivalents per liter (meq/L):

$$\%\text{ difference} = 100 \times \frac{\sum \text{cations} - \sum \text{anions}}{\sum \text{cations} + \sum \text{anions}}$$

The criterion for acceptable charge balance is ±10% for the BRP.

Mass Balance

The ratio of the measured TDS to the calculated TDS will be calculated in instances where the charge balance acceptance criteria are exceeded using the following formula:

$$1.0 < \frac{\text{Measured TDS}}{\text{Calculated TDS}} < 1.2$$

Outliers

Outliers will be evaluated using EPA approved statistical tools before conducting additional statistical evaluation of the groundwater analytical results (EPA, 2009). These tools may include Probability Plots, Box Plots, and Dixon's test.

B.6. Instrument/Equipment Testing, Inspection, and Maintenance

Field equipment used for groundwater or soil gas sampling will be maintained and calibrated according to manufacturer's specifications. Field calibrations using standards will be performed once per day during sampling events. Spare sensors will be kept with water quality monitoring equipment to reduce field downtime and minimize quality control concerns.

Laboratory equipment will be maintained by the laboratory in accordance with NELAP and/or EPA Method requirements.

Field equipment used for geophysical surveys will be maintained by contractors vendors in accordance with the manufacturer's manual.

B.7. Instrument/Equipment Calibration and Frequency

B.7.a. Calibration and Frequency of Calibration

Groundwater Sampling

Water quality sensors used to measure field parameters during groundwater sampling (i.e., pH, temperature, specific conductance, oxidation-reduction potential, turbidity, and dissolved oxygen) will be calibrated according to manufacturer recommendations and equipment manuals each day before sample collection begins. Recalibration is performed if any components yield atypical values or fail to stabilize during sampling. All calibrations will be documented in the field logbook and will include:

- Date/time of calibration,
- Name of person performing the calibration,
- Reference standard used,
- Temperature at which readings were taken, and
- Calibration readings, as appropriate.

The typical calibrations standards for water quality sensors are described in **Table E.1.A.24** below. However, water quality sensor vendor may require different calibration standards.

Table E.1.A.24. Typical Calibration Standard for Field Water Quality Instruments.

Field Parameter	Typical Calibration Standard
pH	2-Point calibration: 4, 7, or 10 pH standard unit solutions
Specific conductance	1-Point calibration: 1,413 microsiemens per centimeter (µS/cm) at 25°C
Dissolved oxygen	1-Point calibration: 100% saturation
Oxidation-Reduction Potential	1-Point calibration: 223 mV Zobell solution at 25°C
Turbidity	1-Point calibration: 10 NTU

Sensor maintenance may also include factory-service, and factory-calibration per manufacturer's recommendations. If equipment is outside the calibration interval, the equipment will be placed out of service and replaced with similar equipment in proper working conditions.

All laboratory equipment testing and maintenance will be the responsibility of the analytical laboratory per standard practices, method-specific protocols (i.e., SOPs), or accreditation agency (e.g., NELAP) requirements.

Soil Gas

For soil gas sampling, the portable handheld meters, if used, will be maintained, factory-serviced, and factory-calibrated per manufacturer's recommendations.

All laboratory equipment, testing, inspection, and maintenance will be the responsibility of the analytical laboratory per standard practices, SOPs, or accreditation agency requirements.

B.7.b. Calibration Methodology

See discussion in Section B.7.a above.

B.7.c. Calibration Resolution and Documentation

Calibration records for equipment used during groundwater and soil gas sampling, as well as any deviation, will be kept in field logbooks by sampling contractor. Corrective actions implemented to resolve any discrepancies will also be recorded.

The laboratory selected for analysis of CO_2 injectate, corrosion coupon, groundwater and soil gas will be responsible for maintaining records of their calibration records in compliance with standard practices, SOPs or accreditation agency requirements. The laboratory may provide applicable certifications of instrument calibration to Caliche upon request.

B.8. Inspection/Acceptance for Supplies and Consumables

B.8.a/b. Supplies, Consumables, and Responsibilities

Samples will be collected in method-specified containers, with appropriate preservatives, supplied and certified contaminant-free by the laboratory.

Sample containers with appropriate preservatives will be inspected by field crew for breakage and proper sealing of caps. Other sampling equipment/supplies (e.g., sample coolers, tubing etc.) and field measurement supplies (e.g., calibration solutions) will also be inspected before use by field personnel for damage and proper seals. Defective supplies and equipment will be discarded and replaced.

B.9. Nondirect Measurements

B.9.a. Data Sources

Seismicity surveys and/or comparative pulse neutron logs will be completed in a repeatable consistent manner to minimize bias and identify potential changes in the subsurface. Each survey will be compared to previous surveys and baseline surveys.

