CLASS VI PERMIT PRE-OPERATIONAL TESTING PLAN

LAC 43:XVII §3617 (B) & LCFS Protocol Subsection C.2.3.1

STRATEGIC BIOFUELS
LOUISIANA GREEN FUELS, PORT OF COLUMBIA FACILITY

Prepared By:
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Revision No. 2
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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. Three injection wells, five In-Zone monitoring wells, and two shallower Above-Confining-Zone monitoring wells are proposed to meet the injection and storage needs for the facility. The facility is proposing to inject into the Upper Tuscaloosa / Paluxy Primary Injection Zone 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 the State of Louisiana per the standards set forth under LAC 43:XVII §3617 (B) 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 and volumes, assist with final surface facility design, and aid in revalidation (and the updating, if needed) of the static and dynamic model and the Area of Review (AoR).

The proposed Injection Zone for the project is the Upper Tuscaloosa / Paluxy Formation (the Primary Injection Zone), which is located at a depth greater than 4,900 feet in the AoR and will be the initial completion interval for all of the injection wells. The Primary Upper Confining Zone is the Austin Chalk Equivalent / Eagleford interval, which directly overlies the Primary Injection Zone, the Upper Tuscaloosa Formation, and consists of alternating calcareous shales and tight limestones.

The regionally extensive Midway Shale, which is predominantly a thick terrigenous shale that exhibits extremely low porosity and permeability, represents an excellent Secondary Upper Confining Zone and is approximately 600 feet to 650 feet thick within the AoR. The Lower Confining Zone is the Lower Cretaceous Ferry Lake Anhydrite. The laterally continuous evaporites of the Ferry Lake Anhydrite interval represent an optimal bottom seal beneath the proposed injection zone, and average 200 to 300 feet in thickness throughout the AoR. As such, the Ferry Lake Anhydrite Formation will act as a highly effective Lower Confining Zone throughout the AoR.

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 with three injection wells. These wells will be completed in the Upper Tuscaloosa / Paluxy Primary Injection Zone, as described above.

All injection wells will follow the LAC 43:XVII §3617 (B) 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 sequester carbon dioxide. 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 appropriate permit limits and conditions.

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 proposed 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 LAC 43:XVII §3617 (B) 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 Commissioner prior to commencing construction operations. The Commissioner will be provided with the opportunity to witness all operations for the drilling and testing of the Injection Wells. Per the §3617 (B)(6) standard, Strategic Biofuels will notify the Louisiana Office of Conservation at least 72 hours before conducting any wireline operations, well integrity tests, and/or reservoir formation tests.

2.1 DEVIATION CHECKS

One injection well will be drilled on the property of the Louisiana Green Fuels Port of Columbia Facility, and two injection wells will be drilled a short distance east and southeast of the facility. All three injection wells will be completed in the Upper Tuscaloosa / Paluxy Injection Zone. The wells are planned to be installed as vertical completions. Wellbore deviation measurements will be conducted at sufficiently frequent intervals (+/-500-foot increments) during the drilling of each phase [per §3617 (B)(1)(a)] using single shot tools (such as a "Totco-type" survey, or equivalent industry tool). After completing each well, a final deviation / gyroscopic survey will be conducted from total depth back to the surface.

2.2 LOGGING PROGRAM

The well logging program will cover open hole and cased hole for all drilling/installation stages for the three injection wells. The logging program will meet all requirements set forth by the [§3617 (B)(1)(a)] and LCFS Protocol standards and will be used to determine *in-situ* formation properties such as: thickness, porosity, permeability, lithology, formation fluid salinity and reservoir pressure [per [§3617 (B)(1) 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 collected from surface to total depth (+/-7,000 feet), with adaptive whole-core sampling through the proposed Confining Zone and Sequestration Complex. Gas chromatograph sampling will also be employed to monitor in-situ gases.

Table 1 provides information on potential logging run types and the data that each run may provide. Required logs per §3617 (B)(1)(b) are identified in detail per each phase of drilling and hole condition (*i.e.* open hole, cased hole).

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 (base of the Sparta Aquifer) and will be cemented to surface. Note that the gamma ray tool will be run within the Potable Water Casing string to differentiate the near surface sediments. Strategic Biofuels has also opted to run a Borehole-Compensated Sonic log in the surface open hole.

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

Open Hole [§3617 (B)(1)(b)(i)] – 22-5/8-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
Borehole-Compensated Sonic	Compressional acoustic transit time; porosity
Open Hole Caliper	Borehole diameter and log correction; identify washouts
Cased Hole [§3617 (B)(1)(b)(ii)] – 18-5/8-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 may be run at the discretion of Louisiana Green Fuel's geological staff and/or consultants or as directed by the authorized regulatory Commissioner.

2.2.2 Intermediate Hole Logging Program

The intermediate casing and open hole 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), placing the Midway Shale, the Secondary Upper Confining Zone, behind the intermediate casing string. The intermediate casing will be cemented to surface for all Injection Wells. The gamma ray tool will be run up into the Surface Casing string to tie the open hole well logs.

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

Open Hole [§3617 (B)(1)(c)(i)] - 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
Natural Gamma Ray	Clay content
Density/Neutron	Porosity and saturation
Open Hole Caliper	Borehole diameter and log correction; identify washouts
Formation Micro-imager[1]	Identify fractures and breakouts in the formation
Sonic Scanner[1]	Acoustic mechanical Properties, compressional and shear wave velocities / travel times
Cased Hole [§3617 (B)(1)(c)(ii)] – 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 (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 Commissioner.
Note[1] Schlumberger Nomenclature used for convenience only

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 to be run upon reaching total depth (~7,000 feet). The protection hole casing will be cemented to the surface for all Injection Wells. Additional logs that exceed the minimum state requirements [§3617 (B)(1)(c)] will also be run as part of the data acquisition program for the Louisiana Green Fuel's Site.

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

Open Hole [§3617 (B)(1)(c)(i)] – 12-1/4-inch Hole Size	
Well Log	**Data Acquisition Profile**
Spontaneous Potential	Spontaneous Potential and formation fluid salinity
Resistivity; RT Scanner[1]	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 Micro-imager[1]	Identify fractures and breakouts in the formation
Modular Dynamics Tester Tool / XPT[1]	Sample formation pressures (XPT) and/or fluids (MDT); mini-frac testing (MDT)
ECS / NGS[1]	Elemental and clay content; lithology
CMR (NMR) [1]	Nuclear magnetic resonance; T1 and T2 relaxation times; permeability, bound water, and movable fluid properties
Rotary Sidewall Core	Formation samples
Sonic Scanner[1]	Acoustic mechanical Properties, compressional and shear wave velocities / travel times
Cased Hole [§3617 (B)(1)(c)(ii)] – 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
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 Commissioner.
Note[1] Schlumberger Nomenclature used for convenience only

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 §3617 (B)(1) & LCFS Protocol Subsection C.2.3.1.(f)(1). 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 Commissioner. 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. Additionally, a pre-operational report and assessment will be submitted to the Commissioner and detail the impacts on the final extent of the delineated Area of Review. Modeling inputs, and any other relevant updates to the submitted application that may change or be verified [LAC 43:XVII §3619 (A)].

2.3 INJECTION WELL CORING PROGRAM

Petrophysical analysis is used in building the static geologic model. 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 test well in April/May 2021. Cores were collected from the Primary Injection Zone and various confining units in line with the standards set forth in §3617 (B)(2). This well will be converted to an In-Zone monitoring well for the project (see Section 3.0, below). 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 in the initial permit application (see **Modules A & B).** This coring program strategy (Table 5) has been developed to obtain *in-situ* well specific data to address remaining sampling objectives, define lateral spatial variabilities, and has been developed specifically for the injection wells to meet the standards outlined in §3617 (B)(2) and LCFS Protocol Subsection C.2.3.1(f)(1).

