Enclosure 2 - Evaluation of Alternative PISC Timeframe
October 2025

Carbon TerraVault Holdings LLC (CTV) III Project
Underground Injection Control (UIC) Permit Application
Class VI Pre-Construction Permit Application No. R9UIC-CA6-FY22-5.1-5.6

This evaluation report for the CTV III Class VI Sequestration Project summarizes EPA's evaluation of Carbon Terravault Holdings, LLC (CTV)'s proposed alternative post-injection site care (PISC) timeframe submitted in *Attachment E: Post-Injection Site Care and Site Closure Plan* (Version 3, dated August 20, 2025). CTV proposes an alternative PISC timeframe of 20 years. Clarifying questions and requests for CTV are provided below in *blue italics*. CTV states that they will not cease post-injection monitoring until a demonstration of non-endangerment of USDWs has been approved by the UIC Program Director pursuant to 40 CFR 146.93(b)(3).

Computational Modeling Results [40 CFR 146.93(c)(1)(i)]

Consistent with 146.93(c)(1)(i), CTV refers to the area of review (AoR) delineation modeling presented in *Attachment B: Area of Review and Corrective Action Plan* (AoR/CA Plan) to support the details described in the following sections. EPA separately evaluated the appropriateness of CTV's modeling approach and the consistency of modeling inputs with planned operations and site-specific geologic data.

Predicted Timeframe for Pressure Decline [40 CFR 146.93(c)(1)(ii)]

CTV's AoR delineation modeling in *Attachment B* predicts the pressure trends for the project, and the predictions presented in the alternative PISC timeframe demonstration are consistent with the AoR modeling effort.

Figure E-1 depicts modeled pressure at monitoring well M2 at 6,900 ft TVDSS. Here, pre-injection pressure in the injection zone is approximately 2,860 psi. Formation pressure is predicted to rise to a maximum of 3,118 psi at 14 years into the injection phase, later peaking again at the cessation of injection (Year 28), then begin decreasing steadily after the end of injection down to a value of 2,993 psi at 10 years post-injection. Formation pressure declines to approximately 2,950 psi at the end of the proposed 20-year alternative PISC timeframe. The pressure is predicted to further decline after this point, reaching near the initial reservoir pressure of 2,860 psi at the end of the modeling period at Year 128.

Figure B-16 from the AoR/CA Plan depicts bottomhole pressures near each injection well across the modeling timeframe. Pre-injection pressure for each injection well varies by location as shown in Figures E-5(a) and B-16. Figure B-16 shows rapid pressure decline near the injection wells following cessation of injection, then asymptotic decline by the end of the modeling period. Specific pre-injection pressures for each injection well are unclear from both figures, and the specific timeframe for decline below pre-injection pressure is not marked.

CTV used Method 1 from Thornhill et al. (1982) to calculate critical pressures for the AoR delineation. Table B-7 shows an example calculation from one reference point on the surface, which indicates that a delta critical pressure of 134 psi above pre-injection pressure in the injection zone is required to force fluid through an open conduit into the USDW. CTV does not discuss this factor in the alternative PISC timeframe discussion.

CTV considered sensitivity cases for different injectate compositions; varying injectate composition had no appreciable effect on the size of the pressure front (Figure B-24) or trends of pressure decline in the injection zone (Figure B-25). CTV also conducted a sensitivity case for varying the modeling grid spacing around the injection wells and found no change in the trend of pressure decline (Figure B-28).

CTV justifies the proposed alternative PISC timeframe by asserting that the trend following the end of the 20-year timeframe, as shown in Figure E-1, declines asymptotically; this assertion appears accurate between Year 48 and Year 128 as the rate of decline decreases. CTV does not discuss the timeframe for pressure decline below critical pressure nor the precise time needed to decline to pre-injection pressures. 40 CFR 146.93(c)(1)(ii) requires a demonstration that the predicted pressure in the injection zone at the end of the proposed alternative PISC timeframe does not exceed the critical pressure (the pressure required to force formation fluids into a USDW through an open conduit) and/or the pre-injection formation pressure.

Predicted Rate of CO_2 Plume Migration [40 CFR 146.93(c)(1)(iii)]

Figure E-3 shows plume evolution and CO_2 saturation in map view at Years 1, 4, 6, 10, 16, and 28 during injection and 50 and 100-years post-injection. According to Figure E-3, the boundary of the CO_2 plume and levels of CO_2 saturation appear to remain effectively constant between 50- and 100-years post-injection, predicting that the plume will be stable during this time period. Figure E-4 shows the evolution of the CO_2 plume horizontally and vertically at Years 1, 4, 6, 10, 14, 16, 20, and 28 during injection and 52 and 100-years post-injection. Note that neither figure shows the predicted extent of the CO_2 plume at 20 years post-injection, i.e., at the end of the proposed alternative PISC timeframe.

Figures E-3 and E-4 show that most of the plume growth is predicted to occur during the injection phase. CTV asserts that horizontal and vertical CO_2 plume migration is predicted to be minimal between the cessation of injection and the end of the alternative PISC timeframe which, CTV asserts, indicates that the plume reaches stability during this period. CTV did not provide timesteps between cessation of injection and the end of the alternative PISC timeframe in their models to support these assertions.

