7.0 TESTING AND MONITORING PLAN
40 CFR 146.90

CAPIO MOUNTAINEER SEQUESTRATION PROJECT

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Well name:	MCCLINTIC SEQUESTRATION 001
Well location:	MASON COUNTY, WEST VIRGINIA Latitude: [redacted] Longitude: [redacted]

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7.0 Testing and Monitoring Plan

7.1 Overall Strategy and Approach for Testing and Monitoring

This Testing and Monitoring Plan describes how Fidelis, LLC's ("Fidelis") will monitor the Capio Mountaineer Sequestration project site pursuant to 40 CFR 146.90.

The Testing and Monitoring Plan has been developed in conjunction with the project risk assessment to reduce the risks associated with carbon dioxide (CO_2) injection into the subsurface at this site. Goals of the monitoring strategy include:

- Meeting the regulatory requirements of 40 CFR 146.90
- Protecting underground sources of drinking water (USDWs)
- Ensuring that the injection well is operating as planned.
- Providing data to validate and calibrate the geological and dynamic models used to predict the distribution of CO_2 within the injection zone
- Support Area of Review (AoR) re-evaluations over the course of the project

The Testing and Monitoring Plan will be adaptive over time; the plan can be adjusted to respond:

- As project risks evolve over the course of the project
- If significant differences between the monitoring data and predicted dynamic modeling results are identified
- If key monitoring techniques indicate anomalous results related to well integrity or the loss of containment

Figure 7-1 illustrates the AoR at the end of the Post Injection Site Closure (PISC) period, the proposed location of the deep monitor well, the conceptual location of the above confining zone (ACZ) well, and the conceptual distribution of seismicity stations. **Figure 7-2** shows the prognosed stratigraphic column for injection well MCCLINTIC SEQUESTRATION 001 from data acquired in a nearby CO_2 sequestration pilot project at American Electric Power's (AEP's) Mountaineer plant, which had numerous wells drilled less than 10 miles northeast from the Capio Mountaineer Sequestration project location. The AoR and Corrective Action Plan, Permit Section 2.0 (40 CFR 146.84 (b)), describes the data and computational techniques used to model the development of the CO_2 plume during injection. It describes how the static earth model (SEM) was built, incorporating the site-specific data collected in the AEP 1 and AEP BA-02 wells (including wireline logs, sidewall, and whole cores). In addition, it explains how the data collected as part of this Testing and Monitoring Plan will be used to re-evaluate the AoR over the pre-operational and injection phases of the project (40 CFR 146.84 (e)).

Certain outcomes of the testing and monitoring activities described below may trigger action according to the Emergency and Remedial Response Plan, Permit Section 10.0 (40 CFR 146.94 (a)).

The Testing and Monitoring Plan will utilize several direct and indirect monitoring technologies throughout the injection and PISC phases of the project that will monitor:

- Daily activities of the injection operations
- Development of the CO_2 and pressure plumes in the storage formation over time
- Well integrity
- CO_2 or brine containment within the injection reservoir
- Groundwater quality in multiple aquifers, including the deepest USDW and the deepest water-bearing formation above the confining zone

Injection operations will be monitored through a range of continuous, daily, and quarterly techniques as detailed in the Well Operations Plan, Permit Section 6.0 (40 CFR 146.82(a)(8), 146.87). The water content and chemical composition of the CO_2 stream will be monitored post-dehydration at the capture facility (40 CFR 146.90 (a)). A corrosion coupon composed of the same material as the well components and CO_2-delivery pipeline will be placed in the delivery pipeline and analyzed on a quarterly basis for signs of corrosion and loss of mass that may be indicative of future potential well integrity issues (40 CFR 146.90 (c)).

Continuous recording devices will monitor injection pressure, temperature, and mass flowrate (40 CFR 146.90 (b)) near the wellhead. The injection mass flowrate will be directly measured at the surface to monitor the cumulative mass of injected CO_2 and ensure compliance with the permit injection limits. The storage formation injection volume will be calculated using the mass flowrate combined with the pressure and temperature conditions in the storage formation. The injection volumes will, in turn, be used to update the computational models at regular intervals throughout the injection phase of the project. The annular pressure between the tubing and the injection casing strings and the annular fluid volumes will also be monitored on a continuous basis (40 CFR 146.90 (b)). As with the previous data, these data will be linked to a Supervisory Control and Data Acquisition (SCADA) system to record the operations data, control injection rates, and initiate system shutdown, if required. The SCADA system can also be used to adjust the volume of annular fluid, and thereby pressure, in the annular space to meet the operational and regulatory objectives. Downhole pressure and temperature measurement devices are planned to be installed allowing real-time monitoring of storage formation pressures and temperatures.

[redacted]

Figure 7-1: Map of Capio Mountaineer Sequestration project, showing the proposed location of the deep monitor well (DMW), conceptual layout of the above confining zone well (ACZ), and seismicity stations relative to injector.

The well integrity of the injection and deep monitoring wells will be monitored using a range of internal and external mechanical integrity evaluation methods. Initially, a mechanical integrity test (MIT) will be performed on the injection well following the well completion to confirm internal integrity as per the Pre-Operations Testing Plan, Permit Section 5.0 (40 CFR 146.82(a)(8), 146.87). External mechanical integrity will be confirmed through annual temperature logging and compared to baseline temperature logging data to identify any deflections from the temperature gradient that could indicate fluid flow behind the casing (40 CFR 146.90 (e)). The same internal and external integrity evaluation methods used in the injection well will be used on the deep monitoring wells.

Pressure fall-off (PFO) tests will be conducted in the injection formation of the injection well to confirm the hydrogeologic characteristics of the storage formation (Permit Section 6.0). During the injection phase of the project, a PFO test will be conducted in the injection well at least once every five years. If there is an injection pressure increase of more than 10% over a period of one month, compared to the computational model, then a PFO test will be conducted sooner (40 CFR 146.90 (f)). The objective of the PFO testing is to periodically monitor for any changes in the near wellbore environment that would impact injectivity or cause injection pressures to increase. The formation characteristics obtained through the PFO testing will be compared to the results from previous tests to identify any changes over time and will be used to calibrate the computational models.

One above confining zone (ACZ) well will be drilled as part of the Testing and Monitoring Plan for the project (**Figure 7-1**). This well will be drilled to the top of the confining zone and will be adjacent to the injection well to monitor the aquifers above the confining layer. This well will be used for pressure and temperature monitoring as well as periodic fluid sampling in the deepest USDW (an independent deep groundwater well may be drilled for fluid sampling if it provides a more efficient sampling procedure). Potential CO_2 or brine migration into the deepest USDW will be initially identified through pressure changes in the formation and will be confirmed through aqueous geochemistry data and analysis of stable isotopes (Permit Section 5.0). If confirmed, this would trigger external well integrity testing of the injection and deep monitoring wells and may trigger the emergency response actions found in the Emergency and Remedial Response Plan (Permit Section 10.0).

[redacted]

Figure 7-2: Prognosed stratigraphic column for injection well from data acquired in offset wells.

Groundwater wells will be drilled to the depth of the predominant aquifer in the area (**Figure 7-1**). The groundwater monitoring program will be designed to address the preferential movement directions of both the primary aquifers and CO_2 plume, in addition to sensitive surface sites in the area. Additional groundwater wells will be drilled if further monitoring locations are required.

