Class VI Permit Application Outline

This document provides an overview of the items and the associated activities an applicant may complete during the development of an application to inject carbon dioxide (CO_2) for geologic sequestration (GS) under the UIC Class VI program. It functions as a detailed index to multiple EPA Class VI guidance documents that steer the development of the information needed for a complete Class VI application. Please note, the permit application items and activities listed herein reflect EPA's *recommendation*s for complying with the federal Class VI rule requirements. It should also be noted that the elements listed below are not inclusive of every activity nor are they at the detail that is needed to meet the permit application requirements of the Federal Class VI Rule and demonstrate that underground sources of drinking water (USDWs) will not be endangered. Prospective permit applicants are encouraged to consult early with their UIC permitting authority about the specific needs for their project and review the Class VI Rule and the EPA guidance documents, which are available on EPA's web site in order to gain a full understanding of the Class VI permit application process.

Item	Activity and Purpose	Guidance Reference
Characterize the geologic setting of the proposed GS site to demonstrate that the Class VI well will be sited in an area with a suitable geologic system, consisting of an injection zone with sufficient capacity to receive the CO_2 and a confining zone that is free of transmissive faults or fractures. This information will satisfy the requirements of 40 CFR 146.82(a)(2),(3),(5), and (6). For additional information, see the Class VI Well Geologic Site Characterization Guidance.		
• ***Regional geology and geologic structure***	Summarize information on lithology, the sequence of geologic units (i.e., the injection and confining zones and USDWs), the thicknesses and lateral extent of formations, and correlation of units near the project site to place the GS project in a regional context.	Sections 2.1, 2.3.1, and 2.3.10 of the Geologic Site Characterization Guidance
• ***Faults and fractures***	Identify and characterize faults and fractures to demonstrate that there are no transmissive faults or fractures in the confining zone(s) so that injection at proposed maximum pressures and volumes can occur without initiating or propagating fractures in the confining zone(s).	Sections 2.1, 2.2, and 2.3.2 of the Geologic Site Characterization Guidance
• ***Injection and confining zone characteristics***	Provide information about the depth, extent, porosity, permeability, and capillary pressure of the injection and confining zones to show that the site can confine CO_2; support estimations of CO_2 storage capacity and injectivity; and support the development of a site-specific area of review (AoR) delineation model.	Sections 2.3.3, 2.3.4, and 2.3.5 of the Geologic Site Characterization Guidance
• ***Hydrologic and hydrogeologic information***	Describe the relationship between the proposed injection formation and any USDWs, springs, and water wells within the AoR to support an understanding of the water resources near the proposed well.	Section 2.3.8 of the Geologic Site Characterization Guidance
• ***Geochemical data***	Provide water chemistry data on all water-bearing formations to identify USDWs, confirm that the injection zone is not a USDW, and establish baseline water quality in any formations for which injection and post-injection phase ground water monitoring is planned for comparison with future monitoring results. Provide geochemical information on solids and fluids to identify potential interactions that could affect injectivity or mobilize trace elements; assess the compatibility of the CO_2 stream with fluids and minerals in the injection and confining zones; and inform CO_2 storage capacity estimates.	Sections 2.3.4 and 2.3.9 of the Geologic Site Characterization Guidance

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• ***Geomechanical and petrophysical information***	Characterize the geomechanical properties of the confining zone (e.g., fractures, stress, ductility, rock strength, and in situ fluid pressures) to demonstrate the integrity of the confining zone and set safe operational parameters.	Sections 2.3.5 and 2.3.6 of the Geologic Site Characterization Guidance
• ***Injection & confining zone mineralogy, petrology, and lithology***	Provide information on the mineralogy, petrology, and lithologies of the injection and confining zones to help identify any geochemical reactions that could change porosity, permeability, or injectivity and potentially affect the storage and containment of injected CO_2 or mobilize trace elements.	Section 2.3.4 of the Geologic Site Characterization Guidance
• ***Seismic history, seismic sources, and seismic risk***	Provide information on seismic history and the presence and depths of seismic sources and seismic risk to understand the potential for seismicity, inform a seismic monitoring program, and support the development of an Emergency and Remedial Response Plan that is appropriate to the potential frequency and magnitude of seismic events in the region.	Section 2.3.7 of the Geologic Site Characterization Guidance
