# AREA OF REVIEW AND CORRECTIVE ACTION PLAN40 CFR 146.84(b)

**INSERT PROJECT NAME**

|  |
| --- |
| **INSTRUCTIONS**This template provides a suggested outline and recommendations for the Area of Review (AoR) and Corrective Action 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. ***Note for all images and maps:*** Please document the location of each image using consistent latitude/longitude coordinates. This applies to images in both plan view and cross section including, but not necessarily limited to: model grid, rock properties and regional geologic information, AoR plume and pressure front maps, and maps documenting the locations of other wells within the AoR.Remember that, pursuant to 40 CFR 146.94(a) of the federal Class VI Rule, the requirement to maintain and implement an approved AoR and Corrective Action 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

## Computational Modeling Approach

*[Please summarize the approach used for AoR modeling and delineation with narrative descriptions and supplemental figures and tables, to fulfil the requirement at 40 CFR 146.84(b)(1). Data relevant to these sections should be uploaded to the GSDT. The summary should include information in all of the subsections outlined below. Information should be presented in a way that demonstrates site-specific compliance with the Class VI Rule and thoroughly explains model construction and methodology.*

*Note: Supplemental information such as raw data in a tabular format (e.g., detailed model grid information, porosity and permeability distributions) should be uploaded directly to the GSDT. Figures and graphics included in the AoR and Corrective Action plan should be used to supplement narrative descriptions of model approach and results.]*

### Model Background

*[Recommended considerations include:*

* *What is the model name and the author(s)/institution?*
* *For what purpose was this model developed? Why was it selected for this project?*
* *What phases are accounted for by the model?*
* *What methods, equations (including primary equation of state), or relationships does the model rely on? What are the key assumptions?*
* *What processes were modeled (e.g., heat transport, multifluid flow, etc.)? These should match the processes selected in the AoR and Corrective Action module of the GSDT.*
* *What were the reasons behind the selection of these specific processes? How will these processes inform AoR delineation?*
* *How might the selection of modeled processes change during AoR reevaluations? If they do change, how will the original model output be compared to subsequent reevaluations?]*

### Site Geology and Hydrology

*[Recommended considerations include:*

* *What site-specific data are available for geology and hydrology?*
* *Identify and describe the injection and confining zones within the geologic context of the region and site (e.g., stratigraphy, depositional history, deformational/tectonic history, hydrogeology), as pertains to the modeling effort. Include maps/cross sections and cite references as necessary.)*

*(Associated figures and graphics may include:*

* *Geologic and hydrologic maps and cross sections.*
* *Regional or local stratigraphic columns.]*

### Model Domain

Model domain information is summarized in Table 1.

*[Recommended considerations include:*

* *What is the size of the modeled area?*
* *What is the grid scaling?*
* *Is the grid scaling consistent throughout the geologic units and distance from the injection well?*
* *How was the model domain generated (e.g., describe any software programs used)?]*

*[Associated figures and graphics may include:*

* *Plan view and cross-sectional figures showing the horizontal and vertical extent of the model grid.]*

Table 1. Model domain information.

|  |  |
| --- | --- |
| **Coordinate System** |  |
| **Horizontal Datum** |  |
| **Coordinate System Units** |  |
| **Zone** |  |
| **FIPSZONE** |  | **ADSZONE** |  |
| **Coordinate of X min** |  | **Coordinate of X max** |  |
| **Coordinate of Y min** |  | **Coordinate of Y max** |  |
| **Elevation of bottom of domain** |  | **Elevation of bottom of domain** |  |
|  |  |  |  |

### Porosity and Permeability

*[Recommended considerations include:*

* *What literature and site-specific data were used to determine the porosity and permeability of the injection and confining zones?*
	+ *How many samples or data sources were used? What method(s) were used?*
	+ *What was the spatial distribution of the samples?*
* *How do the porosity and permeability vary across the unit(s)? How were porosity and permeability distributions determined?*
* *How will porosity and permeability information collected during pre-operational testing be incorporated into the AoR modeling and delineation?*
* *Does the site-specific data match expectations and/or other regional data collected from within the formation?]*

*[Associated figures and graphics may include:*

* *Plan view, cross-sectional, and/or 3-D figures showing the porosity or permeability distribution within the model domain.*
* *Bar charts or line charts showing porosity and permeability distributions in various rock layers.]*

### Constitutive Relationships and Other Rock Properties

*[Recommended considerations include:*

* *What constitutive relationships (e.g., liquid saturation vs. capillary pressure) were included in the model? Why were these included?*
* *What methods or experiments were used to determine constitutive relationships?*
* *Was rock compressibility included as a model parameter? If so, how was it determined?]*

*[Associated figures and graphics may include:*

* *Graphs showing constitutive relationships for relevant rock types (correlation curves) for each defined constitutive relationship.*
* *Any other graphical presentation of fitted functional forms.]*

### Boundary Conditions

*[Recommended considerations include:*

* *What boundary conditions were specified and why?*
* *What assumptions were made?]*

### Initial Conditions

Initial conditions for the model are given in Table 2.

