Enclosure 1 – Geologic Characterization
Request for Additional Information

Carbon TerraVault (CTV) VI Carbon Capture and Storage (CCS) Project
Underground Injection Control (UIC) Permit Application
Class VI Pre-Construction Permit Application Nos. R9UIC-CA6-FY24-2.1 to 2.7

Note – this document contains claimed confidential business information (CBI).

This Enclosure for the proposed CTV VI Class VI geologic sequestration project summarizes the review of the geologic information required at 40 CFR 146.82 (a)(2-5) and the comprehensive information needed to support a determination of site-suitability per 146.83. Clarifying questions or requests that require further work are provided below in ***bold, italic*** text. Text that is not ***bold, italic*** is provided to give context or is recommended for further work.

Overall, the site appears to be a promising candidate for a CCS project, given the favorable characteristics of the injection zones, including high porosity and permeability, paired with low-permeability confining zones. However, the geological support information provided is deficient.

Regional geology and geologic structure

1. The stratigraphic units from the surface to the lower confining and injection zone are partially described. The injection zone is the amalgamation of all lithostratigraphic units from the shallowest to the deepest injection zone and therefore contains layers that are not injection zones. ***Each injection zone isopach should be reported***.

Maps and Cross Sections

2. Structure and isopach maps are only provided for the confining zone and the injection zone. The injection zone is marked as the gross thickness from the top of the upper injection formation to the base of the lowest injection formation, while there are multiple confining formations present withing the injection zone. Although some maps contained roads, no map detailing surface features, including structures intended for human occupancy is present. **Include more detailed maps including for the injection zone, and interpreted cross sections from seismic data to illustrate the regional extent, thickness, and dip of the formations**.

3. Pursuant to 40 CFR 146.82(a)(2), a single map shall be provided that includes items within the AoR including: the number or name and location of all injection wells, producing wells, abandoned wells, plugged wells or dry holes, deep stratigraphic boreholes, State- or EPA-approved subsurface cleanup sites, surface bodies of

water, springs, mines (surface and subsurface), quarries, water wells, other pertinent surface features including structures intended for human occupancy, State, Tribal, and Territory boundaries, and roads. The map should also show faults, if known or suspected. The application includes maps that include all this information separately, but it is not provided within a single map. ***Provide a map that includes all the requirements of 40 CFR 146.82(a)(2).***

Faults and Fractures

4. The location, geometry, depth, or displacement of faults or fractures are not fully described. The geometry and depth of fault traces are missing, and there is no discussion of natural fractures in the AoR, particularly for the confining zone. Seismic traces in the project area must be identified to ensure there are no faults. ***Update the application accordingly***.

5. A vague statement indicates that USGS does not document a fault of any classification within the AoR shown in Figure 2.3-1, but no evidence supporting the claim is provided. ***Provide figures detailing the seismic reflection data and show if any faults that transect the injection or confining zone are transmissive***.

6. The applicant does not provide evidence of the stability and sealing properties of faults using techniques recommended in the Site Characterization Guidance. The application indicates that the faults are too far from the AoR to influence the injection risk, or no faults are identified within or near the AoR. However, it is stated that faults offset in the injection zone reaches 400 feet. ***This needs clarification and additional justification since there are no seismic reflection line figures to support the claim***.

7. It is stated that USGS does not document a fault of any classification within the AoR and Figure 2.3-2 shows a combination of the fault traces taken from the USGS map and fault traces identified using the seismic and well data. Distances from the AoR are not described, but the map shows that they are not located in the proximity of the AoR. **3D data is required to observe presence of regional major fault systems and their distance from the AoR described**.

Injection and Confining Zone Properties

8. The depths and thicknesses of the injection and confining zones are partially described. The thickness and depth are shown in figures that include injection formation isopachs and structure maps. The injection zone is the amalgamation of all lithostratigraphic units from the shallowest to the deepest injection zone and therefore contains layers that are not injection zones. ***This should be revised with each injection zone ispoach being reported***.

9. The confining zone has variable thickness and pinches out of the AoR reaching 0 ft at the eastern and western ends of the model boundary. Regional stratigraphy is used and traced using seismic data, but there is an absence of data to confirm lateral continuity in facies. ***Evidence, such as well logs for better delineation, should be provided to confirm this***.