If used for the Caliche Beaumont Sequestration Project, a baseline, zero-offset, Vertical Seismic Profile ("VSP") will be acquired in cased hole in the IZ monitoring wells and possibly the injection wells. The wells in which a VSP will be acquired and the VSP geometry will be determined based on surface access limitations and optimal plume imaging. The VSP will serve as the baseline for future zero-offset and "walk-away" VSPs that are planned to be acquired within the AoR. Alternatively, a sparse array seismic survey could be acquired. At a minimum, during the acquisition of walk-away vertical seismic profiling and/or sparse array walk-away surveys, the array of acoustic source sites will be oriented along the maximum and minimum orientations of the modeled plume and will be adjusted following a review of the results of each survey.

B.9.b. Relevance to Project

Seismicity monitoring will be used to verify that project activities do not result in induced seismicity. Pulse neutron logs will be used to verify that injection well cement seals remain bonded to the well casing and provide a seal between the receiving reservoir and any confining units within the AoR.

If used for the Caliche Beaumont Sequestration Project, VSPs, especially "walk-away" VSPs, can be used to track changes in the CO_2 plume migration in the subsurface. Processing and comparing subsequent VSPs to the baseline VSP run in IZ monitoring or injection well(s), will allow project managers to monitor plume growth, as well as to ensure that the plume does not move outside of the intended Storage Complex. Numerical modeling will be used to predict the CO_2 plume growth and migration over time by combining the processed seismic data with the existing geologic model. The pressure data collected from IZ monitoring wells will also be used in numerical modeling to predict the plume and pressure front behavior and confirm the plume stage within the AoR.

B.9.c. Acceptance Criteria

Industry standard geotechnical practices will be utilized to ensure that data are collected and interpreted in a consistent manner. Tolerable repeatability guidelines will be established following completion of baseline surveys following selection of the geophysical subcontractor(s) and verification of specific logging equipment.

Similar ground conditions, "walk-away" VSP vertical sections, and similar receiver and source setups will be used from VSP to VSP to ensure consistency of measurements. Preference will be given to the same contractor for repeat surveys, to further increase consistency.

When processing the seismic data gathered during the acquisition of each VSP, several quality assurance checks will be performed in accordance with industry standards, including amplitude compensation, predictive deconvolution, elevation statics correction, root mean square (RMS) amplitude gain, normal move out (NMO) application using picked velocities, random noise attenuation, and instantaneous gain.

B.9.d. Resources/Facilities Needed

Caliche CCS will subcontract qualified specialty services and provide the necessary resources for completion of all required project monitoring programs.

B.9.e. Validity Limits and Operating Conditions

Third party verification will be conducted as needed between subcontractors and oversight personnel to ensure that all data and interpretations are performed on a consistent basis in accordance with applicable industry standards.

B.10. Data Management

B.10.a. Data Management Scheme

Caliche or a designated contractor/consultant will maintain a project database housing all project monitoring data as required by permit. The database will be housed on secure servers and backed up on a regular basis to ensure that data loss/corruption does not occur.

B.10.b. Recordkeeping and Tracking Practices

All monitoring data and project records will be securely held and properly labeled and organized for auditing and data evaluation purposes.

B.10.c. Data Handling Equipment/Procedures

All server equipment will be maintained and operated by Caliche or a designated contractor/consultant. The project database will be constructed and maintained to interface with data analysis/modeling software to support reporting as required by the project permit.

B.10.d. Responsibility

The Caliche designated project manager(s) will be responsible for data management procedures internally or externally through designated contractors/consultants.

B.10.e. Data Archival and Retrieval

All project data will be owned/housed by Caliche, or a designated contractor/consultant as described above in Section B.10.a.

B.10.f. Hardware and Software Configurations

Caliche and/or designated contractors/consultants will ensure that all project hardware/software is configured for data management and analysis in accordance with permit requirements.

B.10.g. Checklists and Forms

Checklists and forms will be developed following issuance of a Draft UIC permit and updated as necessary.

C. ASSESSMENT AND OVERSIGHT

C.1. Assessments and Response Actions

C.1.a. Activities to be Conducted

Monitoring activities are summarized in **Table E.1.A.1**, including groundwater, atmospheric, ecosystem stress, and soil gas. The sampling frequencies and schedules are discussed in the T&M plan (see *Module E.1*) and Post-Injection Site Care and Site Closure Plan (see *Module E.3*). Each sample result will be evaluated for quality control criteria as outlined in Section B.5. Any results failing the quality control check will be re-analyzed within analytical hold time or recollected if necessary.

C.1.b. Responsibility for Conducting Assessments

Data assessments will be conducted by the consultants/contractors collecting the data and will be verified by Caliche. “Stop work” orders for data collection for quality assurance or health and safety purposes will be managed internally by each consultant/contractor or by the facility operator(s), if applicable.

The requirements for evaluating the analytical methods are described in Section B.4.c and assessment of the effectiveness of any corrective actions is described in Section B.4.c for the collection of soil and soil gas samples during the testing and monitoring periods of the BRP.

C.1.c. Assessment Reporting

Assessment information will be reported by field staff to the project managers of any organizations working on the project for Caliche as discussed in Section A.1.a/b.

