CLASS VI PERMIT PRE-OPERATIONAL TESTING PLAN

40 CFR 146.87 & LCFS Protocol Subsection C.2.3.1

STRATEGIC BIOFUELS
LOUISIANA GREEN FUELS SITE

Prepared By:
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1.0 FACILITY INFORMATION

Facility Name: Louisiana Green Fuels, Port of Columbia Facility
Three Class VI Injection Wells

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Well Locations: Port of Columbia,

Caldwell Parish, Louisiana

Name: Latitude / Longitude

Well 1 (W-N1): 32.18812141510 / -92.10986101060

Well 2 (W-N2): 32.18686691570 / -92.05915551900

Well 3 (W-S2): 32.1639375970 / -92.08754320370

This *Pre-Operational Testing Plan* describes how the Louisiana Green Fuels, Port of Columbia Facility will obtain data from the drilling and completion of the proposed injection and monitor wells at or adjacent to the Port of Columbia Facility in Caldwell Parish, Louisiana. A total of three injection wells and two monitor wells are proposed to meet the injection and storage needs for the facility. The injection wells will be completed into two injection zones as identified within "*Section 2 – Site Characterization*" of the Project Narrative Report (submitted in Module A – Project Information Tracking).

This Pre-operational Testing Plan meets the requirements of USEPA 40 CFR §146.87 and the Carbon Capture and Sequestration (CCS) Protocol under the California Air Resources Board (CARB) Low-Carbon Fuel Standard (LCFS) (Subsection C.2.3.1).

1.1 INTRODUCTION

This plan contains a comprehensive pre-operational data acquisition strategy across the confining and injection zones (*i.e.*, the Sequestration Complex) at the Louisiana Green Fuels Port of Columbia Facility. These data will be used for site specific determination to evaluate the injection

rates, injection volumes, assist with final surface facility design, and revalidation (and update, if needed) of the site model and Area of Review.

The proposed Injection Zones for the project are the Annona Formation (Injection Zone 1, located at a depth greater than 3,800 feet in the plant site area) and Tuscaloosa / Paluxy Formation (Injection Zone 2, located at a depth greater than 4,600 feet in the plant site area). The primary Injection Zone will be the Tuscaloosa / Paluxy interval (Injection Zone 2), which will be the initial completion interval for the injection wells. The shallower Annona Formation (Injection Zone 1) is a secondary interval and may be used for additional capacity. The primary Confining Zone is the regionally extensive Midway Shale, which is predominantly a terrigenous shale that exhibits extremely low porosity and permeability and is approximately 600 feet to 650 feet thick within the greater injection area.

This Pre-Operational Testing Plan has been designed to reduce uncertainty and define the depth, thickness, mineralogy, lithology, porosity, permeability, and geomechanical information of the Injection Zone, the overlying Confining Zone, and other relevant geologic formations in the project area. In addition, formation fluid characteristics will be obtained from the Injection Zone and other critical intervals to establish baseline data against which future measurements may be compared after the start of injection operations.

Louisiana Green Fuels has designed the sequestration project using a total of three injection wells. These wells will be completed into one or more of the project Injection Zones described above. All injection wells will follow the 40 CFR §146.87(a), (b), (c), and (d) and CARB LCFS Subsection C.2.3.1 standards for logging and testing requirements. Coring will be adaptive and based upon well spatial variability, wellbore conditions, core recovery, and core quality as each project well is drilled. All wells will demonstrate mechanical integrity prior to receiving authorization to inject. The data obtained in this plan will be used to validate and update, if necessary, the "*Area of Review and Corrective Action Plan*" (submitted in Module B), to define and reduce uncertainties with the site characterization, revise the "*E.1-Testing and Monitoring Plan*" (submitted in Module E), and determine final operational procedures and limits.

This pre-operational logging and testing strategy has been developed based upon the needs and requirements for the Injection Wells (Section 2.0) and for the in-zone monitoring well(s) (Section 3.0).

2.0 INJECTION WELLS – TESTING STRATEGY

The following tests and logs will be conducted during drilling, casing installation, and after casing installation in accordance with the testing required under 40 CFR §146.87(a), (b), (c), and (d) and LCFS Protocol Subsection C.2.3.1. The tests and procedures are described below and in the "*Proposed Injection Well Construction Information*" section of the Project Narrative (submitted in Module A).

All logging and well testing plans will be submitted to the UIC Director 30 days prior to commencing the operations. The UIC director will be provided the opportunity to witness all operations for the drilling and testing of the Injection Wells per the 40 CFR §146.87(f) standard.

2.1 DEVIATION CHECKS

A series of injection wells will be drilled at or adjacent to the Louisiana Green Fuels Port of Columbia Facility. The wells will be completed into either the Tuscaloosa/Paluxy Injection Zone or the Annona Injection Zone. The wells are planned to be installed as vertical completions. Wellbore deviation measurements will be conducted performed at sufficiently frequent intervals during the drilling of each well. Additionally, a final deviation/gyroscopic survey will be conducted from total depth to the surface in each well.

2.2 LOGGING PROGRAM

The well logging program will cover open hole and cased hole for all drilling stages of the injection wells. The logging program will meet all requirements set forth by the EPA Class VI standards and will be used to determine *in-situ* formation properties such as: thickness, porosity, permeability, lithology, formation fluid salinity and reservoir pressure [per 40 CFR 146.87 and LCFS Protocol Subsection C.2.3.1].

A detailed mud logging program will be developed based upon the target depths for each injection well. Cuttings will be caught from surface to total depth (+/-7,000 feet), with adaptive sampling through the proposed Confining Zone and Sequestration Complex. Gas chromatograph sampling will also be employed and correlated across the cuttings and drilling for onsite analysis.

Table 1 provides information on potential logging run types and the data that each run may provide.

Table 1: Potential Logging Runs and Data

Logging Run	Logging tools	Data Acquisition
Triple Combo / RT Scanner or Equivalent	Gamma Ray (GR), Caliper, Spontaneous Potential (SP), Resistivity, Density, Neutron, RT Scanner	Correlation, Shale Volume, Porosity, Saturations, Hole Size, Resistive Anisotropy
Dipole Sonic	Sonic compressional and shear	Porosity, Mechanical Properties,
Formation Micro-Imager	Formation Micro-Imager borehole images (resistivity or sonic)	Structure, Env. Deposition, Fractures
Magnetic Resonance	Magnetic Resonance	Porosity, free and bound fluids, Permeability
Elemental Spectroscopy	Elemental Capture Spectroscopy	Lithology
Natural Gamma Ray Spectroscopy	Spectral GR	Clay Minerals
MDT or Equivalent	Modular formation dynamics tester	*In situ* Fracture Pressure Formation Fluid Samples Mobility
Sidewall Cores	Sidewall Coring Tool (rotary and/or percussion)	Porosity, Permeability, Bulk Density
Temperature Survey	Temperature Log	Geothermal Gradient Baseline for Fluid Migration.
VSP	Vertical Seismic Profile	Tie in to 2D regional profile
CBL/VDL, CCL	Cement Bond Log, Variable Density Log, Casing Collar Locator	Casing & cement integrity

The following sections detail the approach for logging in the open hole and cased hole sections of each injection well and their corresponding completions**.** The injection wells have been designed with three phases: surface hole, intermediate hole, and protection hole.

2.2.1 Surface Hole Logging Program

The surface hole will be analyzed using wireline logging techniques (Table 2), with the following geophysical logs planned upon reaching casing point in the Cane River Formation (~ 1,200 feet). The depth of the surface casing will be set below the lowermost USDW (Sparta Aquifer) and will be cemented to surface.

Table 2: Surface Hole Logging Runs and Data – Injection Wells

Open Hole - 17-1/2-inch Hole Size	
Well Log	**Data Acquisition Profile**
Spontaneous Potential	Spontaneous Potential and formation fluid salinity
Resistivity	Fluid conductivity, presence of fresh vs. saline water
Gamma Ray	Clay content
Borehole-Compensated Sonic	Compressional acoustic transit time; porosity
Open Hole Caliper	Borehole diameter and log correction; identify washouts
Cased Hole – 13-3/8-inch Casing Size	
Well Log	**Data Acquisition Profile**
Cement Bond	Determine the integrity of the cement
Variable Density	Well completion quality/cement integrity
Temperature	Develop temperature profile. Establish Baseline gradient.

Note: Additional diagnostic logs may be run at the discretion of Louisiana Green Fuel's geological staff and/or consultants or as directed by the authorized regulatory UIC Director.

2.2.2 Intermediate Hole Logging Program

The intermediate casing will be analyzed using wireline logging techniques (Table 3), with the following open and cased hole geophysical logs planned to be run upon reaching casing depth approximately 100 feet below the top of the Selma Chalk (depth ~ 3,900 feet). The intermediate casing will be cemented to surface for all Injection Wells.