To establish a baseline of the seasonal variation in the aqueous geochemistry of these shallow groundwater wells, sampling will be conducted prior to the start of CO_2 injection. Throughout the injection and PISC phases of the project, the results of the aqueous geochemistry and stable isotope analyses will be compared to the baseline conditions for any indication of CO_2 or brine migration into the shallow groundwater aquifer. If indications of CO_2 or brine are found in the shallow groundwater aquifer, it will trigger the emergency response actions found in the Emergency and Remedial Response Plan (Permit Section 10.0).

Several indirect monitoring techniques will be deployed to monitor the development of the CO_2 plume and the associated pressure front through the injection and post-injection project phases (40 CFR 146.90 (g)). These techniques include distributed temperature sensing (DTS), pulsed neutron capture (PNC) logging and time-lapse distributed acoustic sensing (DAS) borehole seismic.

The deep monitoring well and ACZ, well will be equipped with FO cable for monitoring the well temperature profile using DTS, in real time on the outside of casing in the deepest USDW, the containment layer and storage formation, for monitoring during the pre-operational, injection, and PISC phases of the project (40 CFR 146.90 (g)). Downhole pressure sensors and DTS in the deep monitoring well and the ACZ well will also be used to measure pressure and temperature variations in the deepest USDW, the containment layer and the storage formation in the pre-operational, injection, and PISC phases of the project (40 CFR 146.90 (g)). The sensors will be real-time surface readout sensors connected and recorded through the SCADA system. The sensors will be programmed to measure and record pressure and temperature every minute and rolled up to daily data for storage.

The deep monitoring well will also be used to collect fluid samples from the storage formation to monitor for changes in the water chemistry over time and verify when the leading edge of the CO_2 plume reaches the well.

PNC logs will be acquired annually in the deep monitoring well and ACZ well to identify the intervals and concentration of CO_2 across the storage formation and primary confining zone, if any. The pressure and PNC log data will also be used to calibrate the dynamic modeling over the injection and PISC phases of the project.

FO cable deployed in the deep monitoring well, ACZ well, and injection well or wireline deployed geophones will be used to acquire time-lapse borehole seismic vertical seismic profile (VSP) data. These data will be used to qualitatively monitor the CO_2 plume development and calibrate the computational modeling results over time. The time-lapse borehole seismic VSP data will also be used to verify CO_2 containment within the storage formation. A robust deterministic seismic-forward modeling project will be undertaken to demonstrate that this technique can successfully detect subsurface changes associated with CO_2 injection at this site (Section 7.8.5).

Background seismic activity will be monitored continuously using a site-specific seismicity monitoring network designed to optimize the accuracy of the event locations and event magnitudes (Section 8.3). The location of individual stations within this network will be adjusted as required in response to monitoring results or future AoR re-evaluations.

The facility is in an area with low rates of seismic activity and risk (Permit Section .0). The primary goals of continuous background seismicity monitoring are:

- Addressing public and stakeholder concerns related to induced seismicity
- Monitoring the spatial extent of the pressure front from the distribution of seismic events
- Identifying activity that may indicate failure of the confining zone and possible containment loss

Table 7-1 presents the general schedule and spatial extent for the monitoring activities in the baseline and injection phases of the project. Refer to the PISC and Site Closure Plan (Permit Section 9.0) for discussion of the monitoring plans related to the PISC phase. Changes to the monitoring schedule may occur over time as the project evolves. For instance, if anomalous results are identified in the existing monitoring data, confirmation sampling will be conducted, and additional monitoring data may be acquired through subsequent investigations into the anomalous results. Likewise, if the CO_2 plume behaves in a stable and predictable manner for many years through the injection phase of the project, some monitoring may be reduced in frequency. Any such changes to the Testing and Monitoring Plan will be made in consultation with the Underground Injection Control (UIC) Program Director (40 CFR 146.90 (j)).

Monitoring Activity	**Baseline Data Frequency**	**Injection Phase Frequency**	**Location**	**Formation top / Depth Range (ft, MD)**
Assurance Monitoring:				
USDW Sampling	Quarterly	Quarterly	AoR Groundwater well network[1]	Producing zone
USDW Isotope Analysis	Biannually	Annually	AoR Groundwater well network[1]	0 – TD
Operational Monitoring:				
CO_2 Stream Analysis	NA	Quarterly	CO_2 Delivery Pipeline	NA
Corrosion Coupon Analysis	NA	Quarterly	CO_2 Delivery Pipeline	NA
Injection Pressure	NA	Continuous	Injection Wellhead	Surface
Mass Injection Rate	NA	Continuous	Injection Wellhead	Surface
Injection Volume (Calculated)	NA	Continuous	Storage Formation	Surface
Annular Pressure	NA	Continuous	Injection Well	Surface
Annular Fluid Volume	NA	Continuous	Injection Well	Surface
Temperature Measurement	Once	Annually	Injection Well	0 – TD
PFO Tests	Once	Every 5 years	Injection Well	Surface

Monitoring Activity	**Baseline Data Frequency**	**Injection Phase Frequency***	**Location**	**Formation top / Depth Range (ft, MD)**
Verification Monitoring:				
Fluid Sampling				
Deepest USDW Top confining zone Injection zone	Twice Twice Twice	Annually Annually Annually	ACZ well or independent groundwater well ACZ well Deep monitor well[2]	TBD TBD TBD
Isotope Analysis	Twice	Annually	ACZ Well	All samples
Pressure Sensors	Prior to injection			
Deepest USDW Top confining zone Injection zone	Continuous Continuous Continuous	Continuous Continuous Continuous	ACZ Well or independent groundwater well ACZ Well Deep monitor well Injection Well	TBD TBD TBD TBD
Temperature Sensors (DTS)	Prior to injection			
Deepest USDW Top confining zone Injection zone	Continuous Continuous Continuous	Continuous Continuous Continuous	ACZ Well ACZ Well Deep monitor well	TBD TBD TBD
PNC Logging				
Deepest USDW Top confining zone Injection zone	Once Once Once	Annually Annually Annually	ACZ Well ACZ Well Deep Monitor well	TBD TBD TBD
Microseismic Monitoring	Prior to injection	Continuous	Surface stations	TBD
Time-lapse Borehole Seismic VSP Data	Once	Every 5 years and as required	Surface Sources, downhole DAS	
[2] In-zone fluid sampling will be discontinued once CO_2 breakthrough occurs at the well				

Table 7-1: General schedule and spatial extent for the testing and monitoring activities for CCS project.

7.1.1 Quality Assurance Procedures

Data quality assurance and surveillance protocols adopted by the project have been designed to facilitate compliance with the requirements specified in 40 CFR 146.90 (k). Quality assurance (QA) requirements for direct measurements within the storage formation, above the confining zone, and within the shallow USDW aquifer are described in the Quality Assurance and Surveillance Plan (QASP) that is attached to this document (**Appendix 7.A)**. These measurements will be performed based on best industry practices and the QA protocols recommended by the service contractors selected to perform the work.

7.1.2 Reporting Procedures

Fidelis will report the results of all testing and monitoring activities to the EPA in compliance with the requirements under 40 CFR 146.91.

7.2 Carbon Dioxide Stream Analysis (40 CFR 146.90 (a))

Fidelis will analyze the CO_2 stream during the injection phase of the project to provide data representative of its chemical characteristics and to meet the requirements of 40 CFR 146.90 (a).

This section describes the measurements and sampling methodologies that will be used to monitor the chemical characteristics of the CO_2 injection stream.