• ***Surface air and/or soil gas monitoring data***	Provide data on CO_2 concentrations and fluxes (if required by the UIC Program Director) to serve as a baseline for comparison to CO_2 levels during and after the operational phase of the project in order to detect any potential leakage.	Section 2.3.11 of the Geologic Site Characterization Guidance
• ***Facies changes in the injection or confining zone***	Evaluate facies changes in the injection or confining zone to inform an understanding of the storage and confinement of CO_2 and support the development of a geologic conceptual model.	Section 3.1 of the Geologic Site Characterization Guidance
• ***Structure of the injection and confining zones***	Provide information on the geologic structure of the injection and confining zones to demonstrate that local and regional geologic structures are conducive to GS and form an adequate confining system.	Section 3.2 of the Geologic Site Characterization Guidance
• ***Compatibility of the CO_2 with subsurface fluids and minerals***	Describe the results of evaluations of the compatibility of the CO_2 stream with subsurface fluids and minerals to identify potential chemical reactions that could mobilize contaminants and potentially endanger USDWs.	Section 3.3 of the Geologic Site Characterization Guidance
• ***Injection zone storage capacity***	Estimate the storage capacity of the injection zone to demonstrate that it is of sufficient areal extent, thickness, porosity, and permeability to receive the total anticipated volume of CO_2 to be injected.	Section 3.4 of the Geologic Site Characterization Guidance
• ***Confining zone integrity***	Demonstrate that the confining zone(s) can contain the CO_2 and not allow migration of CO_2, or other fluids either through interconnected pore spaces across the thickness of the seal or along faults or fractures to prevent fluid movement that could endanger USDWs.	Section 3.5 of the Geologic Site Characterization Guidance
Prepare a proposed AoR Delineation and Corrective Action Plan to demonstrate that the AoR, as modeled, represents the area in which USDWs may be endangered by the injection operation and ensure that all artificial penetrations that may allow fluid movement into USDWs are identified and appropriately addressed. This information will satisfy the requirements of 40 CFR 146.82(a)(4), (13) and 146.84(b). For additional information, see the Class VI AoR Evaluation and Corrective Action Guidance and the Class VI Project Plan Development Guidance.		

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• ***Conceptual site model***	Develop a conceptual site model, which is a representation of the proposed GS project that includes all major geologic elements present in the flow system and any relevant physical processes (as informed by the geologic site characterization) and operational conditions. The conceptual site model illustrates the inputs for the computational AoR model.	Sections 3.3.1 and 3.3.2 of the AoR Evaluation and Corrective Action Guidance
• ***Computational AoR delineation model***	Delineate the AoR using a multi-phase computational model that estimates the extent and migration of the separate-phase CO_2 plume and changes in fluid pressures within the injection zone over time. The model (at an appropriate spatial extent, discretization, and boundary conditions, and timeframe) will help ensure that the extent of the CO_2 plume and pressure front is well-understood and support monitoring of the site over the duration of the project.	Sections 3.3.3 and 3.3.4 of the AoR Evaluation and Corrective Action Guidance
• ***Artificial penetrations within the AoR***	Identify and characterize all artificial penetrations within the delineated AoR that penetrate the confining zone to identify any improperly plugged and abandoned wells that could provide flow conduits out of the injection zone that could potentially endanger USDWs.	Section 4 of the AoR Evaluation and Corrective Action Guidance
• ***AoR and Corrective Action Plan***	Develop a proposed AoR Evaluation and Corrective Action Plan that will ensure that a site-specific strategy is in place to delineate the AoR (initially and throughout the duration of the project) and ensure that all deficient artificial penetrations within the AoR will be addressed through appropriate and timely corrective action methods.	Section 2 of the Project Plan Development Guidance
Provide evidence of financial responsibility to demonstrate that sufficient resources are available for all needed corrective action, injection well plugging, post-injection site care (PISC) and site closure, and emergency and remedial response. This information will satisfy the requirements of 40 CFR 146.82(a)(14) and 146.85(a). For additional information, see the Class VI Financial Responsibility Guidance.		
