

**TESTING AND MONITORING PLAN**  
**40 CFR 146.90**

**Pelican Sequestration Project**

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## **1.0 Facility Information**

Facility name: Pelican Sequestration Project  
Pelican CCS 1 Well

Facility contact: [REDACTED], Project Manager  
5 Greenway Plaza Houston, TX 77046  
[REDACTED]

Well location: Holden, Livingston Parish, Louisiana  
[REDACTED] (NAD 1927, BLM Zone 15N)

This Testing and Monitoring Plan describes how Pelican Sequestration Hub, LLC will monitor the Pelican Sequestration Project site pursuant to 40 CFR 146.90. In addition to demonstrating that the well is operating as planned, the carbon dioxide plume and pressure front are moving as predicted, and that there is no endangerment to USDWs, the monitoring data will be used to validate and adjust the geological models used to predict the distribution of the CO<sub>2</sub> within the storage zone to support AoR reevaluations and a non-endangerment demonstration.

Results of the testing and monitoring activities described below may trigger action according to the Emergency and Remedial Response Plan.

## **2.0 Overall Strategy and Approach for Testing and Monitoring**

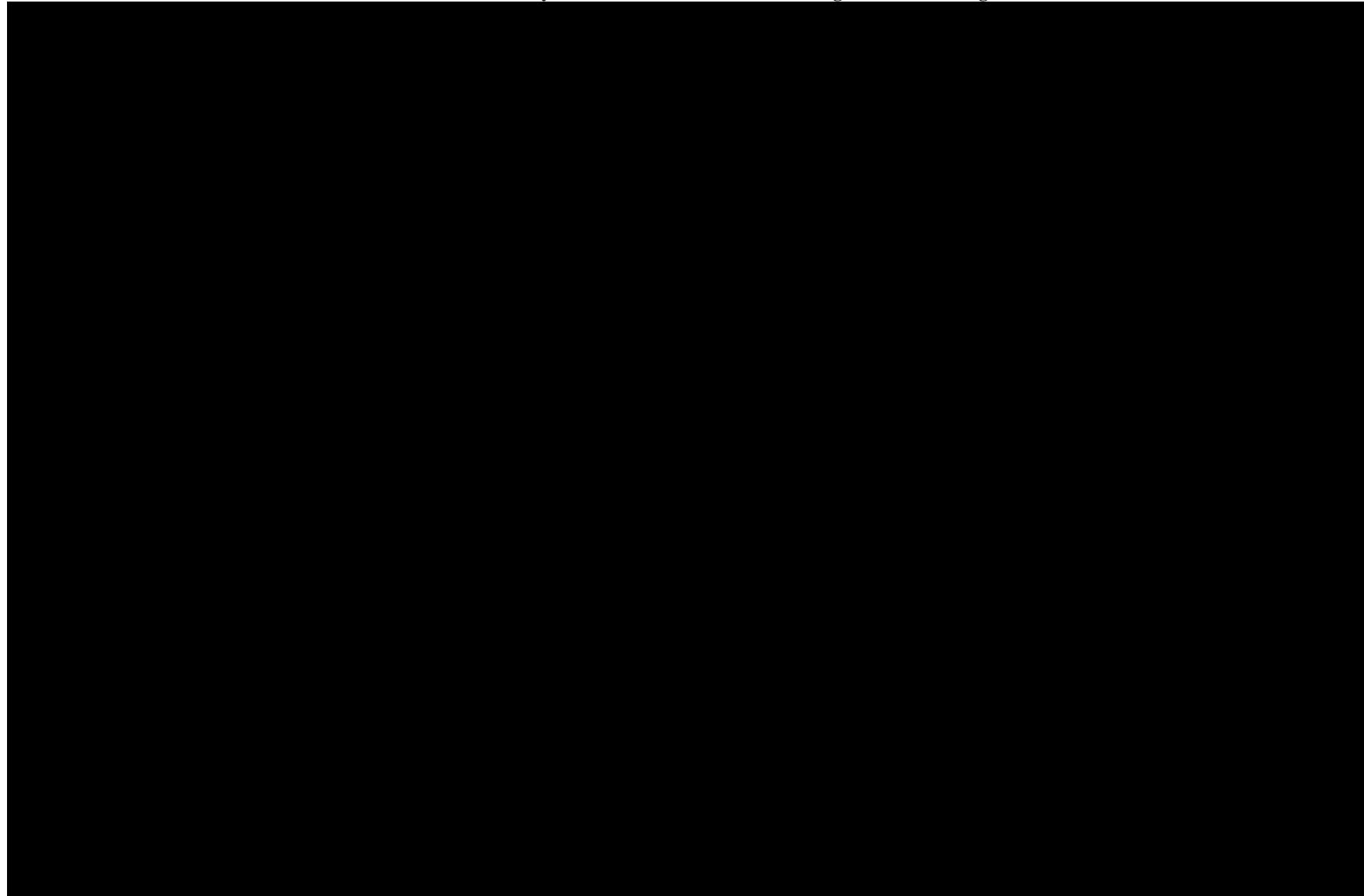
The monitoring well network is designed to detect unforeseen CO<sub>2</sub> and/or brine leakage out of the injection zone that could endanger the USDW, migrate to a different stratus, or create a risk for the people and environment. There are several components that integrate the master monitoring plan for the Pelican Sequestration Project, which are classified in the following categories:

1. Operational Testing and Monitoring During Injection.
2. Mechanical Integrity Testing
3. Ground Water Quality and Geochemical Monitoring
4. Carbon Dioxide Plume and Pressure Front Tracking.
5. Near surface and Surface monitoring
6. Induced Seismicity

Table TM-1 shows a summary of the different methods proposed in the integrated monitoring plan for the Pelican CCS 1.

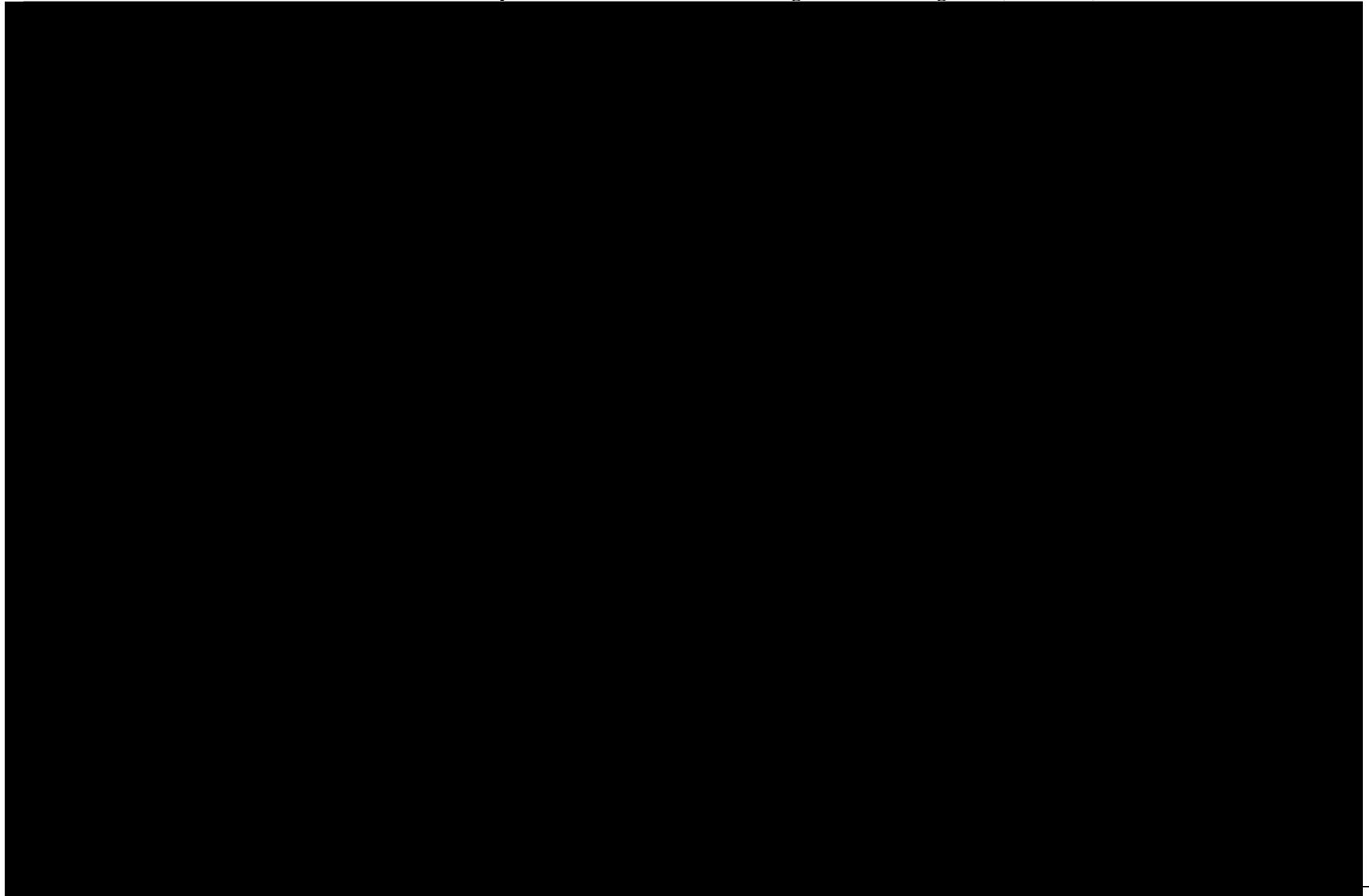
Plan revision number: 0  
Plan revision date: 07/31/23

**Table TM-1—Summary Table for Pelican CCS 1 Testing and Monitoring Plan**



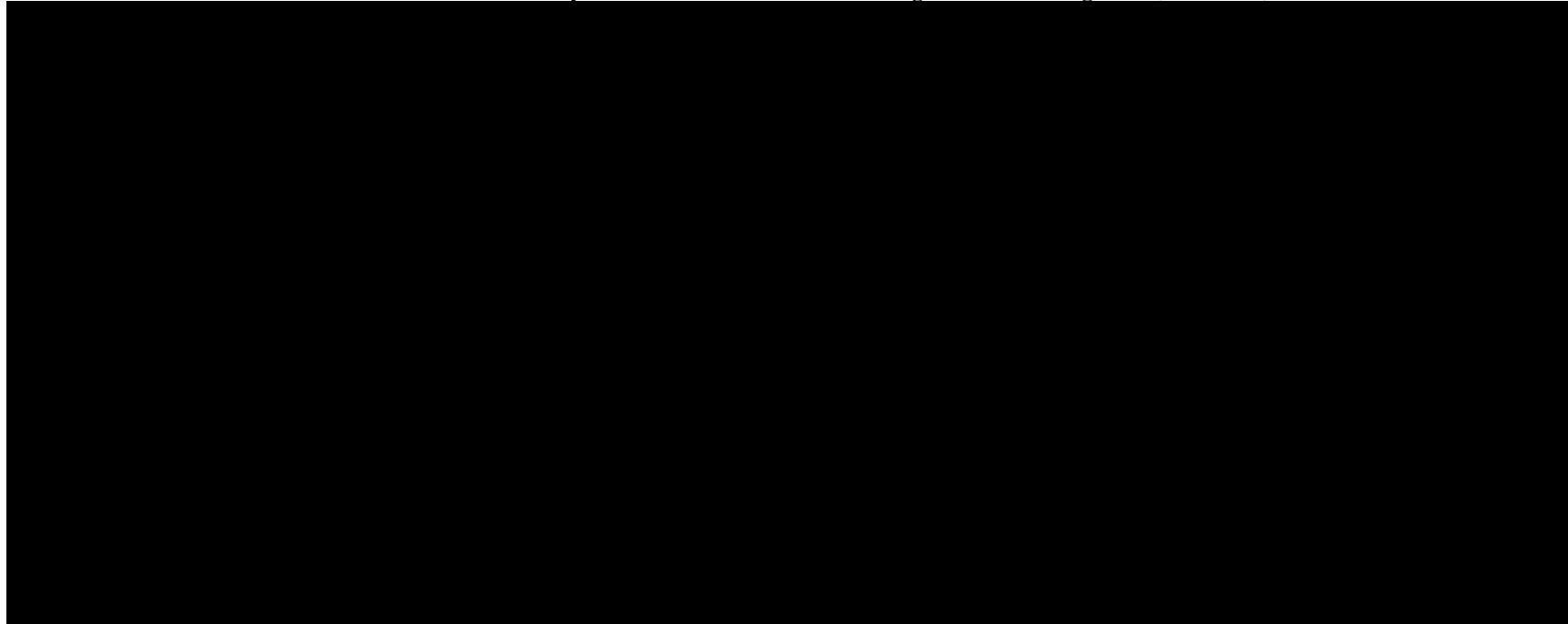
Plan revision number: 0  
Plan revision date: 07/31/23

**Table TM-1—Summary Table for Pelican CCS 1 Testing and Monitoring Plan (continued)**



Plan revision number: 0  
Plan revision date: 07/31/23

**Table TM-1—Summary Table for Pelican CCS 1 Testing and Monitoring Plan (continued)**



Pelican Sequestration Hub, LLC, will drill two CO<sub>2</sub> injector wells Pelican CCS 1 and Pelican CCS 2 as part of the field development plan for the Hub. The monitoring program proposed was designed based on the projected CO<sub>2</sub> plume extension and the propagation of the pressure front for both wells injecting simultaneously according to the AoR delineation process.

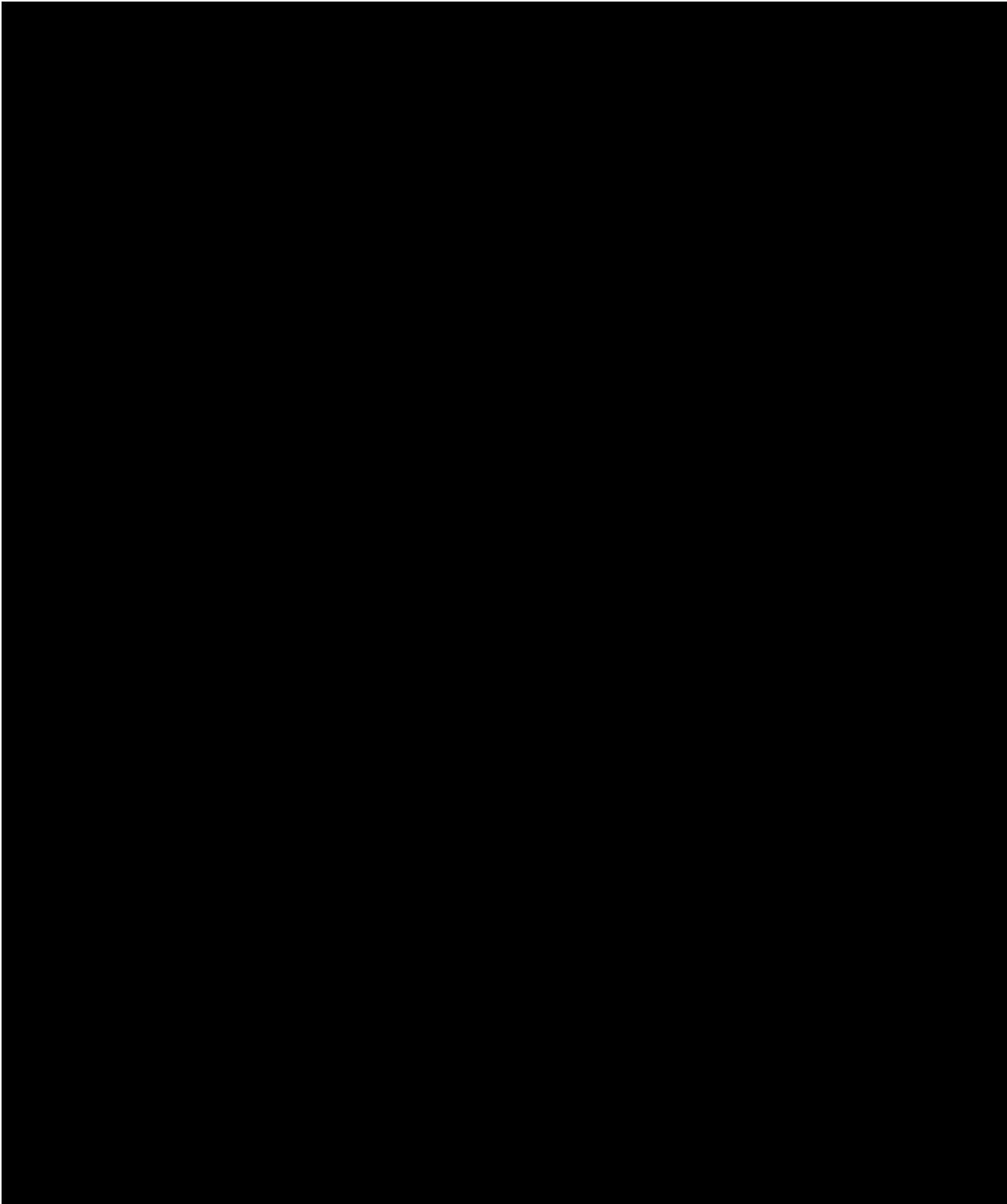
The proposed integrated monitoring plan includes a layout of [REDACTED]

This network is complemented with [REDACTED] seismic surveys and a [REDACTED] plan as indirect methods. Additionally existing water wells in the area will be used to establish the composition of the shallow aquifers and provide characterization of the waters.

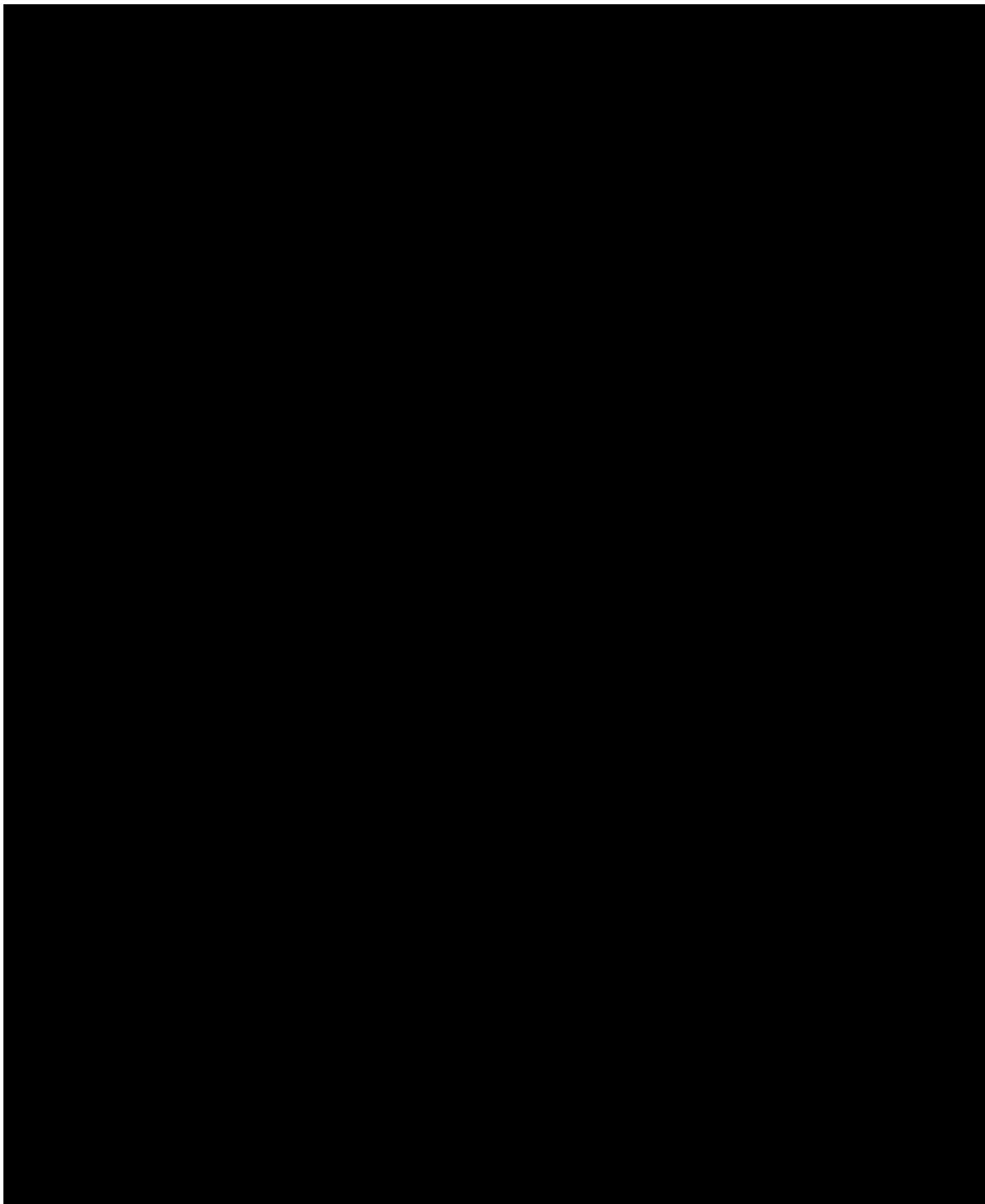
This integrated approach will optimize the surveillance operations of the site with the goal of tracking the CO<sub>2</sub> plume extension and rate of migration, the development of the pressure front, and changes in the composition of deep and shallow aquifers as part of the holistic approach to ensure stakeholders and regulators that the site is operating safely and efficiently, and that the CO<sub>2</sub> is permanently stored in the subsurface. Figures TM-1 and TM-2 show the location and spatial distribution of the monitoring wells.

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**Figure TM-1—Location and layout of In Zone and Above Confining Zone monitoring wells relative to the injector wells and the CO<sub>2</sub> plume and pressure front development.**



**Figure TM-2—Location and layout of USDW monitoring wells and freshwater shallow wells relative to the AOR.**

Well locations show the approximate position of the proposed monitoring wells. The exact locations might have a slight variation in latitude and longitude depending on the final design of the surface pads and the negotiations with the landowners when the locations are surveyed.

The proposed Testing and Monitoring Plan aims to ensure sufficient geospatial and monitoring data is collected to validate the numerical simulation model, history match, and adjust the injection operating parameters and ensure the site is operating as designed, efficiently and safely. The monitoring results would allow the Project to re-evaluate the AOR and prove no endangerment to the USDW.

Each of these methods and their application in the proposed monitoring plan is discussed in the following sections. Results of the testing and monitoring activities described below may trigger action according to the Emergency and Remedial Response Plan.

The proposed Testing and Monitoring Plan will be reviewed and updated as a minimum every 5 years during AOR reevaluation or sooner is needed.

## ***2.1 Quality assurance procedures***

A quality assurance and surveillance plan (QASP) for testing and monitoring activities, required pursuant to 146.90(k), is provided as a separate document in this permit.

## ***2.2 Reporting procedures***

Pelican Sequestration Hub, LLC will report the results of all testing and monitoring activities to EPA in compliance with the requirements under 40 CFR 146.91.

# **3.0 Operational Testing and Monitoring During Injection**

## ***3.1 Carbon Dioxide Stream Analysis [40 CFR 146.90(a)].***

Pelican Sequestration Hub, LLC will analyze the CO<sub>2</sub> stream during the operation period to yield data representative of its chemical and physical characteristics and to meet the requirements of 40 CFR 146.90(a).

### ***3.1.1 Sampling location and frequency***

The CO<sub>2</sub> stream sampling will occur quarterly during operation either upstream or downstream of the custody transfer flowmeter that measures the flow rate of the injectant at the site. Multiple samples will be acquired during the startup period of the project (first injection) to validate the CO<sub>2</sub> stream complies with the requested minimum specifications. After the start up period, a sample will be taken 3 months after start of injection, at 6 months, at 9 months, and at 12 months as minimum frequency, continuing every quarter until injection ceases in the well. The sampling period could be increased and could slightly shift in timing depending on the operations.

The project has developed a standard for CO<sub>2</sub> specification, specifying the max variation in impurities and the delivery conditions at the site, as shown in Table TM-2. This standard CO<sub>2</sub> specifications will be enforced to the CO<sub>2</sub> sources and distribution channels in order to control the quality of the CO<sub>2</sub> injected at the wells. The project will install a gas analyzer at the custody transfer meter located in the sequestration site to monitor CO<sub>2</sub> quality continuously before it is distributed to each well to detect any major deviation from the contractual specifications. The

project could require additional components to be limited and analyzed based on final contractual terms with the emitters.

**Table TM-2—CO<sub>2</sub> Stream Specification**

The CO<sub>2</sub> composition will be monitored continuously at each receipt point into the pipeline network along with at the delivery point to the sequestration site.

If the inline analyzers or sample results indicate a deviation from the CO<sub>2</sub> specification, the sampling frequency for the relevant receipt point(s) will be increased until the sampling results return to normal for a specified period.

If the CO<sub>2</sub> delivered to a receipt point does not meet the CO<sub>2</sub> specification, the project will notify the CO<sub>2</sub> source facility and either shut-in the source facility or increase the sample frequency, depending on the risk associated with the out-of-spec component.

If a CO<sub>2</sub> source facility is shut-in, offtake will only resume from that facility once it has demonstrated the resumption of in-spec product for an agreed period between 12 and 48 hours.

### 3.1.2 Analytical parameters

Pelican Sequestration Hub, LLC, will analyze, as minimum, the CO<sub>2</sub> for the constituents identified in Table TM-3 as minimum requirement, but not limited to.

**Table TM-3—CO<sub>2</sub> Stream Analysis**

Component	Frequency	Analytical Method
CO <sub>2</sub> (% mol)	Quarterly	
Water (lbs/MMCF)	Quarterly	
Nitrogen (%)	Quarterly	
Oxygen (ppm)	Quarterly	
Hydrogen (% mol)	Quarterly	
SO <sub>x</sub> (ppm)	Quarterly	
NO <sub>x</sub> (ppm)	Quarterly	
Hydrogen Sulfide (ppm)	Quarterly	
Hydrocarbons (%)	Quarterly	
Carbon Monoxide (ppm)	Quarterly	
Glycol (gal/MMSCF)	Quarterly	
Ammonia (ppm by wgt)	Quarterly	
Argon (%mol)	Quarterly	
Sulfur (ppm by wgt)	Quarterly	
δ <sup>13</sup> C of CO <sub>2</sub>	During Characterization	
14C of CO <sub>2</sub>	During Characterization	

The project may deem it necessary to test additional elements to ensure the CO<sub>2</sub> delivered in the HUB complies with the contractual specifications. Isotopes will be analyzed during the first year of operation and after any major change of CO<sub>2</sub> source composition to fingerprint the stream.

### ***3.1.3 Sampling methods***

- A sampling station will be installed with the ability to purge and collect samples into a container that will be sealed and sent to the third-party authorized laboratory. All sample containers will be labeled with durable labels and indelible markings. A unique identification number and sampling date will be recorded on the sample containers.
- Sampling procedures will follow contractor protocols to ensure the sample is representative of the injectant and samples will be processed, packaged, and shipped to the contracted laboratory, following standard sample handling and chain-of-custody guidance. Sampling methods are described in the QASP.

### ***3.1.4 Laboratory to be used/chain of custody and analysis procedures***

The samples will be analyzed by a third-party laboratory using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and photo ionization. Analytic methods and chain of custody procedures are described in the QASP.

### ***3.2 Monitoring and Recording of Operating Parameters in Injector Wells [40 CFR 146.88(e)(1), 146.89(b), and 146.90(b)]***

Pelican Sequestration Hub, LLC will install and use continuous recording devices to monitor injection pressure, rate, and volume; the pressure on the annulus between the tubing and the long string casing; and the temperature of the CO<sub>2</sub> stream, as required at 40 CFR 146.88(e)(1), 146.89(b), and 146.90(b).



Injection operations will be continuously monitored and controlled by the operations staff, utilizing the process control system. The system will continuously monitor, control, record, and alarm for critical system parameters of pressure, temperature, and flow rate.

The process control system will limit maximum flow to █ MT/day, or approximately █ MMscfd, and limit the wellhead pressure to █ psig to protect the surface equipment.

The system will initiate a shutdown if specified control parameters deviate from the intended operating range and will allow for remote shutdown under emergency conditions. Trend analysis will help evaluate the performance (e.g., drift) of the instruments, suggesting the need for maintenance or calibration.

#### ***3.2.1 Monitoring location and frequency***

Real time monitoring activities will begin during the start-up of the wells for first injection. The injection pressure and temperature will be continuously measured at the surface via real-time pressure and temperature (P/T) instruments installed in the CO<sub>2</sub> injection line near the interface with the wellhead. The pressure will be measured by electronic pressure transmitter with analog output mounted on the CO<sub>2</sub> line associated with the injection well. The temperature will be measured by an electronic temperature transmitter mounted in the CO<sub>2</sub> line at a location near the pressure transmitter, and both transmitters will be located near the wellhead.

The flow rate of CO<sub>2</sub> injected into the well will be measured by flow meter skids with █ meters in the CO<sub>2</sub> injection line near the interface with the wellhead. Piping and valving will be

configured to permit flow meter calibration. The flow transmitter will be connected to a remote terminal unit (RTU) on the flow meter skid.

A pressure and temperature (P/T) gauge will be installed downhole as part of the upper completion and will be ported into the tubing to continuously measure CO<sub>2</sub> injection pressure and temperature at reservoir. The downhole sensor will be the point of compliance for maintaining injection pressure below 90% of formation fracture pressure, as well as to evaluate the reservoir performance and history match the operation with the projection of the model.