7.2.1 Sampling Location and Frequency

Prior to injection, the CO_2 stream will be sampled during regular plant operations to obtain representative CO_2 samples that will serve as a baseline dataset.

7.2.2 Analytical Parameters

The CO_2 stream will be analyzed with sufficient frequency to yield data representative of its chemical and physical characteristics (40 CFR 146.90(a)). These characteristics include fluid composition (i.e., fraction of CO_2 and other constituents measured on a volumetric or mass basis at a known temperature and pressure), temperature, and pressure, as well as additional parameters that may be used for understanding potential interactions between the injectate and the formation.

The primary purpose of analyzing the CO_2 stream is to evaluate the potential interactions of CO_2 and/or other constituents of the injectate with formation solids and fluids. This analysis can also identify (or rule out) potential interactions with well materials.

Additionally, monitoring the chemical and physical characteristics of the CO_2 (e.g., isotopic signature, other constituents) may help distinguish the injectate from the native fluids and gases in case of a leak. Injectate monitoring is required at a sufficient frequency to detect changes to any physical and chemical properties that may result in a deviation from the permitted specifications (Project Narrative Section 1.1.4).

7.2.3 Sampling Method – CO_2 Injection Stream Gases

Collected samples of the CO_2 stream will be obtained for analysis of the components present in the injection stream. Samples of the CO_2 stream will be collected at a location in the system where the material is representative of the material injected (i.e., between the dehydration system and the injection well; commonly at the injection skid near the wellhead), using a ¼-inch sampling port in the flowline which are standard fitting sizes on double-ended sample cylinders provided by any nationally accredited environmental laboratory (**Figure 7-3**). Quick-connect fittings are attached to the cylinder's ¼-inch national pipe thread (NPT) fittings, and the cylinder is easily connected into the system. The CO_2 stream flows from the pipeline by opening a ball valve, through a pressure reducer, into the cylinder. The pressure regulator will reduce the pressure of the CO_2 stream to approximately 250 psi so that the CO_2 is in the gaseous state when collected rather than a super-critical liquid. The three-way valve upstream from the cylinder allows for greater control of the pressure in the system. Cylinders will be purged with sample gas (i.e., CO_2) at least five times prior to sample collection to remove laboratory-added helium gas and ensure a representative sample. During purging, the outlet of the sample cylinder will be connected to a ventilation line and vented to the atmosphere. Proper sampling technique is critical for any gas analysis program. Therefore, great care will be taken to ensure that the cylinder is not contaminated by atmospheric gas and the sample is representative of the CO_2 in the pipeline. A standard sampling procedure is shown below in **Figure 7-4**. Samples will be shipped to the lab after collection in accordance with the standard operating procedures (SOPs) found in Section B2 of the QASP (**Appendix 7.A**). Further details related to sampling methods can be found in Section B2 of the QASP.

Figure 7-3: Example of double-ended sample cylinder (Atlantic Analytical Laboratory, 2021).

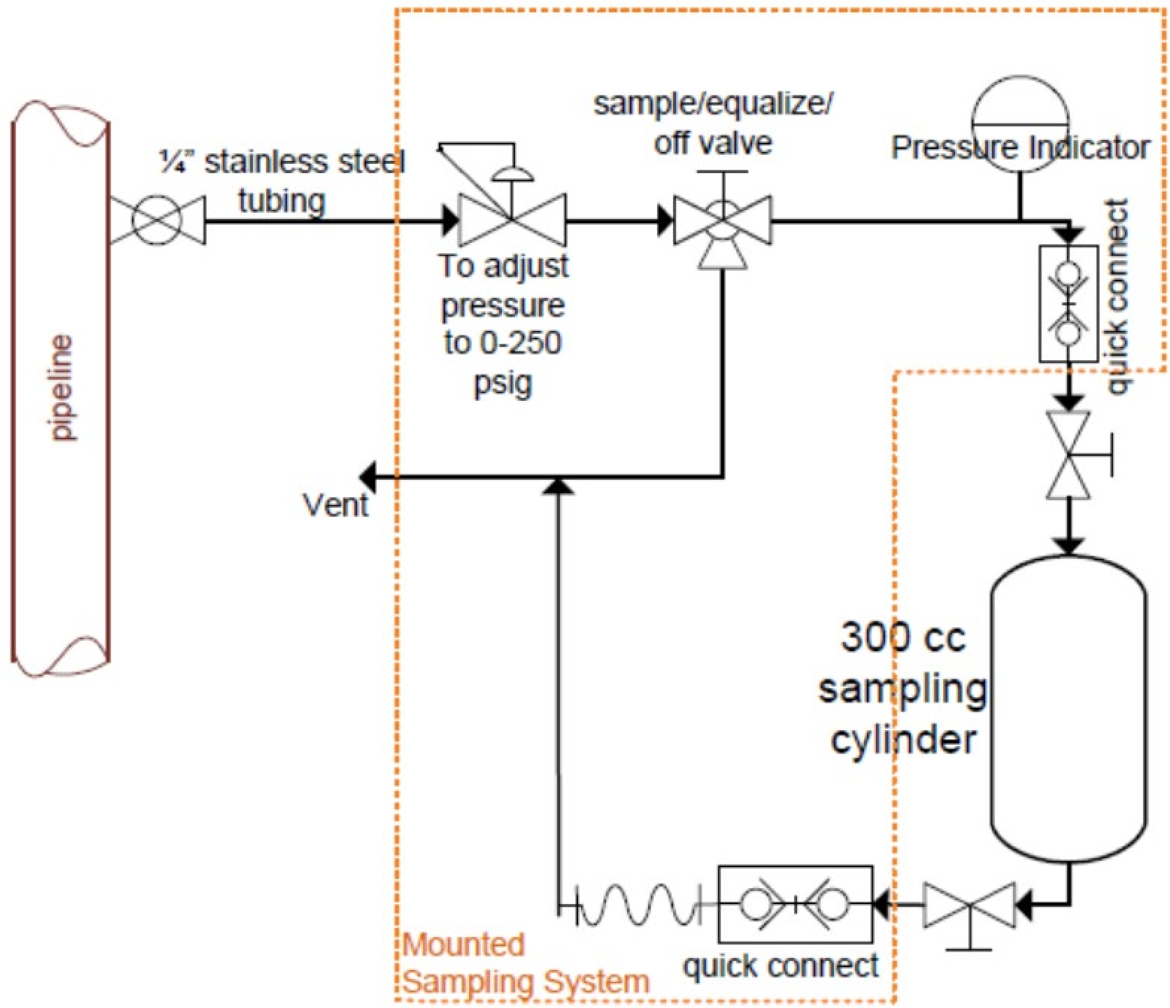

Figure 7-4: Schematic of gas sampling system using a high-pressure cylinder (Atlantic Analytical Laboratory, 2021).

7.2.4 Laboratory to be Used/Chain of Custody and Analysis Procedures

A nationally accredited environmental laboratory will analyze the CO_2 stream samples. The third-party laboratory will follow standard sample handling and chain-of-custody guidance (EPA 540-R-09-03, or equivalent). Details can be found in the QASP (Appendix 7.A).

7.3 Continuous Recording of Operational Parameters (40 CFR 146.88 (e)(1), 146.89 (b), and 146.90(b))

Fidelis will install and use continuous recording devices to monitor injection pressure, mass injection rate, and volume (calculated); the pressure on the annulus between the tubing and the production casing; the annulus fluid volume added; and the temperature of the CO_2 stream, as required at 40 CFR 146.88 (e)(1), 146.89 (b), and 146.90 (b). The details are described in the following sections.