10. Claimed as PBI [redacted] and is shown in Figure 2.2-5 of CTV VI Attachment A (Narrative Report), but is not described in the report. ***Describe and characterize the lower confining zone in the report***.

11. The measured permeabilities, including the geometric average values, presented in the report do not present detailed analysis for the measured permeabilities. Their spatial variabilities are not presented, which are required to evaluate the heterogeneities of the formations mentioned. Provide evidence accordingly so it can be determined if heterogeneities exist that could affect storage or confinement.

Geomechanical and Petrophysical

12. There is no capillary pressure data within the confining zone. ***Provide capillary pressure data***.

13. Stress information is presented in Section 2.5.2 of CTV VI Attachment A and it is stated that there are no site-specific fracture gradient data for the injection or confining layers. In Section 2.5.2 of CTV VI Attachment A, it is stated that the overburden stress gradient in the confining and injection zones is 0.87 to 0.94 psi/ft and the method for calculating the overburden gradient was to integrate density logs using methodology laid out in Claimed as PBI and is given by Eq. (5) of CTV VI Attachment A. But the calculation details are not given in the in CTV VI Attachment A (Narrative Report). ***The calculation details need to be included in the report. Ensure that water and rock densities are presented separately***. See equation reference: https://www.sciencedirect.com/topics/engineering/overburden-stress-gradient.

Seismic History and Seismic Risk

14. Fault systems act as barriers or conduits for CO_2 migration. The area location maps do not provide sufficient detail or context for their geological representations of fault systems in the valley, which provide the basis or foundation for model parameterization. Claimed as PBI [redacted] The unknown

for the modeling is whether a spiked event during injection could exceed the formation fracture gradients and create situations for episodic escape of CO_2 and other formation fluids into the USDW zones. One mechanism for breach could occur through presently unknown or undetected fracture systems or vertical escape features; this further supports the need to review reflection seismic data. ***Update the application accordingly***.

Hydrologic and Hydrogeologic

15. The method(s) used to make the determination of the lowermost USDW was not provided. ***Update the application accordingly***.

16. The difference between the lowermost USDW and confining zone is not clear and not well elucidated. Figures 2.2-4 and 2.7-6 tell two different stories; there would be some separation based on Figure 2.2-4, but almost no separation based on Figure 2.7-6. ***Please add a map of groundwater thickness and depth to compare the injection zone and confining zone depths***.

17. Figures show the base of freshwater map and the depth to lowermost USDW. ***Please provide a map of groundwater thickness and depth, so it could be compared to the injection zone and confining zone depths***.

Facies Changes in the Injection or Confining Zones

18. Regional facies are well described, although the term itself is not used. There is a lack of detail for the AoR and the study area. There are multiple wells drilled in the study area but no attempt at a facies analysis from the well data is made. ***Due to the claim of lateral facies variability in the regional literature, please provide a detailed well-based facies study***.

19. The [redacted] shown in Figure 2.2-5 of CTV VI Attachment A looks sufficiently thick and continuous throughout the AoR, but numerical values regarding its thickness range are not given. ***Please provide numerical values regarding its thickness range***.

20. [redacted]
Since the permeability is measured at two wells, it could not be determined if there are any high permeability zones within the confining zone that can provide pathways for CO_2 migration. Please provide additional discussion regarding whether there are high permeability zones within the confining zone that could provide pathways for CO_2 migration.

Compatibility of the CO_2 Stream with Subsurface Fluids and Minerals

1. ***Provide geochemistry or water chemistry data available in the AoR to justify the statement of no risk of interaction between the CO_2 stream and subsurface fluids and minerals***.

Structure of the injection and confining zones

2. The report indicates that seismic-based depth conversion of the northwest-southeast trending thrust faults to the northeast of the AoR showed minimal offset across the injection zones on the order of zero to approximately 400 feet. ***Please provide supporting seismic reflection figures to justify this statement***.

3. Data for the evaluation of the presence, types, sizes, and orientations of structural features is sparse. The injection zone is an agglomeration of all injection formations with intermediate confining formations. ***Please provide more detailed maps so it can be determined if the various data sources provide a consistent portrayal of structural features, as the only detailed map is for the confining zone***.

Injection Zone Storage Capacity

4. Claimed as PBI [redacted] ***Please clarify and detail whether the injection zone has sufficient areal extent, thickness, and porosity to receive the total anticipated volume of CO_2.***