5.0 PRE-OPERATIONAL TESTING PROGRAM
40 CFR 146.82(a)(8), 146.87

CAPIO MOUNTAINEER SEQUESTRATION PROJECT

Facility Information

Facility name: MOUNTAINEER GIGASYSTEM

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Well name: MCCLINTIC SEQUESTRATION 001

Well location: MASON COUNTY, WEST VIRGINIA
Latitude: [redacted]
Longitude: [redacted]

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5.0 Pre-Operational Testing Program

5.1 Introduction

The pre-operational testing program describes how Fidelis, LLC ("Fidelis") will meet the testing requirements of 40 CFR 146.87 and well construction requirements of 40 CFR 146.86.

The pre-operational formation testing program will supplement the local subsurface characterization data used in the preparation of this permit application which was acquired in the carbon dioxide (CO_2) sequestration pilot project at American Electric Power's (AEP's) Mountaineer plant, less than 10 miles northeast from the Capio Mountaineer Sequestration project location (**Figure 5-1**). The AEP project included numerous wells in which extensive suites of wireline logs, whole core and sidewall cores were acquired.

The injection well, MCLINTIC SEQUESTRATION 001, will be drilled to collect additional stratigraphic information and further reduce uncertainty in the characterization of the reservoir properties, geomechanical and hydrogeological subsurface at the Capio Mountaineer Sequestration project site. Extensive wireline logging, coring, fluid sampling, and formation hydrogeologic testing will be performed. These data will be incorporated into the static earth model (SEM) and dynamic reservoir model (DRM) prior to the start of injection.

An overview of the project site is presented in **Figure 5-1** which shows the location of the proposed injection well, Area of Review (AoR) and local infrastructure.

The pre-operational testing program provides and verifies the depth, thickness, mineralogy, lithology, porosity, permeability, and geomechanical information of the storage formation, the overlying confining layer, and other relevant geologic formations. In addition, pre-operational testing data are used to provide baseline information for the site that will be used for comparative purposes throughout the project. For example, fluid samples collected during the pre-operation testing will be used as a reference to identify geochemical changes in samples collected during injection operation that may result from the injection of CO_2.

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Figure 5-1: Map of Fidelis Capio Mountaineer Sequestration project showing proximity to AEP Mountaineer.

[redacted]

Figure 5-2: Map of Fidelis Capio Mountaineer Sequestration project showing injection well and AoR.

5.2 Pre-Operational Testing During Injection Well Installation (146.87 (a))

Pre-operational testing of the injection well will be completed after drilling to verify depth, thickness, porosity, permeability, and lithology, and the salinity of any formation fluids in all relevant geologic formations to ensure conformance with the injection well construction requirements under 40 CFR 146.86 and to establish accurate baseline data against which future measurements may be compared.

In addition to the characterization data collected, additional information will be collected to serve as baseline data for the monitoring performed during the operation of the CO_2 injection system. A brief description of the baseline sampling/monitoring is provided in this section, and details are included in the Testing and Monitoring Plan (Permit Section 7).

5.2.1 Deviation Surveys (146.87 (a)(1))

Deviation surveys will be obtained as the well is drilled to determine the wellbore path from the surface to the total depth (TD) of the well. The well will be drilled with measurement while drilling (MWD) equipment (inclusive of downhole motor) allowing the wellbore deviation to be corrected if necessary.

5.2.2 Well Logging: Surface Section (146.87 (a)(2))

During drilling, well logs will be acquired prior to setting the surface casing as well as after surface casing is set and cemented, as conditions allow. Open hole logs will include gamma ray, density, neutron porosity, spontaneous potential (SP), resistivity, sonic, and caliper logs. **Table 5-1** summarizes the well logs that will be acquired before and after surface casing is set and the purpose of each well log.

The cased hole well logs will be acquired after the surface casing has been set and cemented. Cement integrity will be evaluated through a basic cement bond log – variable density log (CBL-VDL) with a gamma ray tool for depth correlation (**Table 5-1**).

Open/ Cased Hole	Log Type	Parameters Obtained
Open Hole	Gamma Ray	Lithology
	Density	Porosity, Density
	Neutron Porosity	Porosity
	Spontaneous Potential	Permeability
	Resistivity	Fluid Saturation, Permeability
	Sonic	Porosity, Formation Velocities
	Caliper	Borehole Diameter, Stress
Cased Hole	Cement Bond Log - Variable Density Log	Cement Integrity

Table 5-1: Summary of wireline logs and associated parameters of logging tools to be run before and after surface casing during drilling of injection well.