Table 3: Intermediate Hole Logging Runs and Data – Injection Wells

Open Hole - 12-1/4-inch Hole Size	
Well Log	**Data Acquisition Profile**
Spontaneous Potential	Spontaneous Potential and formation fluid salinity
Resistivity	Fluid conductivity, presence of fresh vs. saline water
Natural Gamma Ray	Clay content
Density/Neutron	Porosity and saturation
Open Hole Caliper	Borehole diameter and log correction; identify washouts
Formation Microimager	Identify fractures and breakouts in the formation

Sonic Scanner	Acoustic mechanical Properties, compressional and shear wave velocities / travel times
Cased Hole – 9-5/8-inch Casing Size	
Well Log	**Data Acquisition Profile**
Cement Bond	Determine the integrity of the cement
Variable Density	Well completion quality/cement integrity
Temperature	Develop temperature profile. Establish Baseline gradient

Note: Additional diagnostic logs (Table 1) may be run at the discretion of Louisiana Green Fuel's geological staff and/or consultants or as directed by the authorized regulatory UIC Director.

2.2.3 Protection Hole Logging Program

The protection hole will be analyzed using wireline logging techniques (Table 4), with the following open and cased hole geophysical logs planned upon reaching total depth (~7,000 feet). The protection hole casing will be cemented to surface for all Injection Wells.

Table 4: Protection Hole Logging Runs and Data – Injection Wells

Open Hole – 8-3/4-inch Hole Size	
Well Log	**Data Acquisition Profile**
Spontaneous Potential	Spontaneous Potential and formation fluid salinity
Resistivity; RT Scanner	Fluid conductivity, presence of fresh vs. saline water; horizontal and vertical resistivity, resistivity anisotropy
Natural Gamma Ray	Clay content
Density/Neutron	Porosity and saturation
Open Hole Caliper	Borehole diameter and log correction; identify washouts
Formation Microimager	Identify fractures and breakouts in the formation
Modular Dynamics Tester Tool / XPT	Sample formation pressures (XPT) and/or fluids (MDT); mini-frac testing (MDT)
ECS / NGS	Elemental and clay content; lithology
CMR (NMR)	Nuclear magnetic resonance; T1 and T2 relaxation times; permeability, bound water, and movable fluid properties
Rotary Sidewall Core	Formation samples
Sonic Scanner	Acoustic mechanical Properties, compressional and shear wave velocities / travel times
Cased Hole – 7-inch Casing Size	

Well Log	Data Acquisition Profile
Cement Bond	Determine the integrity of the cement
Variable Density	Well completion quality / cement integrity
Temperature	Develop temperature profile. Establish Baseline Gradient
Casing Inspection (multi-finger caliper, electromagnetic thickness)	Baseline casing condition
Vertical Seismic Profile	Determine 1-way travel times, formation velocities, and (with walk-away VSP) spread/migration of CO2 plume

Note: Additional diagnostic logs (Table 1) may be run at the discretion of Louisiana Green Fuel's geological staff and/or consultants or as directed by the authorized regulatory UIC Director.

2.2.4 Analysis and Reporting

After the open and cased hole logging program has been completed, Louisiana Green Fuels will prepare an evaluation and interpretation of all the logs prepared by a knowledgeable log analyst [per 40 CFR §146.87(a) & LCFS Protocol Subsection C.2.3.1(l)]. The report will include:

- The date and time of each test, the data of wellbore completion, and the data of installation of all casings and types of cements.
- Chart (graphical) results of each log and any supplemental data.
- The name of the logging company and log analyst and information on their qualifications.
- Interpretation of the well logs by the log analyst, including any assumptions, determination of porosity, permeability, lithology, thickness, depth, and formation fluid salinity of relevant geologic formations; and
- Any changes in interpretation of site stratigraphy based upon the analysis of the logs and tests that were run.

Reports will be submitted to the authorized regulatory UIC Director. The data acquired will be used to validate and/or reduce uncertanties presented in the "*Area of Review and Corrective Action Plan*" submitted in Module B and the application for CCS Project Certification under the LCFS Protocol.

2.3 CORE PROGRAM

Petrophysical analysis is used in building a static geologic model. The uncertainty in the static model depends upon the amount of whole core and rotary sidewall core data that is acquired as well as the amount and quality of the acquired open-hole and cased-hole logging data. Five whole cores and twenty-five rotary sidewall cores were collected during the drilling and logging of the Whitetail Operating, LLC, Louisiana Green Fuels #1 (stratigraphic / injection) test well in April/May 2021. This well will be converted to an In-Zone monitoring well for the project. The data collected during the drilling of the well has been used in support of the local geology and initial static model for the project.

The core program strategy (Table 5) developed in this Pre-Operational Testing Plan for the project accounts for remaining uncertainties and has been developed specifically for the injection wells to meet the standards outlined in 40 CFR §146.87(b) & LCFS Protocol Subsection C.2.3.1(f)(1).

Table 5: Whole Core Sampling Intervals

Formation	Regulatory Intervals	Core Acquisition
Midway Shale	Confining Zone	Attempt 60-feet
Lower (Austin Equiv.) Chalk	Containment Zone	Attempt 60-feet
Annona Formation	Injection Zone No. 1	Attempt 60-feet
Tuscaloosa Formation	Injection Zone No. 2	Attempt 60-feet
Paluxy Formation	Injection Zone No. 2	Attempt 60-feet
Lower Paluxy Formation	Lower Confining Zone	Attempt 60-feet

Whole core collected will be collected in the injection well(s) from the Midway Shale Confining Zone using drilling fluids designed to reduce the swelling of formation clays and improve the quality of the retrieved core. Whole cores will also be cut and recovered from the Annona Injection Zone and the Tuscaloosa / Paluxy Injection Zone for characterization purposes and from the Lower (Austin Equivalent) Chalk interval, a secondary low permeability and porosity interval that will provide additional containment for the sequestered carbon dioxide. A core will also be cut and recovered from the Lower Paluxy confining interval.

The whole coring program will be adaptive with the possible acquisition of additional cores

contingent upon the recoveries from the first core attempt in each zone or to address spatial uncertainty.

The depth at which each whole core will be cut will be projected prior to drilling and then further determined on site by the company's wellsite geologist during the drilling of the well, following the correlative analysis of the lithology and rate of penetration of the well being drilled with that of offset open hole well logs and mudlogs, and will be contingent upon acceptable drilling parameters and hole conditions. If insufficient formation core is determined to have been recovered in any core run, an additional core may be cut and recovered at the discretion of the company's wellsite geologist, or the insufficiently cored interval may be subsequently evaluated with rotary sidewall coring. Whole core depth intervals (as well as mudlog depth intervals) will be adjusted (depth-shifted) to be equivalent to open-hole logging depths.

Each injection well may have rotary sidewall cores collected from the relevant regulatory intervals and may include core samples of other formations in the wellbore, such as dissipation intervals or secondary confining layers in the stratigraphic column, in order to characterize the mitigation potential of overlying and underlying geologic formations. A rotary sidewall coring program will be adaptive, based upon whole core recovery and the evaluated needs of the project.

2.3.1 Analysis

Detailed core analyses will be performed at Stratum Reservoir, a well-respected, experienced core laboratory, to characterize both the injection and confining zones. Analyses will cover the range of rock properties found in the Injection and Confining Zones and will include:

1) petrology and mineralogy;
2) petrophysical properties;
3) geomechanical properties;
    a. relative permeability;
    b. capillary pressure;
    c. fluid compatibility;
    d. wettability, and;
    e. pore volume compressibility

At a minimum, a lithologic core description, thin sections, x-ray diffraction (XRD), and x-ray fluorescence (XRF) will be performed to characterize compositional make-up of the key intervals and to reduce uncertainties that impact the depositional and flow environments. Adaptive special core analyses such as electrical property measurements and/or relative permeability measurements will be determined based upon quality of the core data and the evaluated needs for reducing uncertainty and risk.

The prescribed analysis of the collected core and fluid samples will be used to refine and enhance site characterization per 40 CFR §146.82(a). Suggested analyses that are to be conducted are listed in the following tabulation (Table 6).

Data acquired from the analysis will be used to reduce uncertainties within the model. The analysis results will assist in "fine-tuning" the model. The whole core collection previously accomplished in the stratigraphic/injection test well is expected to be representative of core collections to be undertaken in the proposed injection wells.

