Application No. 45079, 45080, 46169, 46170, and 46171

QUALITY ASSURANCE AND SURVEILLANCE PLAN

Pelican Sequestration Project

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1.0 Facility Information

Facility name: Pelican Sequestration Project
Pelican CCS 1, Pelican CCS 2, Pelican CCS 3, Pelican CCS 4, and Pelican CCS 5 wells

Facility contacts: Tyler Spoede, Project Manager
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Well location: Livingston, Louisiana

Well Name	Longitude (NAD 27)	Latitude (NAD 27)	Longitude (NAD 83)	Latitude (NAD 83)
Pelican CCS 1	-90° 40' 55.76"	30° 35' 19.16"	-90° 40' 56.10"	30° 35' 19.83"
Pelican CCS 2	-90° 40' 58.83"	30° 34' 53.98"	-90° 40' 59.17"	30° 34' 54.66"
Pelican CCS 3	-90° 43' 50.13"	30° 36' 10.56"	-90° 43' 50.48"	30° 36' 11.24"
Pelican CCS 4	-90° 44' 29.72"	30° 36' 41.03"	-90° 44' 30.06"	30° 36' 41.70"
Pelican CCS 5	-90° 46' 30.21"	30° 37' 35.26"	-90° 46' 30.56"	30° 37' 35.93°

2.0 Project Management and Surveillance Process

Characterization of the Injection Zones, Confining Zones, and subsurface features has been done by experienced geoscience professionals using industry-recognized software and techniques. Further characterization of the features will be done using the latest logging and testing technologies during construction and operation of the CO_2 Injection wells.

Pipeline, surface equipment, and well designs comply with industry standards for CO_2 material selection and operating conditions to promote mechanical integrity of the system during the life of the project.

Monitoring programs for leak detection, corrosion, and surveillance have been tailored for the site to ensure protection of the underground sources of drinking water (USDWs) and environment, maintain mechanical integrity of the installation during operations, and maximize the storage life of the asset. These plans incorporate best practices and recommendations for Carbon Capture and Storage projects worldwide as well as Occidental’s (Oxy’s) decades of experience in the development of CO_2 enhanced oil recovery (EOR) fields.

As part of the quality control process during testing and surveillance, most of the samples collected and data gathered will be analyzed, processed, validated, or witnessed by third parties independent of the operations staff. For specialized data such as seismicity and distributed temperature sensing (DTS), the project will have additional support from the providers of the selected technologies in quality control, verification of the data, and system calibration.

Sensors, transducers, and controllers will be connected to a central platform to allow for monitoring of operating conditions, system upset alarming, and safety protocol initiation. System data interfaces will be created and integrated into a unique surveillance platform. The operating parameters, monitoring values, laboratory results, and surveillance documents for the project will be stored in a central database to provide support for Area of Review (AOR) reviews, quality assurance programs, and reporting.

The project will establish key staffing positions for reliable operation, surveillance procedures, storage evaluation, and reporting. Some of the staff will be dedicated full-time to the operation, while others will be assigned as required during AOR reviews, maintenance activities, and other project activities.

Once the project is in operation, Pelican Sequestration Hub, LLC will provide an updated contact list with the names of the individuals in each position. The list will then be updated upon request.

2.1. Project/Task Organization

2.1.1 Key Individuals and Responsibilities

A brief description of the project organization is below:

The Pelican Sequestration Project is supported by multidisciplinary teams from Pelican Sequestration Hub, LLC, consultants, subcontractors, and government entities. Each team will provide technical expertise and economic input into the project to ensure a safe, successful, and efficient operation.

The project is led by the President of 1PointFive Sequestration, LLC, an Oxy subsidiary responsible for the sequestration scope of work. Pelican Sequestration Hub, LLC is a joint venture owned through subsidiaries of Oxy and Enbridge. The President is responsible for the overall execution of the project. Reporting to the President are the Director of Subsurface Evaluation and the Director of Operations and Technical Support.

- **Director Subsurface Evaluation:** This director plays a critical role in the subsurface activities regarding the CO_2 sequestration site, including geological and reservoir modeling, petrophysics, and geophysics. This director is responsible for analyzing the site and ensuring subsurface safety based on various modeling assumptions regarding carbon capture and storage.

- **Director Operations and Technical Support:** This director plays a central role in implementing all data gathering and analysis for the CO_2 Storage Project. This director provides overall coordination and responsibility for organizational and administrative aspects of the project and is also responsible for the planning, funding, schedules, and controls needed to implement project plans and ensure that project participants adhere to the plan.

- **Director Commercial Development:** This director plays an important role in enlisting emitters to provide sources of CO_2 for sequestration. This individual negotiates contracts with the various parties and identifies the financial terms.

- **Project Manager:** The project manager is responsible for project implementation after pore space characterization and project commercial contracting is complete. This role is responsible for coordinating the Class VI permitting process, other environmental and project permit approvals, drilling the wells, facility installation, and project commissioning and startup.

- **Facilities Engineer:** The role of the facilities engineer (FE) is to identify quality-affecting processes and monitor compliance with project requirements. The FE is responsible for establishing and maintaining the project quality assurance plans, monitoring project staff compliance with those plans, and ensuring that this Quality Assurance and Surveillance Plan (QASP) meets the project's quality assurance requirements.

- **Drilling/Production Engineer**: The role of the drilling/production engineer is to design the injection and various monitoring wells, including obtaining budget pricing information, designing the wellbores, drilling the wells, and developing the monitoring programs for the wells involved. One additional responsibility is reviewing the wellbores within the proposed CO_2 plume and pressure front and provide a plan for remediation, as needed.

- **Reservoir Engineer:** The role of the reservoir engineer is to gather subsurface data and run the simulation model to predict the pressure front and CO_2 plume movement. This person must work closely with the other subsurface staff to achieve accurate results with the data available.

- **Geologist**: The role of the geologist is to define the subsurface storage area, to create a geologic model, and incorporate the seismic and petrophysical data into the model.

- **Geochemist:** The role of the geochemist is to evaluate fluid and gas data obtained from wells and integrate the information with the geologic, petrophysical, and reservoir engineering information to characterize fluid and gas compositional changes in the subsurface.

- **Petrophysicist:** The role of the petrophysicist is to analyze the available logs and generate porosity and permeability models for use in the subsurface model of the area.

- **Geophysicist**: The role of the geophysicist is to help define the subsurface storage area by analyzing the available 2D and 3D seismic images of the area and interpreting faults or other areas that could potentially be leakage pathways.

- **Subject Matter Experts/Task Leads:** Well testing and monitoring subject matter experts (SMEs) and task leads comprise both internal and external (subcontractor) geologists, hydrologists, chemists, atmospheric scientists, ecologists, etc. These SMEs help develop testing and monitoring plans, collect environmental data specified in those plans using best practices, and maintain and update those plans as needed.

2.1.2 Independence from Project QA Manager and Data Gathering

Most of the physical samples collected and data gathered as part of the monitoring program will be analyzed, processed, or witnessed by third parties independently and outside of the project management structure.

2.1.3 QA Project Plan Responsibility

The Pelican Sequestration Hub, LLC, will be responsible for maintaining and distributing official, approved QASP project plans. The Pelican Sequestration Hub, LLC, will periodically review the QASP and consult with the Louisiana Department of Conservation and Energy (C&E) if changes are recommended.

2.2. Data Verification and Validation

The project will establish a standardized program for data acquisition and validation methods. The program will verify that collected data is reasonable, processed and analyzed correctly, and reviewed for errors. Peer reviews or third-party consultants will serve as a quality control mechanism. Issues identified during peer reviews will be addressed and corrected by the data owner. Errors identified in the data validation will be corrected, and affected users will be notified. Corrective actions will be coordinated to mitigate and address any impacts from data errors.

2.3 Management of Change

The project will implement a management of change (MOC) procedure to communicate and document any deviation from policies, operational parameters, and standard operating procedures. The MOC procedure aims to mitigate deviations in cost and project scope.

2.4 Contractor Requirements

Each contractor will follow a qualification process before being authorized to execute work on site or in their shop. Each contractor providing service to the Pelican Sequestration Project must provide a copy of their quality assurance/quality control (QA/QC) and safety management program to qualify for performing the work. The contractors may be audited by the Pelican Sequestration Hub, LLC, SMEs, and safety representatives. All contractors are required to comply with the Worker Safety Program and Operations policies at the work site. The Pelican Sequestration Hub, LLC reserves the right to inspect and audit the contractor's operation and quality program to guarantee the safety and quality programs are being followed.

2.5 Special Training and Certificates

Wireline logging, indirect geophysical methods, and nonroutine sampling will be performed by trained, qualified, and certified personnel, according to the service company's requirements.

Routine injectant and groundwater sampling will be performed by trained personnel, but no specialized certifications are required. Some special training will be needed for project personnel, particularly in the areas of logging processing and interpretation, certain geophysical methods, certain data acquisition and transmission systems, and certain sampling technologies.

Training of project staff will be conducted by project personnel knowledgeable in project-specific sampling procedures. Training documentation will be maintained as project QA records.

2.6 Documentation, Records, and Reporting

All data and project records will be stored electronically on secure servers and will have routine backups. Reporting will comply with C&E Class VI Underground Injection Control (UIC) requirements.

All testing and monitoring techniques and other procedures set forth below are subject to change, based on actual operations and technical, operational, and safety concerns encountered.

3.0 Testing and Monitoring Techniques

Calibration and quality control of the tools will follow the service provider's protocols and procedures.

3.1 Cement Bond Log and Variable Density Log

For cement quality evaluation, the testing and monitoring plan proposes using cement bond logs (CBL) and variable density logs (VDL). Table QASP-1 provides the basic data for some of the tools in the market.