*[If parameters are spatially variable, be sure to describe this variability and supplement it with relevant figures and graphics. Any raw data or detailed tabular data regarding the spatial distribution of initial conditions should be uploaded directly to the GSDT AoR module.]*

Table 2. Initial conditions.

| **Parameter** | **Value or Range** | **Units** | **Corresponding Elevation (ft MSL)** | **Data Source** |
| --- | --- | --- | --- | --- |
| Temperature  |  |  |  |  |
| Formation pressure |  |  |  |  |
| Fluid density |  |  |  |  |
| Salinity |  |  |  |  |
| Brine viscosity  |  |  |  |  |
| Rock compressibility |  |  |  |  |

### Operational Information

Details on the injection operation are presented in Table 3.

*[Note: Operating information should be specified for each injection well or production/‌withdrawal well separately, both in this plan and in the GSDT’s AoR and Corrective Action module.]*

Table 3. Operating details. *[Modify the number of wells as needed.]*

| **Operating Information** | **Injection Well 1** | **Injection Well 2** | **Injection Well 3** |
| --- | --- | --- | --- |
| Location (global coordinates)XY |  |  |  |
| Model coordinates (Insert units)XY |  |  |  |
| No. of perforated intervals |  |  |  |
| Perforated interval (Insert units) Z topZ bottom |  |  |  |
| Wellbore diameter (Insert units)  |  |  |  |
| Planned injection periodStartEnd |  |  |  |
| Injection duration (Insert units) |  |  |  |
| Injection rate (Insert units)\* |  |  |  |

\*If planned injection rates change year to year, add rows to reflect this difference, and include an average injection rate per year (or interval if applicable).

### Fracture Pressure and Fracture Gradient

Calculated fracture gradient and maximum injection pressure values are given in Table 4.

*[Recommended considerations include:*

* *What types of tests were conducted to determine the fracture pressure and fracture gradient for the injection and confining zones? What procedures were used?*
* *What intervals were tested?*
* *Are the results consistent with the literature/available data from nearby wells?*
* *Will fracture pressure be measured during pre-operational testing? If so, how will that information be incorporated into AoR modeling and delineation?]*

Table 4. Injection pressure details. *[Modify the number of wells as needed.]*

| **Injection Pressure Details** | **Injection Well 1** | **Injection Well 2** | **Injection Well 3** |
| --- | --- | --- | --- |
| Fracture gradient (Insert units) |  |  |  |
| Maximum injection pressure (90% of fracture pressure) (Insert units) |  |  |  |
| Elevation corresponding to maximum injection pressure (Insert units) |  |  |  |
| Elevation at the top of the perforated interval (Insert units) |  |  |  |
| Calculated maximum injection pressure at the top of the perforated interval (Insert units) |  |  |  |

## Computational Modeling Results

### Predictions of System Behavior

*[Note: Modeling results should be presented both as time-series data and as snapshots. Time-series data should be provided for specific locations (e.g., monitoring well) over the lifetime of the project, and snapshot data should be provided for the entire model domain at a specific time (e.g., at 1 year, 5 years, 30 years, etc.) Please see the GSDT AoR and Corrective Action Module for more details and specific recommended variables to include.]*

*[Recommended considerations include:*

* *What are the positions of the plume and pressure front at the end of the model timeframe? (Include one or more maps as necessary.)*
* *What are the geographic boundaries of the delineated AoR? (Include one or more maps as necessary.)*
* *How does the AoR evolve over time throughout the lifetime of the project? How long does it take to reach maximum extent? Does the AoR decrease after reaching the maximum extent?*
* *Are there any key uncertainties identified during modeling? How will these be addressed through pre-operational testing (if applicable)?*
* *How does the selected AoR accurately define the maximum plume and pressure front extent throughout the lifetime of the project?*
* *How will the computational model output be compared to AoR reevaluations? How will model results be used to evaluate the accuracy of AoR predictions over time?]*

*[Associated figures and graphics may include:*

* *Multiple time series and snapshot maps showing the modeled plume and pressure front in plan view.*
* *Cross sections showing the vertical and horizontal extent of the AoR.*
* *Graph showing the relative contribution of each CO2 phase (e.g., total mass, gas phase, dissolved phase, trapped gas, etc.) over time.]*