C.1.d. Corrective Action

Corrective actions within an individual organization will be handled within that organization by their staff and project manager(s). Communication between organizations will be conducted as needed if issues are identified which may affect the project or the goals/activities of other organizations. Corrective actions may require participation and collaboration from multiple personnel across multiple organizations related to multi-media monitoring. Caliche will coordinate consultants/contractors or third-parties, as needed.

C.2. Reports to Management

C.2.a/b. QA status Reports

Quality assurance status reports are not anticipated to be needed; however, the QASP may be modified as necessary if there are changes in analytical methods or monitoring locations. Any revised documentation will be provided to the Project distribution list identified at the beginning of this document.

D. DATA VALIDATION AND USABILITY

D.1. Data Review, Verification, and Validation

D.1.a. Criteria for Accepting, Rejecting, or Qualifying Data

CO_2 stream, corrosion coupon, groundwater and soil gas data validation will include review of sample results, concentration units, holding times, and review of laboratory quality assurance data including duplicate samples, blanks, continuing calibration and verification samples, and laboratory control samples. The project database containing sample results will be used to streamline data validation where possible. Reporting frequencies will be based upon the conditions of the approved UIC permit and in accordance with Section A.6 of this QASP. Sample results will be presented in tabular and graphical format to aid in the identification of any trends or outlier results.

The selected laboratories will be responsible for conducting internal data review and validation before reporting to Caliche or sampling contractors. The laboratory review and validation process will be conducted in accordance with standard practices, method specific SOPs, or accreditation agency requirements, and will include a multi-level process to assure the integrity and validity of the data generated.

D.2. Verification and Validation Methods

D.2.a. Data Verification and Validation Processes

Data verification and validation will be performed in accordance with Sections B.5 and D.1.a. Appropriate software consistent with USEPA guidelines (EPA, 2009), such as USEPA's ProUCL or similar may be used for any statistical analyses.

D.2.b. Data Verification and Validation Responsibility

Caliche or a designated contractor/consultant will perform data validation for any samples submitted for analysis at a laboratory.

Additionally, Caliche may subcontract a third-party company to conduct an independent data validation of part or complete set of data generated of the Caliche Beaumont Sequestration Project using the data packages received from the selected laboratories. The third-party data validation vendor may qualify the concentration results based on their evaluation of the laboratory report components (e.g., sample results and raw data, calibration results, reporting limits, etc.) as follows:

- Acceptable for use without restriction
- Qualified as an estimated value with a "J"
- Qualified as not detected with a "UJ"
- Rejected as unusable for the intended use with an "R"

D.2.c. Issue Resolution Process and Responsibility

Caliche and their designated consultants/contractors will oversee/perform any physical sample collection as well as any data management or assessment activities. Technical staff completing sample collection or data analysis will be responsible for identifying and resolving issues that may arise.

D.2.d. Checklist, Forms, and Calculations

Checklists, forms, and calculation sheets will be developed to meet any specific UIC permit requirements.

D.3. Reconciliation with User Requirements

D.3.a. Evaluation of Data Uncertainty

Appropriate software consistent with USEPA guidelines (EPA, 2009), such as USEPA's ProUCL or similar will be used to evaluate data uncertainty associated with analytical results.

D.3.b. Data Limitations Reporting

The project managers of each organization involved in the Caliche Beaumont Sequestration Project (e.g., sampling contractors, laboratories and data validation company) will be responsible for ensuring that data developed by their respective organizations is presented with the appropriate data-use limitations.

Caliche will use the operating procedures described in this document for utilizing, sharing, and presenting results and/or data for this project. The procedures have been developed to ensure quality and internal consistency and facilitate tracking and record keeping of data end users and associated publications and reporting, as well as compliance with 40 CFR §146.90(h).

E. CITED REFERENCES

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APPENDIX E.1.B

Appendix E.1.B.1 Proposed Completion Well Schematics: In Zone Monitoring Well

Appendix E.1.B.2 Proposed Completion Well Schematics: Above Confining Zone Monitoring Well

Appendix E.1.B.3 Proposed Completion Well Schematics: USDW Monitoring Well

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

APPENDIX E.1.C

Example of Chain of Custody

GSI ENVIRONMENTAL

CHAIN-OF-CUSTODY RECORD
Date:__________________
Page ______ of ______

FROM: GSI Environmental Inc. 2211 Norfolk Suite 1000 Houston, Texas 77098 713 522 6300	PROJECT NAME: PROJECT CONTACT: GLOBAL ID:	PROJECT NO.: LAB CONTACT: SAMPLER(S): (PRINT)
TEL:	E-MAIL:	
LABORATORY:		

TURNAROUND TIME: ☐ SAME DAY ☐ 24 HR ☐ 48 HR ☐ 72 HR ☐ 5 DAYS ☐ STANDARD

SPECIAL INSTRUCTIONS:

REQUESTED ANALYSES

Please check box or fill in blank as needed.

LAB USE ONLY	SAMPLE ID	SAMPLING DATE	SAMPLING TIME	MATRIX	NO. OF CONT.	Unpreserved	Preserved	Field Filtered																						

Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Received by: (Signature)	Date:	Time: