Illinois Industrial Carbon Capture and Sequestration (IL-ICCS) Project Class VI Injection Well: Quality Assurance and Surveillance Plan

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Prepared by:
Archer Daniels Midland Company (ADM)

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Distribution List

The following project participants should receive the completed Quality Assurance and Surveillance Plan (QASP) and all future updates for the duration of the project. The ADM Corn Plant Manager will be responsible for ensuring that all those on the distribution list will receive the most current copy of the approved Quality Assurance and Surveillance Plan. Names in bold are the primary points of contact with addresses listed below.

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A. Project Management

A.1. Project/Task Organization

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

The project, led by Archer Daniels Midland Company (ADM), includes participation from several subcontractors. The Testing and Monitoring Activities responsibilities will be shared between ADM and their designated subcontractor and the program will be broken in six subcategories:

I) Shallow Groundwater Sampling

II) Deep Groundwater Sampling

III) Well Logging

IV) Mechanical Integrity Testing (MIT)

V) Pressure/Temperature Monitoring

VI) CO_2 Stream Analysis

VII) Geophysical Monitoring

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

The majority of the physical samples collected and data gathered as part of the MVA program is analyzed, processed, or witnessed by third parties independent and outside of the project management structure.

A.1.d. QA Project Plan Responsibility

ADM will be responsible for maintaining and distributing official, approved QA Project Plan. ADM will periodically review this QASP and consult with USEPA if/when changes to the plan are warranted.

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

Figures 1 shows the organization structure of the project. ADM will provide to the UIC Program Director a contact list of individuals fulfilling these roles.

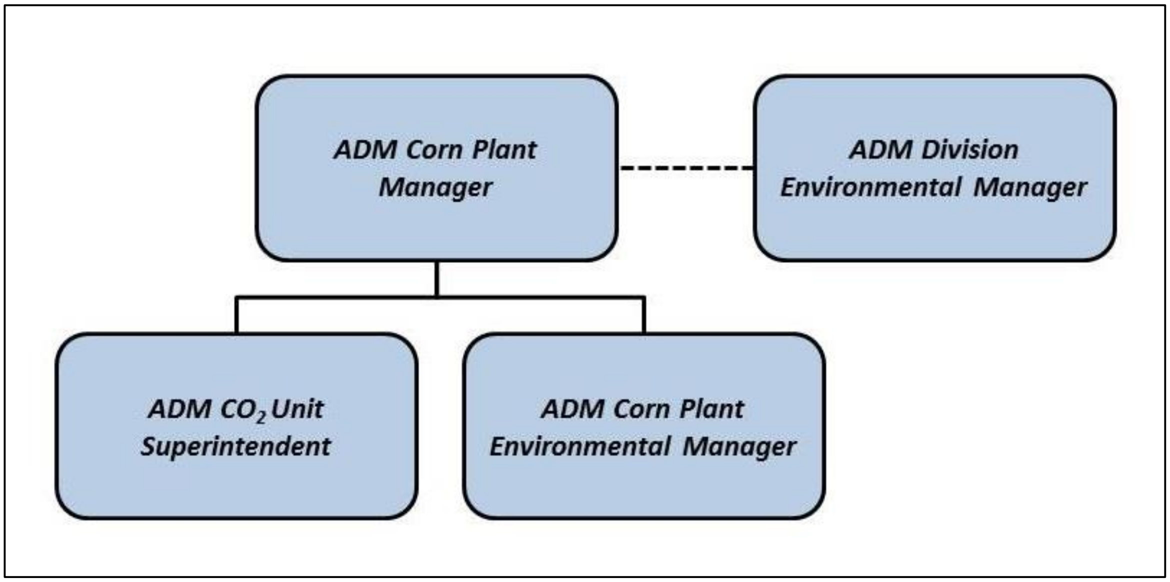


Figure 1. Archer Daniels Midland Company project organization structure.

A.2. Problem Definition/Background

A.2.a Reasoning

The Illinois Industrial Carbon Capture and Storage (IL-ICCS) Project's monitoring, verification, and accounting (MVA) program has operational monitoring, verification, and environmental monitoring components. Operational monitoring is used to ensure safety with all procedures associated with fluid injection, monitor the response of storage unit, and the movement of the CO_2 plume. Key monitoring parameters include the pressure of injection well tubing & annulus, storage unit, above seal strata, and the lowermost USDW reservoir. Other monitoring parameters include injection rate, total mass & volume injected, injection well temperature profile, and passive seismic. The verification component will provide information to evaluate if leakage of CO_2 through the caprock is occurring. This includes pulse neutron logging , pressure, and temperature monitoring. The environmental monitoring components will determine if the injectate is being released into the shallow subsurface or biosphere. This monitoring includes pulse neutron logging and ground water monitoring.

A robust MVA program has been developed for the IL-ICCS project based on the experience gained through the Illinois Basin–Decatur Project (IBDP). The knowledge and experience gained through the IBDP provides a high level of confidence that the storage unit (Mt Simon) is capable to accept and permanently retain the injectate. The primary goal of the IL-ICCS MVA program is to demonstrate that project activities are protective of human health and the environment. To help achieve this goal, this Quality Assurance Surveillance Plan (QASP) was developed to insure the quality standards of the testing and monitoring program meet the requirements of the U.S. Environmental Protection Agency's (USEPA) Underground Injection Control (UIC) Program for Class VI wells.

A.2.b. Reasons for Initiating the Project

The goal of the IL-ICCS injection project is to demonstrate the ability of the Mt. Simon Sandstone to accept and retain industrial-scale volumes of CO_2 for permanent geologic sequestration to reduce atmospheric concentrations of CO_2. In order to demonstrate that this can be done safely and at commercial scale, a rigorous MVA plan is proposed to ensure the injected CO_2 is retained within the intended storage reservoir.

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

The Class VI Rule requires owners or operators of Class VI wells to perform several types of activities during the lifetime of the project in order to ensure that the injection well maintains its mechanical integrity, that fluid migration and the extent of pressure elevation are within the limits described in the permit application, and that underground sources of drinking water (USDWs) are not endangered. These monitoring activities include mechanical integrity tests (MITs), injection well testing during operation, monitoring of ground water quality in several zones, tracking of the CO_2 plume and associated pressure front. This document details both the measurements that will be taken as well as the steps to ensure that the quality of all the data is such that the data can be used with confidence in making decisions during the life of the project.

A.3. Project/Task Description

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

Table 1 describes the Testing and Monitoring tasks, reasoning, responsible parties, locations and testing frequency. Tables 2 and 3 summarize the instrumentation and geophysical surveys, respectively.

Table 1. Summary of testing and monitoring.

			Frequency					
Parameter	**Location**	**Method**	**Pre-injection—Baseline**	**Operation Period—5 years**	**PISC Period—10 years**	**Analytical Technique**	**Lab/Custody**	**Purpose**
Carbon dioxide stream analysis	Compressor	Direct sampling	2 years: Quarterly	Quarterly	None	Chemical analysis	TBD	Monitor injectate
	After CO_2 dehydration	Direct sampling	2 years: Quarterly	Quarterly	None	Chemical analysis	TBD	Monitor injectate
Continuous recording								
Injection rate and volume	After compression	Flow meter	N/A	Continuous	N/A	Direct measurement	N/A	Monitor rate and volume
Injection pressure	CCS2 Wellhead	Pressure gauge	N/A	Continuous	N/A	Direct measurement	N/A	Monitor injection pressure
Annular pressure	CCS2 Wellhead	Pressure gauge	N/A	Continuous	N/A	Direct measurement	N/A	Monitor annular pressure
DTS Fiber Optic Temperature	CCS2 Wellbore	Fiber optic cable	N/A	Continuous	Yr 1- Continuous Yr 2-10 - N/A	Direct measurement	N/A	Wellbore integrity
Downhole pressure/temperature	CCS2: Mt Simon	Downhole gauge	N/A	Continuous	Yr 1-3 Continuous Yr 4-10 – Annual	Direct measurement	N/A	Monitor reservoir
Corrosion monitoring	After compression	Coupon	N/A	Quarterly	N/A	Chemical analysis	TBD	Monitor injectate, wellbore integrity
Mechanical Integrity	CCS2	Various	Prior to operation	Annually	Prior to P/A	§ 146.87 (a)(4) § 146.89 (c)(2)	N/A	Wellbore integrity
DTS Fiber Optic	CCS2	Fiber optic cable	Continuous	Continuous	Yr 1 Continuous Yr 2-10 – N/A	Direct measurement	N/A	Wellbore integrity
Cement evaluation	CCS2	Logging	Baseline	N/A	N/A	Cement evaluation log	N/A	Wellbore integrity
Pressure fall off testing	CCS2: Mt. Simon	Pressure gauge	N/A	During injection- approximately half way through the injection phase and at the end of the injection period.	N/A	Direct measurement	N/A	Wellbore integrity
Microseismic	Various monitoring stations	Multilevel geophones and seismometers	Continuous	Continuous	Continuous	Direct measurement	N/A	Reservoir integrity

Table 1. Summary of testing and monitoring (continued).

Direct Geochemical Measurement			Frequency					
Level	**Location Depth**	**Method**	**Pre-injection—Baseline**	**Operation Period—5 years**	**PISC Period—10 years**	**Analytical Technique**	**Parameters**	**Purposes**
Shallow groundwater (Quaternary & Pennsylvanian)	Figure 2	In-situ	2 years: Quarterly	Year 1–2: Quarterly Year 3–5: Bi-annually	Annually	Chemical analysis	Table 4	Detection of changes in groundwater quality for a shallow USDW.
Lowermost USDW (St. Peter)	GM2	Swab valve or other method	1 sample	Annually	Annually	Chemical analysis	Table 5	Detection of changes in groundwater quality in lowermost USDW.
Above confining zone (Ironton-Galesville)	VW1	In-situ	1 sample	Baseline; Year 1-3: Annual Year 4-5: N/A	None	Chemical analysis	Table 6	Detection of changes in groundwater quality for reservoir directly above the confining zone.
	VW2	In-situ	1 sample	Annually	Annually	Chemical analysis	Table 6	Detection of changes in groundwater quality for reservoir directly above the confining zone.
In-zone monitoring (Mt. Simon)	VW1	In-situ	1 sample	Baseline; Year 1-3: Annual Year 4-5: N/A	None	Chemical analysis	Table 7	Detection of changes in groundwater quality, geochemical monitoring and CO_2 detection in storage reservoir.
	VW2	In-situ	1 sample	Annually	Annually	Chemical analysis	Table 7	Detection of changes in groundwater quality, geochemical monitoring and CO_2 detection in storage reservoir.

* Samples collected using downhole sampling tool run into well on wireline.

* Swab samples collected at surface after well has been swabbed with ample volume to ensure reservoir fluid at surface.

Table 1. Summary of testing and monitoring (continued).

Indirect Methods of CO_2 Plume Tracking					
Method	**Location**	**Pre-injection—Baseline**	**Operation Period—5 years**	**PISC Period—10 Years**	**Purpose**
Time lapse VSP	GM1	2013, 2014, 2015	None	None	Indirect measurement of plume size
Time lapse 3D	Injection area	Baseline survey	Year 2 (2019)	Year 1 and Year 10	Indirect measurement of plume size

Table 2. Instrumentation summary. T = Temperature; P = Pressure; DTS = Distributed Temperature System; F = Flow.

			Operational Period—5 Years		PISC Period—10 Years		
Monitoring Location	**Instrument Type**	**Monitoring Target (Formation or Other)**	**Data Collection Location(s)**	**Frequency**	**Data Collection Location(s)**	**Frequency**	**Explanation**
CO$_2$ Facility	T, P, F	Surface	Discharge High Pressure Pumps	Continuous	Discharge high pressure pumps	NA	Monitoring the operational, equipment, and permit parameters
CCS#1	DTS	All strata	Distributed measurement to 6325 KB/5631 MSL.	Continuous	Distributed measurement to 6325 KB/5631 MSL.	Yr 1: Continuous Yr 2–10: None	Monitoring operational parameters and well integrity
	T, P	Mt. Simon	1 interval PT @ 6325 KB/5631 MSL Perfs @ 6982–7050 KB 6288–6356 MSL	Continuous 1 interval	1 interval PT @ 6325 KB/5631 MSL Perfs @ 6982–7050 KB 6288–6356 MSL	Yr 1–3: Continuous Yr 4–10: Annual	Monitoring operational and equipment parameters
	Geophones	All strata	3 interval array	Note 1.	3 intervals	Note 1.	Note 1: Operator will maintain a passive seismic monitoring system that has the ability to detect seismic events over M1.0 within the AoR.
CCS#2	T, P	Surface well head	Tubing	Continuous	Tubing	Continuous	Monitoring operational, equipment, and permit parameters
	P		Annulus	Continuous	Annulus	Continuous	Monitoring well integrity
	DTS	All geologic strata	Distributed measurement to 6211 KB/5520 MSL.	Continuous	Distributed measurement to 6211 KB/5520 MSL.	Yr 1: Continuous Yr 2–10: None	Monitoring operational parameters and well integrity
	T, P	Mt. Simon	1 point location, 1 interval: PT @ 6270 KB/5579 MSL; Perfs @ 6630 - 6825 KB, 5939 - 6134 MSL	Continuous	1 point location, 1 interval: PT @ 6270 KB/5579 MSL; Perfs @ 6630 - 6825 KB, 5939 - 6134 MSL	Yr 1–3: Continuous Yr 4–10: Annual	Monitoring operational, equipment, and permit parameters
VW1	T, P	Ironton-Galesville	1 interval 4918–5000 KB 4224–4306 MSL	Year 1-3: Continuous Year 4-5: None	1 interval 4918–5000 KB 4224–4306 MSL	None	Monitoring seal formation integrity
		Mt. Simon	1 interval 6945–5654 KB 6251–4960 MSL	Year 1-3: Continuous Year 4-5: None	1 interval 6945–5654 KB 6251–4960 MSL	None	Monitoring plume pressure and temperature front

Table 2. Instrumentation summary. T = Temperature; P = Pressure; DTS = Distributed Temperature System; F = Flow (continued).

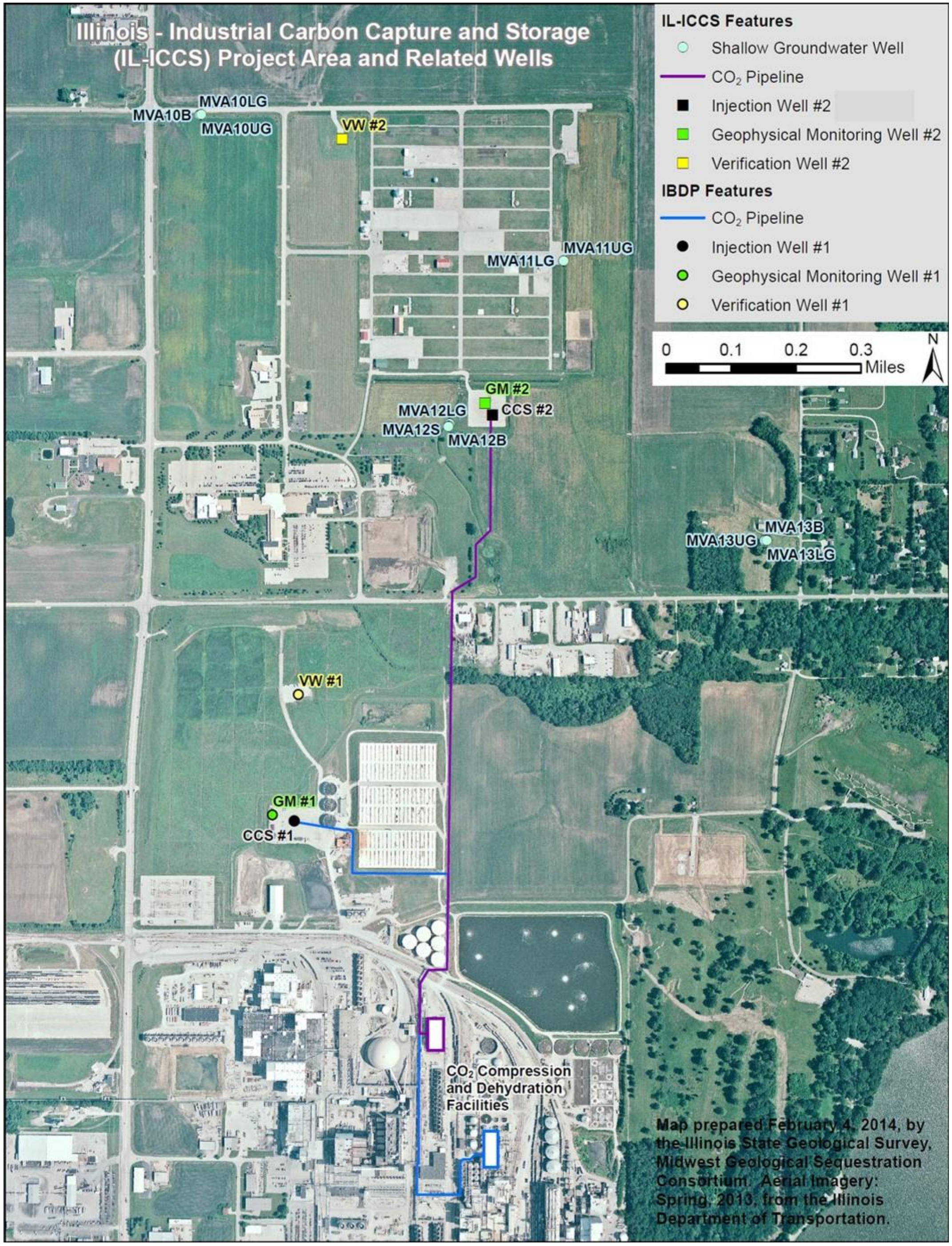
			Operational Period—5 Years		PISC Period—10 Years		
Monitoring Location	**Instrument Type**	**Monitoring Target (Formation or Other)**	**Data Collection Location(s)**	**Frequency**	**Data Collection Location(s)**	**Frequency**	**Explanation**
VW2	T, P	Ironton-Galesville	1 point location, 1 interval: 4902 KB/4199 MSL	Baseline Continuous	1 point location, 1 interval: 4902 KB/4199 MSL	Yr 1–3: Continuous Yr 4–10: Annual	Monitoring seal formation integrity
	T,P	Mt. Simon	1 point location, 4 intervals: 7041, 6681, 6524, 5848 KB; 6338, 5978, 5821, 5145 MSL	Continuous	1 point location, 4 intervals: 7041, 6681, 6524, 5848 KB; 6338, 5978, 5821, 5145 MSL	Continuous	Monitoring plume pressure and temperature front
GM1	Geophones	All strata	20 interval array	Note 1.	20 interval array	Note 1.	Note 1: Operator will maintain a passive seismic monitoring system that has the ability to detect seismic events over M1.0 within the AoR.
GM2	T,P	St. Peter	1 point location, 1 interval: 3450 KB/2759 MSL	Continuous	1 point location, 1 interval: 3450 KB/2759 MSL	Yr 1–3: Continuous Yr 4–10: Annual	Monitoring seal formation integrity
	Geophones	All strata	5 interval array	Note 1.	5 interval array	Note 1.	Note 1: Operator will maintain a passive seismic monitoring system that has the ability to detect seismic events over M1.0 within the AoR.
Seismic Stations	Seismometers & geophones	All strata	Combination of surface and borehole monitoring stations	Note 1.	Various	Note 1.	Note 1: Operator will maintain a passive seismic monitoring system that has the ability to detect seismic events over M1.0 within the AoR.

Table 3. Geophysical surveys summary.

