ATTACHMENT I: PRE-OPERATIONAL TESTING PLAN
CTV II

Table of Contents

Version History

File Name	Version	Date	Description of Change
Preoperational Formation Testing CTV II	1	5/3/2022	Original submission for CTV II project
Pre-Op Testing Plan CTV II	2	12/13/2022	Updated Submission for expanded CTV II project
CTV II Preoperational Plan_Feb 2024	3	2/28/2024	Response to November 27, 2023 EPA Comments
CTV II Preoperational Plan_Nov 2024	4	11/26/2024	Response to August 29, 2024 EPA Comments

Facility Information

Facility Name: CTV II

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Well Location(s): Union Island Gas Field, San Joaquin County, CA
37.868/-121.420

1. Testing Summary

Carbon TerraVault Holdings LLC (CTV) plans to drill five new injection wells (UI-INJ-1, UI-INJ-2, UI-INJ-3, UI-INJ-4, and UI-INJ-5), 6 new monitoring wells (USDW-1, USDW-2, USDW-3, M-1, M-2, and M-3), and repurpose 4 wells (SONOL SECURITIES 2, SONOL SECURITIES 4, PHILLIP YAMADA BROTHERS 2, AND YAMADA BROTHERS 2) for the CTV II storage project, as discussed in Section 5 of **Attachment A: Narrative Report (Attachment A)**. Pre-operational formation testing will include a suite of logging, coring, geohydrologic testing, and other activities during the drilling and completion of these injection wells detailed below.

Electrical logging will support reservoir rock and fluid properties characterization. Formation pressure testing will determine current reservoir pressure and permeability. The other pre-operational tests will confirm the depth, thickness, mineralogy, lithology, porosity, permeability, and geomechanical attributes of the Winters Formation (target injection zone) and the overlying Starkey-Sawtooth confining formations.

Methods for tests will be consistent with U.S. EPA (2013), and testing methods listed in the **Attachment C: Testing and Monitoring Plan (Attachment C)**. Well-specific Construction and Plugging (CP) Plans are submitted for each individual well. This Pre-Operational Testing Plan summarizes planned pre-operational testing activities, schedule, and reporting to the U.S. Environmental Protection Agency (EPA). CTV will commence construction and testing activities following EPA approval of this Pre-Operational Testing Plan and once the necessary permit to construct the new wells has been obtained.

2. Schedule and Reporting

Results of future testing will be documented in a report submitted to the EPA after the new well drilling and testing activities have been completed, but before carbon dioxide (CO_2) injection commences. CTV will notify the Director at least 30 days prior to conducting any testing.

3. Injection Well Testing

Wireline logging of the injection wells will consist of conventional and advanced open-hole logs of the surface, intermediate, and injection hole sections. Cement bond logs will be run on the surface, intermediate, and injection casing sections to verify cement integrity and zonal isolation. A pulsed neutron capture log will be run on the injection hole to provide a baseline water-to-gas saturation to support saturation and injection modeling over the life of the project. All deviation checks will be completed at least every 120 feet.

All tests listed below will be performed at the injection wells.

3.1 Wireline Logs Prior to Running Casing

The following logs will be run for the surface, intermediate and long-string sections:

- Deviation checks
- Dual induction laterolog
- Gamma ray
- Caliper
- Compensated neutron
- Formation density
- Mud log

3.2 Wireline Logs After Running Casing

The following will be conducted for surface, intermediate, and long-string sections:

- Cement bond log
- Casing inspection log

3.3 Additional Injection Well Testing

Additional injection well testing will include the following:

- Internal mechanical integrity/standard annulus pressure test (SAPT)
- External mechanical integrity (at least one of) oxygen activation log, noise log, and temperature log

- Pressure fall-off testing as described in **Attachment C**
- Injectivity tests

4. Coring Program

Several whole cores will be taken from a newly drilled wellbore in the project to evaluate fluid and rock properties to calibrate against open hole logs. The objective of the coring zones is to determine the nature of sand reservoir containers and their transitions to shales. Cores will be taken across sealing interfaces and across the injection zone. Formations to be cored are:

- Winters Formation (Injection Zone)
- Sawtooth Shale (Confining Zone)
- Tracy Formation (Confining Zone)
- Starkey Formation (Confining Zone)
- H&T Shale

