**SECTION D. PRE-OPERATIONAL TESTING PROGRAM**
**40 CFR 146.82(a)(8), 146.87**

**MONTEZUMA NORCAL CARBON SEQUESTRATION HUB**

# Facility Information

| | |
|---|---|
| Facility name: | Montezuma NorCal Carbon Sequestration Hub<br>IW-A1 |
| Facility contact: | Jim Levine, Managing Partner<br>2000 Powell Street, Suite 920<br>Emeryville, CA 94608<br>Phone: (510) 409-1765<br>Email: jim.levine@upstream.us.com |
| Well location: | Collinsville, Solano County, California<br>Lat: 38º 5' 7.334" N Long: -121º 51' 30.914" W NAVD 88<br>Sec 28 T 3 N R 1 E |

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# List of Acronyms and Abbreviations

| | |
|---|---|
| AIM = Advanced Imaging of Materials | MIT = mechanical integrity test |
| Al = Aluminum | Mn = Manganese |
| Ba = Barium | MRMS = Multi-Radar/Multi-Sensor |
| C = Carbon | Na = Sodium |
| Ca = Calcium | Ni = Nickel |
| Cl = Chlorine | O = Oxygen |
| CO2 = Carbon dioxide | PEF = Photoelectric factor |
| CS-XRF = X-Ray Fluorescence Core Scanning | PISC = Post Injection Site Care |
| Fe = Iron | S = Sulfur |
| FNXS = fast neutron cross section | SEM = Scanning Electron Microscope |
| ft = feet | Si = Silicon |
| ft bgs = feet below ground surface | SP = Spontaneous potential |
| Gd = Gadolinium | Ti = Titanium |
| H = Hydrogen | US EPA = United States Environmental Protection Agency |
| ISIP = Instantaneous Shut-in Pressure | USDW = Underground Source of Drinking Water |
| K = Potassium | XRD = X-Ray Diffraction |
| MC = Montezuma Carbon, LLC | |
| Mg = Magnesium | |

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## D.1 SUMMARY

Montezuma Carbon, LLC (MC) will carry out a Pre-Operational Testing Program in conformance to 40 CFR 146.82(a)(8) and 146.87. The plan includes: (a) Comprehensive logging and testing to ensure IW-A1 (and IZMW-A1) conforms to Class VI well construction standards, and establish a baseline of formation properties (depth, thickness, porosity, permeability, lithology, salinity) from field data collected during drilling of IW-A1 and IZMW-A1, (b) Coring and formation fluid sampling in all relevant geologic formations from the upper secondary confining zones down through the lower pressure dissipation zone, (c) Measurement of injection zone fluid temperature, pH, conductivity, reservoir pressure, and static fluid level, (d) Method for determining fracture pressure and other physical and chemical characteristics of the injection and confining zones, and (e) Pressure fall-off test and a pump/injectivity test of IW-A1 to determine near-wellbore formation properties.

The testing activities described in this document are restricted to IW-A1 and IZMW-A1 during the Pre-Injection period. Testing and monitoring activities during the Injection and Post-Injection Site Care (PSIC) periods are described in the Testing and Monitoring Plan, along with other non-related Pre-Injection period activities such as above confining zone geochemical monitoring. Class VI requirements for injection well construction do not strictly apply to a monitoring well, however MC has elected to follow the spirit of 40 CFR 146.87 to ensure IZMW-A1 is built to an appropriate standard. Construction of IZMW-A1 also provides an opportunity to gather additional field data (depth, thickness, porosity, permeability, lithology, salinity) on formation properties within the project site. The testing activities described in this program apply to IW-A1 and IZMW-A1, some or much of this testing may be carried out on a stratigraphic test well prior to issuance of the Class VI permit and that well may be converted to either IW-A1 or IZMW-A1 pending design completion.

## D.2 PRE-INJECTION PERIOD TESTING PLAN FOR IW-A1 (AND IZMW-A1)

Specific objectives of the Pre-Operational Testing Program are to:

- Correlate available research and regional data to the site and confirm assumptions and model inputs of the injection and confining zones.
- Characterize the geomechanical properties of the injection and confining zones, including ductility, rock strength, formation stress, brittleness, pore pressure, and capillary pressure.
- Verify that any localized heterogeneities or facies changes in the injection or confining zones will not affect the storage or confinement of carbon dioxide ($CO_2$).