3.1.1 Tool Specifications

Table QASP-1—Cement bond logging and variable density log specifications (CBL/VDL).

CBL/VDL Tool Specifications		
	Halliburton RBT-M	**SLB DSLT**
Recommended Logging Speed (ft/min)	30	30
Maximum Logging Speed (ft/min)	60	60
Maximum Temperature (°F)	350	302
Max OD (in)	2.75	3.625
Length (in)	9.375	20.63
Maximum Pressure (psi)	20,000	20,000
Minimum Csg/Tbg ID (in.)	3.50	5.50
Maximum Csg/Tbg OD (in.)	10.75	13.375
Weight (lbs)	116	313
Vertical Resolution (ft)	5	5
Borehole Fluid	Water, Oil	Water, Oil
Tool Positioning	Centralized	Centralized
Vertical Resolution (ft) - Sonic Waveform	5	5
Vertical Resolution (ft) - E_1 Peak Amp	3	3

These activities will be executed by specialized contractors with proven industry technology. Calibration and quality control of the tools will follow the service provider's protocols and procedures.

3.1.2 CBL/VDL Log Running Procedure Example.

1. Move in the wireline unit.
2. Ensure the wellbore is filled with treated water or brine.
3. Make sure the wellhead valve is in the closed position. Remove the top cap, then rig up 10K grease injection wireline pressure control equipment (PCE) for attachment to the wellhead. A crane will be required to rig up the wireline unit.
4. Rig up the CBL/VDL tool string.
5. Inspect all connections and accessories and conduct surface tool checks.
6. Lift the tool string into the PCE using wireline.
7. Connect the PCE to the wellhead and equalize the lubricator.
8. Open the wellhead valve and lower tools into wellbore.
9. Run in the hole to the desired depth.
10. Pressure casing up to 500 psi (optional).
11. Log up at vendor-recommended speed over the area of interest.
12. Pull out of the hole, bleed off the lubricator, and lay and rig down the CBL/VDL tool string.

3.2 Electromagnetic and Ultrasonic Cement and Casing Evaluation Tools

For mechanical integrity evaluation, the Testing and Monitoring Plan and Pre-Operational Formation Testing Plan propose using ultrasonic and electromagnetic tools to evaluate the conditions of the tubulars in the well and provide information about thickness, ovality, ruptures, potential corrosion, etc. Table QASP-2 provides the basic data for some of the proposed tools available in the market.

3.2.1 Tool Specifications

Table QASP-2—Tool data sheet summary for magnetic, sonic and ultrasonic tools.

Logging Type	Isolation Scanner	USIT	EM Pipe Xaminer	EM Pipe Scanner	CAST-XR
Acquisition	Real Time	Real Time	Real Time	Real Time	Real Time
Logging speed	2,700 ft/h	1,800 ft/h	900 ft/h	1,800 to 3,600 ft/h	3,600 ft/h
Thickness measurement accuracy				EM thickness 15%	+/- 0.05 in
Range of measurement	0 to 10 MRayl	0 to 10 MRayl		1.5 inch	0 to 10 MRayl
Mud type limitations	none	none	none	none	none
Temperature rating	350°F	350°F	350°F	302°F	350°F
Pressure rating	20,000 psi	20,000 psi	15,000 psi	15,000 psi	20,000 psi
Casing size minimum	4 ½ in.	4 ½ in.	2.38 in.	2 ⅞ in.	4.67 in.
Casing size maximum	9 ⅝ in.	13 ⅜ in.	24 in.	13 ⅜ in.	20 in.
Outside diameter	3.37 in.	3.375 in.	1.69 in.	2.125 in.	3.625 in.
Length	19.73 ft	19.75 ft	17.34 ft	19.7 ft	17.9 ft
Weight	333 lb	333 lb	87 lb	110 lb	316 lb

Logging Type	Isolation Scanner	USIT	EM Pipe Xaminer	EM Pipe Scanner	CAST-XR
1st Pipe defect detection accuracy			1%	± 0.05 in.	
1st Pipe (2Cs) accuracy			2% or 0.015 inch		
Total metal thickness 1.2 in. (3Cs) overall average			7%		
Total metal thickness 1.8 in. (4Cs) overall average			10%		

These activities will be executed by specialized contractors with proven industry technology. Calibration and quality control of the tools will follow the service provider's protocols and procedures.

3.2.2 Ultrasonic/Electromagnetic Log Running Procedure Example

1. Move in the wireline unit.
2. Ensure the wellbore is filled with treated water.
3. Make sure the wellhead valve is in the closed position. Remove the top cap, then rig up 10k grease injection wireline pressure control equipment (PCE) for attachment to the wellhead. A crane will be required to rig up the wireline unit.
4. Rig up the ultrasonic/electromagnetic tool string.
5. Inspect all connections and accessories and conduct surface tool checks.
6. Lift the tool string into the PCE using wireline.
7. Connect the PCE to the wellhead and equalize the lubricator.
8. Open the wellhead valve and lower tools into wellbore.
9. Run in the hole to the desired depth.
10. Log up at the vendor-recommended speed over the area of interest.
11. Pull out of the hole, bleed off the lubricator, and lay and rig down the ultrasonic/electromagnetic tool string.

3.3 Temperature Log

To help locate gas entries, detect casing leaks, and evaluate fluid movement behind the casing in the monitoring wells, the Testing and Monitoring Plan proposes using temperature logs as a potential method. Table QASP-3 provides an example of basic tool specification.

3.3.1 Tool Specifications

Table QASP-3—Halliburton BHPT-I (temperature) specifications.

Halliburton BHPT-I Specifications	
Maximum Temperature	350°F
Maximum Pressure	20,000 psi
Maximum OD	3.625 in.
Tool Length	6.77 ft
Minimum Hole ID	4.25 in.

Halliburton BHPT-I Specifications	
Maximum Hole ID	24 in.
Borehole Fluids	Brine/Fresh/Oil/Air
Tool Positioning	Centralized/Eccentralized
Maximum Logging Speed	60 ft./min.
Pressure Measurement Range	0 - 20,000 psi
Temperature Measurement Range	32 - 350° F
Resistivity Measurement Range	0.01 - 25 Ohm-m
Pressure Resolution	1 psi
Temperature Resolution	.01° F
Resistivity Resolution	0.01 Ohm-m

These activities will be executed by specialized contractors with proven industry technology. Calibration and quality control of the tools will follow the service provider's protocols and procedures.

3.3.2 Temperature Log Running Procedure Example

1. Move in the wireline unit.
2. Make sure the wellhead valve is in the closed position. Remove the top cap, then rig up 10k grease injection wireline pressure control equipment (PCE) for attachment to the wellhead. A crane will be required to rig up the wireline unit.
3. Rig up the temperature tool string.
4. Inspect all connections and accessories and conduct surface tool checks.
5. Lift the tool string into the PCE using wireline.
6. Connect the PCE to wellhead and equalize the lubricator.
7. Open the wellhead valve and lower tools into the wellbore.
8. Run in the hole to the desired depth.
9. Log up at the vendor-recommended speed over the area of interest.
10. Pull out of the hole, bleed off the lubricator, and lay and rig down the temperature tool string.

3.4 Pulse Neutron Log

The pulsed neutron log is considered a proven technique to detect gas saturation in reservoirs. Advances in technology have improved the accuracy of the tool for tracking movement of CO_2 plumes in the reservoir and evaluating flow conformance. Table QASP-4 shows the basic specification of some of the tools in the market.

3.4.1 Tool Specifications

Table QASP-4—Basic tool specifications for pulse neutron.

Logging Type	Pulsar – Neutron (Schlumberger)	TMD3D Pulsed Neutron (Halliburton)
Acquisition	Real Time	Real Time
Logging speed	200 to 3,600 ft/h	60 to 1,800 ft/h

Logging Type	Pulsar – Neutron (Schlumberger)	TMD3D Pulsed Neutron (Halliburton)
Depth of investigation		10 to 14 in.
Vertical resolution		24 in.
Range of measurement	0 to 60 pu	5 to 60 pu
Mud type limitations	none	none
Temperature rating	350°F	300°F
Pressure rating	15,000 psi	15,000 psi
Casing size minimum	2 ⅜ in.	2 in.
Casing size maximum	9 ⅝ in.	16 in.
Outside diameter	1.72 in.	1.69 in.
Length	18.3 ft	14.25 ft
Weight	88 lb	35 lb

These activities will be executed by specialized contractors with proven industry technology. Calibration and quality control of the tools will follow the service provider's protocols and procedures.

3.4.2 Pulse Neutron Log Running Procedures Example

1. Move in the wireline unit.
2. Make sure the wellhead valve is in the closed position. Remove top cap, then rig up 10k grease injection wireline pressure control equipment (PCE) for attachment to the wellhead. A crane will be required to rig up the wireline unit.
3. Equalizing: if possible, the lubricator should be equalized with a standalone CO_2 source/test pump rather than from the wellbore via needle valve.
4. Rig up the pulse neutron tool string.
5. Inspect all connections and accessories and conduct surface tool checks.
6. Lift the tool string into PCE using wireline.
7. Connect PCE to wellhead and equalize the lubricator.
8. Open the wellhead valve and lower tools into wellbore.
9. Function-test tools and conduct any calibrations while running in the hole.
10. Log over known wet zone first if one is available.
11. Proceed to Plugged Back True Depth (PBTD) with the tool string, being careful not to spud the tool string into the PBTD.
12. Upon reaching PBTD, log three passes the over area of interest at the vendor-recommended speed in C/O mode.
13. Proceed to PBTD with tool string, being careful not to spud tool string into PBTD.
14. Upon reaching PBTD, log one pass over the area of interest at the vendor-recommended speed in Sigma mode.
15. Pull out of the hole, bleed off the lubricator, and lay and rig down the pulse neutron tool string.

