# TESTING AND MONITORING PLAN 40 CFR 146.90

**INSERT PROJECT NAME**

|  |
| --- |
| **INSTRUCTIONS**  This template provides a suggested outline and recommendations for the Testing and Monitoring Plan. Permit applicants are not required to use this template. This document does not substitute for promulgated provisions or regulations, nor is it a regulation itself, and it does not impose legally-binding requirements on the U.S. Environmental Protection Agency (EPA), states, or the regulated community.  Note that references to EPA’s Class VI Rule in the code of federal regulations (CFR) are provided in this template. States with Class VI primacy have requirements that are at least as stringent as EPA’s. If your Class VI well is in a primacy state, consult your permitting authority about any additional requirements for what must be included in the plan.  In this template, instructions or suggestions appear in ***blue text***. These are provided to assist with site- and project-specific plan development. These are recommendations and are not required elements of the federal Class VI Rule.  Please delete the ***blue text*** and replace the yellow highlighted text before submitting your document. Similarly, please adjust the example text and tables throughout as necessary (e.g., by adding or removing rows or columns). Appropriate maps, figures, references, etc. should also be included to support the text of the plan.  Remember that, pursuant to 40 CFR 146.94(a) of the federal Class VI Rule, the requirement to maintain and implement an approved Testing and Monitoring Plan is directly enforceable regardless of whether the requirement is a condition of the permit. For more information, see EPA’s Class VI guidance documents at <https://www.epa.gov/uic/class-vi-guidance-documents>. It is the responsibility of the owner or operator to maintain records of previous revisions to this plan.  To avoid duplicative reporting, you are encouraged to provide relevant cross-references to other submissions made with the GSDT. |

## Facility Information

Facility name: INSERT FACILITY NAME  
INSERT WELL NUMBER

Facility contact: INSERT CONTACT NAME/CONTACT TITLE  
INSERT ADDRESS  
INSERT PHONE NUMBER/EMAIL ADDRESS

Well location: INSERT CITY, COUNTY, STATE   
INSERT LAT/LONG COORDINATES

This Testing and Monitoring Plan describes how INSERT PERMIT APPLICANT NAME will monitor the INSERT FACILITY NAME site pursuant to 40 CFR 146.90. In addition to demonstrating that the well is operating as planned, the carbon dioxide plume and pressure front are moving as predicted, and that there is no endangerment to USDWs, the monitoring data will be used to validate and adjust the geological models used to predict the distribution of the CO2 within the storage zone to support AoR reevaluations and a non-endangerment demonstration.

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

## Overall Strategy and Approach for Testing and Monitoring

*[EPA encourages permit applicants/owners or operators to include a short “big-picture” summary of their testing and monitoring approach to demonstrate how they will meet all the applicable requirements of the Class VI Rule. You may use this section to provide a brief narrative description of how the proposed testing and monitoring activities support an overall strategy to fulfil the requirements of the Class VI Rule, demonstrate USDW non-endangerment, and collect sufficient data on site-specific system behavior to support decision-making at project milestones.]*

*[Recommended considerations include:*

* *What is the spatial distribution (depth and areal extent) of the proposed monitoring network, and what is the general schedule for data collection? What site-specific considerations were used to determine data collection locations and frequency?*
* *How does the overall testing and monitoring strategy fit the regional and local site characterization and risk profile? For example, if the region has a history of induced or natural seismic events, how will the Testing and Monitoring Plan account for this?*
* *If specific areas or issues of potential concern were identified during site characterization, AoR delineation modeling, or pre-operational logging/testing, how will the testing and monitoring strategy address these concerns?*
* *Generally, how will collected data be compared to baseline data or otherwise applied to demonstrate Class VI Rule compliance/USDW non-endangerment, verify predictions from computational modeling, and provide support for project decision making?]*

### Quality assurance procedures

*[Please reference or attach a quality assurance and surveillance plan (QASP) for all testing and monitoring activities, which is required pursuant to 146.90(k) in the Testing and Monitoring Plan. A template for the QASP is available.]*

### Reporting procedures

INSERT PERMIT APPLICANT NAME will report the results of all testing and monitoring activities to EPA in compliance with the requirements under 40 CFR 146.91.