- Confirm the storage capacity of the Anderson Sandstone formation based on site-specific data (e.g., porosity, pressure, and temperature) and planned operational data ($CO_2$ density).
- Characterize the baseline geochemistry of the injection zone, the Meganos/Upper Martinez, the Tehama, and the shallow and deep aquifers to provide a baseline for future monitoring.
- Perform geochemical modeling or benchtop laboratory experiments to demonstrate compatibility of the formation fluids and rock of the injection and confining zones with injected $CO_2$, including how geochemical interactions may affect porosity, permeability, injectivity, and storage capacity due to mineralization, mineral precipitation, dissolution, or other processes.
- Establish site-specific pressure, salinity, and temperature initial conditions in the Anderson Formation.
- Establish the total dissolved solids of the Tehama Formation and confirm the depth of the lowermost Underground Source of Drinking Water (USDW).
- Demonstrate the integrity and viability of the Meganos/Upper Martinez shale formations as confining layers in the Area of Review.

The following tests and logs will be conducted on IW-A1 (and IZMW-A1) during drilling, casing installation, and after casing installation in accordance with the requirements of 40 CFR 146.87(a), (b), (c), and (d). The tests and procedures are identified below, with additional information provided in the Well Construction Details and the Testing and Monitoring Plan.

### D.2.1 DEVIATION CHECKS [40 CFR 146.87(A)(1)]

Deviation measurements were conducted during drilling of IW-A1 (and IZMW-A1) at every half-foot, measuring inclination and azimuth in degrees during construction of the well.

### D.2.2 TESTS AND LOGS PERFORMED DURING DRILLING OPERATIONS

Table D-1 outlines the IW-A1 (and IZMW-A1) open hole logging program conducted during drilling operations to ensure conformance to injection well construction requirements and establish a baseline for formation properties per 40 CFR 146.87(a)(2)(i) and (3)(i).

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### TABLE D-1. OPEN HOLE LOGGING FOR IW-A1

<table>
<tr><th>Timing</th><th>Tool</th><th>Description</th><th colspan="2">General Interval, ft bgs</th></tr>
<tr><td rowspan="4">Before/Upon Installing Surface Casing, 40 CFR 146.87(a)(2)(i)</td><td>Triple Combo [Platform Express]</td><td>Gamma ray, porosity, array induction resistivity, neutron porosity, density, PEF, caliper, and SP measurement.</td><td rowspan="4">80</td><td rowspan="4">3,000</td></tr>
<tr><td>Single Arm Caliper</td><td>Used for hole volume and cement volume calculations.</td></tr>
<tr><td>4-Arm Caliper</td><td>Detailed borehole profile. Used for hole volume and cement volume calculations.</td></tr>
<tr><td>Borehole Compensated Sonic</td><td>Sonic porosity with interval transit time</td></tr>
<tr><td rowspan="5">Before/Upon Installing Intermediate Casing</td><td>Triple Combo [Platform Express]</td><td>Gamma ray, porosity, array induction resistivity, neutron porosity, density, PEF, caliper, and SP measurement.</td><td rowspan="5">3,000</td><td rowspan="5">7,900</td></tr>
<tr><td>Single Arm Caliper</td><td>Used for hole volume and cement volume calculations.</td></tr>
<tr><td>4-Arm Caliper</td><td>Detailed borehole profile. Used for hole volume and cement volume calculations.</td></tr>
<tr><td>Borehole Compensated Sonic</td><td>Sonic porosity with interval transit time</td></tr>
<tr><td>Dipole Sonic</td><td>Multi-mode array sonic. Compressional and shear measurement with Anisotropy and Waveform Dispersion Analysis</td></tr>
</table>