3.5 Mud Logging

Mud logging samples will be collected during drilling from the surface to final total depth (TD). Descriptions of the cuttings, Measure while Drilling / Logging While Drilling (MWD/LWD) gamma, and real-time drilling observations will be used to help call formation tops, influence rate of penetration (ROP) before core runs, and call or adjust core depths. Post-drill: cuttings and mud log documents will be used to further describe the subsurface.

3.5.1 Cuttings & IsoTube/Isojar Mudgas Collection

- Dry Cutting Samples
  - Collect unwashed, dry samples (30 grams) every 30 ft from the surface to TD.
- Wet Cutting Samples
  - Collect unwashed, wet samples (250 grams) every 30 ft from the surface to TD.
- Spare Cutting Samples
  - Collect washed, dry samples (30 grams) every 30 ft from the surface to TD (~10,900 ft).
  - Photograph magnified dry samples every 30 ft from the top of Anahuac to the base of the upper Frio (upper confining system and storage reservoir) and every 90 ft outside the previously mentioned interval from spud to TD except while coring.
  - Dispose of spare cutting samples on shakers after use.
- IsoTube/Isojar Mud Gas Collection
  - Collect mud gas samples from the provided manifold within each predetermined depth interval.

3.5.2 Mud Logger Requirements

- If the ROP is too high for the sampling rate, notify the project geologist.
- Contact the project geologist for approval to bring an additional crew member(s) on site to help catch samples at the requested rate.
- If going over the shakers or not using a bypass sluice box, it is the mud logger's responsibility to collect samples representative of the entire sample interval.
- Gas detection and analysis equipment (gas flow lines, filters, gas trap, antifreeze, etc.) shall be checked and/or calibrated at the beginning of each shift. The chromatograph should be calibrated to pentane. This should be noted on the mud log along with mud logger's name. Gas should be reported in parts per million (ppm).
- Do not dry cuttings with a heat lamp. Air dry or use a low-heat vacuum.
- Conduct oil cut and oil show analysis for the entirety of the well, regardless of mud system, for every sample. Photographs should be taken of oil shows under UV and white light in a dimple dish with the MD of each sample written under the respective sample.
- Photographs of cuttings should be taken of every 30-ft sample or as time permits, be magnified, and include a scale.
- All ditch and caving samples shall be examined on site and fully described on a Master Mud log at a scale of 1:100.

3.5.3 Mud Logging Reporting

- All deliverables (i.e., sample bags, IsoTubes, isojars, and AGI) sent out for analysis (wet cuttings, gas, or fluids) should be labelled clearly with a permanent marker, including well name, API number, and depth range in measured depth.
- Shipping containers (e.g., buckets and rice bags) should be clearly labelled with full well name, API number, and depth range of samples within container. Labels should be clearly visible on containers and written with water-resistant ink.
- Each container should include an inventory list of the cuttings within that container.
- Containers should be shipped in accordance with OSHA standards, and a tracking number should be provided to the project geologist once containers have been shipped.

3.6 Coring and SWC Sampling

The coring contractor must provide tools in good condition and according to the program discussed with the technical team. The Pelican Sequestration Project reserves the right to inspect the tools and request a replacement, if substandard conditions are detected. The coring contractor must provide the tools to cut, retrieve, and stabilize the core to get the maximum possible recovery factor. All cores or sidewall cores (SWC) taken shall be placed in a standard core box and preserved according to the recommendation of the Pelican Sequestration Project SME.

3.7 CO_2 Threshold Entry Pressure Measurement

The core plugs will be loaded into core holders and the entire assemblies loaded into a temperature-controlled oven. Pore pressure, net overburden pressure, and temperature are matched to reservoir conditions. Specific permeability to synthetic formation brine is measured. Permeability is monitored to ensure stability is reached. Supercritical CO_2 is then exposed to the inlet face of the plug.

<u>Stepwise Injection Method:</u> For low permeability samples, a series of differential pressures will be applied to observe the injection of CO_2. If no injection occurs after at least two days, the next pressure step is applied. After breakthrough occurs, the differential pressure will be maintained and then increased to the next step to verify if breakthrough occurs.

3.8 Analysis of Injected CO_2

3.8.1 CO_2 Stream Analysis Protocol

The CO_2 injection stream will be continuously monitored at the surface for pressure, temperature, and flow. Quarterly samples will be collected and analyzed to track CO_2 composition and purity. Table QASP-5 shows the list of constituents to be analyzed, based on the anticipated composition of the CO_2 stream.

Table QASP-5—CO_2 Stream Analysis.

Constituent	Frequency
Pressure	Continuous
Temperature	Continuous
Rate	Continuous

Constituent	Frequency
CO_2 (% mol)	Quarterly
Water (lb./MMCF)	Quarterly
Nitrogen (% mol)	Quarterly
Oxygen (% mol)	Quarterly
Hydrogen (% mol)	Quarterly
SOx (ppm by vol.)	Quarterly
NOx (ppm by vol.)	Quarterly
Hydrogen Sulfide (ppm by vol.)	Quarterly
Hydrocarbons (% mol)	Quarterly
Carbon Monoxide (ppm by vol.)	Quarterly
Glycol (gal/MMSCF)	Quarterly
Argon (%mol)	Quarterly
Sulfur (ppm by wgt)	Quarterly
Amines (ppmw)	Quarterly
Alcohols (ppmv)	Quarterly
NH_3 (ppm by wt)	Quarterly
Mercury (nanograms/liter)	Quarterly
$\delta^{13}C$ of CO_2	During Characterization
14C of CO_2	During Characterization

3.8.2 Sampling and Custody

CO_2 sampling will be performed upstream or downstream of the flowmeter. Sampling procedures, including where the sampling will be performed, will be further refined during the front-end engineering and design (FEED) and will follow contractor protocols to ensure samples are representative of the injectant. Samples will be processed, packaged, and shipped to the contracted laboratory, following standard sample-handling and chain-of-custody guidance (EPA 540-R-09-03, or equivalent). Sample tubing, connectors, and valves required to sample the CO_2 gas stream will be supplied by the analytical lab providing the sampling containers. Once the samples are analyzed, the laboratory will be responsible for disposing of the containers and residues properly.

3.8.3 Equipment and Calibration

Sampling equipment in the field will be maintained, serviced, and calibrated per the manufacturer's recommendations. Spare parts that may be needed will be included in the supplies on hand during field sampling. Laboratory equipment supply, testing, calibration, inspection, and maintenance will be the responsibility of the analytical laboratory per its protocols and quality assurance (QA) program. The Pelican Sequestration Project reserves the right to review and audit the protocols and methods of the selected laboratory before awarding the work.

3.8.4 Personnel and Training

During initial operations, sampling will be performed by trained personnel from the laboratory. In addition, the field staff will be trained in the procedures and protocols to take the samples.

4.0 Analytical Methods

4.1 CO_2 Sampling

The operating temperature for the gas chromatography (GC) analytical method is from –10°C to 50°C. Also, the relative humidity should be 95% or less so there is no condensation.

Table QASP-6—Sampling methods summary.

Analytical Parameter	Analytical Method	Typical Precision/Accuracy
CO_2	GC/TCD	± 2% of full scale
Water	Stain Tube	± 10%
Nitrogen	GC/TCD	± 1% of full scale
Oxygen	GC/TCD	± 1% of full scale
Argon	GC/TCD	± 1% of full scale
Hydrogen	GC/TCD or GC/HID	± 1% of full scale
Sulfur Dioxide	GC/SCD	± 2% of full scale
Nitrogen Dioxide	Colorimetric	± 20%
Nitric Oxide	Colorimetric	± 20%
Hydrogen Sulfide	GC/SCD	± 2% of full scale
Hydrocarbons	GC/FID	± 0.5% of full scale
Carbon Monoxide	GC/HID	± 0.5% of full scale
Glycol	GC/FID	± 10%
Sulfur	GC/SCD	± 2%
Carbonyl Sulfide	GC/SCD	± 2%
Alcohols	GC/FID	±5-10%

Notes:

- GC/TCD = gas chromatography with a thermal conductivity detector
- GC/FDP = gas chromatography with flame photometric detector
- GC/HID = gas chromatography with helium ionization detector
- GC/FID = gas chromatography with flame ionization detector
- Oxygen and Argon are reported together.

CO_2 samples will be analyzed during the baseline period to identify isotopes (Table QASP-7).

Table QASP-7—Isotopes Sampled for Identification

Hydrocarbons	Method
$\delta^{13}C$ and ^{14}C of CO_2	GC-IRMS, AMS for ^{14}C

Notes:

- GC-IRMS = Gas chromatography isotope ratio mass spectrometry

- AMS = Accelerator mass spectrometry

Gas samples will be analyzed by a third-party laboratory, which will be responsible for updating protocols and providing a quality control protocol.

If the CO_2 composition shows abnormal values during the testing period, a validation of the sampling process will be performed with a new sample collected by the laboratory technician and sent to the testing facilities for verification.

4.2 Corrosion Coupons

Injection-well material samples, called coupons, will be monitored for signs of corrosion to verify that the well components meet the standards for material strength and performance and identify well maintenance needs. The 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.

4.2.1 Sampling and Custody

The following information must be recorded prior to coupon installation: coupon serial number, installation date, system location identification number (linked to SAP asset numbering), and coupon and holder orientation. The coupon should also be handled carefully to avoid contamination.

