ATTACHMENT K: QUALITY ASSURANCE AND SURVEILLANCE PLAN

Facility Information

Facility name:	Marquis Biocarbon Project MCI CCS 3
Facility address:	10000 Marquis Drive Hennepin, IL 61327
Well location:	S2, T32N, R2W 41.27026520° N, 89.30939322° W

This Quality Assurance and Surveillance Plan (QASP) describes the methods used to perform the activities listed in the Testing and Monitoring Plan (Attachment C) by Marquis Carbon Injection LLC for the Marquis Biocarbon Project site pursuant to 40 C.F.R. § 146.90(k) and per Section L and N of this permit. The performance of the Testing and Monitoring Plan will be shared between MCI and its designated subcontractor.

Results of the QASP activities described herein may trigger action according to the Emergency and Remedial Response Plan in Attachment F of this permit.

APPENDIX 7.A
QUALITY ASSURANCE AND SURVEILLANCE PLAN

MARQUIS BIOCARBON PROJECT

Facility Information

Facility name:	MARQUIS BIOCARBON PROJECT
Facility contact:	ELIZABETH STEINHOUR DIRECTOR OF ENVIRONMENTAL AFFAIRS 10000 MARQUIS DRIVE, HENNEPIN, IL 61327 815.925.7300 / BETHSTEINHOUR@MARQUISENERGY.COM
Well name:	MCI CCS 3
Well location:	PUTNAM COUNTY, ILLINOIS S2 T32N R2W Latitude: 41.27026520 N, Longitude: 89.30939322 W

This Quality Assurance and Surveillance Plan (QASP) is approved for use and implementation at Marquis Biocarbon Project. The signatures below denote the approval of this document and intent to abide by the procedures outlined within it.

Signature   Date

ELIZABETH STEINHOUR
DIRECTOR OF ENVIRONMENTAL
AFFAIRS

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Distribution List

The following project participants (**Table 7A-1**) will receive the completed Quality Assurance and Surveillance Plan (QASP) and all future updates for the duration of the project. The Marquis Carbon Injection LLC Director of Environmental Affairs will be responsible for ensuring that all of those on the distribution list receive the most current copy of the approved QASP. Names in bold are the primary points of contact with addresses listed below.

Name	Organization	Project Role (s)	Contact Information (email / telephone)
Elizabeth Steinhour	Marquis	Director of Environmental Affairs - Lead for Environmental and Quality personnel	bethsteinhour@marquisinc.com 815-925-7300
Trevor Davis	Marquis	Lead for Project Manager and MVA Task	trevordavis@marquisinc.com 217-440-7401

Table 7A-1: Distribution list.

A Project Management

A.1. Project/Task Organization

A.1.1 Key Individuals and Responsibilities

The project will be led by Marquis Carbon Injection LLC (MCI). MCI will retain the services of qualified subcontractors. The performance of the Testing and Monitoring Plan will be shared between MCI and our designated subcontractor. This QASP describes the methods used to perform the activities listed in the Testing and Monitoring Plan.

The key roles and responsibilities of the personnel involved in implementation of the Testing and Monitoring Plan are listed in **Table 7A-2**.

Role	Responsibility
Project Manager	The Project Manager (PM) plays a central role in the implementation of all data gathering and analysis for the Project and provides overall coordination and responsibility for all organizational and administrative aspects. The PM is responsible for the planning, funding, schedules, and controls needed to implement project plans and ensure that project participants adhere to the plan.
Quality Representative	The role of the Quality Representative (QR) is to identify quality-affecting processes and to monitor compliance with project requirements. The QR is responsible for establishing and maintaining the project quality assurance plans and monitoring project staff compliance with them. The QR is responsible for ensuring that this Quality Assurance and Surveillance Plan (QASP) meets the project's quality assurance requirements.
Monitoring, Verification, and Accounting Task Lead	Well testing and monitoring activities are the responsibility of the Monitoring, Verification, and Accounting (MVA) Task Lead. The MVA Task Lead is responsible for developing, maintaining, and updating all well testing and monitoring plans, including this QASP.
Subject Matter Experts (SMEs) /Subtask Task Leads	The role of these SMEs is to develop testing and monitoring plans, to collect environmental data specified in those plans using best practices, and to maintain and update those plans as needed. The SMEs, assisted by the MVA Task Lead, are responsible for planning, collecting, and ensuring the quality of testing and monitoring data and managing all necessary metadata and provenance for these data. The SMEs are also often responsible for data analysis, data products and acquisition of independent data quality/peer reviews. The SMEs will be involved in the project as needed. They will be qualified third party individuals.

Table 7A-2: Key individuals and responsibilities.

A.1.2 Independence from Project QA Manager and Data Gathering

To ensure quality assurance, the sample collection process, data analysis and processing will be performed or witnessed by independent third parties outside the management structure in most cases.

A.1.3 QA Project Plan Responsibility

MCI will be responsible for maintaining and distributing the official, approved QASP. MCI will periodically review this QASP and consult with EPA when changes to the plan are required.

A.1.4 Organizational Chart for Key Project Personnel

Figure 7A-1: Marquis Carbon Injection LLC project organization structure is set out below. As depicted, the figure shows the organizational structure of the Marquis BioCarbon project. MCI will provide a contact list of individuals fulfilling these roles to the UIC Program Director, if required. The project manager and Monitoring, Verification, and Accounting (MVA) task lead are part of the Project Development team, and the Environmental and Quality representatives are part of the Environmental team.

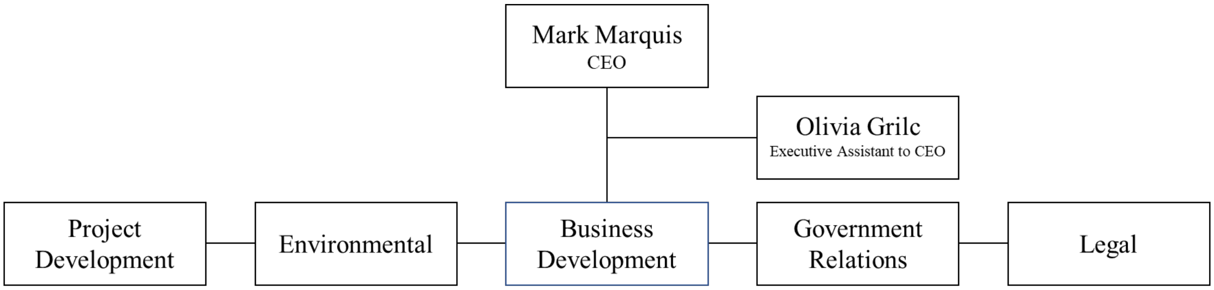


Figure 7A-1: Marquis Carbon Injection LLC project organization structure.

A.2. Problem Definition/Background

A.2.1 Reasoning

The goals of the Testing and Monitoring Plan (Permit Section 7.0) include:

- Protecting Underground Sources of Drinking Water (USDWs);
- Meeting the regulatory requirements of 40 Code of Federal Regulations (CFR) 146.90;
- 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 carbon dioxide (CO_2) within the injection zone; and

- Support Area of Review (AoR) re-evaluations over the course of the project.

These objectives will be met through the collection of pressure/temperature data within and above the storage formation, the collection of groundwater and fluid samples from shallow and deep monitoring wells, wireline logging techniques, pressure/temperature measurements in the tubing and annular space of the injection well and deep monitoring wells, sample collection/analysis of the injection stream, and geophysical monitoring.

This QASP was developed to ensure the quality standards of the Testing and Monitoring Plan to meet the requirements of the EPA Underground Injection Control (UIC) Program for Class VI wells.

A.2.2 Reasons for Initiating the Project

The objective of the Marquis BioCarbon Project is to safely and permanently store injected CO_2 in the Mt. Simon Sandstone. The Testing and Monitoring Plan for this project has been designed to confirm the safe and permanent storage of the CO_2 within the intended storage reservoir.

A.2.3 Regulatory Information, Applicable Criteria, Action Limits

US EPA regulation 40 CFR 146 Subpart H requires owners or operators of Class VI wells to monitor several parameters over the life of the project to ensure that:

- Mechanical integrity of the injection well is maintained;
- Fluid migration and the extent of pressure elevation are within the limits described in the permit application; and
- USDWs are not endangered.

Monitoring activities include mechanical integrity tests (MITs), pressure fall-off (PFO) tests during the injection phase of the project, monitoring of shallow and deep groundwater quality, and development of the CO_2 plume and associated pressure front. This document details the measurements that will be required as well as the steps used to ensure that the quality of all data is such that it can be used in the decision-making process over the life of the project.

A.3. Project/Task Description

A.3.1 Summary of Work to be Performed and Work Schedule

Tables 7A-3 and **7A-4** provide a summary of the testing and monitoring tasks, purpose of those tasks, responsible parties, locations, and the testing frequency.