7.3.1 Monitoring Location and Frequency

Fidelis will perform the activities identified in **Table 7-2** to monitor operational parameters and verify internal mechanical integrity of the injection well. All monitoring will take place at the locations and frequencies shown in **Table 7-2**. All of the data recorded on a continuous basis will be connected to the main facility Control Room through a SCADA system. The hourly average value of the parameter being continuously monitored and logged shall be recorded for purposes of reporting. If the electronic data logging system is out of service, field monitoring of manual gauges and annulus pressure will be recorded at least twice per shift (i.e., every 4 hours) for periods when the injection well is operational.

Parameter	Device(s)	Location	Min. Sampling Frequency	Min. Recording Frequency
Injection pressure	Pressure Gauge	Injection wellsite	Every 1 min.	Hourly
Mass injection rate	Coriolis Meter	Injection wellsite	Every 10 sec.	Hourly
Annular pressure	Pressure Gauge	Injection wellsite	Every 1 min.	Hourly
Annulus fluid volume	Volume	Injection wellsite	Every 1 min.	Hourly
CO_2 stream temperature	Thermocouple	Injection wellsite	Every 1 min.	Hourly

Notes:

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

Table 7-2: Sampling devices, locations, and frequencies for continuous monitoring.

7.3.2 Monitoring Details

7.3.2.1 Continuous Recording of Injection Pressure

The CO_2 injection pressure will be monitored on a continuous basis near the wellhead to ensure that injection pressures do not exceed 90% of the fracture propagation pressure of the storage formation (40 CFR 146.88 (a)). Further details are found in the Well Operations Plan (Permit Section 6.0). If injection pressure exceeds 90% of the storage formation fracture pressure, then the injection process will be automatically shut down in accordance with the Well Operations Program.

Any anomalies outside of the normal operating specifications may indicate that an issue has occurred with the well, such as a loss of mechanical integrity or blockage in the tubing or may be caused by a change in injection flowrate. Anomalous pressure measurements would trigger the need for further investigation of the cause of the change (40 CFR 146.89 (b)). The wellhead injection pressure will also be used to calibrate the computational modeling throughout the injection phase of the project.

The wellhead pressure of the injected CO_2 will be continuously measured by an electronic pressure transducer with analog output mounted on the CO_2 line near the injection well. The transmitter will be electronically connected to the SCADA system and tied into the Control Building, which can shut down the system or change the flowrate depending on the pressures measured at the wellhead. The transducer will be calibrated prior to the start of injection operations, and annually thereafter.

7.3.2.2 Continuous Recording of Injection Mass Flowrate

The mass flowrate of CO_2 injected into the well will be measured by a Coriolis mass flow meter. This flow meter will be placed in the CO_2 delivery line near the wellhead. The meter will have an analog output (Endress & Hauser Promass-Q or F Series, Micro Motion Coriolis Flow and Density Meter Elite Series, or similar). Two flow meters will be supplied; this will provide one spare flow meter to allow for flow meter servicing and calibration. The flow meter will be connected to the SCADA system for continuous monitoring and control of the CO_2 injection rate into the well. Using two flow meters will allow confirmation of accurate flow measurements. The mass flow meters will be calibrated annually.

7.3.2.3 Injection Volume

The injection volume into the reservoir will be calculated on a continuous basis based on the injection mass and the pressure and temperature conditions in the storage formation. The volume calculated will be used in the computational models to determine storage formation capacity and flow.

7.3.2.4 Continuous Recording of Annular Tubing Pressure

As described in the Well Operation Plan (Permit Section 6.0), the pressure on the annulus between the injection tubing and the production casing will be measured by an electronic pressure transducer with analog output, such as a Endress & Hauser pressure transmitter (transducer), a Foxboro I/A Series® IAP20, or similar, that is mounted on the wing valve/annular fluid line connected to the wellhead of the injection well. The transmitter will be connected to the well control system and the SCADA system to allow regulation of the annular pressure.

Annular pressures are expected to vary up to 20% during normal operations due to atmospheric and CO_2 stream temperature fluctuations. The annular pressure gauge will be calibrated annually, and the transducer will be recalibrated according to the manufacturer's recommendations or replaced.

7.3.2.5 Continuous Recording of Annulus Fluid Volume

As described in the Well Operation Plan (Permit Section 6.0), the volume of the annulus fluid between the injection tubing and the production casing will be measured using the accumulator levels and the brine reservoir level on the well control system. The accumulator levels will be measured using a level transmitter (Endress & Hauser level device, a Temposonics linear-position sensor R-series Model RH or equivalent). The brine reservoir level will be measured using a level transmitter (Omega LVCN414 series or equivalent). The transmitters will be connected to the well control system and to the SCADA system; and tied into the facility Control Room.

The annular fluid volume is expected to fluctuate as atmospheric and injection stream temperatures change. These changes are expected to be most dramatic during startup and shutdown operations.

7.3.2.6 Continuous Recording of CO_2 Stream Temperature

The temperature of the CO_2 injection stream will be continuously measured using an electronic thermocouple. The thermocouple will be mounted in a temperature well in the CO_2 line at a location close to the pressure transmitter near the wellhead. The transmitter will be electronically connected to the SCADA system. The transmitter will be calibrated prior to the start of injection operations and calibrated annually. The thermocouple for measuring surface injection temperature will be recalibrated annually or it will be replaced with a calibrated thermocouple.

7.3.2.7 Bottomhole Pressure and Temperature

Bottomhole pressure and temperature will be monitored prior to and during injection. These data will be used with the mass flowrate to calculate the volume injection rate of the CO_2 into the reservoir.

7.4 Corrosion Monitoring (40 CFR 146.90 (c))

To meet the requirements of 40 CFR 146.90 (c), well materials (**Table 7-3**) and components will be monitored during the operational period for loss of mass, thickness, cracking, pitting, and other signs of corrosion to ensure that the well components meet the minimum standards for material strength and performance. This section presents the procedures that will be followed to monitor the corrosion of well materials used in the casing and tubing. For Class VI injection wells, corrosion monitoring of the well materials is required on a quarterly basis (40 CFR 146.90 (c)).

7.4.1 Monitoring Location and Frequency

The corrosion coupon will be retrieved and analyzed quarterly after the start of injection. If the coupons show evidence of corrosion, the injection well itself will be assessed for signs of corrosion using well logging techniques such as multi-finger caliper logging or an ultrasonic casing evaluation tool.

Equipment Coupon	Material of Construction
Pipeline	Carbon Steel
Wellhead (non-flow-wetted)	Carbon Steel Alloy
Production Casing (top)	Carbon Steel
Production Casing (bottom)	13CR Steel Alloy
Flow-wetted surface equipment (Injection Tree)	Corrosion resistant material
Injection Tubing	Corrosion resistant material
Packer	Corrosion resistant material

Table 7-3: List of equipment coupon with material of construction.

7.4.2 Sample Description

The coupons will be made from the same materials as the production casing and tubing (**Table 7-3**). Prior to placement of the corrosion coupons in the CO_2 stream, they will be weighed and measured for thickness, width, and length as a baseline measurement.