• ***Cost estimates***	Provide estimates of the cost for contracting an independent third party to carry out corrective action, injection well plugging, PISC and site closure, and emergency and remedial response to prevent the general public from bearing the costs of abandoned GS projects.	Sections 3 and 4 of the Financial Responsibility Guidance
• ***Financial instruments***	Describe proposed financial responsibility instruments that are secure and meet the UIC requirements to facilitate enforceability and prevent gaps in financial coverage over the duration of the project.	Section 6 of the Financial Responsibility Guidance
Submit proposed well construction schematics and procedures for the injection well to demonstrate that it will be constructed in a manner that is appropriate to planned operations, is compatible with the CO_2 stream and subsurface chemistry (as informed by baseline geochemical data), and will maintain mechanical integrity. This information will satisfy the requirements of 40 CFR 146.82(a)(11), (12) and 146.86. For additional information, see the Class VI Injection Well Construction Guidance.		

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• ***Injection well casing***	Design and describe casing strings that are appropriate to the geology and planned operations to ensure that the surface casing will protect all USDWs and the long-string casing will extend into the injection zone; and that they are made of materials that can withstand contact with formation fluids, the injected CO_2 stream, the product of mixing formation and injection fluids, and the down-hole stresses they will encounter so that they won't experience degradation during injection operations.	Sections 2.1 to 2.4 of the Well Construction Guidance
• ***Cementing procedures***	Design and describe the cement/additives and a cementing program to demonstrate that the cement will be properly emplaced and provide a continuous sheath of cement from the bottom of each casing string to the surface to prevent CO_2 or other fluids from entering a permeable zone or potentially migrate into a USDW.	Section 2.5 of the Well Construction Guidance
• ***Tubing and packer***	Design and describe tubing and packer that are properly placed and compatible with the CO_2 stream, the formation fluids, and/or the product of mixing formation and injection fluids that may be encountered so that they can resist corrosion for the duration of the project.	Section 2.6 of the Well Construction Guidance
• ***Continuous monitoring devices***	Design and describe continuous monitoring and shutoff devices and automatic alarms and surface shut-off systems that are appropriate to planned operational limits and will shut-in when injection or annulus pressures exceed limits to prevent fracturing of the confining zone or damaging to the well.	Section 2.8 of the Well Construction Guidance
Prepare a Pre-Operational Testing Plan to demonstrate that information will be collected to address any uncertainties about subsurface formations and fluid geochemistry that were identified during the geologic site characterization and verify that the well is properly constructed. This information will satisfy the requirements of 40 CFR 146.82(a)(8) and 146.87. For additional information, see the Class VI Injection Well Construction Guidance, the Class VI Well Geologic Site Characterization Guidance, and the Class VI Reporting, Recordkeeping, and Data Management Guidance.		