Activity	Location(s)	Method	Frequency			Analytical Technique	Lab/Custody	Purpose
			Baseline	Injection Phase	PISC Phase			
CO_2 stream analysis	Post-Compressor	Direct sampling	N/A	Quarterly	None	Laboratory analysis	TBD	Monitor injectate
CO_2 stream analysis, including N_2, H_2O and O_2	CO_2 Delivery Plant Piping to Wellhead	Direct sampling	N/A	Quarterly (Note 3)	None	Gas Chromatogaph	N/A	Monitor gas stream
CO_2 Injection mass rate	Post-Compressor	Coriolis Flow meter	N/A	Continuous	N/A	Direct measurement	N/A	Monitor injection rate
Injection pressure	Injection Wellhead	Pressure gauge	N/A	Continuous	N/A	Direct measurement	N/A	Monitor injection pressure
Injection temperature	Injection Wellhead	Temperature gauge	N/A	Continuous	N/A	Direct measurement	N/A	Monitor injection temperature
Down hole pressure/temperature monitoring (Note 1)	MCI CCS 3	Downhole transducer and thermocouple	Continuous from installation through CO_2 injection	Continuous	N/A	Direct measurement	N/A	Monitor storage formation
Annular pressure	Wellhead Annulus Monitoring System (WAMS) Skid	Pressure gauge	N/A	Continuous	N/A	Direct measurement	N/A	Wellbore integrity – Annular fluid monitoring of differential pressure across the packing surface to downhole
Annulus Fluid Volume Added		Annulus Fluid Tank Level Indicator						

Activity	Location(s)	Method	Frequency			Analytical Technique	Lab/Custody	Purpose
			Baseline	Injection Phase	PISC Phase			
Annulus pressure	MCI MW 1, MCI MW 2, & MCI ACZ 1	Surface gauge	N/A	Weekly	Weekly while wells are open	Direct measurement	N/A	Wellbore integrity - Monitor annular pressure between casing and tubing string
Down hole pressure/temperature	MCI MW 2 & MCI ACZ 1	Downhole gauge	N/A	Continuous	Continuous while wells are open	Direct measurement	N/A	Monitor storage and ACZ formations
Wellbore Temperature Profile (storage formation) (Distributed Temperature Sensing) (DTS Fiber Optic System	MCI CCS 3, MCI MW 1, and MCI MW 2 – within the cement behind the borehole casing from the surface to downhole	DTS Fiber Optic Cable	Once	Annually	N/A	Direct measurement	N/A	Monitor storage formation – Obtain temperature profile for entire fiber length throughout the well
Corrosion monitoring	Pipe	Coupon	N/A	Quarterly	N/A	Chemical analysis	TBD	Wellbore integrity
	MCI CCS 3	Multi-Finger Caliper Logging or Ultrasonic Casing Evaluation Tool	N/A	Every 6 years after beginning of injection	Every 6 years through end of post-closure period	Downhole Direct measurement	TBD	25Cr Casing and tubing corrosion (integrity)
	MCI CCS 3	Logging	Once	N/A	N/A	Direct measurement	N/A	CO_2 plume development/baseline

Activity	Location(s)	Method	Frequency			Analytical Technique	Lab/Custody	Purpose
			Baseline	Injection Phase	PISC Phase			
Pulsed Neutron Capture	MCI MW 2 & ACZ 1	Logging	Once	Annually	Annually while wells are open	Direct measurement	N/A	CO_2 plume development, well Integrity
Pressure fall-off testing	Injection Well (MCI CCS3)	Pressure gauge	Once	Every 5 years	N/A	Direct measurement	N/A	Reservoir evaluation
Microseismic monitoring	Surface monitoring stations	Seismometer stations	Continuous starting 4-6 months prior to injection	Continuous	Continuous	Indirect measurement	N/A	Pressure plume development, confining zone integrity
Time-Lapse 3D Surface Seismic data	Surface	Geophones and seismic sources	Once	Every 5 years or 4 Million Tonnes of Injection, whichever occurs first (Note 2)	Year 5, Year 10 (Note 2)	Indirect measurement	N/A	CO_2 plume development, verify containment

Notes:

(1) Injection pressure at the storage formation is collected from a transducer downhole in the CCS3 well. Data will be collected on a continuous basis and pressure recorded to the distributed control system. See **Section 7.3.2.1**.

(2) A seismic survey will be conducted no more than 1 year prior to shutting down the injection well and prior to entering post-closure care.

(3) After initial startup of the well and during the first quarter, continuous CO_2 stream analysis will be conducted by a dedicated real time Gas Chromatograph (GC). After the first quarter, continuous analysis will be collected by the GC for a 7-day period each quarter during the injection phase.

Table 7A-3: Summary of testing and monitoring.

Level	Location(s)	Method	Frequency			Analytical Technique	Lab/Custody	Purpose
			Baseline	Injection Phase	PISC Phase			
Shallow groundwater monitoring & Isotope analysis - (Quaternary)	MCI GW 1 thru MCI GW 5	Dedicated Pump	Quarterly	Semi-Annually	Annually	Laboratory analyses	Table 7A-5: Summary of analytical and field parameters for shallow Quaternary Groundwater Samples.	Detection of changes in groundwater quality for a shallow USDW
Fluid sampling & Isotope analysis - Deepest USDW (Gunter Sandstone)	MCI ACZ 1	Bailer	Semi-Annually (Note 2)	Semi-Annually	Annually	Laboratory analyses	Table 7A-6: Summary of laboratory analytical and field parameters for the deepest USDW, Galesville Sandstone, and Mt. Simon Sandstone groundwater samples.	Detection of changes in quality in the deepest USDW compared to baseline

Level	Location(s)	Method	Frequency			Analytical Technique	Lab/Custody	Purpose
			Baseline	Injection Phase	PISC Phase			
Fluid sampling & Isotope analysis – (Galesville Sandstone)	MCI ACZ 1	Bailer	Semi-Annually(2)	Semi-Annually	Annually	Laboratory analyses	Table 7A-6: Summary of laboratory analytical and field parameters for the deepest USDW, Galesville Sandstone, and Mt. Simon Sandstone groundwater samples.	Detection of changes in quality in the ACZ aquifer compared to baseline.
In-zone monitoring Fluid sampling & Isotope analysis - (Mt. Simon Sandstone) (Note 1)	MCI MW 2	Bailer	Semi-Annually (Note 2)	Semi-Annually	None	Laboratory analyses	Table 7A-6: Summary of laboratory analytical and field parameters for the deepest USDW, Galesville Sandstone, and Mt. Simon Sandstone groundwater samples.	Detection of changes in quality, geochemistry and CO_2 detection in storage formation compared to baseline

Level	Location(s)	Method	Frequency			Analytical Technique	Lab/Custody	Purpose
			Baseline	Injection Phase	PISC Phase			

Notes:

(1) Sampling will occur in the upper Mt. Simon at 3,225 ft is the location of the first perforation of the top most injection zone. Sampling frequency may be adjusted once model is updated post drilling to try and detect CO_2 fluid mixing front as it passes by the well.

(2) For establishing baseline, sampling of the deep wells will occur during well drilling and prior to start of injection.

Table 7A-4: Summary of direct geochemical measurements.

A.3.2 Geographic Location

Figure 7A-2 identifies the Marquis BioCarbon Project site and monitoring infrastructure.

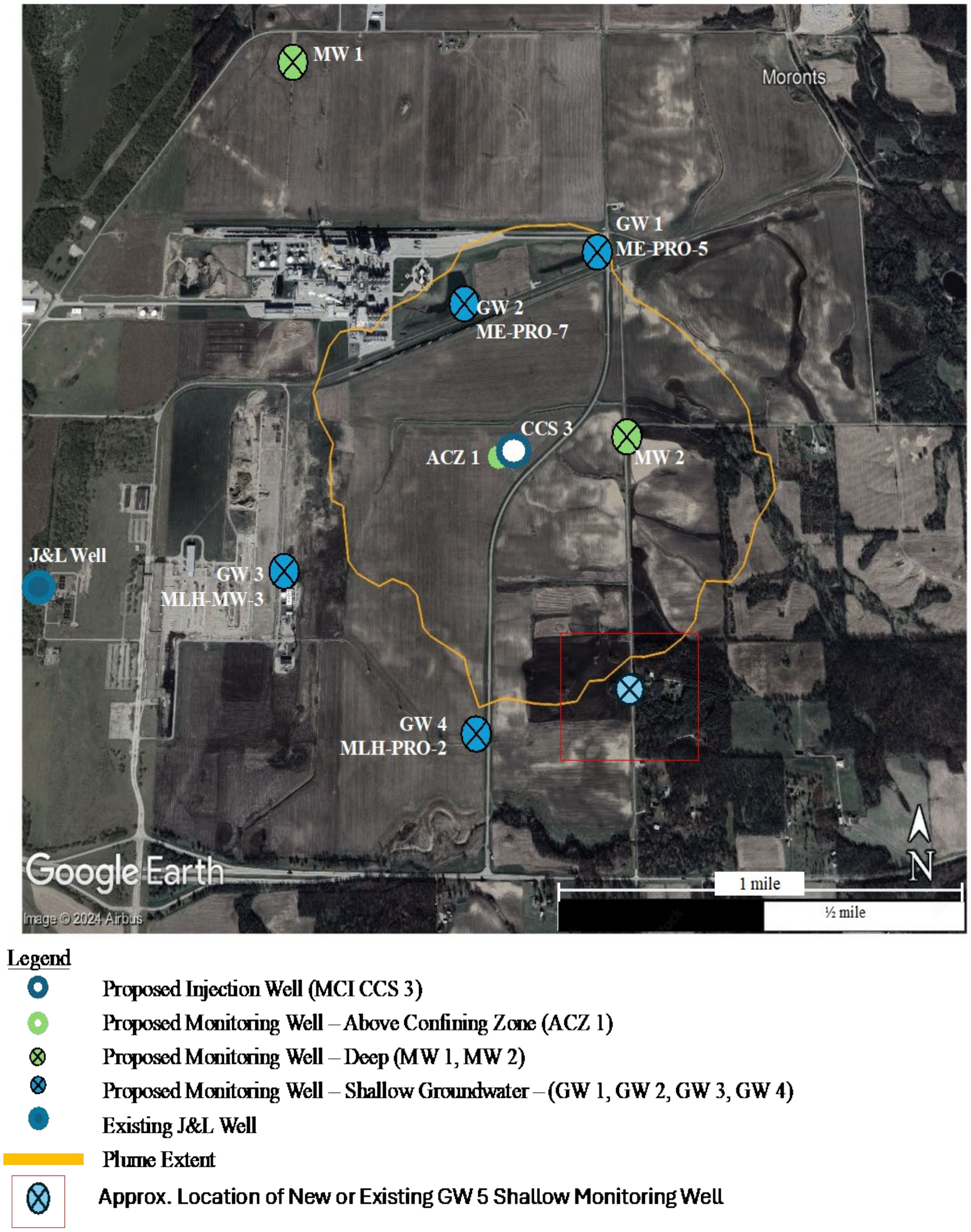


Figure 7A-2: Marquis Carbon Injection Project area showing location of the injection, deep, above confining zone (ACZ), and shallow groundwater monitoring wells.

A.3.3 Resource and Time Constraints

MCI proposes a 12-year post injection site care (PISC) phase and will continue PISC monitoring for 12 years. See Permit **Section 2.2.2** that details current modeling results on plume stability.

Computer Modelling Group (CMG-GEM) simulations will be run throughout the project and matched with actual field data collected under the Testing and Monitoring Plan. The simulations and field testing will confirm that plume stability modeling will be accurate beyond the 12-year period. However, no resource and time constraints have been identified for the Testing and Monitoring Plan beyond the 12-year PISC funding levels.

A.4. Quality Objectives and Criteria

A.4.1 Performance/Measurement Criteria

The overall quality assurance (QA) objective for the testing and monitoring plan is to develop and implement procedures to monitor the CO_2 injection system, development of the CO_2 plume and associated pressure front, and to confirm that CO_2 or other fluids have not migrated beyond the confining layer. This objective will be accomplished through the implementation of the methods provided in **Tables 7A-3** and **7A-4** (Summary of Direct Geochemical Measurements). The Tables below **(Tables 7A-5** to **Table 7A-15**) detail the specific performance and measurement criteria for each testing and monitoring output.

Parameters	Analytical Methods (Notes 1-5)	Detection Limit/Range	Typical Precisions	QC Requirements
Cations (Na, Ca, Mg, Ba, Sr, Fe, K)	ASTM D1976 (Note 2)	<1 to 8 mg/L (analyte, dilution, and matrix dependent)	±10%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Anions (Cl, Br, SO_4)	ASTM D4327	0.03 to 0.13 mg/L (analyte, dilution, and matrix dependent)	±15%	Daily calibration; blanks and duplicates at 10% or greater frequency
Dissolved Inorganic Carbon	EPA 9060	0.2 mg/L	±20%	Duplicate measurement; standards at 10% or greater frequency
Total Dissolved Solids	ASTM D5907	12 mg/L	±10%	Balance calibration, duplicate analysis
Alkalinity	ASTM D3875	1 mg/L	±10%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
pH	ASTM D1293	1 to 13 pH units	0/2 pH unit	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Density	ASTM D4052	0.01 g/mL	±10%	Daily calibration; blanks, duplicates and matrix spikes at 10% or greater frequency
Conductivity/Resistivity	ASTM D1125	0 to 100	±1%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Stable C, H, O Isotopes	CRDS Laser H Isotope Ratio Mass Spectrometry (IRMS) for C	200 to 500‰ 50 ppm of DIC	±4‰ ±0.2‰	Duplicates, working standards at 10%
Radiocarbon (Carbon-14)	Accelerator Mass Spectrometry (AMS)	0 to 200 pMC	±0.5 pMC%	Duplicates, working standards at 10%
pH (field)	EPA 150.1	2 to 12 pH units	±0.2 pH unit	User calibration per manufacturer recommendation

Parameters	Analytical Methods (Notes 1-5)	Detection Limit/Range	Typical Precisions	QC Requirements
Specific conductance (field)	APHA 2510	0 to 200 mS/cm	±1% of reading	User calibration per manufacturer recommendation
Temperature (field)	Thermocouple	-5 to 50°C	±0.2°C	Factory calibration

Notes:

(1) An equivalent method may be utilized with prior approval of the UIC Program Director.

(2) An alternate method for cations may be used. EPA Method 6020 for each constituent, except Strontium. EPA Method 6010 for Strontium.

(3) An alternate method for anions may be used. EPA Method 300.

(4) An alternate standard method (SM) 4500H may be used for pH.

(5) An alternate SM 2320B for alkalinity, SM2540C for Total Dissolved Solids, SM 2710F for Density, SM 5310C for Dissolved Inorganic Carbon, and SM2510B for Conductivity/Resistivity.

Table 7A-5: Summary of analytical and field parameters for shallow Quaternary Groundwater Samples.

Parameters	**Analytical Methods (*)**	**Detection Limit/Range**	**Typical Precisions**	**QC Requirements**
Cations: Na, Ca, Mg, Ba, Sr, Fe, K	ASTM D1976	<1 to 8 mg/L (analyte, dilution, and matrix dependent)	±10%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Anions: Cl, Br, SO_4	ASTM D4327	0.03 to 0.13 mg/L (analyte, dilution, and matrix dependent)	±15%	Daily calibration; blanks and duplicates at 10% or greater frequency
Dissolved Inorganic Carbon	EPA 9060	0.2 mg/L	±20%	Duplicate measurement; standards at 10% or greater frequency
Total Dissolved Solids	ASTM D5907	12 mg/L	±10%	Balance calibration, duplicate analysis
Alkalinity	ASTM D3875	1 mg/L	±10%	Daily calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
pH	ASTM D1293	1 to 13 pH units	0/2 pH unit	
Density	ASTM D4052	0.01 g/mL	±10%	
Conductivity/Resistivity	ASTM D1125	0 to 100	±1%	
Stable C, H, O Isotopes	CRDS Laser H IRMS for C	200 to 500‰ 50 ppm of DIC	±4‰ ±0.2‰	Duplicates, working standards at 10%
Radiocarbon	AMS	0 to 200 pMC	±0.5 pMC%	Duplicates, working standards at 10%
pH (field)	EPA 150.1	2 to 12 pH units	±0.2 pH unit	User calibration per manufacturer recommendation
Specific conductance (field)	APHA 2510	0 to 200 mS/cm	±1% of reading	User calibration per manufacturer recommendation
Temperature (field)	Thermocouple	-5 to 50°C	±0.2°C	Factory calibration

Note:
* An equivalent method may be utilized with the prior approval of the UIC Program Director.

Table 7A-6: Summary of laboratory analytical and field parameters for the deepest USDW, Galesville Sandstone, and Mt. Simon Sandstone groundwater samples.

Parameters	Analytical Methods (Note 1)	Detection Limit/Range	Typical Precisions	QC Requirements
CO2 Purity	GC/TCD	0.1-100%	±10 % across range	Standard with every sample, duplicate analysis within 10 % of each other
Oxygen	ISBT 4.0 (GC/DID)	1 uL/L to 5,000 uL/L (ppm by volume)	± 10 % of reading	Daily standard within 10 % of calibration, secondary standard after calibration
Nitrogen	ISBT 4.0 GC/DID	1 uL/L to 5,000 uL/L (ppm by volume)	± 10 % of reading	Daily standard within 10 % of calibration, secondary standard after calibration
Hydrogen Sulfide	ISBT 14.0 (GC/SCD)	0.01 uL/L to 50 uL/L (ppm by volume)- dilution dependent	5 - 10 % of reading relative across the range	Daily blank, daily standard within 10 % of calibration, secondary standard after calibration
Water Content	ISBT 11.0 (GC/FID)	0.1 uL/L to 100 uL/L (ppm by volume)- dilution dependent	5 - 10 % of reading relative across the range	Daily blank, daily standard within 10 % of calibration, secondary standard after calibration
Total Hydrocarbons	ISBT 10.0 THA (FID)	1 uL/L to 10,000 uL/L (ppm by volume)	5 - 10 % of reading relative across the range	Daily blank, daily standard within 10 % of calibration, secondary standard after calibration
Ethanol	ISBT 11.0 (GC/FID)	0.1 uL/L to 100 uL/L (ppm by volume)- dilution dependent	5 - 10 % of reading relative across the range	Daily blank, daily standard within 10 % of calibration, secondary standard after calibration
Acetaldehyde	ISBT 11.0 (GC/FID)	0.1 uL/L to 100 uL/L (ppm by volume)- dilution dependent	5 - 10 % of reading relative across the range	Daily blank, daily standard within 10 % of calibration, secondary standard after calibration
Methane	ISBT 10.1 (GC/FID)	0.1 uL/L to 1,000 uL/L (ppm by volume)- dilution dependent	5 - 10 % of reading relative across the range	Daily blank, daily standard within 10 % of calibration, secondary standard after calibration

Note:
(1) An equivalent method may be utilized with the prior approval of the UIC Program Director.
All analysis will be performed by a certified third-party laboratory.

Table 7A-7: Summary of analytical parameters for CO_2 gas stream.

Parameters	Analytical Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Mass	NACE RP0775-2005	0.005mg	+/-2%	Annual Calibration of Scale (3rd Party AldingerCo. – Cert #664896F)
Thickness	NACE RP0775-2005	0.001mm	+/-005mm	Factory calibration

Table 7A-8: Summary of analytical parameters for corrosion coupons.

Parameters	Detection Limit/Range
Calibrated working flow rate range	Normal process parameters are 118,224 to 386,353 lb/hr and 24.48 MMSCFD to 80 MMSCFD. Coriolis meter range 8″ body x 6″1,100 to 600,000 lb/hr.
Mass flow rate accuracy	< 0.2% Coriolis meter Accuracy ±0.10% of rate, Repeatability 0.05% of rate
Mass flow rate resolution	2.6 MT/day
Mass flow rate drift stability	To be determined after first year

Table 7A-9: Mass Flow Rate Field Gauge— CO_2 Mass Flow Rate.

Parameters	Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Compressor discharge pressure HP CO_2 Discharge Header & Wellhead Line pressure	ANSI/NCSL Z540-1-1994	+/- 0.001 psig / 0-4000 psig	± 0.04% of span	Calibration range 0-3000psig
Wellhead Injection Tubing Temperature	ANSI/NCSL Z540-1-1994	+/- 0.001 F / 0-500 F	+/- 0.01 F	Calibrated per manufacturer specification
Annulus Pressure	ANSI/NCSL Z540-1-1994	+/- 0.001 psi / 0-3000 psi	+/- 0.01 psi	Calibrated per manufacturer specification
Wellhead Injection Tubing Pressure	ANSI/NCSL Z540-1-1994	+/- 0.001 psi / 0-3000 psi	+/- 0.01 psi	Calibrated per manufacturer specification

Parameters	Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Injection Mass Flow Rate	API MPMS	+/- 0.1000% of rate / 5-5,000 MT/day	+/- 0.01 lbs./hr.	Calibrated per manufacturer specification
Reservoir Pressures Silicon-sapphire	UNKNOWN	+/-0 0.03 psi / 0-6000 PSI	+/- 0.1 psi	Calibrated by manufacturer

Table 7A-10: Summary of measurement parameters for field gauges.

Parameters	Detection Limit/Range
Calibrated working pressure range	0 to 3,000 psi and 4–20 mA
Initial pressure accuracy	< 0.04375%
Pressure resolution	0.001 psi and 0.00001 mA
Pressure drift stability	To be determined after first year

Table 7A-11: Pressure Field Gauge —Injection tubing, annulus, pipeline.

Parameters	Detection Limit/Range
Calibrated working temperature range	0 to 500°F and 4–20 mA
Initial temperature accuracy	< 0.0055 %
Temperature resolution	0.001°F and 0.0001 mA
Temperature drift stability	To be determined after first year

Table 7A-12: Temperature Field Gauge —Injection tubing, annulus, pipeline.

Parameters	Detection Limit/Range
Calibrated working pressure range	Atmospheric to 6,000 psi
Initial pressure accuracy	<+/-0.03 psi over full scale
Pressure resolution	0.0003% psi over full scale
Pressure drift stability	<3 psi per year over full scale
Calibrated working temperature range	257°F
Initial temperature accuracy	<+/-0.9°F
Temperature resolution	0.009°F
Temperature drift stability	<+/-0.1°F per year
Max temperature	257°F

Table 7A-13: Pressure and temperature—bottomhole gauge specifications (PPS25).

Table 7A-15 presents the monitoring methods that will require additional testing or monitoring if exceedances or variances are observed. In the table, the routine measurement method is followed by the additional monitoring that would occur if an exceedance were measured.

Method	PNC	CBL	USI	Isolation Scanner
Logging speed	1,800 ft/hr.	3,600 ft/hr.	Standard resolution: 2,700 ft/hr. High resolution: 563 ft/hr.	Standard resolution: 2,700 ft/hr. High resolution: 563 ft/hr.
Vertical resolution	15 inches	3 ft	Standard resolution: 0.6 in High speed: 6 in	High resolution: 0.6 in. High speed: 6 in

Method	PNC	CBL	USI	Isolation Scanner
Investigation	Formation	Casing, annulus, and formation	Casing and annulus	Casing and annulus
Temperature rating	302°F	350°F	350°F	350°F
Pressure rating	15,000 psi	20,000 psi	20,000 psi	20,000 psi

Table 7A-14: Representative logging tool specifications. Actual tools used will be comparable.

Activity or Parameter	Project Action Limit	Detection Limit	Anticipated Reading
MIT—PNC	Action taken when PNC indicates CO_2 outside of expected range	+/- 0.5 SIGMA	Brine saturated ~ 60 CO_2 saturated ~ 8
Temperature Measurement – External Mechanical Integrity	Action taken when temperature measurement displays deflection that varies from baseline logs	+/- 1 °F	Continuous increasing gradient with depth
Internal Mechanical Integrity—Annular Pressure/ Fluid Volume Gauges	>5% pressure loss over 1hour	Refer to Table 7A-10	<5% pressure loss over 1 hour
Surface and downhole pressure gauges	Action will be taken when pressure outside of modeled/expected range	Refer to Table 7A-11 for surface gauges and Table 7A-13 for downhole gauge	Within storage formation: <90% fracture propagation pressure (2,207 psi at 3,226 ft)
Groundwater Chemical Data	Action will be taken if there is analytical evidence that CO_2 has migrated out of the injection zone or AOR	Refer to Table 7A-5 and Table 7A-6.	No presence of CO_2 or chemical indicators of CO_2 outside the injection zone or AoR.
Time-lapse surface seismic data	Detected CO_2 outside theAOR or above the confining zone	Dependent on fluid saturation and formation velocities	CO_2 plume migration similar to modeled outcome

Table 7A-15: Actionable testing and monitoring outputs.

A.4.2 Precision

The specification and precision of each monitoring method is detailed in the tables above. For groundwater sampling, the accuracy of the data will be assessed by the collection and analysis of field blanks to test sampling procedures and matrix spikes to test lab procedures. Field blanks will be taken no less than one per sampling event to determine if the sample bottle is contaminated. Laboratory assessment of analytical precision will be the responsibility of the individual laboratories per their standard operating procedures.

A.4.3 Bias

Laboratory assessment of analytical bias will be the responsibility of the individual laboratories per their standard operating procedures (SOPs) and analytical methodologies. For direct pressure or logging measurements, there is no bias.

A.4.4 Representativeness

For groundwater sampling, data representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. The sampling network has been designed to provide data that are representative of site conditions. For the analytical results of individual groundwater samples, representativeness will be estimated by ion charge and mass balances. Ion balances with ±10% error or less will be considered valid. Mass balance assessment will be used in cases where the ion balance is greater than ±10% to help determine the source of error. For a sample and its duplicate, if the relative percent difference (RPD) is greater than 10%, the sample may be considered non-representative.

A.4.5 Completeness

For groundwater sampling, data completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. It is anticipated that data completeness of 90% for groundwater sampling will be acceptable to meet monitoring goals. For direct pressure, temperature, and flow measurements, it is expected that data will be recorded no less than 90% of the time.

A.4.6 Comparability

Data comparability expresses the confidence with which one data set can be compared to another. The data sets to be generated by this project will be very comparable to future data sets because of the use of standard methods and the level of quality assurance/quality control (QA/QC) effort. Direct pressure, temperature, and logging measurements will be directly comparable to previously obtained baseline data sets or project data.

A.5. Special Training/Certifications

A.5.1 Specialized Training and Certifications

The geophysical survey equipment and wireline logging tools will be operated by trained, qualified, and certified personnel, according to the service company which provides the equipment. The subsequent data will be processed and analyzed according to industry standards. Examples of these are shown in **Attachment 1**.

No specialized certifications are required for personnel conducting groundwater sampling, but field sampling will be conducted by trained personnel. Groundwater sampling will be conducted by personnel trained to understand and follow the project-specific sampling procedures.

Upon request, the Agency will be provided with all laboratory SOPs developed for the specific parameter using the appropriate standard method. Each laboratory technician conducting the analysis on the in-house samples will be trained on the SOP developed for each standard method. The technician's training certification will be included with the biannual report. Certifications will not be included for technicians conducting sample analysis from an accredited laboratory. Laboratory accreditation information will be provided upon request.

A.5.2 Training Provider and Responsibility

Training for personnel will be provided by the operator or by the subcontractor responsible for the data collection activity.

A.6. Documentation and Records

A.6.1 Report Format and Package Information

A semi-annual report from Marquis Carbon Injection LLC to EPA will contain all required project data, including the testing and monitoring information as specified by the UIC Class VI permit. Data will be provided in electronic or other formats as required by the UIC Program Director.

A.6.2 Other Project Documents, Records, and Electronic Files

Other documents, records, and electronic files such as well logs, test results, or other data will be provided as required by the UIC Program Director.

A.6.3 Data Storage and Duration

Maquis Carbon Injection LLC or a designated contractor will maintain the required project data as provided elsewhere in the permit.

A.6.4 QASP Distribution Responsibility

The Marquis Carbon Injection LLC Manager will be responsible for ensuring that all those on the distribution list will receive the most current copy of the approved QASP.

B. Data Generation and Acquisition

B.1. Sampling Process Design (Pre-Injection Phase)

During the pre-injection phase, fluid samples will be collected and analyzed for geochemical parameters listed in **Table 7A-5** and **Table 7A-6** to establish baseline conditions of the fluids within the target formations. Regular sampling will be performed during the injection and post-injection phases of the project to track the migration of CO_2 through the storage formation and to confirm that CO_2 and other fluids of interest have not migrated out of the storage formation. Analytes will include selected constituents that are:

- Primary and secondary EPA drinking water contaminants.
- Those most responsive in the interaction of CO_2 with the formation fluids and minerals; and
- Those needed for Quality Control.

The full set of selected parameters for each sampling interval is given in **Table 7A-5** (Summary of analytical and field parameters for shallow Quaternary Groundwater Samples) and **Table 7A-6** (Summary of laboratory analytical and field parameters for the deepest USDW, Galesville Sandstone, and Mt. Simon Sandstone groundwater samples).

All samples will be analyzed using a laboratory that meets the requirements under the EPA Environmental Laboratory Accreditation Program. Isotopic analysis will be conducted using established methods. The pressure, temperature, and flowrate of the CO_2 injection stream will be monitored on a continuous basis using instrumentation located in the flowline between the final compression stage and the wellhead. In addition, samples of the injection stream will be collected on a quarterly basis for analysis. The sampling and analysis will be completed to ensure compliance with the approved Class VI permit.

B.1.1 Design Strategy

CO_2 Stream Monitoring Strategy

Continuous analysis through the gas chromatograph and regular sampling of the CO_2 stream provides an evaluation of the potential interactions of the CO_2 and other constituents of the injection stream with mineral components and fluids within the storage formation. It can also identify increases in trace components, such as water content, that could accelerate well corrosion and negatively impact well integrity. Minor variation (<5%) is expected in the composition of the injected CO_2 stream which will pass through at least one scrubber prior to entering the compressor and the pipeline. As a result, quarterly sampling of the CO_2 injection stream will be sufficient to accurately track the composition of the stream. An initial calibration and validation of the instruments will be performed by the manufacturers and will be verified by the project on a regular basis.

Corrosion Monitoring Strategy

Corrosion coupon analyses will be conducted quarterly to assess the mechanical integrity of the well components that are in contact with the CO_2. The coupons will be assessed for signs of corrosion and any loss of mass thickness, cracking, pitting, and other signs of corrosion that could be indicative of future well integrity issues. The analysis will be in accordance with National Association of Corrosion Engineers (NACE) Standard RP-0775 (or similar) to determine and document corrosion wear rates.

Every 6 years after the beginning of injection through the end of the post-closure period, the MCI CCS 3 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. A 6-year period for enhanced corrosion monitoring was selected based on the limited time period for actual injection and plume migration and the corrosion modeling results. Marquis' corrosion modeling conducted by Viking projected a corrosion rate of 0.05% per year based on the thickness of the pipe. See **Appendix Y**. The multi-finger caliper is a downhole logging tool that can accurately detect penetration variations as small as 0.6% in pipes with a nominal thickness of 0.408 in. Prior to a 6-year period, a measurable amount of corrosion could not be detected, and conducting the monitoring would not provide meaningful results.

Shallow Groundwater Monitoring Strategy

Five dedicated shallow groundwater wells in the AoR will be used for shallow groundwater monitoring (**Figure 7A-2**). These wells penetrate the Quaternary-age deposits to depths less than 300 feet (ft) below ground surface, which is deeper than any drinking water well in the area. Baseline groundwater samples will be acquired from these wells at a minimum of once per quarter to obtain baseline data for the water quality within the AoR prior to the start of CO_2 injection. These groundwater samples will also have their geochemistry and stable isotopes analyzed by a qualified laboratory. Throughout the injection and PISC phases of the project, the results of the aqueous geochemistry and isotope analyses will be compared to the baseline conditions for any indication of CO_2 or brine migration into the shallow groundwater aquifer.

Deep Groundwater Monitoring Strategy

A deep, above confining zone (ACZ 1) groundwater well will be drilled for the project (40 CFR 146.90 (d)). MCI ACZ 1 will be near the injection well to monitor the aquifers immediately above the confining layer in the event that there is CO_2 or brine migration out of the storage formation along the injection wellbore (**Figure 7A-2**). This well will allow for pressure and temperature monitoring as well as periodic fluid sampling in the Galesville Sandstone and Gunter Sandstone, the deepest USDW. The well will be equipped with continuous pressure and temperature gauges. A bailer system will be used to collect the fluid samples to evaluate geochemical changes in groundwater fluids. Samples will be analyzed for field constituents using a calibrated water quality meter (Horiba U-53, or similar). The geochemical analyses will be performed by a qualified laboratory. The isotopic analyses will be performed by a qualified laboratory.

CO_2 or brine migration into the Galesville or Gunter Sandstone will most likely be first identified through pressure changes in the formation. The presence of CO_2 or brine in the overlying aquifers can be further confirmed through aqueous geochemistry data and analysis of isotopes. If deep early-detection monitoring data indicate that CO_2 has migrated out of the primary storage formation, it will trigger external well integrity testing of the injection and deep monitoring wells. It may also trigger a time-lapse three-dimensional (3D) surface seismic survey earlier than initially planned.

Storage Formation Monitoring Strategy

The storage formation will be monitored through pressure and temperature sensors, fluid sampling and analysis, pulsed neutron capture (PNC) logging, time-lapse 3D surface seismic data, and microseismic monitoring to characterize the development of the CO_2 and pressure plumes over the injection and PISC phases of the project. Fluid samples will be collected from the deep monitor well on a biannual basis until the well becomes saturated with CO_2, while the pressure/temperature gauges will be retrieved for data download. PNC logging will be used to determine the CO_2 saturation adjacent to the deep monitoring well. The PNC logging will also confirm that CO_2 has not migrated above the confining layer.

Deep Monitoring Well (MCI MW 2) Sampling Strategy

The deep monitoring well (MCI MW 2) will be used to monitor the pressure and CO_2 plume development in the storage formation through the injection phase of the project. Fluid samples will be collected on a semi-annual basis from the Mt. Simon Sandstone to monitor aqueous geochemistry changes within the formation. The well will be swabbed to produce representative formation fluid in the well. During the swabbing process, the swab water will be analyzed in the field using a calibrated water quality meter (Horiba U-53, or similar). After swabbing the well, fluid samples will be collected using a bailer-style system. Samples will be analyzed for constituents that can be used to measure changes in chemistry that would be caused by interaction with the injected CO_2. See Table 7A-6 for list of analytes. Analysis will be conducted by an accredited laboratory. For example, Isotech or a similar laboratory will perform the isotopic analyses. A set of memory-style pressure and temperature gauges (Petrotech PPS25 or similar) will also be placed in the deep monitoring well to track the pressure response due to CO_2 injection. These gauges will be programmed to collect data every 60 seconds.

Deep Monitoring Well (MCI MW 1) Sampling Strategy

This deep well will be used for extended field monitoring. It will be used as a contingency in the monitoring plan. Should the need arise for cross-well measurements or downhole measurements, like Vertical Seismic Profile (VSP), this well will be employed as an additional data point to confirm pressure front or CO_2 plume movement.

B.1.2 Type and Number of Samples/Test Runs

The types, frequencies, and additional details of the sampling and monitoring methods are provided in (**Table 7A-3**) of this document.

B.1.3 Site/Sampling Locations

Five shallow groundwater wells (MCI GW 1-5), a deep groundwater monitoring well (MCI MW 2), and a monitoring well above the confining zone (MCI ACZ 1) will be installed and geochemical and isotope analysis will be conducted. See **Figure 7A-2** and **Table 7A-2**.

The chemical composition, pressure and temperature, and mass flowrates of the CO_2 injection stream will be monitored downstream of the last stage of compression and upstream of the injection well. At the injection well, the wellhead and storage formation pressure and temperature will be measured along with the annular pressure and volume. In addition, corrosion monitoring will be completed in the CO_2 pipe between the compressor and the injection well.

PNC logging will be performed in the ACZ 1 well and the deep monitoring well (MCI MW 2) to monitor the CO_2 plume development in the storage formation as well as for potential migration of CO_2 above the confining layer. Temperature measurements will be acquired in the injection and wells (MCI ACZ 1 and MCI MW 2) on an annual basis to confirm external mechanical integrity.

B.1.4 Sampling Site Contingency

The shallow groundwater, MCI ACZ 1, and deep monitoring wells (MCI MW 1 and MCI MW 2) are all located on Marquis property where the Marquis BioCarbon Project is located. Access to the wells is not anticipated to be a problem over the course of the project. The wells are all located on flat farmland, accessible, and not on any rough terrain. If inclement weather makes site access difficult, sampling schedules will be reviewed, and alternative dates may be selected that would still meet permit-related conditions.

B.1.5 Activity Schedule

Table 7A-3 provides the schedules for the sampling and monitoring activities along with other pertinent details regarding the techniques.

B.1.6 Critical/Informational Data

During data acquisition for the testing and monitoring activities, field and laboratory information will be documented in detail. Information will be recorded in field and laboratory forms and notebooks. Critical information will include the time and date of activity, person(s) performing activity, location of the activity or instrument, field or laboratory instrument calibration data, and field parameter values. For laboratory analyses, much of the critical data will be generated during the analysis and provided to the project in digital and printed formats. Noncritical data may include the appearance and problems with the wells or sampling/monitoring equipment, and weather conditions.

B.1.7 Sources of Variability

Potential sources of variability related to monitoring activities include:

- Natural variations in fluid geochemistry, formation pressure and temperature, and seismic activity;
- Variation in fluid geochemistry, formation pressure and temperature, and seismic activity due to project operations;
- Changes in groundwater recharge due to rainfall, drought, and snowfall;
- Changes in instrument calibration during sampling or analytical activity;
- Variations in the staff collecting or analyzing samples;
- Differences in environmental conditions during field activities;
- Changes in analytical data quality during life of project; and
- Data entry errors related to maintaining project database.

Activities to eliminate, reduce, or reconcile variability related to monitoring activities include:

- Collection of long-term baseline data to observe and document natural variation in monitoring parameters;
- Evaluation of data in timely manner after collection to observe anomalies in data that can be addressed through resampling;
- Conducting statistical analysis of monitoring data to determine whether variability in a data set is the result of project activities or natural variation;
- Checking instrument calibration before, during and after sampling or sample analysis
- Staff training;
- The use of standard operating procedures to describe testing and monitoring activities;
- Use of accredited laboratory and chain of custody procedures; and

- Conducting laboratory QA checks using third party reference materials, and/or blind and/or replicate sample checks.

B.2. Sampling Methods

Well logging, geophysical monitoring, and pressure/temperature monitoring do not apply to this section.

B.2.1 Sampling SOPs

B.2.1.1 Shallow Groundwater Wells

Groundwater samples will be collected from the shallow groundwater wells using a low-flow sampling method consistent with ASTM D6452-99 (2005) or Puls and Barcelona (1996). If a flow-through cell is not used, field parameters will be measured in grab samples. Groundwater wells will be purged to ensure samples are representative of formation water quality. Static water levels in each well will be determined using an electronic water level indicator before any purging or sampling activities begin. Dedicated pumps (e.g., bladder pumps) will be installed in each monitoring well to minimize potential cross contamination between wells. The pH, temperature, specific conductance, and dissolved oxygen of the purge water will be monitored in the field using portable probes and a flow-through cell consistent with standard methods given sufficient flow rates and volumes. Field chemistry probes will be calibrated at the beginning of each sampling day according to equipment manufacturer procedures using standard reference solutions. When a flow-through cell is used, field parameters will be continuously monitored and will be considered stable when three successive measurements made three minutes apart meet the criteria listed in **Table 7A-16**.

Field Parameter	Stabilization Criteria
pH	+/- 0.2 units
Temperature	+/- 1°C
Specific Conductance	+/- 3% of reading in µS/cm
Dissolved Oxygen	+/- 10% of reading or 0.3 mg/L whichever is greater

Table 7A-16: Stabilization criteria of water quality parameters during shallow well purging

After field parameters have stabilized, samples will be collected. Samples requiring filtration will be filtered through 0.45 micrometer (µm) flow-through filter cartridges as appropriate and consistent with ASTM D6564-00. Prior to sample collection, filters will be purged with a minimum of 100 milliliters (mL) of well water (or more if required by the filter manufacturer). For alkalinity and total CO_2 samples, efforts will be made to minimize exposure to the atmosphere during filtration.

B.2.1.2 Deep Monitoring Wells and ACZ 1 Well

Samples will be collected from the MCI ACZ 1 and deep monitoring well MCI MW2 using a bailer system lowered into the wells via slickline. Prior to sample collection, the well will be purged by swabbing the well to remove stagnant fluids and to ensure representative formation fluids are present in the well. During drilling of the wells, extensive infiltration of drilling fluids during construction and development activities will occur. Therefore, prior to sampling, each discrete zone interval where samples are being collected will be purged to ensure the samples are representative of site conditions. The pH, temperature, specific conductance, and dissolved oxygen of the swabbed water will be monitored every swab run in the field using portable probes until the parameters stabilize for three successive runs, and grab samples will be used to collect the samples. Field chemistry probes will be calibrated at the beginning of each sampling day according to equipment manufacturer procedures using standard reference solutions.

After the well has been swabbed, the bailer system will be lowered into the well to collect sufficient volume of the fluid to complete the analyses. The samples will be transferred to the appropriate bottles for each analytical method. Samples that require filtering will be filtered through a 0.45 µm cartridge filter per the procedure.