Table 5: Core Sampling Intervals

Formation	Regulatory Intervals	Core Acquisition
Midway Shale	Secondary Upper Confining Zone	Cut 4-6 Rotary Cores
Austin Chalk Eq. / Eagleford	Primary Upper Confining Zone	Attempt 1/2 60-foot Cores
Upper Tuscaloosa Formation	Primary Injection Zone	Attempt 2 60-foot Cores
Paluxy Formation	Primary Injection Zone	Attempt 1 60-foot Core
Ferry Lake Anhydrite Formation	Lower Confining Zone	Attempt 1 60-foot Core

The plan is to acquire at least one whole core from the Primary Upper Confining Zone, the Austin Chalk Equivalent / Eagleford interval, in each of the three injection wells (the above plan contemplates cutting a second core across the interface at the Base Eagleford / Top Upper Tuscaloosa boundary in one of the three wells). Low water loss freshwater drilling fluids designed to reduce the dissolution and/or swelling of the formation clays during the coring process should improve the quality of the retrieved core. Whole cores will also be cut from targeted sandstone intervals within the Upper Tuscaloosa Primary Injection Zone for characterization purposes. In addition, whole cores are planned to be cut adaptively in targeted sandstone intervals within the Paluxy Formation, and a core will also be cut in the Lower Confining Zone, the Ferry Lake Anhydrite, in one well.

The whole coring program will be adaptive, with the acquisition of additional cores contingent upon the recoveries from the initial core attempt in each zone and/or to address spatial variability. 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. This will be determined by using the correlative analysis of the lithologies penetrated and the rate of penetration of the bit, combined with that of offset open hole geophysical well logs and mud logs, to determine the core points. Core attempts 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. Alternatively, if insufficiently cored material is recovered in the well, certain intervals may be supplemented with rotary sidewall coring techniques following the logging of the well. Whole core depth intervals (as well as mud log depth intervals) will be adjusted (depth-shifted) to be equivalent to open-hole logging depths.

Each injection well may have supplemental rotary sidewall cores collected from other relevant regulatory intervals, such as the Midway Shale, and may include core samples of other formations in the wellbore, such as from pressure dissipation intervals or secondary confining layers present within the stratigraphic column. These data will be used to characterize the mitigation potential of overlying and underlying geologic formations to constrain and/or prevent fluid movement. It is anticipated that the rotary sidewall coring program will be adaptive, based upon whole core recovery, the results of the open hole logging program, and the evaluated needs of the project.

2.3.1 Core Laboratory Analysis

Detailed core analyses will be performed at one or more well-respected, experienced industry core laboratory(s), to characterize both the injection and confining zones. Samples may be distributed to more than one laboratory, based on their individual capability, schedule considerations, and backlog at the time of coring. Analyses will cover the range of rock properties found in the Primary Injection and Confining Zones and will include:

1) petrology, grain size, and mineralogy;
2) geomechanical properties;
3) petrophysical properties;
    a. porosity and permeability
    b. relative permeability to carbon dioxide;
    c. capillary pressure and pore throat sizing;
    d. fluid compatibility;
    e. wettability; and
    f. pore volume compressibility.

At a minimum, routine core analyses (porosity, permeability, and bulk density) will be performed on a distribution of samples characterizing differing lithologies. Sample intervals may be programmatic (i.e., every foot, *etc*.) or based on observed lithology changes in the recovered core. Additional analyses are expected to include a lithologic core description, thin section preparation and analyses, x-ray diffraction (XRD), and x-ray fluorescence (XRF) 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 conducted based upon quality and quantity of the recovered core and the need for reducing uncertainty and risk in the dynamic modeling.

The prescribed analyses of the collected core and fluid samples will be used to refine and enhance site characterization per §3607 (C)(2)(a). Specific analyses that are to be conducted are listed in the following tabulation (Table 6). The actual core analysis program will be dependent upon the amount and quality of core samples recovered from each injection well.

Data acquired from the analyses will be used to reduce uncertainties within the model and detail spatial variability in the various parameters. These testing results will enable the "fine-tuning" of the static and dynamic site model. Note that the whole core previously collected in the Whitetail Operating, LLC, Louisiana Green Fuels #1 stratigraphic test well is expected to be representative of whole core 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	NA
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 describing the testing and analytical results of the coring program [per §3617 (B)(2)] The report will include information on data collection and testing methods employed, specific reports on the core intervals that were recovered, identification of laboratory instrumentation calibration, analytical results in either tabular or graphic form, and core photographs and photomicrographs as appropriate. This report will be submitted to the Commissioner. Additionally, a pre-operational report and assessment will be submitted to the Commissioner and detail the impacts on the final extent of the delineated Area of Review, Modeling inputs, and any other relevant updates to the submitted application that may change or be verified [§3619 (A)].

2.4 FORMATION FLUID ANALYSIS

The downhole system used to sample and retain 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 the recovery and analysis of hydrocarbons; however, this testing will focus on all sampled formation gases and fluids. Downhole samples retrieved and preserved at reservoir pressure are preferred; however, based on subsurface and well conditions, surface samples may be collected for expediency.

The anticipated fluid sampling protocol will be as follows:

1. Purge the well casing volume to bring fresh fluids that have not reacted with drilling muds, completion fluids, or casing and tubing to the sample point within the wellbore (swab, nitrogen back-lift, etc.). If several well volumes are removed from the well, monitor fluid parameters at surface until properties stabilize.
2. Deploy a 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. Preserve fluid and gas volumes in preparation for shipping and analysis.
4. Filter and preserve 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, accredited by the Louisiana Department of Environmental Quality.

Repeat sampling and frequency for baseline characterization (adaptive program) to be determined based on initial sampling and analysis results.

2.4.1 Fluid Analysis

At least one initial baseline fluid sample will be collected from the Upper Tuscaloosa / Paluxy Primary Injection Zone during completion activities in each of the injection wells per §3617 (B)(2)(a), §3617 (B)(4)(c), and §3607 (B)(2)(e). These injection well fluid samples will provide the baseline measurements for formation fluids and document any spatial variability. The temperature, pH, and conductivity will be measured and recorded per §3617 (B)(3). The static level of the fluid will also be recorded. Table 7 identifies the full spectrum of the planned parameters to be monitored and the analytical methods the Louisiana Green Fuels, Port of Columbia Facility will use for the Injection Zone fluids.

The initial parameters identified in Table 7 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.

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
$\delta D\ CH_{24}$	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)

Parameters	Analytical Methods
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 §3617 (B)(2)]. The report 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 Commissioner.

2.5 FRACTURE PRESSURE DETERMINATION

The fracture pressure of the confining and injection zones must be determined or calculated pursuant to §3617 (B)(4)(a) and 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, safe injection pressures for the project injection 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 micro-imager log run in each injection well. Evaluation of the formation micro-imager will also 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 injection well. These testing and logging activities may be undertaken during the drilling of each injection well to determine the state of stress of the injection zone and the primary confining layer. In general, mini-frac testing conducted on wireline is less invasive and less destructive on the tested interval versus the induced propagation of a large fracture out into the formation, as would occur during bull-head step-rate well testing. Experience has demonstrated that fractured half-wing lengths can extend hundreds of feet out into the formation, potentially compromising the future integrity of the well completion across the Injection Zone as well as the overlying Upper 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 an equivalent industry tool, will be conduct mini-frac testing to determine the minimum horizontal stress of the formations in the Primary Injection Zone and the Primary Upper Confining Zone. These mini-frac operations will be performed using the MDT set in dual-packer tool configuration. The Louisiana Office of Conservation will be provided a 72-hour notice before any such proposed mini-frac tests are performed [§3617 (B)(6)].

