CLASS VI PERMIT APPLICATION NARRATIVE
40 CFR 146.82(a)

RUSSELL CO_2 CAPTURE AND SEQUESTRATION

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List of Acronyms and Abbreviations

3D = three-dimensional AoR = Area of Review API = American Petroleum Institute ASTM = ASTM International CARB = California Air Resources Board CO_2 = carbon dioxide ft bgs = feet below ground surface GS = geologic sequestration GSDT = Geologic Sequestration Data Tool M_L = local magnitude MMA = maximum monitoring area PCC = PureField Carbon Capture, LLC PFI = PureField Ingredients, LLC	PISC = Post-Injection Site Care ppmv = parts per million by volume psi = pound-force per square inch psia = pound-force per square inch, absolute psig = pound-force per square inch, gauge psi/ft = pounds per square inch per foot TDS = total dissolved solids UIC = Underground Injection Control USDW = Underground Source of Drinking Water US EPA = United States Environmental Protection Agency

A.1. Project Background and Contact Information

The overall goal is to implement a successful geologic sequestration (GS) project for the PureField facilities in Russell, KS. The owner/operator of the GS facility is PureField Carbon Capture, LLC (PCC), which is a wholly owned subsidiary of PureField Ingredients, LLC (PFI) - owner/operator of existing facilities in Russell, KS that produce fuel-grade ethanol and other products. The overall objectives are:

- Capture up to 150,000 metric ton per year of carbon dioxide (CO_2) from the existing fermentation off-gas system at the PFI ethanol plant,
- Compress the captured CO_2 using surface equipment co-located at the PFI ethanol plant,
- Transport the compressed CO_2 to a nearby GS storage complex owned and operated by PCC,
- Sequester the CO_2 in the storage complex operated under a United States Environmental Protection Agency (US EPA) Underground Injection Control (UIC) Class VI permit and California Air Resources Board (CARB) Permanence Certification programs, and
- Inject the CO_2 into the storage complex for at least 12 years, followed by post-injection site care (PISC) and site closure of the storage complex per US EPA and CARB regulations.

Figure A.1-1 shows the GS storage complex is located approximately 6-miles east of the existing PFI facilities. The solid pink line represents the areal extent of the Area of Review (AoR), as delineated in Section B.4 of the Area of Review and Corrective Action Plan for the following permit basis: CO_2 injection into the storage complex at 150,000 metric ton per year for 12-years followed by PISC and site closure. The project will likely be subject to reporting to the US EPA Greenhouse Gas Reporting Program under Subpart RR regulations (40 CFR 98.440 through 449). Other project maps in this application may also show the maximum monitoring area (MMA), defined in 40 CFR 98.448 and 449 as the areal extent of the AoR plus a ½-mile buffer zone expansion to the region of interest for testing and monitoring.

Figure A.1-2 illustrates the integration of the GS project with the existing PFI facilities. Currently, the PFI ethanol plant water washes and then vents the CO_2-rich fermentation off-gas to atmosphere. The addition of the GS project diverts these CO_2 emissions into long-term underground storage in a saline aquifer. There are two potential future modifications to the scope of the Class VI permit:

- PCC may elect to include additional CO_2 sources generated by PFI in the stream sent to the GS facility.
- PCC may elect to utilize a second injection zone in the Lansing-Kansas City Groups of the GS facility, in addition to the primary injection zone in the Arbuckle Group.

Any such future modification will undergo a permit amendment, review, and approval process per 40 CFR 144.39 and 144.41, and will not be implemented without prior approval by the US EPA Program Director.

No Injection Depth waiver or Aquifer Exemption Expansion is required.