B.2.1.3. CO_2 Gas Stream

For the CO_2 stream, samples will be collected from a sampling port located between the final compression stage and the wellhead where the injectate is representative of the stream being injected into the well. The samples will be collected in Department of Transportation (DOT)-rated pressure cylinders that can be sent to an accredited analytical laboratory for analysis. A pressure regulator will reduce the pressure of the CO_2 to approximately 250 pounds per square inch (psi) so that the CO_2 is in the gaseous state when collected rather than a super-critical liquid. 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. Appropriate 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.

B.2.2 In-Situ Monitoring

In-situ monitoring of groundwater chemistry is not currently planned.

B.2.3 Continuous Monitoring

The pressure and temperature in the deep monitoring wells will be continuously monitored using downhole pressure/temperature gauges.

B.2.4 Sample Homogenization, Composition, Filtration

Sample homogenization, composition, and filtrations is described in **Section B.2.1**.

B.2.5 Sample Containers and Volumes

For CO_2 stream monitoring, samples will be collected in a clean sample cylinder rated for the appropriate collection pressure provided by a laboratory such as Atlantic Analytical Laboratory.

CO_2 quarterly gas analysis will include:

- CO_2 Purity (% volume [v]/v, gas chromatograph [GC])
- Oxygen (O_2, parts per million [ppm] v/v)
- Nitrogen (N_2, ppm v/v)
- Hydrogen Sulfide (H_2S ppm v/v)
- Potential Trace Contaminants – See Table 7A-7

For shallow and deep fluid samples, all sample bottles will be new. Sample bottles for analytes will be used as received from the vendor or contract analytical laboratory for the analyte of interest. A summary of sample containers is presented in **Table 7A-17** (Preservation, Containers, and Holding Times for Aqueous Samples).

B.2.6 Sample Preservation

For groundwater and other aqueous samples, the preservation methods provided in **Table 7A-17** will be used.

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-mLGlass	1 year
C Stable Isotope	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 7A-17: Preservation, containers, and hold times for aqueous samples.

No preservation will be required for the CO_2 injection stream samples, additional details for the gas sampling are provided in Table 7A-7 and Table 7A-18..

Target Parameters	Volume/Container Material	Preservation Technique	Sample Holding time(max)
CO_2 gas stream	300-ml cylinder	NA	5 Days

Table 7A-18: Preservation, containers, and hold times for aqueous samples.

Corrosion coupon sampling requires that the coupons be physically separated (e.g., sleeves, baggies) during transportation to prevent physical abrasion.

B.2.7 Cleaning/Decontamination of Sampling Equipment

Dedicated pumps (e.g., bladder pumps) will be installed in each shallow groundwater monitoring well to minimize potential cross contamination between wells. These pumps will remain in each well throughout the project period except for maintenance. Prior to installation, the pumps will be cleaned on the outside with a non-phosphate detergent. Pumps will be rinsed a minimum of three times with deionized water and a minimum of 1 liter (L) of deionized water will be pumped through the pump and sample tubing. Individual cleaned pumps and tubing will be placed in plastic bags for transport to the field for installation. All field glassware (pipets, beakers, filter holders, etc.) will be cleaned with tap water to remove any loose dirt and rinsed three times with deionizedwater before use. CO_2 gas stream sampling cylinders will be decontaminated by the analytical lab, and no sampling equipment will be utilized with the corrosion coupons or annual field gauge calibrations.

B.2.8 Support Facilities

Field activities are usually completed in mobile laboratory vehicles or trailers located on site. Fluid sampling may require the use of an air compressor, vacuum pump, generator, filters, and analytical meters (pH, specific conductance, etc.). Sample tubing, connectors and valves required to sample the CO_2 gas stream will be supplied by the analytical lab providing the sampling containers. Sampling will occur within the CO_2 compression building or at the wellsite building prior to injection. Similarly, corrosion coupons will be removed from the CO_2 injection line.

B.2.9 Corrective Action, Personnel, and Documentation

Field staff will be responsible for testing equipment and performing corrective actions on broken or malfunctioning field equipment. If corrective action cannot be taken in the field, then equipment will be returned to the manufacturer for repair or replacement. Significant corrective actions that occur during the sampling and data collection activities that affect analytical results will be documented in field notes.

B.3. Sample Handling and Custody

Well logging, geophysical monitoring, and pressure and temperature monitoring do not apply to this section and are omitted.

Sample holding times will be consistent with standard methods. After collection and any necessary preservation, samples will be placed in ice chests in the field and maintained thereafter at approximately 4 degrees Celsius (°C) until analysis. The samples will be maintained at their preservation temperature and sent to the designated laboratory within 24 hours. Analysis of the samples will be completed within the holding time listed in **Table 7A-17**. See **Table 7A-17** (Preservation, Containers and Hold Times for Aqueous Samples).

As appropriate, alternative sample containers and preservation techniques approved by the UIC Program Director will be used to meet analytical requirements.

B.3.1 Maximum Hold Time/Time Before Retrieval

See **Table 7A-17** (Preservation, Containers and Hold Times for Aqueous Samples).

B.3.2 Sample Transportation

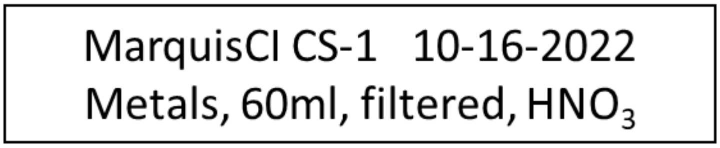
See description in **Section B.2.**

B.3.3 Sampling Documentation

Field notes will be collected for all groundwater samples collected. These forms will be retained and archived as reference. The sample documentation is the responsibility of groundwater sampling personnel. A chain-of-custody form will be provided with each CO_2 gas stream sample or fluid sample provided for analysis as shown in **Figure 7A-4** (Example of chain-of-custody form for the CO2 injection stream gas analysis).

B.3.4 Sample Identification

All sample bottles will have waterproof labels with information denoting project, sampling date, sampling location, sample identification number, fluid sample, sample type, analyte, volume, filtration used (if any), and preservative used (if any). See **Figure 7A-3**: (Example label for groundwater sample bottles)



MarquisCI CS-1 10-16-2022
Metals, 60ml, filtered, HNO_3

Figure 7A-3: Example label for groundwater sample bottles.

B.3.5 Sample Chain-of-Custody

For CO_2 stream analysis, a chain-of-custody form will accompany the sample to the laboratory. As example of the form is provided in **Figure 7A-4**. The chain-of-custody form will include sample identification (ID), sample collection date/time, sample pressure, and analytical requirements. A chain-of-custody form will accompany the sample through the analytical process. Copies of the chain-of-custody forms will be retained in the monitoring files.

For groundwater samples, the chain-of-custody will be documented using a standardized form. A typical form is shown in **Figure 7A-5** (Example chain-of-custody form for the fluid sample analysis). Copies of the chain-of-custody forms will be provided to the person or lab receiving the samples as well as the person or lab transferring the samples. These forms will be retained and archived to allow simplified tracking of sample status. The chain-of -custody form and record keeping is the responsibility of groundwater sampling personnel.

B.4. Analytical Methods

Well logging, geophysical monitoring, and pressure and temperature monitoring do not apply to this section and are omitted.

B.4.1 Analytical SOPs

Analytical methods are referenced in **Table 7A-5** (Summary of analytical and field parameters for shallow Quaternary Samples) and **Table 7A-6** (Summary of laboratory analytical and field parameters for deepest USDW, Galesville Sandstone, and Mt. Simon Sandstone groundwater samples). Upon request, Marquis Carbon Injection LLC will provide the EPA with all laboratory SOPs developed for the specific parameter using the appropriate standard method.

B.4.2 Equipment/Instrumentation Needed

Equipment and instrumentation are specified in the individual analytical methods referenced in **Table 7A-5** (Summary of analytical and field parameters for shallow Quaternary Groundwater Samples) and **Table 7A-6** (Summary of analytical and field parameters for the deepest USDW, Galesville Sandstone, and Mt. Simon Sandstone groundwater samples).

B.4.3 Method Performance Criteria

Nonstandard method performance criteria are not anticipated for this project.

B.4.4 Analytical Failure

Each laboratory conducting the analyses in **Table 7A-5** through **7A-8** will be responsible for appropriately addressing analytical failure according to their individual SOPs.