Monitoring Activity	Well	Tools or Survey Description	Pre-Injection - Baseline	Operation Period - 5 Years	PISC Period - 10 Years	Explanation
Logging	GM#1	CBL	1 Baseline	None	None	Mechanical Integrity
	GM#2	CBL	1 Baseline	None	None	Mechanical Integrity
	VW#1	Cement evaluation tool	1 Baseline	None	None	Mechanical Integrity
		Pulse neutron	1 Baseline	Year 2, 4	Year 1, 3, 5, 7, 10	Fluid movement, salinity, CO_2 detection, mechanical integrity
	VW#2	Cement evaluation tool	1 Baseline	None	None	Mechanical Integrity
		Pulse neutron	1 Baseline	Year 2, 4	Year 1, 3, 5, 7, 10	Fluid movement, salinity, CO_2 detection, mechanical integrity
	CCS#1	Pulse neutron	1 Baseline	Year 2, 4	Year 1, 3, 5, 7, 10	Fluid movement, salinity, CO_2 detection, mechanical integrity
		Casing inspection	1 Baseline	None	None	Mechanical Integrity
		Cement evaluation tool	1 Baseline	None	None	Mechanical Integrity
	CCS#2	Pulse neutron	1 Baseline	Year 2, 4	Year 1, 3, 5, 7, 10	Fluid movement, salinity, CO_2 detection, mechanical integrity
		Casing inspection	1 Baseline	None	None	Mechanical Integrity
		Cement evaluation tool	1 Baseline	None	None	Mechanical Integrity
Seismic	GM#1	Time-lapse VSP survey	2013, 2014, 2015	None	None	Monitor spatial extent of plume
	Area	3D surface seismic survey	1 Baseline	Year 2 (2019)	Year 1, Year 10	Monitor spatial extent of plume

A.3.c. Geographic Locations

Figure 2 shows the IL-ICCS site and monitoring infrastructure.


Illinois - Industrial Carbon Capture and Storage (IL-ICCS) Project Area and Related Wells

Map prepared February 4, 2014, by the Illinois State Geological Survey, Midwest Geological Sequestration Consortium. Aerial Imagery: Spring, 2013, from the Illinois Department of Transportation.

Figure 2. IL-ICCS Project area showing location of shallow groundwater monitoring wells and deep monitoring wells.

A.3.d. Resource and Time Constraints

At the conclusion of the IBDP project, the availability of wells associated with that project (VW#1, GM#1, CCS#1) are potential resource constraints for IL-ICCS. Under its current state-issued UIC permit, IBDP post-injection monitoring will continue for at least 2 to 3 years after injection ceases in November 2014. Thereafter, the status and availability of the IBDP wells for use by the IL-ICCS project is uncertain. No additional resource or time constraints have been identified for the IL-ICCS testing and monitoring plan beyond project funding levels and the proposed timeline.

A.4.Quality Objectives and Criteria

A.4.a. Performance/Measurement Criteria

The overall QA objective for monitoring is to develop and implement procedures for subsurface monitoring, field sampling, laboratory analysis, and reporting which will provide results that will meet the characterization and non-endangerment goals of this project. Groundwater monitoring will be conducted during the pre-injection, injection, and post-injection phases of the project. Shallow and deep groundwater monitoring wells will be used to gather water-quality samples and pressure data. All the groundwater analytical and field monitoring parameters for each interval are listed in Table 4 through Table 7. Table 8, Table 9 and Table 10 show analytical parameters for CO2 stream gas monitoring, corrosion coupon assessment, and gauge specifications. Table 11 shows the monitoring outputs. The list of analytes may be reassessed periodically and adjusted to include or exclude analytes based on their effectiveness to the overall monitoring program goals.

Key testing and monitoring areas include:

I. Shallow Groundwater Sampling
    - Aqueous chemical concentrations

II. Deep Formation Fluid Sampling
    - Aqueous chemical concentrations

III. Well Logging
    - pulse neutron

IV. Mechanical Integrity Testing (MIT)
    - Pulsed neutron, temperature, cement evaluation logging

V. Pressure/Temperature Monitoring
    - Pressure/temperature from in-situ gauges
    - Pressure/temperature from surface gauges

VI. CO_2 Stream Analysis
    - CO_2 Purity (% v/v, [GC])
    - Oxygen (O_2, ppm v/v)
    - Nitrogen (N_2, ppm v/v)
    - Carbon Monoxide (CO, ppm v/v)
    - Oxides of Nitrogen (NOx, ppm v/v)
    - Total Hydrocarbons (THC, ppm v/v as CH_4)

- Methane (CH_4, ppm v/v)
- Acetaldehyde (AA, ppm v/v)
- Sulfur Dioxide (SO_2, ppm v/v)
- Hydrogen Sulfide (H_2S ppm v/v)
- Ethanol (ppm v/v)

VII. Geophysical Monitoring

- Seismic data files (e.g., segd file)
- Processed time-lapse report

Table 4. Summary of analytical and field parameters for Quaternary/Pennsylvanian groundwater samples. All analysis will all be performed by ADM or a designated third party laboratory.
ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography - pyrolysis.

Parameters	Analytical Methods[1]	Detection Limit/Range	Typical Precisions	QC Requirements
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 mg/L (analyte, dilution and matrix dependent)	±15%	Daily calibration; blanks, duplicates and matrix spikes at 10% or greater frequency
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES, EPA Method 6010B	0.005 to 0.5 mg/L (analyte, dilution and matrix dependent)	±15%	Daily calibration; blanks, duplicates and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO_3, and SO_4	Ion Chromatography, EPA Method 300.0	0.02 to 0.13 mg/L (analyte, dilution and matrix dependent)	±15%	Daily calibration; blanks and duplicates at 10% or greater frequency
Dissolved CO_2	Coulometric titration, ASTM D513-11	25 mg/L	±15%	Duplicate measurement; standards at 10% or greater frequency
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Alkalinity	APHA 2320B	4 mg/L	±3 mg/L	Duplicate analysis
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 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

Table 5. Summary of analytical and field parameters for St Peter Reservoir groundwater samples. All analysis will be performed by ADM or a designated third party laboratory. ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography - pyrolysis.

Parameters	Analytical Methods(1)	Detection Limit/Range	Typical Precisions	QC Requirements
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 mg/L (analyte, dilution and matrix dependent)	±15%	Daily calibration; blanks, duplicates and matrix spikes at 10% or greater frequency
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES, EPA Method 6010B	0.005 to 0.5 mg/L (analyte, dilution and matrix dependent)	±15%	Daily calibration; blanks, duplicates and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO_3, and SO_4	Ion Chromatography, EPA Method 300.0	0.02 to 0.13 mg/L (analyte, dilution and matrix dependent)	±15%	Daily calibration; blanks and duplicates at 10% or greater frequency
Dissolved CO_2	Coulometric titration, ASTM D513-11	25 mg/L	±15%	Duplicate measurement; standards at 10% or greater frequency
Isotopes: δ^{13}C of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO_3^- for δ^{13}C	±0.15‰ for δ^{13}C	10% duplicates; 4 standards/batch
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Water Density(field)	Oscillating body method	0.0000 to 2.0000	±0.0002 g/mL	Duplicate measurements
Alkalinity	APHA 2320B	4 mg/L	±3 mg/L	Duplicate analysis
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 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

Note:2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007)

Table 6. Summary of analytical and field parameters for Ironton-Galesville groundwater samples. Note: Cation, anion, TDS, and alkalinity measurements will all be performed by a laboratory meeting the requirements under the USEPA Environmental Laboratory Accreditation Program. Isotope and dissolved CO_2 analyses will be performed by ADM or a designated laboratory. ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography - pyrolysis.

Parameters	Analytical Methods(1)	Detection Limit/Range	Typical Precisions	QC Requirements
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 mg/L (analyte, dilution and matrix dependent)	±15%	Daily calibration; blanks, duplicates and matrix spikes at 10% or greater frequency
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES, EPA Method 6010B	0.005 to 0.5 mg/L (analyte, dilution and matrix dependent)	±15%	Daily calibration; blanks, duplicates and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO_3, and SO_4	Ion Chromatography, EPA Method 300.0	0.02 to 0.13 mg/L (analyte, dilution and matrix dependent)	±15%	Daily calibration; blanks and duplicates at 10% or greater frequency
Dissolved CO_2	Coulometric titration, ASTM D513-11	25 mg/L	±15%	Duplicate measurement; standards at 10% or greater frequency
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO_3^- for $\delta^{13}C$	±0.15‰ for $\delta^{13}C$	10% duplicates; 4 standards/batch
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Water Density(field)	Oscillating body method	0.0000 to 2.0000	±0.0002 g/mL	Duplicate measurements
Alkalinity	APHA 2320B	4 mg/L	±3 mg/L	Duplicate analysis
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 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

Note:2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007)

Table 7. Summary of analytical and field parameters for Mt Simon groundwater samples. All analysis will be performed by ADM or a designated third party laboratory. ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography - pyrolysis.

Parameters	**Analytical Methods**[(1)]	**Detection Limit/Range**	**Typical Precisions**	**QC Requirements**
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, and Tl	ICP-MS, EPA Method 6020	0.001 to 0.1 mg/L (analyte, dilution and matrix dependent)	±15%	Daily calibration; blanks, duplicates and matrix spikes at 10% or greater frequency
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES, EPA Method 6010B	0.005 to 0.5 mg/L (analyte, dilution and matrix dependent)	±15%	Daily calibration; blanks, duplicates and matrix spikes at 10% or greater frequency
Anions: Br, Cl, F, NO$_3$, and SO$_4$	Ion Chromatography, EPA Method 300.0	0.02 to 0.13 mg/L (analyte, dilution and matrix dependent)	±15%	Daily calibration; blanks and duplicates at 10% or greater frequency
Dissolved CO$_2$	Coulometric titration, ASTM D513-11	25 mg/L	±15%	Duplicate measurement; standards at 10% or greater frequency
Isotopes: δ^{13}C of DIC	Isotope ratio mass spectrometry[2]	12.2 mg/L HCO$_3^-$ for δ^{13}C	±0.15‰ for δ^{13}C	10% duplicates; 4 standards/batch
Total Dissolved Solids	Gravimetry; APHA 2540C	12 mg/L	±10%	Balance calibration, duplicate analysis
Water Density(field)	Oscillating body method	0.0000 to 2.0000	±0.0002 g/mL	Duplicate measurements
Alkalinity	APHA 2320B	4 mg/L	±3 mg/L	Duplicate analysis
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 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

Note:2: Gas evolution technique by Atekwana and Krishnamurthy (1998), with modifications made by Hackley et al. (2007)

Table 8. Summary of analytical parameters for CO_2 gas stream. All analysis will be performed by ADM or a designated third party laboratory.