If the downhole gauge stops working between scheduled maintenance events, then the surface pressure limitation approved for this permit will be used as a backup until the downhole gauge is repaired or replaced. For calibration purposes, in lieu of removing the injection tubing, the accuracy of the downhole gauges will be demonstrated by using a second pressure gauge with current certified calibration lowered into the well at the same depth as the permanent downhole gauge.

Electronic pressure gauges and temperature sensors will be used to continuously monitor the pressure and temperature of the annulus between the tubing and long string casing at the surface. Gauges and sensors will be connected to the automation system to provide continuous data analysis as well as alarms for malfunctioning events when the values deviate from the intended operating range.

Annular pressure will be kept between [REDACTED] psi on surface and the addition of volume or changes in pressure will be noted by the operator in the field and recorded in the project well databases weekly. A pressure gauge and temperature sensor will be installed downhole as part of the upper completion and will be ported into the annular above the packer to continuously measure pressure in the annular space and identify any potential loss of mechanical integrity. If major variation of pressure is observed in the annular gauges (surface/downhole), then the field operator will proceed to troubleshoot the well.



Automated shut off devices will be installed at each exit of the flow lines in the wellhead and will be connected to the control system. If the operation parameters deviate from the program operational limits, the system will send an alarm to the operators to evaluate and correct the situation and might start shut down protocol, if the parameter exceeds the maximum operating limits.

Pelican Sequestration Hub, LLC will perform the activities identified in Table TM-4 to monitor operational parameters. All monitoring will take place at the locations and frequencies shown in the table.

**Table TM-4—Monitoring Devices, Locations, and Frequencies for Continuous Monitoring During Injection Operations in the CO<sub>2</sub> Injector Wells**

Parameter	Device(s)	Location	Min. Sampling Frequency	Min. Recording Frequency
Parameter 1	Device A	Location 1	10 Hz	10 Hz
Parameter 2	Device B	Location 2	20 Hz	10 Hz
Parameter 3	Device C	Location 3	15 Hz	10 Hz
Parameter 4	Device D	Location 4	10 Hz	10 Hz
Parameter 5	Device E	Location 5	10 Hz	10 Hz
Parameter 6	Device F	Location 6	10 Hz	10 Hz
Parameter 7	Device G	Location 7	10 Hz	10 Hz
Parameter 8	Device H	Location 8	10 Hz	10 Hz
Parameter 9	Device I	Location 9	10 Hz	10 Hz
Parameter 10	Device J	Location 10	10 Hz	10 Hz

### ***3.2.2 Monitoring devices description and technical specifications***

Technical specifications for the tools to use for real time data acquisition are described in the QASP.

### **3.3 Corrosion Monitoring [40 CFR 146.90(c)]**

To meet the requirements of 40 CFR 146.90(c), Pelican Sequestration Hub, LLC will monitor well materials during the operation period for loss of mass, thickness, cracking, pitting, and other signs of corrosion to ensure that the well components meet the minimum standards for material strength and performance.

Pelican Sequestration Hub, LLC will monitor corrosion using Corrosion Coupons and collect samples according to the description below. The project will complement the corrosion coupons with visual inspection of the facilities, a robust leak detection and repair program, the use of optical gas imaging cameras (OGI), and the data collected in real-time from the fiber optic installed in the injector wells.

During well material selection, Pelican Sequestration Hub, LLC simulated the chemical reactions of the selected material, the formation waters, and the proposed CO<sub>2</sub> stream at downhole conditions. The Project proceeded to test the selected metallurgic to the maximum limits of the specification and operating parameters to validate the correct selection for downhole materials that will be exposed to the injection stream and formation waters. The results of material testing are in progress and will be available for the Director to review.

During planned well maintenance operation in the CO<sub>2</sub> injector wells, Pelican Sequestration Hub, LLC, will run a casing inspection log to evaluate the casing conditions downhole (Casing Inspection Logs are discussed in the section associated with mechanical integrity).

### ***3.3.1 Monitoring location and frequency***

**Table TM-5—Monitoring Location and Frequency of Leak and Corrosion Detection Devices**

Tool	Location	Pre-Injection	Injection
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Notes:

1. [REDACTED]

Visual inspection will continue weekly, during the injection period, after the start-up of the well to identify potential leaks, as well as to validate that the system is operating between design limits and efficiently. The field operator will be provided with handheld devices to measure explosive gases, H<sub>2</sub>S, and CO<sub>2</sub> as part of the safety requirements of the site. The field inspection will continue quarterly in the post injection period.

[REDACTED]

### 3.3.2 Corrosion Coupons analysis description

Samples of selected materials in the wells and facilities (coupons) will be exposed to the injected CO<sub>2</sub> stream and monitored for signs of corrosion to verify that the selected materials meet the minimum standards for material strength and performance and to identify well maintenance needs. Coupons shall be collected and sent quarterly to a third-party company for analysis conducted in accordance with NACE Standard SP-0775-2018-SG to determine and document corrosion wear rates based on mass loss. The project will start corrosion coupon monitoring after the start of injection and will continue quarterly.

**Table TM-6—Summary of methods to evaluate Corrosion Coupons**

Parameters	Analytical Method	Resolution Instruments	Precisions/Std Dev
Parameter 1	Method A	Instrument 1	Precision 1
Parameter 2	Method B	Instrument 2	Precision 2

**Table TM-7—List of Equipment with Materials of Construction**

A horizontal bar chart comparing two categories across ten samples. The 'Equipment Coupon' column on the left shows varying lengths of black bars, with the first bar being significantly shorter than the others. The 'Material of Construction' column on the right shows consistent lengths of black bars. The bars are set against a background of alternating light and dark gray horizontal stripes.

	Equipment Coupon	Material of Construction
1	Short	Medium
2	Medium	Medium
3	Medium	Medium
4	Medium	Medium
5	Medium	Medium
6	Medium	Medium
7	Medium	Medium
8	Medium	Medium
9	Medium	Medium
10	Medium	Medium

### **3.4 Pressure Fall-Off Testing [40 CFR 146.90(f)]**

Pelican Sequestration Hub, LLC will perform pressure fall-off tests in the CO<sub>2</sub> injector well during the injection phase as described below to meet the requirements of 40 CFR 146.90(f).

### ***3.4.1 Testing location and frequency***

Pressure fall-off testing will be conducted upon completion of the injection well to characterize reservoir hydrogeologic properties, aquifer response model characteristics, and changes in near-well/reservoir conditions that may affect operational CO<sub>2</sub> injection behavior.

Pressure fall-off testing will be conducted in the CO<sub>2</sub> injector wells at least once every five (5) years during injection for AoR review until the wells are plugged. The objective of the periodic pressure fall-off testing is to determine whether any significant changes in the near-wellbore conditions have occurred that may adversely affect the well or reservoir performance.

### ***3.4.2 Testing details***

Detailed procedure and analytics proposed for the fall-off test are described in the QASP.

## ***3.5 Tracking and Recording Surface Pressure and Temperature in Monitoring Wells***

Pelican Sequestration Hub, LLC will continuously measure pressure and temperature in monitoring wells (In Zone and Above Confining Zone) at the surface via real-time pressure and temperature (P/T) instruments installed in the wellhead.

A pressure and temperature (P/T) gauge will be installed downhole as part of the upper completion and will be ported into the tubing to continuously measure pressure and temperature in the reservoir. These measurements will allow the project to calibrate and verify the model, improve predictive capability for confirming CO<sub>2</sub> containment, and evaluate the development of the pressure front.

Since the changes in reservoir pressure precede the movement of the CO<sub>2</sub> plume, In Zone Monitoring wells will provide data to history match the model and calibrate the response expected from the reservoir regarding the development of pressure front and CO<sub>2</sub> plume migration.

Abnormal changes of pressure in Above Confining Zone monitoring wells could indicate a potential leak path from the reservoir to the upper zones.

Details of the In Zone Monitoring wells as well as the Above Confining Zone monitoring wells are provided in the following sections.

### ***3.5.1 Monitoring location and frequency***

**Table TM-8—Monitoring Location and Frequency of Pressure and Temperature Gauges**

Tool	Location	Pre-Injection	Injection	Min. Sampling Frequency	Min. Recording Frequency
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

If the downhole gauge stops working between scheduled maintenance events during the injection period, the project might install a temporary downhole gauge with wireline and reduce the frequency of data collection to 1 sample per day or less, depending on the pressure behaviors observed before the failure.

If the downhole gauge stops working between scheduled maintenance events during the post injection period, the project might install a temporary downhole gauge with wireline and reduce the frequency of data collection to 1 sample per month or less, according to the predicted pressure changes from the numerical simulation.

### ***3.6 Visual Inspection and Leak Detection and Repair (LDAR) Program Using Optical Gas Imaging Camera (OGI)***

The project will perform visual inspection of the facilities and wells as part of the maintenance and mechanical integrity program. Inspection will start from the commissioning date, during startup of the facilities and well, and will continue weekly after the site is injecting steadily. Quarterly, field inspections will be performed after the start of injection and continue to injection ceases and will be aimed at identifying potential leaks, with the use of OGI cameras.

OGI cameras are highly specialized versions of infrared or thermal imaging cameras. They are composed of a lens, detector, and some electronics to process the signal and a viewfinder to give the user the final product. The material used as the detector will depend on the type of gas to be measured. Detectors are cooled to specific operating temperatures where they become nonconductive. Once exposed to the incident photon, the electron will move to the conduction band and detector can carry a photocurrent proportional to the intensity of the incident radiation.

During this process, the camera software will process and adjust the signal of the detector array, giving a thermographic image that shows relative temperatures across the target object or scene. The image is a true representation of the radiation intensity regardless of the source of thermal radiation. The OGI cameras use unique spectral filters that enable them to detect a gas compound. The filter restricts the wavelengths of radiation allowed to pass through the detector to a very narrow band called band pass. This technique is called spectral adaptation.

Optical Gas Imaging cameras provide the power to spot invisible gases as they escape, so that the operation team can find the leak in a reliable way. Cameras rely on infrared images to detect the leaks and they are used during the inspection of facilities, pipelines, and well locations.

## **4.0 Mechanical Integrity Testing**

### ***4.1 External Mechanical Integrity Testing [40 CFR 146.89(c) ,40 CFR 146.90(e), 40 CFR 146.87 (a)(2)(ii), 40 CFR 146.87 (a)(3)(ii)]***

After installation of the long string casing during construction the CO<sub>2</sub> injector and monitoring wells, Pelican Sequestration Hub, LLC will perform a cement logging evaluation, with one or more of the following tools, to validate zonal isolation between the injection zone, confining zones, and overburden formations [40 CFR 146.87 (a)(2)(ii) 40 CFR 146.87 (a)(3)(ii)]:

- a. Cement Bond Logging
- b. Ultrasonic cement evaluation tool
- c. Variable density log (VDL)

Pelican Sequestration Hub, LLC will

[REDACTED]

[REDACTED]

- a. Pulse neutron through tubing.
- b. Electromagnetic casing inspection log.
- c. Temperature Log

Additionally, during well maintenance operations or workovers for the CO<sub>2</sub> injector well and the monitoring wells, an ultrasonic casing inspection tool might be run to evaluate casing thickness and conditions. At the end of the injection period, Pelican Sequestration Hub, LLC plans to properly abandon the CO<sub>2</sub> injector well.

[REDACTED]

- a. Pulse neutron through tubing.
- b. Electromagnetic casing inspection log.
- c. Temperature Log

#### ***4.1.1 Testing location and frequency***

Table TM-9 below provides a summary of the external mechanical integrity tools.

**Table TM-9—Corrosion Monitoring and Surface Leak Detection Tools**

### 4.1.2 Testing details

The logging industry has made an impressive advance in tools that provide images of and data identifying the quality of the cement bond behind the casing after cementing jobs are complete. The casing inspection tool and multi-finger calipers can provide information about ovality, collapse, or damage in the casing, as well as estimations of wall thickness to evaluate wearing and corrosion effects.

The most advanced tools can evaluate up to five concentric tubulars to measure changes in thickness that could be related to corrosion or wearing effects.

The tools described below are readily available technologies on the market and the basis of the project's master monitoring program for mechanical integrity. No specific provider has been selected. In the future, new technologies or tools may be proposed for further discussion with regulators.

#### 4.1.2.1 Cement bond logging, variable density log and ultrasonic cement evaluation

**Cement Bond Log (CBL):** is a basic method to evaluate cement quality in the annulus. It is an acoustic wave measurement. The tool usually includes a transmitter and receiver, separated by three (3) ft. The acoustic wave is emitted by the transmitter, propagated down and across the annulus, and recorded by the receiver. The attenuation of the wave is analyzed to interpret the bonding behind the pipe. Signal coming from a properly cemented casing will be more attenuated than the signal coming from a poorly cemented one.

The arriving signal recorded by the receiver is a mixed signal coming from casing, cement, mud, and formations. Each signal has its own pathway because they travel at different velocities through each medium. The signal through the casing is the fastest, as sound travels the quickest through steel. As a result, it is the first signal detected on the receiver. The second signal most likely to arrive is the signal through the formation and the last one is the drilling fluid signal, because sound travels slower in a liquid.

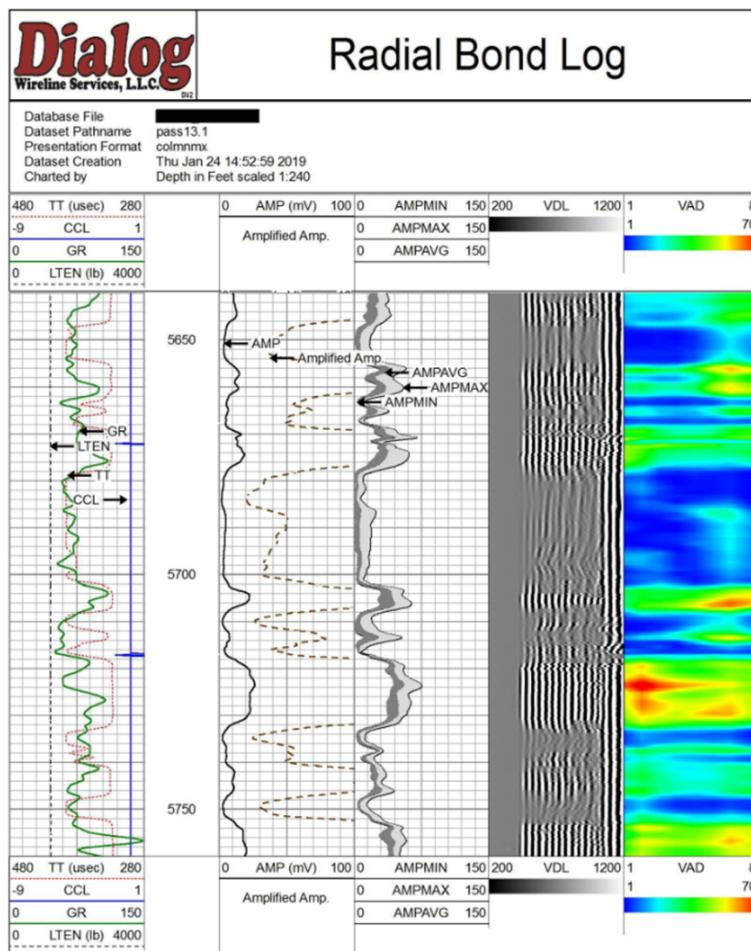


Figure TM-3—CBL and VDL Example from Dialog Wireline Services Web Page

**Variable Density Log (VDL):** is commonly used as an adjunct to the cement bond log and offers better insights with its interpretation. In most cases, micro-annulus and fast-formation-arrival effects can be identified using this additional display.

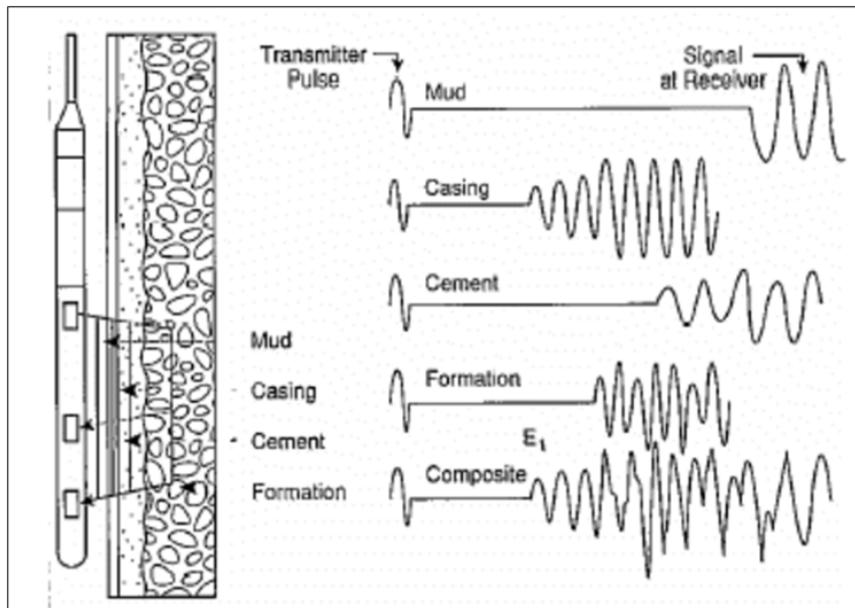
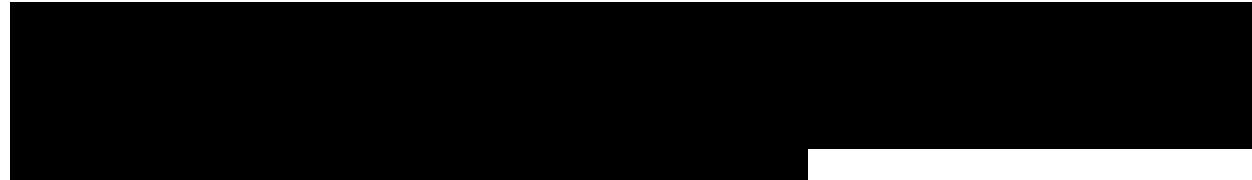
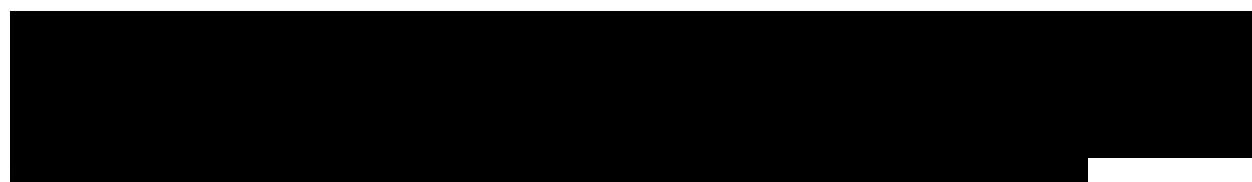
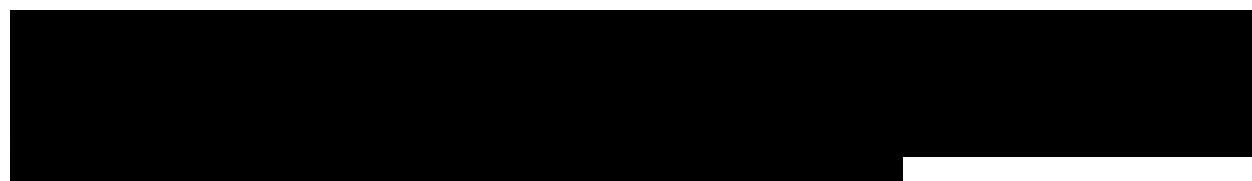


Figure TM-4—Signal Received by CBL-VDL

#### 4.1.2.2 Ultrasonic cement and casing evaluation tools



The rate of decay of the waveforms received indicates the quality of the cement bond at the cement-casing interface and the resonant frequency of the casing provides the casing wall thickness required for pipe inspection. The resulting 360° data coverage enables evaluation of the quality of the cement bond and determination of both the internal and external condition of the casing.



#### 4.1.2.3 Distributed temperature sensing (DTS)

Distributed Temperature Sensing (DTS) technology uses fiber optic sensor cables, typically several kilometers in length, that function as linear temperature sensors. The result is a continuous temperature profile along the entire length of the sensor cable. DTS utilizes the Raman effect to measure temperature. An optical laser pulse sent through the fiber results in some scattered light reflecting to the transmitting end, where the information is analyzed. The intensity of the Raman scattering is a measure of the temperature along the fiber. The Raman anti-Stokes signal changes its amplitude significantly with changing temperature, while the Raman Stokes signal is relatively stable. The position of the temperature reading is determined by measuring the arrival timing of the returning light pulse like a radar echo.

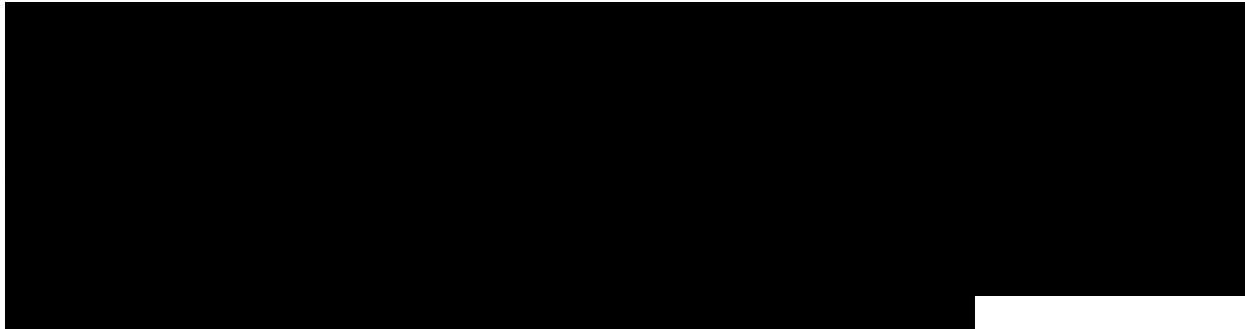
The fiber optic cable is run alongside the casing as an umbilical and it is protected with clamps and centralizers to avoid any damage while deploying it into the well. The fiber is connected on the surface to an interrogator to convert the signal to temperature values and data is transmitted to the monitoring platform in real time for surveillance purposes.

The maintenance and calibration of the equipment will be performed according to the manufacturer's manuals and will be the responsibility of the technology provider. Tables TM-10 and TM-12 show technical specifications for DTS systems and fiber optic cable.

**Table TM-10—Technical Specification for DTS**

**Table TM-11—Technical Specification for Fiber Optic Cable**

#### 4.1.2.4 Electromagnetic casing inspection tool



#### 4.1.2.5 Temperature log

Temperature logs are used to locate gas entries, detect casing leaks, and evaluate fluid movement behind casing. They are also used to detect lost-circulation zones and cement placement. Temperature logs are used as a basic diagnostic tool and are usually paired with other tools like acoustics or multi arms calipers if more in depth analysis is required.

Temperature instruments used today are based on elements with resistances that vary with temperature. The variable resistance element is connected with bridge circuitry or constant current circuit, so that a voltage response proportional to temperature is obtained. The voltage signal from temperature device is then usually converted to a frequency signal transmitted to the surface, where it is converted back to a voltage signal and recorded. The absolute accuracy of temperature logging instruments is not high (in the order of +/- 5°F), but the resolution is good (0.05°F) or better, although this accuracy can be compromised by present day digitalization of the signal on the surface. The temperature instrument usually can be included in the string with other tools, such as radioactive tracer tools or spinners flowmeters. Temperature logs are run continuously, typically at cable speeds of 20 to 30 ft/min. (A.Daniel Hill).

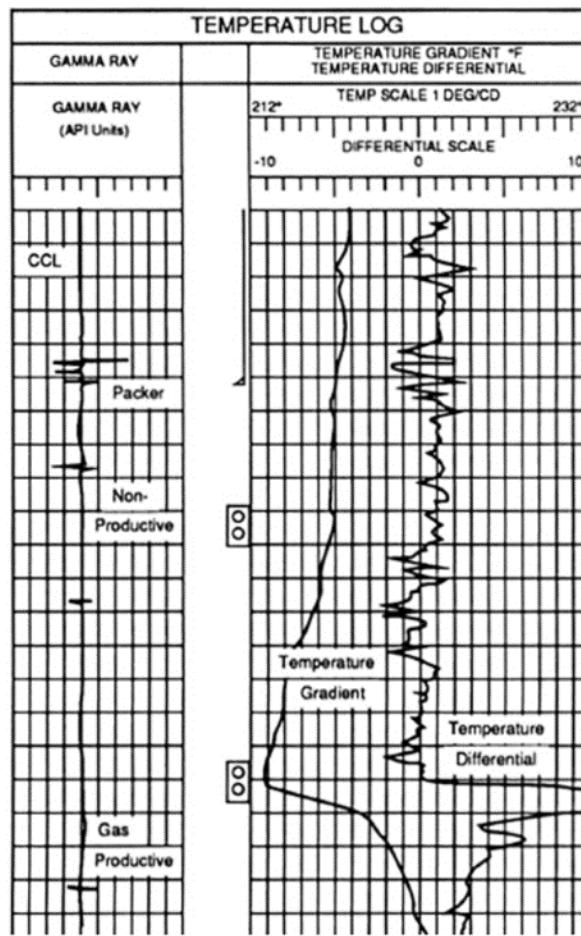
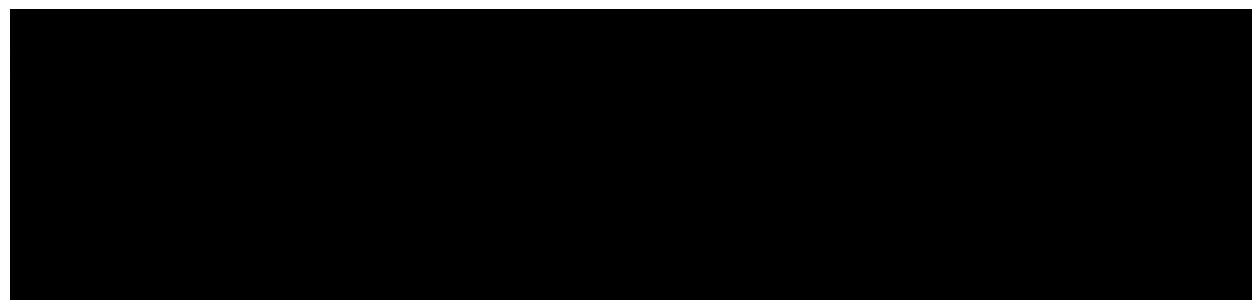


Figure TM-5—Example of temperature log output

#### 4.1.2.6 Pulse neutron log

Pulse neutron log (PNL) provides formation evaluation and reservoir monitoring in cased holes. PNL is deployed as a wireline logging tool with an electronic pulsed neutron source and one or more detectors that typically measure neutrons or gamma rays. High-speed digital signal electronics process the gamma ray response and its time of arrival relative to the start of the neutron pulse. Spectral analysis algorithms translate the gamma ray energy and time relationship into concentrations of elements. Each logging company has its own proprietary designs and improvements on the tool.





#### ***4.1.3 Description and technical specifications of the tools for external mechanical integrity evaluation***

Detailed information and technical references of these tools are provided in the QASP.

#### ***4.2 Internal Mechanical Integrity Testing [40 CFR 146.89(b)]***

Pelican Sequestration Hub, LLC, will perform an annular pressure test in the CO<sub>2</sub> injector well as well as in monitoring wells to proof internal mechanical integrity of the system according to 40 CFR 146.89(b).

Annular pressure testing is used to validate mechanical integrity in the system. Tests will be performed according to the frequency presented in table TM-12.

**Table TM-12—Annular Pressure Testing Frequency**

Tool	Location	Pre-Injection	Injection
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

If the additional monitoring systems indicate a potential mechanical integrity issue, Pelican Sequestration Hub, LLC will perform trouble shouting and perform an annular pressure test as part of the protocol, if needed.

An overview of the procedure is as follows: First, shut-in the well to stabilize the pressures in the injectors and validate static conditions in the monitoring wells. Connect the testing equipment to the annular valves and test surface lines to 1,500 psi above the testing pressure. Ensure that there are no surface leaks from the pumping unit to the wellhead valve. Bleed any air in the system. If needed, fill the annular space with packer fluid and corrosion inhibitor (if so, it should require only a minimal amount). Record the initial tubing and casing pressure. The well will be tested to [REDACTED]

psi in the annular space and the pressure should not decrease more than █% in █ minutes. Monitor continuously the tubing and casing pressures. Record the final tubing and casing pressure, then bleed the pressure and volume. If the pressure decreases more than █%, bleed the pressure, test the surface connection, and repeat the test. If there is an indication of mechanical failure, the operator will prepare a plan to repair the well and discuss it with the Director.

Surface gauges should be calibrated according to manufacturer recommendations. There should be a pressure range that will allow the test pressure to be near the mid-range of the gauge. Additionally, the gauge must be of sufficient accuracy and scale to allow an accurate reading of █% change to be read. The test results will be documented and stored in the centralized database of the project for reporting and documentation.

## **5.0 Ground Water Quality and Geochemical Monitoring [40 CFR 146.90(d)]**

Pelican Sequestration Hub, LLC, will monitor groundwater quality and geochemical changes above the confining zone during the operation period to meet the requirements of 40 CFR 146.90(d).