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| Timing | Tool | Description | General Interval, ft bgs | |
|---|---|---|---|---|
| Before/Upon Installing Long String Casing, 40 CFR 146.87(a)(3)(i) | Dielectric Scanner | Multi-frequency dielectric dispersion. Measure water volume independent of resistivity at investigation depth to 4.0-in. Water salinity application. | 7,900 | 12,920 |
| | Magnetic Resonance. T2 Relaxation | Lithology independent porosity, pore and grain size distribution, volume of irreducible fluid and permeability | | |
| | Natural Gamma Ray Spectroscopy | Total gamma ray and weight fraction of potassium, thorium, and uranium | | |
| | Triple Combo [Platform Express] | Gamma ray, porosity, array induction resistivity, neutron porosity, density, PEF, caliper, and SP measurement. | | |
| | Single Arm Caliper | Used for hole volume and cement volume calculations. | | |
| | Array Induction Resistivity | Formation resistivity at 2 ft and 4 ft vertical resolution. Radial depths at 10, 20, 30, 60, and 90-inches into formation. Also includes SP measurement. | | |
| | Dipole Sonic | Multi-mode array sonic. Compressional and shear measurement with Anisotropy and Waveform Dispersion Analysis | | |
| | Formation Micro-Imager | Resistivity image provides structural geology, sedimentary features, rock texture analysis. 0.2-inch vertical resolution. | | |
| | Litho Scanner with Chlorine Analysis | Measures suite of elements for baseline salinity. Elements measured include: Al, Ba, C, Ca, Cl, Cu, Fe, Gd, H, K, Mg, Mn, Na, Ni, O, S, Si, Ti | | |
| | Mudlog | Formation lithology description from mud and cuttings analysis; depth annotations for testing procedures | | |

Al = Aluminum, Ba = Barium, C = Carbon, Ca = Calcium, Cl = Chlorine, Fe = Iron, ft = feet, Gd = Gadolinium, H = Hydrogen, K = Potassium, Mg = Magnesium, Mn = Manganese, Na = Sodium, Ni = Nickel, O = Oxygen, PEF = Photoelectric Factor, S = Sulfur, Si = Silicon, SP = Spontaneous Potential, Ti = Titanium

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**Coring Program**

Whole core will be collected in each potential injection and confining zone on IZMW-A1 and is presented in Table D-2 below. Whole core will only be collected in potential injection zones on IW-A1. It is assumed that the decisions regarding sidewall sampling will be made at the time of logging when the well is at total depth. Rotary sidewall cores may be collected from select intervals between approximately 7,900 ft and the total depth of the well. Decisions on whether sidewall cores should be collected, and the targeted depths, will be made at the time of logging when the well is at total depth.

The coring and analysis program will include:

- Conventional Core Description
- Detailed Fracture Analysis
- Thin Section Preparation Only with RapidZoom™ High Resolution Image
- Thin Section Petrography
- Scanning Electron Microscope (SEM)-Sandstones
- Advanced Imaging of Materials (AIM)-SEM Analysis of Mudrocks (Shale)
- X-Ray Fluorescence Core Scanning (CS-XRF) – Continuous Scanning
- X-Ray Diffraction (XRD) Bulk and Clay
- Wettability
- Mercury Injection Capillary Pressure
- Threshold Entry Pressure
- Rock Mechanics
- Relative Permeability
- Formation Damage/Compatibility Testing (e.g., thermal and chemical interactions with $CO_2$ injection flow tests)
- Dean Stark Fluid Saturation
- Hot Solvent Batch Extraction and Leaching of Plug Sample
- Standard Analysis at One Pressure – includes porosity and grain density by the Boyle's Law technique, permeability to air by unsteady-state technique. Data are reported in tabular, graphical and digital format.
- Porosity Determination at Each Additional Confining Pressure

- Permeability Determination at Each Additional Confining Pressure
- Vertical - Permeability Determination at Each Additional Confining Pressure
- Shale and Organics-Rich Core Analysis – GRI Method (including absolute matrix permeability)
- GRI Add on: Unconfined Gas Transport Model Technique in Conjunction with Other Analyses
- Porosity Determination by NMR T2 at 100% $S_w$ (In Conjunction with XRD for Clay Bound Porosity)