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

INSERT PERMIT APPLICANT NAME will analyze the CO2 stream during the operation period to yield data representative of its chemical and physical characteristics and to meet the requirements of 40 CFR 146.90(a).

### Sampling location and frequency

*[Recommended considerations include:*

* *What is the specific schedule for CO2 stream sampling? For example, “Sampling will take place quarterly, by the following dates each year: 3 months after the date of authorization of injection, 6 months after the date of authorization of injection, 9 months after the date of authorization of injection, and 12 months after the date of authorization of injection.”*
* *The Class VI Rule requires that the CO2 stream be analyzed at a sufficient frequency to yield data representative of chemical and physical CO2 stream characteristics. How was this “sufficient frequency” determined in the context of this project?*
* *How will it be determined if data deviate from baseline, predicted, or average values?*
* *If tracers are used, where/how and at what concentration will they be added?*
* *Will certain changes in CO2 stream chemical and physical characteristics trigger a change in sampling schedule? For example:*
  + *If the well is shut-in for X amount of time, the CO2 stream will be analyzed X (days, weeks) after operations resume.*
  + *An alternative CO2 stream sampling schedule (define) based on injected amount, not time, will be triggered if the Summary of Requirements to this permit is modified or if injection activities deviate significantly (define) from expected rates (e.g., if injection volume is less than X over X period).*
  + *A significant (define) change in chemical or physical characteristics of the CO2 stream will trigger additional sampling at a frequency of X to collect sufficient data to characterize the CO2 stream.]*

### Analytical parameters

INSERT PERMIT APPLICANT NAME will analyze the CO2 for the constituents identified in Table 1 using the methods listed.

Table 1. Summary of analytical parameters for CO2 stream.

| **Parameter** | **Analytical Method(s)** |
| --- | --- |
| Insert Parameter 1 |  |
| Insert Parameter 2 |  |
| Insert Parameter 3 |  |
| *Add rows as needed* |  |

### Sampling methods

*[Recommended considerations include:*

* *Where will sample collection take place?*
* *What materials/equipment will be used?*
* *What sample collection procedures will be implemented to ensure a representative sample? (Refer to the QASP as appropriate.)]*

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

*[Recommended considerations include:*

* *Where will this analysis be conducted? What chain of custody procedures will be implemented? (Refer to the QASP as appropriate.)*
* *What are the detection limits for the analytical methods that will be used? (Refer to the QASP as appropriate.)]*

## Continuous Recording of Operational Parameters [40 CFR 146.88(e)(1), 146.89(b) and 146.90(b)]

INSERT PERMIT APPLICANT NAME will install and use continuous recording devices to monitor injection pressure, rate, and volume; the pressure on the annulus between the tubing and the long string casing; the annulus fluid volume added; and the temperature of the CO2 stream, as required at 40 CFR 146.88(e)(1), 146.89(b), and 146.90(b).

### Monitoring location and frequency

INSERT PERMIT APPLICANT NAME will perform the activities identified in Table 2 to monitor operational parameters and verify internal mechanical integrity of the injection well. All monitoring will take place at the locations and frequencies shown in the table.