• ***Tests during well drilling/construction***	Describe logs and tests to be performed during the construction of the injection well to determine or verify the depth, thickness, porosity, permeability, lithology, and formation fluid salinity in all relevant geologic formations and demonstrate that the well was appropriately constructed and has mechanical integrity.	Section 2.2 of the Well Construction Guidance and Section 4.1 of the Geologic Site Characterization Guidance
• ***Injection and confining zone core sampling***	Describe plans to collect and analyze core samples within the injection and confining zones to refine site characterization data and provide information to support stratigraphic correlation, interpretation of depositional environments, and wireline log calibration.	Section 4.2 of the Geologic Site Characterization Guidance
• ***Injection zone characterization***	Describe plans to gather information on the fluid temperature, pH, conductivity, reservoir pressure, and static fluid level of the injection zone(s).	Sections 4.3 and 4.4 of the Geologic Site Characterization Guidance

Item	Activity and Purpose	Guidance Reference
• ***Fracture pressure, fluid characteristics, and downhole conditions***	Describe a plan to determine or calculate the confining zone fracture pressure (to inform injection pressure limits) and to determine the physical chemical characteristics of the injection and confining zones and characterize formation fluids in the injection zone (to evaluate the compatibility of the injectate with the formation fluids).	Sections 4.3 and 4.4 of the Geologic Site Characterization Guidance
• ***Injection and confining zone formation testing***	Describe planned pre-operational formation tests/logging (i.e., pressure fall-off test, pump test, or injectivity tests) that will provide needed data on the geologic and hydrogeologic properties of subsurface formations.	Section 4.5 of the Geologic Site Characterization Guidance
• ***Quality Assurance Surveillance Plan (QASP)***	Describe quality assurance/quality control (QA/QC) procedures for required logs and tests, such as equipment calibration information and sample QA, to ensure that pre-operational testing and monitoring will provide accurate information about the site.	Section 4.4 of the Reporting, Recordkeeping, and Data Management Guidance
Describe the proposed operating conditions to demonstrate that the planned injection rate, pressure, and volume are appropriate to the site geology (as informed by the geologic site characterization) and the well's construction. This information will satisfy the requirements of 40 CFR 146.82(a)(7),(9),(10) and 146.88. For additional information, see the Class VI Well Geologic Site Characterization Guidance, the Class VI Well Testing and Monitoring Guidance, and the Class VI Injection Well Construction Guidance.		
• ***Injection rate***	Describe a proposed injection rate that is appropriate to the site geology (i.e., the properties of the injection zone) and the well's construction.	Section 3.4 of the Geologic Site Characterization Guidance
• ***Maximum injection pressure***	Describe the proposed injection pressure that is no more than 90 percent of the injection zone fracture pressure to prevent the injection zone from being fractured and reduce the potential for fracturing the confining zone.	Section 4.1 of the Well Construction Guidance and Section 3.3 of the Testing and Monitoring Guidance
• ***CO_2 volume***	Propose a total volume of CO_2 to be injected throughout the life of the GS project that the injection zone can receive and contain without endangering USDWs.	Section 3.4 of the Geologic Site Characterization Guidance
• ***Annulus pressure***	Provide information to demonstrate that the proposed maximum annular pressure will be greater than the injection pressure or propose an alternative annular pressure and demonstrate that it will be appropriate and protective.	Section 4.2 of the Well Construction Guidance
• ***Well stimulation procedures***	If well stimulation is planned, describe the stimulation fluids and procedures to ensure that stimulation will not fracture the confining zone, affect well integrity, or otherwise allow injection or formation fluids to endanger USDWs.	Section 4.1 of the Well Construction Guidance
• ***CO_2 stream characteristics***	Describe the physical and chemical characteristics of the CO_2 stream to ensure that (1) interactions among the CO_2, fluids, and solids will not affect permeability, porosity, or injectivity; (2) trace elements will not be liberated from subsurface solids; and (3) no interactions among the fluid, CO_2, and cement will deteriorate the well cement.	Section 3.3 of the Geologic Site Characterization Guidance

Item	Activity and Purpose	Guidance Reference
Prepare a proposed Testing and Monitoring Plan to demonstrate that planned testing and monitoring of the injectate, the well, and the geologic environment will be appropriate to planned operations, the well's construction, and site-specific geologic conditions. This information will satisfy the requirements of 40 CFR 146.82(a)(15), 146.89, and 146.90. For additional information, see the Class VI Well Testing and Monitoring Guidance and the Class VI Reporting, Recordkeeping, and Data Management Guidance.		