Mini-frac testing will be used to determine formation breakdown pressure gradient, fracture propagation, and closure pressures. For stress testing to provide accurate information on the state of stress and breakdown pressure for the Primary Injection Zone and the overlying Primary Upper 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 micro-imager logging tool to ensure the absence of fractures and to select packer-setting depths within "in-gauge" boreholes for such testing to prevent packer by-pass.

Procedure

1. Rig up modular dynamics tool string for straddle-packer pressure testing.

2. Once tool is ready, run in the hole with tool and run a baseline testing gamma ray strip. Match current baseline gamma ray strip in the well to the initial open-hole logging run.

3. Straddle the lowermost test interval and inflate the dual packers.

4. Attempt to perform an initial pre-test. If the interval is acceptable for mini-frac formation testing (*i.e.*, rate will exceed matrix injection capacity).

    a. Initiate injection and ramp up rate in discrete rate steps, if needed, until formation breakdown is achieved;
    b. Continue to pump at a constant rate in order to propagate the fracture;
    c. Shut off the pump and record the pressure recovery;
    d. Repeat the injection/shut-in cycles at least 2 more times.

5. Complete testing of other intervals and pull tool from well.

Option:

6. Rig up Formation Micro-imager Tool and run in well for a final imaging pass.

7. Run tool below the lowest formation breakdown testing location and set tool for logging.

8. Extend pads and log image data upward across all of the formation breakdown depths, recording log data at normal logging speeds.

9. Once the Formation Micro-imager Tool of above the top of uppermost breakdown point, retract pads and pull tool to surface.

10. Break down Formation Micro-imager Tool and retrieve from well.

11. Demobilize wireline unit.

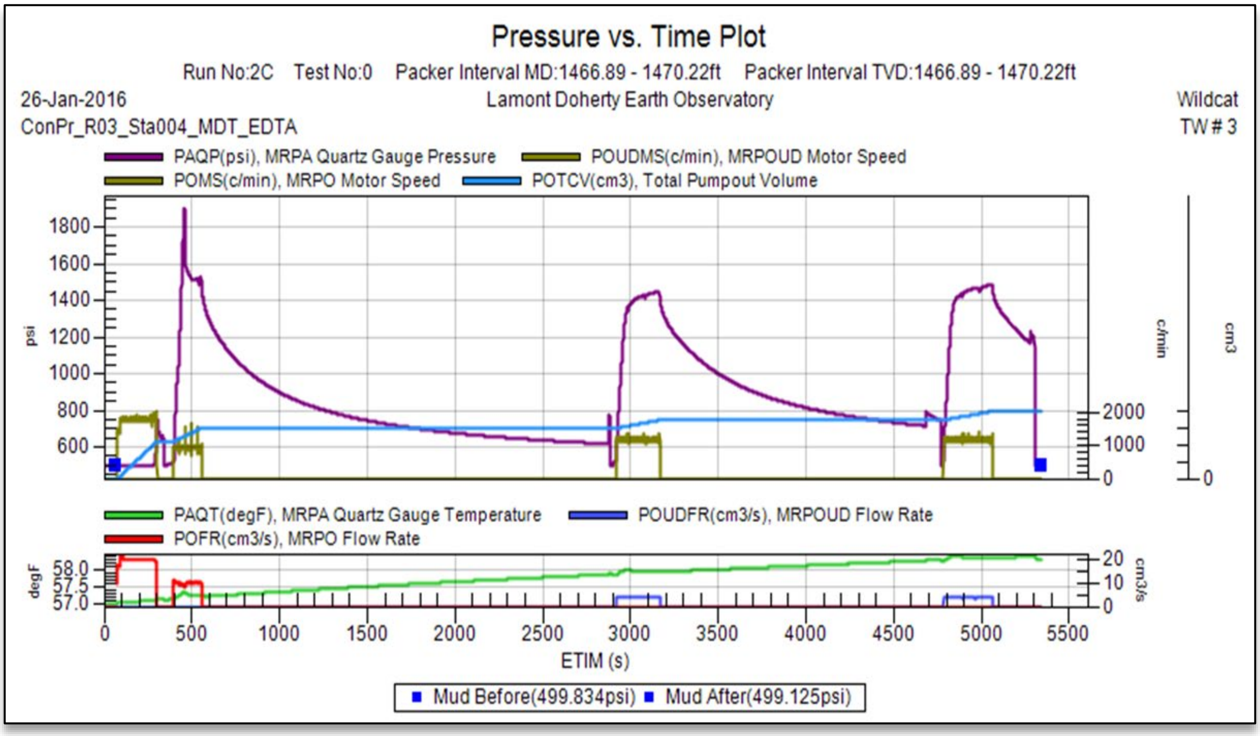

Figure 1: Time-Pressure Plot of a Mini-frac Test

(Note: Analysis procedure for mini-frac testing is presented in Section 2.5.1.)

<u>Confining Zone – Alternate Diagnostic Fracture Injection Test (DFIT)</u>

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 with injection down a test string or drill pipe. Preferred testing will be performed in open hole conditions, therefore reducing the alleviating the need to squeeze perforations in casing. 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, depending on the permeability of the test interval. 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 and propagation of a new fracture will result in 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). If performed in open hole, skip this step.
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 (potassium chloride 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 break down 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/DFIT 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 fracture in excess of the pressure that is 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 or slow 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)

<u>G-Function Analysis</u>

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).

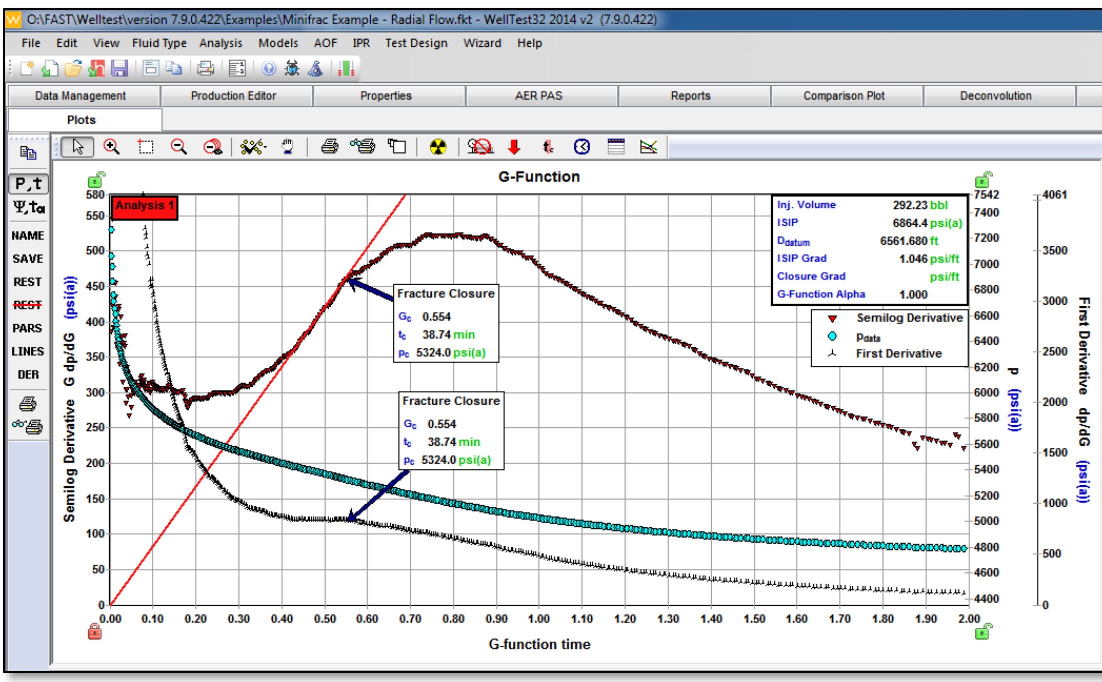

Figure 2: G-Function derivative prior to closure (from IHS, 2017)

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).