The selection of the ground water monitoring locations was based on the original assessment of the AOR for existing legacy wells, the results of the numerical simulation for CO<sub>2</sub> plume and pressure front, and the risk assessment performed by the project. The location, techniques, and frequency were optimized taking in consideration the complementary techniques proposed in this monitoring plan for direct and indirect measurements, such as 3D seismic surveys, 3D time lapse VSP, pulse activate neutron logs, soil gas analysis, and others that are explained in additional sections of this document.

Pelican Sequestration Hub, LLC selected █ potential shallow water wells distributed around the AoR to sample and test the freshwater aquifer in the area. These wells targeted the Chicot, Evangeline and Jasper Aquifer to provide water for domestic and irrigation uses, as well as industrial uses. Additionally, the project will drill █ USDW wells targeting the lower section of the USDW targeting Evangeline-Jasper Aquifer.

Pelican Sequestration Hub, LLC will drill █ confining zone. This well will provide water characterization and fingerprinting of the water above the lower confining zone and below the USDW. During injection and post injection period, the well will provide information about any potential change in water composition due to an unexpected leak path from the reservoir.

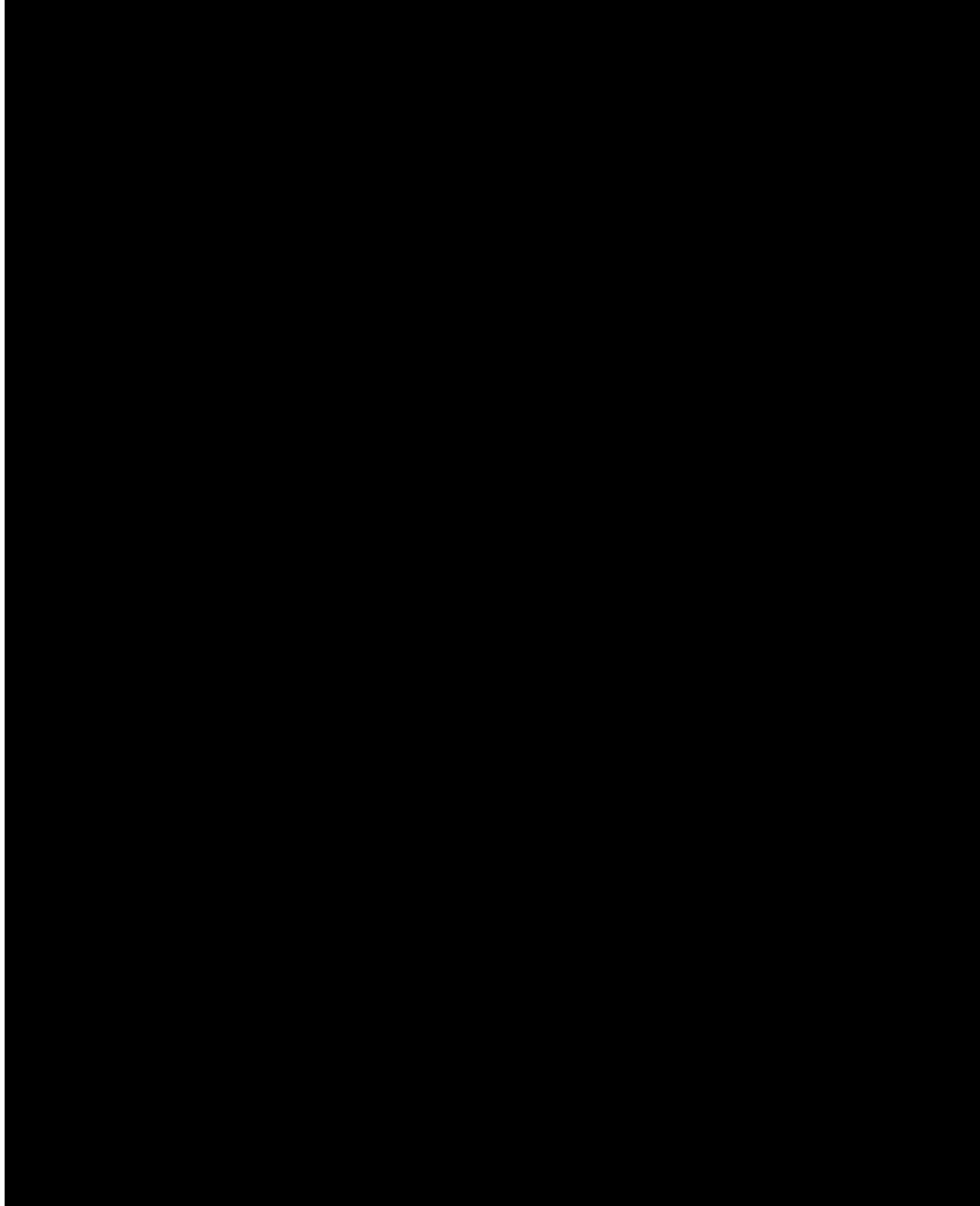
As part of the monitoring system, Pelican Sequestration Hub, LLC, plans to install █ that will allow to detect any mechanical integrity issue that could cause contamination of CO<sub>2</sub> or brines in the above confining zone and / or in the USDW. This technique is described in the mechanical integrity section.

Pelican Sequestration Hub, LLC plans also to install █. These wells will be described in the section related to CO<sub>2</sub> plume extension and pressure front tracking, but as they penetrate the above confining zone and the USDW, they will

be to track any potential leakage from the reservoir through logging in the wells, pressure and temperature measurements in the reservoir and the used of indirect methods as [REDACTED].

A 3D time lapse seismic survey will be used at the site as part of the indirect methods to track the CO<sub>2</sub> plume extension and will complement the well monitoring network. See Section 6.1.1 for details.

Figure TM-6 shows the proposed well network for groundwater and above confining zone monitoring.



**Figure TM-6—Proposed well network for groundwater and above confining zone monitoring**

### **5.1 Freshwater shallow aquifer water sampling and testing**

The shallowest freshwater aquifer of importance, the Chicot aquifer, is predominantly composed of Pleistocene sand and gravel and is directly underlain by the Evangeline then Jasper aquifers, predominantly composed of Pliocene sand and clay. These two aquifers are hydraulically connected and separated only by a gradation in grain size with depth. The Chicot and Evangeline aquifers are the primary sources of groundwater used for drinking in the region, and thus, will be the most likely regional target for USDW monitoring.

The proposed locations for sampling and testing the shallow freshwater aquifer (show in the figure TM-6 in purple) were selected to cover an extensive area inside and around the defined AOR. The identified locations for sampling were evaluated for age of installation, use, depth, and relative location to the AoR and the other monitoring wells. Pelican Sequestration Hub, LLC, plans to start sampling and characterization of the shallow freshwater aquifer [REDACTED] before the start of the injection period. The characterization includes not only the complete water analytics shown in Table TM-19 but the isotopic fingerprinting of wells to be reviewed in the future to be used as appropriation tools.

Some of these locations might present mechanical integrity or accessibility issues at the moment of acquiring the sample and those will be reported once the complete assessment is done and sampling protocols are started.

#### **4.1.1 Monitoring location and frequency**

Table TM-13 shows the planned location for sampling of the fresh water shallow aquifer and Table TM-15 shows the frequencies proposed.

**Table TM-13—Fresh Water Testing Locations**

A 10x10 grid of black and white rectangles. The grid is composed of 100 individual rectangles, each 1x1 unit in size. The colors of the rectangles are arranged in a repeating pattern: the first column and the 10th column are entirely black; the second column and the 9th column are entirely white; the third column contains 5 black and 5 white rectangles; the fourth column contains 6 black and 4 white rectangles; the fifth column contains 7 black and 3 white rectangles; the sixth column contains 8 black and 2 white rectangles; the seventh column contains 9 black and 1 white rectangle; and the eighth column is entirely black. This pattern repeats for all 10 columns.

**Table TM-14—Location and Frequency of Water Sampling and Testing in the Freshwater Shallow Water Wells**

Monitoring Location(s)	Monitoring Activity	Target Formation	Pre-Injection	Injection Period
				
				
				

## 5.2 USDW wells water sampling and testing

These wells will allow the characterization and fingerprinting of waters in the deepest section of the USDW. The well will monitor water composition changes during injection and post injection periods.

### 5.2.1 Monitoring location and frequency for water sampling in USDW wells

Table TM-15—Location of USDW Wells to be Drilled for Water Sampling and Testing

Well Name	Latitude	Longitude	Elevation (ft)	Status	Measured Depth (ft)	Target Formation
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Table TM-16—Location and Frequency of the Water Sampling and Testing in the USDW Wells

Monitoring Location(s)	Monitoring Activity	Target Formation	Pre-Injection	Injection Period
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Figures TM-7 and TM-8 show the well designs and schematics of the Pelican USDW 1 and Pelican USDW 2, respectively.

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Figure TM-7—[REDACTED] Design



Figure TM-8—[REDACTED] Design

### 5.3 Above Confining Zone Well water sampling and testing

[REDACTED] well will be drilled as part of the master monitoring plan. The well will be drilled and perforated in the first permeable zone above the [REDACTED] confining zone. Pressure and temperature gauges will be tubing deployed to track any changes above the seal that could indicate a potential leak into the USDW. The well will test water quality at the first permeable sand above the [REDACTED] confining zone and will track potential changes of pressure above that could indicate a leak path. Figure TM-7 shows a diagram and detailed construction of the [REDACTED] well.

The well will be equipped with a U-Tube line that allows to collect samples from the reservoir at the frequency proposed by the project. Those samples will be sent to third party laboratory for the analysis. The description of the system is presented in the QASP document.

[REDACTED] is located in the zone of highest differential pressure between CCS 1 and CCS 2 to evaluate the effect of the reservoir pressurization at the highest point of pressure and validate the sealing capacity of the upper confining zone.

#### 5.3.1 Monitoring location and frequency for water sampling in Above Confining Zone Well

Table TM-17—Location of the Pelican ACZ 1 Well

Well Name	Latitude	Longitude	Elevation (ft)	Status	Target monitoring interval TVDSS (ft)	Target Formation
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Table TM-18—Location and Frequency of Water Sampling and Testing in Pelican ACZ 1 Well

Monitoring Locations	Monitoring Activity	Target Formation	Pre-injection	Injection Period
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

If the downhole gauge stops working between scheduled maintenance events during the injection period, the project might install a temporary downhole gauge with wireline and reduce the frequency of data collection to 1 sample per day or less, depending on the pressure behaviors observed before the failure.

Figure TM-7 shows the well design and schematic of Pelican ACZ 1.



Figure TM-9—Well Design and Schematic for [REDACTED] Well

#### *5.4 Analytical parameters for water testing in groundwater and above confining zone samples*

Table TM-19 identifies the parameters to be tested and monitored and the analytical methods Pelican Sequestration Hub, LLC proposed as minimum required in the water testing protocol, but not limited to, for groundwater and above confining zone water samples.

An extensive characterization program is planned and includes the identification of natural tracers and unique characteristics of the waters in the different sections of the storage complex (reservoir, above confining zone, USDW, and freshwater aquifers) that will serve to tailor the final protocol to be used for evaluating and appropriate changes on the geochemistry of the water. This approach will enable the team to differentiate between changes in the composition of the water due to natural process and changes due to a potential leak from the reservoir and overburden.

Water testing will be performed by personnel of a certified laboratory, following the specific methods approved by EPA or others standard. Operators might audit the procedures and results of the selected laboratory with a third party to improve quality control.

The samples will be analyzed by a third-party laboratory using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and photo ionization. Sampling methods and chain of custody procedures are described in the QASP.

**Table TM-19—Summary of Analyses and Methods for Groundwater and ACZ Water Samples Testing**

### *5.5 Sampling methods for groundwater and above confining zone water samples*

Water sampling will be performed by personnel of a certified laboratory, following the specific methods approved by the EPA or other standards. Operators might audit the procedures and results of the selected laboratory with a third party to improve quality control.

### **5.6 Laboratory to be used/chain of custody procedures**

The samples will be analyzed by a third-party laboratory using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and photo ionization. Sampling methods and chain of custody procedures are described in the QASP.

## 6.0 Carbon Dioxide Plume and Pressure Front Tracking 40 CFR 146.90(g)

Pelican Sequestration Hub, LLC will employ direct and indirect methods to track the extent of the carbon dioxide plume and presence or absence of elevated pressure during the operation period to meet the requirements of 40 CFR 146.90(g).

### *6.1 Methods for CO<sub>2</sub> plume extension and pressure front monitoring*

Table TM-20 and Table TM-21 present methods that Pelican Sequestration Hub, LLC will use to monitor the position of the CO<sub>2</sub> plume, including the activities, locations, and frequencies for the Pelican Sequestration Hub.

**Table TM-20—Summary of Analyses and Methods for monitoring of CO<sub>2</sub> Plume Extension**

### ***6.1.1 Methods for CO<sub>2</sub> Plume extension and pressure front monitoring details***

#### **6.1.1.1 3D surface seismic baseline survey**

[REDACTED]

[REDACTED]

[REDACTED]

#### **6.1.1.2 3D surface seismic time-lapse surveys**

[REDACTED]

#### **6.1.1.3 3D VSP baseline and time-lapse surveys**

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

#### 6.1.1.4 Surface Gravity (Neda)

[REDACTED]

[REDACTED]

[REDACTED]

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**Table TM-21—In Zone monitoring wells application for monitoring the AOR**

Monitoring Locations	Monitoring Activity	Target Formation	Pre-injection	Injection Period
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

**Table TM-22—Summary of Location and Sampling Frequency for Pressure Front Monitoring**

Location	Device(s)	Location	Min. Sampling Frequency	Min. Recording Frequency
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

### 6.3 Location selection for the In Zone Monitoring wells

Table TM-23—Location and Depth of In Zone Monitoring Wells

Well Name	Latitude	Longitude	Status	Depth (ft)	Target Formation	Target monitoring interval TVDSS (ft)
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

#### 6.3.1 [REDACTED]



The proposed schematics for the well are presented in Figures TM-11 and TM-12.

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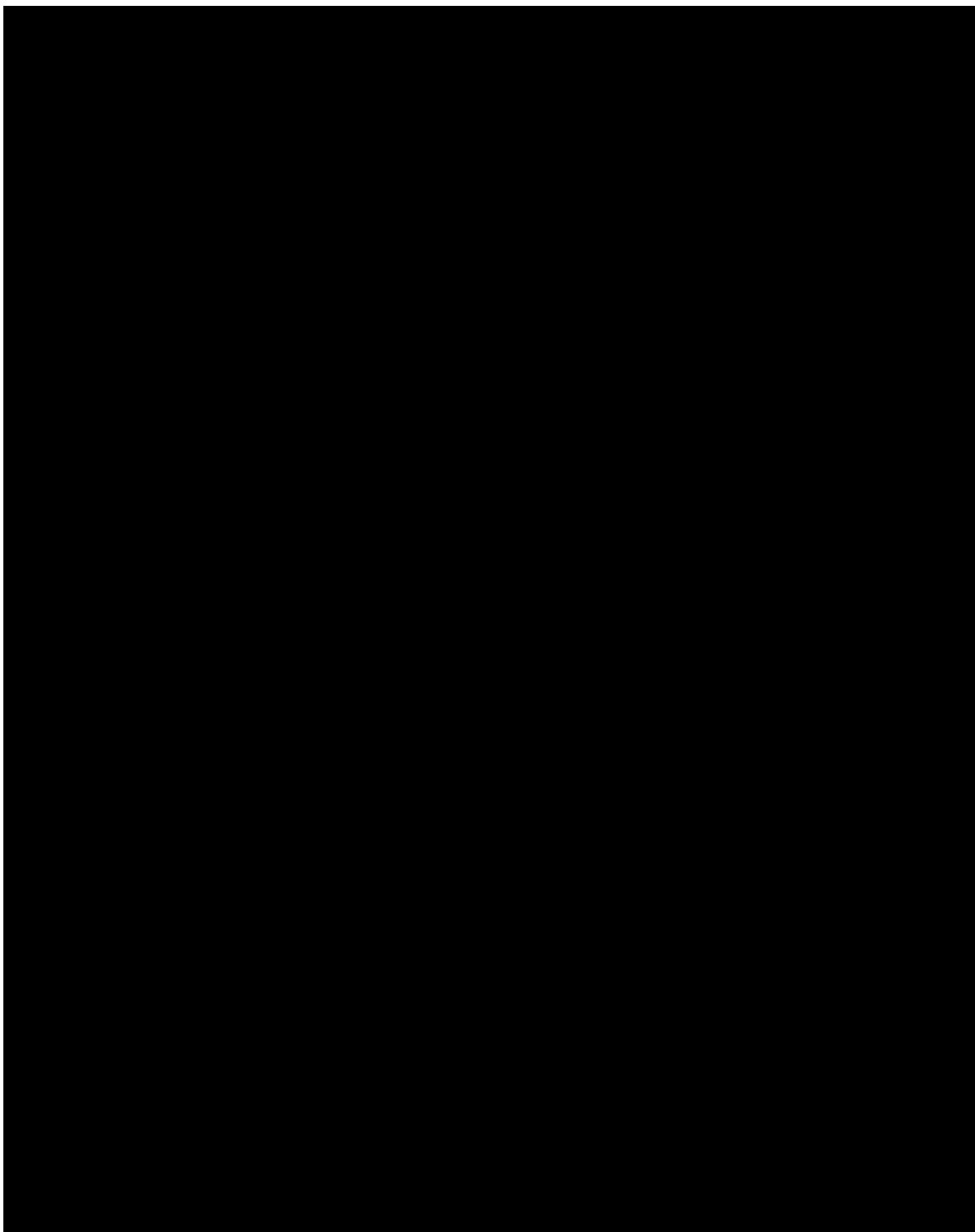


Figure TM-11—Well Design and Schematic for [REDACTED] Well- Original Completion

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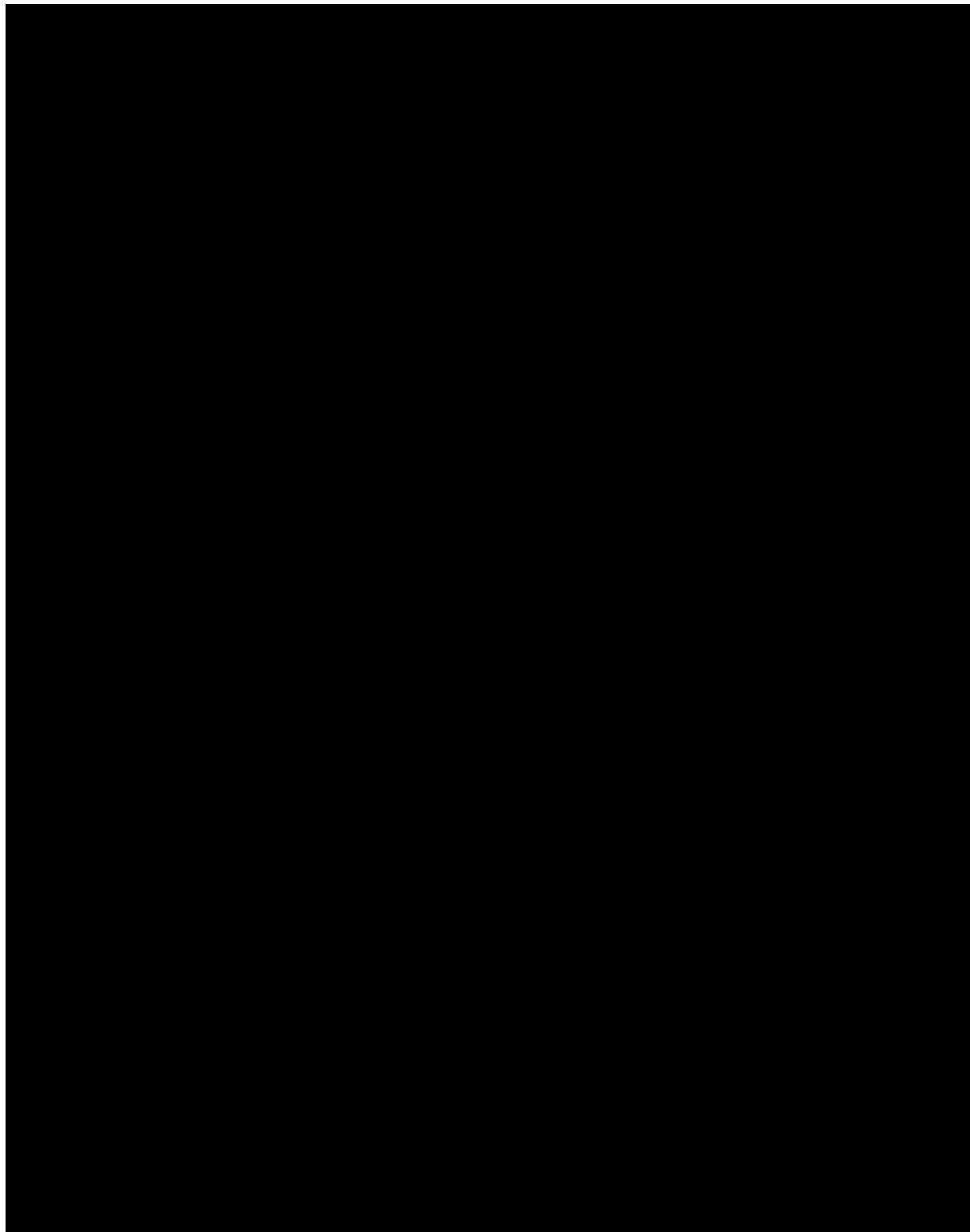


Figure TM-12—Well Design and Schematic for ██████████ Well- Recompletion

**6.3.2 [REDACTED]**



The proposed schematics for the well are presented in Figures TM-13 and TM-14.

Plan revision number: 0  
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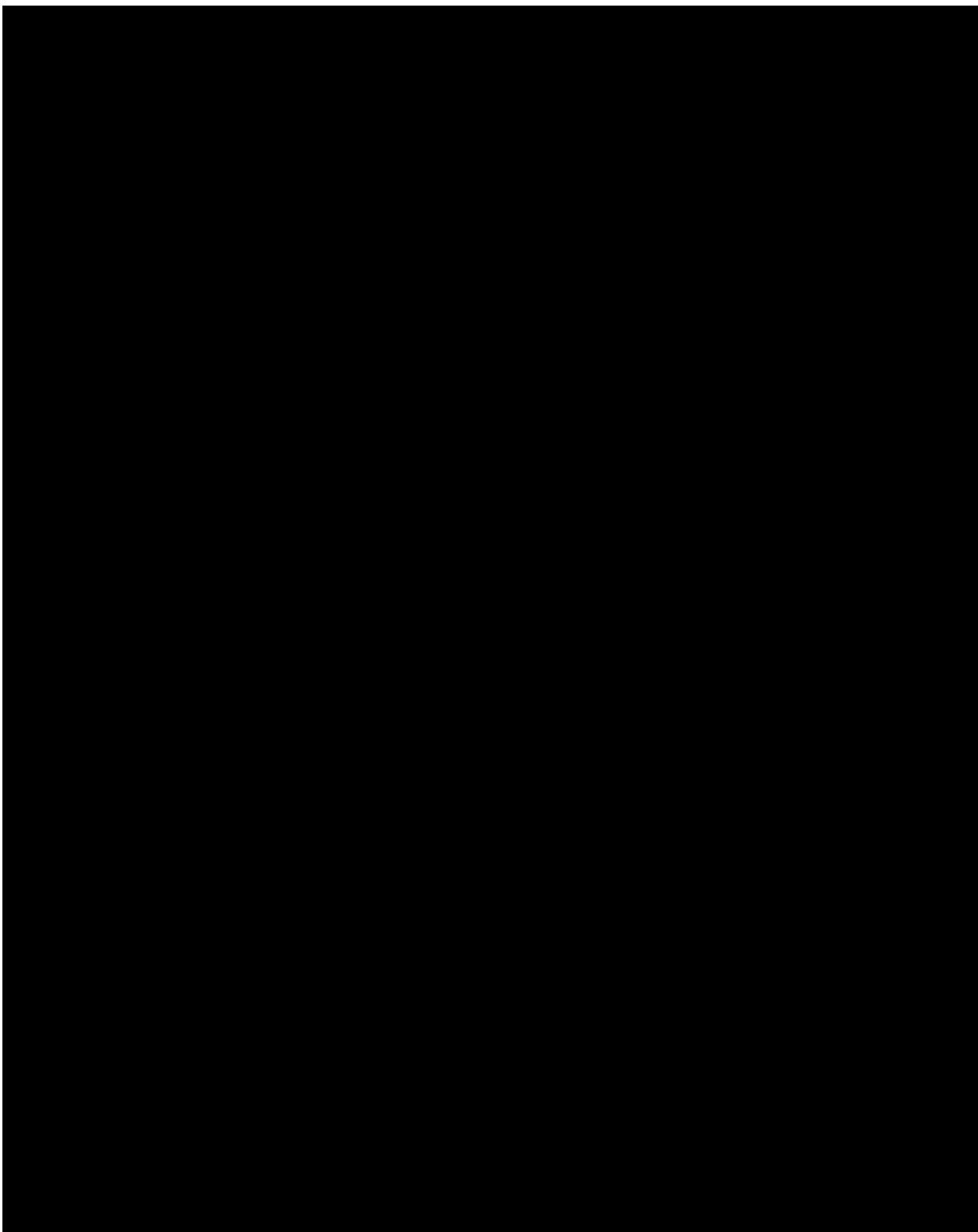
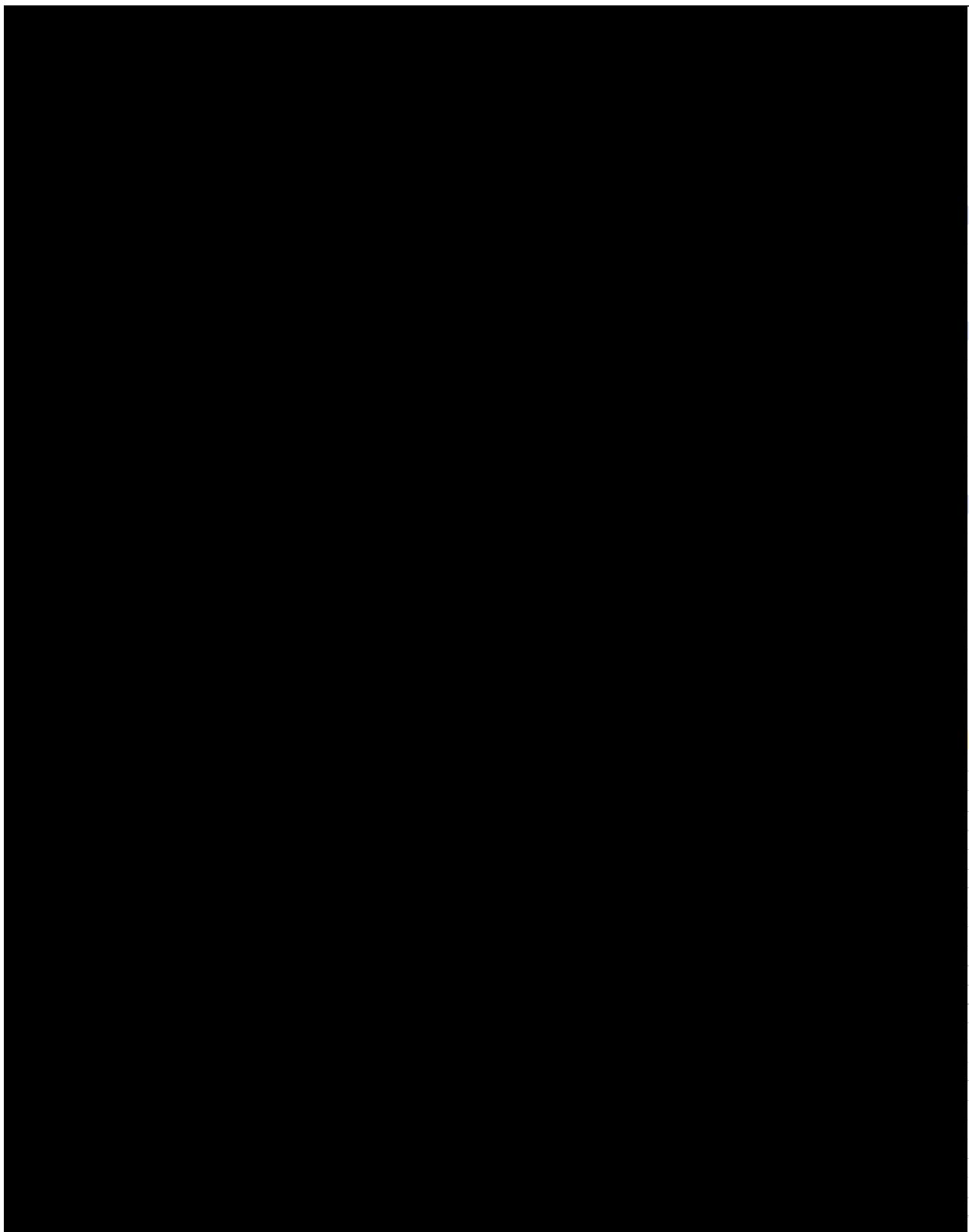


Figure TM-13—Well Design and Schematic for \_\_\_\_\_ Well Original Completion

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**Figure TM-14—Well Design and Schematic for [REDACTED] Recompletion**

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**6.3.2 [REDACTED]**



The proposed schematics for the well are presented in Figures TM-15 and TM-16.