B.4.5 Sample Disposal

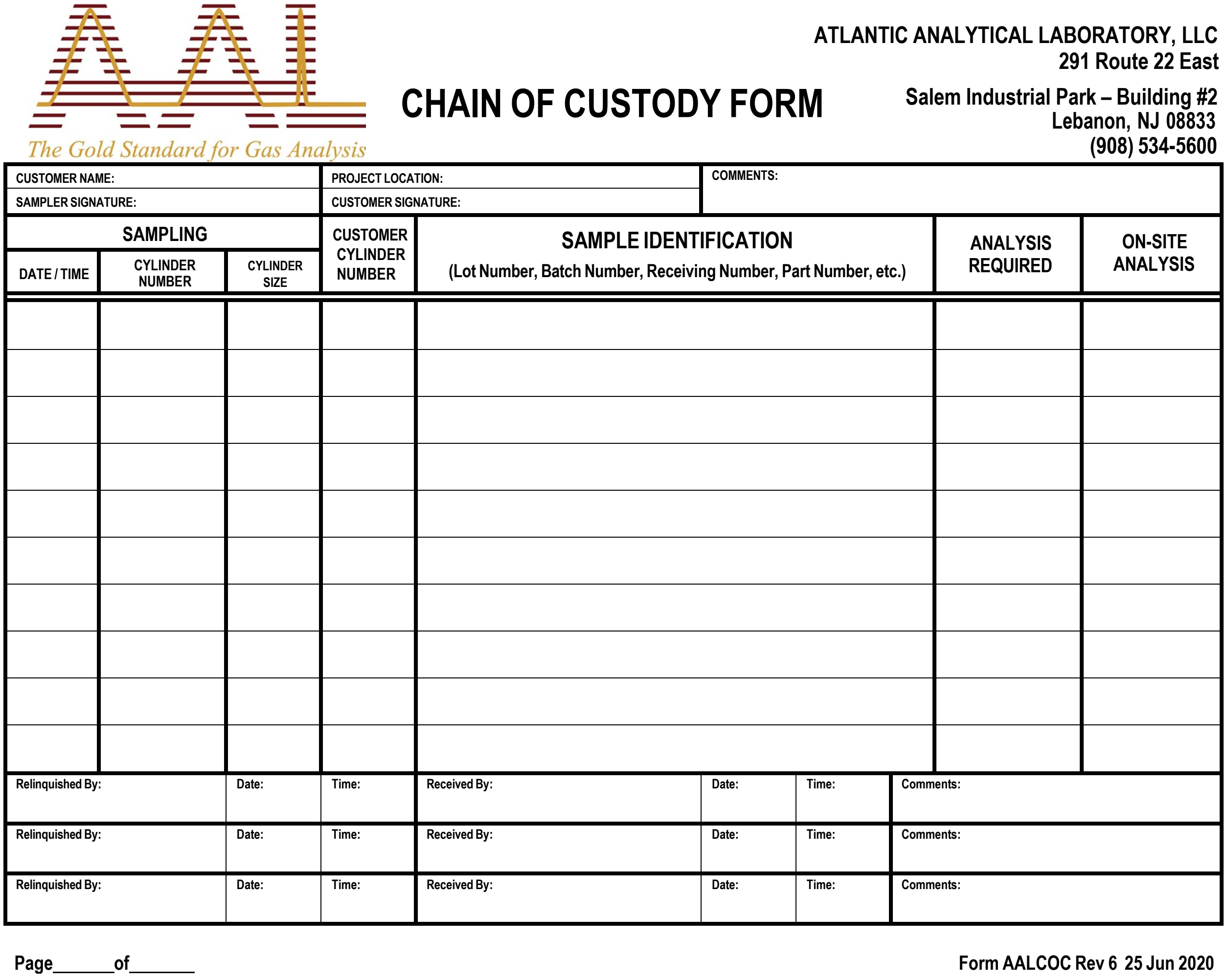
Each laboratory conducting the analyses in **Table 7A-5** through **7A-6** will be responsible for appropriate sample disposal according to their individual SOPs.

B.4.6 Laboratory Turnaround

Laboratory turnaround will vary by laboratory, but generally turnaround of verified analytical results within one month will be suitable for project needs.

B.4.7 Method Validation for Nonstandard Methods

Nonstandard methods are not anticipated for this project.



The Gold Standard for Gas Analysis

CHAIN OF CUSTODY FORM

ATLANTIC ANALYTICAL LABORATORY, LLC
291 Route 22 East
Salem Industrial Park – Building #2
Lebanon, NJ 08833
(908) 534-5600

CUSTOMER NAME:	PROJECT LOCATION:	COMMENTS:
SAMPLER SIGNATURE:	CUSTOMER SIGNATURE:	

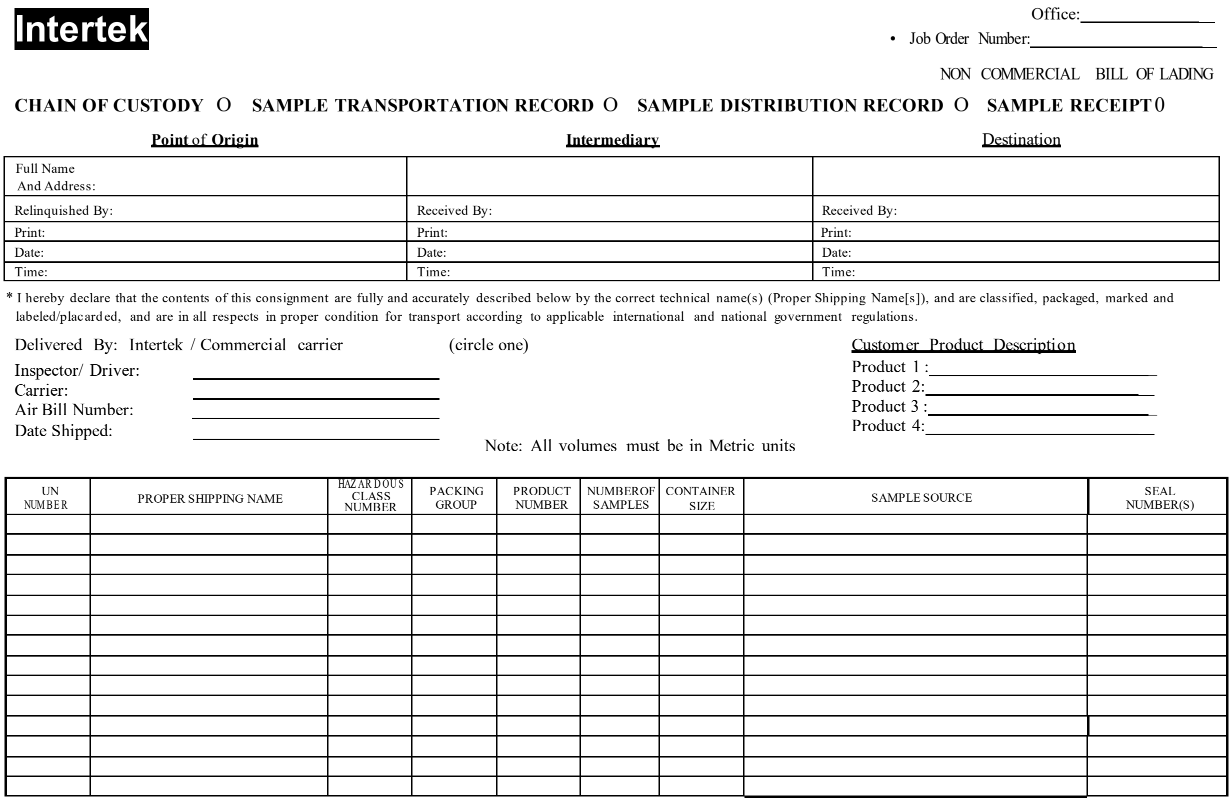
SAMPLING			CUSTOMER CYLINDER NUMBER	SAMPLE IDENTIFICATION (Lot Number, Batch Number, Receiving Number, Part Number, etc.)	ANALYSIS REQUIRED	ON-SITE ANALYSIS
DATE / TIME	CYLINDER NUMBER	CYLINDER SIZE				

Relinquished By:	Date:	Time:	Received By:	Date:	Time:	Comments:
Relinquished By:	Date:	Time:	Received By:	Date:	Time:	Comments:
Relinquished By:	Date:	Time:	Received By:	Date:	Time:	Comments:

Page______of______

Form AALCOC Rev 6 25 Jun 2020

Figure 7A-4: Example of chain-of-custody form for the CO_2 injection stream gas analyses.



Intertek

Office:_______________
- Job Order Number:____________________

NON COMMERCIAL BILL OF LADING

CHAIN OF CUSTODY ○ **SAMPLE TRANSPORTATION RECORD** ○ **SAMPLE DISTRIBUTION RECORD** ○ **SAMPLE RECEIPT** ○

Point of Origin	**Intermediary**	**Destination**
Full Name And Address:		
Relinquished By:	Received By:	Received By:
Print:	Print:	Print:
Date:	Date:	Date:
Time:	Time:	Time:

* I hereby declare that the contents of this consignment are fully and accurately described below by the correct technical name(s) (Proper Shipping Name[s]), and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national government regulations.

Delivered By: Intertek / Commercial carrier (circle one)

Inspector/ Driver: ____________________
Carrier: ____________________
Air Bill Number: ____________________
Date Shipped: ____________________

Note: All volumes must be in Metric units

Customer Product Description
Product 1 :____________________
Product 2:____________________
Product 3 :____________________
Product 4:____________________

UN NUMBER	PROPER SHIPPING NAME	HAZARDOUS CLASS NUMBER	PACKING GROUP	PRODUCT NUMBER	NUMBER OF SAMPLES	CONTAINER SIZE	SAMPLE SOURCE	SEAL NUMBER(S)

Figure 7A-5: Example chain-of-custody form for the fluid sample analyses.

B.5. Quality Control

Geophysical monitoring and pressure/temperature monitoring do not apply to this section and are omitted. For wireline log QC, please refer to **Section 7A-Attachment 1**.

B.5.1 QC Activities

Blanks

For shallow and deep groundwater/brine sampling, a field blank will be collected and analyzed for the inorganic analytes in **Table 7A-5** and **7A-6** at a frequency of no less than one blank for field event. Field blanks will be exposed to the same field and transport conditions as the groundwater samples. Field blanks will be used to detect contamination resulting from the collection and transportation process.

No field blanks will be collected for the injection stream sampling. Contamination and representative sampling will be determined through the concentrations of nitrogen and helium (that have been spiked into the cylinder) in the sample.

Duplicates

For each fluid sampling round, at least one duplicate sample will be collected from a well. Duplicate samples will be collected from the same source immediately after the original sample in different sample containers and processed in the same manner as all other samples. Duplicate samples will be used to assess sample heterogeneity and analytical precision.

B.5.2 Exceeding Control Limits

If the sample analytical results exceed control limits (i.e., ion balances > ±10%), further examination of the analytical results will be done by evaluating the ratio of the measured total dissolved solids (TDS) tothe calculated TDS (i.e., mass balance) per the method. The method indicates which ion analyses should be considered suspect based on the mass balance ratio. Suspect ion analyses are then reviewed in the context of historical data and interlaboratory results. If available, suspect ion analyses will then be brought to the attention of the analytical laboratory for confirmation and/or reanalysis. The ion balance will be recalculated, and if the error is still not resolved, the suspect data will be identified and may be given less importance in data interpretations. Additional samples may be collected for repeat analyses to confirm the analytical results.

B.5.3 Calculating Applicable QC Statistics

Charge Balance

The analytical results will be evaluated to determine correctness of analyses based on the anion-cation charge balance calculation. Since fluid samples should be electrically neutral, the chemical analyses should yield equally negative and positive ionic activity. The anion-cation charge balance will be calculated using the formula:

$$\% \, difference = 100 \frac{\sum cations - \sum anions}{\sum cations + \sum anions} ,$$ (Equation

where the sums of the ions are represented in milliequivalents per liter and the criteria for acceptable charge balance is ±10%.