Parameters	Analytical Methods[(1)]	Detection Limit/Range	Typical Precisions	QC Requirements
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
	GC/TCD	0.1 % to 100 %	5 - 10 % relative across the range, RT ± 0.1 min	daily standard, duplicate analysis within 10 % of each other
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
	GC/TCD	0.1 % to 100 %	5 - 10 % relative across the range, RT ± 0.1 min	daily standard, duplicate analysis within 10 % of each other
Carbon Monoxide	ISBT 5.0 Colorimetric	5 uL/L to 100 uL/L (ppm by volume)	± 20 % of reading	duplicate analysis
	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
Oxides of Nitrogen	ISBT 7.0 Colorimetric	0.2 uL/L to 5 uL/L (ppm by volume)	± 20 % of reading	duplicate analysis
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
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
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
Sulfur Dioxide	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
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
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
CO_2 Purity	ISBT 2.0 Caustic absorption Zahm-Nagel	99.00% to 99.99%	± 10 % of reading	User calibration per manufacturer recommendation
	ALI method SAM 4.1 subtraction method (GC/DID)	1 ppm for each target analyte (analyte dependent) - refer to Oxygen and Nitrogen analysis.	5-10 % relative across the range	duplicate analysis within 10 % of each other
	GC/TCD	0.1 % to 100 %	5-10 % relative across the range, RT ± 0.1 min	standard with every sample, duplicate analysis within 10 % of each other

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

Table 9. Summary of analytical parameters for corrosion coupons.

Parameters	Analytical Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Mass	NACE RP0775-2005	.005mg	+/-2%	Annual Calibration of Scale (3rd Party Aldinger Co. – Cert #664896F)
Thickness	NACE RP0775-2005	.001mm	+/-005mm	Factory calibration

Table 10. Summary of measurement parameters for field gauges.

Parameters	Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Booster pump discharge pressure (PIT-012)	ANSI Z540-1-1994	+/- 0.001 psi / 0-3000 psi	+/- 0.01 psi	Annual Calibration of Scale (3rd party)
Injection Tubing Temperature (TIT-019)	ANSI Z540-1-1994	+/- 0.001 F / 0-500 F	+/- 0.01 F	Annual Calibration of Scale (3rd party)
Annulus Pressure (PIT-014)	ANSI Z540-1-1994	+/- 0.001 psi / 0-3000 psi	+/- 0.01 psi	Annual Calibration of Scale (3rd party)
Injection Tubing Pressure (PIT-009)	ANSI Z540-1-1994	+/- 0.001 psi / 0-3000 psi	+/- 0.01 psi	Annual Calibration of Scale (3rd party)
Injection Mass Flow Rate (FIT-006)	UNKNOWN	+/- 0.1000% of rate / 50,522-303,133 lb/hr	+/- 0.01 lbs/hr	Annual Calibration of Scale (3rd party)
Westbay Pressures (MOSDAX)	UNKNOWN	+/0 0.01 psi / 0-4000 PSI	+/- 0.1 psi	Annual Calibration of Scale (3rd party)

Table 11. Actionable testing and monitoring outputs.

	Project Action Limit	**Detection Limit**	**Anticipated Reading**
MIT—Pulse neutron logging	Action taken when RST indicates CO_2 outside of expected range	+/- 0.5 SIGM	Brine saturated ~ 60 CO_2 saturated ~ 8
Wellbore integrity—annular pressure gauge	<3% pressure loss over 1 hour	Refer to Appendix A (annular pressure gauge table)	>3% pressure loss over 1 hour
Surface and downhole pressure gauges	Action will be taken when pressures are well outside of modeled/expected range	Refer to Table 11 and 12 for surface gauges Refer to Table 9 for downhole gauge	Within injection formation: >80% fracture gradient 0.71 psi/ft
Wellbore integrity—DTS fiber optic temperature	Action will be taken when there is an anomaly in temperature profile	Refer to Appendix A	DTS provides continuous temperature profile
Seismic data files	Detected CO_2 outside the AOR	Dependent on fluid saturation, and formation velocities	CO_2 plume migration similar to modeled outcome

A.4.b. Precision

For groundwater sampling, data accuracy 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 spot check for sample bottle contamination. Laboratory assessment of analytical precision will be the responsibility of the individual laboratories per their standard operating procedures.

Table 12 summarizes the specifications of each monitoring method. For direct pressure and logging measurements, precision data is presented in Table 13.

A.4.c. Bias

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

A.4.d. Representativeness

For groundwater sampling, data representativeness expresses the degree to which data accurately and precisely represents 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 representative of site conditions. For analytical results of individual groundwater samples, representativeness will be estimated by ion 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 is greater than 10%, the sample may be considered non-representative.

A.4.e. 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 and temperature measurements, it is expected that data will be recorded no less than 90% of the time.

A.4.f. 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 QA/QC effort. If historical groundwater quality data become available from other sources, their applicability to the project and level of quality will be assessed prior to use with data gathered on this project. Direct pressure, temperature, and logging measurements will be directly comparable to previously obtained data.

A.4.g. Method Sensitivity

Table 14 through Table 19 provide additional details on gauge specifications and sensitivities.

Table 12. Pressure and temperature—downhole quartz gauge specifications.

Calibrated working pressure range	Atmospheric to 10,000 psi
Initial pressure accuracy	<+/-2 psi over full scale
Pressure resolution	0.005 psi at 1-s sample rate
Pressure drift stability	<+/-1 psi per year over full scale
Calibrated working temperature range	77–266°F
Initial temperature accuracy	<+/-0.9°F per +/-0.27°F
Temperature resolution	0.009°F at 1-s sample rate
Temperature drift stability	<+/-0.1°F per year at 302
Max temperature	302°F

Table 13. Representative Logging tool specifications.

	RST	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
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 14. Pressure Field Gauge PIT-009—Injection Tubing Pressure.

Calibrated working pressure range	0 to 3000 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 15. Pressure Field Gauge PIT-014—Annuls Pressure.

Calibrated working pressure range	0 to 3000 psi and 4–20 mA
Initial pressure accuracy	< 0.02500%
Pressure resolution	0.001 psi and 0.00001 mA
Pressure drift stability	To be determined after first year

Table 16. Pressure Field Gauge PIT-012.

Calibrated working pressure range	0 to 3000 psi and 4–20 mA
Initial pressure accuracy	< 0.03125%
Pressure resolution	0.001 psi and 0.00001 mA
Pressure drift stability	To be determined after first year

Table 17. Temperature Field Gauge TIT-019 —Injection Tubing Temperature.

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 18. Mass Flow Rate Field Gauge—FT-006 CO_2 Mass Flow Rate.

Calibrated working flow rate range	50,522 to 303,133 lbs/hr and 4–20 mA
Initial mass flow rate accuracy	< 0.18%
Mass flow rate resolution	0.0001 lb/hr
Mass flow rate drift stability	To be determined after first year

Table 19. Westbay Field Gauge—Westbay (MOSDAX) Pressure.

Calibrated working pressure range	0 to 4000 psi
Initial pressure accuracy	< 0.01 %
Pressure resolution	0.001 psi
Pressure drift stability	To be determine after first year

A.5. Special Training/Certifications

A.5.a. 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 (Appendix B). 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 ADM will provide the agency with all laboratory SOPs developed for the specific parameter using the appropriate standard method. Each laboratory technician conducting the analysis on the samples will be trained on the SOP developed for each standard method. ADM will include the technician's training certification with the biannual report.

A.5.b/c. 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.a. Report Format and Package Information

A semi-annual report from ADM to USEPA will contain all required project data, including 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.b. 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.c/d. Data Storage and Duration

ADM or a designated contractor will maintain the required project data as provided elsewhere in the permit.

A.6.e. QASP Distribution Responsibility

The ADM Corn Plant Manager will be responsible for ensuring that all those on the distribution list will receive the most current copy of the approved Quality Assurance and Surveillance Plan.

B. Data Generation and Acquisition

B.1. Sampling Process Design (Experimental Design)

Discussion in this section is focused on groundwater and fluid sampling and does not address monitoring methods that do not gather physical samples (e.g., logging, seismic monitoring, and pressure/temperature monitoring). During the pre-injection and injection phases, groundwater sampling is planned to include an extensive set of chemical parameters to establish aqueous geochemical reference data. Parameters will include selected constituents that: (1) have primary and secondary USEPA drinking water maximum contaminant levels, (2) are the most responsive to interaction with CO_2 or brine, (3) are needed for quality control, and (4) may be needed for geochemical modeling. The full set of parameters for each sampling interval is given in Table 4-Table **7**. After a sufficient baseline is established, monitoring scope may shift to a subset of indicator parameters that are (1) the most responsive to interaction with CO_2 or brine and (2) are needed for quality control. Implementation of a reduced set of parameters would be done in consultation with the USEPA. Isotopic analyses will be performed on baseline samples to the degree that the information helps verify a condition or establish an understanding of non-project related variations. For non-baseline samples, isotopic analyses may be reduced in all monitoring wells if a review of the historical project results or other data determines that further sampling for isotopes is unneeded. During any period where a reduced set of analytes is used, if statistically significant trends are observed that are the result of unintended CO_2 or brine migration, the analytical list would be expanded to the full set of monitoring parameters. The Ironton-Galesville groundwater samples will be analyzed using a laboratory meeting the requirements under the USEPA Environmental Laboratory Accreditation Program. All other samples will be analyzed by the operator or a third party laboratory. Dissolved CO_2 will be analyzed by methods consistent with Test Method B of ASTM D 513-06, "Standard Test Methods for Total and Dissolved Carbon Dioxide in Water" or equivalent. Isotopic analysis will be conducted using established methods.