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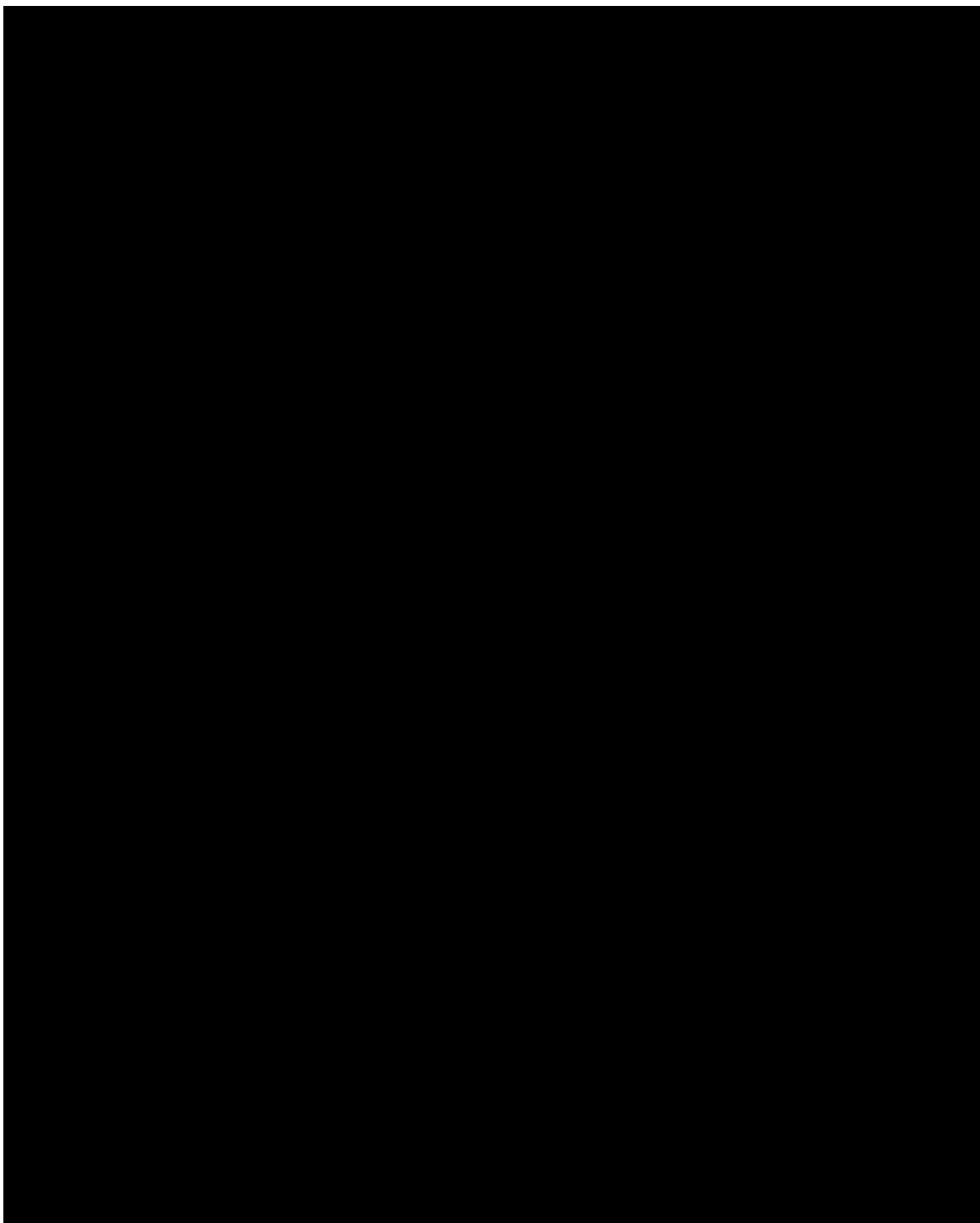


Figure TM-15—Well Design and Schematic for [REDACTED] Well Original Completion

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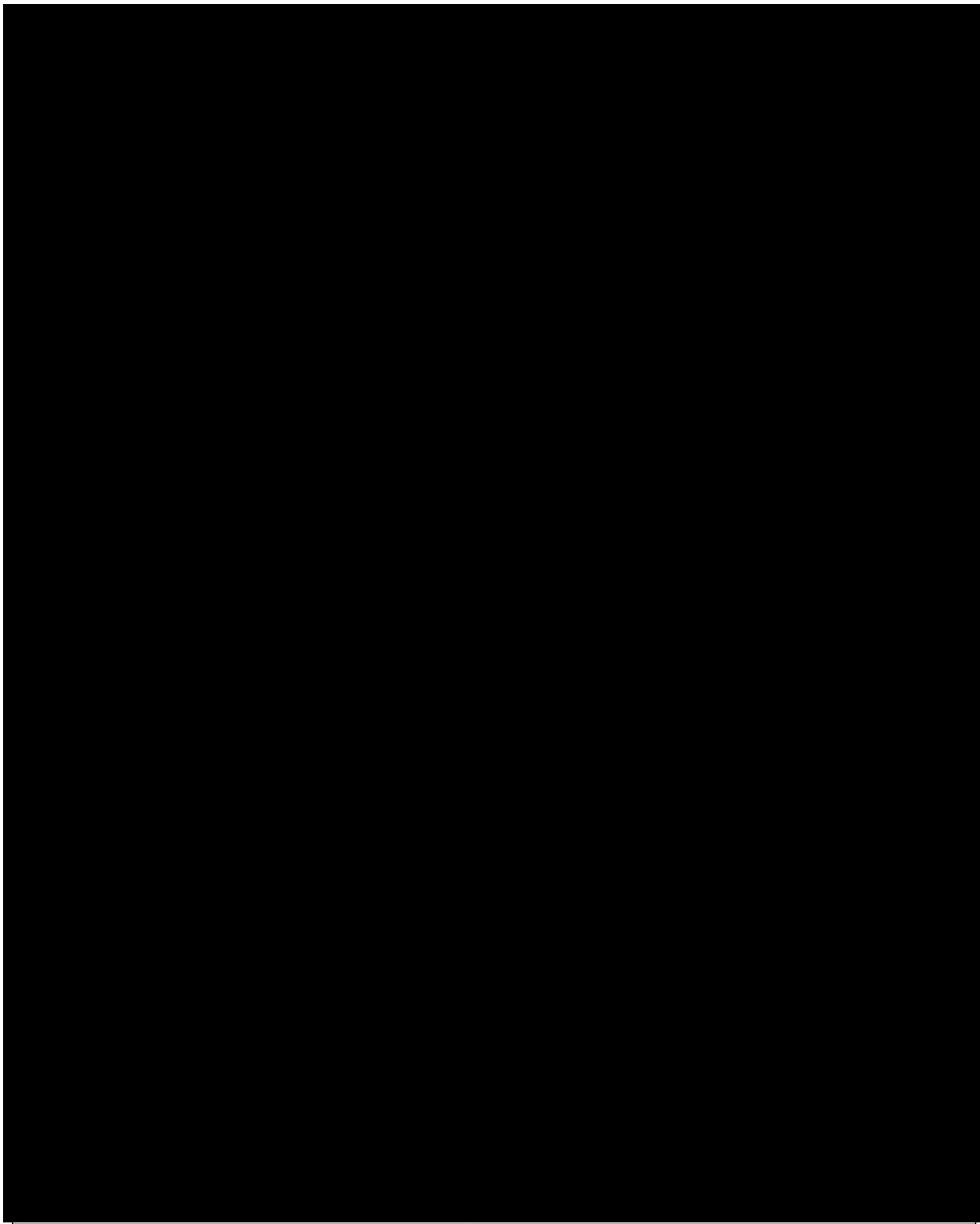
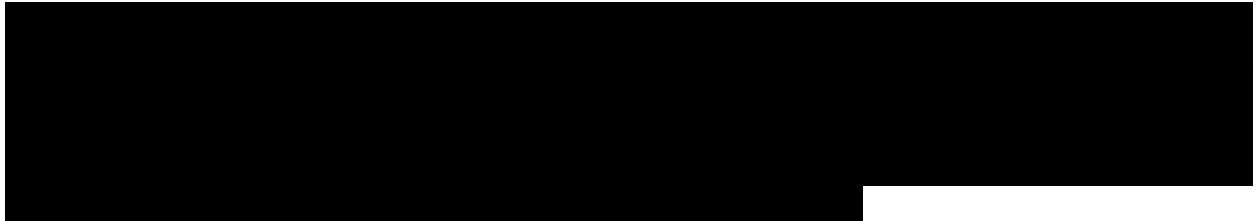


Figure TM-16—Well Design and Schematic for [REDACTED] Well Recompletion

**6.3.3 [REDACTED]**



The current and proposed schematic for the well are presented in Figures TM-17 and TM-18.

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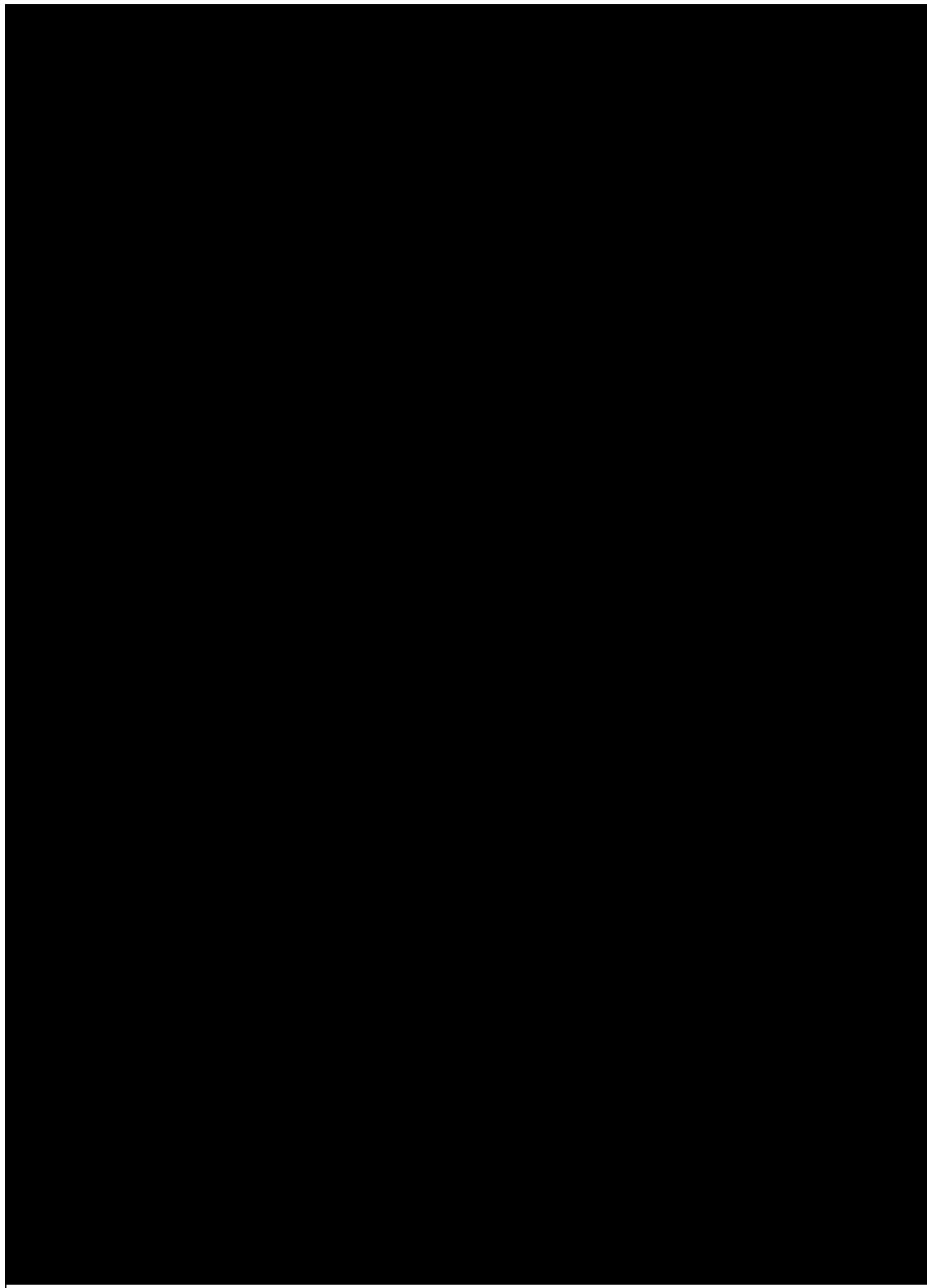
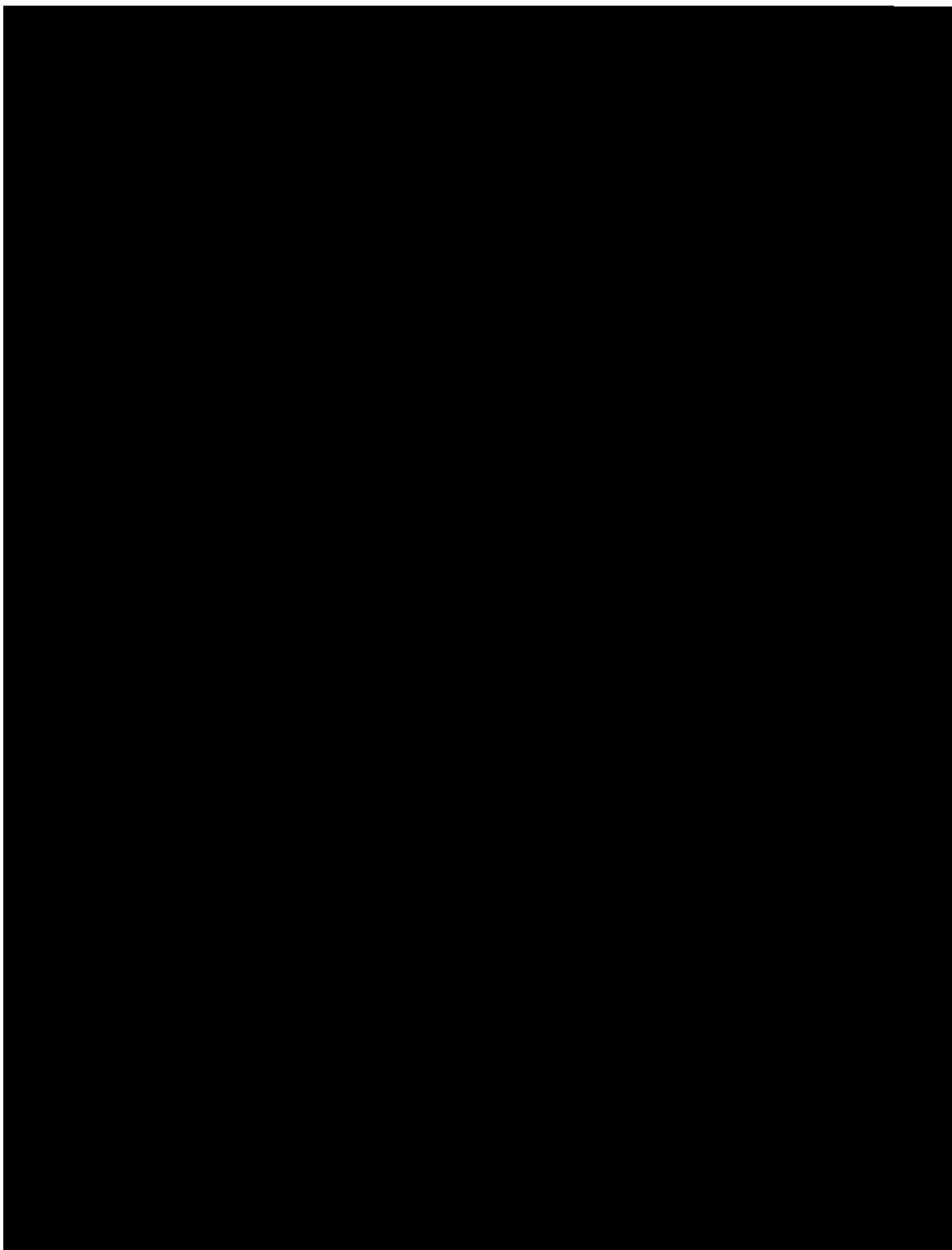


Figure TM-17—Actual Well Schematic for [REDACTED]

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**Figure TM 18 – Proposed Recompletion of [REDACTED] as In Zone Monitoring Well**

#### **6.4 Design Bases for Plume and Pressure Front Tracking**

This section presents the forecasted injector bottom-hole pressure, reservoir pressure near the top perforation for the injection well, and the pressure and CO<sub>2</sub> saturation at the In-Zone monitoring wells from during the CO<sub>2</sub> injection period starting at time 0 to year 15 of injection. These predictions were based on our current understanding of the subsurface conditions and are the most likely outcomes of our monitoring program.

Pelican Sequestration Hub, LLC, will continue to monitor and history match the field values with the numerical simulation model if the data gathered in the future tracks the forecasted results. Significant deviations from these forecasts will trigger revisiting subsurface characterization and updating AoR delineation.

Figure TM-19 depicts the forecasted bottom hole pressure at the injection wells during injection and for 50 years post-injection. This bottom hole pressure is reported at the location of the pressure gauge. The gauge will be relocated when the well is recompleted at year [REDACTED]. In well CCS 1, the gauge is initially located at [REDACTED] ft (TVDSS) and at [REDACTED] ft (TVDSS) after recompletion. In well CCS 2, the gauge is initially located at [REDACTED] ft (TVDSS) and at [REDACTED] ft (TVDSS) after recompletion.

The [REDACTED] and the intermittent shale intervals between zones results in zonal variations in the pressure and CO<sub>2</sub> saturation response at the monitor wells. Table TM-27 and Table TM-28 shows the expected differential pressure increase expected at the top of the [REDACTED] and the [REDACTED] intervals at the in-zone monitoring wells. Figures TM-20 thru TM-24 show a map view of the pore-volume weighted average CO<sub>2</sub> saturation and the pore-volume weighted change in pressure from pre-injection to years 1-5. These maps only consider interval [REDACTED] since injection is only into these zones through year [REDACTED]. Maps are only presented for years 1-5 since an AoR re-evaluation will be performed at or prior to year 5.



Figure TM-19—Forecasted bottom-hole pressure for injector CCS 1 and CCS 2

Table TM-24— Simulated pressure change from pre-injection pressure at the top of the ██████████ zone at each monitoring well location.

Year	██████████	██████████	██████████	██████████
0 (start of injection)	████	████	████	████
1	████	████	████	████
2	████	████	████	████
3	████	████	████	████
4	████	████	████	████
5	████	████	████	████
██████████	████	████	████	████
████	████	████	████	████
████	████	████	████	████
████	████	████	████	████
██████████	████	████	████	████

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**Table TM-25— Simulated pressure change from pre-injection pressure at the top of the [REDACTED] zone at each monitoring well location.**

Year	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
0 (start of injection)	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
1	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
2	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
3	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
4	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
5	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

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**Figure TM-20—Maps of the predicted CO<sub>2</sub> plume and the average change in pressure in zones [REDACTED] after 1 year of injection.**



**Figure TM-21—Maps of the predicted CO<sub>2</sub> plume and the average change in pressure in zones [REDACTED] after 2 years of injection.**

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**Figure TM-22—Map of the predicted CO<sub>2</sub> plume and the average change in pressure in zones [REDACTED] after 3 years of injection.**



**Figure TM-23—Map of the predicted CO<sub>2</sub> plume and the average change in pressure in zones [REDACTED] after 4 years of injection.**



Figure TM-24—Map of the predicted CO<sub>2</sub> plume and the average change in pressure in zones [REDACTED] after 5 years of injection.

## **7.0 Surface and Near Surface monitoring [40 CFR 146.90 (h)]**

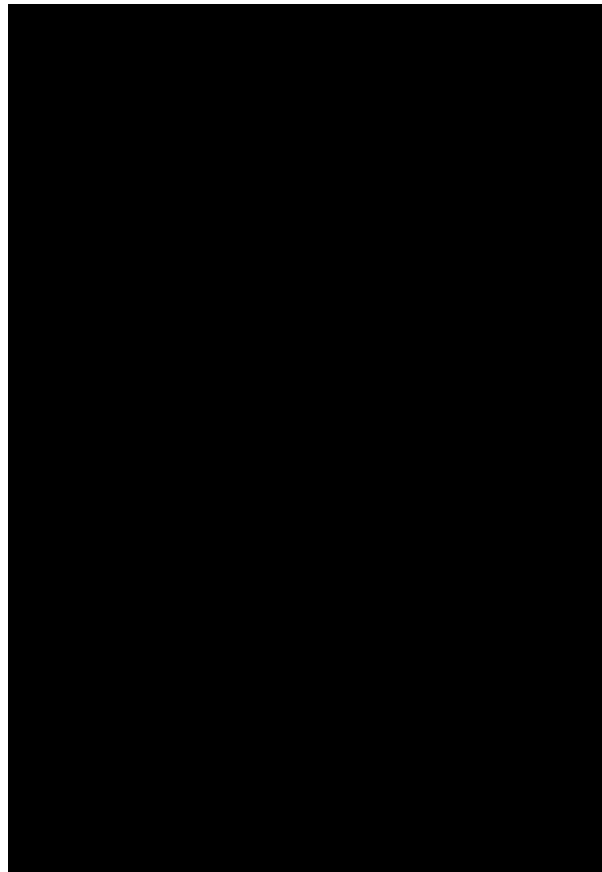
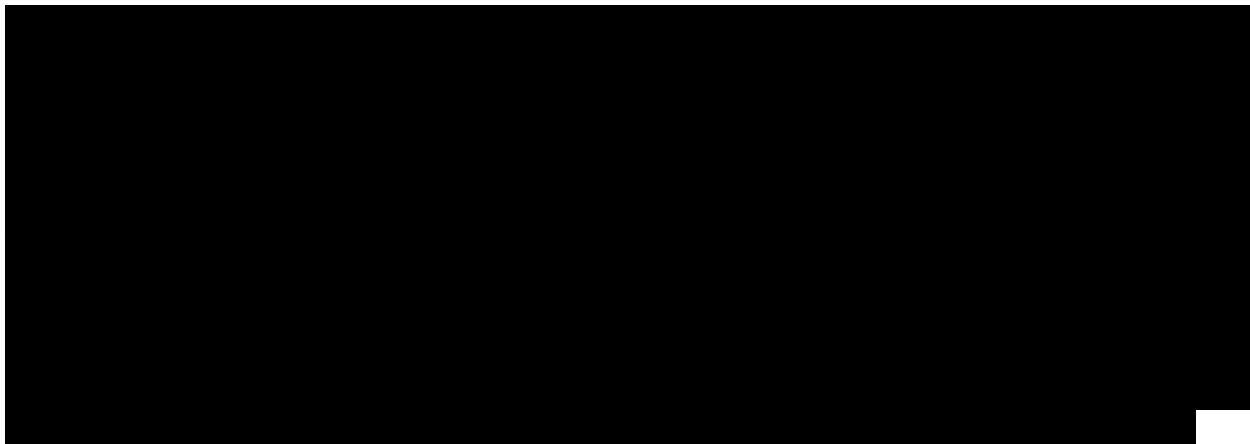
### ***7.1 Soil Gas Monitoring and isotopic fingerprinting***

Pelican Sequestration Hub, LLC will install soil gas sample stations and collect soil gas samples utilizing methodology developed by researchers at the GCCC. The samples will be analyzed by a certified commercial laboratory to determine gas composition as well as isotopic signatures of carbon and hydrogen elements. This data will be used to inform Process Based Soil Gas Monitoring to monitor for ecological stress and distinguish a leakage signal from natural vadose zone CO<sub>2</sub> providing for attribution at the site. Modeling and additional geochemical data from the subsurface overburden will be used to define diagnostic parameters for attribution in soil gas.

Soil gas assessment will consist of characterization of soil gas CO<sub>2</sub>, CH<sub>4</sub>, O<sub>2</sub>, and N<sub>2</sub> ratios within a process-based framework and collection of additional isotopic parameters for further assessment, if thresholds are ever exceeded (Table TM-27). [REDACTED], soil gas will be analyzed for CO<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub>, CH<sub>4</sub>, C1-C5 hydrocarbons,  $\delta^{13}\text{C}$  and  $^{14}\text{C}$  of CO<sub>2</sub>, and CH<sub>4</sub> and  $\delta\text{D}$  of CH<sub>4</sub>. At the end of characterization period, protocols for detection of leakage signal will be tailored to site base data.

As part of the process for designing and selection of the soil gas station locations, an airborne electromagnetic survey will be conducted over the area of interest. The aerial electromagnetic (EM) data will be used to identify and map the extent of near-surface and surface salinization. This environmental determination will inform additional parameters for groundwater monitoring to complement soil gas as part of the near surface monitoring strategy. This survey will be performed with aircraft mounted sensors that allow it to cover extensive areas of investigation

### ***7.1.1 Sampling location and frequency for soil gas***



*Figure 1. Schematic of gas sampling station construction showing individual gas wells set at different levels. Not to scale.*

**Figure TM-25—Schematic of Gas Sampling Station**

**Table TM-26—Gas Sampling Locations, Frequencies, and Methods**

Monitoring Locations	Monitoring Activity	Target Formation	Pre-injection	Injection Period
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

### **7.1.2 Parameters for soil gas analysis**

**Table TM-27—Soil Gas Analysis Parameters**

Soil Gas Parameter	Analysis method
[REDACTED]	[REDACTED]

### **7.1.3 Sampling soil gas analysis**

Sampling will be performed by trained or specialize personnel from the lab at the beginning of the operation, and the field operator will be trained in the process to be able to take samples and monitor gas compositions with handheld devices as routine operation. The samples are taken in specialized bags to collect the gas and will be sent to a third-party laboratory. Calibration of the field equipment will be performed by manufacturer protocol.

### **7.1.4 Laboratory to be used/chain of custody and analysis procedures**

The samples will be analyzed by a third-party laboratory using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and photo ionization. Analytic methods and chain of custody procedures will follow the laboratory protocol.

## **7.2 CO<sub>2</sub> sensors in injector and monitoring wellheads**

Pelican Sequestration Hub, LLC will install infrared gas detectors close to the wellheads of the injector and monitoring wells. These sensors will interface with the surveillance system to set alarms and provide information on potential leaks at the surface. The final selection of the technology will consider the integration of all the sensors and transducers in a unique surveillance system. Calibration and maintenance protocols will be based on the manufacturer specifications and will be performed by specialized professionals. Table TM-28 shows referential technical specifications for the CO<sub>2</sub> leak detector.

**Table TM-28—Infrared Gas Detector Parameters**

Type of Sensor	[REDACTED]
<b>Measurement Ranges</b>	
Combustible	[REDACTED]
CO <sub>2</sub>	[REDACTED]
<b>Resolution</b>	
Response Time	[REDACTED]
<b>Approval Classification</b>	
Operating Ranges	[REDACTED]
<b>Relative Humidity</b>	

**Table TM-29—Atmospheric CO<sub>2</sub> Sensor in wellhead**

Tool	Pre-Injection	Injection
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]

### ***7.3 Induced seismicity monitoring***

Pelican Sequestration Hub, LLC will deploy a seismometer monitoring network to determine the locations, magnitudes, and focal mechanisms of the injection-induced seismic events in case they are observed. This information will be used to address public concerns and identify features that may help to evaluate the plume and pressure front behavior.

#### ***7.3.1 Monitoring location and frequency for seismicity measurement***

**Table TM-30—Seismicity Monitoring Tools**

Tool	Pre-Injection	Injection
[REDACTED]	[REDACTED]	[REDACTED]

#### ***7.3.2 Traffic light system***

While the historical seismicity of the project area indicates few earthquakes in the area, the operator intends to maintain a surface array for the duration of the project to ensure the safe operation of both the storage facility and adjacent infrastructure in the area. This seismic monitoring will be conducted with a surface array deployed to ensure detection of events above ML 2.0 with epicentral locations within 5.6 miles of the injection well.

If an event is recorded by either the local private array or public national array to have occurred within 5.6 miles of the injection well, the operator would implement its response plan subject to detected earthquake magnitude limits defined below to eliminate or reduce the magnitude and/or frequency of seismic events.

- For events above ML 2.0 within 5.6 miles of the injection well, the operator will closely monitor seismic activity and may implement a pause to operations or continue operations at a reduced rate, should analysis indicate a causal relationship between injection operations and detected seismicity.
- For events above ML 4.0 within 5.6 miles of the injection well, the operator will reduce the injection rate by not less than 50%. A detailed analysis is conducted to determine if a causal relationship exists. Should a causal relationship be determined, a revised injection plan would be developed to reduce or eliminate operationally related seismicity. Such plans are dependent on the pressures and seismicity observed and may include, but not be limited to:
  1. Pausing operations until reservoir pressures fall below a critical limit,
  2. Continuing operations at a reduced rate and/or below a revised maximum operation pressure.
- For events above ML 4.5 within 5.6 miles of the injection well, the operator will stop injection as soon as safely practical. The operator will then immediately inform the regulator of seismic activity and inform them that operations have stopped pending a technical analysis. The operator will initiate an inspection of surface infrastructure for damage that may have resulted from the earthquake. A detailed analysis is conducted to

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determine if a causal relationship exists between injection operations and observed seismic activity. Should a causal relationship be determined, a revised injection plan would be developed to reduce or eliminate operationally related seismicity before resuming injection operations. Such plans are dependent on the pressures and seismicity observed, and may include, but not be limited to:

1. Pausing operations until reservoir pressures fall below a critical limit,
2. Continuing operations at a reduced rate and/or below a revised maximum operation pressure.