*[Note: As applicable, please provide sampling/recording frequencies for both active operation and shut-in periods.]*

Table 2. Sampling devices, locations, and frequencies for continuous monitoring.

| **Parameter** | **Device(s)** | **Location** | **Min. Sampling Frequency** | **Min. Recording Frequency** |
| --- | --- | --- | --- | --- |
| Insert Injection pressure |  |  |  |  |
| Insert Injection rate |  |  |  |  |
| Insert Injection volume |  |  |  |  |
| Insert Annular pressure |  |  |  |  |
| Insert Annulus fluid volume |  |  |  |  |
| Insert CO2 stream temperature |  |  |  |  |
| *Add rows as needed* |  |  |  |  |
| Notes:   * Sampling frequency refers to how often the monitoring device obtains data from the well for a particular parameter. For example, a recording device might sample a pressure transducer monitoring injection pressure once every two seconds and save this value in memory. * Recording frequency refers to how often the sampled information gets recorded to digital format (such as a computer hard drive). For example, the data from the injection pressure transducer might be recorded to a hard drive once every minute. | | | | |

### Monitoring details

*[EPA recommends that, for each the parameters required by the Class VI Rule (injection pressure, injection rate, injection volume, annular pressure, annulus fluid volume, and CO2 stream temperature) and any optional operational parameters that will be monitored (e.g., bottomhole pressure/‌temperature), the plan specify the following:*

* *Where specifically will this monitoring take place? What equipment/instrumentation will be used and how often will data be sampled/recorded? (Refer to Table 2 as appropriate.)*
* *What are the instrument calibration standards, precision, and tolerances? How will any necessary supporting information (e.g., fluid density) be measured or calculated? (Refer to the QASP as appropriate.)*
* *If applicable, what formulas or conversion factors will be used? (Provide citations as appropriate.)*
* *How will it be determined if data deviate from baseline, predicted, or average values?*
* *How will the data be used to demonstrate internal mechanical integrity, pursuant to 40 CFR 146.89(b)?*
* *How might changes in injection rate or annular pressure trigger additional sample collection or change the sampling schedule for other aspects of the Testing and Monitoring Plan (above confining zone monitoring, mechanical integrity testing, etc.)?]*

## Corrosion Monitoring

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

INSERT PERMIT APPLICANT NAME will monitor corrosion using INSERT METHOD and collect samples according to the description below.

### Monitoring location and frequency

*[Recommended considerations include:*

* *What is the specific schedule for corrosion monitoring? For example, “This monitoring will occur quarterly, by the following dates each year: 3 months after the date of authorization of injection, 6 months after the date of authorization of injection, 9 months after the date of authorization of injection, and 12 months after the date of authorization of injection.”*
* *Will additional corrosion monitoring be added if there are deviations from expected operations? For example, the quarterly monitoring schedule could be supplemented with samples collected based on injected volume (rather than time) to ensure sufficient characterization of well materials.]*

### Sample description

*[Recommended considerations include:*

* *What materials will be monitored for corrosion? (Refer to Table 3; modify table as necessary for methods other than corrosion coupons.)*
* *What baseline assessment will be conducted prior to exposing the materials to corrosive conditions?]*

Table . List of equipment with material of construction. *[Specify the equipment to be tested (e.g., corrosion coupons or loops)]*

| **Equipment Coupon** | **Material of Construction** |
| --- | --- |
| Insert Well component 1 |  |
| Insert Well component 2 |  |
| Insert Well component 3 |  |
| *Add rows as needed* |  |

### Monitoring details

*[Recommended considerations include:*

* *How will the system be designed to ensure samples are exposed to representative conditions?*
* *What techniques will be used to assess and quantify the corrosion? (Cite references as necessary.)*
* *How will it be determined if data deviate from baseline, predicted, or average values?*
* *Will any additional wellbore tests be conducted (e.g., periodic wireline logs) to supplement the corrosion tests described above?*
* *Will any verification tests will be done to demonstrate that the methods described above are accurately representing downhole conditions?]*

## Above Confining Zone Monitoring

INSERT PERMIT APPLICANT NAME will monitor groundwater quality and geochemical changes above the confining zone during the operation period to meet the requirements of 40 CFR 146.90(d).