B.1.a. Design Strategy

CO_2 Stream Monitoring Strategy

The primary purpose of analyzing the carbon dioxide stream is to evaluate the potential interactions of carbon dioxide 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. Establishing the chemical composition of the injectate also supports the determination of whether the injectate meets the qualifications of hazardous waste under the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6901 et seq. (1976), and/or the Comprehensive Environmental Response, Compensation, and Liability Act, (CERCLA) 42 U.S.C. 9601 et seq. (1980). Additionally, monitoring the chemical and physical characteristics of the carbon dioxide (e.g., isotopic signature, other constituents) may help distinguish the injectate from the native fluids and gases if unintended leakage from the storage reservoir occurred. 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.

Calibration of transmitters used to monitor pressures, temperatures, and flow rates of CO_2 into the injection well at the injection well and at the verification well shall be conducted annually (e.g., Durkin Equipment Company, St. Louis, MO). Reports shall contain test equipment used to calibrate the transmitters, including test equipment manufacturers, model numbers, serial numbers, calibration dates and expiration dates.

Corrosion Monitoring Strategy

Corrosion coupon analyses will be conducted quarterly to aid in ensuring the mechanical integrity of the equipment in contact with the carbon dioxide. Coupons shall be sent quarterly to a company for analysis (e.g., SGS) and an analysis conducted in accordance with NACE Standard RP-0775 (or similar) to determine and document corrosion wear rates based on mass loss.

Shallow Groundwater Monitoring Strategy

Four dedicated monitoring wells have been selected for shallow groundwater monitoring. These wells have already been installed and screened in the Quaternary-age deposits to depths less than 150 ft below ground surface (bgs). The local Quaternary-age deposits are used predominantly as private water well sources in the area. The wells are designated as IL-ICCS-MVA 10LG, IL-ICCS-MVA 11LG, IL-ICCS-MVA 12LG, and IL-ICCS-MVA 13LG (Figure 2). The wells were selected to give a spatial distribution around the planned CO_2 injection well (CCS#2) location.

Deep Groundwater Monitoring Strategy

Monitoring of the deeper St. Peter and Ironton-Galesville Sandstones will be used for early leakage detection in formations that are much closer to the Mt. Simon Sandstone injection reservoir. Fluid sampling at wells VW#1, VW#2, and GM#2 in combination with pressure monitoring, temperature monitoring, and pulse neutron logging will be used to determine if leakage is occurring at or near the injection well. The Ironton-Galesville Sandstone, has sufficient permeability (over 100 mD) such that pressure monitoring at the verification wells would detect a failure of the confining zone should it occur. MIT testing and DTS monitoring at the injection well will also provide data to insure the mechanical integrity of the well is maintained. With the planned sampling and monitoring frequencies, it is expected that baseline conditions can be documented, natural variability in conditions can be characterized, unintended brine or CO_2 leakage could be detected if it occurred, and sufficient data will be collected to demonstrate that the effects of CO_2 injection are limited to the intended storage reservoir. No groundwater fluid sampling is planned for the Mt Simon intervals where free phase CO_2 has broken through.

GM#2 Sampling

The IL-ICCS geophysical monitoring well, GM#2, will be used for fluid sampling of the St. Peter Sandstone, a USEPA identified USDW. At prescribed frequencies (in consultation with USEPA), fluid sampling will occur using a portable swabbing rig or other available sampling technologies. Samples will be analyzed for constituents listed in Table 5 to document baseline fluid chemistry and to detect changes in fluid chemistry that could result from the movement of brine or CO_2 from the storage interval through the seal formation.

VW#1 Sampling

The IBDP verification well, VW#1, will be used to monitor the pressure and temperature in the Ironton-Galesville Sandstone above the Eau Claire Formation, the primary reservoir seal. This well will serve as an early leak detection system by allowing the operator to monitor for changes above the primary caprock. Groundwater samples will collected and analyzed for constituents listed in Table 6 to document baseline fluid chemistry and to detect changes in fluid chemistry that could result from the movement of brine or CO_2 from the storage interval through the seal formation. The well has been completed with a Westbay multilevel sampling system and fluid samples will be collected as described by Locke et al. (2013).

VW#2 Sampling

The IL-ICCS verification well, VW#2, will allow monitoring within the Mt. Simon injection zone as well as immediately above the Eau Claire Formation. This well will serve as an early leak detection system by allowing the operator to monitor for changes above the primary caprock. VW#2 will be equipped with a multilevel pressure and temperature monitoring system with fluid sampling capability at four (4) intervals. The system uses packers to isolate each perforation interval and hydraulically operated sliding sleeves to facilitate sampling. Pressure and temperature will be continuously monitored and recorded in each of the five (5) perforation intervals. The pressure inside the tubing just above the uppermost packer (~4900 Kb) will be monitored and recorded. At prescribed frequencies (in consultation with USEPA), fluid sampling will occur by opening the appropriate sliding sleeve across from the zone to be sampled. Each sample interval will be analyzed for constituents list in Table 6 for the Ironton Galesville or Table 7 for the Mt Simon to document baseline fluid chemistry and to detect changes in fluid chemistry that could result from the movement of brine or CO_2 from the storage interval through the seal formation.

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

Groundwater sampling frequencies are detailed in Table 1.
CO_2 gas stream and corrosion coupon frequencies are detailed in Table 1.

B.1.c. Site/Sampling Locations

Shallow groundwater monitoring will use existing wells IL-ICCS-MVA 10LG, IL-ICCS-MVA 11LG, IL-ICCS-MVA 12LG, and IL-ICCS-MVA 13LG (Figure 2) as noted in Section B.1.a. Deep groundwater monitoring will use existing wells VW#1, VW#2, and GM#2 (Figure 2) as noted in Section B.1.a.
CO_2 gas stream and corrosion coupon sampling locations will occur in the compressor building after the last stage of compression.

B.1.d. Sampling Site Contingency

The shallow and deep groundwater monitoring wells are located on property of the project participants (e.g., ADM, Richland Community College) and access permissions have already been granted. No problems of site inaccessibility are anticipated. 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.

No problems of site inaccessibility are anticipated for CO_2 gas stream or corrosion coupon sampling. 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.e. Activity Schedule

The groundwater sampling activities and frequencies are summarized in Table 1.
The CO_2 gas stream and corrosion coupon sampling activities and frequencies are summarized in Table 1.

B.1.f. Critical/Informational Data

During both groundwater sampling and analytical efforts, detailed field and laboratory documentation will be taken. Documentation will be recorded in field and laboratory forms and notebooks. Critical information will include time and date of activity, person/s performing activity, location of activity (well-field sampling) or instrument (lab analysis), field or laboratory instrument calibration data, field parameter values. For laboratory analyses, much of the critical data are generated during the analysis and provided to end users in digital and printed formats. Noncritical data may include appearance and odor of the sample, problems with well or sampling equipment, and weather conditions.

B.1.g. Sources of Variability

Potential sources of variability related to monitoring activities include (1) natural variation in fluid quality, formation pressure and temperature and seismic activity; (2) variation in fluid quality, formation pressure and temperature, and seismic activity due to project operations; (3) changes in recharge due to rainfall, drought, and snowfall; (4) changes in instrument calibration during sampling or analytical activity; 5) different staff collecting or analyzing samples; (6) differences in environmental conditions during field sampling activities; (7) changes in analytical data quality during life of project; and (8) data entry errors related to maintaining project database.

Activities to eliminate, reduce, or reconcile variability related to monitoring activities include (1) collecting long-term baseline data to observe and document natural variation in monitoring parameters, (2) evaluating data in timely manner after collection to observe anomalies in data that can be addressed be resampled or reanalyzed, (3) conducting statistical analysis of monitoring data to determine whether variability in a data set is the result of project activities or natural variation, (4) maintaining weather-related data using on-site weather monitoring data or data collected near project site (such as from local airports), (5) checking instrument calibration before, during and after sampling or sample analysis, (6) thoroughly training staff, (7) conducting laboratory quality assurance checks using third party reference materials, and/or blind and/or replicate sample checks, and (8) developing a systematic review process of data that can include sample-specific data quality checks (i.e., cation/anion balance for aqueous samples).

B.2. Sampling Methods

Logging, geophysical monitoring, and pressure/temperature monitoring does not apply to this section, and is omitted.

B.2.a/b. Sampling SOPs

Groundwater samples will be collected primarily 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. Groundwater pH, temperature, specific conductance, and dissolved oxygen will be monitored in the field using portable probes and a flow-through cell consistent with standard methods (e.g., APHA, 2005) 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 20.

Table 20. Stabilization criteria of water quality parameters during shallow well purging.

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

After field parameters have stabilized, samples will be collected. Samples requiring filtration will be filtered through 0.45 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 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, collection in sample containers, and analysis.

For deep groundwater sampling of VW#1, ISGS-SOP-WB-V1.14 (dated August 10, 2012) will be used for the collection and processing of Westbay samples. Wells GM#2 and VW#2 will not have a Westbay installation for sampling and are anticipated to use a wireline sampling system with a sampling device (e.g., Kuster sampler or similar) capable of collecting a sample from a discrete interval. Samples from GM#2 and VW#2 will be processed in a manner consistent with ISGS-SOP-WB-V1.14.

VW#1 was developed and purged extensively at the time of completion and similar plans to develop VM#2 are in place and will be executed when completion occurs. Prior to sampling, each zone will be purged to ensure representative samples are collected. Due to the extensive well development, the amount of fluid to be purged at the time of sampling will be relatively small. If a three-foot zone is perforated (similar to VW#1), then the annular space between the 2-7/8-in. tubing and the 5-1/2-in. casing is only 1.92 gal. Thus, relatively small purge volumes will adequately refresh each isolated sampling interval. Similar purging techniques will be used for VW#1 and VW#2. Additional information about sampling procedures at VW#1 are given in Locke et al. (2013).