## **References**

Romanak, K. D., P. C. Bennett, C. Yang, and S. D. Hovorka (2012), Process-based approach to CO<sub>2</sub> leakage detection by vadose zone gas monitoring at geologic CO<sub>2</sub> storage sites, *Geophys. Res. Lett.*, 39, L15405, doi:10.1029/2012GL052426.

A. Daniel Hill, Production Logging: Theoretical and interpretive elements, second edition, page 67

**TESTING AND MONITORING PLAN**  
**40 CFR 146.90**

**Pelican Sequestration Project**

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## **1.0 Facility Information**

Facility name: Pelican Sequestration Project  
Pelican CCS 2 Well

Facility contact: [REDACTED], Project Manager  
5 Greenway Plaza Houston, TX 77046  
[REDACTED]

Well location: Holden, Livingston Parish, Louisiana  
[REDACTED] (NAD 1927, BLM Zone 15N)

This Testing and Monitoring Plan describes how Pelican Sequestration Hub, LLC will monitor the Pelican Sequestration Project site pursuant to 40 CFR 146.90. In addition to demonstrating that the well is operating as planned, the carbon dioxide plume and pressure front are moving as predicted, and that there is no endangerment to USDWs, the monitoring data will be used to validate and adjust the geological models used to predict the distribution of the CO<sub>2</sub> within the storage zone to support AoR reevaluations and a non-endangerment demonstration.

Results of the testing and monitoring activities described below may trigger action according to the Emergency and Remedial Response Plan.

## **2.0 Overall Strategy and Approach for Testing and Monitoring**

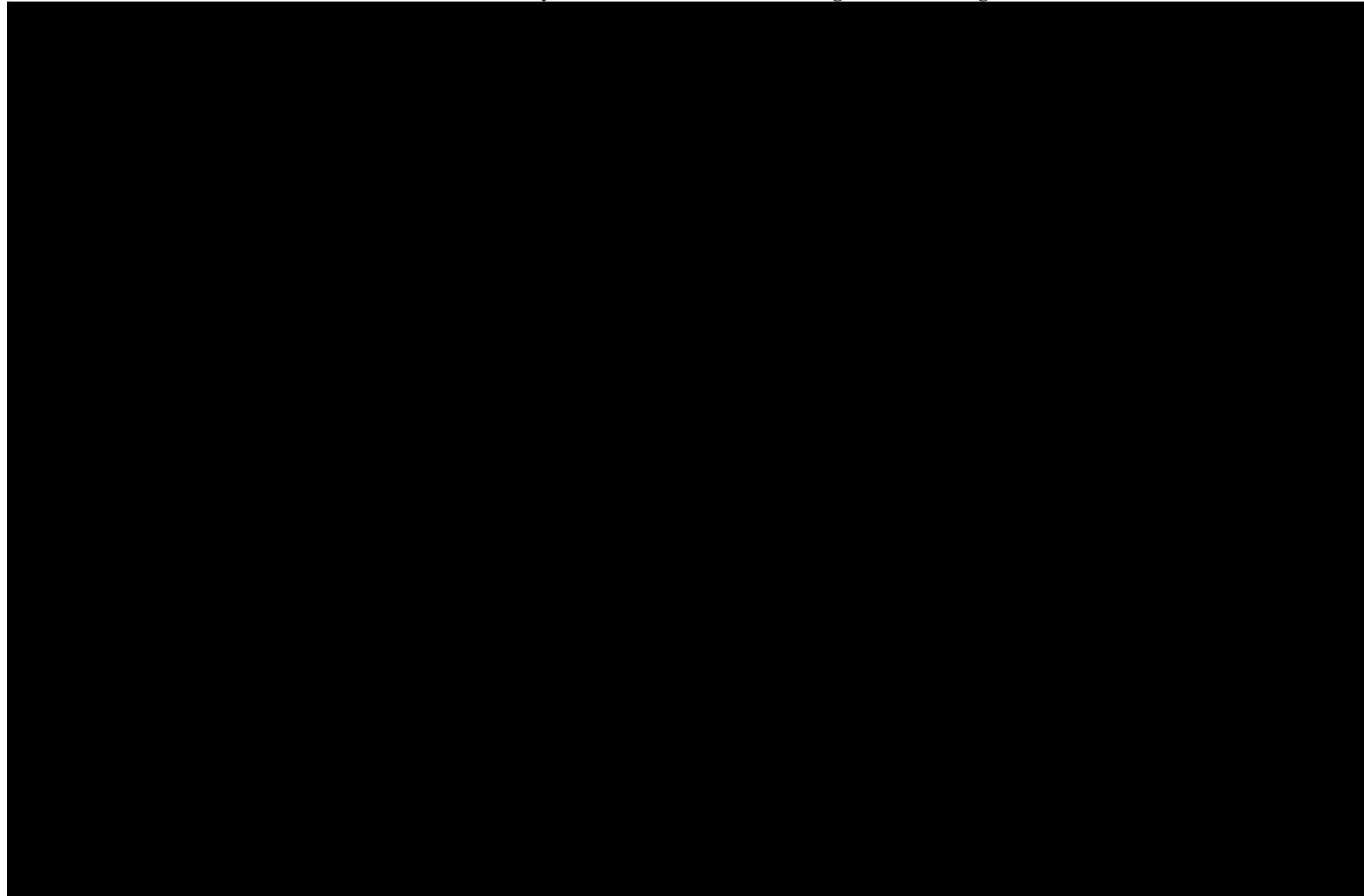
The monitoring well network is designed to detect unforeseen CO<sub>2</sub> and/or brine leakage out of the injection zone that could endanger the USDW, migrate to a different stratus, or create a risk for the people and environment. There are several components that integrate the master monitoring plan for the Pelican Sequestration Project, which are classified in the following categories:

1. Operational Testing and Monitoring During Injection.
2. Mechanical Integrity Testing
3. Ground Water Quality and Geochemical Monitoring
4. Carbon Dioxide Plume and Pressure Front Tracking.
5. Near surface and Surface monitoring
6. Induced Seismicity

Table TM-1 shows a summary of the different methods proposed in the integrated monitoring plan for the Pelican CCS 2.

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**Table TM-1—Summary Table for Pelican CCS 2 Testing and Monitoring Plan**



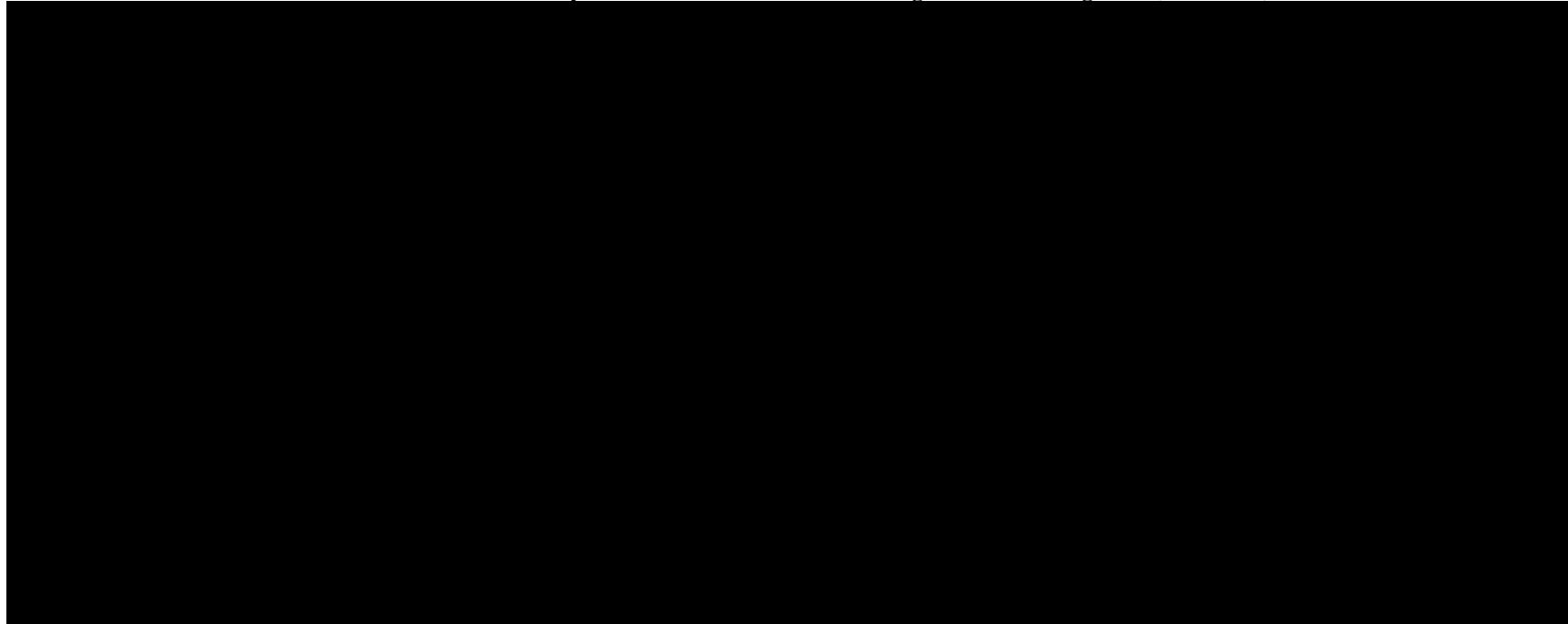
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**Table TM-1—Summary Table for Pelican CCS 2 Testing and Monitoring Plan (continued)**



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**Table TM-1—Summary Table for Pelican CCS 2 Testing and Monitoring Plan (continued)**



Pelican Sequestration Hub, LLC, will drill two CO<sub>2</sub> injector wells Pelican CCS 1 and Pelican CCS 2 as part of the field development plan for the Hub. The monitoring program proposed was designed based on the projected CO<sub>2</sub> plume extension and the propagation of the pressure front for both wells injecting simultaneously according to the AoR delineation process.

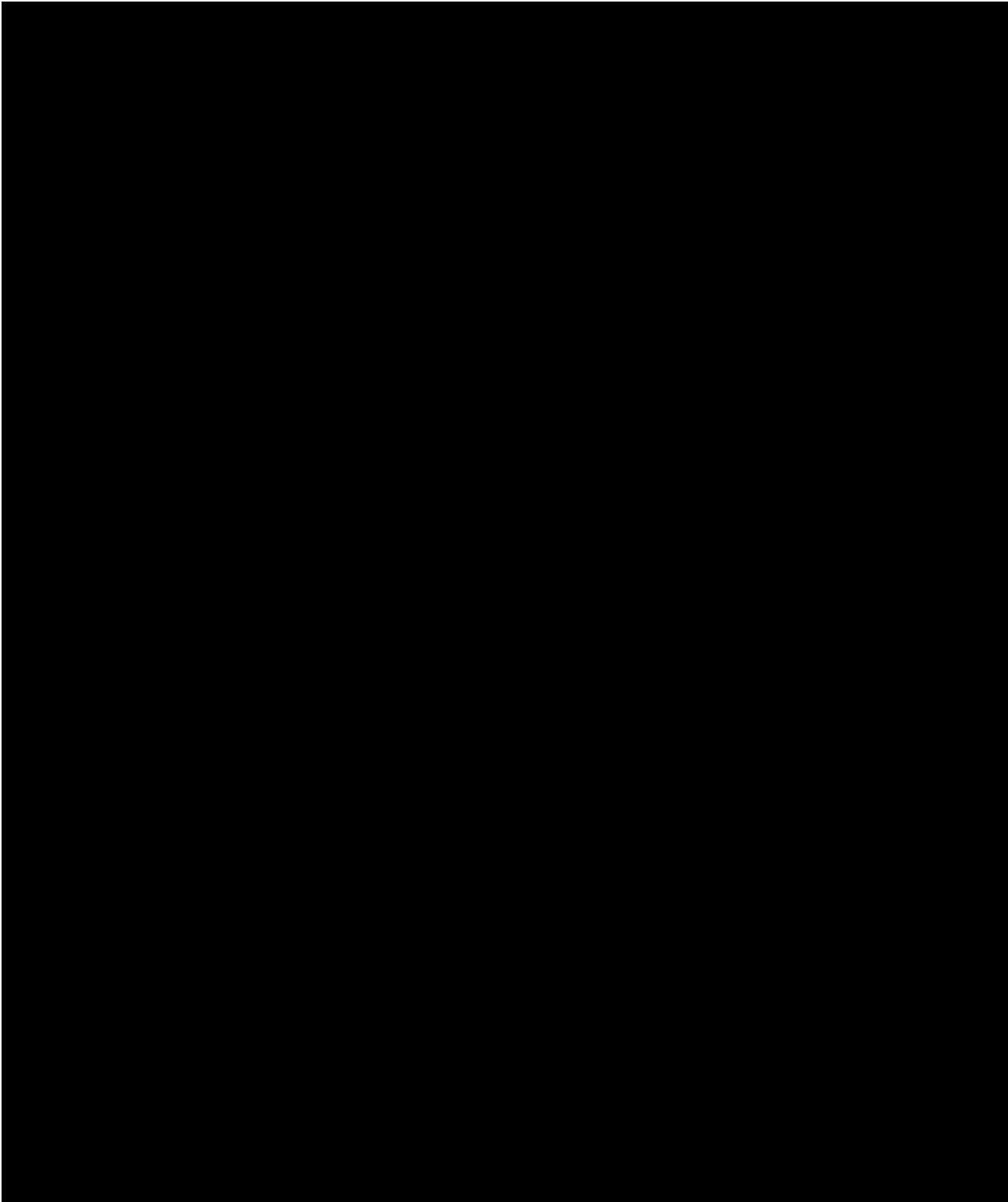
The proposed integrated monitoring plan includes a layout of [REDACTED]

This network is complemented with [REDACTED] seismic surveys and a [REDACTED] plan as indirect methods. Additionally existing water wells in the area will be used to establish the composition of the shallow aquifers and provide characterization of the waters.

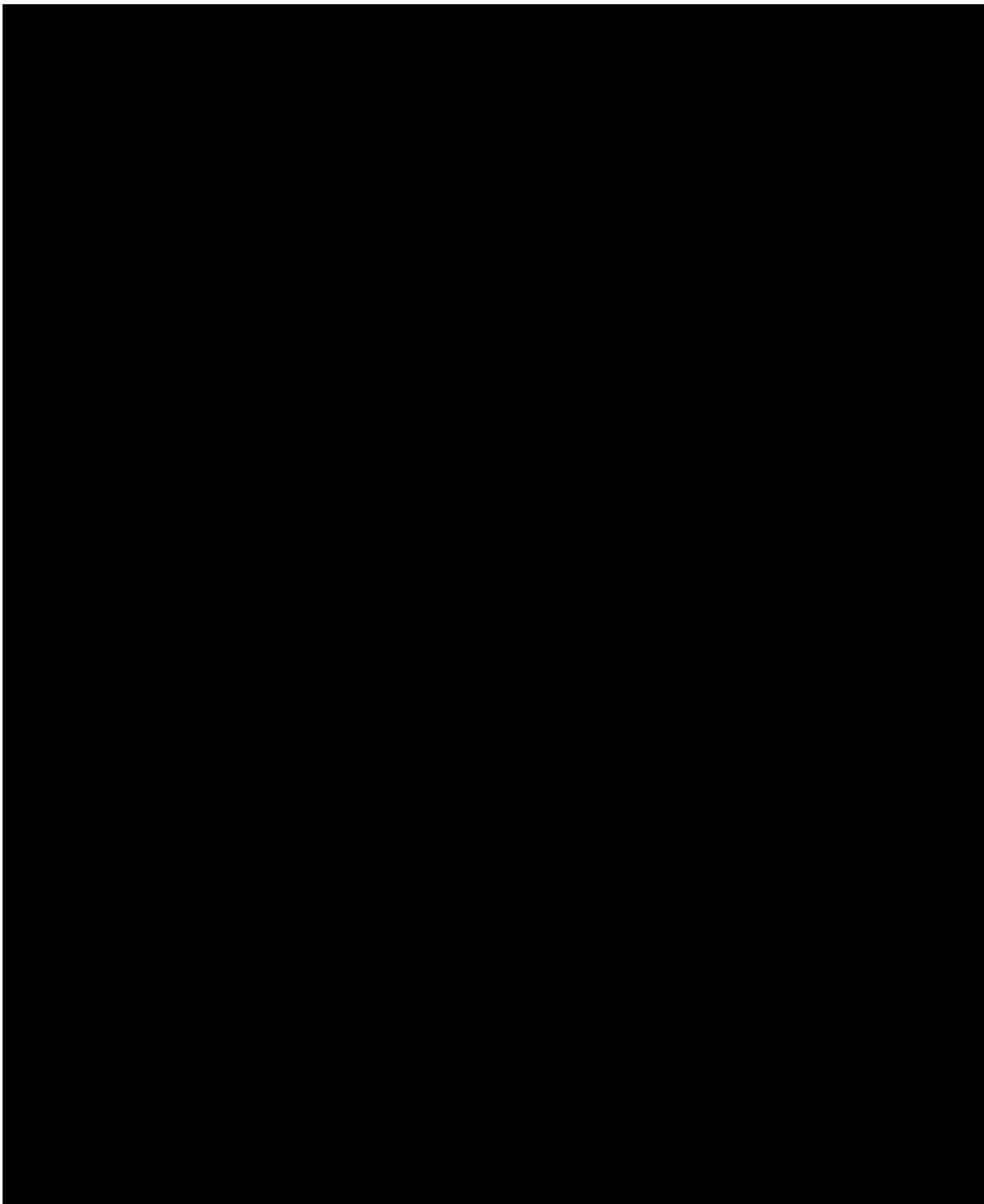
This integrated approach will optimize the surveillance operations of the site with the goal of tracking the CO<sub>2</sub> plume extension and rate of migration, the development of the pressure front, and changes in the composition of deep and shallow aquifers as part of the holistic approach to ensure stakeholders and regulators that the site is operating safely and efficiently, and that the CO<sub>2</sub> is permanently stored in the subsurface. Figures TM-1 and TM-2 show the location and spatial distribution of the monitoring wells.

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**Figure TM-1—Location and layout of In Zone and Above Confining Zone monitoring wells relative to the injector wells and the CO<sub>2</sub> plume and pressure front development.**



**Figure TM-2—Location and layout of USDW monitoring wells and freshwater shallow wells relative to the AOR.**

Well locations show the approximate position of the proposed monitoring wells. The exact locations might have a slight variation in latitude and longitude depending on the final design of the surface pads and the negotiations with the landowners when the locations are surveyed.

The proposed Testing and Monitoring Plan aims to ensure sufficient geospatial and monitoring data is collected to validate the numerical simulation model, history match, and adjust the injection operating parameters and ensure the site is operating as designed, efficiently and safely. The monitoring results would allow the Project to re-evaluate the AOR and prove no endangerment to the USDW.

Each of these methods and their application in the proposed monitoring plan is discussed in the following sections. Results of the testing and monitoring activities described below may trigger action according to the Emergency and Remedial Response Plan.

The proposed Testing and Monitoring Plan will be reviewed and updated as a minimum every 5 years during AOR reevaluation or sooner is needed.

## ***2.1 Quality assurance procedures***

A quality assurance and surveillance plan (QASP) for testing and monitoring activities, required pursuant to 146.90(k), is provided as a separate document in this permit.

## ***2.2 Reporting procedures***

Pelican Sequestration Hub, LLC will report the results of all testing and monitoring activities to EPA in compliance with the requirements under 40 CFR 146.91.

# **3.0 Operational Testing and Monitoring During Injection**

## ***3.1 Carbon Dioxide Stream Analysis [40 CFR 146.90(a)].***

Pelican Sequestration Hub, LLC will analyze the CO<sub>2</sub> stream during the operation period to yield data representative of its chemical and physical characteristics and to meet the requirements of 40 CFR 146.90(a).

### ***3.1.1 Sampling location and frequency***

The CO<sub>2</sub> stream sampling will occur quarterly during operation either upstream or downstream of the custody transfer flowmeter that measures the flow rate of the injectant at the site. Multiple samples will be acquired during the startup period of the project (first injection) to validate the CO<sub>2</sub> stream complies with the requested minimum specifications. After the start up period, a sample will be taken 3 months after start of injection, at 6 months, at 9 months, and at 12 months as minimum frequency, continuing every quarter until injection ceases in the well. The sampling period could be increased and could slightly shift in timing depending on the operations.

The project has developed a standard for CO<sub>2</sub> specification, specifying the max variation in impurities and the delivery conditions at the site, as shown in Table TM-2. This standard CO<sub>2</sub> specifications will be enforced to the CO<sub>2</sub> sources and distribution channels in order to control the quality of the CO<sub>2</sub> injected at the wells. The project will install a gas analyzer at the custody transfer meter located in the sequestration site to monitor CO<sub>2</sub> quality continuously before it is distributed to each well to detect any major deviation from the contractual specifications. The

project could require additional components to be limited and analyzed based on final contractual terms with the emitters.

**Table TM-2—CO<sub>2</sub> Stream Specification**

The CO<sub>2</sub> composition will be monitored continuously at each receipt point into the pipeline network along with at the delivery point to the sequestration site.

If the inline analyzers or sample results indicate a deviation from the CO<sub>2</sub> specification, the sampling frequency for the relevant receipt point(s) will be increased until the sampling results return to normal for a specified period.

If the CO<sub>2</sub> delivered to a receipt point does not meet the CO<sub>2</sub> specification, the project will notify the CO<sub>2</sub> source facility and either shut-in the source facility or increase the sample frequency, depending on the risk associated with the out-of-spec component.

If a CO<sub>2</sub> source facility is shut-in, offtake will only resume from that facility once it has demonstrated the resumption of in-spec product for an agreed period between 12 and 48 hours.

### 3.1.2 Analytical parameters

Pelican Sequestration Hub, LLC, will analyze, as minimum, the CO<sub>2</sub> for the constituents identified in Table TM-3 as minimum requirement, but not limited to.

**Table TM-3—CO<sub>2</sub> Stream Analysis**

Component	Frequency	Analytical Method
CO <sub>2</sub> (% mol)	Quarterly	
Water (lbs/MMCF)	Quarterly	
Nitrogen (%)	Quarterly	
Oxygen (ppm)	Quarterly	
Hydrogen (% mol)	Quarterly	
SO <sub>x</sub> (ppm)	Quarterly	
NO <sub>x</sub> (ppm)	Quarterly	
Hydrogen Sulfide (ppm)	Quarterly	
Hydrocarbons (%)	Quarterly	
Carbon Monoxide (ppm)	Quarterly	
Glycol (gal/MMSCF)	Quarterly	
Ammonia (ppm by wgt)	Quarterly	
Argon (%mol)	Quarterly	
Sulfur (ppm by wgt)	Quarterly	
δ <sup>13</sup> C of CO <sub>2</sub>	During Characterization	
14C of CO <sub>2</sub>	During Characterization	

The project may deem it necessary to test additional elements to ensure the CO<sub>2</sub> delivered in the HUB complies with the contractual specifications. Isotopes will be analyzed during the first year of operation and after any major change of CO<sub>2</sub> source composition to fingerprint the stream.

### ***3.1.3 Sampling methods***

- A sampling station will be installed with the ability to purge and collect samples into a container that will be sealed and sent to the third-party authorized laboratory. All sample containers will be labeled with durable labels and indelible markings. A unique identification number and sampling date will be recorded on the sample containers.
- Sampling procedures will follow contractor protocols to ensure the sample is representative of the injectant and samples will be processed, packaged, and shipped to the contracted laboratory, following standard sample handling and chain-of-custody guidance. Sampling methods are described in the QASP.

### ***3.1.4 Laboratory to be used/chain of custody and analysis procedures***

The samples will be analyzed by a third-party laboratory using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and photo ionization. Analytic methods and chain of custody procedures are described in the QASP.

### ***3.2 Monitoring and Recording of Operating Parameters in Injector Wells [40 CFR 146.88(e)(1), 146.89(b), and 146.90(b)]***

Pelican Sequestration Hub, LLC will install and use continuous recording devices to monitor injection pressure, rate, and volume; the pressure on the annulus between the tubing and the long string casing; and the temperature of the CO<sub>2</sub> stream, as required at 40 CFR 146.88(e)(1), 146.89(b), and 146.90(b).



Injection operations will be continuously monitored and controlled by the operations staff, utilizing the process control system. The system will continuously monitor, control, record, and alarm for critical system parameters of pressure, temperature, and flow rate.

The process control system will limit maximum flow to █ MT/day, or approximately █ MMscfd, and limit the wellhead pressure to █ psig to protect the surface equipment.

The system will initiate a shutdown if specified control parameters deviate from the intended operating range and will allow for remote shutdown under emergency conditions. Trend analysis will help evaluate the performance (e.g., drift) of the instruments, suggesting the need for maintenance or calibration.

#### ***3.2.1 Monitoring location and frequency***

Real time monitoring activities will begin during the start-up of the wells for first injection. The injection pressure and temperature will be continuously measured at the surface via real-time pressure and temperature (P/T) instruments installed in the CO<sub>2</sub> injection line near the interface with the wellhead. The pressure will be measured by electronic pressure transmitter with analog output mounted on the CO<sub>2</sub> line associated with the injection well. The temperature will be measured by an electronic temperature transmitter mounted in the CO<sub>2</sub> line at a location near the pressure transmitter, and both transmitters will be located near the wellhead.

The flow rate of CO<sub>2</sub> injected into the well will be measured by flow meter skids with █ meters in the CO<sub>2</sub> injection line near the interface with the wellhead. Piping and valving will be

configured to permit flow meter calibration. The flow transmitter will be connected to a remote terminal unit (RTU) on the flow meter skid.

A pressure and temperature (P/T) gauge will be installed downhole as part of the upper completion and will be ported into the tubing to continuously measure CO<sub>2</sub> injection pressure and temperature at reservoir. The downhole sensor will be the point of compliance for maintaining injection pressure below 90% of formation fracture pressure, as well as to evaluate the reservoir performance and history match the operation with the projection of the model.

If the downhole gauge stops working between scheduled maintenance events, then the surface pressure limitation approved for this permit will be used as a backup until the downhole gauge is repaired or replaced. For calibration purposes, in lieu of removing the injection tubing, the accuracy of the downhole gauges will be demonstrated by using a second pressure gauge with current certified calibration lowered into the well at the same depth as the permanent downhole gauge.

Electronic pressure gauges and temperature sensors will be used to continuously monitor the pressure and temperature of the annulus between the tubing and long string casing at the surface. Gauges and sensors will be connected to the automation system to provide continuous data analysis as well as alarms for malfunctioning events when the values deviate from the intended operating range.

Annular pressure will be kept between [REDACTED] psi on surface and the addition of volume or changes in pressure will be noted by the operator in the field and recorded in the project well databases weekly. A pressure gauge and temperature sensor will be installed downhole as part of the upper completion and will be ported into the annular above the packer to continuously measure pressure in the annular space and identify any potential loss of mechanical integrity. If major variation of pressure is observed in the annular gauges (surface/downhole), then the field operator will proceed to troubleshoot the well.



Automated shut off devices will be installed at each exit of the flow lines in the wellhead and will be connected to the control system. If the operation parameters deviate from the program operational limits, the system will send an alarm to the operators to evaluate and correct the situation and might start shut down protocol, if the parameter exceeds the maximum operating limits.

Pelican Sequestration Hub, LLC will perform the activities identified in Table TM-4 to monitor operational parameters. All monitoring will take place at the locations and frequencies shown in the table.

**Table TM-4—Monitoring Devices, Locations, and Frequencies for Continuous Monitoring During Injection Operations in the CO<sub>2</sub> Injector Wells**

Parameter	Device(s)	Location	Min. Sampling Frequency	Min. Recording Frequency
Parameter 1	Device A	Location 1	10 Hz	10 Hz
Parameter 2	Device B	Location 2	20 Hz	10 Hz
Parameter 3	Device C	Location 3	15 Hz	10 Hz
Parameter 4	Device D	Location 4	10 Hz	10 Hz
Parameter 5	Device E	Location 5	10 Hz	10 Hz
Parameter 6	Device F	Location 6	10 Hz	10 Hz
Parameter 7	Device G	Location 7	10 Hz	10 Hz
Parameter 8	Device H	Location 8	10 Hz	10 Hz
Parameter 9	Device I	Location 9	10 Hz	10 Hz
Parameter 10	Device J	Location 10	10 Hz	10 Hz

### ***3.2.2 Monitoring devices description and technical specifications***

Technical specifications for the tools to use for real time data acquisition are described in the QASP.

### **3.3 Corrosion Monitoring [40 CFR 146.90(c)]**

To meet the requirements of 40 CFR 146.90(c), Pelican Sequestration Hub, LLC will monitor well materials during the operation period for loss of mass, thickness, cracking, pitting, and other signs of corrosion to ensure that the well components meet the minimum standards for material strength and performance.