7.4.3 Monitoring Details

Corrosion monitoring of well materials will be conducted using a coupon placed in the CO_2 pipeline (**Figure 7-5**). The coupon will be made of the same material as the production casing and other well and piping materials. The coupon will be removed quarterly and assessed for corrosion using American Society for Testing and Materials (ASTM) G1-03: Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens (ASTM, 2017). This method measures the corrosivity of steel to both aqueous and non-aqueous liquids. Upon removal, coupons will be inspected visually for evidence of corrosion, which may include pitting, cracking, and loss of mass or thickness. The weight and size (thickness, width, length) of the coupon will also be measured and recorded each time it is removed and compared to the baseline measurements. Corrosion rate will be calculated as the weight loss during the exposure period divided by the duration (i.e., weight loss method).

If data from the coupon monitoring suggest there is the potential for corrosion of the well materials, the injection well will be evaluated using wireline tools such as a multi-finger caliper or ultrasonic casing evaluation tool. The frequency of running these tubing and casing inspection logs will be contingent on the corrosion data from the coupon monitoring program. Wireline tools are lowered into the well to directly measure properties of the well casing that indicate corrosion. As the name implies, multi-finger wireline calipers have several fingers and are capable of recording information measured by each finger so that the data can be used to produce detailed three-dimensional (3D) images of the well. Ultrasonic wireline tools are capable of measuring wall thickness in addition to the inner diameter of the well tubular. Consequently, these tools can also provide information about the outer surface of the casing.

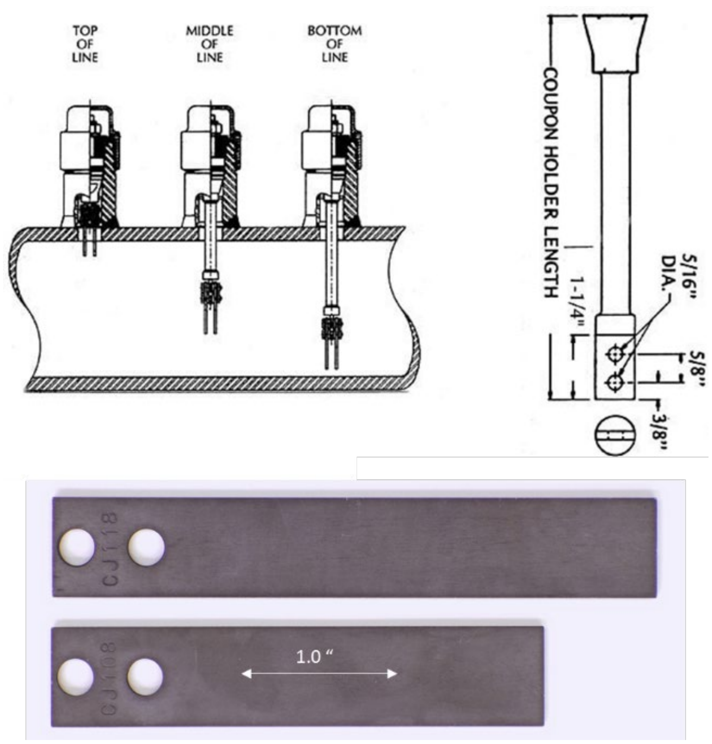

Figure 7-5: Type Corrosion coupon illustration in pipeline (top), types of coupons to be used for corrosion monitoring (below) (Cosasco, 2021).

7.5 Above Confining Zone Monitoring (40 CFR 146.90 (d))

Fidelis will monitor groundwater quality and geochemical conditions of the USDW and above/near the confining zone during the operational period to meet the requirements of 40 CFR 146.90 (d).

7.5.1 Monitoring Location and Frequency

In addition to the shallow groundwater wells, a deep well will be drilled terminating above the confining zone as part of the Testing and Monitoring Plan for the project. This ACZ well will be drilled adjacent to the injection well to primarily monitor for any CO_2 leakage or brine migration into the deepest USDW, as well any early warning of CO_2 leakage into permeable zones immediately above the primary confining zone.

Table 7-4 shows the proposed deep ACZ monitoring methods, depths, and frequencies. In addition to the data collected for the Pre-Operational Testing Program (Permit Section 5.0), fluids from the deepest USDW and the top of the confining zone will be sampled twice prior to the start of CO_2 injection to determine if there is any natural variability in the fluids in these formations.

Baseline shallow groundwater samples will be collected from the proposed groundwater well network within the AoR (**Figure 7-1**.) on a quarterly schedule starting prior to the start of injection to characterize the seasonal variations in shallow groundwater quality within the AoR (40 CFR 146.90 (d)).

Target Formation	Monitoring Activity	Depth (ft, MD)	Baseline Frequency	Injection Phase Frequency
Shallow Groundwater Wells	Groundwater Geochemistry	0 - TD	Quarterly	Quarterly
Shallow Groundwater Wells	Stable Isotopes	0 - TD	Quarterly	Quarterly
ACZ well - deepest USDW	Pressure/ Temperature (DTS)	TBD	Continuous	Continuous (Every minute)
ACZ well - deepest USDW	Groundwater Geochemistry	TBD	Twice	Annually
ACZ well - top confining zone	Pressure/ Temperature (DTS)	TBD	Continuous	Continuous (Every minute)
ACZ well - top confining zone	Groundwater Geochemistry	TBD	Twice	Annually
ACZ well - top confining zone	Stable Isotopes	TBD	Twice	Annually

Table 7-4: Monitoring schedule for the ACZ and shallow groundwater monitoring wells during the pre-operational and injection phases of the project.

Migration of CO_2 or brine into aquifers above the confining zone will likely first be identified through pressure changes in the aquifers. An increasing pressure trend would suggest that leakage across the confining layer is occurring. While any increasing trend in pressure or temperature will be evaluated, an increase in pressure or temperature greater than 10% above baseline values will warrant additional monitoring and inspections to rule out the possibility of fluid leakage out of the storage formation. Such an increase in pressure or temperature would initiate more frequent fluid sampling and analysis for geochemical parameters from the aquifer with the pressure/temperature increase. An increase in pressures or temperature in one of the aquifers above the confining zone may also trigger additional external well integrity investigations in the injection or deep monitoring well.

The accumulation of CO_2 or brine in an overlying aquifer will likely result in the following changes:

- Aqueous geochemistry parameters such as pH and alkalinity
- Reaction of cements, mineral surface coatings, and clay particles with the CO_2 may liberate cations and anions into the aqueous phase
- Oxygen and carbon isotopes may be used to differentiate between existing CO_2 sources (if present) within the AoR and the injected CO_2

If anomalous changes in the aqueous geochemistry are observed in the ACZ monitoring zones, new samples will be obtained from the affected aquifer to verify the changes. The frequency with which fluid samples are obtained from each of the ACZ aquifers for analysis may be increased. As a precautionary measure, the fluid sampling frequency for the shallow groundwater monitoring wells may also be increased. If the injected CO_2 has a unique isotopic signature from the existing isotopes in the overlying aquifers, a new round of samples will be collected for isotopic analysis from the affected aquifer. Anomalous changes may also trigger the need for additional well integrity testing in both the deep monitoring well and the injection well to ensure that no well integrity issues have developed since the last set of external MITs.