For VW#2, it is anticipated that air lifting with nitrogen will be used to draw fluid into the well for purging. A gas lift valve will be placed in the tubing string at approximately 1,200 ft below ground surface at the time of the completion. The sampler will be positioned at the same elevation as the discrete perforated interval, and a sample would be collected after sufficient purging.

B.2.c. In-situ Monitoring.

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

B.2.d. Continuous Monitoring.

Pressure data will be collected from shallow groundwater wells on a periodic basis (e.g., hourly to daily) using dedicated pressure transducers with data loggers to generally characterize shallow water level trends. These data are informational only.

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

Described in section B.2.b.

B.2.f. Sample Containers and Volumes

For CO_2 stream monitoring, samples will be collected in a clean sample container rated for the appropriate collection pressure (i.e. mini cylinders or polybags provided by Airborne Labs International Inc., Somerset, NJ).

Assay for CO_2 Quarterly Gas Analysis:

- CO_2 Purity (% v/v, [GC])
- Oxygen (O_2, ppm v/v)
- Nitrogen (N_2, ppm v/v)
- Carbon Monoxide (CO, ppm v/v)
- Oxides of Nitrogen (NOx, ppm v/v)
- Total Hydrocarbons (THC, ppm v/v as CH_4)
- Methane (CH_4, ppm v/v)
- Acetaldehyde (AA, ppm v/v)
- Sulfur Dioxide (SO_2, ppm v/v)
- Hydrogen Sulfide (H_2S ppm v/v)
- Ethanol (ppm v/v)

For shallow and deep groundwater samples, all sample bottles will be new. Sample bottles and bags for analytes will be used as received (ready for use) from the vendor or contract analytical laboratory for the analyte of interest. A summary of sample containers is presented in Table 22.

B.2.g. Sample Preservation

For groundwater and other aqueous samples, the preservation methods in Table 22 will be used.

No preservation is required or used for CO_2 gas stream, and additional details of sampling requirements are shown in Table 21. Corrosion coupon sampling only requires that the coupons be physically separated (e.g., sleeves, baggies) during transportation to prevent physical abrasion.

Table 21. Summary of sample containers, preservation treatments, and holding times for CO_2 gas stream analysis.

Target Parameters	Volume/Container Material	Preservation Technique	Sample Holding time (max)
CO_2 gas stream	(2) 2L MLB Polybags (1) 75 cc Mini Cylinder	Sample Storage Cabinets	5 Business Days

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

Dedicated pumps (e.g., bladder pumps) will be installed in each 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 L of deionized water will be pumped through pump and sample tubing. Individual cleaned pumps and tubing will be placed in plastic garbage bags for transport to the field for installation. All field glassware (pipets, beakers, filter holders, etc.) are cleaned with tap water to remove any loose dirt, washed in a dilute nitric acid solution, and rinsed three times with deionized water before use.

CO_2 gas stream sampling containers will be either disposed or decontaminated by the analytical lab. No sampling equipment will be utilized with the corrosion coupons or annual field gauge calibrations.

B.2.i Support Facilities

For sampling of groundwater, the following are required: air compressor, vacuum pump, generator, multi-electrode water quality sonde, analytical meters (pH, specific conductance, etc.). Field activities are usually completed in field vehicles and portable laboratory trailers located on site.

Sampling 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 existing CO_2 compression building.

Similarly, corrosion coupons will be removed from the CO_2 injection line within the existing CO_2 compression building.

Field gauges will be removed from the injection well and verification well utilizing existing standard industry tools and equipment. Deployment and retrieval of verification well gauges will be done using procedures and equipment recommended by the vendor, subcontractor, or is standard per industry practice.

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

Field staff will be responsible for properly 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 replaced. Significant corrective actions affecting analytical results will be documented in field notes.

B.3. Sample Handling and Custody

Logging, geophysical monitoring, and pressure/temperature monitoring does not apply to this section, and is omitted.

Sample holding times (Table 22) will be consistent with those described in US EPA (1974), American Public Health Association (APHA, 2005), Wood (1976), and ASTM Method D6517-00 (2005). After collection, samples will be placed in ice chests in the field and maintained thereafter at approximately 4°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 22. As appropriate, alternative sample containers and preservation techniques approved by the UIC Program Director will be used to meet analytical requirements.

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

See Table 22.

B.3.b. Sample Transportation

See description at the beginning of Section B.3.

B.3.c. 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.

An analysis authorization form shall be provided with each CO_2 gas stream sample provided for analysis as shown by the example in Figure 4.

B.3.d. Sample Identification

All sample bottles will have waterproof labels with information denoting project, sampling date, sampling location, sample identification number, sample type (freshwater or brine), analyte, volume, filtration used (if any), and preservative used (if any). See Figure 3 for an example of a label.

Table 22. Summary of anticipated sample containers, preservation treatments, and holding times.

Target Parameters	Volume/Container Material	Preservation Technique	Sample Holding time	Relative Sampling Depth
Cations: Ca, Fe, K, Mg, Na, Si, Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, Tl	250 ml/HDPE	Filtered, nitric acid, cool 4°C	60 days	Shallow
Dissolved CO_2	2 × 60 ml/HDPE	Filtered, cool 4°C	14 days	Shallow
Dissolved CO_2	60 ml/HDPE	Filtered, cool 4°C	14 days	Deep
Isotopes: ^{3}H, δD, δ^{18}O, δ^{34}S, and δ^{13}C	2 × 60 ml/HDPE	Filtered, cool 4°C	4 weeks	Shallow
Isotopes: δ^{34}S	250 ml/HDPE	Filtered, cool 4°C	4 weeks	Deep
Isotopes: δD, δ^{18}O, δ^{13}C	60 ml/HDPE	Filtered, cool 4°C	4 weeks	Deep
Alkalinity, anions (Br, Cl, F, NO_3, SO_4**)**	500 ml/HDPE	Filtered, cool 4°C	45 days	Shallow
Field Confirmation: Temperature, dissolved oxygen, specific conductance, pH	200 ml/glass jar	None	< 1 hour	Deep
Field Confirmation: Density	60 ml/HDPE	Filtered	< 1 hour	Deep

IL-ICCS_10LG_20A (fresh water)
01-23-2014
Metals, 60 ml, filtered, HNO_3

Figure 3. Example label for groundwater sample bottles.

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

For CO_2 stream analysis, an analysis authorization form (Figure 4) will accompany the sample to the lab at which point a chain-of-custody accompanies the sample through their processes.

For groundwater samples, chain-of-custody will be documented using a standardized form. A typical form is shown in Figure 5, and it or a similar form will be used for all groundwater sampling. Copies of the form will be provided to the person/lab receiving the samples as well as the person/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

Logging, geophysical monitoring, and pressure/temperature monitoring does not apply to this section, and is omitted.

B.4.a. Analytical SOPs

Analytical SOPs are referenced in Table 4-Table 7. Other laboratory specific SOPs utilized by the laboratory will be determined after a contract laboratory has been selected. Upon request ADM will provide the agency with all laboratory SOPs developed for the specific parameter using the appropriate standard method. Each laboratory technician conducting the analysis on the samples will be trained on the SOP developed for each standard method. ADM will include the technician's training certification with the biannual report.

B.4.b. Equipment/Instrumentation Needed

Equipment and instrumentation is specified in the individual analytical methods referenced in Table 4-Table 7.

B.4.c. Method Performance Criteria

Nonstandard method performance criteria are not anticipated for this project.

B.4.d. Analytical Failure

Each laboratory conducting the analyses in Table 4-Table 7 will be responsible for appropriately addressing analytical failure according to their individual SOPs.

B.4.e. Sample Disposal

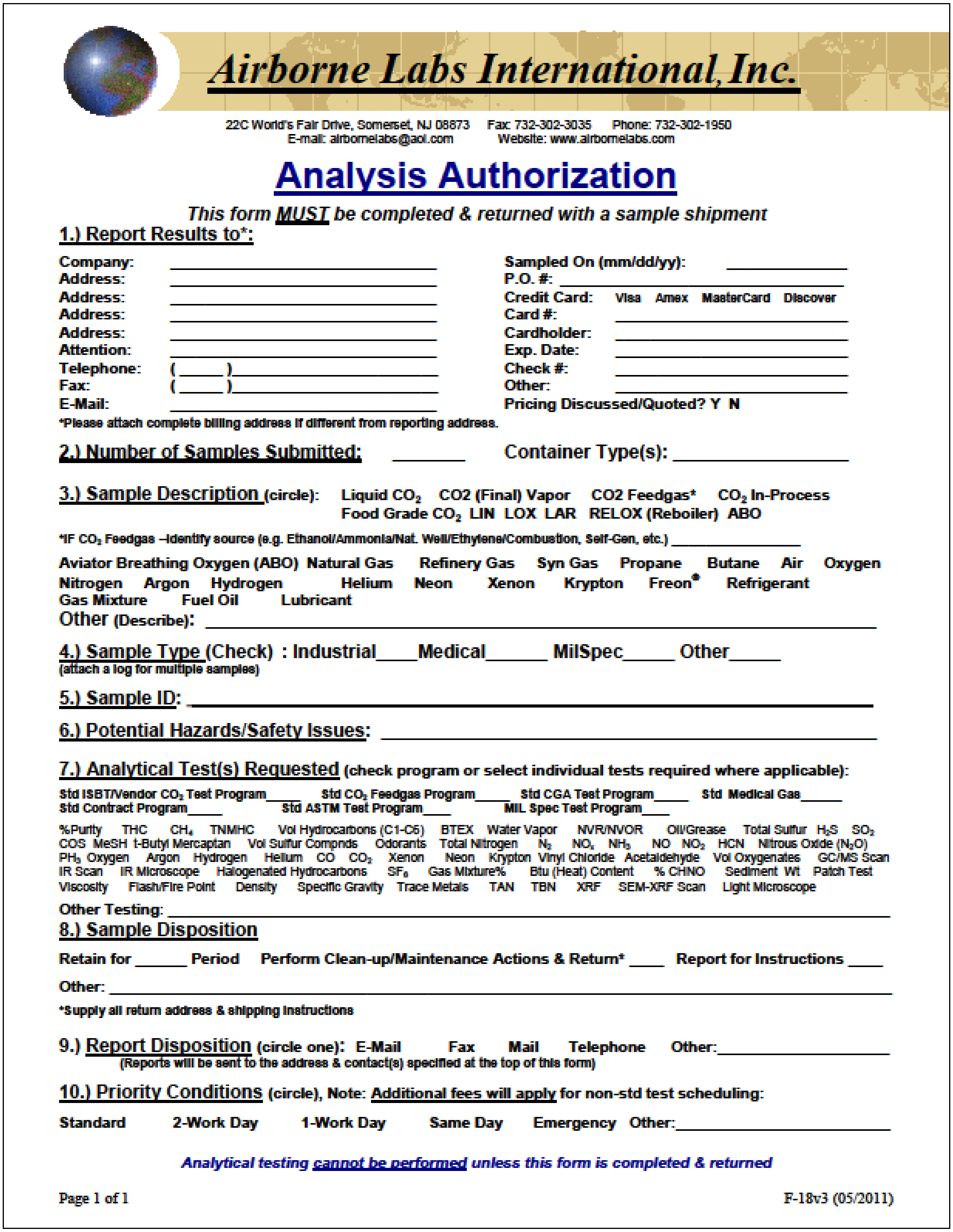
Each laboratory conducting the analyses in in Table 4-Table 7 will be responsible for appropriate sample disposal according to their individual SOPs.