• ***CO_2 stream analysis***	Prepare an injectate (CO_2 stream) analysis plan to demonstrate that the parameters for which the CO_2 stream will be analyzed—and the associated analytical procedures—are appropriate to characterize the CO_2 stream.	Section 3.1 of the Testing and Monitoring Guidance
• ***Mechanical integrity and corrosion testing***	Describe planned methods for corrosion monitoring; continuous recording of injection pressure, rate, and volume; and annual external MITs that will provide early detection of potential or actual damage to the well that could compromise well integrity and provide a conduit for fluid movement that could endanger USDWs.	Sections 2, 3.2, 3.3, and 3.4 of the Testing and Monitoring Guidance
• ***Pressure fall-off testing***	Describe planned fall-off testing to monitor for changes in the near-well bore environment that could affect injectivity and increase pressure.	Section 3.5 of the Testing and Monitoring Guidance
• ***Groundwater quality monitoring***	Develop and describe a groundwater monitoring plan (i.e., with appropriate monitoring locations, sampling frequencies, and analytical parameters) to identify potential CO_2 migration and/or native fluid displacement from the injection zone or other water quality changes that may lead to endangerment of USDWs.	Section 4 of the Testing and Monitoring Guidance
• ***CO_2 plume and pressure front tracking***	Develop a plan to track the plume and pressure front to identify potential risks to USDWs, verify modeled predictions of the project behavior, and inform reevaluations of the AoR.	Section 5 of the Testing and Monitoring Guidance
• ***Surface air and/or soil gas monitoring***	Develop an air and/or soil gas monitoring plan (if applicable) to provide an additional line of evidence of whether CO_2 has leaked from the injection zone and could endanger USDWs.	Section 6 of the Testing and Monitoring Guidance
• ***Testing and monitoring plan QASP***	Describe QA/QC procedures to ensure that all testing and monitoring provides accurate results that meet the requirements of 40 CFR 146.90.	Section 3.1.6 of the Reporting, Recordkeeping, and Data Management Guidance
Prepare a proposed Injection Well Plugging Plan to demonstrate that the materials and procedures proposed for injection well plugging are appropriate to the well's construction and the site's geology and geochemistry so that the well will not serve as a conduit for fluid movement that could endanger USDWs following cessation of injection. This information will satisfy the requirements of 40 CFR 146.82(a)(16) and 146.92. For additional information, see the Class VI Well Plugging, Post-Injection Site Care, and Site Closure Guidance and the Class VI Project Plan Development Guidance.		
• ***Injection Well Plugging Plan***	Prepare an Injection Well Plugging Plan that describes the procedures for properly plugging the Class VI well to prevent fluid movement that could endanger USDWs following the cessation of injection.	Section 2 of the Well Plugging, Post-Injection Site Care, and Site Closure Guidance and Section 4 of the Project Plan Development Guidance

Item	Activity and Purpose	Guidance Reference
Prepare a proposed Post-Injection Site Care and Site Closure Plan to demonstrate that post-injection monitoring strategies will ensure non-endangerment of USDWs throughout the PISC phase and the site will be properly closed. This information will satisfy the requirements of 40 CFR 146.82(a)(17),(18) and 146.93. For additional information, see the Class VI Well Plugging, Post-Injection Site Care, and Site Closure Guidance.		