Table 6: Whole Core Analytical Program

Parameter	Measurement	Units
Porosity	Total Porosity Diffuse Porosity	Percent
Permeability	Vertical Permeability Horizontal Permeability	mD/nD
Relative Permeability	Relative Gas Permeability Relative Aqueous Permeability	mD/nD
Saturation	Fluid Saturation Residual Aqueous Saturation Residual Gas Saturation	Percent
Resistivity	Formation Factor as well as Resistivity Index	Ohm-meters
Compressibility	Bulk Compressibility Pore Compressibility	1/Pa
Physical Properties	Rock Strength Ductility Elastic Properties	UCS % Pa
Lithology	Description	
Rock/Soil Type	Petrology Mineralogy	SEM Thin sections
Capillary Pressure/Relative Permeability	Mercury methods Porous-plate methods Centrifuge methods	P_c

2.3.2 Reporting

Louisiana Green Fuels will submit a report prepared by a reputable and experienced core analyst for the details on the core results [per 40 CFR §146.87(b)]. It will include information on the collection and testing method, specific reports on the core intervals that were recovered, laboratory instrumentation calibration, analytical results in either tabular or graphic form, and core photographs and photomicrographs as appropriate. The report will be submitted to the UIC Director.

2.4 FORMATION FLUID ANALYSIS

The sampling system used to sample and quantify free and dissolved gases and the aqueous phases in equilibrium with such gasses will be supplied by a third-party vendor (Schlumberger, Expro, or an equivalent vendor using a downhole PVT sampler or equivalent tool). Note that most deep sampling is designed for hydrocarbons; this testing should focus on all sampled formation gasses

and fluids. Downhole samples are preferred; however, surface samples may be collected for expediency.

The following sampling protocol would be as follows:

1. Purge the casing volume to bring fresh fluids that have not reacted with casing and tubing to the sample point within the wellbore.
2. Deploy commercial downhole sampler on slickline to collect a fluid sample at formation pressure at the targeted depth. Upon completion, close sampler to retain the collected fluid and gas as it is pulled out of hole.
3. Conserve fluid and gas volumes in preparation for shipping and analysis.
4. Filter and conserve samples following protocols for brine sampling.

All sample containers will be labeled with durable labels and indelible markings. A unique sample identification number and sampling date will be recorded on the sample containers. The sample containers will be sealed and sent to an authorized third-party laboratory.

Repeat sampling and frequency (adaptive program) to be determined based on results.

2.4.1 Analysis

At least one initial baseline fluid sample will be collected from the Tuscaloosa Injection Zone during completion activities in the monitor wells prior to the commencement of injection operations in the injection wells. These monitor well fluid samples will provide the baseline measurements for formation fluids and document any spatial variability. Table 7 identifies the parameters to be monitored and the analytical methods the Louisiana Green Fuels, Port of Columbia Facility will use.

The initial parameters identified in Table 6 may be revised and include additional components for testing dependent on the initial geochemical evaluation. The fluid samples will be sent to a third-party laboratory accredited by the Louisiana Department of Environmental Quality for analysis.

Table 7: Summary of analytical and field parameters for ground water samples – Injection Wells

Parameters	Analytical Methods
Dissolved CO_2 gas by headspace	Gas Chromatography (GC)
Dissolved CH_4 gas by headspace	Gas Chromatography (GC)
Hydrocarbons	Gas Chromatography (GC)
Dissolved inorganic carbon	Combustion
Bicarbonate	Titration
δD CH_{24}	Gas chromatography combustion isotope ratio mass spectrometry (GC/C/IRMS)
δC^{13} CO_2	Gas chromatography combustion isotope ratio mass spectrometry (GC/C/IRMS)
δC^{13} CH_4	Gas chromatography combustion isotope ratio mass spectrometry (GC/C/IRMS)
C^{14} CO_2	Accelerated mass spectrometry (AMS).
C^{14} Methane	Accelerated mass spectrometry (AMS).
Isotopic composition of selected major or minor constituents (*e.g.*, Sr $^{87/86,}$ S)	Multicollector-Inductively Coupled Plasma Mass Spectrometer (MC-ICPMS)
Cations: Al, As, B, Ba, Ca, Cd, Cr, Cu, Fe, K, Mg, Mn, Na, Pb, Sb, Se, Si, Ti, Zn,	ICP-MS or ICP-OES, ASTM D5673, EPA 200.8 Ion Chromatography, EPA Method 200.8, ASTM 6919
Anions: Br, Cl, F, NO_3, SO_4,	Ion Chromatography, EPA Method 300.8, ASTM 4327
Total Dissolved Solids	EPA 160.1, ASTMN D5907-10
Alkalinity	EPA 310.1
pH (field)	EPA Method 150.1
Specific Conductance (field)	EPA 120.1, ASTM 1125
Temperature (field)	Thermocouple
Hardness	ASTM D1126
Turbidity	EPA 180.1
Specific Gravity	Modified ASTM 4052
Density	Modified ASTM 4052

2.4.2 Reporting

Louisiana Green Fuels will submit a report prepared by a specialist for the details on the fluid sampling results [per 40 CFR §146.87(b)]. It will include information pertaining to collection and testing methods, specific details on the collection of the samples and the calibration of test

instrumentation as appropriate, with results presented in either tabular or graphic form, including any photographs as deemed appropriate for inclusion in said report. The report will be submitted to the UIC Director.

2.5 FRACTURE PRESSURE DETERMINATION

The fracture pressure of the confining and injection zones must be determined or calculated pursuant to 40 CFR §146.87(d)(1) & LCFS Protocol Subsection C.3.2(e)(1). This information will be used (along with measured pore pressures in the injection zone) to determine appropriate injection pressures for the project wells. Louisiana Green Fuels will utilize density and dipole sonic logs run in each injection well to determine the vertical stress (S_v). This vertical stress calculation will be conducted in conjunction with a detailed review of the formation microimager log run in the well, which will aid in the identification of any borehole breakouts or open fractures.

Pursuant to LCFS Protocol Subsection C 2.3(a)(3)(A) and C.2.3.1(h), the fracture/parting pressure of the sequestration zone and the primary confining layer and the corresponding fracture gradients determined via step rate or leak-off tests must be performed in each wellbore. These testing and logging activities may be undertaken during the drilling of an injection or monitoring well(s) to determine the state of stress of the injection zone and the primary confining layer. In general, mini-frac testing is less invasive and less destructive on the test interval versus propagating a large fracture out into the formation as would occur during step-rate testing. Experience has demonstrated that fracture half-wing lengths could possibly extend hundreds of feet out into the formation, compromising the future integrity of the well completion across the Injection Zone as well as the overlying Confining Zone.

Immediately following the drilling and logging of the injection and/or monitoring well(s), an open hole Schlumberger Modular Dynamics Tester (MDT), or equivalent, mini-frac will be completed to determine the minimum horizontal stress of the formations (Injection Zone and Confining Zone). These mini-frac operations will be performed using the MDT dual-packer tool configuration and will be conducted on both the Injection Zone and the overlying Confining Zone to determine the maximum horizontal stress.

Mini-frac testing will be conducted with the Schlumberger MDT tester in Dual-Packer Mode to determine the breakdown pressure gradient. For stress testing to provide accurate information on the state of stress and breakdown pressure for the Injection Zone and the overlying Confining Zone, the tested interval must first be determined to have no pre-existing structural weaknesses, such as natural fractures. Proposed test intervals will be pre-screened with the processed formation microimager logging tool to ensure the absence of fractures and to select packer-setting depths for such testing.

Confining Zone – Alternate Diagnostic Fracture Injection Test (DFIT)

In a diagnostic fracture injection test (DFIT), a relatively small volume of fluid is injected into the subsurface, creating a hydraulic fracture. The testing is essentially similar to the mini-frac test, but the test is conducted in either open or cased hole with dual packers straddling the test interval. After the fracture has been created and injection has ceased, the pressure in the wellbore is monitored for a set duration, which could range from several hours to several days. Formation pressures measured during the injection and recovery periods are used to infer properties of the formation, including the leak-off coefficient, permeability, fracture closure pressure (related to the magnitude of the minimum principal stress and the net pressure), and formation pressure.

During the initial DFIT injection phase, prior to the formation of a fracture, wellbore storage controls the pressure behavior and pressure increases with increasing injection volume. At formation breakdown pressure, a fracture is initiated in the formation. The initiation of a new fracture will cause a decrease in pressure while the expansion of an already existing fracture will cause pressure to plateau. Following breakdown, continued injection causes the fracture to extend further out into the formation (propagation pressure); once injection ceases, the well is shut in and the ISIP (initial shut-in pressure) is measured. The DFIT analysis primarily focuses on the analysis of the trends in propagation and shut-in pressure that occur in the hours and days immediately following the shutting in of the well.