5.2.3 Well Logging: Intermediate Section (146.87 (a)(2))

During drilling, open hole well logs will be acquired in the intermediate section after the intermediate section of the well has been drilled to characterize the deeper geology at the proposed site. Open hole logs will include caliper, gamma ray, SP, resistivity, neutron porosity, density, and sonic. **Table 5-2** summarizes the well logs that will be acquired in the intermediate well section and the purpose of each well log. Data from the resistivity log will be used to evaluate the salinity (total dissolved solids [TDS]) of the geologic formations above the confining zone and will be used to confirm the deepest underground source of drinking water (USDW).

After the intermediate casing string has been cemented, logs will be acquired to evaluate the cement integrity. Cement integrity will be evaluated through a CBL-VDL that will be run with a gamma ray tool for depth correlation (**Table 5-2**).

Open/ Cased Hole	Log Type	Parameters Obtained
Open Hole	Caliper	Borehole Diameter, Stress
	Gamma Ray	Lithology
	Spontaneous Potential	Permeability
	Resistivity	Fluid Saturation, Permeability
	Neutron Porosity	Porosity
	Density	Porosity, Density
	Sonic - DT	Porosity, Formation Velocities
Cased Hole	Cement Bond Log - Variable Density Log	Cement Integrity
	Ultrasonic Cement Evaluation	Cement Integrity

Table 5-2: Summary of wireline logs and associated parameters of logging tools to be run before and after intermediate casing during drilling of injection well.

5.2.4 Well Logging: Production Section (146.87 (a)(3))

During drilling, open hole well logs will be acquired in the deeper section of the well to characterize the deeper geology at the site. Open hole logs will include caliper, gamma ray, SP, resistivity, neutron porosity, density, dipole sonic, magnetic resonance, and formation imager. **Table 5-3** summarizes the well logs that will be acquired in the deep section and the purpose of each well log.

After the production casing has been cemented, logs will be acquired to evaluate cement quality and provide baseline data for external well integrity. Cement quality will be evaluated through a CBL-VDL log and an advanced ultrasonic logging tool with a gamma ray tool for depth correlation (**Table 5-3**). Finally, a pulsed neutron log in sigma mode and a temperature log will be acquired to serve as a baseline dataset for the Testing and Monitoring Plan (Permit Section 7). The pulsed neutron capture log and temperature log will be performed after drilling muds are no longer present near the well and temperature has stabilized to ensure accurate results from the logging effort.

Open/ Cased Hole	Log Type	Parameters Obtained
Open Hole	Caliper	Borehole Diameter, Stress
	Gamma Ray	Lithology
	Spontaneous Potential	Permeability
	Resistivity	Fluid Saturation, Permeability
	Neutron Porosity	Porosity
	Density	Porosity, Density
	Dipole Sonic - DT	Porosity, Formation Velocities
	Magnetic Resonance	Porosity and Permeability
	Formation Imager	Detection of fractures and geologic features
Cased Hole	Cement Bond Log - Variable Density Log	Cement Integrity
	Ultrasonic Cement Evaluation	Cement Integrity
	Temperature	Temperature
	Pulsed Neutron	Lithology, Fluid Saturation, Porosity

Table 5-3: Summary of wireline logs and associated parameters of logging tools to be run before and after long string casing during drilling of injection well.

5.2.5 Injection Well Mechanical Integrity Testing (146.87 (a)(4))

5.2.5.1 Internal Mechanical Integrity Testing (146.87 (a)(4)(i))

Internal mechanical integrity refers to the internal integrity or seal within the production casing string (i.e., between the production casing string, tubing, and packer). The quality of this seal can be confirmed with a mechanical integrity test (MIT) and tubing-casing annular pressure monitoring. Corrosion of the tubing string can result in internal mechanical issues, and inspection of the tubing will be performed to monitor the tubing for corrosion (Testing and Monitoring Plan, Permit Section 7).