The field operator will collect the coupons and identify them by the serial number, date, company name, location identification number, and field operator name. The operator in the field will visually inspect the coupon for signs of erosion, pitting, scale, or other damage, and will take a picture before packing the sample. The coupon will be protected from oxidation and handling contamination by placing the coupon in a designated, moisture-proof envelope that is impregnated with a volatile corrosion inhibitor and shipped immediately to the laboratory for analysis.

As part of the training program, the field operator will be trained in best practices to mitigate coupon contamination.

4.2.2 Equipment Calibration

Preparation, cleaning, and evaluation of corrosion specimens will be handled by a certified third-party contractor following NACE RP0775-2005 or its equivalent. The contractor is responsible for calibrating and maintaining the measurement equipment as well as disposing of the samples when the analysis is finished.

Table QASP-8—Analytical methods.

Parameters	Analytical Method	Resolution Instruments	Precisions/Std Dev
Mass	NACE SP0775-2018-SC	0.05 mg	2%
Thickness	NACE SP0775-2018-SC	0.01 mm	± 0.05 mm

Notes:

- NACE SP0775-2018-SC – Preparation, Installation, Analysis, and Interpretation of Corrosion Coupons in Oilfield Operations

4.2.3 Quality Control

The Pelican Sequestration Project reserves the right to audit the QA/QC procedures before awarding the work to a contractor and during the execution of the service.

4.3 Soil Gas Sampling

The method for soil gas sampling is described in Section 8.1 of the Testing and Monitoring Plan. The samples will be sent to a specialized laboratory to determine gas composition and perform isotopic analysis to characterize the fluid and get a fingerprint for source characterization and discrimination.

4.3.1 Analytical Method

Compositional analysis of the gases includes chromatographic determination of the concentrations of fixed gases and hydrocarbons listed in Table QASP-9.

Table QASP-9—Soil gas analysis parameters.

Soil Gas Parameter	Analysis method	Detection Limit	Typical Precision/Accuracy
CO_2	GC/TCD	10 ppm	± 2% of full scale
N_2	GC/TCD	10 ppm	± 2% of full scale
O_2	GC/TCD	10 ppm	± 2% of full scale
CH_4, C_2-C_4	GC/FID	10 ppm	± 2% of full scale
C_5-C_6	GC/FID	10 ppm	± 2% of full scale
$\delta^{13}C$ of CO_2	Gas chromatography with combustion isotope ratio mass spectrometry (GC/C/IRMS)	1000 ppm	± 1%
$\delta^{13}C$ of CH_4	Gas chromatography with combustion isotope ratio mass spectrometry (GC/C/IRMS)	1000 ppm	± 1%
$\delta^{2}H$ of CH_4	Gas chromatography combustion isotope ratio mass spectrometry (GC/C/IRMS)	1000 ppm	± 1%

Notes:

- GC = Gas Chromatography
- IRMS = Isotope Ratio Mass Spectrometry

Isotopes are different forms of the same element, differing only in the number of neutrons in the nucleus of the atom. Although some isotopes are unstable and decay radioactively, most are stable. Isotopes are a valuable tool for distinguishing the source of the element and creating a fingerprint of the gas.

4.3.2 Equipment Calibration

Calibration will be performed by manufacturer using their protocol. Sampling will be performed by trained or specialized 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 composition with handheld devices as a part of routine operations.

5.0 Water Sampling

The following methodology will be used to collect ground water samples:

1. Purge the well to remove standing and/or stagnant water from the well casing. Purging also reduces chemical and biochemical artifacts caused by the materials used for well installation and construction and reactions occurring within an open borehole or annular space between a well casing and borehole wall.
2. Purge a minimum of three well-casing volumes while monitoring the temperature, pH, and conductivity until the readings have stabilized.
3. Record the well diameter, water level, well bottom depth, and purge volume on the field data sheet.
4. If the readings have stabilized after purging with three well volumes and meet the criteria in Table QASP-10, then proceed with sample collection.
5. If readings have not stabilized after three well volumes, continue to purge until they are stable, but do not exceed ten purge volumes before collecting samples.
6. If purging three well-casing volumes is not reasonably achievable but field measurements have stabilized, proceed with sample collection.
7. Document those instances when the readings were not stable prior to sample collection or if purge volumes were not achievable.

The measurement stability criteria in Table QASP-10show the allowable variations among five or more field measurements.

Table QASP-10—Field measurement stability criteria.

Field Measurement	Stability Criteria
pH	± 0.1 standards units
Temperature, °C	± 0.5°C
Conductivity, mS/cm	± 5%

5.1 Equipment and Calibration

For groundwater sampling, field equipment will be maintained, serviced, and calibrated according to the manufacturers' recommendations. Spare parts that may be needed will be included in supplies on hand during field sampling. All laboratory equipment, testing, inspection, maintenance, and calibration will be the responsibility of the analytical laboratory according to method-specific protocols and the laboratory's QA program.

5.2 Personnel and Training

Water testing will be performed by certified laboratory personnel following the specific methods approved by the EPA or other applicable industry standards. The Pelican Sequestration Project reserves the right to audit the procedures and results of the selected laboratory with a third party to improve quality control. Field personnel should be trained to perform sampling collection following the laboratory's protocols.

5.3 Analytical Method

Where possible, methods are based on standard protocols from the EPA or standard methods for water analysis. Laboratories shall have standard operating procedures for the analytical methods performed.

Table QASP-11—Analytical method selected for various parameters.

Parameter	Analytical Method	Detection Limit	Typical Precision/ Accuracy
Cations: Al, Ba, B, Cd, Ca, Cu, Cr, Fe, Pb, Li, Mg, Mn, Ni, P, K, Si, Na Sr, Zn	ICP-OES, EPA Method 6010d, ICP-MS Method 200.8 or equivalent (ICP-OES)	< 0.1	± 1%
Other Metals: As, U, Co, Se, Pb, Mo, V	ICP-MS Method 200.8 or equivalent	< 0.1	± 1%
Mercury	EPA 245.7 CVAA, or equivalent (ICP-OES)	< 0.1	± 1%
Anions: Cl^-, Br^-, F^-, SO_4^{2-}, PO_4^{3-}, NO_3^-, NO_2^-	Ion Chromatography, EPA Method 300.1 or similar	< 0.1	± 1%
Alkalinity (carbonate, bicarbonate, and hydroxide)	Titration, ASTM D3875. IC	< 0.1	± 1%
Gravimetric Total Dissolved Solids (TDS)	Gravimetric Method Standard Methods 2540C, ASTM D5907 or equivalent	10 ppm	± 1%
Water Density (specific gravity)	ASTM D5057, ASTM D4052 or equivalent	N/A	± 1%
Stable Carbon Isotopes $^{13/12}C$ (^{113}C) of Dissolved Inorganic Carbon DIC in Water	Gas Bench and CF-IRMS for $\delta^{13}C$	N/A	3 reference standard comparison
Radiocarbon ^{14}C of DIC in Water	AMS for ^{14}C	N/A	± 0.0007 $F^{14}C$
Hydrogen and Oxygen Isotopes $^{2/1}H$ (δ) and $^{18/16}O$ (^{118}O) of Water	CRDS H_2O	N/A	± 1%
Compositional Analysis of Dissolved Gas in Water (including N_2, CO_2, O_2, Ar, H_2, He, CH_4, C_2H_6, C_3H_8, iC_4H10, nC_4H_{10}, iC_5H_{12}, nC_5H_{12}, and C_{6+})	GC, ASTM 1945D, RSK 175 or equivalent	10 ppm per component	± 1%
pH	ASTM D1293, EPA 150.23 or equivalent	N/A	± 3%
Temperature	ASTM 2550		

Parameter	Analytical Method	Detection Limit	Typical Precision/ Accuracy
Conductivity	ASTMD1125	10 microSiemens/ centimeter	± 3%
Conductivity (field)	EPA 120.1		

ICP-OES = inductively coupled plasma optic emission spectrometry; ICP-MS = inductively coupled plasma mass spectrometry; GC/MS = gas chromatography–mass spectrometry; AMS = accelerator mass spectrometry; CRDS = cavity ring down spectrometry; IRMS = isotope ratio mass spectrometry; CVAA: Cold Vapor Atomic Absorption;

Note: Isotopes will be analyzed only during the pre-injection baseline, and if required for appropriation based on other monitoring results.

5.4 Quality Control

Quality control of the sampling and results will follow the protocols established in the standard analytical method used for testing (Table QASP-12). The Pelican Sequestration Project reserves the right to audit the laboratory procedures and protocols to validate that the methods are being followed, and results are accurate.

6.0 Continuous Recording of Injection Parameters

Injection pressure and temperature (P/T) will be measured continuously at the surface via real-time P/T instruments installed in the CO_2 flowline near the interface with the wellhead. The flow rate of CO_2 injected into the wellhead will be measured by flowmeter skids with a Coriolis meters. Automated shutoff devices will be used to stop injection, if injection parameters deviate outside operational limits.

Table QASP-12—Technical specification for surface pressure transducers.

Surface Pressure Transducer Specifications	
Parameter	**Specification**
Calibrated Working Pressure Range	0 to 3,000 psi
Pressure Accuracy	± 0.0065%
Pressure Resolution	0.001 psi
Type of Sensor	4-20 ma output transmitter; static measurement; 4-wire

Table QASP-13—Technical specification for surface temperature transducers.

Surface Temperature Transducer Specifications	
Parameter	**Specification**
Calibrated Working Temperature Range	0 to 150°F
Temperature Accuracy	± 0.0055%

Temperature Resolution	0.01°F
Type of Sensor	4-20 ma output; RTD

P/T gauges will be deployed on the tubing above and below the injection packer to monitor bottomhole conditions in real time. The gauges and cables will be selected to withstand CO_2 service conditions, and the data will be integrated into the SCADA system and surveillance platform. Table QASP-14 shows an example of the technical specifications for downhole gauges.