In general, the DFIT procedure is as follows:

1. In a cased hole, perforate the well (small interval or full set).
2. Install high-resolution surface electronic memory gauges on wellhead and run high-resolution gauges downhole (set recording rate set to 1 second intervals). The use of high-resolution gauges will ensure that virtually all pressure changes are recorded (a 0.1 to 0.001 psi gauge resolution is recommended).
3. Load wellbore with water (KCl or saltwater with minimal additives as needed (to avoid clay swelling, etc.).
4. Start pressure recording before pumping starts and end recording after the fall-off (pressure recovery) is complete.
5. Commence pumping. The injection rate/pressure should be high enough to breakdown the perforations and initiate a small fracture. After breakdown, the fluid injection rate should be increased to the designed maximum pressure limit and injection should be continuous at a steady rate for 3 to 5 minutes.
6. The step-down phase of the DFIT procedure should then be commenced. The rate should be stepped down to 75%, then 50%, and optionally 30% of the maximum rate. The duration of each step-down rate drop can be as short as 10 seconds.
7. Following the completion of the step-down phase, pumping will be immediately stopped, the total volume pumped will be recorded, and the wellhead will be secured to prevent tampering.
8. Rig down the pumping equipment without disturbing the isolated electronic gauges.
9. Collect the data from the pump unit as well as the acquisition setup.

2.5.1 Analysis

The analysis of mini-frac test data is performed in two parts: pre-closure analysis and after-closure analysis. Pre-closure analysis consists of identifying closure and analyzing the early pressure falloff period while the induced fracture is closing. One of the most critical parameters in fracture treatment design is the fracture closure pressure.

The following parameters are determined from the post-closure analysis:

- Instantaneous Shut-In Pressure (ISIP) = Final injection pressure - Pressure drop due to friction
- ISIP Gradient = ISIP / Formation Depth
- Closure Gradient = Closure Pressure / Formation Depth
- Net Fracture Pressure (Δp_{net}) – Net fracture pressure is the additional pressure within the frac above the pressure required to keep the fracture open. It is an indication of the energy available to propagate the fracture.
    - Δp_{net} = ISIP - Closure Pressure
- Fluid efficiency – Fluid efficiency is the ratio of the stored volume within the fracture to the total fluid injected. A high fluid efficiency means low leak-off and indicates the energy used to inject the fluid was efficiently utilized in creating and growing the fracture. Low leak-off is also an indication of low permeability. For mini-frac after-closure analysis, high fluid efficiency is coupled with long closure durations and even longer identifiable flow regime trends
- Gc is the G-function time at fracture closure
- Formation leak-off characteristics and fluid loss coefficients.
- Fracture closure pressure (pc)

G-Function Analysis

Post-injection (pre-closure) pressure falloff analysis can be performed using the "G-function" and root time methods. The G-function is a dimensionless time function designed to linearize the pressure behavior during normal fluid leak-off from a bi-wing fracture. Any deviations from this behavior can be used to characterize other leak-off mechanisms. The root time plot exhibits similar behavior and can be used to support the G-function analysis (IHS, 2017).

A straight-line trend of the G-function derivative (Gdp/dG) is expected where the slope of the derivative is still increasing. Position the Fracture Closure Identification line, which is anchored to the origin by default, through the straight-line portion of the G-Function derivative. Fracture closure is identified as the point where the G-Function derivative starts to deviate downward from the straight line as shown in the following graphic (IHS, 2017).

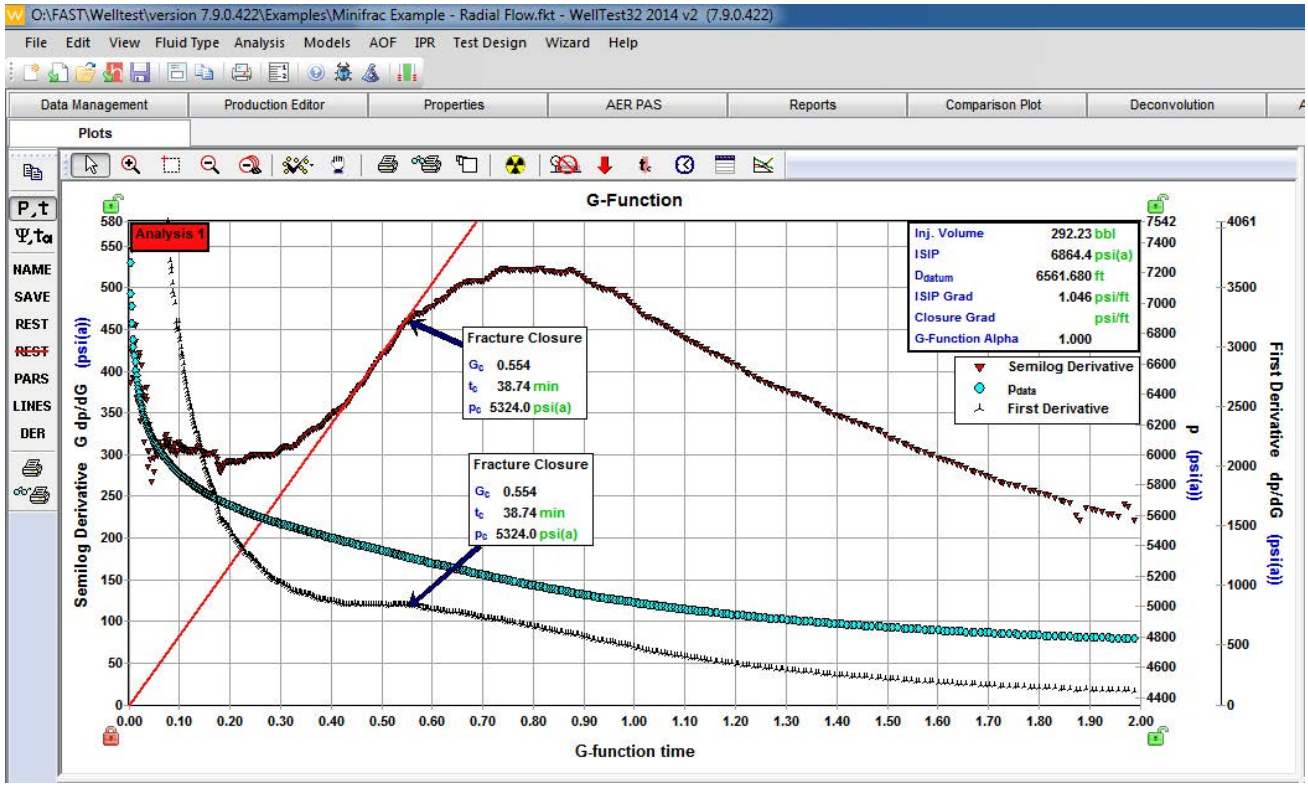

Figure 1: G-Function derivative prior to closure (from IHS, 2017)

https://www.ihsenergy.ca/support/documentation_ca/WellTest/content/html_files/analysis_types/minifrac_test_analyses/minifrac-pre-closure_analysis.htm

Square Root Time Analysis

Fracture closure can be identified by the peak of the first derivative on the sqrt(t) plot, which corresponds to an inflection point on the pressure curve. The semi-log derivative behaves similar to the G-Function Analysis. A user-defined (Sqrt(t)) analysis line may be added to the sqrt(t) plot to help identify the point of inflection (IHS, 2017).