### Model Calibration and Validation

*[Recommended considerations include:*

* *What calibration or history-matching has been conducted?*
* *What data sources were used?*
* *What methods were used for sensitivity analysis? Why were these methods selected? What were the results? Note: Sensitivity analyses are not required by 40 CFR 146.84, but are recommended by EPA. However, if you are proposing an alternative PISC timeframe, sensitivity analyses are required pursuant to 40 CFR 146.93(c)(2)(vi), to identify and assess parameters that contribute significantly to uncertainty.]*

*[Associated figures and graphics may include:*

* *Comparison maps showing modeled AoR extent using different parameters (e.g., decreased injection zone porosity, increased reservoir permeability, etc.).*
* *Graphical results of any sensitivity analyses performed.*
* *Boundary plots and uncertainty plots (if applicable) for various CO2 phases, plume area, and reservoir pressure.]*

## AoR Delineation

### Critical Pressure Calculations

*[Recommended considerations include:*

* *What method was used to calculate the critical pressure? (Cite references as necessary.)*
* *What are the assumptions used in these calculations?*
* *What parameters were specified as input, and which were calculated?]*

### AoR Delineation

*[Note: the AoR delineation must reflect anticipated operating data (including anticipated injection pressures, rates, and volumes over the proposed life of the project), pursuant to 40 CFR 146.84(c)(1)(i).]*

*[Recommended considerations include:*

* *How was the AoR delineation selected (what model results were used to define the AoR)? Justify how the AoR delineation represents the largest area in which USDWs may be endangered by the injection activity.*
* *How might the AoR delineation be verified and/or changed during AoR reevaluation, or following pre-operational testing?*
* *What are the locations of the injection well(s) and any monitoring wells used to track plume and pressure front migration? How will results of testing and monitoring in these wells help verify the extent and location of the delineated AoR?]*

*[Associated figures and graphics may include:*

* *Map(s) of the AoR showing the AoR delineation relative to injection/monitoring well locations, the predicted maximum extent of the plume and/or pressure front, or other important features.]*

## Corrective Action

### Tabulation of Wells within the AoR

*[Note: Files with the locations of all wells within the AoR should be uploaded to the GSDT. The operator is encouraged to provide a map of these wells as part of this plan.]*

#### Wells within the AoR

*[Recommended considerations include:*

* *What databases or other information sources were used to identify these wells?*
* *What is the type and status of each well (e.g., operating Class II injection well, temporarily abandoned oil well, etc.)? (Attach tables as necessary.)*
* *Are there historical wells believed to be in the area that may not be captured in available data sources?]*

#### Wells Penetrating the Confining Zone

*[Recommended considerations include:*

* *How were the depths of these wells determined?*
* *What is the type and status of each well (e.g., operating Class II injection well, temporarily abandoned oil well, etc.)? (Attach tables as necessary.)*
* *What is the condition of each well?*
* *If corrective action is needed, what activities will be completed and when?]*

### Plan for Site Access

*[Recommended considerations include:*

* *What agreements have been made for access so that corrective action can be performed?*
* *For what period of time has site access been guaranteed?]*

### Corrective Action Schedule

*[Recommended considerations include:*

* *Will phased corrective action be conducted? What is the specific schedule that will be implemented? How will the proposed phased corrective action schedule protect USDWs?*
* *What benchmarks or triggers are included as part of a phased corrective action plan? What information was used to determine these triggers?*
* *How might the results of testing and monitoring, and/or AoR reevaluation inform changes to the phased corrective action plan?]*

## Reevaluation Schedule and Criteria

### AoR Reevaluation Cycle

INSERT PERMIT APPLICANT NAME will reevaluate the above described AoR every X years during the injection and post-injection phases.

*[Note: Pursuant to 40 CFR 146.84(e), AoR reevaluation must occur at least once every five years. The operator is also required to include in the reevaluation plan any benchmarks or milestones (e.g., from testing and monitoring) that may trigger additional AoR reevaluations.]*

*[Recommended considerations include:*

* *What are the specific procedures that will be followed for the AoR reevaluation? (Provide a list of steps or similar description.)*
* *What monitoring and operational data will be used? What specific thresholds or benchmarks will be used to determine if the testing and monitoring data are consistent with the model predictions?*
* *How will new data be incorporated into the model?*
* *How will model reevaluations be compared to the initial AoR modeling and delineation?]*

### Triggers for AoR Reevaluations Prior to the Next Scheduled Reevaluation

*[Recommended considerations include:*

* *What changes in what specific parameters (temperature, pressure, RST saturation, etc.) would trigger a reevaluation? What are the quantitative thresholds for these determinations?*
* *What other events (e.g., a seismic event) would trigger an AoR reevaluation?]*

INSERT PERMIT APPLICANT NAME will discuss any such events with the UIC Program Director to determine if an AoR reevaluation is required. If an unscheduled reevaluation is triggered, INSERT PERMIT APPLICANT NAME will perform the steps described at the beginning of this section of this Plan.