Tests that are planned to be performed are:

- Routine core analysis (porosity, permeability, saturation, grain density): All zones
- Rock mechanics (including triaxial load testing): Injection zone and confining layers
- Capillary pressure (MICP) to determine pore throats and relate water saturations to permeability (K) and porosity (φ): All zones
- Threshold entry pressure (TEP): All confining layers and H&T Shale
- X-ray diffraction (XRD) to determine clay mineralogy and validate petrophysical clay volume calculations: All zones
- Thin section and scanning electron microscopy (SEM) analyses: All zones
- CO_2-water relative permeability: Injection Zone
- Pore volume compressibility: Injection Zone
- Geochemical compatibility: Injection Zone and Sawtooth Shale
- Thermal conductivity: Injection Zone and Sawtooth Shale
- Core descriptions: All zones

5. Additional Pre-Operational Testing

Additional pre-operational testing will include the following.

- Hydrologic and Hydrogeologic Information:

- Groundwater sample collection and analysis during well construction to establish the depth of the lowermost underground source of drinking water (USDW) within the area of review (AoR) (analytes and testing methods in **Attachment C**).
- Baseline pressure and temperature data will be collected at all monitoring wells using methods described in **Attachment C**. Monitoring well M-2 will collect pressure data (RFT) in the Winters and Lathrop Formations.

- Geochemistry/Geochemical Data
  - Characterize the baseline geochemistry of the USDW, Mokelumne River Formation, and the Winters Formation for all parameters (and methods) described in the Testing and Monitoring Plan to (1) confirm the inputs to the geochemical modeling and (2) establish a baseline for monitoring. Baseline geochemistry samples will be collected at all monitoring wells (**Attachment C**).
  - Characterize mineralogy of the Upper Confining Zone and Winters Formation to confirm inputs to the geochemical modeling.
  - Geochemical modeling (PHREEQC) will be revised with newly collected data during the pre-operational phase.

- Geomechanics
  - Clarify formation ductility, principal stresses, pore pressure, fracture gradient, and other petrophysical parameters to confirm geomechanical assumptions based on data collected during logging, testing, and coring described above.

- Seismic History and Seismic Risk
  - Establish pressure in the Injection Zone (anticipated testing methods: pressure gauge measurement).
  - Continue to establish baseline seismicity using methods listed in **Attachment A: Application Narrative (Attachment A)** and **Attachment C**.

- Facies Changes in the Injection or Confining Zones/Site Geomodel
  - Confirm the thickness of the Winters Formation sands at the location of the injection wells to provide additional information on their suitability for injection, including facies changes that could facilitate preferential flow (anticipated testing methods: cores and well logging data, see Sections 3 and 4).
  - Confirm thickness of the Upper Confining Zone.
  - Update site geomodel as needed to reflect any heterogeneities identified during the pre-operational phase based on data collected during logging, testing, and coring described above.

- CO_2 Stream Compatibility with Subsurface Fluids and Minerals
  - Confirm the composition of the CO_2 injectate as part of baseline sampling and provide verification that it will not react with the formation matrix (anticipated testing methods: injectate analysis and core testing, geochemical modeling).

- Confirm that the properties of the CO_2 stream are consistent with the AoR delineation model inputs (anticipated testing methods: various geochemical analyses).
- Confirm that the analytes for the injectate and ground water quality monitoring are appropriate based on the results of the geochemical modeling evaluation (anticipated testing methods: various geochemical analyses).

- Injection and Confining Zone Integrity
  - Confirm the fracture pressure of the injection zone via a site-specific step rate test in the project area on newly drilled injection wells.
  - Determine the fracture pressure of the confining zone via a site-specific step rate test in the project area.

- Injection Well Construction
  - Following pre-construction measurement of the composition, properties, and corrosiveness of the injectate, review well construction materials and cement in the context of the results of these tests (anticipated testing methods: various geochemical analyses).

- Storage Capacity
  - Reevaluate CO_2 storage capacity based on site-specific injection zone characteristics.

References

U.S. Environmental Protection Agency (U.S. EPA), 2013. Underground Injection Control (UIC) Program Class Six Well Testing and Monitoring Guidance. Office of Water (4606M) EPA 816-R-13-001, March 2013.