Pelican Sequestration Hub, LLC will monitor corrosion using Corrosion Coupons and collect samples according to the description below. The project will complement the corrosion coupons with visual inspection of the facilities, a robust leak detection and repair program, the use of optical gas imaging cameras (OGI), and the data collected in real-time from the fiber optic installed in the injector wells.

During well material selection, Pelican Sequestration Hub, LLC simulated the chemical reactions of the selected material, the formation waters, and the proposed CO<sub>2</sub> stream at downhole conditions. The Project proceeded to test the selected metallurgic to the maximum limits of the specification and operating parameters to validate the correct selection for downhole materials that will be exposed to the injection stream and formation waters. The results of material testing are in progress and will be available for the Director to review.

During planned well maintenance operation in the CO<sub>2</sub> injector wells, Pelican Sequestration Hub, LLC, will run a casing inspection log to evaluate the casing conditions downhole (Casing Inspection Logs are discussed in the section associated with mechanical integrity).

### ***3.3.1 Monitoring location and frequency***

**Table TM-5—Monitoring Location and Frequency of Leak and Corrosion Detection Devices**

Tool	Location	Pre-Injection	Injection
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Notes:

1. [REDACTED]

Visual inspection will continue weekly, during the injection period, after the start-up of the well to identify potential leaks, as well as to validate that the system is operating between design limits and efficiently. The field operator will be provided with handheld devices to measure explosive gases, H<sub>2</sub>S, and CO<sub>2</sub> as part of the safety requirements of the site. The field inspection will continue quarterly in the post injection period.

[REDACTED]

### **3.3.2 Corrosion Coupons analysis description**

Samples of selected materials in the wells and facilities (coupons) will be exposed to the injected CO<sub>2</sub> stream and monitored for signs of corrosion to verify that the selected materials meet the minimum standards for material strength and performance and to identify well maintenance needs. Coupons shall be collected and sent quarterly to a third-party company for analysis conducted in accordance with NACE Standard SP-0775-2018-SG to determine and document corrosion wear rates based on mass loss. The project will start corrosion coupon monitoring after the start of injection and will continue quarterly.

**Table TM-6—Summary of methods to evaluate Corrosion Coupons**

Parameters	Analytical Method	Resolution Instruments	Precisions/Std Dev
Parameter 1	Method A	Instrument B	Precision C
Parameter 2	Method D	Instrument E	Precision F

**Table TM-7—List of Equipment with Materials of Construction**

### **3.4 Pressure Fall-Off Testing [40 CFR 146.90(f)]**

Pelican Sequestration Hub, LLC will perform pressure fall-off tests in the CO<sub>2</sub> injector well during the injection phase as described below to meet the requirements of 40 CFR 146.90(f).

### ***3.4.1 Testing location and frequency***

Pressure fall-off testing will be conducted upon completion of the injection well to characterize reservoir hydrogeologic properties, aquifer response model characteristics, and changes in near-well/reservoir conditions that may affect operational CO<sub>2</sub> injection behavior.

Pressure fall-off testing will be conducted in the CO<sub>2</sub> injector wells at least once every five (5) years during injection for AoR review until the wells are plugged. The objective of the periodic pressure fall-off testing is to determine whether any significant changes in the near-wellbore conditions have occurred that may adversely affect the well or reservoir performance.

### ***3.4.2 Testing details***

Detailed procedure and analytics proposed for the fall-off test are described in the QASP.

## ***3.5 Tracking and Recording Surface Pressure and Temperature in Monitoring Wells***

Pelican Sequestration Hub, LLC will continuously measure pressure and temperature in monitoring wells (In Zone and Above Confining Zone) at the surface via real-time pressure and temperature (P/T) instruments installed in the wellhead.

A pressure and temperature (P/T) gauge will be installed downhole as part of the upper completion and will be ported into the tubing to continuously measure pressure and temperature in the reservoir. These measurements will allow the project to calibrate and verify the model, improve predictive capability for confirming CO<sub>2</sub> containment, and evaluate the development of the pressure front.

Since the changes in reservoir pressure precede the movement of the CO<sub>2</sub> plume, In Zone Monitoring wells will provide data to history match the model and calibrate the response expected from the reservoir regarding the development of pressure front and CO<sub>2</sub> plume migration.

Abnormal changes of pressure in Above Confining Zone monitoring wells could indicate a potential leak path from the reservoir to the upper zones.

Details of the In Zone Monitoring wells as well as the Above Confining Zone monitoring wells are provided in the following sections.

### ***3.5.1 Monitoring location and frequency***

**Table TM-8—Monitoring Location and Frequency of Pressure and Temperature Gauges**

Tool	Location	Pre-Injection	Injection	Min. Sampling Frequency	Min. Recording Frequency
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

If the downhole gauge stops working between scheduled maintenance events during the injection period, the project might install a temporary downhole gauge with wireline and reduce the frequency of data collection to 1 sample per day or less, depending on the pressure behaviors observed before the failure.

If the downhole gauge stops working between scheduled maintenance events during the post injection period, the project might install a temporary downhole gauge with wireline and reduce the frequency of data collection to 1 sample per month or less, according to the predicted pressure changes from the numerical simulation.

### ***3.6 Visual Inspection and Leak Detection and Repair (LDAR) Program Using Optical Gas Imaging Camera (OGI)***

The project will perform visual inspection of the facilities and wells as part of the maintenance and mechanical integrity program. Inspection will start from the commissioning date, during startup of the facilities and well, and will continue weekly after the site is injecting steadily. Quarterly, field inspections will be performed after the start of injection and continue to injection ceases and will be aimed at identifying potential leaks, with the use of OGI cameras.

OGI cameras are highly specialized versions of infrared or thermal imaging cameras. They are composed of a lens, detector, and some electronics to process the signal and a viewfinder to give the user the final product. The material used as the detector will depend on the type of gas to be measured. Detectors are cooled to specific operating temperatures where they become nonconductive. Once exposed to the incident photon, the electron will move to the conduction band and detector can carry a photocurrent proportional to the intensity of the incident radiation.

During this process, the camera software will process and adjust the signal of the detector array, giving a thermographic image that shows relative temperatures across the target object or scene. The image is a true representation of the radiation intensity regardless of the source of thermal radiation. The OGI cameras use unique spectral filters that enable them to detect a gas compound. The filter restricts the wavelengths of radiation allowed to pass through the detector to a very narrow band called band pass. This technique is called spectral adaptation.

Optical Gas Imaging cameras provide the power to spot invisible gases as they escape, so that the operation team can find the leak in a reliable way. Cameras rely on infrared images to detect the leaks and they are used during the inspection of facilities, pipelines, and well locations.

## **4.0 Mechanical Integrity Testing**

### ***4.1 External Mechanical Integrity Testing [40 CFR 146.89(c) ,40 CFR 146.90(e), 40 CFR 146.87 (a)(2)(ii), 40 CFR 146.87 (a)(3)(ii)]***

After installation of the long string casing during construction the CO<sub>2</sub> injector and monitoring wells, Pelican Sequestration Hub, LLC will perform a cement logging evaluation, with one or more of the following tools, to validate zonal isolation between the injection zone, confining zones, and overburden formations [40 CFR 146.87 (a)(2)(ii) 40 CFR 146.87 (a)(3)(ii)]:

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- a. Cement Bond Logging
- b. Ultrasonic cement evaluation tool
- c. Variable density log (VDL)

Pelican Sequestration Hub, LLC will

[REDACTED]

[REDACTED]

- a. Pulse neutron through tubing.
- b. Electromagnetic casing inspection log.
- c. Temperature Log

Additionally, during well maintenance operations or workovers for the CO<sub>2</sub> injector well and the monitoring wells, an ultrasonic casing inspection tool might be run to evaluate casing thickness and conditions. At the end of the injection period, Pelican Sequestration Hub, LLC plans to properly abandon the CO<sub>2</sub> injector well.

[REDACTED]

- a. Pulse neutron through tubing.
- b. Electromagnetic casing inspection log.
- c. Temperature Log

#### ***4.1.1 Testing location and frequency***

Table TM-9 below provides a summary of the external mechanical integrity tools.

**Table TM-9—Corrosion Monitoring and Surface Leak Detection Tools**

### 4.1.2 Testing details

The logging industry has made an impressive advance in tools that provide images of and data identifying the quality of the cement bond behind the casing after cementing jobs are complete. The casing inspection tool and multi-finger calipers can provide information about ovality, collapse, or damage in the casing, as well as estimations of wall thickness to evaluate wearing and corrosion effects.

The most advanced tools can evaluate up to five concentric tubulars to measure changes in thickness that could be related to corrosion or wearing effects.

The tools described below are readily available technologies on the market and the basis of the project's master monitoring program for mechanical integrity. No specific provider has been selected. In the future, new technologies or tools may be proposed for further discussion with regulators.

#### 4.1.2.1 Cement bond logging, variable density log and ultrasonic cement evaluation

**Cement Bond Log (CBL):** is a basic method to evaluate cement quality in the annulus. It is an acoustic wave measurement. The tool usually includes a transmitter and receiver, separated by three (3) ft. The acoustic wave is emitted by the transmitter, propagated down and across the annulus, and recorded by the receiver. The attenuation of the wave is analyzed to interpret the bonding behind the pipe. Signal coming from a properly cemented casing will be more attenuated than the signal coming from a poorly cemented one.

The arriving signal recorded by the receiver is a mixed signal coming from casing, cement, mud, and formations. Each signal has its own pathway because they travel at different velocities through each medium. The signal through the casing is the fastest, as sound travels the quickest through steel. As a result, it is the first signal detected on the receiver. The second signal most likely to arrive is the signal through the formation and the last one is the drilling fluid signal, because sound travels slower in a liquid.

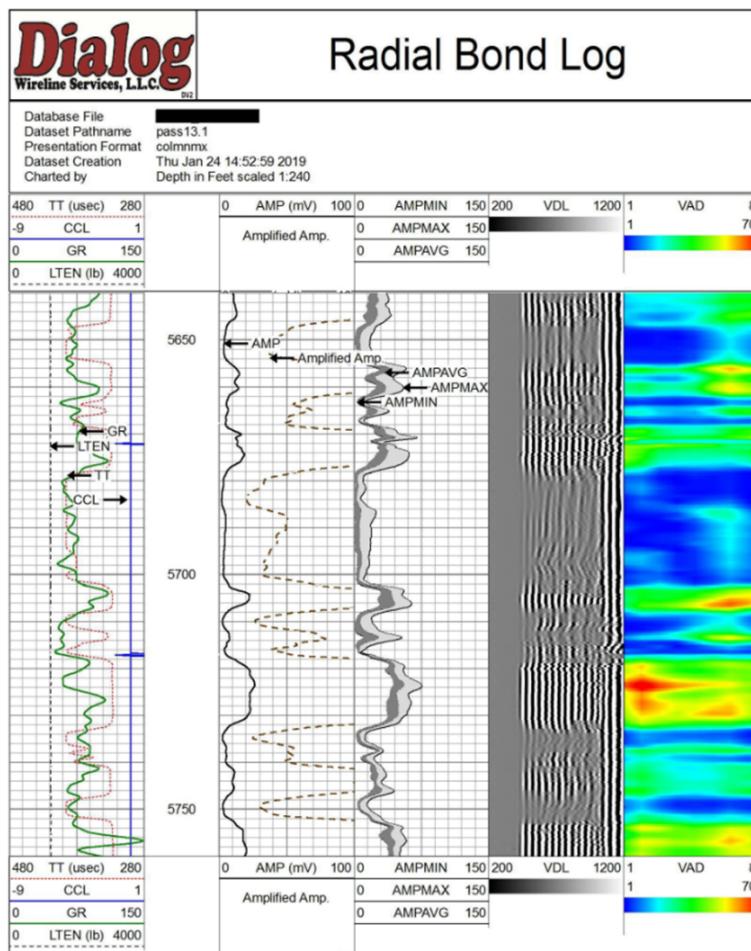


Figure TM-3—CBL and VDL Example from Dialog Wireline Services Web Page

**Variable Density Log (VDL):** is commonly used as an adjunct to the cement bond log and offers better insights with its interpretation. In most cases, micro-annulus and fast-formation-arrival effects can be identified using this additional display.

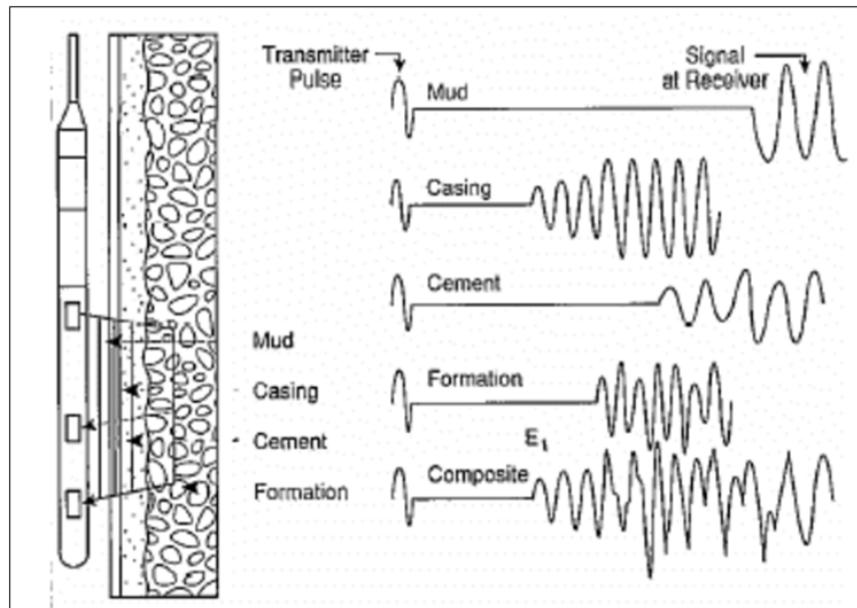
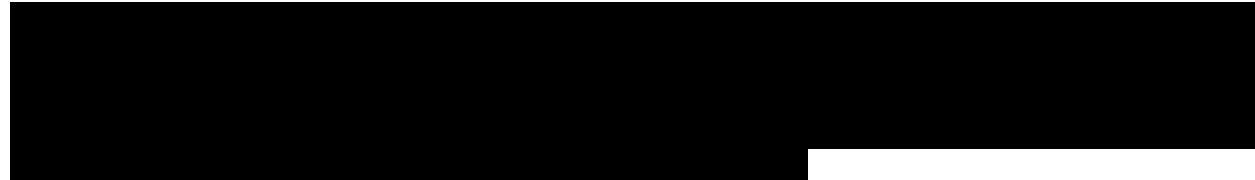
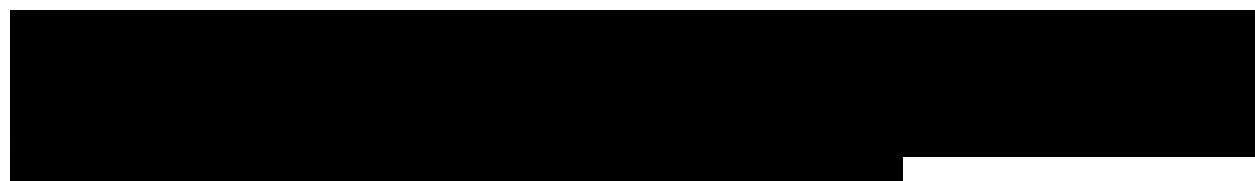


Figure TM-4—Signal Received by CBL-VDL

#### 4.1.2.2 Ultrasonic cement and casing evaluation tools



The rate of decay of the waveforms received indicates the quality of the cement bond at the cement-casing interface and the resonant frequency of the casing provides the casing wall thickness required for pipe inspection. The resulting 360° data coverage enables evaluation of the quality of the cement bond and determination of both the internal and external condition of the casing.



#### 4.1.2.3 Distributed temperature sensing (DTS)

Distributed Temperature Sensing (DTS) technology uses fiber optic sensor cables, typically several kilometers in length, that function as linear temperature sensors. The result is a continuous temperature profile along the entire length of the sensor cable. DTS utilizes the Raman effect to measure temperature. An optical laser pulse sent through the fiber results in some scattered light reflecting to the transmitting end, where the information is analyzed. The intensity of the Raman scattering is a measure of the temperature along the fiber. The Raman anti-Stokes signal changes its amplitude significantly with changing temperature, while the Raman Stokes signal is relatively stable. The position of the temperature reading is determined by measuring the arrival timing of the returning light pulse like a radar echo.

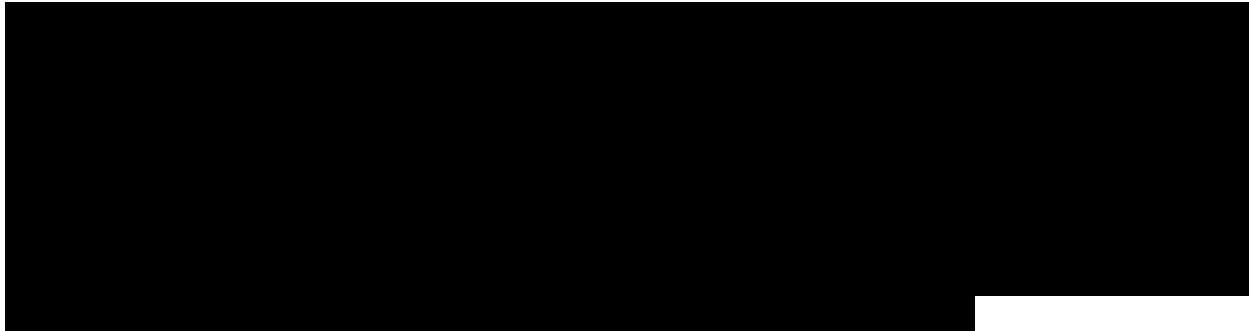
The fiber optic cable is run alongside the casing as an umbilical and it is protected with clamps and centralizers to avoid any damage while deploying it into the well. The fiber is connected on the surface to an interrogator to convert the signal to temperature values and data is transmitted to the monitoring platform in real time for surveillance purposes.

The maintenance and calibration of the equipment will be performed according to the manufacturer's manuals and will be the responsibility of the technology provider. Tables TM-10 and TM-12 show technical specifications for DTS systems and fiber optic cable.

**Table TM-10—Technical Specification for DTS**

**Table TM-11—Technical Specification for Fiber Optic Cable**

#### 4.1.2.4 Electromagnetic casing inspection tool



#### 4.1.2.5 Temperature log

Temperature logs are used to locate gas entries, detect casing leaks, and evaluate fluid movement behind casing. They are also used to detect lost-circulation zones and cement placement. Temperature logs are used as a basic diagnostic tool and are usually paired with other tools like acoustics or multi arms calipers if more in depth analysis is required.

Temperature instruments used today are based on elements with resistances that vary with temperature. The variable resistance element is connected with bridge circuitry or constant current circuit, so that a voltage response proportional to temperature is obtained. The voltage signal from temperature device is then usually converted to a frequency signal transmitted to the surface, where it is converted back to a voltage signal and recorded. The absolute accuracy of temperature logging instruments is not high (in the order of +/- 5°F), but the resolution is good (0.05°F) or better, although this accuracy can be compromised by present day digitalization of the signal on the surface. The temperature instrument usually can be included in the string with other tools, such as radioactive tracer tools or spinners flowmeters. Temperature logs are run continuously, typically at cable speeds of 20 to 30 ft/min. (A.Daniel Hill).

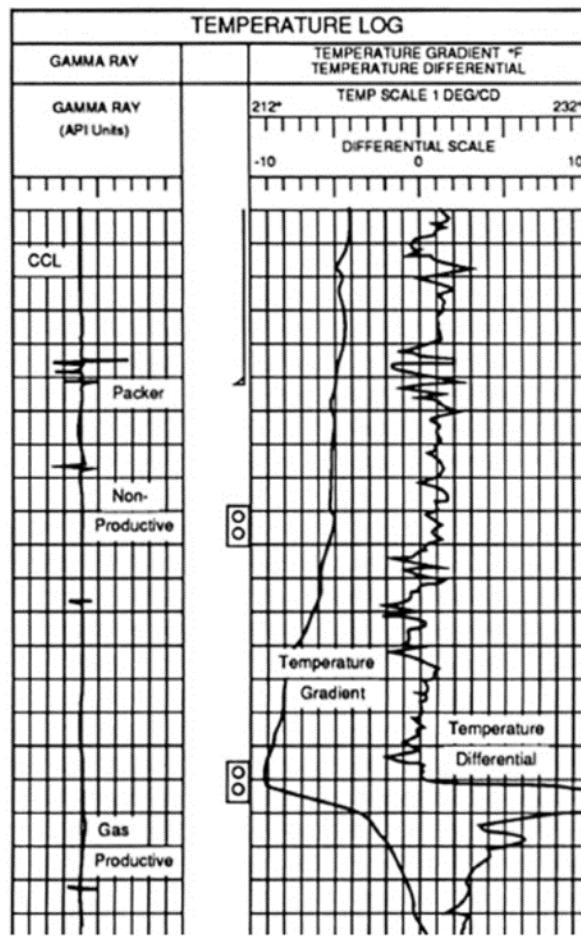
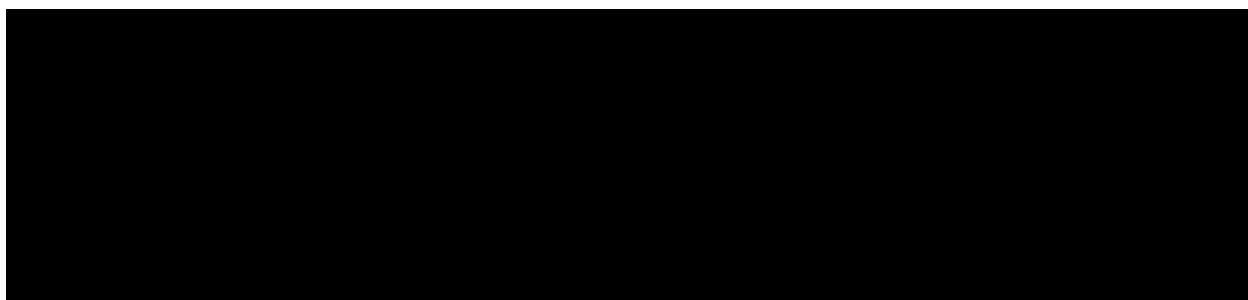


Figure TM-5—Example of temperature log output

#### 4.1.2.6 Pulse neutron log

Pulse neutron log (PNL) provides formation evaluation and reservoir monitoring in cased holes. PNL is deployed as a wireline logging tool with an electronic pulsed neutron source and one or more detectors that typically measure neutrons or gamma rays. High-speed digital signal electronics process the gamma ray response and its time of arrival relative to the start of the neutron pulse. Spectral analysis algorithms translate the gamma ray energy and time relationship into concentrations of elements. Each logging company has its own proprietary designs and improvements on the tool.





#### ***4.1.3 Description and technical specifications of the tools for external mechanical integrity evaluation***

Detailed information and technical references of these tools are provided in the QASP.

#### ***4.2 Internal Mechanical Integrity Testing [40 CFR 146.89(b)]***

Pelican Sequestration Hub, LLC, will perform an annular pressure test in the CO<sub>2</sub> injector well as well as in monitoring wells to proof internal mechanical integrity of the system according to 40 CFR 146.89(b).

Annular pressure testing is used to validate mechanical integrity in the system. Tests will be performed according to the frequency presented in table TM-12.

**Table TM-12—Annular Pressure Testing Frequency**

Tool	Location	Pre-Injection	Injection
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

If the additional monitoring systems indicate a potential mechanical integrity issue, Pelican Sequestration Hub, LLC will perform trouble shouting and perform an annular pressure test as part of the protocol, if needed.

An overview of the procedure is as follows: First, shut-in the well to stabilize the pressures in the injectors and validate static conditions in the monitoring wells. Connect the testing equipment to the annular valves and test surface lines to 1,500 psi above the testing pressure. Ensure that there are no surface leaks from the pumping unit to the wellhead valve. Bleed any air in the system. If needed, fill the annular space with packer fluid and corrosion inhibitor (if so, it should require only a minimal amount). Record the initial tubing and casing pressure. The well will be tested to [REDACTED]

psi in the annular space and the pressure should not decrease more than █% in █ minutes. Monitor continuously the tubing and casing pressures. Record the final tubing and casing pressure, then bleed the pressure and volume. If the pressure decreases more than █%, bleed the pressure, test the surface connection, and repeat the test. If there is an indication of mechanical failure, the operator will prepare a plan to repair the well and discuss it with the Director.

Surface gauges should be calibrated according to manufacturer recommendations. There should be a pressure range that will allow the test pressure to be near the mid-range of the gauge. Additionally, the gauge must be of sufficient accuracy and scale to allow an accurate reading of █% change to be read. The test results will be documented and stored in the centralized database of the project for reporting and documentation.

## **5.0 Ground Water Quality and Geochemical Monitoring [40 CFR 146.90(d)]**

Pelican Sequestration Hub, LLC, will monitor groundwater quality and geochemical changes above the confining zone during the operation period to meet the requirements of 40 CFR 146.90(d).

The selection of the ground water monitoring locations was based on the original assessment of the AOR for existing legacy wells, the results of the numerical simulation for CO<sub>2</sub> plume and pressure front, and the risk assessment performed by the project. The location, techniques, and frequency were optimized taking in consideration the complementary techniques proposed in this monitoring plan for direct and indirect measurements, such as 3D seismic surveys, 3D time lapse VSP, pulse activate neutron logs, soil gas analysis, and others that are explained in additional sections of this document.

Pelican Sequestration Hub, LLC selected █ potential shallow water wells distributed around the AoR to sample and test the freshwater aquifer in the area. These wells targeted the Chicot, Evangeline and Jasper Aquifer to provide water for domestic and irrigation uses, as well as industrial uses. Additionally, the project will drill █ USDW wells targeting the lower section of the USDW targeting Evangeline-Jasper Aquifer.

Pelican Sequestration Hub, LLC will drill █ confining zone. This well will provide water characterization and fingerprinting of the water above the lower confining zone and below the USDW. During injection and post injection period, the well will provide information about any potential change in water composition due to an unexpected leak path from the reservoir.

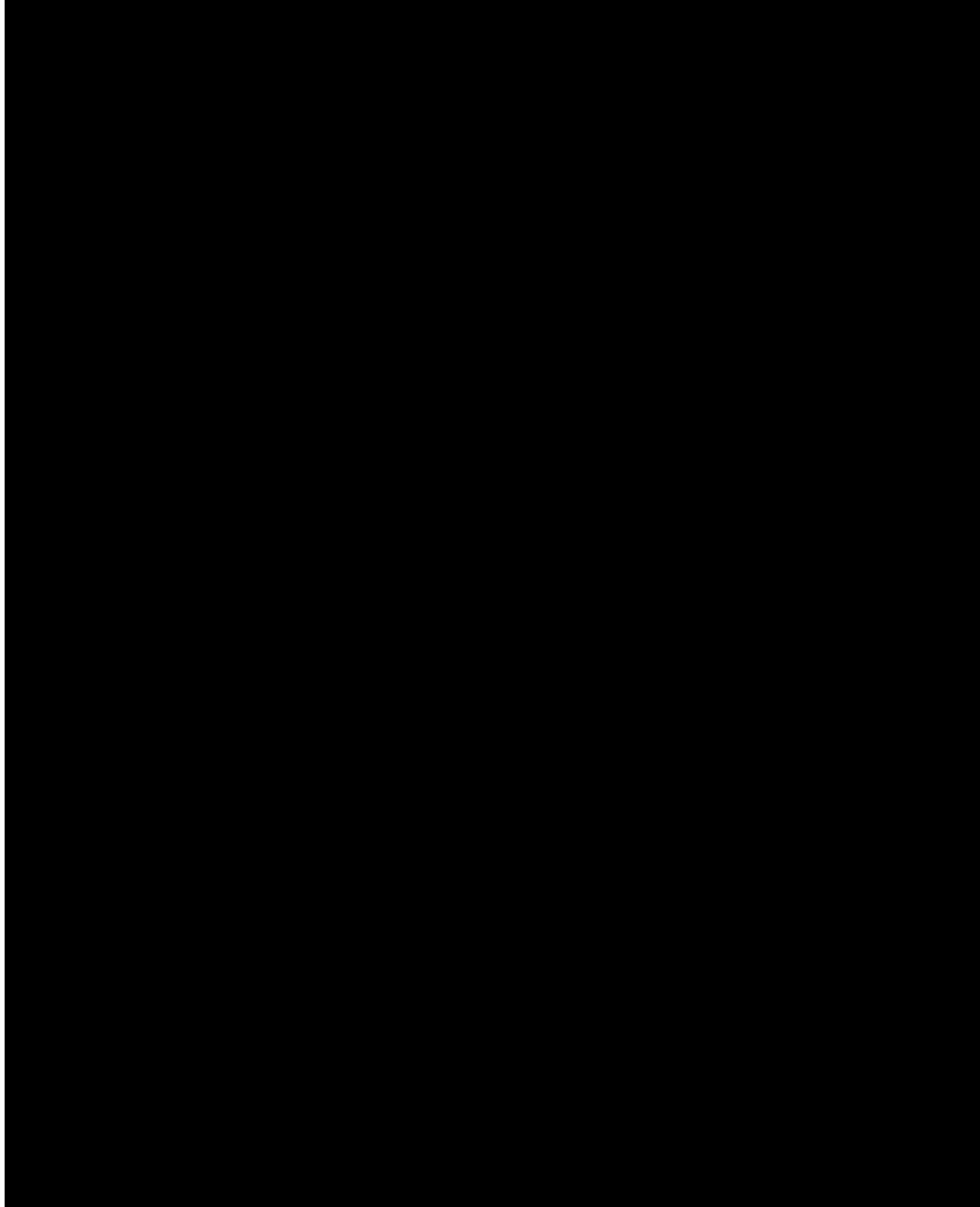
As part of the monitoring system, Pelican Sequestration Hub, LLC, plans to install █ that will allow to detect any mechanical integrity issue that could cause contamination of CO<sub>2</sub> or brines in the above confining zone and / or in the USDW. This technique is described in the mechanical integrity section.