To meet the requirements at 40 CFR 146.95(f)(3)(i), INSERT PERMIT APPLICANT NAME will also monitor groundwater quality, geochemical changes, and pressure in the first USDWs immediately above and below the injection zone(s). *[Delete this paragraph if the project will not be operating under an injection depth waiver.]*

### Monitoring location and frequency

Table 4 shows the planned monitoring methods, locations, and frequencies for groundwater quality and geochemical monitoring above the confining zone.

*[Recommended considerations include:*

* *What is the specific schedule for sampling? Define terms such as “quarterly,” for example:*
  + *Quarterly sampling will take place by the following dates each year: 3 months after the date of authorization of injection, 6 months after the date of authorization of injection, 9 months after the date of authorization of injection, and 12 months after the date of authorization of injection.*
  + *Semi-annual sampling will take place by the following dates each year: 6 months after the date of authorization of injection and 12 months after the date of authorization of injection.*
  + *Annual sampling will occur up to 45 days before the anniversary date of authorization of injection each year.*
  + *Logging will take place up to 45 days before the anniversary date of authorization of injection each year.*
* *What is the depth or elevation below mean sea level of each sampling interval?*
* *How will it be determined if data deviate from baseline, predicted, or average values?*
* *How is the network of monitoring wells sufficient to monitor above the confining zone throughout the AoR, given specific geologic characteristics of the site? A map showing monitoring well locations relative to the AoR delineation is encouraged.*
* *Are there any geochemical changes that might trigger a change in the sampling schedule? If so, how will the schedule change to sufficiently identify leaks/characterize groundwater quality above the confining zone?*
* *How will indirect monitoring activities (if used) complement direct fluid sampling to create a comprehensive leak detection/groundwater monitoring strategy?*
* *Is any phased monitoring planned based on predicted plume migration within the AoR?]*

Table 4. Monitoring of groundwater quality and geochemical changes above the confining zone.   
*[If indirect monitoring techniques such as logging will be used to complement direct fluid sampling, they can also be included in this table.]*

| **Target Formation** | **Monitoring Activity** | **Monitoring Location(s)** | **Spatial Coverage** | **Frequency** |
| --- | --- | --- | --- | --- |
| Insert Formation 1 |  |  |  |  |
| Insert Formation 2 |  |  |  |  |
| Insert Formation 3 |  |  |  |  |
| *Add rows as needed* |  |  |  |  |

### Analytical parameters

Table 5 identifies the parameters to be monitored and the analytical methods INSERT PERMIT APPLICANT will use.

*[Recommended considerations include:*

* *How will the suite of parameters presented in Table 5 be sufficient to meet site-specific monitoring objectives? What criteria will be used to determine if additional parameters are needed during the life of the project?*
* *If tracers are used, what detected concentrations will trigger additional action?]*

Table 5. Summary of analytical and field parameters for groundwater samples.

| Parameters | Analytical Methods |
| --- | --- |
| INSERT FORMATION NAME | |
| Insert Parameter 1 |  |
| Insert Parameter 2 |  |
| Insert Parameter 3 |  |
| *Add rows as needed* |  |
| INSERT FORMATION NAME | |
| Insert Parameter 1 |  |
| Insert Parameter 2 |  |
| Insert Parameter 3 |  |
| *Add rows as needed* |  |

### Sampling methods

*[Recommended considerations include:*

* *What materials will be used?*
* *What sample collection procedures will be implemented to ensure a representative sample? (Refer to the QASP as necessary.)]*

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

*[Recommended considerations include:*

* *Where will this analysis be conducted? What chain of custody procedures will be implemented? (Refer to the QASP as necessary.)*
* *What are the detection limits for the analytical methods that will be used? (Refer to the QASP as necessary.)]*

## External Mechanical Integrity Testing

INSERT PERMIT APPLICANT NAME will conduct at least one of the tests presented in Table 6 periodically during the injection phase to verify external MI as required at 146.89(c) and 146.90.