Table QASP-14—Technical specifications for downhole P/T sensors.

Downhole P/T Sensor Specifications	
Parameter	**Specification**
Pressure sensor	Quartz / Inconel Carriers
Pressure accuracy	± 0.02%
Pressure repeatability	≤ 0.01% of full scale
Temperature sensor	Quartz / Inconel Carriers
Temperature accuracy	± 0.5°C
Temperature resolution	0.005°C
Operating temperature ranges	-20°C to 200°C
Sample Rate	1 sec
Inconel cable	Required

The flow rate of CO_2 injected into the well will be measured by flowmeter skids with a Coriolis-type flowmeter. Table QASP-15 is an example of typical meter specifications.

Table QASP-15—Example of Coriolis meter specifications.

Parameter	Specification
Mass flow accuracy (Liquid)	±0.10% of rate (standard)±0.05% of rate (optional)
Mass flow repeatability (Liquid)	±0.05% of rate (standard)±0.025% of rate (optional)
Volume flow accuracy (Liquid)	±0.10% of rate (standard)±0.05% of rate (optional)
Volume flow repeatability (Liquid)	±0.05% of rate (standard)±0.025% of rate (optional)
Mass flow accuracy (Gas)	±0.35% of rate
Mass flow repeatability (Gas)	±0.20% of rate
Density accuracy (Liquid)	±0.0005 g/cm3 (±0.5 kg/m3) (standard)±0.0002 g/cm3 (±0.2 kg/m3) (optional)
Density repeatability (Liquid)	±0.0002 g/cm3 (±0.2 kg/m3) (standard)±0.0001 g/cm3 (±0.1 kg/m3) (optional)
Temperature accuracy	±1 °C ±0.5% of reading
Sensor maximum working pressure	2,855 psig (197 barg)

Automated shutdown valves will be used to stop the flow of CO_2 to the well in the event that operation parameters deviate from program operational limits. The valves are currently planned as ASME 1500 RF trunnion ball, full port, CS x SS, soft seated, gear operated, and NACE, with electrically operated actuator, but will be confirmed during detailed engineering of the surface facilities.

7.0 CO_2 Injection Well – Well Testing

7.1 Step Rate Test

A step rate test (SRT) is normally used to estimate fracture pressure in an injection well for given geologic formation. The test is conducted by injecting fluid into the formation at a series of increasing rates, allowing each rate to stabilize, and noting the stabilized injection pressure for each rate. The injection pressure is then plotted against the injection rate to identify the fracture pressure.

7.1.1 Equipment for Step Rate Test

The basic equipment required is as follows:

- A water supply truck capable of pumping the water downhole under increasing pressures.
- Surface monitoring equipment capable of measuring injection rate and pressure.
- Enough storage and volume of the water and additives to avoid interruption of the test.
- Bottomhole pressure (BHP) memory gauge or permanent pressure gauges installed in the well during original completions. It is recommended to use redundant pressure gauges during the test with one gauge serving as a backup or for verification in cases of questionable data quality.

To convert surface pressure to BHP, the inside diameter and condition of the tubing must be known to compute frictional losses, and the density of the injected fluid must be known to compute the hydrostatic pressure. A BHP gauge should be used to measure BHP to provide two sources of pressure data for comparison.

7.1.2 Procedure for Step Rate Test

The following SRT procedure is recommended.

The test well should be shut in long enough, but not less than 48 hours, so that the BHP is near the shut-in formation pressure. The SRT should start at a suitably low rate such that at least two injection rate steps are below the formation fracture pressure and at least three rates are above the formation fracture pressure. A plot of the injection rate versus surface pressure and BHP will facilitate the determination of the formation fracture pressure. The point at which the slope of the lower fracture rates intersects the slope of the higher fracture rates is the formation fracture pressure, which can be expressed as a fracture gradient (psi/ft).

It is recommended that the injection rate step is stable before proceeding to the next higher rate. The duration of each step will be at least 30 minutes since the permeabilities of the formations to test are greater than 10 mD. Each step should last exactly as long as the preceding step. Surface pressure and BHP measurements should be recorded at shut-in (instantaneous shut-in pressure or ISIP), after 5 minutes of shut-in, and after 10 minutes of shut-in.

It is recommended to use redundant pressure gauges during the test with one or more gauges serving as a backup or for verification in cases of questionable data quality.

7.1.3 Analysis of Step Rate Test (SRT)

The SRT analysis consists of plotting the injection pressure at the end of each rate versus the injection rate. It is preferable to plot the BHP, but the surface pressure may be used if it is positive throughout the test and the friction effects are not significant. The plot should have two straight lines segments, as illustrated in the Figure QASP-1.

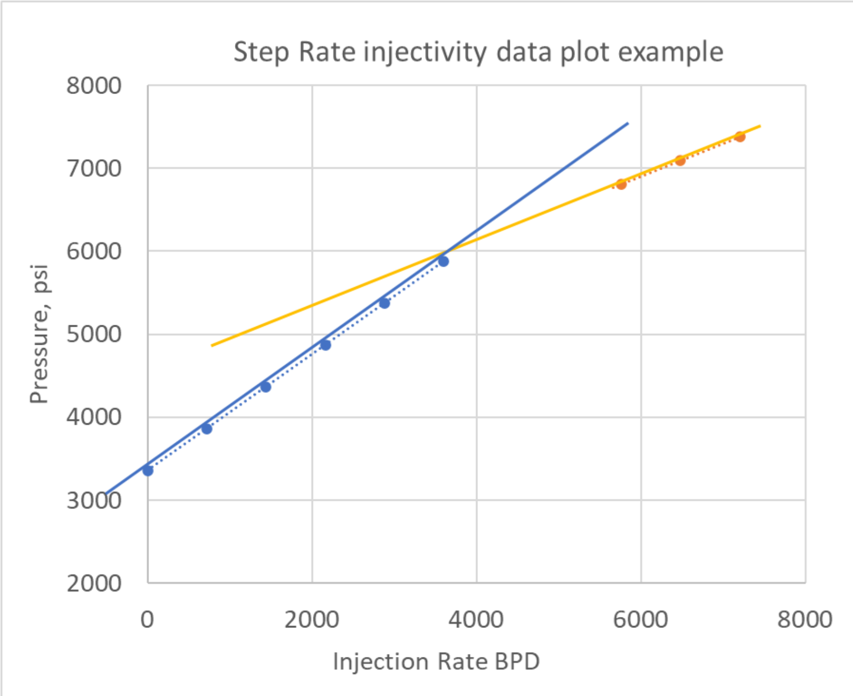


Figure QASP-1—Step rate data plot example

7.2 Injectivity Test

The injectivity test is pressure-transient testing during injection into a well. It is analogous to drawdown testing, for both constant and variable rates. This test and the analysis only apply to liquid-filled reservoirs with the mobility of the injected fluid like or equal to the mobility of the in-situ fluid (Robert Earlougher, 1997).

The test will be performed after the tubing and packer are installed in the CO_2 injection well and will be performed with water and clay inhibitors, if required to avoid formation damage. Before the injectivity test, an SRT will be conducted to validate fracture pressure values and identify the optimum injection rates. After the injectivity test is performed, the well will be shut in to proceed with the falloff test.

7.2.1 Equipment for Injectivity Test

The basic equipment required is as follows:

- A water supply truck capable of pumping the water downhole under increasing pressures.
- Enough storage and volume of the water and additives to avoid interruption of the test.
- Surface monitoring equipment capable of measuring injection rate and pressure.
- BHP memory gauge or permanent pressure gauges installed in the well during original completions. It is recommended to use redundant pressure gauges during the test with one gauge serving as a backup or for verification in cases of questionable data quality.

7.2.2 Procedure for Injectivity Test

1. The well is initially shut in and pressure is stabilized at the initial reservoir pressure, pi.
2. Measure the initial reservoir pressure on the surface as well as downhole with the permanent gauges installed in the completion.
3. At time zero, injection starts at a constant rate established after the SRT is performed. The selected rate should be high enough to cause a pressure that is equal to the depth of the top of the tested zone times the 90% of the fracture gradient value identified during the SRT.
4. Continue injection until the pressure measurement is nearly stable unless this is impossible due to slow increase or high injection pressures. If the pressure is stable, inject enough fluid to reach modeled conditions to start the falloff test.
5. It is advisable to monitor the injection rate carefully to adjust the interpretation in case the rate varies significantly.
6. Shut in the well and start the falloff test.

7.3 Falloff Test

A falloff test is a pressure-transient test that consists of shutting in an injection well and measuring the pressure falloff. The falloff period is a replay of the injection preceding it; consequently, it is impacted by the magnitude, length, and rate fluctuations of the injection period. Falloff testing analysis provides transmissibility, skin factor, and well flowing and static pressures.

7.3.1 Equipment for Falloff Test

The basic equipment required is as follows:

- Pumping system (trucks or surface pump) and enough amount of the injectant to ensure an adequate test.
- Surface monitoring equipment capable of measuring injection rate and pressure.
- BHP memory gauge or permanent pressure gauges installed in the well during original completions. It is recommended to use redundant pressure gauges during the test with one gauge serving as a backup or for verification in cases of questionable data quality.

7.3.2 General Considerations Falloff Test

- Adequate volume of the injectant should be ensured for the duration of the test.
- The radial flow portion of the test is the basis for all pressure transient calculations. Therefore, the injectivity and falloff portions of the test should be designed not only to

reach radial flow, but to sustain a time frame sufficient for analysis of the radial flow period.