**TABLE D-2. CORING PLAN FOR MW-IZA1**

| Zone | Type | No. of 30 ft Whole Cores | Depth of Formation (ft MSL) | Approx. Depth of Cores (ft) | Thickness of Cores (ft) |
|---|---|---|---|---|---|
| Nortonville Shale | Confinement | 2 | 7,900 – 8,150 | 7,900 – 7,960 | 60 |
| Domengine (middle) | Injection | 2 | 8,150 – 8,550 | 8,250 – 8,310 | 60 |
| Capay Shale (top) | Confinement | 2 | 8,550 – 9,200 | 8,600 – 8,660 | 60 |
| Capay Shale (base) | Confinement | 2 | 8,550 – 9,200 | 9,100 – 9,160 | 60 |
| Hamilton sand (top) | Injection | 1 | 9,200 – 9,900 | 9,300 – 9,330 | 30 |
| Hamilton sand (bottom) | Injection | 2 | 9,200 – 9,900 | 9,800 – 9,860 | 60 |
| Meganos shale (top) | Confinement | 1 | 9,900 – 10,300 | 9,900 – 9,930 | 30 |
| U. Martinez shale (bottom) | Confinement | 1 | 10,300 – 11,300 | 11,000 – 11,060 | 30 |
| Anderson Sand (top) | Injection | 2 | 11,300 – 12,600 | 11,400 – 11,460 | 60 |
| Anderson Sand (middle) | Injection | 4 | 11,300 – 12,600 | 11,900 – 12,020 | 120 |
| Anderson Sand (base) | Injection | 2 | 11,300 – 12,600 | 12,400 – 12,460 | 60 |
| L. Martinez | Confinement | 2 | 12,600 – Total Depth | 12,600 – 12,660 | 60 |
| TOTALS | | 23 | | | 690 |

**Fluid Sampling, Geomechanical Logging and Formation Pressure Buildup Tests**

Fluid sampling, geomechanical logging, and formation pressure buildup tests will be conducted in each injection and confining interval other than the Lower Martinez. The sampling will include a pump-out module, in-situ fluid analyzer, up to (3) 1-gallon sample chambers, and one MRMS Module (Multisample Module) with six 450cc sample bottles. Fluid samples de-pressurized and drained at surface. Includes real-time domain support during operation and post-collection contamination write up report. Formation pressure buildup tests will be collected near fluid sampling locations. Geomechanical logging will include mini-frac and micro-frac stress testing resulting in a one-dimensional mechanical earth model providing calibrated minimum horizontal stress across the wellbore.

Together, the above tests are sufficient to provide the following information on the injection and confining zones: depth, thickness, mineralogy, porosity, permeability, and capillary pressure characteristics.
40 CFR 146.82(a)(3)(iii) also requires that the areal extent of the injection and confining zones be characterized. The Site Characterization document provides cross sections that demonstrate that the injection and confining zones are continuous across the Area of Review.

### D.2.3 TESTS AND LOGS PERFORMED DURING AND AFTER CASING INSTALLATION

We will conduct baseline cement and casing integrity analysis combined with Pulsed Neutron gas and super-critical $CO_2$ (carbon dioxide) FNXS (fast neutron cross section) measurements along with water saturation analysis with intrinsic permeability.

### D.2.4 DEMONSTRATION OF MECHANICAL INTEGRITY IN IW-A1 (AND IZMW-A1)

Table D-3 summarizes the internal mechanical integrity test (MIT) on IW-A1 to ensure there is no significant leak in the casing, tubing, or packer; the external MIT on IW-A1 to ensure there is no significant fluid movement into an USDW through channels adjacent to the well bore; plus, the pressure fall-off and pump/injectivity tests on IW-A1 to verify hydrogeologic characteristics of the injection zone. These tests are to be completed prior to placing IW-A1 into service as an injection well.

**TABLE D-3. MECHANICAL INTEGRITY AND INJECTION ZONE TESTS FOR IW-A1 (AND IZMW-A1)**

| Requirement | Selected Test Method |
|---|---|
| Internal MIT<br>40 CFR 146.89(a)(1) | Annulus Pressure Test |
| External MIT<br>40 CFR 146.87(a)(4) | Temperature Log |
| Injection Zone Test<br>40 CFR 146.87(e)(1) | Pressure Fall-Off Test |
| Injection Zone Test<br>40 CFR 146.87(e)(2/3) | Pump Test or<br>Injectivity Test |

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MC will notify the United States Environmental Protection Agency (US EPA) at least 30 days prior to conducting a test and provide a detailed description of the testing procedure. Notice and the opportunity to witness these tests/logs shall be provided to the US EPA at least 48 hours in advance of a given test/log.

The external MIT temperature log will establish a baseline for static geothermal conditions, needed for interpretation of future temperature logs obtained during Injection and PISC periods of the project.

### D.2.5 ANNULUS PRESSURE TEST PROCEDURES

See Section E.3 of the Testing and Monitoring Plan.