● ***Pressure differential and position of the CO_2 plume and pressure front***	Predict and present the pre- and post-injection pressure differential and the predicted position of the CO_2 plume and pressure front at site closure to demonstrate that the predicted pressure decline and fluid movement on which the PISC and Site Closure Plan are based are consistent with the results of AoR delineation modeling.	Section 3.2 of the Well Plugging, Post-Injection Site Care, and Site Closure Guidance
● ***Post-injection phase monitoring plan***	Develop a plan to monitor the site (e.g., groundwater quality and the CO_2 plume and pressure front) to ensure that any unforeseen USDW endangerment during the post-injection phase is identified and mitigated and to collect data to inform the non-endangerment demonstration. This monitoring will be an extension of some components of the injection-phase Testing and Monitoring Plan.	Section 3.3 of the Well Plugging, Post-Injection Site Care, and Site Closure Guidance
● ***Alternative PISC timeframe***	If approval of a shorter PISC timeframe than the 50-year default is sought, provide site-specific data and evidence to show that the project will no longer pose a risk of endangerment to USDWs at the end of the proposed PISC timeframe.	Section 3.2.2 of the Well Plugging, Post-Injection Site Care, and Site Closure Guidance
● ***Non-endangerment demonstration criteria***	Describe the criteria on which the non-endangerment demonstration will be based; this optional step will allow the applicant and the permitting authority to agree early in the project on the criteria that will need to be met prior to authorization for site closure.	Section 3.4 of the Well Plugging, Post-Injection Site Care, and Site Closure Guidance
● ***Monitoring well plugging and site closure plan***	Describe how all monitoring wells will be plugged and site closure and site restoration activities will be performed so that the project will not pose a risk of endangerment to USDWs after closure.	Sections 2 and 4 of the Well Plugging, Post-Injection Site Care, and Site Closure Guidance
Prepare a proposed Emergency and Remedial Response Plan to demonstrate that appropriate and timely responses will be taken to protect USDWs from endangerment should an emergency event occur during the construction, operation, and post-injection phases of the project. This information will satisfy the requirements of 40 CFR 146.82(a)(19) and 146.94. For additional information, see the Class VI Project Plan Development Guidance.		
● ***Emergency and Remedial Response Plan***	Prepare a proposed Emergency and Remedial Response Plan that describes the actions that would be taken in the unlikely event of an emergency in order to expeditiously mitigate any emergency situations and protect USDWs from endangerment. The Plan should consider the geologic setting, planned operations, and the well's construction.	Section 6.0 of the Project Plan Development Guidance
Prepare an Injection Depth Waiver Application, if appropriate, to demonstrate that USDWs above and below the injection zone are protected from endangerment if injection into non-USDWs that are located above or between USDWs is planned. This information will satisfy the requirements of 40 CFR 146.82(d) and 146.95(a). For additional information, see the Class VI Reporting, Recordkeeping, and Data Management Guidance.		

Item	Activity and Purpose	Guidance Reference
● ***Injection depth waiver application***	Provide information on the upper and lower confining zones; the injection zone; drinking water resources and water supply needs and plans for securing alternative water resources or treating USDWs; and hydrocarbon or mineral resource exploitation to demonstrate that USDWs will not be endangered if the project operates under an injection depth waiver.	Section 3.2 of the Reporting, Recordkeeping, and Data Management Guidance
Apply to expand the areal extent of an existing Class II aquifer exemption, if appropriate, to demonstrate that an appropriately sized area is exempted such that the CO_2 plume and pressure front remain within the approved exempted area. Note that no new aquifer exemptions will be approved for Class VI injection activities (only expansions of existing aquifer exemptions). This information will satisfy the requirements of 40 CFR 144.7(d)(1) and 40 CFR 146.4(d). For additional information, see the Class VI Reporting, Recordkeeping, and Data Management Guidance.		
● ***Aquifer exemption expansion area***	Delineate and describe the proposed areal extent of a requested expansion to an existing Class II aquifer exemption based on the predicted extent of the injected CO_2 plume and any mobilized fluids (as informed by computational modeling of the AoR) to demonstrate that the project will not allow these fluids to move into a USDW over the lifetime of the project.	Section 3.3 of the Reporting, Recordkeeping, and Data Management Guidance
● ***Demonstration that the aquifer is not a USDW***	Demonstrate that the proposed area of the expanded aquifer exemption (1) does not currently serve as a source of drinking water; (2) has a TDS content of more than 3,000 mg/L and less than 10,000 mg/L; and (3) is not reasonably expected to supply a public water system.	Section 3.3 of the Reporting, Recordkeeping, and Data Management Guidance