- Offset wells completed in the same formation as the test well should be shut in, or, at a minimum, provisions should be made to maintain a constant injection rate prior to and during the test.
- The location of the shut-in valve on the well should be at or near the wellhead to minimize the wellbore storage period.
- The condition of the well, junk in the hole, wellbore fill, or the degree of wellbore damage (as measured by skin) may impact the length of time the well must be shut in for a valid falloff test. This is especially critical for wells completed in relatively low transmissibility reservoirs or wells that have large skin factors.
- Cleaning out the well and acidizing may reduce the wellbore storage period, and therefore, the shut-in time of the well.
- Accurate recordkeeping of injection rates is critical, including a mechanism to synchronize times reported for injection rate and pressure data. Time synchronization of the data is especially critical when the analysis includes the consideration of injection from more than one well.
- If more than one well is completed into the same reservoir, operators are encouraged to send at least two pulses to the test well by way of rate changes in the offset well following the falloff test. These pulses will demonstrate communication between the wells and if maintained for sufficient duration, they can be analyzed as an interference test to obtain interwell reservoir parameters.

7.3.3 Site-Specific Pretest Planning

- Maintain a constant injection rate in the test well prior to shut-in. This injection rate should be high enough and maintained for a sufficient duration to produce a measurable pressure transient that will result in a valid falloff test.
- Offset wells should be shut-in prior to and during the test. If shut-in is not feasible, a constant injection rate should be recorded and maintained during the test and then accounted for in the analysis.
- Do not shut in two wells simultaneously or change the rate in an offset well during the test.
- The test well should be shut-in at the wellhead to minimize wellbore storage and afterflow. If the well goes on vacuum, the wellhead should be opened to the atmosphere.
- Maintain accurate rate records for the test well and any offset wells completed in the same injection interval.
- Measure and record the viscosity of the injectate periodically during the injectivity portion of the test to confirm the consistency of the test fluid.

7.3.4 Evaluation of the Falloff Test

Note: EPA Region 6 UIC Pressure Falloff Testing Guideline- Third Revision (August 8, 2022) to be followed as a guide for falloff testing.

1. Prepare a Cartesian plot of the pressure and temperature versus real time or elapsed time.
2. Confirm pressure stabilization prior to shut-in of the test well.
3. Look for anomalous data, i.e., pressure drop at the end of the test, and determine if the pressure drop is within the gauge resolution.
4. Prepare a log-log diagnostic plot of the pressure and semilog derivative. Identify the flow regimes present in the well test.

5. Use the appropriate time function, depending on the length of the injection period and variation in the injection rate preceding the falloff.
6. Mark the various flow regimes, particularly the radial flow period.
7. Include the derivative of other plots, if appropriate (e.g., square root of time for linear flow).
8. If there is no radial flow period, attempt to type-curve match the data.
9. Prepare a semilog plot.
10. Use the appropriate time function, depending on the length of injection period and injection rate preceding the falloff.
11. Draw the semilog straight line through the radial flow portion of the plot and obtain the slope of the line.
12. Calculate the transmissibility, kh.
13. Calculate the skin factor, s, and skin pressure drop, DP skin.
14. Calculate the radius of investigation, ri.
15. Explain any anomalous results.

8.0 Distributed Temperature Sensing

Distributed temperature sensing (DTS) 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 well. DTS specifications are shown below in Table QASP-16 and fiber optic cable technical specifications are shown in Table QASP-17.

Table QASP-16—DTS technical specifications.

Parameter	Value
Spatial Resolution	1 m (3.2 ft) across entire measurement range
Sampling Resolution	Down to 0.5 m (1.6 ft) across entire measurement range
Temperature Resolution	0.1°C (0.18°F)
Accuracy	±0.5°C (±0.9°F)
Measurement Range	Up to 12 Km
Measurement Temperature Range	-250°C to 400°C
Measurement Times	10 seconds to 24 hours
Dynamic Range	30 db
Operating Environment	-10°C to 60°C, humidity 0–95% non-condensing

Table QASP-17—Fiber optic cable technical specifications.

Parameter	Value
Tensile Strength	2,372 lbs
Yield Strength	2,018 lbs
Strain @ Yield	0.31%
Hydrostatic Pressure	23,872 psi
Burst Pressure	28,050 psi
Working Pressure	20,526 psi
Static Bend Radius	3 in.

9.0 Leak Detection

9.1 Optical Gas Imaging Camera

Optical Gas Imaging (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. OGI cameras will be used to identify fugitive emissions or other leaks of specified constituents from facilities, pipelines, wells, and other equipment at the project.