### D.2.6 PRESSURE FALL-OFF TEST PROCEDURES

See Section E.8 of the Testing and Monitoring Plan.

### D.2.7 INJECTIVITY TEST PROCEDURES

An injectivity test will be conducted in conjunction with the pressure fall-off test. The procedure to conduct a combine injectivity/pressure fall-off test is:

1. Establish injection interval. This is done by setting packer depths in uncompleted wells, or by recording the completion interval in completed wells.
2. Measure initial reservoir pressure. Pressure should be static. It can be measured at the reservoir level by means of a downhole gauge, or by measurement of pressure at the surface or near the surface and addition of the pressure exerted by the column of liquid in the well.
3. Begin pressure measurements at high rate.
4. Establish injection rate. A short pretest at a low rate may be used to determine an appropriate rate for testing. The testing rate should be high enough to cause a pressure which is equal to the depth of the top of the tested zone times 0.75 pounds per square inch per foot.
5. Continue injection until pressure measurements become near stable unless this is impossible due to slow increase, insufficient injection fluid, or high injection pressure.
6. Shut in the injection well.
7. Continue to collect pressure measurements for a period equal in length to the injection portion of the test. The resulting data will constitute a pressure fall-off test.
8. Remove test tools from the well.

### D.2.8 STEP RATE TEST PROCEDURE

The test will be performed using regulatory guidelines to establish fracture gradient. Stress testing is being conducted on core, including for the confining layers.

1. The well will be shut-in long enough prior to testing such that the bottom hole pressures approximate shut-in formation pressures. If the shut-in well flows to the surface, the wellhead injection string will be equipped with a gauge and the static surface pressure read and recorded.
2. A series of successively higher injection rates are used, and the elapsed time and pressure values are read and recorded for each rate and time step, which is the same amount of time as the previous step.
3. Record injection rates using a chart recorder or a strip chart.
4. Pressures measured with a down hole pressure gauge.
5. Measure and record injection pressures with a gauge or recorder (for immediate test results). Record each time step and corresponding pressure.
6. A plot of injection rates and the corresponding stabilized pressure values should be graphically represented as a constant slope straight line to a point at which the formation fracture, or "breakdown", pressure is exceeded. The slope of this subsequent straight line should be less than that of the before-fracture straight line.
7. If the formation fracture pressure has definitively been exceeded, as evidenced by at least two injection rate-pressure combinations greater than the breakdown pressure, the injection pump can be stopped, the line valve closed and pressure allowed to bleed-off into the injection zone. There will occur a significant instantaneous pressure drop (Instantaneous Shut-in Pressure [ISIP]), after which the pressure values will level out. This ISIP value must be read and recorded. The ISIP obtained in this manner may be considered to be the minimum pressure required to hold open a fracture in this formation at this well.
8. Once the ISIP is obtained, the step rate test is concluded.
9. In the event that the breakdown pressure was not obtained at the maximum test injection pressure utilized, the test results may indicate that the formation is accepting fluids without fracturing.

### D.2.9 INJECTION AND CONFINING ZONES FORMATION FLUID ANALYSIS

Formation fluid analysis in IW-A1 and IZMW-A1 during the Pre-Injection period for the injection and confining zones will be consistent with sampling as part of the Injection and Post-Injection periods that will take place in IZMW-A1. Analytes will include cations, anions, stable carbon isotopes of dissolved inorganic carbon, TDS, water density, alkalinity, pH, specific conductance, and temperature. See Section E.9 of the Testing and Monitoring Plan (Table E-12) for details on analytical and field methods for this sampling.

### D.2.10 3D SEISMIC IMAGING

Prior to injection initiation, baseline seismic imaging will be conducted. This will include conventional time-lapse 3D and time-lapse vertical seismic profiling (VSP). The pre-operational testing or baseline measurements will serve as the first data collection event. The conventional 3D survey will encompass the entire AoR. This will aid in site characterization and placing the monitoring well. After the monitoring well is completed, a 3D VSP will be acquired to provide parameters (velocity/attenuation, etc.) that aid in processing and interpretation of the baseline 3D survey, and that provide parameters for microseismic event locations. Additional details of the seismic imaging, including a map of the planned extent, is provided in the Testing and Monitoring Plan.