7.5.2 Analytical Parameters

Table 7-5 identifies the geochemical parameters to be monitored and the analytical methods to be used on all fluid samples collected from the ACZ well, shallow groundwater wells, and the deep monitoring well. Fluid samples collected from these wells will be analyzed for cations, trace metals, anions, pH, alkalinity, TDS, density, dissolved inorganic carbon, and conductivity/resistivity. The cations, anions, TDS, density, and conductivity/resistivity provide details of the overall geochemistry of these aquifers. Changes in these parameters during the injection phase of the project may provide an indication of CO_2 or brine movement above the confining layer. While pH and alkalinity may be indicators of CO_2 migration above the confining layer, the dissolved inorganic carbon analysis could provide direct evidence of CO_2 migration into these formations. Stable isotopes of C (in dissolved inorganic carbon), O, and H may provide an indication of fluid or CO_2 migration into the deep ACZ aquifers and may also provide information about the origin of any migrating fluids. The presence of Carbon-14 may provide an indication of CO_2 migration into the deep ACZ aquifers as any naturally occurring Carbon-14 originally in these aquifers would have decayed long ago.

The relative benefit of each analytical measurement will be evaluated throughout the design and initial injection testing phase of the project to identify the analytes best suited to meeting project monitoring objectives under site-specific conditions. If some analytical measurements are shown to be of limited use, they will be removed from the analyte list and not carried forward through the operational phases of the project. Any modification to the parameter list in **Table 7-5** will be made in consultation with the UIC Program Director.

There are no plans to use tracers during operations. However, as the monitoring plan is designed to be adaptive as project risks evolve over time, this decision may be reassessed later.

Parameters	**Analytical Methods**
Cations (Na, Ca, Mg, Ba, Sr, Fe, K)	ASTM D1976
Anions (Cl, Br, SO_4)	ASTM D4327
pH	ASTM D1293
Alkalinity	ASTM D3875
Total Dissolved Solids (TDS)	ASTM D5907
Density	ASTM D4052
Dissolved Inorganic Carbon	ASTM D513-11
Conductivity/Resistivity	ASTM D1125
Stable Isotopes of C, O, and H	ASTM STP 573
Carbon-14	ASTM D6866

Table 7-5: Summary of analytical and field parameters for groundwater samples.

7.5.3 Monitoring and Sampling Methods

Pressure sensors will be placed on the outside of the casing of the ACZ well to allow continuous pressure measurements within the first permeable layer above the confining layer. The sensors will be real-time surface readout sensors connected and recorded through the SCADA system. The sensors will be programmed to measure and record pressure and temperature every minute and rolled up to daily data for storage. A pair of sensors will be used to limit the possibility of data loss. Continuous temperature measurements will be acquired using DTS located on the outside of the casing of the ACZ well.

For fluid sampling, a bailer or pump system will be used to collect the water samples. Prior to sample collection the well will be purged to remove stagnant water from the well and ensure representative water is collected from the formation. The amount of water that will be purged will be determined by the volume of water and/or field parameter stabilization. The fluid purged from the well will be monitored for field parameters, such as pH, specific conductance, and temperature, using a calibrated water quality meter (Horiba U-53, or similar). Once these parameters stabilize, it will be an indication that representative formation fluid is in the well at the time the sample is collected.

Preservation, preparation methods, container type, and holding times for the analyte classes are presented in **Table 7-6**. The analytical methods for the metals in solution require acidification with nitric acid, and the samples will be filtered. The remainder of the analyses do not require preparation or preservation other than chilling the samples. The samples will be collected in either glass or polyethylene bottles ranging in size from 50 milliliters (mL) to 1.5 liters (L). Hold times from the analytes range from 7 days for TDS to 1 year for the oxygen and hydrogen isotopes.

Parameters	Preservation/Preparation	Container	Holding Time
Total Metals by ICP Na, Ca, Mg, Ba, Sr, Fe, K	HNO_3 to pH<2, Filter 4-µm	1.5 L Poly	6 months
Anions Cl, Br, SO_4	Cool, 4±2°C, no chemical preservation	1 L Poly	28 days
pH	Cool, 4±2°C, no chemical preservation	1 L Poly	None
Alkalinity	Cool, 4±2°C, no chemical preservation	1 L Poly	28 days
Total Dissolved Solids	Cool, 4±2°C, no chemical preservation	1 L Poly	7 days
Specific Gravity	None	1 L Poly	None
Dissolved Inorganic Carbon	None	1 L Poly	7 days
H and O Stable Isotopes	None	50 mL Glass	1 year
C Stable Isotopes	Cool, 4±2°C, no chemical preservation	150 mL Poly	14 days
Carbon-14	Cool, 4±2°C, no chemical preservation	150 mL Poly	6 months

Table 7-6: Preservation methods, container type, and holding times for analyte classes.

7.5.4 Laboratory to be Used/Chain of Custody Procedures

The geochemical analyses will be performed by accredited laboratories. Samples will be tracked using appropriately formatted chain-of-custody forms. See the QASP for additional information (Appendix 7.A).

7.6 Mechanical Integrity Testing (MIT)

Demonstrating and maintaining the mechanical integrity of a well is a key aspect of protecting USDWs from possible endangerment due to injection activities.

7.6.1 Internal Mechanical Integrity Testing

Internal mechanical integrity refers to the integrity or seal within the production casing between the production casing, tubing, and packer. The quality of this seal can be confirmed with a MIT and annular pressure monitoring. Both methods will be used during the injection phase of this project to monitor and confirm internal mechanical integrity. **Table 7-7** presents the details for conducting the annular pressure MIT and the annular pressure monitoring.

Testing/Monitoring Method	Frequency	Location of Monitoring	Parameters Measured
Annular Pressure MIT	After completion or workover	Tubing/casing annulus	Ability to hold pressure testing
Annular Pressure Monitoring	Continuous	Tubing/casing annulus	Pressure, temperature, annular fluid volume

Table 7-7: Internal mechanical integrity monitoring details.

After the packer, tubing, and downhole equipment have been re-installed, the tubing/casing annulus will be filled with a corrosion-inhibited fluid, such as a potassium chloride (KCl) solution with additives. The temperature of the annular space will be allowed to stabilize, and an annular pressure MIT will be conducted to ensure that there are no leaks in the tubing, casing, or packer. This approach is also described in the Pre-Operation Testing Program (Permit Section 5.0). The annular pressure test will be performed by pumping additional fluid into the annulus to increase the pressure to a level that exceeds the maximum tubing injection pressure. The annular pressure will be monitored for a minimum of 30 minutes (EPA, 2008). A change in pressure less than 3% of applied surface pressure would indicate normal internal mechanical integrity. If a pressure loss greater than 3% is observed, the cause of the poor mechanical integrity will be identified and corrected. Following the annular pressure test, the annular pressure will be relieved by releasing the fluid to a vessel for volumetric measurement. The volume of the recovered liquid returned from the annulus is expected to be proportional to the volume of the annulus and the amount of pressurization.

The annular pressure test will be repeated any time the packer has been released, for instance, during well workovers. An annular pressure test may also be repeated if there is an indication of lost internal integrity.

In addition to the annular pressure MIT, the annular pressure will be continuously monitored throughout the injection period in conjunction with the annular pressure monitoring and control system to ensure internal mechanical integrity. Once injection commences, injection pressure, annular pressure, and annular fluid volumes will be monitored continuously to ensure that internal well integrity and proper annular pressure are maintained.

If a change in the annular pressure or annular fluid volume displays a change of greater than 20% from baseline conditions, the cause of the change will be investigated. Note that changes in the temperature of the injection stream can result in changes in the temperature of the annular space and variations in annular pressure. Initial investigations would focus on correlations between the temperature of the injection stream and the variations in annular pressure.