Table QASP-18—FLIR optical gas imaging camera specifications

SPECIFICATIONS

	Gx320	Gx620	G620	G343	G346	G304	G306	GF77	
Primary Gas Seen	Hydrocarbons (CxHx)	Hydrocarbons (CxHx)	Hydrocarbons (CxHx)	Carbon dioxide (CO_2)	Carbon monoxide (CO)	Refrigerants	Sulfur hexafluoride (SF_6), ammonia (NH_3)	LR lens: methane, R-134a, R-152a	HR lens: sulfur hexafluoride (SF_6), ammonia (NH_3), ethylene
Detector Type	Cooled InSb	Cooled InSb	Cooled InSb	Cooled InSb	Cooled QWIP	Cooled QWIP	Cooled QWIP	Uncooled microbolometer	
Spectral Range	3.2 µm to 3.4 µm	3.2 µm to 3.4 µm	3.2 µm to 3.4 µm	4.2 µm to 4.4 µm	4.52 µm to 4.67 µm	8.0 µm to 8.6 µm	10.3 µm to 10.7 µm	LR lens: 7 µm to 8.5 µm	HR lens: 9.5 µm to 12 µm
Resolution	320 × 240 (76,800 pixels)	640 × 480 pixels (307,200 pixels)	640 × 480 pixels (307,200 pixels)	320 × 240 (76,800 pixels)	320 × 240 (76,800 pixels)	320 × 240 (76,800 pixels)	320 × 240 (76,800 pixels)	320 × 240 (76,800 pixels)	
Quantification in Camera	Yes	Yes	Yes	No	No	No	No	No	
Thermal Sensitivity	<10 mK at 30°C (86°F)	20 mK at 30°C (86°F)	20 mK at 30°C (86°F)	15 mK at 30°C (86°F)	15 mK at 30°C (86°F)	15 mK at 30°C (86°F)	15 mK at 30°C (86°F)	25° lens: <25 mK at 30°C (86°F) 6° lens: <40 mK at 30°C (86°F)	
Accuracy	±1°C (±1.8°F) for temperature range (0°C, to 100°C, 32°F to 212°F) or ±2% of reading for temperature range (>100°C, >212°F)	±1°C (±1.8°F) for temperature range (0°C to 100°C, 32°F to 212°F) or ±2% of reading for temperature range (>100°C, >212°F)	±1°C (±1.8°F) for temperature range (0°C to 100°C, 32°F to 212°F) or ±2 % of reading for temperature range (>100°C, >212°F)	N/A	±1°C (±1.8°F) for temperature range (0°C to 100°C, 32°F to 212°F) or ±1% of reading for temperature range (>100°C, >212	±1°C (±1.8°F) for temperature range (0°C, to 100°C, 32°F to 212°F) or ±2% of reading for temperature range (>100°C, >212°F)	±1°C (±1.8°F) for temperature range (0°C, to 100°C, 32°F to 212°F) or ±2 % of reading for temperature range (>100°C, >212°F)	±5°C (±9°F) for ambient temperatures 15°C to 35°C (59°F to 95°F)	
Noise Equivalent Concentration Length (NECL) [ΔT=10°C, Distance= 1 m]	Methane - 13 ppm-m	Methane - 29 ppm-m	Methane - 29 ppm-m	Carbon dioxide (CO_2) - 5.6 ppm-m	Carbon monoxide (CO) - 9 ppm-m	-	Sulfur hexafluoride (SF_6) - 0.3 ppm-m, Ethylene (C_2H_4) - 6.3 ppm-m	LR lens: CH_4: <100 ppm × m R-134a: <20 ppm × m R-152a: <100 ppm × m	HR lens: SF_6: <1 ppm × m C2H4: <20 ppm × m NH_3: <20 ppm × m
Minimum Laboratory Leak Rate (MLLR) [known gases]	Methane: 0.6 g/hr Propane: 0.6 g/hr Butane: 0.4 g/hr	Methane: 0.6 g/hr Propane: 0.6 g/hr	Methane: 0.6 g/hr Propane: 0.6 g/hr	-	-	-	Sulfur hexafluoride (SF_6): 0.026 g/hr Ammonia: 0.127 g/hr	Methane: 2.7 g/hr	Sulfur hexafluoride (SF_6): 0.74 g/hr
Temperature Range	-20°C to 350°C (-4°F to 662°F)	-20°C to 350°C (-4°F to 662°F)	-20°C to 350°C (-4°F to 662°F)	-	-20°C to 350°C (-4°F to 662°F)	-20°C to 250°C (-4°F to 482°F)	-40°C to 500°C (-40°F to 932°F)	-20°C to 80°C (-4°F to 176°F), 0°C to 250°C (32°F to 482°F) 100°C to 500°C (212°F to 932°F)	
Available Lenses	24° × 18° (23 mm); 14.5° × 10.8° (38 mm)	24° × 18° (23 mm); 14.5° × 10.8° (38 mm)	24° × 18° (23 mm); 14.5° × 10.8° (38 mm)	24° × 18° (23 mm); 14.5° × 10.8° (38 mm)	24° × 18° (23 mm); 14.5° × 10.8° (38 mm)	24° × 18° (23 mm); 14.5° × 10.8° (38 mm)	24° × 18° (23 mm); 14.5° × 10.8° (38 mm); 6° × 4.5° (92 mm)	24° × 18° (23 mm); 14.5° × 10.8° (38 mm)	
Zoom	1–8× continuous, digital zoom	1–8× continuous, digital zoom	1–8× continuous, digital zoom	1–8× continuous, digital zoom	1–8× continuous, digital zoom	1–8× continuous, digital zoom	1–8× continuous, digital zoom	1–6× continuous, digital zoom	
Focus	Manual	Manual	Autofocus, manual	Autofocus, manual	Autofocus, manual	Autofocus, manual	Autofocus, manual	Continuous (laser), one-shot (laser), one-shot contrast, manual	
Display									
Adjustable Viewfinder	4", 640 × 480 pixel rotatable, touchscreen LCD	4", 640 × 480 pixel rotatable, touchscreen LCD	4", 640 × 480 pixel rotatable, touchscreen LCD	4", 640 × 480 pixel rotatable, touchscreen LCD	4", 640 × 480 pixel rotatable, touchscreen LCD	4", 640 × 480 pixel rotatable, touchscreen LCD	4", 640 × 480 pixel rotatable, touchscreen LCD	Dragontrail® Touchscreen (QVGA), 640 × 480 pixels	
Visual Camera w/ Lamp	3.2 MP	3.2 MP	3.2 MP	3.2 MP	3.2 MP	3.2 MP	3.2 MP	5 MP	
Laser Pointer	Class 2 Semiconductor AlGaInP diode laser, 1 mW, 635 nm (red)	Class 2 Semiconductor AlGaInP diode laser, 1 mW, 635 nm (red)	Class 2 Semiconductor AlGaInP diode laser, 1 mW, 635 nm (red)	Class 2 Semiconductor AlGaInP diode laser, 1 mW, 635 nm (red)	Class 2 Semiconductor AlGaInP diode laser, 1 mW, 635 nm (red)	Class 2 Semiconductor AlGaInP diode laser, 1 mW, 635 nm (red)	Class 2 Semiconductor AlGaInP diode laser, 1 mW, 635 nm (red)	Class 2, dedicated button, used in focus and distance measurement	
Video Out	HDMI, DVI	HDMI, DVI	HDMI, DVI	HDMI, DVI	HDMI, DVI	HDMI, DVI	HDMI, DVI	DisplayPort over USB Type-C	
Certifications									
Hazardous Locations	ATEX/IECEx, Ex ic nC op is IIC T4 Gc II 3 G - ANSI/ ISA-12.12.01-2013, Class I Division 2 - CSA 22.2 No. 213, Class I Division 2	ATEX/IECEx, Ex ic nC op is IIC T4 Gc II 3 G - ANSI/ISA-12.12.01-2013, Class I Division 2 - CSA 22.2 No. 213, Class I Division 2	-	-	-	-	-	-	
US EPA 0000a	Yes	Yes	Yes	-	-	-	-	-	
Image Analysis	10 spots, 5 boxes with max/ min/average, 1 line, Delta T, measurement corrections	10 spots, 5 boxes with max/ min/average, 1 line, Delta T, measurement corrections	10 spots, 5 boxes with max/ min/average, 1 line, Delta T, measurement corrections	-	10 spots, 5 boxes with max/ min/average, 1 line, Delta T, measurement corrections	10 spots, 5 boxes with max/ min/average, 1 line, Delta T, measurement corrections	10 spots, 5 boxes with max/min/ average, 1 line, Delta T, measurement corrections	3 spot and boxes in live mode	
Annotations	Voice: 60 secs with Bluetooth on still images and video Text from predefined list or soft keyboard on touchscreen	Voice: 60 secs with Bluetooth on still images and video Text from predefined list or soft keyboard on touchscreen	Voice: 60 secs with Bluetooth on still images and video Text from predefined list or soft keyboard on touchscreen	Voice: 60 secs with Bluetooth on still images and video Text from predefined list or soft keyboard on touchscreen	Voice: 60 secs with Bluetooth on still images and video Text from predefined list or soft keyboard on touchscreen	Voice: 60 secs with Bluetooth on still images and video Text from predefined list or soft keyboard on touchscreen	Voice: 60 secs with Bluetooth on still images and video Text from predefined list or soft keyboard on touchscreen	Voice: 60 secs with Bluetooth on still images and video Text from predefined list or soft keyboard on touchscreen	
Communication Interfaces	USB 2.0, Bluetooth via headset, Wi-Fi, HDMI	USB 2.0, Bluetooth via headset, Wi-Fi, HDMI	USB 2.0, Bluetooth via headset, Wi-Fi, HDMI	USB 2.0, Bluetooth via headset, Wi-Fi, HDMI	USB 2.0, Bluetooth via headset, Wi-Fi, HDMI	USB 2.0, Bluetooth via headset, Wi-Fi, HDMI	USB 2.0, Bluetooth via headset, Wi-Fi, HDMI	USB 2.0, Bluetooth, Wi-Fi, DisplayPort	
Data Storage	Removable SD card, cloud via FLIR Ignite	Removable SD card, cloud via FLIR Ignite	Removable SD card, cloud via FLIR Ignite	Removable SD card, cloud via FLIR Ignite	Removable SD card, cloud via FLIR Ignite	Removable SD card, cloud via FLIR Ignite	Removable SD card, cloud via FLIR Ignite	Removable SD card, cloud via FLIR Ignite	
File Format	Standard JPEG, MJEG, MPEG4, H.264, RTRR(.csq)	Standard JPEG, MJEG, MPEG4, H.264, RTRR(.csq)	Standard JPEG, MJEG, MPEG4, H.264, RTRR(.csq)	Standard JPEG, MJEG, MPEG4, H.264, RTRR(.csq)	Standard JPEG, MJEG, MPEG4, H.264, RTRR(.csq)	Standard JPEG, MJEG, MPEG4, H.264, RTRR(.csq)	Standard JPEG, MJEG, MPEG4, H.264, RTRR(.csq)	Standard JPEG, RTRR(.csq)	
MultiREC Recording	Record multiple files automatically in customizable order	Record multiple files automatically in customizable order	Record multiple files automatically in customizable order	Record multiple files auto-matically in customizable order	Record multiple files automatically in customizable order	Record multiple files automatically in customizable order	Record multiple files automatically in customizable order	-	
GPS	Location data automatically added to every still image; first frame in video from built-in GPS; data logging feature	Location data automatically added to every still image; first frame in video from built-in GPS; data logging feature	Location data automatically added to every still image; first frame in video from built-in GPS; data logging feature	Location data automatically added to every still image; first frame in video from built-in GPS; data logging feature	Location data automatically added to every still image; first frame in video from built-in GPS; data logging feature	Location data automatically added to every still image; first frame in video from built-in GPS; data logging feature	Location data automatically added to every still image; first frame in video from built-in GPS; data logging feature	Location data automatically added to every still image; first frame in video from built-in GPS	

For an overview of the specifications for the FLIR GF77a and G300a please visit FLIR.com

9.2 Atmospheric CO_2 Sensor

Table QASP-18—Infrared gas detector specifications.

Model	GF343
Detector Type	Focal plane array, cooled InSb
Spectral Range	4.2 – 4.4 μm
Resolution	320 x 240 pixels
Detector Pitch	30 μm
NETD/Thermal Sensitivity	< 15 mK @ +30°C (+86°F)
Sensor Cooling	Stirling Microcooler (FLIR MC-3)
Electronics / Imaging	
Image Modes	IR image, visual image, High Sensitivity Mode (HSM)
Frame Rate (Full Window)	60 Hz
Dynamic Range	14-bit
Video Recording / Streaming	Real-time non-radiometric recording: MPEG4/H.264 (up to 60 min./clip) to memory card Real-time non-radiometric streaming: RTP/MPEG4
Visual Video	MPEG4 (25 min./clip) to memory card
Visual Image	3.2 MP from integrated visible camera
GPS	Location data stored with every image
Camera Control	Remote camera control via USB
File Storage	
Storage Media	Removable SD or SDHC memory card; two card slots
Image Storage Capacity	> 1200 images (JPEG) with post-process capability per GB on memory card
Optics	
Camera f/number	f/1.5
Available Fixed Lenses	14.5° (38 mm), 24° (23 mm)
Focus	Automatic (one touch) or manual (electric or on the lens)
Image Presentation	
On-Camera Display	Built-in widescreen, 4.3 in. LCD, 800 x 480 pixels
Automatic Gain Control	Continuous/manual, linear, histogram
Menu Commands	Level/span, auto adjust continuous/manual/semi-automatic, zoom, palette, start/stop recording, store image, playback/recall image
Color palettes	Iron, Gray, Rainbow, Arctic, Lava, Rainbow HC
Zoom	1-8x continuous, digital zoom
General	
Operating Temperature Range	–20°C to +50°C (–4°F to +122°F)
Storage Temperature Range	–30°C to +60°C (–22°F to +140°F)
Encapsulation	IP 54 (IEC 60529)
Bump / Vibration	25 g (IEC 60068-2-27) / 2 g (IEC 60068-2-6)
Power	AC adapter 90-260 VAC, 50/60 Hz or 12 V from a vehicle
Battery System	Rechargeable Li-ion battery
Weight w/ Battery & Lens	2.48 kg (5.47 lb.)
Size (L x W x H) w/ Lens	306 × 169 × 161 mm (12.0 × 6.7 × 6.3 in.)
Mounting	Standard, 1/4″-20

The Pelican Sequestration Project will install infrared gas detectors close to the wellheads of the injection and monitoring wells. These sensors will interface with the surveillance system to set alarms and provide information on potential leaks at the surface.