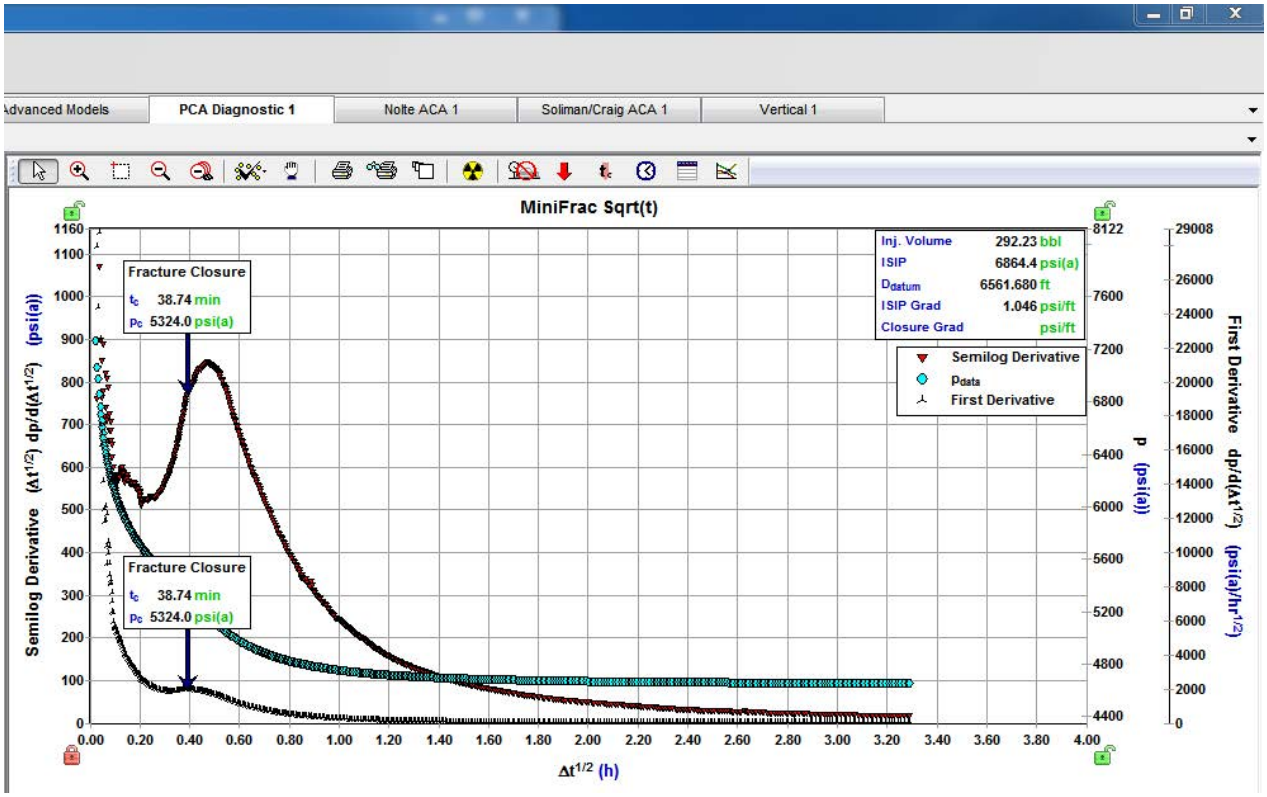

Figure 2: Fracture Closure (from IHS, 2017)

https://www.ihsenergy.ca/support/documentation_ca/WellTest/content/html_files/analysis_types/minifrac_test_analyses/minifrac-pre-closure_analysis.htm

2.5.2 Reporting

Louisiana Green Fuels will submit a report prepared by a specialist for the details on the formation fracture results [per 40 CFR §146.87(b)]. It will include information on collection and testing methods, specifics on the test run and calibration of instrumentation as appropriate, results in tabular or graphic form, and photographs as appropriate. The report will be submitted to the UIC Director.

2.6 DEMONSTRATION OF INJECTION WELL MECHANICAL INTEGRITY

Tabulated below is a summary of the Mechanic Integrity Tests (MITs) to be performed on the Injection Wells at the Louisiana Green Fuels Port of Columbia Facility, after installation and prior to commencing sequestration injection operations. Tests conducted to ensure mechanical integrity of the wells are described in Table 8. The tests will include a pressure test of the well annulus using fluid or gas to ensure there are no leaks internal to the well. Additionally, a radioactive tracer

survey or noise log will be run to ensure there is no movement of fluid behind pipe. The purpose of these tests is to ensure that the well's integrity is mechanically sound and that there is no movement of formation fluid along the wellbore. If a well fails to demonstrate mechanical integrity, the well will be repaired prior to advancing to the next phase of drilling and construction.

Table 8: Summary of Mechanical Integrity Testing – Injection Wells

Class VI Rule Citation	Rule Description	Test Description	Program Period
40 CFR §146.89(a)(1) & LCFS C 4.2(b)(3)(A)	MIT – Internal	Pressure test using liquid or gas to determine that there is no significant leak in the casing, tubing or packer	After construction
40 CFR §146.87(a)(4) & LCFS C 4.2(b)(3)(A)	MIT – External	Pressure test using liquid or gas and a casing inspection log to demonstrate the internal and external mechanical integrity of the well	
40 CFR §146.87(a)(4) & LCFS C 4.2(b)(4)	MIT – External		
40 CFR §146.87(e)(1) & LCFS C 2.3.1(i)	Testing prior to operating	Pressure fall-off test, pump test and injectivity test to verify the hydrogeologic characteristics of the injection zone	Prior to operation

Louisiana Green Fuels will notify the EPA or the regulatory UIC Director least 30 days prior to conducting the test and provide a detailed description of the testing procedure to be performed. Notice and the opportunity to witness the test/log shall be provided to EPA or regulatory UIC Director at least 48 hours in advance of a given test/log. The wireline logs that will be run during such MITs are listed below (Table 9).

In addition to running wireline logs, an Annulus Pressure Test (APT) will be run to verify the well integrity. The test will be run after well completion and prior to injection operations.

Pressures will be recorded on a time-drive recorder for at least 60 minutes in duration and the chart or digital printout of times and pressures will be certified as true and accurate. The pressure scale on the chart will be low enough to readily show a 5 percent change from the starting pressure. In general, the test procedure will be as follows:

Table 9: Mechanical Integrity Test Logging Summary

Test	Description
Casing Inspection Log (Internal MIT)	To detect deformation, physical wear and or corrosion
Cement Bond Log (External MIT)	To evaluate integrity of cement job between the casing and the formation
Tracer Survey (Oxygen Activation Log)	To detect the movement of fluid behind pipe
Temperature or Noise Log (External MIT)	To detect thermal or acoustic anomalies that deviate from the baseline gradient and thus detect the movement of fluid behind pipe

Pressures will be recorded on a time-drive recorder for at least 60 minutes in duration and the chart or digital printout of times and pressures will be certified as true and accurate. The pressure scale on the chart will be low enough to readily show a 5 percent change from the starting pressure. In general, the test procedure will be as follows:

1. Connect a high-resolution pressure transducer to the annulus and increase annulus pressure to at least 200 psig over the permitted maximum tubing/injection pressure. Conduct Annulus Pressure Test (APT) by holding annular pressure a minimum of 100 psi above the well's maximum permitted surface injection pressure for a minimum of 60 minutes.

2. At the conclusion of the APT, annular pressure will be lowered to the well's normal, safe pressure and the pressure recording equipment will be removed from the wellbore.

A successful pressure test will "PASS" if the pressure holds to +/-5 percent of the starting pressure. **IF** the test indicated that the wellbore is not able to hold pressure for a selected period of time, then the test will be considered a "FAIL". The test will be repeated and if the well continues to "FAIL", the construction of the well may have lost its integrity. Additional tests at progressively lower pressures may be run to identify the pressure at which the annulus can hold a differential. Continuous monitoring of the annulus system will be reviewed to identify if there are any data that may lead to a potential leak and assist in diagnosing potential issues with the annulus. Reponses to potential loss of well integrity during the construction and testing phase are included in *"E.4 – Emergency and Remedial Response Plan"* submitted in Module E -Project Plans.

2.6.1 Reporting

The Louisiana Green Fuels will submit a descriptive report prepared by an experienced log analyst that includes the results of any mechanical integrity test with the application for Project Certification. At a minimum, the report must include:

- Chart and tabular results of each log or test;
- The interpretation of log results provided by the log analyst;
- A description of all tests and methods used;
- The records and schematics of all instrumentation used for the tests and the most recent calibration of any instrumentation;
- The identification of any loss of mechanical integrity, evidence of fluid leakage, and remedial action taken;
- The date and time of each test;
- The name of the logging company and log analyst;
- For any tests conducted during injection, operating conditions during measurement, including injection rate, pressure, and temperature (for tests run during well shut-in, this information must be provided relevant to the period prior to shut-in); and
- For any tests conducted during shut-in, the date and time of the completion of injection and records of well pressure re-equilibration.

2.7 FORMATION TESTING

The Louisiana Green Fuels, Port of Columbia Facility will perform pressure fall-off tests during the injection phase as described below to meet the requirements of 40 CFR §146.90(f), LAC §3625.A.6 (State of Louisiana), and LCFS Protocol Subsection C.2.3.1(i)(1) and LCFS Protocol Subsection C.4.1(a)(8). Pressure fall-off testing will be conducted upon completion of each injection well to characterize baseline formation properties, as well as determine near wellbore/reservoir conditions that may impact the injection of carbon dioxide.

2.7.1 Ambient Pressure Falloff Testing

The Louisiana Green Fuels, Port of Columbia Facility will perform an initial (baseline) pressure fall-off test in each injection well using brine or municipal water mixed with a clay stabilizer to avert clay swelling. This will allow for baseline characterization of the transmissibility to fluid within the Tuscaloosa/Paluxy Injection Zone. The initial pressure fall-off testing will be repeated using carbon dioxide within the first 60 days of initiation of injection operations. This will allow for comparison to the baseline fluid-to-fluid test with the change in the injection fluid from brine water to carbon dioxide.

A pressure fall-off test will be performed annually (within approximately +/-45 days of the anniversary of the previous test), at a minimum, during the first five years of injection and then at subsequent 5-year intervals, thereafter, for the lifetime of injection operations ((LCFS Protocol Subsection C.4.3.1.5). Periodic testing is expected to provide insight into the performance of the Storage Complex and potentially aid in assessing the dimensions of the expanding carbon dioxide plume, based on the expected lateral transition from supercritical carbon dioxide near the wellbore and to native formation brine beyond the plume. The Director may request more frequent testing which will be dependent on test results. A final pressure fall-off test will be run after the cessation of injection into each injection well.