B.4.f 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.g. Method Validation for Nonstandard Methods

Nonstandard methods are not anticipated for this project. If nonstandard methods are needed or proposed in the future, the USEPA will be consulted on additional appropriate actions to be taken.



Airborne Labs International, Inc.

22C World's Fair Drive, Somerset, NJ 08873   Fax: 732-302-3035   Phone: 732-302-1950
E-mail: airbornelabs@aol.com   Website: www.airbornelabs.com

Analysis Authorization

This form MUST be completed & returned with a sample shipment

1.) Report Results to*:

Company: ____________
Address: ____________
Address: ____________
Address: ____________
Address: ____________
Attention: ____________
Telephone: (____) ____________
Fax: (____) ____________
E-Mail: ____________

Sampled On (mm/dd/yy): ____________
P.O. #: ____________
Credit Card: Visa Amex MasterCard Discover
Card #: ____________
Cardholder: ____________
Exp. Date: ____________
Check #: ____________
Other: ____________
Pricing Discussed/Quoted? Y N

*Please attach complete billing address if different from reporting address.

2.) Number of Samples Submitted: ________ Container Type(s): ____________

3.) Sample Description (circle):

Liquid CO_2 CO2 (Final) Vapor   CO2 Feedgas* CO_2 In-Process
Food Grade CO_2 LIN   LOX   LAR   RELOX (Reboiler)   ABO

*IF CO_2 Feedgas –Identify source (e.g. Ethanol/Ammonia/Nat. Well/Ethylene/Combustion, Self-Gen, etc.) ____________

Aviator Breathing Oxygen (ABO)   Natural Gas   Refinery Gas   Syn Gas   Propane   Butane   Air   Oxygen
Nitrogen   Argon   Hydrogen   Helium   Neon   Xenon   Krypton   Freon®   Refrigerant
Gas Mixture   Fuel Oil   Lubricant

Other (Describe): ____________

4.) Sample Type (Check) : Industrial____Medical______ MilSpec_____ Other_____

(attach a log for multiple samples)

5.) Sample ID: ____________

6.) Potential Hazards/Safety Issues: ____________

7.) Analytical Test(s) Requested (check program or select individual tests required where applicable):

Std ISBT/Vendor CO_2 Test Program_____   Std CO_2 Feedgas Program_____   Std CGA Test Program_____   Std Medical Gas______
Std Contract Program_____   Std ASTM Test Program____   MIL Spec Test Program____

%Purity   THC CH_4 TNMHC   Vol Hydrocarbons (C1-C6)   BTEX   Water Vapor   NVR/NVOR   Oil/Grease   Total Sulfur H_2S SO_2
COS   MeSH   t-Butyl Mercaptan   Vol Sulfur Compnds   Odorants   Total Nitrogen N_2 NO_x NH_3 NO NO_2 HCN   Nitrous Oxide (N_2O)
PH_3 Oxygen   Argon   Hydrogen   Helium   CO CO_2 Xenon   Neon   Krypton   Vinyl Chloride   Acetaldehyde   Vol Oxygenates   GC/MS Scan
IR Scan   IR Microscope   Halogenated Hydrocarbons SF_6 Gas Mixture%   Btu (Heat) Content   % CHNO   Sediment Wt   Patch Test
Viscosity   Flash/Fire Point   Density   Specific Gravity   Trace Metals   TAN   TBN   XRF   SEM-XRF Scan   Light Microscope

Other Testing: ____________

8.) Sample Disposition

Retain for ______ Period   Perform Clean-up/Maintenance Actions & Return* ____   Report for Instructions ____

Other: ____________

*Supply all return address & shipping instructions

9.) Report Disposition (circle one): E-Mail   Fax   Mail   Telephone   Other: ____________

(Reports will be sent to the address & contact(s) specified at the top of this form)

10.) Priority Conditions (circle), Note: Additional fees will apply for non-std test scheduling:

Standard   2-Work Day   1-Work Day   Same Day   Emergency   Other: ____________

Analytical testing cannot be performed unless this form is completed & returned

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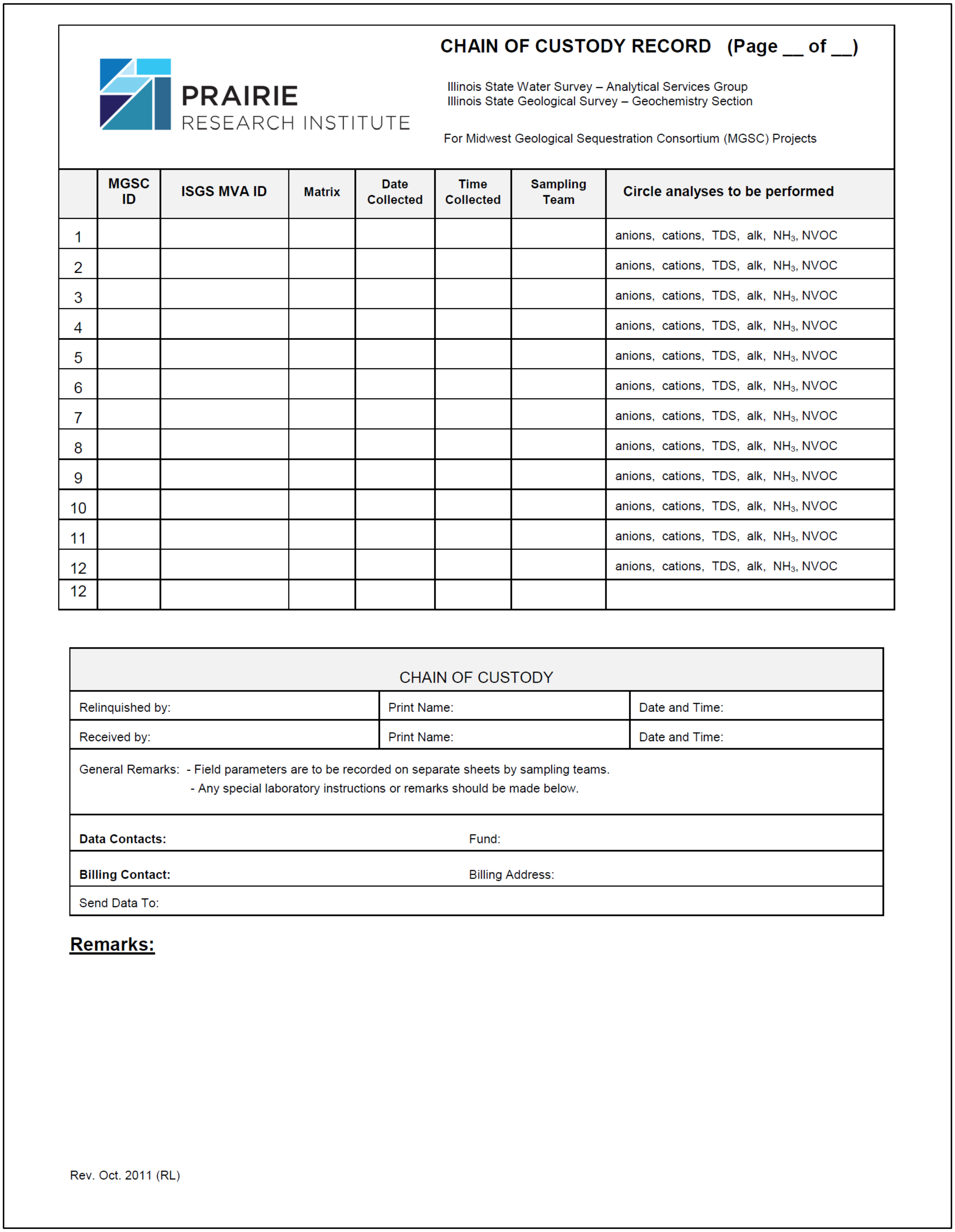
Figure 4. Example of CO_2 gas stream analysis authorization form.