7.6.2 External Mechanical Integrity Testing (40 CFR 146.90 (e))

Fidelis will conduct external integrity testing annually to meet the requirements of 146.89(c) and 146.90(e).

7.6.2.1 Testing Location and Frequency

External mechanical integrity refers to the absence of fluid movement through channels between the production casing and the borehole or the intermediate casing string. Migration of fluids through this zone could result in contamination of USDWs; therefore, the external integrity of the injection well will be confirmed throughout the injection phase of the project.

Temperature measurements will be acquired in the injection well and deep monitoring well to ensure external mechanical integrity of the wells. A temperature profile will be acquired in both wells prior to injection which will serve as a baseline (**Table 7-8**).

Test	Well	Depth Range (ft, MD)	Schedule
Temperature Measurements	Injection	0 – TD	Continuous
	Deep monitor	0 – TD	Continuous
Oxygen Activation Log	Injection	0 – TD	As required
	Deep monitor	0 – TD	As required

Table 7-8: External mechanical integrity tests.

7.6.2.2 Testing Details

Temperature data acquired during injection will be compared to the baseline data to determine if there are any inconsistencies between the two datasets. If inconsistencies appear, the cause of the deviations will be investigated. An oxygen-activation log will be performed over the zone where the inconsistency was found to substantiate results of the temperature measurements, as warranted.

7.7 Pressure Fall-Off Testing (40 CFR 146.90 (f))

Fidelis will perform PFO tests during the injection phase as described below to meet the requirements of 40 CFR 146.90(f).

PFO testing involves the measurement and analysis of pressure data from a well after it has been shut in. PFO tests provide the following information:

- Confirmation of hydrogeologic reservoir properties such as injectivity and average effective permeability
- Formation damage (skin) near the wellbore, which can be used to diagnose the need for well remediation/rehabilitation
- Changes in reservoir performance over time, such as long-term pressure buildup in the storage formation that may indicate formation damage or a boundary condition
- Average reservoir pressure that can be used to calibrate modeled predictions of reservoir pressure to verify that the operation is responding as modeled/predicted

7.7.1 Testing Location and Frequency

PFO testing will be performed in the injection well once every five years during the injection operations. However, additional PFO testing may be performed opportunistically if the system is shut down for a maintenance event, and the fall-off data may be collected and analyzed by converting SCADA data to subsurface conditions. In addition, data from these opportunistic tests can be used to determine the duration of shut-in desired for the scheduled PFO testing. The scheduled PFO tests will likely be performed during scheduled shutdown events to prevent additional system downtime.

7.7.2 Testing Details

A PFO test has a period of injection followed by a period of shut in. The on-going injection at the well satisfies the needs so long as it has been relatively stable. The bottom-hole pressure is monitored and recorded for sufficient time during both phases of the testing to make a valid observation of the pressure fall-off curve. The optimal duration for the shut-in periods will be determined through the opportunistic PFO test completed prior to the first scheduled PFO. To reduce the wellbore storage effects attributable to the pipeline and surface equipment, the well will be shut in near the wellhead nearly instantaneously with direct coordination with the injection facility operator. A steady injection rate will be maintained for a minimum of one week prior to the PFO. Additional data from the month prior to shut in will also be included in the analysis of the PFO test. Downhole and near wellhead sensors will be used to record and monitor pressures during the injection period and the fall-off period. Specifications for the pressure sensors are provided in the QASP.

Reservoir pressures will be measured to capture the change in bottom-hole pressure throughout the test period; this includes the rapidly changing pressures immediately following cessation of injection. The fall-off period will continue until radial flow conditions are observed as indicated by stabilization of the surface pressure and the plateau of the pressure derivative curve. The PFO test may also be truncated if boundary effects are encountered or if radial flow conditions are not observed. In addition to the radial flow regime, other flow regimes may be observed from the PFO test including spherical flow, linear flow, and fracture flow. The shut-in period of the PFO test is expected to last at least five days, but data collected during the opportunistic PFO test will be used to assess the duration of this phase of the test. Analysis of PFO test data will be done using transient-pressure analysis techniques that are consistent with EPA guidance for conducting PFO tests (EPA, 1998, 2002).

Pressure gauges that are used for the purpose of the PFO test will be calibrated according to the recommendations of the manufacturer and current calibration certificates will be provided with the test results to EPA.

A report containing the PFO data and interpretation of the reservoir ambient pressure within the radius of investigation will be submitted to the permitting agency within 90 days of the test.

7.8 Carbon Dioxide Plume and Pressure Front Tracking (40 CFR 146.90 (g))

Fidelis will employ direct and indirect methods to track the extent of the CO_2 plume and the presence or absence of elevated pressure during the operation period to meet the requirements of 40 CFR 146.90 (g).

7.8.1 Plume Monitoring Location and Frequency

Table 7-9 presents a summary of the methods that will be used to monitor the location of the CO_2 plume, including the activities, locations, and frequencies. The parameters to be analyzed as part of fluid sampling in the injection zone and associated analytical methods are presented in **Table 7-4**. The corresponding QA procedures for these methods are presented in the QASP.

Fluid samples will be obtained for analysis from the injection intervals in accordance with the Pre-Operational Testing Plan. The final sampling interval will be determined after the injection well has been drilled and the well logs have been analyzed.

PNC logs will be used to identify differences in reservoir fluids near the wells and will be used to aid in monitoring the migration of the injected CO_2. PNC logs operate by generating a pulse of high energy neutrons, subsequently measuring the neutron decay over time and across a wide energy spectrum (Conner et al., 2017).

Baseline PNC logs will be acquired in the deep and ACZ monitoring wells prior to the start of CO_2 injection and annually during injection.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Direct Plume Monitoring				
Injection formation	Fluid sampling	Deep monitor	TBD	Twice / year until CO_2 breakthrough
Indirect Plume Monitoring				
Deepest USDW Top confining zone Injection formation	DTS	Deep monitor ACZ	Well	Continuous
Confining layer Injection formation	Time-lapse borehole seismic VSP. Sparse 2D or nodal seismic as required	Surface	Over project AoR	Every 5 years or as required.
Deepest USDW Top confining zone Injection formation	PNC logging	Deep monitor ACZ	TBD	Annually

Table 7-9: CO_2 plume monitoring activities.

Time-lapse borehole seismic VSP is proposed as the primary indirect technique to monitor the development of the CO_2 plume during and after injection. FO cables in the deep monitoring, and ACZ wells will be utilized for distributed acoustic sensing (DAS) to map the development of the CO_2 plume. During the latter stages of the injection period the subsurface coverage achievable using borehole seismic VSP may not be sufficient to adequately map the development of the CO_2 plume. In this case the VSP data will be supplemented with a sparse 2D seismic of nodal acquisition program. Detailed seismic modeling will be completed using data acquired in the injection well to establish the full extent of the required seismic monitoring program and pre-injection baseline surveys will be acquired.

No phased or adaptive monitoring has been planned for the project in terms of expanding the monitoring network. However, if the AoR is reassessed over the injection phase of the project, the Testing and Monitoring Plan will also be reassessed.