Test Details

Testing procedures will follow the methodology detailed in "*EPA Region 6 UIC Pressure Falloff Testing Guideline-Third Revision (August 8, 2002)*"[1]. Bottomhole pressure measurements near the perforations are preferred due to phase changes within the column of carbon dioxide in the tubing. A surface pressure gauge may also serve as a monitoring tool for tracking the test progress.

The pressure gauge can be either installed as part of the completion or can be deployed via a wireline truck. If a wireline truck deployed gauge is used, the wireline should be corrosion resistant (such as MP-35 line), and the deployed gauges should consist of a surface read-out gauge with a memory backup. Gauge specifications should be as follows or similar:

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

Table 10: Injection/Falloff Pressure Gauge Information – Wireline Testing Operations

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

The general testing procedure is as follows (and presumes that a wireline-deployed unit is used for the testing). **NOTE**: a dedicated downhole monitoring gauge may be used if installed on each of the injection wells:

1. Mobilize wireline unit to the injection well and rig up on wellhead.

2. Rig up a wireline lubricator containing a calibrated downhole surface-readout (SRO) pressure gauge with memory gauge installed in the tool string as a backup, to the adapter above the crown valve. Each gauge should have an operating range of 0 - 10,000 psi. Reference the gauge to kelly bushing (KB) reference elevation as well as the elevation above ground level.

3. Open crown valve, record surface injection pressure, and run in hole with SRO pressure gauge to just above the shallowest perforations in the completion while maintaining injection at a constant rate. Steady rates of injection should be maintained for at least 24 hours ahead of the planned shut-in of the injection well. Any offset injection well(s) should be either shut-in ahead of the testing or should maintain a constant rate of injection for the entire duration of the testing. This will minimize cross-well interference effects.

4. With the SRO pressure gauge positioned just above the perforations, monitor the bottom-hole injection pressure response for ±1 hour to allow the gauge to stabilize (temperature and pressure stabilization). Ensure that the injection rate and pressure are stable.

5. Cease injection as rapidly as possible (controlled quick shut-in); close the control valve and the manual flowline valve at well site (start with the valve **closest** to the wellhead so that wellbore storage effect in early time is minimized). Conduct the pressure fall-off test for approximately 24 hours, or until bottomhole pressures have stabilized.

6. Lock out all valves on the injection annulus pressure system so that annulus pressure cannot be changed during the falloff period. Ensure that valves on flow line to the injection well are closed and locked to prevent flow to the well during the fall-off period.

7. After 24 hours, download data and make preliminary field analysis of the fall-off test data with computer-aided transient test software to estimate if or when radial flow conditions might be reached. If sufficient data acquisition is confirmed, end fall-off test. If additional data is required, extend the fall-off test until radial flow conditions are confirmed. After confirmation of sufficient data acquisition, end fall-off test.

8. Retrieve the SRO pressure gauge tool out of the well, stopping at 1,000-foot increments and allowing the gauge to stabilize (5 minutes each stop). Record the stabilized temperature and pressure. Repeat the process to collect stabilized pressure data (5-minute stops) at 1,000-foot intervals and in the lubricator.

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

Reports will be submitted to the EPA within 30 days of the test [per 40 CFR §146.91 (e) and §146.91 (b)(3)].

3.0 MONITORING WELLS – TESTING STRATEGY

The following tests and log acquisitions have or will be conducted during drilling, casing installation, and after casing installation in the monitor wells. As such, similar information to the injection wells may be gathered in the monitor wells. The project currently anticipates that two monitor wells will be drilled for the project. The first well, the Whitetail Operating, LLC, Louisiana Green Fuels #1 (SN975841) was drilled as a Class V stratigraphic/injection test well in April/May 2021. The well is located approximately 5,273 feet east-southeast of the proposed facility and is cross-dip to downdip in its position relative to the facility. The data collected during the drilling of the well has been used in support of the local geology and initial static model for this project.

The second monitor well will be the Bradford-Brown Trust Shipp No. 1 (SN20131) well. This well is located approximately 10,152 feet up dip of the facility and aligns with the expected plume track for the sequestered carbon dioxide. This well will be re-entered and repurposed by deepening and completing the well across the entire Tuscaloosa Sandstone and into the Paluxy. The well originally penetrated only the upper one-third of the Tuscaloosa interval and will be deepened and completed for monitoring purposes across the Tuscaloosa/Paluxy Injection Zone.

3.1 LOGGING PROGRAM

The well logging program in the monitor wells will cover open hole and cased hole for all drilling stages. The logging program will generally meet similar requirements as those for the injection wells. These data will be used to reduce uncertainty and will be used to determine *in-situ* formation properties such as: thickness, porosity, permeability, lithology, formation fluid salinity and reservoir pressure [per 40 CFR 146.87 and LCFS Protocol Subsection C.2.3.1].

3.1.1 Surface Hole Logging Program

The surface hole in the Whitetail Operating, LLC, Louisiana Green Fuels #1 (SN975841) monitor well was evaluated using wireline logging techniques (Table 11), with the following geophysical logs run at casing point in the Cane River Formation (~ 1,200 feet). Note that the depth of the surface casing in the Whitetail Operating, LLC, Louisiana Green Fuels #1 monitor is set below the

lowermost USDW (Sparta Aquifer), and this casing has been cemented to surface.

Table 11 - Whitetail Operating, LLC, Louisiana Green Fuels #1 – Surface Hole Logging Runs

Open Hole – Surface 14-3/4-inch - Hole Size to 1,240 feet	
Well Log	**Data Acquisition Profile**
Spontaneous Potential	Spontaneous Potential and formation fluid salinity
Resistivity	Fluid conductivity, presence of fresh vs. saline water
Gamma Ray	Clay content
Open Hole Caliper	Borehole diameter and log correction; identify washouts

Issues with the wellbore prevented the open-hole logging of the well below 770 feet following the drilling of the well to 1,230 feet (driller's depth; below the USDW). A string of 10-3/4-inch surface casing was subsequently cemented in the hole to a total depth of 1,212 feet. After the surface casing was set, the hole was drilled to the intermediate casing point at 3,903 feet, and the intermediate hole was logged in open hole (see below). In addition, the Gamma Ray and Compensated Neutron log tools were logged up through the surface casing to a depth of 10 feet, providing data from those two log curves in cased hole across the interval from 770 feet to 1,212 feet (the interval that could not be logged in open hole during the first (surface casing) log run).

In the second monitor well, the Bradford-Brown Trust Shipp No. 1 (SN137738), an Induction-Electric Log was run from total depth in the upper one-third of the Upper Tuscaloosa Formation back up to the surface casing shoe at 423 feet. The base of the USDW is indicated by the log to be at a measured log depth of 1,023 feet. Because it did not penetrate the entire stratigraphic equivalent of the Injection Zone, this well will be deepened to a depth sufficient to monitor that entire interval during its recompletion.

3.1.2 Intermediate Hole Logging Program

Intermediate casing was set in the Whitetail Operating, LLC, Louisiana Green Fuels #1 at a depth of 3,903 feet, which is 93 feet beneath the top of the Selma Chalk (observed at 3,810 feet). The intermediate borehole was evaluated using open-hole wireline logging (Table 12).

In the second monitor well, the Bradford-Brown Trust Shipp No. 1 (SN137758), an Induction-Electric Log was run in open hole from a total depth of 4,518 feet in the upper part of the Upper Tuscaloosa, across the correlative intermediate hole section, and back up to the surface casing shoe at 423 feet. This log shows the top of the Selma Chalk at a measured log depth of 3,449 feet.

Table 12 - Whitetail Operating, LLC, Louisiana Green Fuels #1 – Intermediate Hole Logging Runs

Open Hole – 9-5/8-inch Hole Size	
Well Log	**Data Acquisition Profile**
Spontaneous Potential	Spontaneous Potential and formation fluid salinity
Resistivity	Fluid conductivity, presence of fresh vs. saline water
Gamma Ray	Clay content
Open Hole Caliper	Borehole diameter and log correction; identify washouts
Density & Neutron	Porosity and formation bulk density
Temperature and Hole Deviation	Wellbore temperature gradient; hole deviation from vertical

3.1.3 Protection Hole Logging Program

The protection hole was drilled in the Whitetail Operating, LLC, Louisiana Green Fuels #1 into the upper Paluxy Formation at a measured log depth of 6,203 feet and protection casing was set at 6,100 feet. The protection borehole was evaluated using open-hole wireline logging (Table 13). Some of the wireline logging tools run in the hole were unable to reach total depth, as described in Table 13. The proposed Injection Zones were entirely evaluated by all open-hole logging tools run in the wellbore.