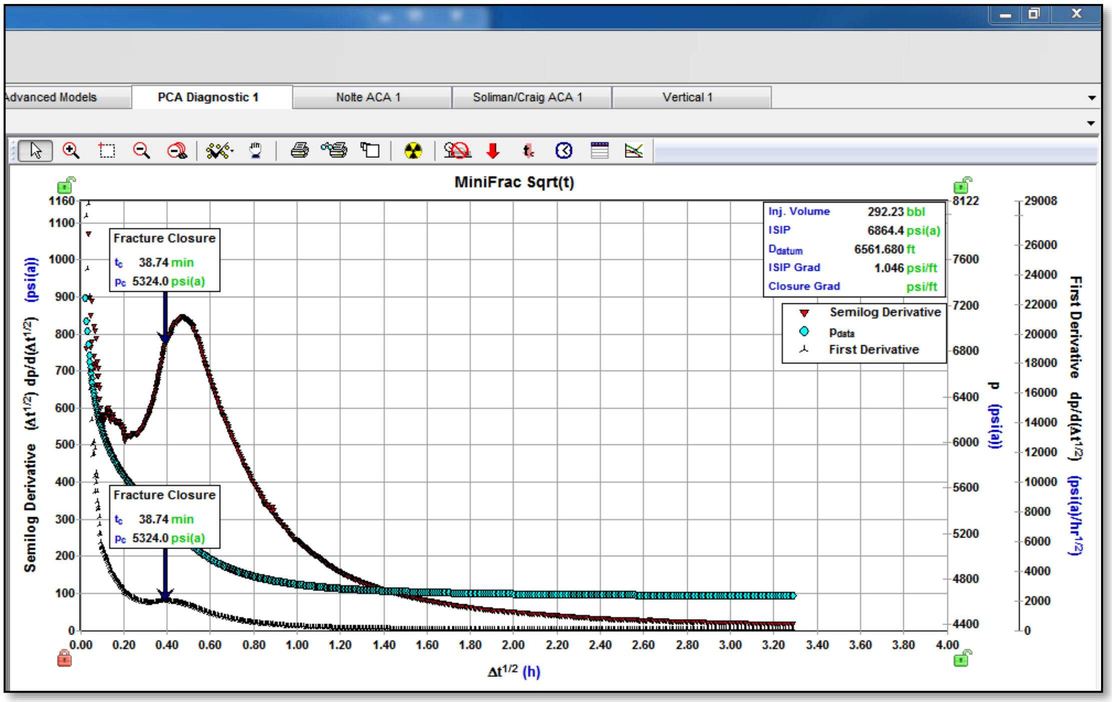

Figure 3: Fracture Closure (from IHS, 2017)

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 testing results [per §3617 (B)(2)]. The report will include information on collection and testing methods employed and specific data pertaining to the test run and the calibration of instrumentation, with results in tabular or graphic form, and photographs as appropriate. A pre-operational report and assessment will be submitted to the Commissioner and will detail the impacts on the final extent of the delineated Area of Review, Modeling inputs, and any other relevant updates to the submitted application that may change or be verified [§3619 (A)].

2.6 DEMONSTRATION OF INJECTION WELL MECHANICAL INTEGRITY

Tabulated below is a summary of the Mechanic Integrity Tests (MITs) to be performed on each injection well drilled and completed at the Louisiana Green Fuels Port of Columbia Facility. These tests will be run after installation and prior to commencing sequestration operations. Tests conducted to ensure the mechanical integrity of the wells are described in Table 9. The tests will include a pressure test of the well annulus using fluid or gas to ensure there are no significant 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 integrity of each well is mechanically sound and that there is no out-of-zone movement of formation fluid up or down the wellbore. If the testing of an injection 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
LAC 43:XVII §3627 (A)(2) & 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
LAC 43:XVII §3627 (A)(3) & 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	
LAC 43:XVII §3627 (A)53)) & LCFS C 4.2(b)(4)	MIT – External		
LAC 43:XVII §3617 (A)(5) & 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

Radioactive Tracer Survey Test Procedure

The recommended technique for the Radioactive Tracer Survey (RTS) includes the use of a wireline logging tool with gamma ray detectors positioned above and below the ejector port. The tool should be able to continuously record during tracer fluid ejection. The upper detector should be recorded in track 1 at a scale of 0 to 100 or 150 API units. The lower detector(s) should be recorded in tracks 2 and 3 at a higher scale, typically 0 to 1,000 API units.

1. Rig up a wireline unit with lubricator to the wellhead. Check tool and open crown valve. Run log in hole to test depth.

2. An initial pre-test gamma ray baseline tracer log should be recorded from at least 100 feet above the injection tubing packer to total depth or plugged-back total depth (TD/PBTD) of the well, or as agreed between the well operator and the Commissioner:

    a. at least 100 feet below the lowest perforated interval, or

    b. the top of the screen, if present, or

    c. the top of fill or obstructions,

    whichever is deepest. The concurrent running of a casing collar locator ("CCL") log for casing collar / depth correlation is recommended.

3. Two five (5) minute time statistical background checks should also be run prior to the planned ejection of the tracer fluid from the tool. These timed statistical checks are run to determine background radiation prior to tracer fluid ejection. It is recommended that such checks be run above the packer and above the completion perforations.

4. Set the injection flow rates at a rate at which the fluid will be under laminar flow, while remaining within the maximum permitted operating parameters. The volume of the tracer fluid slug should be sufficient to cause a gamma curve deflection of at least 25x background reading as the ejected slug passes the lower detector(s). This would typically constitute a full-scale deflection.

5. A constant injection (moving) survey should be run from, at least, above the packer to the perforations or screen to check for leaks between those two points. This survey should consist of ejecting a slug above the packer, verifying the ejection, and then dropping down through the slug, and then logging up through the slug to above where the slug was first ejected. The tool should then be lowered through the slug again and logging should continue upward to above where the slug was encountered on the previous pass. This process should be repeated a minimum of two times, until the slug dissipates into the formation. If necessary, the injection rate may be decreased to accomplish the objectives of this test.

6. A stationary survey should be run approximately 20 feet or less above the top of the perforated interval or screen to check for upward fluid migration outside the cemented casing. If this depth cannot be reached due to fill or obstructions, the log should be run

at the lowest possible depth. Flow during the stationary surveys should be at sufficient rates to approximate normal operating conditions in the well. As a guideline, this rate can be determined by dividing the total volume injected by the total hours the well is/was operated for the previous year (not the total number of hours in a year unless the well was operated continuously, without interruption). The procedure consists of logging on time drive, ejecting a slug, verifying the ejection, and waiting an appropriate amount of time to allow the slug to exit the wellbore and return through channels outside pipe. The time spent at the station will vary but should be at least twice the time estimated to detect the tracer fluid if channeling existed, or for a minimum of 15 minutes, whichever is the greater duration. If tracer fluid is detected channeling outside of the pipe at any time during the stationary survey, then the survey may be stopped and the tracer fluid's movement shall be documented by logging up on depth drive, until the tracer is observed to exit the channel.