7.8.2 Plume Monitoring Details

As CO_2 is injected into the formation, the geochemistry of the fluids and C, O, and H isotopes are expected to change. Geochemical modelling will be used to predict the geochemical changes to the injection formation fluids once data from the Pre-Operational Testing have been analyzed. The results of the geochemical and isotope analysis will be delivered in the form of laboratory reports. Section 7.5 of this document details the sampling procedures that will be used. **Table 7-5** summarizes the analytical and field parameters for the fluid sampling and **Table 7-6** summarizes the methods, containers, and preparation methods for the fluid sampling. Further information can also be found in the QASP (Appendix 7.A).

PNC logging will be used to monitor the distribution and saturation of CO_2 adjacent to the wellbores in the ACZ and deep monitoring wells. The PNC logs will be acquired through the top of the confining layer to confirm the absence of CO_2 accumulations along the wellbore above the confining layer.

Technical details on PNC logging tools can be found in the QASP (Appendix 7.A).

The results of the geochemical and isotope analysis, PNC logging, and time-lapse borehole seismic VSP data will all be integrated to develop a comprehensive understanding of the CO_2 plume development over time. PNC logging and time-lapse borehole seismic VSP data can be incorporated into the SEM for comparison to the computational modelling predictions at different points in time. The data can be used to constrain the computational modelling results and produce better plume predictions over the course of the project.

If the CO_2 plume monitoring data diverge significantly from the modelled plume predictions, it may result in a reassessment of the AoR as per the AoR and Corrective Action Plan.

7.8.3 Pressure-Front Monitoring Location and Frequency

Table 7-10 presents the methods that Fidelis will use to monitor the position of the pressure front, including the activities, locations, and frequencies. QA procedures for these methods are presented in the QASP.

Pressure sensors will be placed on the outside of the casing of the deep monitoring and ACZ wells to allow continuous pressure measurements within the injection zone and first permeable layer above the confining layer. The sensors will be real-time surface readout sensors connected and recorded through the SCADA system. The sensors will be programmed to measure and record pressure and temperature every minute and rolled up to daily data for storage. A pair of sensors will be used to limit the possibility of data loss.

Target Formation	Monitoring Activity	Monitoring Location(s)	Spatial Coverage	Frequency
Direct pressure front monitoring				
Injection formation	Pressure Monitoring	Deep Monitor Well	TBD	Continuous
Indirect pressure front monitoring				
Confining zone & Injection formation	Microseismic Monitoring	Surface Stations	TBD through modelling	Continuous

Table 7-10: Pressure plume monitoring activities

Microseismic data will be recorded from a surface-based network of sensors on a continuous basis. These data will be sent to a cloud-based service via a cellular connection for data processing and archiving. Baseline microseismic data will be acquired prior to the start of injection operations.

No phased or adaptive monitoring has been planned for the project in terms of expanding the monitoring network. However, if the AoR is reassessed over the injection phase of the project, the Testing and Monitoring Plan will be reassessed (Permit Section 7.0).

7.8.4 Pressure-Front Monitoring Details

Pressure sensors will be placed on the casing of the deep monitoring well to monitor the pressures in the injection formation (**Table 7-10**). The sensors will be real-time surface readout sensors connected and recorded through the SCADA system. The sensors will be programmed to measure and record pressure and temperature every minute and rolled up to daily data for storage Refer to the QASP for technical information on the potential pressure sensors (Appendix 7.A).

The pressure data will be stored as time-stamped data pairs. The pressures in the injection interval will begin to increase once injection operations begin. These data will be used to calibrate the computational modelling results over the injection and PISC phases of the project. Calibrating the computational model with pressure and temperature data from the storage formation will lead to more accurate predictions of pressure plume behavior over time. The AoR and Corrective Action Plan further describes how the pressure and temperature data will be used to calibrate the computational modelling, and how it might be used to trigger an early reassessment of the AoR (Permit Section 2.0).

The proposed microseismic monitoring array will have multiple surface stations. The number and physical locations of these stations will be determined using a network design process. Each standalone station will likely consist of a seismometer, digitizer, solar panel with battery backup, and a cell modem/ antenna. Triggered data will be processed to provide event magnitude and location information, and results will be reviewed by a data processor and event data will be received by the project daily. The event locations will be incorporated in the SEM. Microseismic activity will provide qualitative information on the spatial extent of pressure plume over time. The USGS seismographic monitoring array was analyzed for the possibility of improving the proposed microseismic monitoring array, but no suitable seismographic stations were found.

7.9 Surface Air Monitoring and/or Soil Gas Monitoring (40 CFR 146.90 (h))

The UIC Director may require surface air monitoring and/or soil gas monitoring to detect movement of CO_2 that could endanger a USDW.

7.10 Additional Monitoring (40 CFR 146.90 (i))

The UIC Director may require additional monitoring, necessary to support, upgrade, and improve computational modeling of the AoR as required under 40 CFR146.84(c) and 40 CFR144.12.

7.11 Testing and Monitoring Plan Review (40 CFR 146.90 (j))

Fidelis shall periodically review the Testing and Monitoring Plan to incorporate monitoring data collected under this subpart, operational data collected as part of injection operations (40 CFR 146.88), and the most recent AoR reevaluation performed (40 CFR 146.84). In no case shall Fidelis review the Testing and Monitoring Plan less often than once every five years. Based on this review, Fidelis, LLC shall submit an amended Testing and Monitoring Plan or demonstrate to the UIC Director that no amendment to the Testing and Monitoring Plan is needed. Any amendments to the Testing and Monitoring Plan must be approved by the UIC Director, must be incorporated into the permit, and are subject to the permit modification requirements pursuant to 40 CFR 144.39 or 40 CFR 144.41, as appropriate. Amended plans or demonstrations shall be submitted to the UIC Director as follows:

(1) Within one year of an AoR reevaluation

(2) Following any significant changes to the project, such as addition of monitoring wells or newly permitted injection wells within the AoR, on a schedule determined by the UIC Director

(3) When required by the UIC Director.

7.12 References

American Society of Testing and Materials, 2017. Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens, G1-03. 9 p.

Atlantic Analytical Laboratory, 2021. https://atlanticanalytical.com/

Calvert, R., 2005, Insights and methods for 4D reservoir monitoring and characterization: SEG, EAGE/SEG Distinguished Instructor Short Course, no. 8.

Conner, A. et al. Developing Best Practices for Evaluating Fluid Saturations with Pulsed Neutron Capture Logging Across Multiple Active CO_2-EOR Fields, Energy Procedia, Volume 114, 2017, Pages 3636-3648, ISSN 1876-6102.

Cosasco, 2021. https://www.cosasco.com/

EPA (United States Environmental Protection Agency). 2002. "UIC Pressure Falloff Testing Guideline." EPA Region 6, August 8, Third Revision; http://www.epa.gov/region6/water/ swp/uic/guideline.pdf.

EPA (United States Environmental Protection Agency). 2008. "Determination of Mechanical Integrity of Injection Wells." EPA Region 5, February, https://www.epa.gov/sites/default/files/2015-09/documents/r5-deepwell-guidance5-determation-mechanical-integrity-200802.pdf

EPA (United States Environmental Protection Agency), 2011. Contract Laboratory Program Guidance for Field Samplers, EPA 540-R-09-03. 84 p.

EPA (United States Environmental Protection Agency), 2013. Geologic Sequestration of Carbon Dioxide: Underground Injection Control (UIC) Program Class VI Well Testing and Monitoring Guidance, EPA 816-R-13-001. 142 p.

Appendix 7.A Quality Assurance and Surveillance Plan

The Quality Assurance and Surveillance Plan is presented in a separate document accompanying this permit application.