After the packer, tubing, and downhole equipment have been installed, and the tubing/casing annulus has been filled with a corrosion-inhibited fluid (a dilute potassium chloride [KCl] solution with additives, or equivalent), a MIT will be conducted on the annular space of all deep wells to ensure that there are no leaks in the tubing, casing, or packer. The MIT will be performed by pumping additional annular fluid into the annulus to increase the pressure to the maximum allowable injection pressure. The annular pressure will be monitored for 30 minutes to measure pressure loss. A pressure loss of less than 3% of the initial value would indicate proper internal mechanical integrity. If a pressure loss greater than 3% is observed, the cause of the poor mechanical integrity will be identified and corrected.

Once injection commences, injection pressure, annular pressure, and annular fluid volumes will be monitored continuously to ensure internal well integrity and proper annular pressure is maintained (Testing and Monitoring Plan, Permit Section 7).

5.2.5.2 External Mechanical Integrity (146.87 (a)(4) (ii – iv))

External mechanical integrity refers to the absence of fluid movement/leaks through channels between the long casing string and the borehole or the intermediate casing string. Migration of fluids through this zone could result in contamination of USDWs. The external integrity of the wells that penetrate the confining zone will be confirmed throughout the project.

Generally accepted methods for evaluating external mechanical integrity include the following:

- Temperature or noise log
- Radioactive tracer logging
- Oxygen-activation logging

A baseline temperature measurement will be acquired from surface to total depth (TD) of the injection well to provide initial temperature conditions over the well. Temperature measurements acquired after injection has started will be compared to this log to determine if anomalies are present in the subsequent logging events that may be attributed to external integrity issues (Testing and Monitoring Plan, Permit Section 7.0). If the temperature measurement data suggest an issue with external well integrity exists, an oxygen-activation logging run will be performed to evaluate external well integrity with greater sensitivity.

In addition to the baseline temperature log, a CBL-VDL and an advanced ultrasonic cement evaluation log will be run over the entire depth of the long casing string shortly after completion of the injection well to confirm that the casing string was properly cemented. CBL-VDLs are recorded with sonic tools that detect the bond of the casing and formation to the cement between the casing and wellbore to identify damage. Ultrasonic tools provide higher accuracies and resolutions for cement evaluation.

5.3 Injection Well Core Program (146.87 (b)(d))

Whole cores will be collected during drilling to supplement those already collected at AEP and will serve as the primary geologic characterization for the injection site.

5.4 Injection Well: Fluid Sampling and Analysis (146.87 (b – d))

Characterization of reservoir fluids will be performed using samples acquired during drilling. The analytical results from these samples will be used to:

- Determine the deepest USDW

- Provide baseline geochemical conditions in the injection reservoir, the deepest water bearing zone above the confining zone and the deepest USDW
- Evaluate geochemical reactions that may occur during the injection of the CO_2 that could affect the porosity and/or permeability of the storage formation or confining zone formations

The analyses performed on the fluid samples provide baseline geochemical conditions of the aquifers at the injection site. These data will be used for comparative purposes through the operational/injection and post-injection phases of the project. Additional details on the sampling and analysis of samples collected throughout the remainder of the project are provided in the Testing and Monitoring Plan and Post-Injection Site Closure Plan (Permit Sections 7 and 9, respectively).

5.5 Injection Well Geomechanical Testing (146.87 (d))

The geomechanical characterization for the site will be completed using data acquired in the injection well and is described in the Project Narrative (Permit Section 1.1).

5.6 Injection Well Hydrogeologic Characteristics (146.87 (e))

Hydrogeologic characterization of the injection site will be performed through testing conducted during drilling. These data will be used in the development of the dynamic flow models to determine the CO_2 plume geometry and distribution and are described in the AoR and Corrective Action Plan (Permit Section 2).

Additional hydrogeologic testing may be performed as required by the Underground Injection Control (UIC) Director.

5.7 Injection Well Schedule (146.87 (f))

Fidelis will provide the UIC Director with the opportunity to witness all logging and testing activities associated with the drilling and testing of the injection well. Fidelis will submit an initial schedule of such activities to the UIC Director 30 days prior to conducting the first test or as well conditions allow.

Figure 5-3 and **Table 5-4** provide a tentative schedule based on the number of days to complete each task. It is anticipated that the drilling schedule will be updated once the Class VI permit is received.

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Figure 5-3: Tentative injection well drilling schedule.

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Table 5-4: Tentative injection well drilling schedule based on offset information.