7. Other stationary or moving surveys may be required, depending upon well construction, test results, or to investigate previously known problem conditions. At least two repeatable logs of every tracer survey, moving and stationary, should be run.
8. Upon completion of the tracer surveys, a final background gamma log should be run for comparison with the initial background log.
9. Unload iodine from the tool and pump away tracer material. Pull out of hole with the tool.

Interpretation

Where a measurable amount of tracer material leaks from the tubing, it will be observed as a small area of increased radioactivity after the slug has passed. If an area of elevated radioactivity is observed, additional runs should clarify what becomes of the material. This will demonstrate whether only the tubing is leaking, or if both the tubing and casing lack integrity. In most cases, if the casing of the well has integrity but a tubing leak exists, the pressure equalization and cessation of leaking will occur until a change in injection pressure allows the leak to resume. This is why it is important to ensure a pressure differential exists between the injection tubing and the annulus.

If annulus pressure is lower than injection pressure and both the tubing and casing are leaking, any tracer material that leaks out of the tubing will generally move toward and out through the casing leak. This is because the annulus pressure normally will be higher than the hydrostatic pressures within adjacent formations at all depths. If only the tubing is leaking, the tracer material will remain near the leak, spreading slowly both up and down from the leak location.

Adherence of tracer material to the tubing can be differentiated from a tubing leak because any material adhering to the tubing will eventually be washed away with no movement evident.

If no evidence of leaking is observed, the well has demonstrated part 1 of mechanical integrity. Demonstrations of mechanical integrity using RTS logs will be examined very closely, and any conditions that threaten to impede the ability to accurately interpret them must be removed.

Differential Temperature Survey Procedure

The temperature log is also one of the approved logs for detecting fluid movement outside pipe [LAC 43:XVII §3617 (B)(1)(d)(iii) and §3627 (A)(3)(b)]. It will include both an absolute temperature curve and a differential temperature curve. The well should be shut in **at least** 36 hours to allow for temperature stabilization, though a shorter time period may be used with concurrence of the Commissioner. The temperature log should be run over the entire interval of cemented casing, logging down from the surface to total obtainable well depth.

1. Rig up a wireline unit with lubricator to the wellhead. Calibrate the log if at all possible. This can be done by comparing measurements made using the tool in any two liquids to the known temperatures of those liquids. For instance, both a thermometer and the thermistor to be used for the logging may be used to measure the temperature of water at ambient conditions and a bucket of ice water. Even a single measurement made in a well-mixed bucket of ice water would be useful.
2. Log the well from the surface downward, lowering the tool at a rate of no more than 30 feet to 40 feet per minute. The 30 feet to 40 feet per minute limitation is a practical balance between the tool response time and normal time constraints, with slower speeds provide increasing detail. Time coding of the log (either a tick or gap in the log grid at one-minute intervals or a logging speed trace) should be used to confirm the tool speed.

3. If the well has not been shut in for at least 36 hours before the log is run, a comparison with either a second log run six hours before the time the log of record is started or a log from another well at or adjacent to the same site that exhibits no temperature anomalies should be available to demonstrate normal patterns of temperature change.
4. Presentation of the log digital data in either LAS or ASCII format is needed for ease of interpretation. A gamma ray log acquired at the time of logging or from a previous log run that can be correlated to the temperature data is needed for accurate interpretation.
5. Once total depth has been reached, logging is complete; pull out of hole with the tool.

The absolute temperature curve should be scaled in increments no larger than 20º F and subsequently displayed in API log tracks 3 or 4. The differential temperature curve may be scaled in any manner appropriate to the specific logging vendor's software, but it must be sensitive enough to readily indicate anomalies and should also be displayed in API tracks 3 or 4. One or more correlation log curves (SP, gamma ray) should be displayed in API track 1.

Interpretation

The validity of the temperature log upon recording at the well site shall be determined by comparing it to similar logs acquired at or near the same site. When lithology and injectate characteristics are similar, the thermal effects along the wellbore should also be very similar. After the temperature effects caused by casing joints, packers, well diameter, casing string differences, and cement have dissipated, the temperature profiles should be similar, although not identical. If construction features are evident, a longer shut-in period is probably needed.

The testing described in this section consists of the collection of baseline data and initial mechanical integrity prior to authorization to inject under LAC 43:XVII §3617 (B)(1). Future mechanical integrity testing during active operations and the post-injection period is detailed in **Module E** Testing and Monitoring Plan and will be performed annually (every 12 months) as per LAC 43:XVII §3627. The initial log can also be compared to temperature logs in other nearby wells if such logs exist. Lithological effects manifested on one log should show up similarly in other wells at the same site. Temperature logs acquired at or near the same site under thermally stabile conditions should exhibit similar downhole temperature gradients; therefore, any significant deviation in such temperature gradients constitutes an anomaly.

In those incidences where there are no nearby temperature logs available or suitable for comparison, then significant deviations from a predictable geothermal gradient would constitute anomalies. One such deviation would be the observation of a nearly constant temperature logged across a significant interval of different reservoir strata.

Such a temperature anomaly is likely to "repeat" over the course of additional log runs and will be observed to persist or increase whereas, elsewhere, the temperature profile resumes a natural and predicted geothermal gradient while comparative differences in observed temperature recorded in the different log runs diminish elsewhere. Areas with active fluid movement will reach a stable temperature more quickly than other areas. If no injection-induced anomalies exist, there should be a natural, predicted geothermal gradient observed at the depth of the source reservoir.

If potential injection-induced anomalies are observed, a failure of mechanical integrity may be indicated. In such instances, the re-running of the temperature log may be necessary to show whether the anomalies observed on the initial log run are diminishing and/or resemble analogous temperature patterns observed on the temperature log from another adjacent well. Comparison of these temperature logs should show increasing parallelism along the cased well bore; if that is not observed, then there may be flow along a channel adjacent to the wellbore.

If this flow results in the movement of liquid into unauthorized zones and/or between USDWs, the well does not have mechanical integrity. In the event that there are unresolved temperature anomalies that indicate such an absence of mechanical integrity, another investigatory method (radioactive tracer, noise, oxygen activation, or other logs approved by the Commissioner) must be used to confirm the absence of flow into unauthorized zones or between USDWs.

Noise Log (if run)

A noise log is an approved method to demonstrate mechanical integrity prior to operations [§3617 (B)(1)(d)(iii)] and is considered as part of the additional / optional logging runs for the injection wells at the Louisiana Green Fuels site. Channeling along well bores is very rarely uniform. When flow is occurring, irregularities in channel cross section usually result in generation of some turbulence which occurs in the audible range. Sonic energy travels for considerable distances through solids, allowing sensitive microphones to detect the effects of turbulent fluid flow at considerable distances. Different types of turbulence create sounds (noise) having different frequencies. Single phase turbulence creates low frequency sounds, while two phase turbulence usually creates high frequency sounds. High pass filters are used to determine the intensity of the noise detected within various ranges of frequency.