### Testing location and frequency

*[Recommended considerations include:*

* *When specifically will MITs be performed? For example, “MITs will be performed annually, up to 45 days before the anniversary date of authorization of injection each year.”]*

Table . MITs.

| **Test Description** | **Location** |
| --- | --- |
| Insert Test 1 |  |
| Insert Test 2 |  |
| Insert Test 3 |  |
| *Add rows as needed* |  |

### Testing details

*[Recommended considerations include:*

* *What are the specific procedures that will be followed for each type of test? (Provide a list of steps or similar description.)*
* *What gauges or other equipment will be used? What is the range, precision, etc. of the equipment?*
* *What will constitute a “pass” or “fail” for each test?*
* *Will any other data be used to demonstrate that there are no significant leaks? For example, continuous monitoring of annulus and injection pressure can be used to identify the presence of leaks.*
* *Will any MIT(s) be conducted on monitoring wells? It may be important to demonstrate mechanical integrity for any wells that penetrate the confining zone. If MITs will be conducted on monitoring wells, this information can also be included in Table.]*

## Pressure Fall-Off Testing

INSERT PERMIT APPLICANT NAME will perform pressure fall-off tests during the injection phase as described below to meet the requirements of 40 CFR 146.90(f).

### Testing location and frequency

*[Recommended considerations include:*

* *When will pressure fall-off tests be performed? For example, “During injection, approximately half way through the injection phase (i.e., year 2.5) and at the end of the injection period.”]*

### Testing details

*[Recommended considerations include:*

* *What are the specific procedures that will be followed for the test? (For example, provide a list of steps or similar description.)*
* *What gauges or other equipment will be used? What is the range, precision, etc. of the equipment?]*

## Carbon Dioxide Plume and Pressure Front Tracking

INSERT PERMIT APPLICANT NAME will employ direct and indirect methods to track the extent of the carbon dioxide plume and the presence or absence of elevated pressure during the operation period to meet the requirements of 40 CFR 146.90(g).

### Plume monitoring location and frequency

Table 7 presents the methods that INSERT PERMIT APPLICANT NAME will use to monitor the position of the CO2 plume, including the activities, locations, and frequencies INSERT PERMIT APPLICANT NAME will employ. The parameters to be analyzed as part of fluid sampling in the injection zone and associated analytical methods are presented in Table 8.

Quality assurance procedures for these methods are presented in INSERT SECTION X of the QASP.

*[Recommended considerations include:*

* *What is the specific schedule for each monitoring activity? For example, “Logging will take place up to 45 days before the anniversary date of authorization of injection each year.”*
* *For continuous monitoring methods, how often will data be sampled and recorded?*
* *Will monitoring locations/frequencies be fixed or adaptive (e.g., according to the evolution and growth of the plume)? What specific, quantitative triggers or timeframes will be used for phased or adaptive monitoring? Consider including one or more maps showing monitoring locations relative to the AoR delineation and the anticipated position of the plume at certain time intervals (e.g., predicted arrival times at monitoring locations).*
* *What is the depth or elevation below mean sea level of each monitoring interval?]*

### Plume monitoring details

*[Recommended considerations include:*

* *What type(s) of data or output will result from each monitoring method?*
* *What gauges or other equipment will be used? What is the range, precision, etc. of the equipment?*
* *For methods involving fluid sample collection (refer to the QASP as necessary):*
  + *What materials will be used?*
  + *What sample collection procedures will be implemented to ensure a representative sample?*
  + *Where will sample analysis be conducted? What chain of custody procedures will be implemented?*
  + *What are the detection limits for the analytical methods that will be used?*
* *For geophysical methods, what data processing procedures will be implemented?*
* *How will it be determined if data deviate from baseline, predicted, or average values? For point locations, how will plume arrival determined? (e.g., using criteria related to CO2 saturation values, tracer concentrations, etc.)*
* *How will the proposed combination of direct and indirect monitoring satisfy the requirements at 40 CFR 146.90(g)? For example, how will data from the various proposed monitoring methods complement each other? How will the various monitoring results be synthesized to monitor the extent of the plume and verify the AoR delineation?]*