Table 13 - Whitetail Operating, LLC, Louisiana Green Fuels #1 – Protection Hole Logging Runs

Open Hole – 6-3/4-inch Hole Size	
Well Log	**Data Acquisition Profile**
Spontaneous Potential (LTD 5,930 feet)	Spontaneous Potential and formation fluid salinity
Resistivity (LTD 5,930 feet)	Fluid conductivity, presence of fresh vs. saline water
RT Scanner (LTD 5,930 feet)	Vertical and horizontal resistivity
Gamma Ray (LTD 5,930 feet)	Clay content

Density/Neutron (LTD 5,930 feet)	Porosity and formation bulk density
Open Hole Caliper (LTD 6,203 feet)	Borehole diameter and log correction; identify washouts
Magnetic Resonance (LTD 6,203 feet)	Porosity, permeability; fluid analysis
Formation Pressure (XPT) (LTD 5,930 feet)	Formation pressure
Elem. Capt. Spectroscopy (LTD 6,203 feet)	Elemental composition
Rotary Sidewall Core (LTD 5,930 feet)	Formation samples
Sonic Scanner (LTD 5,930 feet)	Mechanical Properties; compressional and shear
Cased Hole – 5-Inch Casing Size	
Well Log	**Data Acquisition Profile**
Segmented Bond / Gamma Ray	Determine cement integrity
Flowmeter	Flow Proportion
Differential Temperature	Baseline and after injection temperature profile

**LTD = Log Total Depth*

In the second monitor well, the Bradford-Brown Trust Shipp No. 1 (SN137758), an Induction-Electric Log was run in open hole from a total depth of 4,518 feet in the upper part of the Upper Tuscaloosa, across the correlative intermediate hole section, and back up to the surface casing shoe at 423 feet. This log shows the top of the Upper Tuscaloosa at a measured log depth of 4,410 feet.

No protection casing was run during completion of the Bradford-Brown Trust Shipp No. 1 well. A more detailed open hole logging program similar to the Whitetail Operating, LLC, Louisiana Green Fuels #1 well will be run during the re-entry, deepening and conversion to a monitor well.

3.1.4 Logging Additional Monitor Wells

Should additional monitor wells be required for the project, they will be logged with a program similar to that employed for the Whitetail Operating, LLC, Louisiana Green Fuels #1 well.

3.1.5 Analysis and Reporting

An evaluation and interpretation of all the logs for the Whitetail Operating, LLC, Louisiana Green Fuels #1 well is included within "*Section 2 – Site Characterization*" of the Project Narrative Report

(submitted in Module A – Project Tracking Information). This section has been prepared by a knowledgeable log analyst [per 40 CFR §146.87(a) & LCFS Protocol Subsection C.2.3.1(l)].

These data are used to validate and/or reduce uncertanties presented in the "*Area of Review and Corrective Action Plan*" submitted in Module B and the application for CCS Project Certification under the LCFS Protocol.

3.2 CORE PROGRAM

Petrophysics is used in building a static geologic model. The uncertainty in the static model is impacted by the amount and quality of open hole log, whole core, and rotary sidewall core data that is collected and analyzed. Whole core and rotary sidewall core samples were collected during the drilling and logging of the Whitetail Operating, LLC, Louisiana Green Fuels #1 (stratigraphic / injection test well) in April/May 2021. This well will be converted to an In-Zone monitoring well for the project. The data collected during the drilling and logging of the well has been used in support of the local geology and initial static model for the project within "*Section 2 – Site Characterization*" of the Project Narrative Report (submitted in Module A – Summary of Requirements). Whole-core samples were collected from the following intervals:

- Midway Shale
- Austin Chalk (Equivalent)
- Tuscaloosa (upper and lower portions of the formation)
- Paluxy

In addition to whole cores, rotary sidewall cores were also collected from the following intervals:

- Annona Sand
- Tuscaloosa

Whole core and rotary sidewall core samples may be collected in other project monitor wells on an adaptive basis. The acquisition of such samples will be prioritized to reduce uncertainty and identify special variability in the key regulatory horizons.

Table 14 Whole Core Sampling Intervals – Monitor Wells

Formation	Regulatory Intervals	Core Acquisition
Midway Shale	Confining Zone	Attempt 60-feet
Selma-Austin Chalk	Containment Zone	Attempt 60-feet
Annona Formation	Injection Zone No. 1	Attempt 60-feet
Tuscaloosa Formation	Injection Zone No. 2	Attempt 60-feet
Paluxy Formation	Injection Zone No. 2	Attempt 60-feet
Lower Paluxy Formation	Lower Confining Zone	Attempt 60-feet

Whole core sampling (depth) points will be selected during the drilling of new monitor wells after a review of, and correlation with, offset open hole well logs and drilling parameters (principally, rate of penetration). If an insufficient amount (footage) of the cored interval is recovered in any one core attempt, one or more additional core attempts may be undertaken at the discretion of the project geological consultant or wellsite geologist. It may also be supplanted by the acquisition of rotary sidewall core samples during the subsequent open-hole logging program. Whole core interval depths will be adjusted relative to the actual measured log depth intervals that were cored.

3.2.1 Analysis

Detailed core analyses will be performed at a well-respected, experienced core laboratory (to be determined) to characterize both the injection and confining zones. Analyses will cover the range of rock properties found in the Injection and Confining Zones and will include:

4) petrology and mineralogy;
5) petrophysical properties;
6) geomechanical properties;
    a. relative permeability;
    b. capillary pressure;
    c. fluid compatibility;
    d. wettability, and;
    e. pore volume compressibility

At a minimum, lithologic core descriptions, thin sections, x-ray diffraction (XRD) analyses, and x-ray fluorescence (XRF) analyses will be performed to characterize compositional make-up of

the key intervals and to reduce uncertainties that impact the depositional and flow environments. Adaptive special core analyses such as electrical property measurements and/or relative permeability measurements will be determined based upon quality of the core data and the evaluated needs for reducing uncertainty and risk.

The prescribed analysis of the collected core (Table 15) and fluid samples will be used to refine and enhance site characterization per 40 CFR §146.82(a). Suggested analysis that are to be conducted are listed in the following tabulation.

Data acquired from the analysis will be used to reduce uncertainties within the model. The results will assist in "fine-tuning". Whole core collection in the stratigraphic test well is expected to be representative of conditions of the injection wells.

Table 15: Whole Core Analytical Program – Monitor Wells

Parameter	Measurement	Units
Porosity	Total Porosity Diffuse Porosity	Percent
Permeability	Vertical Permeability Horizontal Permeability	mD/nD
Relative Permeability	Relative Gas Permeability Relative Aqueous Permeability	mD/nD
Saturation	Fluid Saturation Residual Aqueous Saturation Residual Gas Saturation	Percent
Resistivity	Formation Factor as well as Resistivity Index	Ohm-meters
Compressibility	Bulk Compressibility Pore Compressibility	1/Pa
Physical Properties	Rock Strength Ductility Elastic Properties	UCS % Pa
Lithology	Description	
Rock/Soil Type	Petrology Mineralogy	SEM Thin sections
Capillary Pressure/Relative Permeability	Mercury methods Porous-plate methods Centrifuge methods	P_c

3.2.2 Reporting

Louisiana Green Fuels will submit a report prepared by a core analyst pertaining to the results of the core analyses [per 40 CFR §146.87(b)]. This report will include information on collection and testing method, specifics on the samples and calibration of instrumentation as appropriate, results in tabular or graphic form, and photographs as appropriate. The report will be submitted to the UIC Director.

3.3 FORMATION FLUID ANALYSIS

Formation fluid samples were collected from the Whitetail Operating, LLC, Louisiana Green Fuels #1 well for each injection interval and analyzed by Stratum Reservoir in Houston, Texas, recognized as one of the industry leaders in core testing and analysis. The dataset obtained from testing the samples was used to establish the model parameters and inputs for the proposed injection site. Results are reported within "*Section 2 – Site Characterization*" of the Project Narrative Report (submitted in Module A – Project Tracking Information).

Additional fluid samples may be collected from the Bradford-Brown Trust Shipp No. 1 (SN137738) well during its re-entry, deepening and recompletion. The sampling system used to sample and quantify free and dissolved gases and the aqueous phases in equilibrium with these gasses will be supplied by a third-party (Schlumberger, Expro, or equivalent) vendor using a downhole PVT sampler or equivalent tool. Note that most sampling tools and techniques are designed for the sampling of hydrocarbons; this testing would focus on the sampling and analysis of all formation fluids and gasses. The acquisition of samples at formation depths are preferred; however, samples may be collected at surface conditions for expediency.