Procedure

The noise log is a versatile cased-hole diagnostic wireline logging tool since it may be run while injection is occurring in multiple wells because the inherent flow restriction caused by the presence of the wireline and noise logging tool is typically insufficient to cause turbulence. It is especially desirable to run the noise log while injecting to look for flow resulting from a pressure increase near the top of the injection zone. If ambient noise while injecting is greater than 10 mv, injection should be halted. Logging procedures should include the following steps:

1. Obtain noise measurements at intervals of 100 feet to create a log on a coarse grid;
2. If any anomalies are evident on the initial coarse-gridded noise log, compile a finer grid noise log by making additional noise measurements at intervals of 20 feet within the coarse-gridded depth intervals observed to manifest anomalously high noise levels;
3. Obtain noise measurements at intervals of 10 feet through the first 50 feet above the injection zone and at intervals of 20 feet within the 100-foot intervals containing:
    - the base of the lowermost bleed-off zone above the injection zone,
    - the base of the lowermost USDW, and

- in the case of varying water quality within the zone of USDW, the top and base of each interval with significantly different water quality from the next interval; while

4. Additional measurements may be made to pinpoint the exact depths that are the sources of the anomalous noise; and

5. The final noise log is created using a vertical scale of 1 or 2 inches per 100 feet.

Interpretation

The interpretation of noise logs for the purpose of demonstrating mechanical integrity is straightforward. The following steps are used:

1. Determine the base noise level in the well (dead well level);

2. Identify significant departures from this base noise level. An increase in noise near the surface due to the operation of equipment on site is to be expected;

3. Utilize the noise log in an attempt to determine the extent of any fluid / gas movement (this may be difficult when there are few constrictions to flow);

4. If the observed flow is into or between USDWs, a lack of mechanical integrity is indicated. If the observed flow is indicated to be moving upward from the injection zone into or above the confining zone, the failure of containment is indicated.

If the log measurements are ambiguous, the determination of the possible loss of mechanical integrity or containment should be confirmed using another method.

Oxygen Activation Log (if run)

The oxygen activation method is based on the use of the Oxygen Activation Log tool to convert oxygen into an isotope of nitrogen (N_{16}) within a short radial distance of the tool. It is an approved logging method under §3617 (B)(1)(d)(ii). This is accomplished by the emission of high energy neutrons from the tool's neutron source. N_{16} is an unstable isotope of nitrogen which is also referred to as “activated oxygen”. The half-life of activated oxygen is just 7.13 seconds, and the release of gamma rays as the activated oxygen decays into oxygen can be measured. If the tool is stationary and oxygen is activated, detectors placed near the activator device will detect increased gamma radiation. The intensity of the additional radiation will be inversely proportional to the square of the distance of the activated oxygen from the detector. Most of the elemental oxygen near the tool is bound in the surrounding water (H_2O), which may be mobile or static depending on wellbore conditions. If the water containing such activated oxygen is actively moving (flowing), the measured intensity of gamma radiation will increase if the water containing activated oxygen moves closer to a tool detector and will lessen as it moves further away from the other detector on the tool. By comparing the intensity of gamma radiation measured at the two detectors on the oxygen activation tool, the probable direction and velocity of water movement can be determined. Studies under controlled conditions indicate water velocities between 2 to 120 feet per minute can be measured.

Procedure

All measurements should be taken for periods of at least five minutes with the well injecting at the maximum normal rate. A total of at least 15 minutes measurement time is required at each station. This total time may be accumulated in one, two, or three operations. If open hole caliper logs are available, the caliper log should be used to ensure all readings are taken at depths where the wellbore is in gauge. The method for obtaining measurements shall conform to optimum procedures contained in the operator's manual for the tool. The following steps are recommended for demonstrating mechanical integrity using the oxygen activation log tool:

1. Obtain a reference log for lithology determination. If no such log is available, run a cased-hole gamma ray-neutron log to aid in the identification of porous intervals;

2. If required for tool calibration, background checks will be run with no injection occurring in an interval where no flow is thought to occur. Background calibration should be run for each interval of varying well construction;

3. Take measurements at stations at least 10 feet above the open injection interval;

4. Take measurements at the top of the confining zone and at two or three formation changes between the confining zone and the base of the USDW;

5. Take measurements within 50 feet below the base of each USDW, within 50 feet of the top of the first underlying aquifer, and at least one depth between these two points;

6. If activated oxygen anomalies are found, additional readings, including readings made while the well is injecting (if the original measurements were made while not injecting, or not injecting if the original measurements were made while injecting), should be made above and below the depth of the anomaly to confirm the anomalous reading and determine the extent of fluid movement; and

7. If flow is indicated, another cased-hole diagnostic log may be used to confirm the measurement and define the extent of flow. The choice for the confirmation log to be used should be based on all wellbore and environmental factors, and the tool choice must be approved by the Commissioner prior to commencing testing operations.

Interpretation

A 3 or 4 : 1 ratio of the short-spaced flow indicator results to a standard deviation indicates flow. Indicated water-flow velocities should be in excess of two feet per minute; lower values should be viewed with skepticism. Velocities near and above two feet per minute have been measured at several depths at several sites; however, other diagnostic logs did not indicate flow. In some cases the occurrences were repeatable, at least during the period of one logging operation. Although the cause of such false or misleading measurements is not known, the assumption is that the logging tool was not properly calibrated for the interval being tested.

To minimize false positives, it is recommended that all measurements be confirmed at several nearby depths and/or measurements be taken under a minimum of 3 varying injection rates, *i.e.* at 75%, 50%, and 25% of maximum permitted injection rates. Before costly remedial measures are undertaken, such anomalies should be confirmed by the acquisition of other logs.

Louisiana Green Fuels will notify the Commissioner at least 30 days prior to conducting any mechanical integrity test and will provide, at that time, a detailed description of the testing procedure to be performed. Notice and the opportunity to witness the test/log shall be provided to the Commissioner at least 72 hours in advance of a given test / log run. The cased hole wireline logs that may be run during such MITs are listed on the following page (Table 9).

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

<u>Annulus Pressure Test Procedure</u>

To evaluate the absence of significant leaks, an Annulus Pressure Test (APT) will be run on the injection wells after construction and prior to authorization to inject [§3627 (A)(2)]. Temperature stabilization of the well and annulus liquid is necessary prior to conducting the test. This may be achieved by filling the annulus with liquid and either ceasing injection or maintaining stabilized injection (*i.e.*, continuous injection at a constant rate and constant injection fluid temperature) before and through the test (dynamic APT test). 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 block off the surface annulus system. Increase annulus pressure to at least 200 psig over the permitted maximum tubing/injection pressure. Allow pressure to stabilize. Conduct 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, the annular pressure will be reduced to the well's normal, safe pressure and the recording equipment will be removed from the wellbore.

A successful pressure test will "PASS" if the pressure holds to +/-5 percent of the starting test pressure. If the test indicates 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 then be repeated and if the well continues to "FAIL", it will be determined that the construction of the well might have lost 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. Responses to the potential loss of well integrity during the construction phase will include the remediation of such loss prior to the initiation of injection operations.