Table . Plume monitoring activities.

| **Target Formation** | **Monitoring Activity** | **Monitoring Location(s)** | **Spatial Coverage** | **Frequency** |
| --- | --- | --- | --- | --- |
| **DIRECT PLUME MONITORING** | | | | |
| Insert Formation 1 |  |  |  |  |
| Insert Formation 2 |  |  |  |  |
| Insert Formation 3 |  |  |  |  |
| *Add rows as needed* |  |  |  |  |
| **INDIRECT PLUME MONITORING** | | | | |
| Insert Formation 1 |  |  |  |  |
| Insert Formation 2 |  |  |  |  |
| Insert Formation 3 |  |  |  |  |
| *Add rows as needed* |  |  |  |  |

Table . Summary of analytical and field parameters for fluid sampling in the injection zone.

| Parameters | Analytical Methods |
| --- | --- |
| FORMATION NAME | |
| Insert Parameter 1 |  |
| Insert Parameter 2 |  |
| Insert Parameter 3 |  |
| *Add rows as needed* |  |

### Pressure-front monitoring location and frequency

Table 9 presents the methods that INSERT PERMIT APPLICANT NAME will use to monitor the position of the pressure front, including the activities, locations, and frequencies INSERT PERMIT APPLICANT NAME will employ.

Quality assurance procedures for these methods are presented in SECTION X of the QASP.

*[Recommended considerations include:*

* *What is the specific schedule for each monitoring activity? For example, “Logging will take place up to 45 days before the anniversary date of authorization of injection each year.”*
* *For continuous monitoring methods, how often will data be sampled and recorded?*
* *Will monitoring locations/frequencies be fixed or adaptive (e.g., according to the evolution and growth of the pressure front)? What specific, quantitative triggers or timeframes will be used for phased or adaptive monitoring? Consider including one or more maps showing monitoring locations relative to the AoR delineation and the anticipated position of the pressure front at certain time intervals (e.g., predicted arrival times at monitoring locations).*
* *What is the depth or elevation below mean sea level of each monitoring interval?]*

### Pressure-front monitoring details

*[Recommended considerations include:*

* *What type(s) of data or output will result from each monitoring method?*
* *What gauges or other equipment will be used? What is the range, precision, etc. of the equipment?*
* *For geophysical methods, what data processing procedures will be implemented?*
* *How will it be determined if data deviate from baseline, predicted, or average values?*
* *How will the proposed combination of direct and indirect monitoring satisfy the requirements at 40 CFR 146.90(g)? For example, how will data from the various proposed monitoring methods complement each other? How will the various monitoring results be synthesized to monitor the extent of the plume and verify the AoR delineation?]*

Table . Pressure-front monitoring activities.

| **Target Formation** | **Monitoring Activity** | **Monitoring Location(s)** | **Spatial Coverage** | **Frequency** |
| --- | --- | --- | --- | --- |
| **DIRECT PRESSURE-FRONT MONITORING** | | | | |
| Insert Formation 1 |  |  |  |  |
| Insert Formation 2 |  |  |  |  |
| Insert Formation 3 |  |  |  |  |
| *Add rows as needed* |  |  |  |  |
| **INDIRECT PRESSURE-FRONT MONITORING** | | | | |
| Insert Formation 1 |  |  |  |  |
| Insert Formation 2 |  |  |  |  |
| Insert Formation 3 |  |  |  |  |
| *Add rows as needed* |  |  |  |  |

## Soil Gas Monitoring/Other Testing and Monitoring

*[Additional testing and monitoring may need to be added as required by the UIC Program Director. If so, describe sampling locations (e.g., in areas, such as near faults, fractures, or abandoned well bores with potential for carbon dioxide migration) and monitoring methods.]*