Pelican Sequestration Hub, LLC plans also to install █. These wells will be described in the section related to CO<sub>2</sub> plume extension and pressure front tracking, but as they penetrate the above confining zone and the USDW, they will

be to track any potential leakage from the reservoir through logging in the wells, pressure and temperature measurements in the reservoir and the used of indirect methods as [REDACTED].

A 3D time lapse seismic survey will be used at the site as part of the indirect methods to track the CO<sub>2</sub> plume extension and will complement the well monitoring network. See Section 6.1.1 for details.

Figure TM-6 shows the proposed well network for groundwater and above confining zone monitoring.



**Figure TM-6—Proposed well network for groundwater and above confining zone monitoring**

### **5.1 Freshwater shallow aquifer water sampling and testing**

The shallowest freshwater aquifer of importance, the Chicot aquifer, is predominantly composed of Pleistocene sand and gravel and is directly underlain by the Evangeline then Jasper aquifers, predominantly composed of Pliocene sand and clay. These two aquifers are hydraulically connected and separated only by a gradation in grain size with depth. The Chicot and Evangeline aquifers are the primary sources of groundwater used for drinking in the region, and thus, will be the most likely regional target for USDW monitoring.

The proposed locations for sampling and testing the shallow freshwater aquifer (show in the figure TM-6 in purple) were selected to cover an extensive area inside and around the defined AOR. The identified locations for sampling were evaluated for age of installation, use, depth, and relative location to the AoR and the other monitoring wells. Pelican Sequestration Hub, LLC, plans to start sampling and characterization of the shallow freshwater aquifer [REDACTED] before the start of the injection period. The characterization includes not only the complete water analytics shown in Table TM-19 but the isotopic fingerprinting of wells to be reviewed in the future to be used as appropriation tools.

Some of these locations might present mechanical integrity or accessibility issues at the moment of acquiring the sample and those will be reported once the complete assessment is done and sampling protocols are started.

#### **4.1.1 Monitoring location and frequency**

Table TM-13 shows the planned location for sampling of the fresh water shallow aquifer and Table TM-15 shows the frequencies proposed.

**Table TM-13—Fresh Water Testing Locations**

A 10x10 grid of black and white squares. The pattern is a checkerboard, starting with a black square in the top-left corner. The grid is composed of 100 individual squares, arranged in 10 rows and 10 columns.

**Table TM-14—Location and Frequency of Water Sampling and Testing in the Freshwater Shallow Water Wells**

Monitoring Location(s)	Monitoring Activity	Target Formation	Pre-Injection	Injection Period
				
				
				

## 5.2 USDW wells water sampling and testing

These wells will allow the characterization and fingerprinting of waters in the deepest section of the USDW. The well will monitor water composition changes during injection and post injection periods.

### 5.2.1 Monitoring location and frequency for water sampling in USDW wells

Table TM-15—Location of USDW Wells to be Drilled for Water Sampling and Testing

Well Name	Latitude	Longitude	Elevation (ft)	Status	Measured Depth (ft)	Target Formation
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Table TM-16—Location and Frequency of the Water Sampling and Testing in the USDW Wells

Monitoring Location(s)	Monitoring Activity	Target Formation	Pre-Injection	Injection Period
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Figures TM-7 and TM-8 show the well designs and schematics of the Pelican USDW 1 and Pelican USDW 2, respectively.

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Figure TM-7—[REDACTED] Design



Figure TM-8—[REDACTED] Design

### 5.3 Above Confining Zone Well water sampling and testing

[REDACTED] well will be drilled as part of the master monitoring plan. The well will be drilled and perforated in the first permeable zone above the [REDACTED] confining zone. Pressure and temperature gauges will be tubing deployed to track any changes above the seal that could indicate a potential leak into the USDW. The well will test water quality at the first permeable sand above the [REDACTED] confining zone and will track potential changes of pressure above that could indicate a leak path. Figure TM-7 shows a diagram and detailed construction of the [REDACTED] well.

The well will be equipped with a U-Tube line that allows to collect samples from the reservoir at the frequency proposed by the project. Those samples will be sent to third party laboratory for the analysis. The description of the system is presented in the QASP document.

[REDACTED] is located in the zone of highest differential pressure between CCS 1 and CCS 2 to evaluate the effect of the reservoir pressurization at the highest point of pressure and validate the sealing capacity of the upper confining zone.

#### 5.3.1 Monitoring location and frequency for water sampling in Above Confining Zone Well

Table TM-17—Location of the Pelican ACZ 1 Well

Well Name	Latitude	Longitude	Elevation (ft)	Status	Target monitoring interval TVDSS (ft)	Target Formation
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Table TM-18—Location and Frequency of Water Sampling and Testing in Pelican ACZ 1 Well

Monitoring Locations	Monitoring Activity	Target Formation	Pre-injection	Injection Period
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

If the downhole gauge stops working between scheduled maintenance events during the injection period, the project might install a temporary downhole gauge with wireline and reduce the frequency of data collection to 1 sample per day or less, depending on the pressure behaviors observed before the failure.

Figure TM-7 shows the well design and schematic of Pelican ACZ 1.

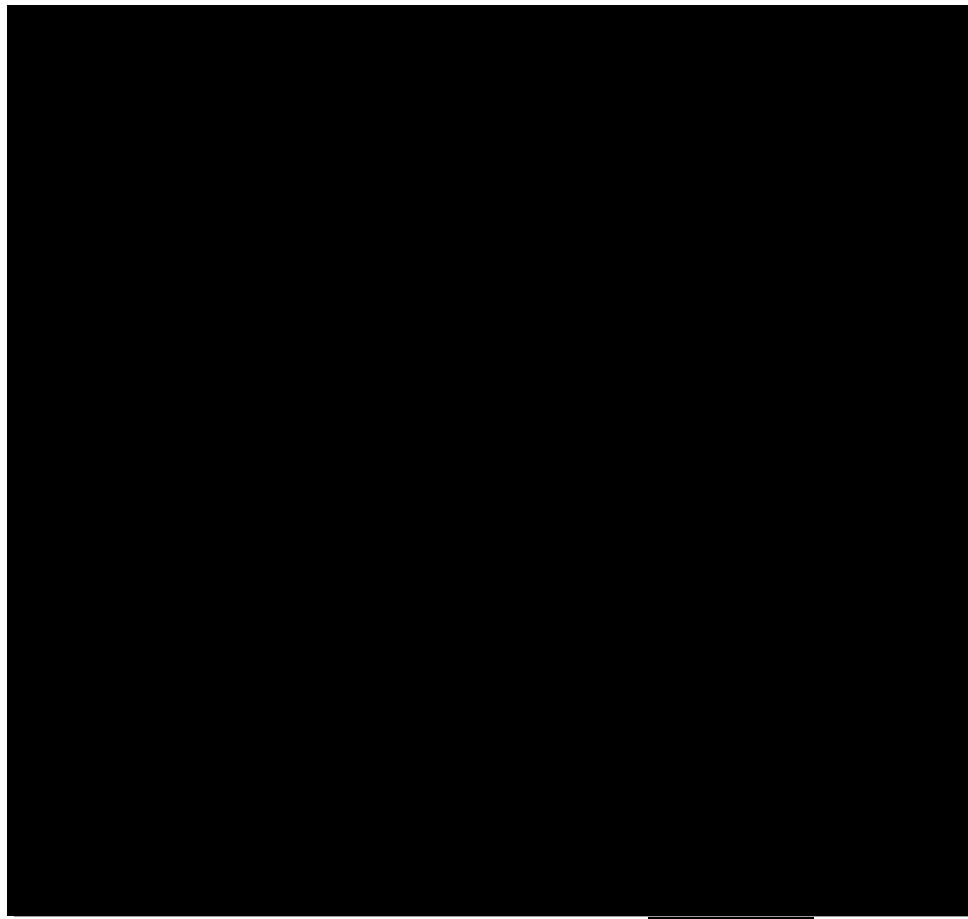


Figure TM-9—Well Design and Schematic for [REDACTED] Well

#### *5.4 Analytical parameters for water testing in groundwater and above confining zone samples*

Table TM-19 identifies the parameters to be tested and monitored and the analytical methods Pelican Sequestration Hub, LLC proposed as minimum required in the water testing protocol, but not limited to, for groundwater and above confining zone water samples.

An extensive characterization program is planned and includes the identification of natural tracers and unique characteristics of the waters in the different sections of the storage complex (reservoir, above confining zone, USDW, and freshwater aquifers) that will serve to tailor the final protocol to be used for evaluating and appropriate changes on the geochemistry of the water. This approach will enable the team to differentiate between changes in the composition of the water due to natural process and changes due to a potential leak from the reservoir and overburden.

Water testing will be performed by personnel of a certified laboratory, following the specific methods approved by EPA or others standard. Operators might audit the procedures and results of the selected laboratory with a third party to improve quality control.

The samples will be analyzed by a third-party laboratory using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and photo ionization. Sampling methods and chain of custody procedures are described in the QASP.

**Table TM-19—Summary of Analyses and Methods for Groundwater and ACZ Water Samples Testing**

A treemap visualization showing the distribution of analytical methods across different parameters. The left column represents the 'Parameter' and the right column represents the 'Analytical Method'. The size of each bar indicates the relative proportion of the analytical method within that parameter. The bars are black on the left and white on the right, with a thin black border separating the two sections.

Parameter	Analytical Method
Parameter 1	Method A (Large)
Parameter 1	Method B (Medium)
Parameter 2	Method C (Large)
Parameter 2	Method D (Medium)
Parameter 3	Method E (Large)
Parameter 3	Method F (Medium)
Parameter 4	Method G (Large)
Parameter 4	Method H (Medium)
Parameter 5	Method I (Large)
Parameter 5	Method J (Medium)
Parameter 6	Method K (Large)
Parameter 6	Method L (Medium)
Parameter 7	Method M (Large)
Parameter 7	Method N (Medium)
Parameter 8	Method O (Large)
Parameter 8	Method P (Medium)
Parameter 9	Method Q (Large)
Parameter 9	Method R (Medium)
Parameter 10	Method S (Large)
Parameter 10	Method T (Medium)
Parameter 11	Method U (Large)
Parameter 11	Method V (Medium)
Parameter 12	Method W (Large)
Parameter 12	Method X (Medium)
Parameter 13	Method Y (Large)
Parameter 13	Method Z (Medium)

### *5.5 Sampling methods for groundwater and above confining zone water samples*

Water sampling will be performed by personnel of a certified laboratory, following the specific methods approved by the EPA or other standards. Operators might audit the procedures and results of the selected laboratory with a third party to improve quality control.

### **5.6 Laboratory to be used/chain of custody procedures**

The samples will be analyzed by a third-party laboratory using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and photo ionization. Sampling methods and chain of custody procedures are described in the QASP.

## 6.0 Carbon Dioxide Plume and Pressure Front Tracking 40 CFR 146.90(g)

Pelican Sequestration Hub, LLC will employ direct and indirect methods to track the extent of the carbon dioxide plume and presence or absence of elevated pressure during the operation period to meet the requirements of 40 CFR 146.90(g).

### *6.1 Methods for CO<sub>2</sub> plume extension and pressure front monitoring*

Table TM-20 and Table TM-21 present methods that Pelican Sequestration Hub, LLC will use to monitor the position of the CO<sub>2</sub> plume, including the activities, locations, and frequencies for the Pelican Sequestration Hub.

**Table TM-20—Summary of Analyses and Methods for monitoring of CO<sub>2</sub> Plume Extension**

### ***6.1.1 Methods for CO<sub>2</sub> Plume extension and pressure front monitoring details***

#### **6.1.1.1 3D surface seismic baseline survey**

[REDACTED]

[REDACTED]

[REDACTED]

#### **6.1.1.2 3D surface seismic time-lapse surveys**

[REDACTED]

#### **6.1.1.3 3D VSP baseline and time-lapse surveys**

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

#### 6.1.1.4 Surface Gravity (Neda)

[REDACTED]

[REDACTED]

[REDACTED]

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**Table TM-21—In Zone monitoring wells application for monitoring the AOR**

Monitoring Locations	Monitoring Activity	Target Formation	Pre-injection	Injection Period
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

**Table TM-22—Summary of Location and Sampling Frequency for Pressure Front Monitoring**

Location	Device(s)	Location	Min. Sampling Frequency	Min. Recording Frequency
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

### 6.3 Location selection for the In Zone Monitoring wells

Table TM-23—Location and Depth of In Zone Monitoring Wells

Well Name	Latitude	Longitude	Status	Depth (ft)	Target Formation	Target monitoring interval TVDSS (ft)
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

#### 6.3.1 [REDACTED]



The proposed schematics for the well are presented in Figures TM-11 and TM-12.

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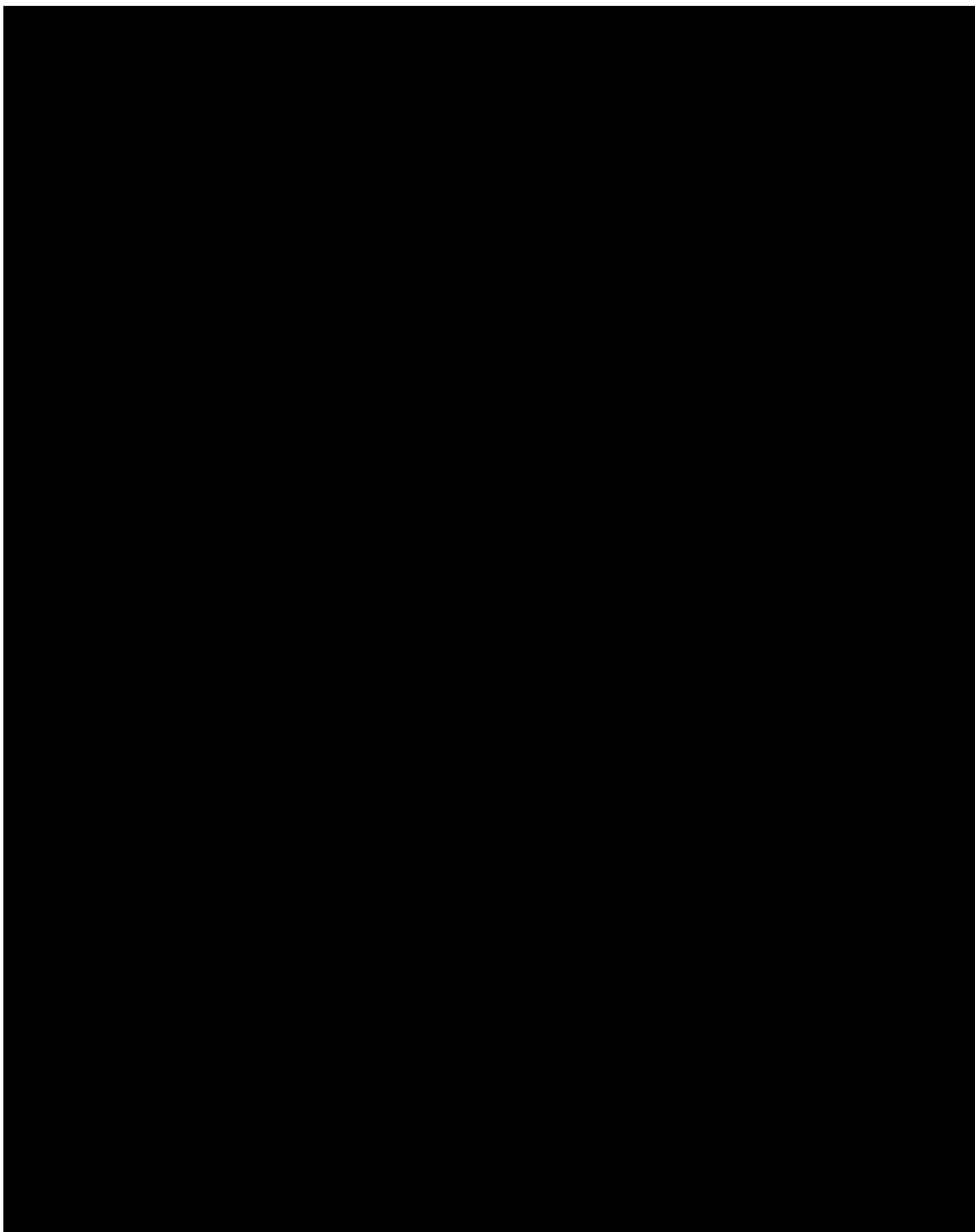


Figure TM-11—Well Design and Schematic for [REDACTED] Well- Original Completion

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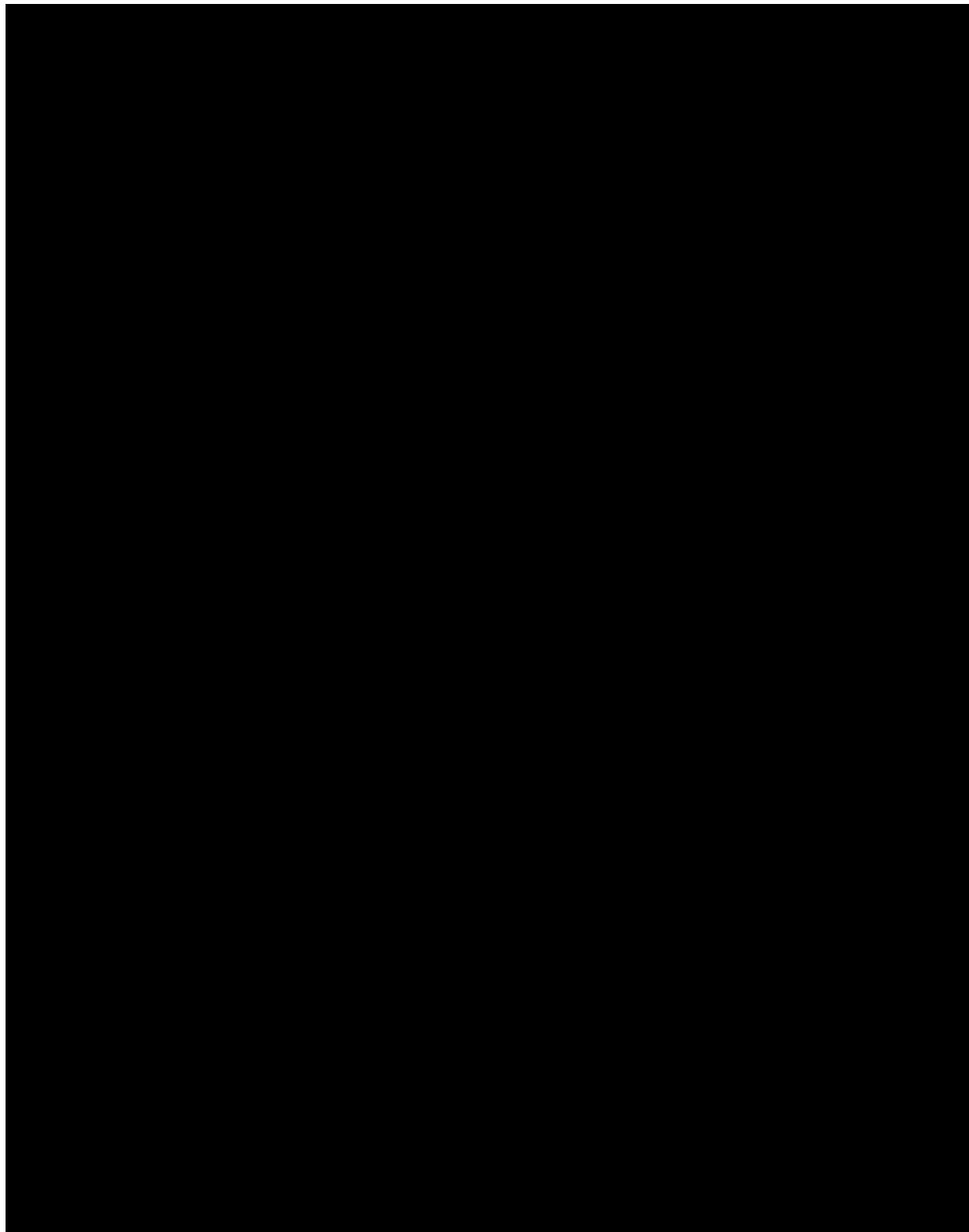


Figure TM-12—Well Design and Schematic for ██████████ Well- Recompletion

**6.3.2 [REDACTED]**



The proposed schematics for the well are presented in Figures TM-13 and TM-14.

Plan revision number: 0  
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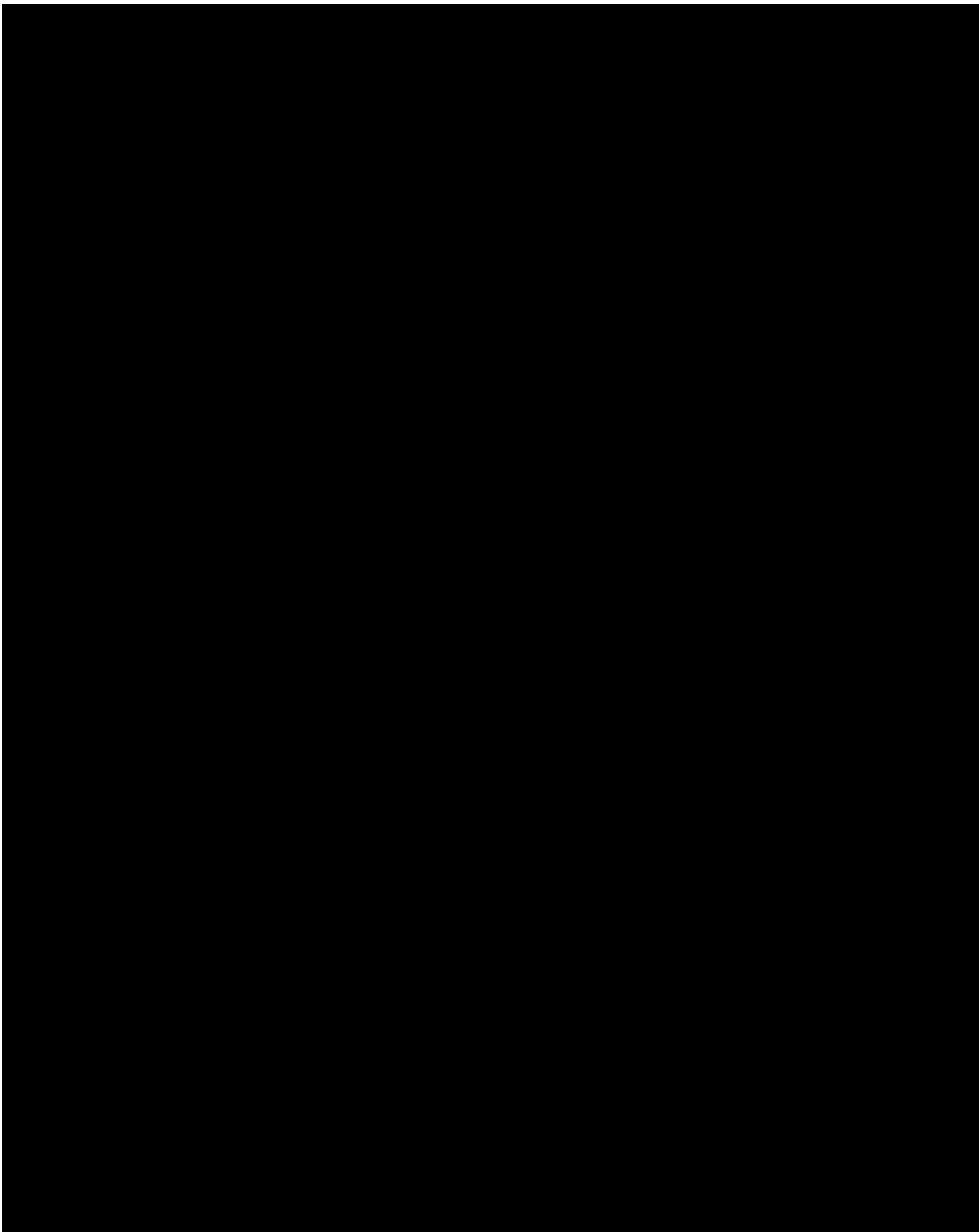
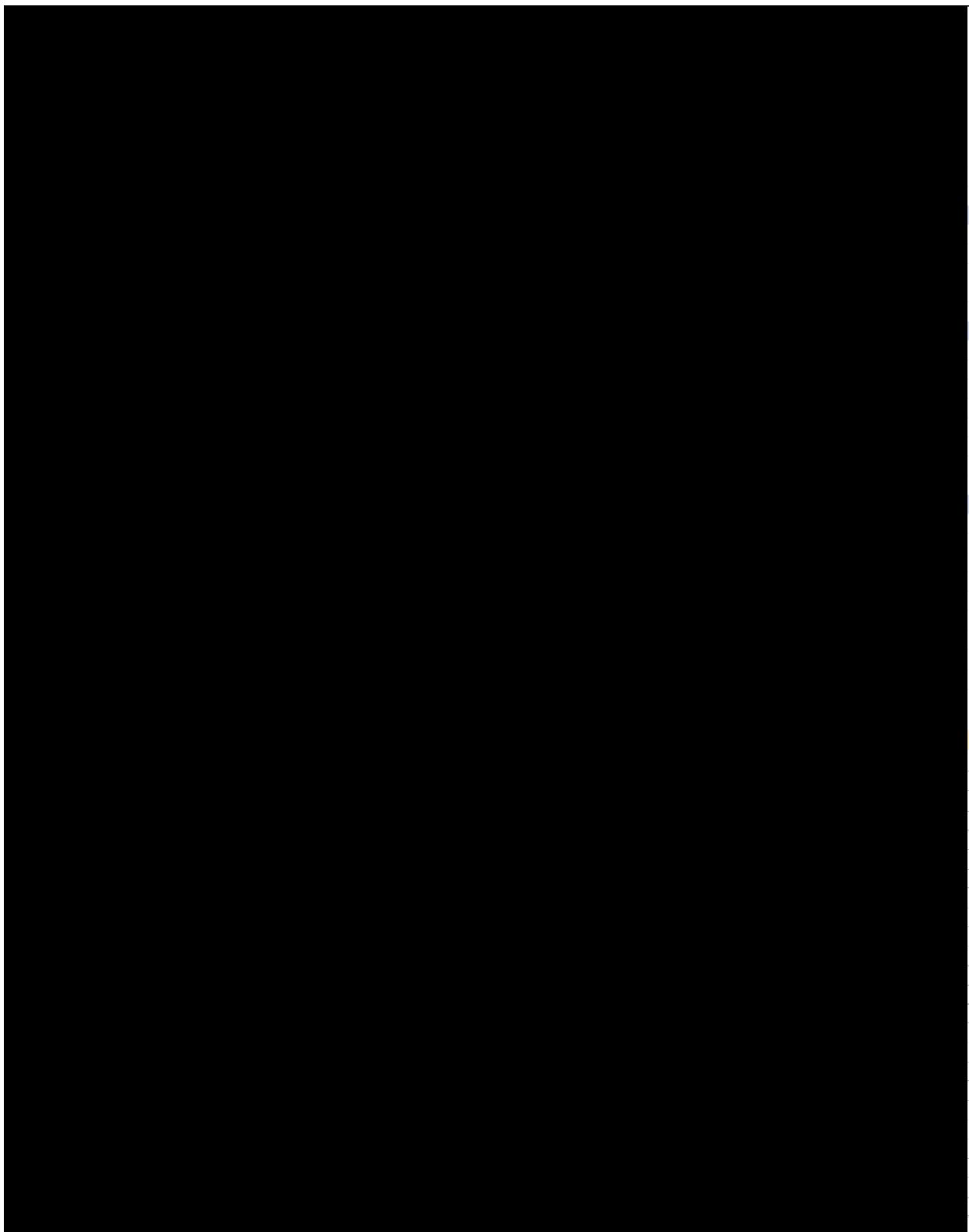


Figure TM-13—Well Design and Schematic for \_\_\_\_\_ Well Original Completion

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**Figure TM-14—Well Design and Schematic for [REDACTED] Recompletion**

**6.3.2 [REDACTED]**



The proposed schematics for the well are presented in Figures TM-15 and TM-16.