Site-Specific Trapping Processes [40 CFR 146.93(c)(1)(iv)-(vi)]

CTV indicates that trapping occurs primarily by capillary trapping and CO_2 dissolution into the brine. CTV asserts that the fraction of CO_2 predicted to be stored via capillary trapping in pore space remains relatively constant over the post-injection period. This is consistent with the modeling discussion in the AoR and Corrective Action Plan.

Figure B-20 of the AoR and Corrective Action Plan displays the mass of CO_2 predicted to be contained via different trapping mechanisms with respect to time. The majority of CO_2 (around 83%) is predicted to remain in a supercritical state and stored by capillary trapping, with the remainder to be dissolved in the formation brine. Figure B-20 shows that most CO_2 remains stored via capillary trapping in the supercritical phase with minimal phase changes up until the end of the modeling timeframe.

Mineral trapping was not included in the computational modeling due to the predicted insignificance of the amount of CO_2 trapped by mineralization reactions within the modeling timeframe as indicated in the geochemical modeling in Appendix 3. CTV also cites peer-reviewed studies, such as IPCC, 2005: IPCC Special Report on Carbon Dioxide Capture and Storage, prepared by Working Group III of the Intergovernmental Panel on Climate Change.

Confining Zone Characterization [40 CFR 146.93(c)(1)(vii)]

The Capay Shale formation is an appropriate confining zone based on the information provided in the permit application narrative. CTV states that the Capay Shale ranges from 100 to 360 ft thick with an average permeability of 0.34 mD; this is based on NMR permeability data from the Citizen_Green_1 well, about 8 miles north of the AoR, and XRD and FTIR mineralogy data from three wells located in the Rio Vista Gas Field located approximately 12 miles north of the AoR. As described in EPA's site characterization evaluation, CTV's pre-operational testing plan will provide site-specific data to address uncertainties.

There is a normal fault that transects the injection zone, and CTV asserts the vertical offset is not enough to completely offset the Capay Shale to another formation. As described in EPA's site characterization evaluation, the fault must be demonstrated to not interfere with containment of the injectate. CTV provided an Allan diagram, shale gouge ratio, and shale smear factor analyses in the permit application narrative to demonstrate the sealing nature of the normal fault and other regional faults. These are further characterized by 2D and 3D seismic data. Additional step-rate testing to determine fracture pressure will be needed to ensure that operating pressures are appropriate to confining zone geomechanical properties.

Assessment of Fluid Movement Potential [40 CFR 146.93(c)(1)(viii)-(ix)]

CTV provided information on artificial penetrations that could potentially act as conduits for fluid movement in the AoR in the Corrective Action Plan in *Attachment B* and in Appendix B-1. Figure 1 of Appendix B-1 depicts the 57 wells identified in the AoR and reviewed for corrective action as identified in CTV's internal databases and California Geologic Energy Management Division (CalGEM) records. Table 1 of Appendix B-1 provides documentation of the construction, plugging, and testing of each well. Per the Corrective Action Plan, there are three wells that penetrate the injection zone within the modeled extent of the plume (Figure B-30). CTV states that corrective action is planned for all three wells prior to injection. However, some follow-up requests regarding identification and assessment of wells within the AoR provided in Section I of Enclosure 1 of this RAI are pending.

Location of USDWs [40 CFR 146.93(c)(1)(x)]

As described in the permit application narrative report, the base of the lowermost USDW at the project site has been mapped to the top of the Nortonville Shale, within the overlying Markley Formation. The base of the USDW is approximately 3,200 feet above the top of the Capay Shale, providing significant separation between the upper confining zone and the base of the USDW. CTV notes a minimum distance of 2,575 feet between the injection zone and lowermost USDW in the AoR, per the thickness map in Figure 1 of Report 2 in Appendix B-4.

Requests for CTV:

1. *For each injection-zone monitoring well and each injection well, please:*
   a. *specify the critical pressures calculated using Method 1;*
   b. *specify the pre-injection pressures in the injection zone;*
   c. *specify the values for model-predicted formation pressures at the end of the proposed 20-year alternative PISC timeframe; and*
   d. *describe the predicted timeframes for formation pressure to decline below the critical pressures and/or to return to pre-injection levels.*
2. *It appears that pre-injection pressures for each injection well as shown in Figures B-16 and E-5(a) are inconsistent. Please clarify these discrepancies and revise the figures as necessary.*
3. *Please provide a version of Figures E-3 and E-4 showing the plume and pressure front extent at time steps during the proposed alternative PISC timeframe (e.g., at 10, 15, and 20 years post-injection). Please include the locations of the wells needing corrective action on these figures.*
4. *Please provide a table containing the following information for the 57 wells identified within the AoR.*

Well Name	**Pre-injection Pressure in Injection Zone, psi**	**Calculated Critical Pressure in Injection Zone using Method 1, psi**	**Model-predicted Injection Zone Pressure at End of 20-year Alt PISC Timeframe, psi**