2.6.1 Reporting

Louisiana Green Fuels will submit a descriptive report prepared by an experienced cased hole log analyst [§3617 (B)(2)] 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 a qualified 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, the evidence of fluid leakage, and any remedial action recommended or taken;
- The date and time of each test;
- The name of the logging company that conducted the testing and the cased hole log analyst than evaluated the test;

- For any tests conducted during injection: the operating conditions during measurement, including the 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 periods: the date and time of the completion / cessation 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 LAC 43:XVII §3607 (C)(2)(g), §3625 (A)(6), and LCFS Protocol Subsections C.2.3.1(i)(1), C.4.1(a)(8) and C.4.3.1.5. 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

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 the baseline characterization of the transmissibility to fluid within the Upper Tuscaloosa / Paluxy Primary Injection Zone. The initial pressure fall-off testing will be repeated using supercritical carbon dioxide within the first 60 days following the initiation of sequestration operations. This will allow for comparison to the baseline fluid-to-fluid test with the change in the injection fluid from brine or treated municipal water to supercritical 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 (§3625 (A)(6) and 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 supercritical carbon dioxide plume(s), based on the expected lateral transition from supercritical carbon dioxide near the wellbore to native formation brine beyond the plume. The

Commissioner may request more frequent testing which will be dependent on test results. A final pressure fall-off test will be run after the final cessation of injection in each such 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 initial completion procedure or can be deployed via wireline. If a wireline-deployed gauge is used, the wireline run in the hole should be corrosion resistant (such as MP-35 line), and the deployed gauges should consist of a surface readout gauge with a memory backup. Gauge specifications should be as follows or similar:

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 gauge is used for the testing). A dedicated downhole monitoring gauge may be used if installed on each of the injection wells:

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

1. Mobilize wireline unit to the injection well and rig up on the 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 shall have an operating range of 0 - 10,000 psi. Reference the wireline gauge depth to the original kelly bushing (KB) elevation as well as the elevation above ground level.

3. Open the 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 help to minimize cross-well interference effects.

   NOTE: Rates from offset well may be superpositioned out of the test well data during analysis should an anomaly be observed, that may be attributed to significant rate change in an offset well. Rate information may also provide a reason for the final pressure being higher due to pressure buildup from an offset well and will be considered in the final interpretation of the test.

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 / secure all valves on the injection annulus pressure system so that annulus pressure cannot be changed during the falloff period. Ensure also 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, terminate the fall-off test at that time. If additional data is required, extend the fall-off test until radial flow conditions are confirmed. After confirmation of sufficient data acquisition, terminate the 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. If the well goes on a vacuum, the static fluid level shall also be recorded.

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 activities (due to possible damage from well perforation) will be assessed for the wells injectivity and potential well cleanouts in the future. Data reduction and analyses will follow the EPA's *UIC Pressure Falloff Testing Guidelines – Third Revision* (https://www.epa.gov/sites/default/files/2015-07/documents/guideline.pdf). These tests can also measure drops in pressure due to potential damage/leakage over time. In the presence of supercritical CO_2, it is anticipated that pressure drops may indicate multiple fluid phases. The analysis will be designed to consider all parameters.

A pre-operational report and assessment will be submitted to the Commissioner and detail the impacts of the formation testing on the final extent of the delineated Area of Review, Modeling inputs, and any other relevant updates to the submitted application that may change or be verified [§3619 (A)].

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 project monitor wells. As such, similar information to the injection wells may be gathered in the monitor wells. The project currently anticipates that five existing wells will be re-entered and recompleted as monitor wells for the project; these five wells are featured in detailed recompletion wellbore schematics in Section 7.0 of the "*Area of Review and Corrective Action Plan*" submitted in **Module B** as part of the corrective action plan; specifically. The first well to be converted to an In-Zone monitoring well will be the Whitetail Operating, LLC, Louisiana Green Fuels #1 (SN975841), which was drilled as a Class V stratigraphic test well for the project in April / May 2021. This 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 and testing of this Class V stratigraphic test well has been used in support of the local subsurface geology and the initial dynamic and static models for this project.

Additionally, the following offset wells will be reentered and converted to In-Zone monitoring wells:

- Artificial Penetration No. 69 - Bradford-Brown Trust Shipp No. 1 (SN137783) well, located approximately 10,152 feet north and updip of the facility.
- Artificial Penetration No. 76 - Bass Keahey No.1 (SN165395) well, located approximately 13,730 feet northeast and updip of the facility.
- Artificial Penetration No. 101 - Southern Carbon USA No. 1 (SN34225) well, located approximately 37,850 feet east- southeast and downdip of the facility.
- Artificial Penetration No. 276 - Murphy Meredith No. 1 (SN23356) well, located approximately 28,150 feet east-southeast and downdip of the facility.

The **Bradford-Brown Trust Shipp No. 1** (SN20131) will be re-entered and repurposed by deepening and completing the well for monitoring purposes across the entire Upper Tuscaloosa -

Paluxy Formation interval. The well originally penetrated only 110 feet of the Upper Tuscaloosa interval; for more effective monitoring, the hole will be deepened to 7,000 feet and logged.

During or immediately following the deepening of the well to 7,000 feet, supplemental coring or rotary coring operations may be conducted across certain zones of interest if deemed necessary. The well will then be cased to bottom with 5-1/2-inch casing and subsequently completed for monitoring purposes across sequestration reservoirs encountered in the Upper Tuscaloosa / Paluxy Primary Injection Zone.

The **Bass Keahey No.1** (SN165395) will be re-entered and cleaned out to 7,000 feet and logged. Supplemental rotary coring operations may be conducted across certain zones of interest if deemed necessary. The well will then be cased to bottom with 5-1/2-inch casing and subsequently completed for monitoring purposes across sequestration reservoirs encountered in the Upper Tuscaloosa / Paluxy Primary Injection Zone.

The **Southern Carbon USA No. 1** (SN34225) will be re-entered and cleaned out its original total depth of 6,005 feet and then deepened to 7,000 feet and logged. During or immediately following the deepening of the well to 7,000 feet, supplemental coring or rotary coring operations may be conducted across certain zones of interest if deemed necessary. The well will then be cased to bottom with 5-1/2-inch casing and subsequently completed for monitoring purposes across sequestration reservoirs encountered in the Upper Tuscaloosa / Paluxy Primary Injection Zone.

The **Murphy Meredith No. 1** (SN23356) will be re-entered and cleaned out its original total depth of 6,505 feet and then deepened to 7,000 feet and logged. During or immediately following the deepening of the well to 7,000 feet, supplemental coring or rotary coring operations may be conducted across certain zones of interest if deemed necessary. The well will then be cased to bottom with 5 ½” casing and subsequently completed for monitoring purposes across sequestration reservoirs encountered in the Upper Tuscaloosa / Paluxy Primary Injection Zone.

In addition, Strategic Biofuels intends to re-enter and convert the **Magnolia Petroleum Co. O.N. Reynolds No. 1** (SN57466) well, a legacy Annona Sand test (and dry hole), to an Above-Confining-Zone (ACZMI) monitoring well prior to any active injection of carbon dioxide into the Upper Tuscaloosa / Paluxy Primary Injection Zone. The Reynolds dry hole bottomed just beneath the base of the Annona Sand and did not penetrate the Primary Upper Confining Zone, the Austin Chalk Equivalent / Eagleford interval but is geographically well placed to be repurposed as an ACZMI monitoring well. Strategic Biofuels also plans to drill and complete a new ACZMI monitoring well to a depth just above the top of the Secondary Upper Confining Zone, the Midway Shale, at a location adjacent to Injection Well W-N1 drilled on the plant site. This monitoring well will be completed across the basal sandstone of the Wilcox Formation and serve as a valuable Midway ACZMI well. Though shallower, this well will also be evaluated with a robust logging program.

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 for baseline data acquisition. 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 LAC 43:XVII §3607 (C)(2)(a) 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 (base of the 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 other four planned monitor wells, an Induction-Electric Log has been run from total depth up to the original surface casing shoe in each well. In the Bradford-Brown Trust Shipp No. 1 (SN20131), the Southern Carbon USA No. 1 (SN34225) well and the Murphy Meredith No. 1 (SN23356), logs will be run across the new open hole interval up to the base of the existing surface casing. The gamma ray log will be run further uphole within the current surface casing of all three wells for correlation purposes and to acquire clay lithology data. In the Bass Keahey No.1 (SN165395) well, a "deep" surface casing string was originally set to 3,045 feet just into the Selma Chalk. An induction log run from total depth to 100 feet clearly illuminates the shallow aquifers and the base of the lowermost USDW that is behind pipe. No other surface log is needed.