Mass Balance

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

$$1.0 < \frac{measured\,TDS}{calculated\,TDS} < 1.2 ,$$ (Equation

where the anticipated values are between 1.0 and 1.2.

Outliers

The determination of one or more statistical outliers is essential prior to the statistical evaluation of groundwater. This project will use the USEPA's Unified Guidance (March 2009) as a basis for selection of recommended statistical methods to identify outliers in water/brine chemistry data sets as appropriate. These techniques include Probability Plots, Box Plots, Dixon's test, and Rosner's test. The EPA-1989 outlier test may also be used as another screening tool to identify potential outliers.

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

Logging tool equipment will be maintained as per wireline industry best practices (**Section 7A-Attachment 1**).

All pressure, temperature, and mass flow measurement equipment will be maintained per the manufacturer's specifications. Any necessary calibrations or repairs will also be performed per the manufacturer's specification or by the manufacturer of the equipment.

For fluid sampling, the field equipment will be maintained, factory serviced, and factory calibrated per manufacturer's recommendations. Spare parts that may be needed during sampling will be included in supplies on hand during field sampling.

For all laboratory equipment, testing, inspection, and maintenance will be the responsibility of the analytical laboratory per standard practice, method-specific protocol, or National Environmental Laboratory Accreditation Program (NELAP) requirement.

B.7. Instrument/Equipment Calibration and Frequency

Geophysical monitoring does not apply to this section and is omitted.

B.7.1 Calibration and Frequency of Calibration

Pressure and temperature gauge calibration information will be performed annually. Logging tool calibration will be at the discretion of the service company providing the equipment and following standard industry practices noted in **Section 7A-Attachment 1**.

For groundwater sampling, the portable field meters or multiprobe sondes used to determine field parameters (e.g., pH, temperature, specific conductance, dissolved oxygen) will be calibrated according to manufacturer recommendations and equipment manuals (i.e., each day before sample collection begins). Recalibration will be performed if any components yield atypical values or fail to stabilize during sampling.

B.7.2 Calibration Methodology

Logging tool calibration methodology will follow standard industry practices in **Section 7A-Attachment 1**.

The pressure, temperature, and mass flow meters will be calibrated annually.

For groundwater sampling, standards used for calibration are typically 7 and 10 for pH, a potassium chloride solution yielding a value of 1413 microsiemens per centimeter (µS/cm) at 25°C for specific conductance, and a 100% dissolved O_2 solution for dissolved oxygen. Calibration is performed for the pH meters per manufacturer's specifications using a 2-point calibration bounding the range of the sample. For coulometry, sodium carbonate standards (typically yielding a concentration of 4,000 milligrams [mg] CO_2/L) are routinely analyzed to evaluate the instrument.

B.7.3 Calibration Resolution and Documentation

Logging tool calibration resolution and documentation will follow standard industry practices in **Section 7A-Attachment 1**.

Manufacturers of the pressure, temperature, and mass flow equipment will provide calibration certifications for their equipment. If calibration cannot be achieved with the equipment, this piece of equipment will be replaced with a new or calibrated piece of equipment.

For groundwater sampling, calibration values are recorded in daily sampling records and any errors in calibration are noted. For parameters where calibration is not acceptable, redundant equipment may beused so loss of data is minimized.

B.8. Inspection/Acceptance for Supplies and Consumables

B.8.1 Supplies, Consumables, and Responsibilities

Supplies and consumables for field and laboratory operations will be procured, inspected, and accepted as required from vendors approved by Marquis Carbon Injection LLC, or the respective subcontractor responsible for the data collection activity. Acquisition of supplies and consumables related to groundwater analyses will be the responsibility of the laboratory per established standard methodology or operating procedures.

B.9. Non-direct Measurements

B.9.1 Seismic Monitoring Methods

Data Sources

3D seismic surveys will be conducted at regular intervals during and after CO_2 injection. Each of these surveys will be compared to the baseline survey which was acquired before the start of CO_2 injection. It is important that the only difference between the surveys is the change in acoustic properties of the injection formation caused by the presence of CO_2. Consequently, repeatability of source and receiver types and spacing, source size, and other acquisition parameters between surveys is paramount for an accurate comparison.

Relevance to Project

Time-lapse 3D seismic surveys will be used to track changes in the CO_2 plume in the subsurface. A modeling exercise has been completed to confirm that the planned injected volumes of CO_2 will result in sufficient change in the rock properties of the Mt. Simon to be measured with 3D seismic.

Processing and comparing subsequent surveys to a baseline survey will allow the project to monitor plume growth as well as to ensure that the plume does not migrate beyond the confining layer. Computational 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.

Acceptance Criteria

To ensure survey repeatability, consistent acquisition geometry (receiver line spacing, source line spacing, line direction) is required. The seismic sources (vibroseis trucks) should be the same for each survey, including the number of trucks, their specifications, and the characteristics (sweep parameters) of the seismic energy they generate.

Data processing for each survey should be the same and the baseline seismic survey should be reprocessed alongside each additional repeat seismic survey to ensure consistency.

Resources/Facilities Needed

Marquis Carbon Injection LLC will subcontract all necessary resources and facilities for the seismic monitoring, in-zone pressure monitoring, and groundwater sampling.

Validity Limits and Operating Conditions

For seismic surveys and computational modeling, intraorganizational checks between trained and experienced personnel will ensure that all surveys and computational modeling are conducted conforming to standard industry practices.

B.10. Data Management

B.10.1 Data Management Scheme

Marquis Carbon Injection LLC, or a designated contractor, will maintain the project data required in the permit. Data will be backed up in electronic format and/or held on secure servers. A separate Data Management Plan will be developed to track and store project data.

B.10.2 Record-keeping and Tracking Practices

All records of gathered data will be securely held and properly labeled for auditing purposes.

B.10.3 Data Handling Equipment/Procedures

All equipment used to store data will be properly maintained and operated according to proper industry techniques and/or manufacturer's requirements.

B.10.4 Responsibility

The primary project managers will be responsible for ensuring proper data management is maintained.

B.10.5 Data Archival and Retrieval

All data will be held by Marquis Carbon Injection LLC. These data will be maintained and stored for auditing purposes as described in **Section B.10.1**.

B.10.6 Hardware and Software Configurations

All Marquis Carbon Injection LLC and vendor hardware and software configurations will be appropriately interfaced.

B.10.7 Checklists and Forms

Checklists and forms will be procured and generated as necessary.

C. Assessment and Oversight

C.1. Assessments and Response Actions

C.1.1 Activities to be Conducted

Groundwater quality data will be collected at the frequency outlined in **Table 7A-4**. After completion of sample analysis, results will be reviewed for QC criteria, as noted in **Section B.5**. If the data quality fails to meet criteria set in **Section B.5**, samples will be reanalyzed, if still within holding time criteria. If outside of holding time criteria or at the operator's choosing, additional samples may be collected, or sample results may be excluded from data evaluations and interpretations. Evaluation for data consistency will be performed according to procedures described in the EPA 2009 Unified Guidance (EPA, 2009).

C.1.2 Responsibility for Conducting Assessments

Organizations gathering data will be responsible for conducting their internal assessments. All stop-work orders will be handled internally within individual organizations.

C.1.3 Assessment Reporting

All assessment information should be reported to the individual organizations project manager outlined in Section A.1.1.F.

C.1.4 Corrective Action

All corrective action affecting only an individual organization's data collection responsibility should be addressed, verified, and documented by the individual project managers and communicated to the other project managers as necessary. Corrective actions affecting multiple organizations should be addressed by all members of the project leadership and communicated to other members on the distribution list for the QASP. Assessments may require integration of information from multiple monitoring sources across organizations (operational, in-zone monitoring, above-zone monitoring) to determine whether correction actions are required and/or the most cost-efficient and effective action toimplement. Marquis Carbon Injection LLC will coordinate multiorganization assessments and corrective actions as warranted based on the severity of the event as described in the Emergency and Remedial Response Plan (Permit Section 10.0).

C.2. Reports to Management

C.2.1 QA Status Reports

QA status reports should not be needed. If any testing or monitoring techniques are changed, the QASP will be reviewed and updated as appropriate in consultation with EPA. Revised QASPs will be distributed by Marquis Carbon Injection LLC to the full distribution list at the beginning of this document.

D. Data Validation and Usability

D.1. Data Review, Verification, and Validation

D.1.1 Criteria for Accepting, Rejecting, or Qualifying Data

The groundwater/brine and injection stream analytical data validation will include the review of the concentration units, sample holding times, and the review of duplicate, blank and other appropriate QA/QC results. All analytical results will be entered into a database or spreadsheet with periodic data review and analysis. Marquis Carbon Injection LLC will retain copies of the laboratory analytical test results and/or reports. Analytical results will be reported on a frequency based on the approved UIC permit conditions. In the periodic reports, data will be presented in graphical and tabular formats as appropriate to characterize general system operations and variability with time.

D.2. Verification and Validation Methods

D.2.1 Data Verification and Validation Processes

See **Sections D.1.1**. and **B.5** for data verification and validation processes.

Appropriate statistical software will be used to determine data consistency.

D.2.2 Data Verification and Validation Responsibility

Marquis Carbon Injection LLC or its designated subcontractor will verify and validate the injection stream and groundwater analytical data.

D.2.3 Issue Resolution Process and Responsibility

Marquis Carbon Injection LLC or its designated coordinator will provide an overview of the injection stream and groundwater data handling, management, and assessment process. Staff involved in these processes will consult with the coordinator to determine actions that are required to resolve issues.

D.2.4 Checklist, Forms, and Calculations

Checklists and forms will be developed specifically to meet permit requirements.

D.3. Reconciliation with User Requirements

D.3.1 Evaluation of Data Uncertainty

Statistical software will be used to determine groundwater data consistency.

D.3.2 Data Limitations Reporting

The organization-level project managers will be responsible for ensuring that data developed by their respective organizations is presented with the appropriate data-use limitations.

Marquis Carbon Injection LLC will use the current operating procedure for the use, sharing, and presentation of results and/or data for the Marquis BioCarbon Project. This procedure has been developed to ensure quality, internal consistency and facilitate tracking and record keeping of data end-users and associated publications.

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