The following sampling protocol would be:

1. Purge the casing volume to bring fresh fluids that have not reacted with casing and tubing to the sample point within the wellbore.
2. Deploy commercial downhole sampler on slickline to collect a fluid sample at pressure and then close to retain gas phases as sample is transported to the surface.
3. Conserve gas volumes as samples are stepped to atmospheric pressure for shipping and analysis.

4. Filter and conserve samples following protocols for brine sampling.

All sample containers will be labeled with durable labels and indelible markings. A unique sample identification number and sampling date will be recorded on the sample containers. The sample container will be sealed and sent to an authorized third-party laboratory.

Repeat sampling and frequency (adaptive program) to be determined based on results.

3.3.1 Analysis

An initial baseline fluid sample will be collected from the Tuscaloosa/Paluxy Injection Zone during completion and well development activities in the monitor wells prior to injection operations. These fluid samples will provide the baseline measurements for formation fluids and document any spatial variability. Table 16 identifies the parameters to be monitored and the analytical methods the Louisiana Green Fuels, Port of Columbia Facility will use.

Table 16: Summary of analytical and field parameters for ground water samples – Monitor Wells

Parameters	Analytical Methods
Dissolved CO_2 gas by headspace	Gas Chromatography (GC)
Dissolved CH_4 gas by headspace	Gas Chromatography (GC)
Hydrocarbons	Gas Chromatography (GC)
Dissolved inorganic carbon	Combustion
Bicarbonate	Titration
$\delta D\ CH_{24}$	Gas chromatography combustion isotope ratio mass spectrometry (GC/C/IRMS)
$\delta C^{13}\ CO_2$	Gas chromatography combustion isotope ratio mass spectrometry (GC/C/IRMS)
$\delta C^{13}\ CH_4$	Gas chromatography combustion isotope ratio mass spectrometry (GC/C/IRMS)
$C^{14}\ CO_2$	Accelerated mass spectrometry (AMS).
C^{14} Methane	Accelerated mass spectrometry (AMS).
Isotopic composition of selected major or minor constituents (*e.g.*, Sr $^{87/86,}$ S)	Multicollector-Inductively Coupled Plasma Mass Spectrometer (MC-ICPMS)
Cations: Al, As, B, Ba, Ca, Cd, Cr, Cu, Fe, K, Mg, Mn, Na, Pb, Sb, Se, Si, Ti, Zn,	ICP-MS or ICP-OES, ASTM D5673, EPA 200.8 Ion Chromatography, EPA Method 200.8, ASTM 6919
Anions: Br, Cl, F, NO_3, SO_4,	Ion Chromatography, EPA Method 300.8, ASTM 4327

Parameters	Analytical Methods
Total Dissolved Solids	EPA 160.1, ASTMN D5907-10
Alkalinity	EPA 310.1
pH (field)	EPA Method 150.1
Specific Conductance (field)	EPA 120.1, ASTM 1125
Temperature (field)	Thermocouple
Hardness	ASTM D1126
Turbidity	EPA 180.1
Specific Gravity	Modified ASTM 4052
Density	Modified ASTM 4052

The initial parameters identified in Table 16 may be revised and include additional components for testing dependent on the initial geochemical evaluation. The fluid samples will be sent to a third-party laboratory accredited by the Louisiana Department of Environmental Quality for analysis.

3.3.2 Reporting

The dataset obtained from testing the samples was used to establish the model parameters and inputs for the proposed injection site. Results are reported within "*Section 2 – Site Characterization*" of the Project Narrative Report (submitted in Module A – Project Information Tracking).

For future samples, Louisiana Green Fuels will submit a report prepared by a specialist for the details on the fluid sampling results [per 40 CFR §146.87(b)]. It will include information on collection and testing method, specifics on the samples and calibration of instrumentation as appropriate, results in tabular or graphic form, and photographs as appropriate. The report will be submitted to the UIC Director.

3.4 FRACTURE PRESSURE DETERMINATION

As part of the adaptive sampling and testing program, the fracture pressure of the confining and injection zones must be determined or calculated per 40 CFR §146.87(d)(1) & LCFS Protocol Subsection C.3.2(e)(1). This information will be collected from the Class VI injection wells and

used (along with pore pressures in the injection zone) to determine appropriate injection pressures for the project wells (See Section 2.5, above). Similar data may be obtained from the monitor wells during drilling. Tests may include an open hole Schlumberger Modular Dynamics Tester (MDT), or equivalent, mini-frac test intended to determine the minimum horizontal stress of the formations (Injection Zone and Confining Zone). These mini-frac tests will be performed using a dual packer setup and will be conducted on both the injection zone and overlying confining zone to determine the maximum horizontal stress.

Note that step rate tests were conducted in the Whitetail Operating, LLC, Louisiana Green Fuels #1 well, however, injection rates and pressures were specifically limited to values less that that needed to break down the formation and are only used to confirm matrix flow for the longer duration injection tests. These data are included within "*Section 2 – Site Characterization*" of the Project Narrative Report (submitted in Module A – Project Information Tracking).

If conducted, mini-frac testing will be conducted with the Schlumberger MDT tester in Dual-Packer Mode to determine the breakdown pressure gradient. For stress testing to provide accurate information on the state of stress and breakdown pressure for the injection zone and confining zone (caprock), the tested interval must have no pre-existing weaknesses, such as natural fractures. Proposed test intervals will be pre-screened with the imager tool to select packer setting depths for testing.

Confining Zone – Alternate Diagnostic Fracture Injection Test (DFIT)

In a diagnostic fracture injection test (DFIT), a relatively small volume of fluid is injected into the subsurface, creating a hydraulic fracture. The testing is essentially similar to the mini-frac test, but the test is conducted in the open hole or the cased hole with dual packers straddling the test interval. After the end of injection, the pressure in the wellbore is monitored for durations of hours to days. The pressure measurements from the injection and recovery periods are used to infer properties of the formation, including the leak-off coefficient, permeability, fracture closure pressure (which is related to the magnitude of the minimum principal stress and the net pressure), and formation pressure.

3.4.1 Analysis and Reporting

The analysis of mini-frac and DFIT test data in the monitor wells is as presented in Section 2.5.1, above. Louisiana Green Fuels will submit a report prepared by a specialist for the details on the formation fracture results [per 40 CFR §146.87(b)]. It will include information on collection and testing method, specifics on the test run and calibration of instrumentation as appropriate, results in tabular or graphic form, and photographs as appropriate. The report will be submitted to the UIC Director.

3.5 DEMONSTRATION OF MONITOR WELL MECHANICAL INTEGRITY

A baseline Pulsed Neutron Tool will be run in cased hole in each Monitor Well after installation and prior to commencement of sequestration injection operations to establish initial conditions. Thereafter, an adaptive program of repeat surveys will be performed if indications of carbon dioxide approaching the monitor locations are indicated on the pressure/temperature gauges. Additionally, a baseline temperature survey will be run in each Monitor Well and thereafter under an adaptive program to ensure there is no movement of fluid behind pipe. The purpose of these tests is to ensure that the well's integrity is mechanically sound and that there is no movement of formation fluid along the wellbore annulus.

3.5.1 Reporting

The Louisiana Green Fuels will submit a descriptive report prepared by an experienced engineer that includes the results of any mechanical integrity test with the application for Project Certification. At a minimum, the report will include:

- Chart and tabular results of each log or test;
- The interpretation of log results provided by the engineer;
- A description of all tests and methods used;
- The records and schematics of all instrumentation used for the tests and the most recent calibration of any instrumentation;
- The identification of any loss of mechanical integrity, evidence of fluid leakage, and remedial action taken;

- The date and time of each test;
- The name of the logging company and any log analyst the analyzed the log data;
- For any tests conducted during injection, operating conditions during measurement, including injection rate, pressure, and temperature (for tests run during well shut-in, this information must be provided relevant to the period prior to shut-in); and
- For any tests conducted during shut-in, the date and time of the completion of injection and records of well pressure re-equilibration.

3.6 FORMATION TESTING

The Louisiana Green Fuels, Port of Columbia Facility will perform baseline pressure fall-off tests during the Monitor Well construction phase.

3.6.1 Ambient Pressure Falloff Testing

The Louisiana Green Fuels, Port of Columbia Facility performed baseline pressure fall-off tests in the Whitetail Operating, LLC, Louisiana Green Fuels #1 well. These data are included within "*Section 2 – Site Characterization*" of the Project Narrative Report (submitted in Module A – Summary of Requirements) and are used in the modeling included in Module B – AOR and Corrective Action. These tests may be repeated during the recompletion of the Bradford-Brown Trust Shipp No. 1 (SN137738) well after that well has been re-entered, deepened, and cased to total depth. Procedures are included in Section 2.7.1, above.