

**ATTACHMENT I: PRE-OPERATIONAL TESTING PLAN**  
**40 CFR 146.87**

**CTV IV**

**1.0     Document Version History**

Version	Revision Date	File Name	Description of Change
1	4/15/2023	Att I Pre-Operational Testing Plan_v1	Original Submission

**2.0     Facility Information**

Facility Name:           CTV IV

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Well Location(s):      [REDACTED]

**3.0     Testing Summary**

TerraVault Holdings, LLC (CTV) plans to drill five new injection wells [REDACTED] in the Lower Injection Zone and three new injection wells in the Upper Injection Zone [REDACTED] for a total of eight injection wells for the CTV IV storage project. Pre-operational formation testing will include a suite of logging, coring, geohydrologic testing and other activities during the drilling and completion or conversion 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 Upper Confining Zone, Upper Injection Zone, Internal Barrier, and Lower Injection Zone as defined in **Attachment A**.

Methods for tests will be consistent with U.S. EPA (2013), and testing methods listed in the Testing and Monitoring Plan (Attachment C). Well-specific Construction and Plugging (CP) Plans (Attachment G1 through G8) are submitted for each individual well. This Pre-Operational Testing Plan summarizes planned pre-operational testing activities, schedule and reporting to EPA.

#### **4.0 Schedule and Reporting**

Results of testing will be documented in a report submitted to the U.S. EPA after new well drilling and testing activities have been completed, but before CO<sub>2</sub> injection commences.

CTV will notify the Director at least 30 days prior to conducting any testing.

#### **5.0 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 tests listed below will be performed for new injection wells.

##### **5.1. Wireline logs prior to running casing**

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

- Deviation checks
- Spontaneous Potential
- Dual Induction Laterolog
- Gamma Ray
- Caliper
- Compensated Neutron
- Formation Density
- Mud Log

##### **5.2. Wireline logs after running casing**

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

- Cement Bond Log
- Casing Inspection Log

##### **5.3. 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, temperature log
- Pressure fall-off Testing as described in the Testing and Monitoring Plan (Attachment C).

## **6.0     Coring Program**

Several whole and sidewall 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 zones. Targets include the Upper Confining Zone, Upper Injection Zone, Internal Barrier, and Lower Injection Zone as defined in **Attachment A**.

### Proposed Core Analyses:

- Porosity
- Permeability to air
- Saturations
- Grain density – to calibrate porosity logs
- Gamma ray – to correlate to open hole logs
- Core descriptions

### Proposed Special Core Analysis:

- Capillary pressure on select plugs to determine pore throats and relate water saturations to permeability (K) and porosity ( $\phi$ )
- X-ray diffractograms (XRD) to determine clay mineralogy and validate petrophysical clay volume calculations
- CO<sub>2</sub> to water relative permeability
- Geomechanical measurements of containment and injection zones
- Pore compressibility
- Thin section and scanning electron microscopy (SEM) analyses

## **7.0     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 USDW within the AoR (analytes and testing methods in the Testing and Monitoring Plan).

### Geochemistry/Geochemical Data

- Characterize the baseline geochemistry of the USDW and the Upper and Lower Injection Zones 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.

### 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 the Narrative Application Report (Attachment A).

### Facies Changes in the Injection or Confining Zones

- Confirm the thickness of the Upper and Lower Injection Zones 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 4 and 5 above).

### CO<sub>2</sub> Stream Compatibility with Subsurface Fluids and Minerals

- Confirm the composition of the CO<sub>2</sub> 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<sub>2</sub> 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).

### Confining Zone Integrity

- Confirm the fracture pressure of the injection zone via a site-specific step rate test in the project area.
- 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).

## **8.0 References**

United States 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.