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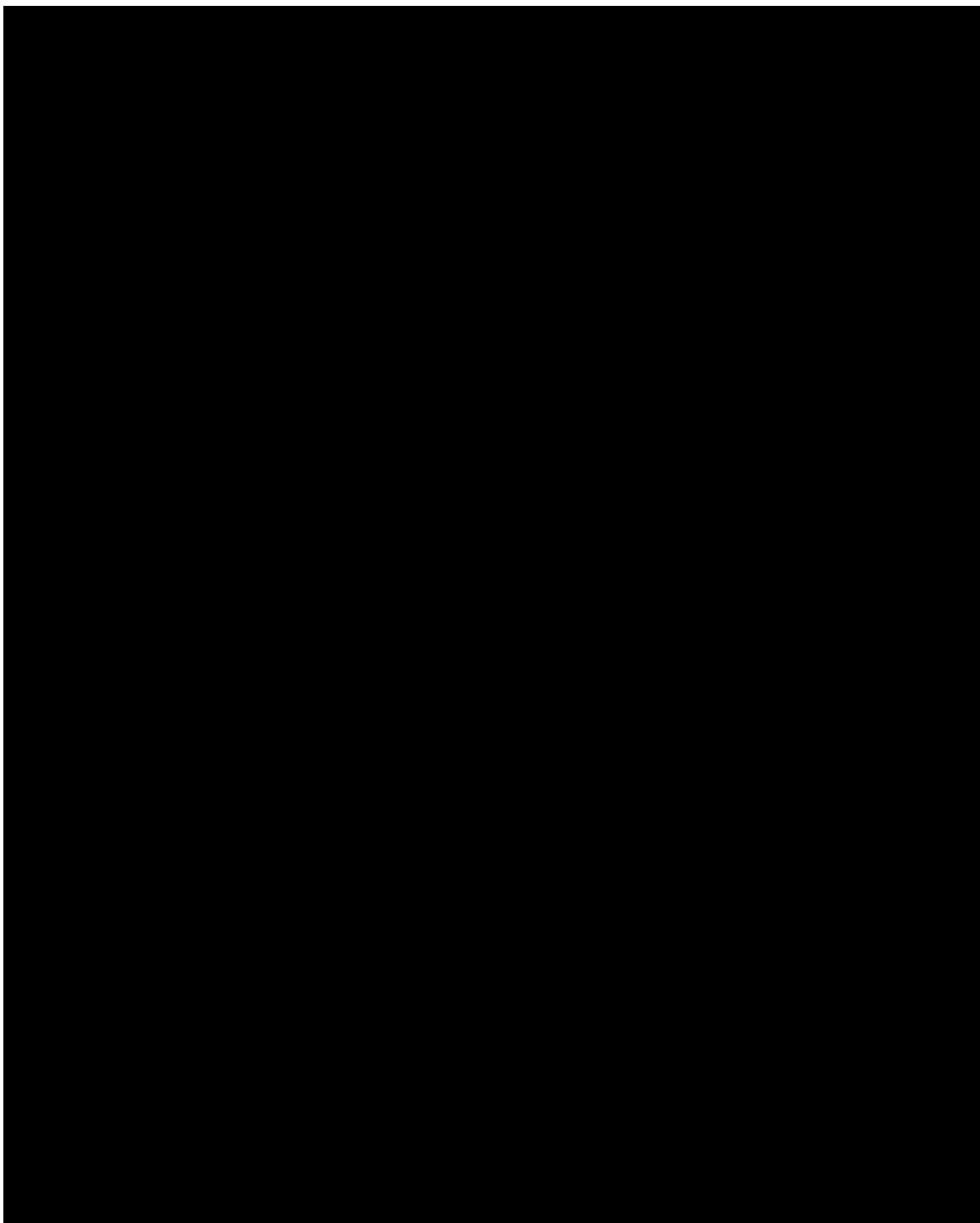


Figure TM-15—Well Design and Schematic for [REDACTED] Well Original Completion

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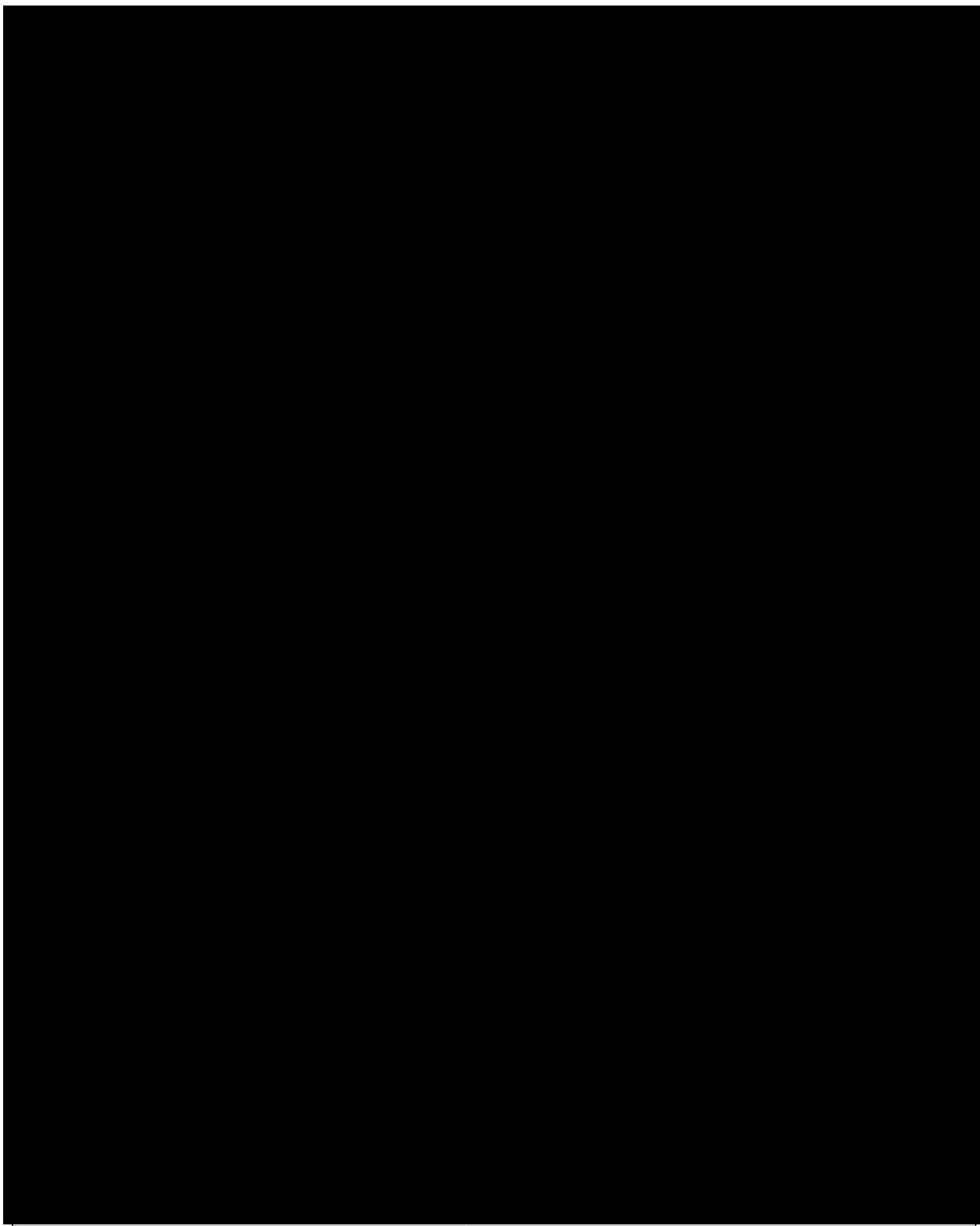
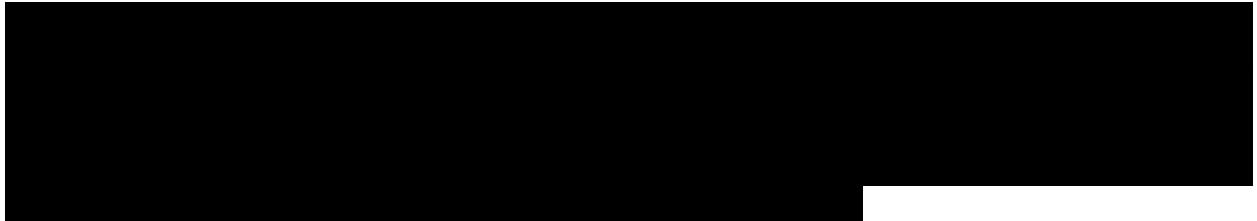


Figure TM-16—Well Design and Schematic for ██████████ Well Recompletion

**6.3.3 [REDACTED]**



The current and proposed schematic for the well are presented in Figures TM-17 and TM-18.

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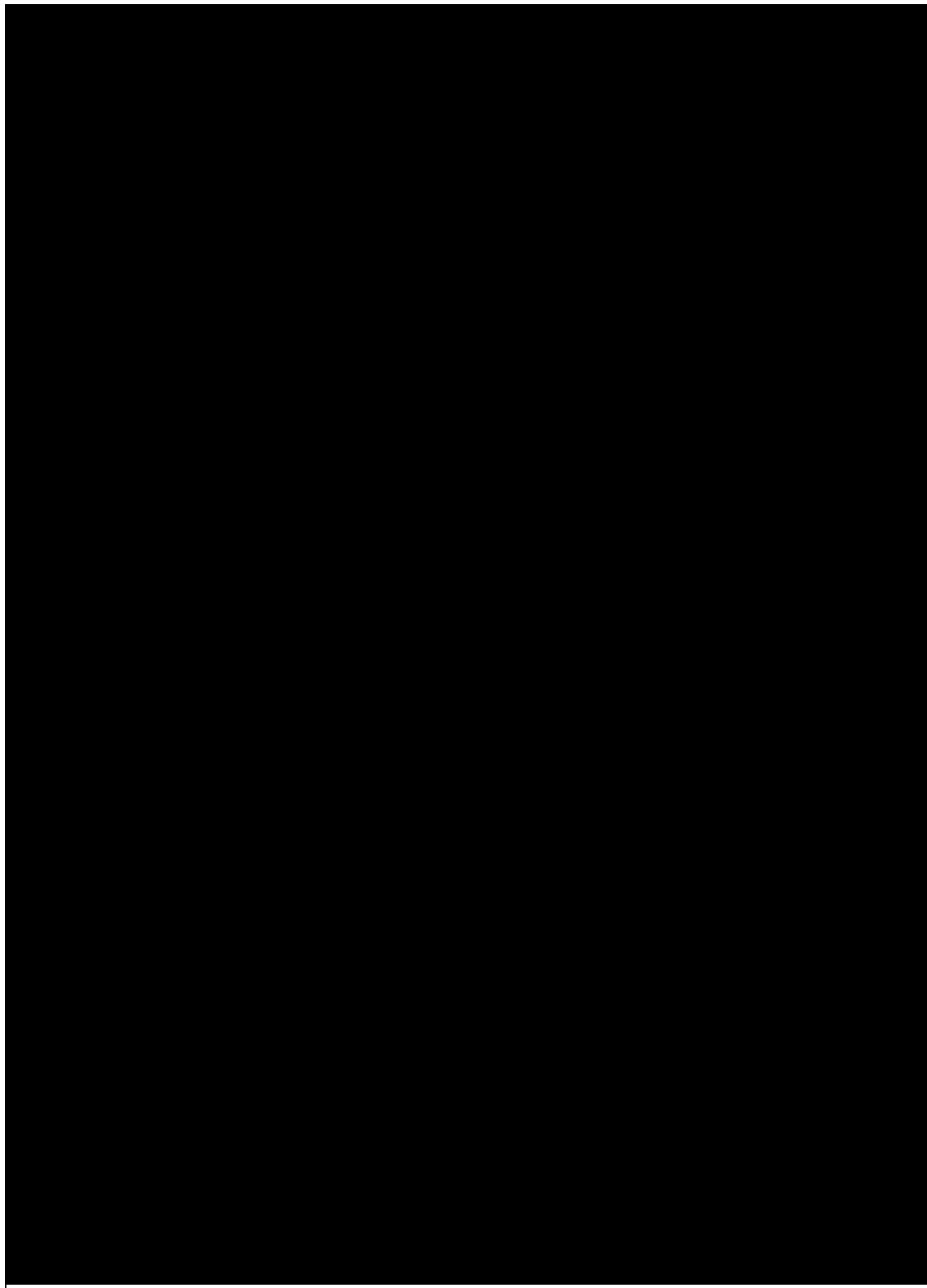
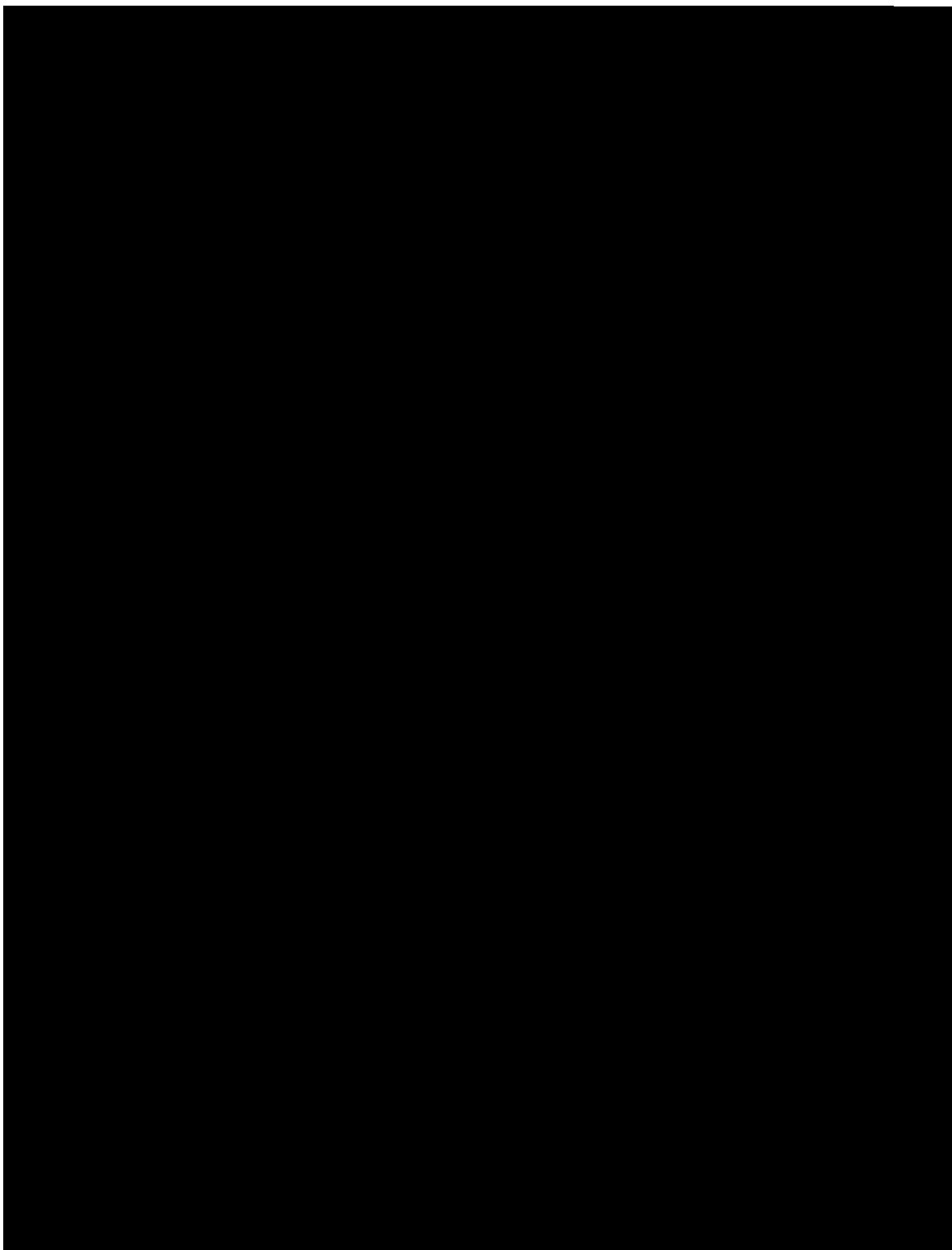


Figure TM-17—Actual Well Schematic for [REDACTED]

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**Figure TM 18 – Proposed Recompletion of [REDACTED] as In Zone Monitoring Well**

#### **6.4 Design Bases for Plume and Pressure Front Tracking**

This section presents the forecasted injector bottom-hole pressure, reservoir pressure near the top perforation for the injection well, and the pressure and CO<sub>2</sub> saturation at the In-Zone monitoring wells from during the CO<sub>2</sub> injection period starting at time 0 to year 15 of injection. These predictions were based on our current understanding of the subsurface conditions and are the most likely outcomes of our monitoring program.

Pelican Sequestration Hub, LLC, will continue to monitor and history match the field values with the numerical simulation model if the data gathered in the future tracks the forecasted results. Significant deviations from these forecasts will trigger revisiting subsurface characterization and updating AoR delineation.

Figure TM-19 depicts the forecasted bottom hole pressure at the injection wells during injection and for 50 years post-injection. This bottom hole pressure is reported at the location of the pressure gauge. The gauge will be relocated when the well is recompleted at year █. In well CCS 1, the gauge is initially located at █ ft (TVDSS) and at █ ft (TVDSS) after recompletion. In well CCS 2, the gauge is initially located at █ ft (TVDSS) and at █ ft (TVDSS) after recompletion.

The █ and the intermittent shale intervals between zones results in zonal variations in the pressure and CO<sub>2</sub> saturation response at the monitor wells. Table TM-27 and Table TM-28 shows the expected differential pressure increase expected at the top of the █ and the █ intervals at the in-zone monitoring wells. Figures TM-20 thru TM-24 show a map view of the pore-volume weighted average CO<sub>2</sub> saturation and the pore-volume weighted change in pressure from pre-injection to years 1-5. These maps only consider interval █ since injection is only into these zones through year █. Maps are only presented for years 1-5 since an AoR re-evaluation will be performed at or prior to year 5.



Figure TM-19—Forecasted bottom-hole pressure for injector CCS 1 and CCS 2

Table TM-24— Simulated pressure change from pre-injection pressure at the top of the ██████████ zone at each monitoring well location.

Year	██████████	██████████	██████████	██████████
0 (start of injection)	████	████	████	████
1	████	████	████	████
2	████	████	████	████
3	████	████	████	████
4	████	████	████	████
5	████	████	████	████
██████████	████	████	████	████
████	████	████	████	████
████	████	████	████	████
████	████	████	████	████
██████████	████	████	████	████

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**Table TM-25— Simulated pressure change from pre-injection pressure at the top of the [REDACTED] zone at each monitoring well location.**

Year	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
0 (start of injection)	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
1	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
2	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
3	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
4	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
5	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

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**Figure TM-20—Maps of the predicted CO<sub>2</sub> plume and the average change in pressure in zones [REDACTED] after 1 year of injection.**



**Figure TM-21—Maps of the predicted CO<sub>2</sub> plume and the average change in pressure in zones [REDACTED] after 2 years of injection.**

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**Figure TM-22—Map of the predicted CO<sub>2</sub> plume and the average change in pressure in zones [REDACTED] after 3 years of injection.**



**Figure TM-23—Map of the predicted CO<sub>2</sub> plume and the average change in pressure in zones [REDACTED] after 4 years of injection.**



Figure TM-24—Map of the predicted CO<sub>2</sub> plume and the average change in pressure in zones [REDACTED] after 5 years of injection.

## **7.0 Surface and Near Surface monitoring [40 CFR 146.90 (h)]**

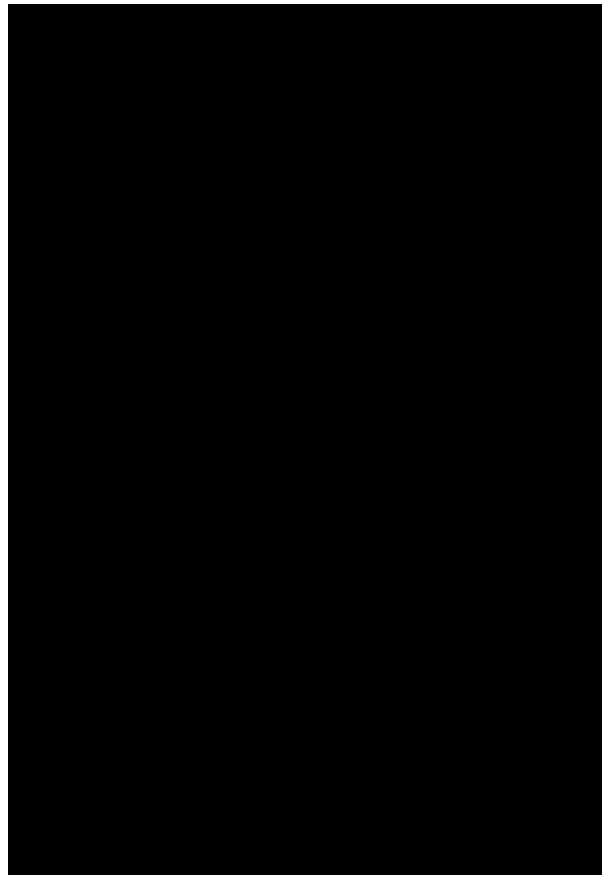
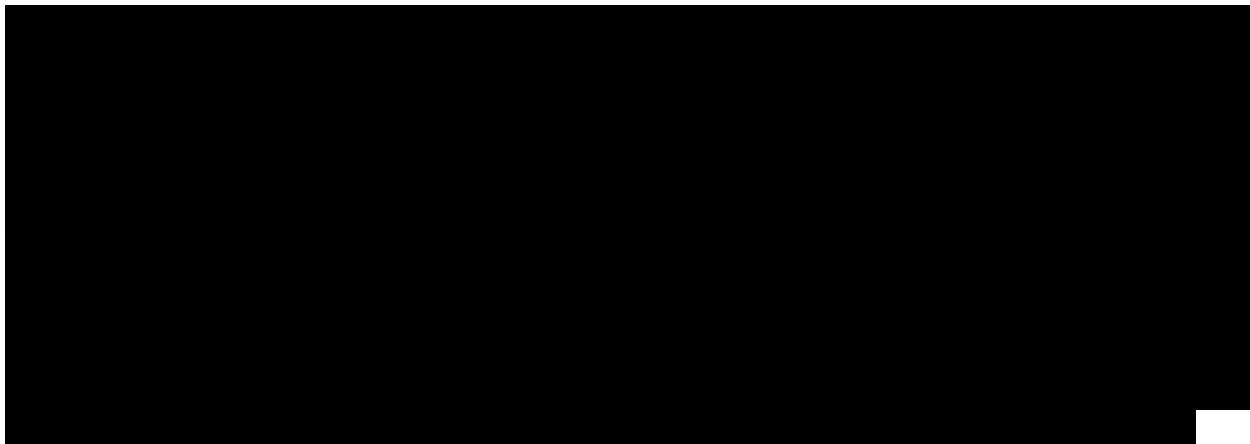
### ***7.1 Soil Gas Monitoring and isotopic fingerprinting***

Pelican Sequestration Hub, LLC will install soil gas sample stations and collect soil gas samples utilizing methodology developed by researchers at the GCCC. The samples will be analyzed by a certified commercial laboratory to determine gas composition as well as isotopic signatures of carbon and hydrogen elements. This data will be used to inform Process Based Soil Gas Monitoring to monitor for ecological stress and distinguish a leakage signal from natural vadose zone CO<sub>2</sub> providing for attribution at the site. Modeling and additional geochemical data from the subsurface overburden will be used to define diagnostic parameters for attribution in soil gas.

Soil gas assessment will consist of characterization of soil gas CO<sub>2</sub>, CH<sub>4</sub>, O<sub>2</sub>, and N<sub>2</sub> ratios within a process-based framework and collection of additional isotopic parameters for further assessment, if thresholds are ever exceeded (Table TM-27). [REDACTED], soil gas will be analyzed for CO<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub>, CH<sub>4</sub>, C1-C5 hydrocarbons,  $\delta^{13}\text{C}$  and  $^{14}\text{C}$  of CO<sub>2</sub>, and CH<sub>4</sub> and  $\delta\text{D}$  of CH<sub>4</sub>. At the end of characterization period, protocols for detection of leakage signal will be tailored to site base data.

As part of the process for designing and selection of the soil gas station locations, an airborne electromagnetic survey will be conducted over the area of interest. The aerial electromagnetic (EM) data will be used to identify and map the extent of near-surface and surface salinization. This environmental determination will inform additional parameters for groundwater monitoring to complement soil gas as part of the near surface monitoring strategy. This survey will be performed with aircraft mounted sensors that allow it to cover extensive areas of investigation

### ***7.1.1 Sampling location and frequency for soil gas***



*Figure 1. Schematic of gas sampling station construction showing individual gas wells set at different levels. Not to scale.*

**Figure TM-25—Schematic of Gas Sampling Station**

**Table TM-26—Gas Sampling Locations, Frequencies, and Methods**

Monitoring Locations	Monitoring Activity	Target Formation	Pre-injection	Injection Period
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

### **7.1.2 Parameters for soil gas analysis**

**Table TM-27—Soil Gas Analysis Parameters**

Soil Gas Parameter	Analysis method
[REDACTED]	[REDACTED]

### **7.1.3 Sampling soil gas analysis**

Sampling will be performed by trained or specialize personnel from the lab at the beginning of the operation, and the field operator will be trained in the process to be able to take samples and monitor gas compositions with handheld devices as routine operation. The samples are taken in specialized bags to collect the gas and will be sent to a third-party laboratory. Calibration of the field equipment will be performed by manufacturer protocol.

### **7.1.4 Laboratory to be used/chain of custody and analysis procedures**

The samples will be analyzed by a third-party laboratory using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and photo ionization. Analytic methods and chain of custody procedures will follow the laboratory protocol.

## **7.2 CO<sub>2</sub> sensors in injector and monitoring wellheads**

Pelican Sequestration Hub, LLC will install infrared gas detectors close to the wellheads of the injector and monitoring wells. These sensors will interface with the surveillance system to set alarms and provide information on potential leaks at the surface. The final selection of the technology will consider the integration of all the sensors and transducers in a unique surveillance system. Calibration and maintenance protocols will be based on the manufacturer specifications and will be performed by specialized professionals. Table TM-28 shows referential technical specifications for the CO<sub>2</sub> leak detector.

**Table TM-28—Infrared Gas Detector Parameters**

Type of Sensor	[REDACTED]
<b>Measurement Ranges</b>	
Combustible	[REDACTED]
CO <sub>2</sub>	[REDACTED]
<b>Resolution</b>	
Response Time	[REDACTED]
<b>Approval Classification</b>	
Operating Ranges	[REDACTED]
<b>Relative Humidity</b>	

**Table TM-29—Atmospheric CO<sub>2</sub> Sensor in wellhead**

Tool	Pre-Injection	Injection
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]

### ***7.3 Induced seismicity monitoring***

Pelican Sequestration Hub, LLC will deploy a seismometer monitoring network to determine the locations, magnitudes, and focal mechanisms of the injection-induced seismic events in case they are observed. This information will be used to address public concerns and identify features that may help to evaluate the plume and pressure front behavior.

#### ***7.3.1 Monitoring location and frequency for seismicity measurement***

**Table TM-30—Seismicity Monitoring Tools**

Tool	Pre-Injection	Injection
[REDACTED]	[REDACTED]	[REDACTED]

#### ***7.3.2 Traffic light system***

While the historical seismicity of the project area indicates few earthquakes in the area, the operator intends to maintain a surface array for the duration of the project to ensure the safe operation of both the storage facility and adjacent infrastructure in the area. This seismic monitoring will be conducted with a surface array deployed to ensure detection of events above ML 2.0 with epicentral locations within 5.6 miles of the injection well.

If an event is recorded by either the local private array or public national array to have occurred within 5.6 miles of the injection well, the operator would implement its response plan subject to detected earthquake magnitude limits defined below to eliminate or reduce the magnitude and/or frequency of seismic events.

- For events above ML 2.0 within 5.6 miles of the injection well, the operator will closely monitor seismic activity and may implement a pause to operations or continue operations at a reduced rate, should analysis indicate a causal relationship between injection operations and detected seismicity.
- For events above ML 4.0 within 5.6 miles of the injection well, the operator will reduce the injection rate by not less than 50%. A detailed analysis is conducted to determine if a causal relationship exists. Should a causal relationship be determined, a revised injection plan would be developed to reduce or eliminate operationally related seismicity. Such plans are dependent on the pressures and seismicity observed and may include, but not be limited to:
  1. Pausing operations until reservoir pressures fall below a critical limit,
  2. Continuing operations at a reduced rate and/or below a revised maximum operation pressure.
- For events above ML 4.5 within 5.6 miles of the injection well, the operator will stop injection as soon as safely practical. The operator will then immediately inform the regulator of seismic activity and inform them that operations have stopped pending a technical analysis. The operator will initiate an inspection of surface infrastructure for damage that may have resulted from the earthquake. A detailed analysis is conducted to

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determine if a causal relationship exists between injection operations and observed seismic activity. Should a causal relationship be determined, a revised injection plan would be developed to reduce or eliminate operationally related seismicity before resuming injection operations. Such plans are dependent on the pressures and seismicity observed, and may include, but not be limited to:

1. Pausing operations until reservoir pressures fall below a critical limit,
2. Continuing operations at a reduced rate and/or below a revised maximum operation pressure.

## **References**

Romanak, K. D., P. C. Bennett, C. Yang, and S. D. Hovorka (2012), Process-based approach to CO<sub>2</sub> leakage detection by vadose zone gas monitoring at geologic CO<sub>2</sub> storage sites, *Geophys. Res. Lett.*, 39, L15405, doi:10.1029/2012GL052426.

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