Table QASP-19—Wellhead atmospheric CO_2 sensor specification example

Parameter	Specification
Detector Type	Infrared Absorption
Measuring Range	0 to 5000 ppm CO_2
Accuracy @ 25° C	± 5% FS2500 ppm
Response Time With 5000 ppm CO_2 Applied	T50<7 seconds & T90<15 seconds
Operating Temperature Range	-40°F to +122°F -40°C to +50°C
Operating Humidity Range	5 to 100% Relative Humidity

10.0 Induced Seismicity Tracking

The Pelican Sequestration Project will deploy a seismometer monitoring network to determine the locations, magnitudes, and focal mechanisms of seismic events (if any).

10.1 Geophone Array for Seismicity

Based on the information provided by United States Geological Survey (USGS), the selected area does not show high seismic activity that could endanger the containment of the CO_2 in the storage complex or nearby infrastructure. Seismicity history is discussed in more detail in the Area of Review and Corrective Action Plan document of the permit.

Changes of in-situ stresses on existing faults caused by human activities (e.g., mining, dam impoundment, geothermal reservoir stimulation, wastewater injection, hydraulic fracturing, and CO_2 sequestration) may induce earthquakes on critically stressed fault segments. To monitor potentially induced seismicity due to the injection of CO_2 in the area, the project proposes deploying surface seismometer stations. While the historical seismicity of the project area indicates no earthquakes in the immediate vicinity, the Pelican Sequestration Project intends to monitor both the storage facility and adjacent infrastructure with a seismic monitoring system for the duration of the project. The seismic monitoring will be conducted with a surface array deployed to detect events above M_L1.0, with epicentral locations within 10 miles of the injection wells.

If an event is recorded by either the local private array or a public (national or state) array to have occurred within 5.6 miles of the injection wells, the Pelican Sequestration Project will implement its response plan subject to detected earthquake magnitude limits defined below to eliminate or reduce the magnitude and/or frequency of seismic events. A traffic light system is described in the Testing and Monitoring Plan Section 9.2.

10.1.1 Personnel

The design and installation of the station array will be performed by specialized contractors and will include the following activities:

- Project management support to design the seismometer array, model the network performance, coordinate permitting and equipment installation, conduct testing and maintenance, and ensure optimum execution of the project.
- Field operations to deploy seismic station instrumentation, run power and communication systems, monitor data quality, and perform commissioning.
- Data acquisition, system configuration, and process setup.
- Continuous support and monitoring for data verification and QA/QC.
- Continuous near-real-time reporting, including analyst reviews and alert notifications, for events at or above predetermined magnitude thresholds over the seismic area.

10.1.2 Equipment

The equipment proposed for seismic station includes:

- Broadband sensors
- Data logger
- Solar power system and backup battery
- Communication system
- Cabling
- Mounting equipment

Figure QASP-2 shows the technical specifications for broadband seismometer as a reference.

Figure QASP-3 shows an example of a setup for data acquisition, transfer, storage, and analysis.

TECHNICAL SPECIFICATIONS TRILLIUM COMPACT PH

Specifications subject to change without notice

TECHNOLOGY

Topology: Symmetric triaxial
Feedback: Force balance with capacitive transducer
Mass Centering: Not required

SEISMOMETER MODULE PERFORMANCE

Self-noise: See self-noise graph
Nominal Sensitivity: 750 V-s/m (reference User Guide for precise value)
Precision: ±0.5% relative to User Guide specification
Bandwidth/120s: -3 dB points at 120 s and 108 Hz
Bandwidth/20s: -3 dB points at 20 s and 108 Hz
Off-axis Sensitivity: ±0.5%
Clip level: 26 mm/s up to 10 Hz and 0.17 *g* above 10 Hz
Oper. Tilt Range/120s: ±2.5°
Oper. Tilt Range/20s: ±10°
Parasitic Resonances: None below 200 Hz
Dynamic Range/120s: > 159 dB @ 1 Hz
Dynamic Range/20s: > 152 dB @ 1 Hz

LEVELING AND ALIGNMENT

Digital bubble level: Graphical bullseye level is available via Centaur digital recorder GUI
Physical Bubble level: Optional accessory
Alignment: Vertical scribe marks for (N and S); precision guide in cover for straight-edge, line, or laser level

INTERFACE

Connector: 16-pin, marine SubConn MCBH16MSS, top-mounted

Velocity Output: 40 V peak-to-peak differential
- Selectable XYZ or UVW mode

Mass Position Output: Single ±4 V output representing maximum mass position
- 3-channel mass positions available through serial port

Calibration Input: Single voltage input and one active high control signal to enable all 3 channels
- Remote calibration in XYZ or UVW mode
- Independent channel selection by serial port

Control Lines: Cal. Enable or Long/Short Period mode, XYZ/UVW mode

Serial Port: RS-232 compatible serial IP (SLIP)
- Onboard web server standard HTTP
- For enhanced instrument control and status: UVW/XYZ mode, short/long period mode, firmware updates, temperature, mass position, case tilt, digital bubble level, serial number and factory info

POWER

Supply Voltage: 9 to 36 VDC isolated input
Power Consumption:
- 180 mW typical (model TC120-PH2)
- 195 mW typical (model TC20-PH2)

Protection: Reverse-voltage and over-voltage protected
- Self-resetting over-current protection

PHYSICAL

Diameter: 97 mm
Height:
- Body & connector: 160 mm
- On fixed studs: 167 mm

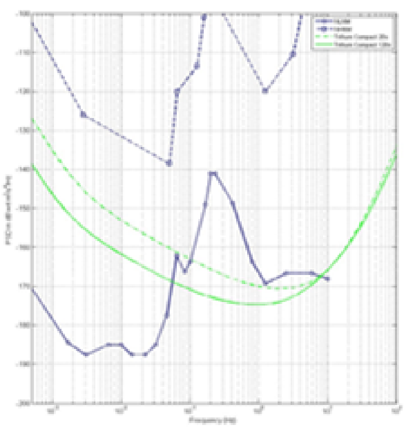
Weight/120s: 3.2 kg
Weight/20s: 3.2 kg
Housing: Stainless steel, resistant to corrosion, scratches & chips

ENVIRONMENT

Operating temperature:
-20°C to 60°C (Standard Model)
-50°C to 60°C (Polar Certified Model)
Storage temperature: -40°C to 70°C
Shock:
- 100 *g* half sine, 5 ms without damage, 6 axes
- No mass lock required for transport

Magnetic: Insensitive to natural variations of the earth's magnetic field
Ingress Protection: Rated to IP68 to 300 m for prolonged immersion

SELF-NOISE PERFORMANCE PLOT



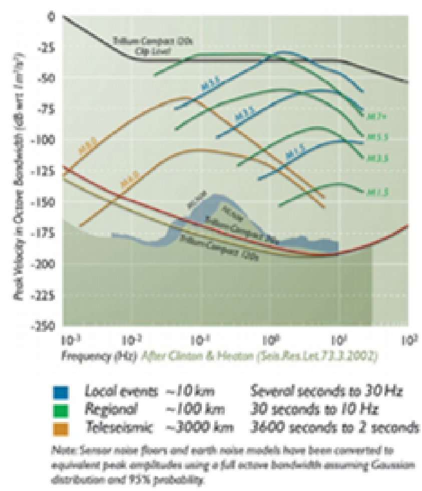


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Figure QASP-2—Technical specification for a broadband seismometer.

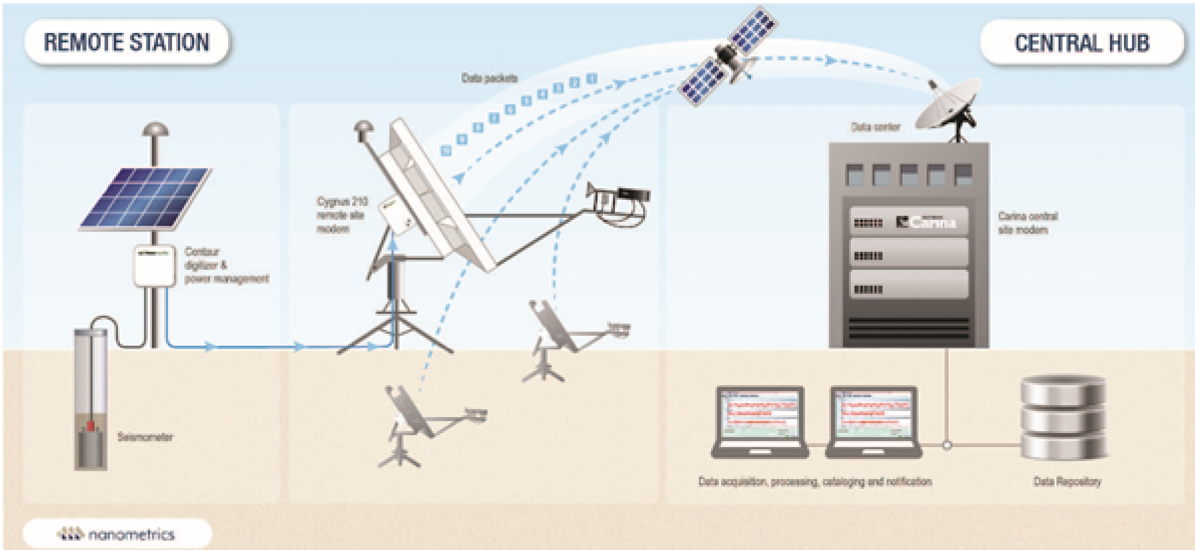

Figure QASP-3—Data acquisition setup example.

11.0 <u>Open Hole and Cased Hole Wireline Logs Technical Specification and Procedures</u>

See Quality Assurance and Surveillance Plan – Appendix A.