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 below the top of the Selma Chalk (observed at 3,810 feet measured log depth). The intermediate borehole was evaluated using open-hole wireline logging (Table 12).

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 open hole wireline logging tools run in the hole were unable to reach total depth, as described in Table 13; others were successfully run to total depth. The proposed Injection Zones that were encountered were 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 four legacy wells slated for re-entry and conversion to In-Zone monitoring wells, barring any insurmountable difficulties, the minimal open hole well logging program will consist of the first five logs in Table 13. More extensive logging may include the additional logs run in the Whitetail Operating, LLC, Louisiana Green Fuels #1 well.

3.1.4 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 §3617 (B)(2) & LCFS Protocol Subsection C.2.3.1(f)(1)]. 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.

After the open and cased hole logging program has been completed in each additional monitor well, Louisiana Green Fuels will prepare an evaluation and interpretation of all the logs prepared by a knowledgeable log analyst [per §3617 (B)(2) & 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 log analysis and tests run.

Reports will be submitted to the Commissioner.

3.2 MONITOR WELL CORING PROGRAM

Petrophysical analysis is utilized in building the static geologic model for the project. The uncertainty in the static model is impacted by the amount and quality of open hole log, whole core, and rotary sidewall core data. Whole core and rotary sidewall core samples were collected during the drilling and logging of the Whitetail Operating, LLC, Louisiana Green Fuels #1 stratigraphic 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
- Upper Tuscaloosa (one each from the 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 (Intraformational Chalk monitoring reservoir)
- Upper Tuscaloosa
- Lower Tuscaloosa

As described above, Strategic Biofuels plans on re-entering and converting this well and four other existing offset wells to In-Zone monitoring wells for the Port of Columbia project. Three wells (Bradford-Brown Trust Shipp No. 1 (SN20131); Southern Carbon USA No. 1 (SN34225); and Murphy Meredith No. 1 (SN23356)) will be deepened to some extent to penetrate all of the potential Injection Zone. Accordingly, Louisiana Green Fuels may opt for an adaptive coring program comprised of rotary sidewall cores or whole core samples in these three deepened wells.

The acquisition of such samples will be prioritized to reduce uncertainty and identify special variability in the key regulatory horizons. The selection of the potential intervals to be cored will be made via the correlation of the rate of penetration in the deepened well with the legacy open hole well logs of offset wells at the time of recompletion. 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. Such whole coring may also be supplanted by the acquisition of rotary sidewall core samples during the subsequent open hole logging program.

3.2.1 Core Laboratory Analysis

If core is collected from the Bradford-Brown Trust Shipp No. 1 (SN20131), Southern Carbon USA No. 1 (SN34225), and/or Murphy Meredith No. 1 (SN23356) monitoring wells, routine core analyses (porosity, permeability, and bulk density) will be performed on a distribution of samples characterizing differing lithologies in the monitor wells. Additional analyses may include a lithologic core description, thin section preparation and analyses, x-ray diffraction (XRD), and x-ray fluorescence (XRF). These tests will be used to characterize reservoir composition, storage and flow capacity and to understand depositional uncertainties that impact the flow environments.

3.2.2 Reporting

Louisiana Green Fuels will submit a report prepared by an experienced core analyst pertaining to the results of any core analyses [per §3617 (B)(2)] if such analyses are performed and the results impact the model, area of review, and/or the site characterization of the project. This report will include information on collection and testing methods, specific details regarding the samples and the calibration of instrumentation, analysis results in tabular or graphic form, and core photographs as appropriate; all such data to be submitted as soon as practicable to the State.

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 facility. 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 re-entered monitor wells during re-entry and/or recompletion. The downhole system used to sample and retain 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; however, this testing will focus on all sampled formation gasses and fluids.

Downhole samples retained under pressure are preferred; however, based on subsurface and well conditions, surface samples may be collected for expediency.

The anticipated additional fluid sampling protocol will be as follows:

1. Purge the well casing volume to bring fresh fluids that have not reacted with drilling muds, completion fluids, or casing and tubing to the sample point within the wellbore (swab, nitrogen back-lift, etc.). If several well volumes are removed from the well, monitor fluid parameters at surface until properties stabilize.
2. Deploy a 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. Preserve fluid and gas volumes in preparation for shipping and analysis.
4. Filter and preserve 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, accredited by the Louisiana Department of Environmental Quality.

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

3.3.1 Analysis

An initial baseline fluid sample will be collected from the Upper Tuscaloosa / Paluxy Injection Zone during completion and well development activities in the monitor wells prior to injection operations [§3607 (C)(2)(e)]. These fluid samples will provide the baseline measurements for formation fluids and document any spatial variability. Table 14 identifies the parameters to be monitored and the analytical methods the Louisiana Green Fuels, Port of Columbia Facility will use.

Table 14: 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
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

Parameters	Analytical Methods
Hardness	ASTM D1126
Turbidity	EPA 180.1
Specific Gravity	Modified ASTM 4052
Density	Modified ASTM 4052

The initial parameters identified in Table 14 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 an experienced specialist for the details on the fluid sampling results [per §3617 (B)(2)]. 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 Commissioner.

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 §3607 (C)(2)(b), §3617 (B)(4)(a) & 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 re-entry / deepening operations. Tests may include an open hole Schlumberger Modular Dynamics Tester (MDT), or an equivalent industry tool, to determine the minimum horizontal stress of the formations (the Primary Injection and Confining Zones). These formation tests, if performed, will employ a dual packer setup, and will be conducted on both injection zone candidates and overlying containment intervals and/or confining zones 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 were only used to confirm matrix flow parameters for the longer duration constant rate 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 using the Schlumberger MDT tool in Dual Packer Mode (or industry tool equivalent) 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 formation micro-imager tool, if available, 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 an experienced specialist for the details on the formation fracture results [per §3617 (B)(2)]. 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 State.

3.5 DEMONSTRATION OF MONITOR WELL MECHANICAL INTEGRITY

The 5-1/2-inch casing run in each Monitor Well identified in Section 3.0 will be pressure tested following cementing operations. A baseline Pulsed Neutron Tool (or equivalent) will then be run in cased hole in each Monitor Well prior to the commencement of sequestration injection operations to establish initial conditions. Thereafter, an adaptive program of repeat surveys will be performed if indications of supercritical carbon dioxide approaching the monitor locations are indicated on the in-zone 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 5-1/2-inch casing run in each Monitor Well will be pressure tested on a regular basis once monitoring is underway. The purpose of these tests is to ensure that the well's integrity remains mechanically sound and that there is no movement of formation fluid along the wellbore annulus.

3.5.1 Reporting

Louisiana Green Fuels will submit a descriptive report prepared by an experienced accredited 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 may elect to use tubing or wireline – conveyed packer and retrievable bridge plug assemblies to isolate certain perforated intervals or zones and perform baseline pressure fall-off tests during the Monitor Well construction phase. These tests, if conducted, will be used to quantify spatial variability in the Upper Tuscaloosa / Paluxy Primary Injection Zone.

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 (SN20131), Southern Carbon USA No. 1 (SN34225), and/or Murphy Meredith No. 1 (SN23356) wells after those wells have been re-entered, deepened, and cased to total depth; or the Bass Keahey No.1 (SN165395) after it has been cleaned out and cased to 7,000 feet. Procedures are included in Section 2.7.1, above.