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CHAIN OF CUSTODY RECORD (Page __ of __)

Illinois State Water Survey – Analytical Services Group
Illinois State Geological Survey – Geochemistry Section

For Midwest Geological Sequestration Consortium (MGSC) Projects

	MGSC ID	ISGS MVA ID	Matrix	Date Collected	Time Collected	Sampling Team	Circle analyses to be performed
1							anions, cations, TDS, alk, NH_3, NVOC
2							anions, cations, TDS, alk, NH_3, NVOC
3							anions, cations, TDS, alk, NH_3, NVOC
4							anions, cations, TDS, alk, NH_3, NVOC
5							anions, cations, TDS, alk, NH_3, NVOC
6							anions, cations, TDS, alk, NH_3, NVOC
7							anions, cations, TDS, alk, NH_3, NVOC
8							anions, cations, TDS, alk, NH_3, NVOC
9							anions, cations, TDS, alk, NH_3, NVOC
10							anions, cations, TDS, alk, NH_3, NVOC
11							anions, cations, TDS, alk, NH_3, NVOC
12							anions, cations, TDS, alk, NH_3, NVOC
12							

CHAIN OF CUSTODY

Relinquished by:	Print Name:	Date and Time:
Received by:	Print Name:	Date and Time:

General Remarks: - Field parameters are to be recorded on separate sheets by sampling teams.
- Any special laboratory instructions or remarks should be made below.

Data Contacts:	Fund:
Billing Contact:	Billing Address:

Send Data To:

Remarks:

Rev. Oct. 2011 (RL)

Figure 5. Example chain-of-custody form.

B.5. Quality Control

Geophysical monitoring and pressure/temperature monitoring does not apply to this section, and is omitted. For log quality control, please refer to Appendix B.

B.5.a. QC activities

Blanks

For shallow groundwater sampling, a field blank will be collected and analyzed for the inorganic analytes in Table 4-Table 7 at a frequency of 10% or greater. Field blanks will be exposed to the same field and transport conditions as the groundwater samples. Blanks will also be utilized for deep groundwater sampling and analyzed for the inorganic analytes in Table 4-Table 7 at a frequency of 10% or greater. Field blanks will be used to detect contamination resulting from the collection and transportation process.

Duplicates

For each shallow groundwater sampling round, a duplicate groundwater sample is collected from a well from a rotating schedule. Duplicate samples are collected from the same source immediately after the original sample in different sample containers and processed as all other samples. Duplicate samples are used to assess sample heterogeneity and analytical precision.

B.5.b. 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) to the calculated TDS (i.e., mass balance) per APHA 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 are then brought to the attention of the analytical laboratory for confirmation and/or reanalysis. The ion balance is recalculated, and if the error is still not resolved, suspect data are identified and may be given less importance in data interpretations.

B.5.c. Calculating Applicable QC Statistics

Charge Balance

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

$$\%\, difference = 100\frac{\sum cations - \sum anions}{\sum cations + \sum anions}, \qquad \text{(Equation 1)}$$

where the sums of the ions are represented in milliequivalents (meq) 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 charge balance acceptance criteria are exceeded using the formula:

$$1.0 < \frac{measured\ TDS}{calculated\ TDS} < 1.2, \quad \text{(Equation 2)}$$

where the anticipated values are between 1.0 and 1.2.

Outliers

A 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 groundwater 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 (Appendix B).

For groundwater sampling, 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 NELAP requirement.

B.7. Instrument/Equipment Calibration and Frequency

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

B.7.a. Calibration and Frequency of Calibration

Pressure/temperature gauge calibration information is located in Table 12-Table 19. Logging tool calibration will be at the discretion of the service company providing the equipment, following standard industry practices noted in Appendix B. Calibration frequency will be determined by standard industry practices.

For groundwater sampling, portable field meters or muliprobe sondes used to determine field parameters (e.g., pH, temperature, specific conductance, dissolved oxygen) are calibrated according to manufacturer recommendations and equipment manuals (Hach, 2006) each day before sample collection begins. Recalibration is performed if any components yield atypical values or fail to stabilize during sampling.

B.7.b. Calibration Methodology

Logging tool calibration methodology will follow standard industry practices in Appendix B.

For groundwater sampling, standards used for calibration are typically 7 and 10 for pH, a potassium chloride solution yielding a value of 1413 microseimens 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 manufactuer'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 mg CO_2/L) are routinely analyzed to evaluate instrument.

B.7.c. Calibration Resolution and Documentation
Logging tool calibration resolution and documentation will follow standard industry practices in Appendix B.

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 be used so loss of data is minimized.

B.8. Inspection/Acceptance for Supplies and Consumables

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

Supplies and consumables for field and laboratory operations will be procured, inspected, and accepted as required from vendors approved by ADM 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. Nondirect Measurements

Seismic Monitoring Methods

B.9.a Data Sources
For time lapse seismic surveys, repeatability is paramount for accurate differential comparison. Therefore, to ensure survey quality, the locations for the shots and acquisition methodology of sequential surveys will be consistent. Once these surveys are conducted, they will be compared to a baseline survey to track and monitor plume development.

For in-zone pressure monitoring, the in-zone pressure gauges in VW#1 and VW#2 will be used to gather pressure data.

B.9.b. Relevance to Project
Time lapse seismic surveys will be used to track changes in the CO_2 plume in the subsurface. Processing and comparing subsequent surveys to a baseline will allow project managers to monitor plume growth, as well as to ensure that the plume does not move outside of the intended storage reservoir. Numerical modeling will be used to predict the CO_2 plume growth and migration over time by combining the processed seismic data with the existing geologic model.

In-zone pressure monitoring data will be used in numerical modeling to predict plume and pressure front behavior and confirm the plume stage within the AOR.

B.9.c. Acceptance Criteria
Following standard industry practices will ensure that the gathered seismic data will be used for accurate modeling and monitoring. Similar ground conditions, shot points located within tolerable limits, functional geophones, and similar seismic input signal will be used from survey to survey to ensure repeatability.

When processing seismic data, several QA checks will be done in accordance with industry standards including reformatting to Omega structured files, geometry application, amplitude compensation, predictive deconvolution, elevation statics correction, RMS amplitude gain, velocity analysis every 2 km, NMO application using picked velocities, CMP stacking, random noise attenuation, and instantaneous gain.

B.9.d. Resources/Facilities Needed

ADM will subcontract all necessary resources and facilities for the seismic monitoring, in-zone pressure monitoring, and groundwater sampling.

B.9.e. Validity Limits and OperatingCconditions

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

B.10. Data Management

B.10.a. Data Management Scheme

ADM or a designated contractor will maintain the required project data as provided elsewhere in the permit. Data will be backed up on tape or held on secure servers.

B.10.b. Record-keeping and Tracking Practices

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

B.10.c. Data Handling Equipment/Procedures

All equipment used to store data will be properly maintained and operated according to proper industry techniques. ADM SCADA system and vendor data acquisition systems will interface with one another and all subsequent data will be held on a secure server.

B.10.d. Responsibility

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

B.10.e. Data Archival and Retrieval

All data will be held by ADM.   These data will be maintained and stored for auditing purposes as described in section B.10.a.

B.10.f. Hardware and Software Configurations

All ADM and vendor hardware and software configurations will be appropriately interfaced.

B.10.g. 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.a. Activities to be Conducted

Please refer to Table 1 in section A.3.a/b. (Summary of work to be performed and work schedule); groundwater quality data will be collected at the frequency outlined in that table. 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, 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 USEPA 2009 Unified Guidance (USEPA, 2009).

C.1.b. 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.c. Assessment Reporting

All assessment information should be reported to the individual organizations project manager outlined in A.1.a/b.

C.1.d. 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 to implement. ADM will coordinate multiorganization assessments and corrective actions as warranted.

C.2. Reports to Management

C.2.a/b. 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 USEPA. Revised QASPs will be distributed by ADM 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.a. Criteria for Accepting, Rejecting, or Qualifying Data

Groundwater quality 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 groundwater quality results will be entered into a database or spreadsheet with periodic data review and analysis. ADM 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 groundwater quality and identify intrawell variability with time. After sufficient data have been collected, additional methods, such as those described in the USEPA 2009 Unified Guidance (USEPA, 2009), will be used to evaluate intrawell variations for groundwater constituents, to evaluate if significant changes have occurred that could be the result of CO_2 or brine seepage beyond the intended storage reservoir.

D.2. Verification and Validation Methods

D.2.a. Data Verification and Validation Processes

See sections D.1.a. and B.5.

Appropriate statistical software will be used to determine data consistency.

D.2.b. Data Verification and Validation Responsibility

ADM or its designated subcontractor will verify and validate groundwater sampling data.

D.2.c. Issue Resolution Process and Responsibility

ADM or its designated Coordinator will overview the groundwater data handling, management, and assessment process. Staff involved in these processes will consult with the Coordinator to determine actions required to resolve issues.

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

Checklists and forms will be developed specifically to meet permit requirements. Table 23 provides an example of the type of information used for data verification of groundwater quality data.

Table 23. Example table of criteria used to evaluate data quality.

MVA ID	Anion charge	Cation charge	Charge balance	CB rating	Calculated TDS	Measured TDS	TDS ratio	TDS rating
ICCS_10B_01A	14.4	13.60	-2.84	pass	760.50	785	1.0	pass
ICCS_10B_02A	14.26	15.06	2.73	pass	783.03	777	1.0	pass
ICCS_10B_03A	14.39	14.96	1.94	pass	786.86	806	1.0	pass
ICCS_10B_04A	14.39	14.79	1.38	pass	780.15	777	1.0	pass
ICCS_10B_04B	14.33	14.90	1.96	pass	780.95	785	1.0	pass

D.3. Reconciliation with User Requirements

D.3.a. Evaluation of Data Uncertainty

Statistical software will be used to determine groundwater data consistency using methods consistent with USEPA 2009 Unified Guidance (USEPA, 2009).

D.3.b. 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.

ADM will use the current operating procedure on the use, sharing, and presentation of results and/or data for the IL-ICCS 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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Appendices

APPENDIX A. DTS and Down-hole Pressure Gauge Information

APPENDIX B. Log Quality Control Reference Manual (LQCRM)