Figure A.1-1. Overall Map of GS Project

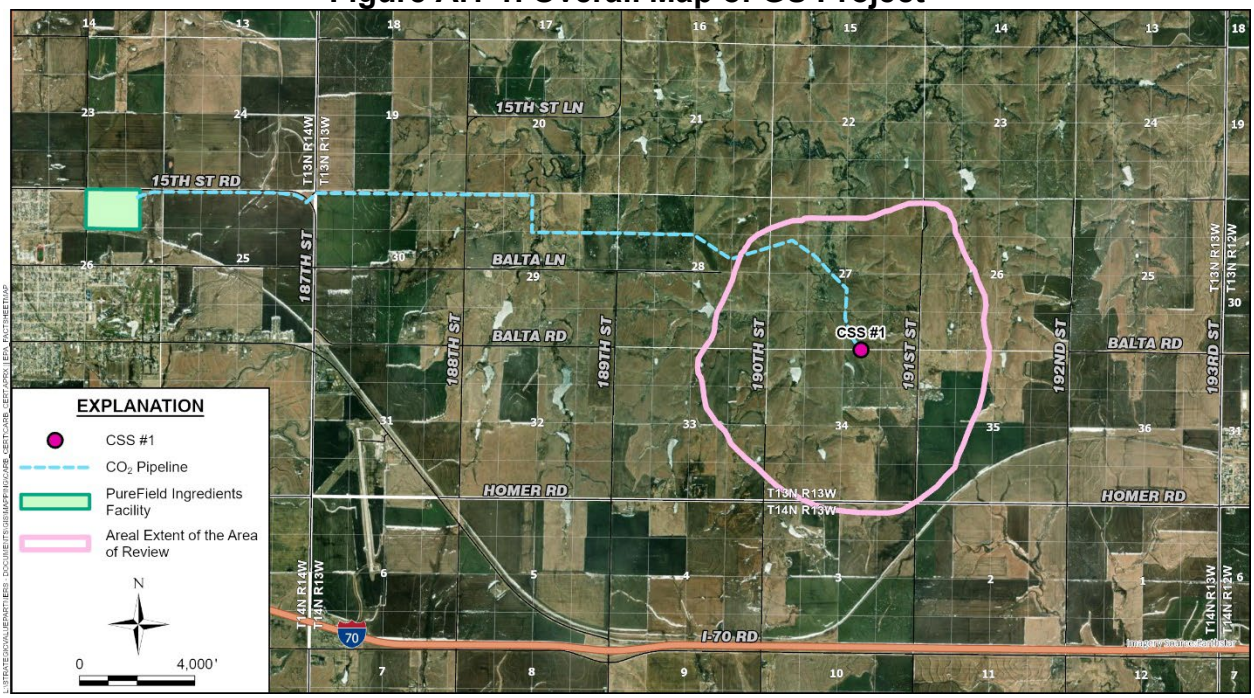


Figure A.1-2. Integration of GS Project with Existing PFI Facilities

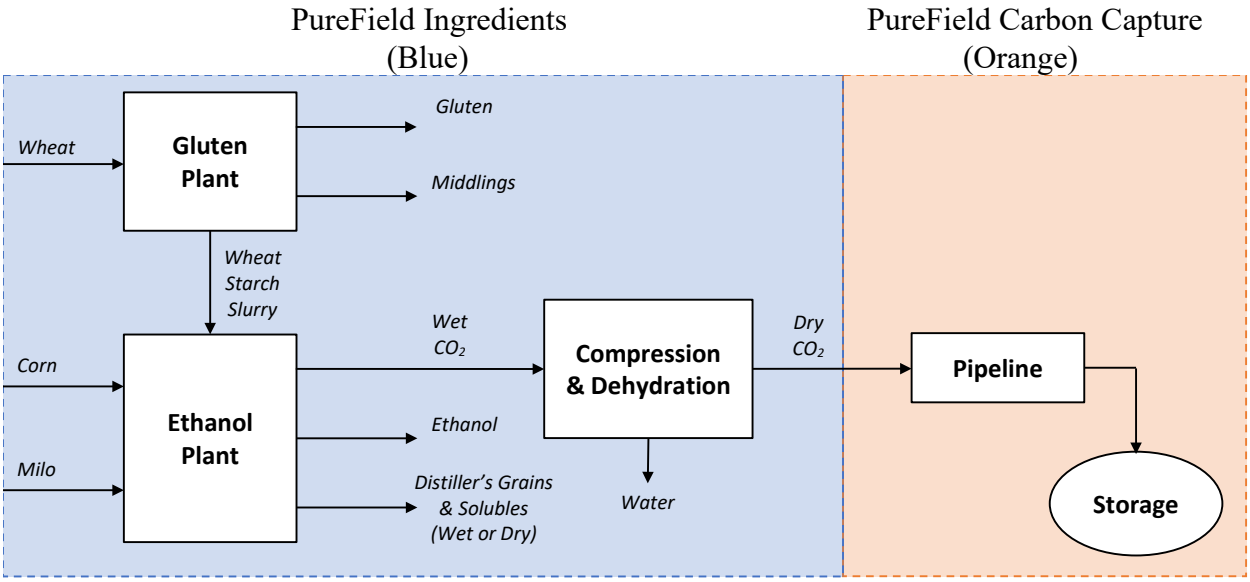
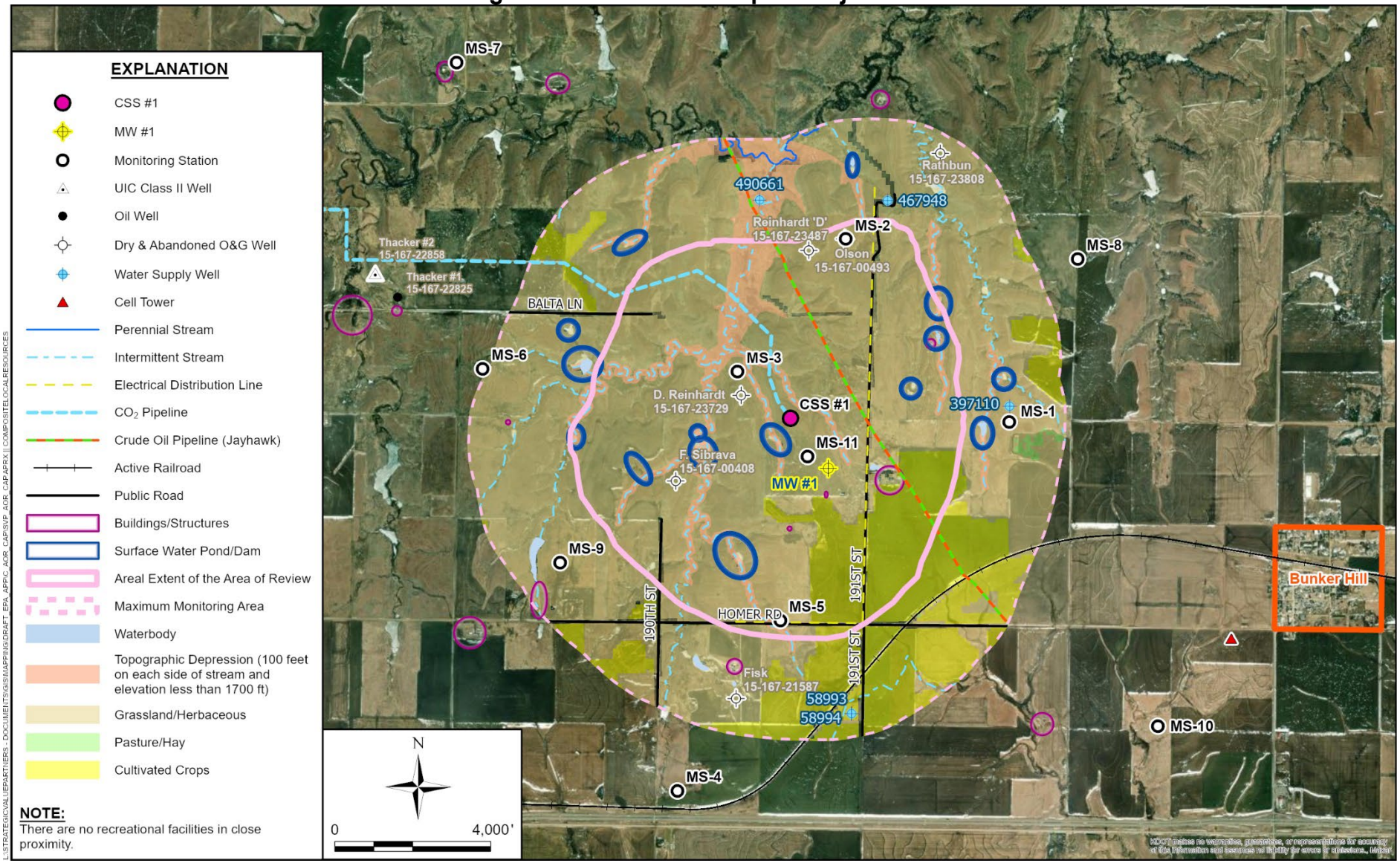


Figure A.1-3 provides a more detailed map of the project site illustrating the following characteristics in conformance to 40 CFR 146.82(a)(2):

- Injection Well: Denoted by the red dot for CSS #1.
- Area of Review: The inner irregular ellipse (solid pink line) represents the areal extent of the AoR. The outer irregular ellipse (dashed pink line) represents the MMA.
- Oil & Gas Wells: No active or planned oil & gas wells were identified within the areal extent of the AoR or MMA. There are several known legacy oil and gas wells within the areal extent of the AoR and MMA that have been plugged and abandoned. Section B.5 of the Area of Review and Corrective Action Plan provides an evaluation for each legacy well along with a corrective action plan (as appropriate).
- UIC Class I through Class VI Wells: No active, planned, or legacy Class I through Class VI wells were identified within the areal extent of the AoR or the MMA, except for the planned Class VI well of this permit.
- Deep Stratigraphic Boreholes: No deep stratigraphic boreholes were identified within the areal extent of the AoR or MMA, with the exception of CSS #1 and MW #1 – the stratigraphic test wells drilled to obtain information for this permit.
- State- or US EPA-approved subsurface Clean-up Sites: No State- or US EPA-approved subsurface clean-up sites were identified within the areal extent of the AoR or MMA.
- Surface Bodies of Water: Cedar Creek and un-named tributaries of Cedar Creek flow through the areal extent of the AoR and MMA, plus there are multiple un-named surface ponds within the areal extent of the AoR and MMA.
- Springs: PCC searched public records (USGS National Hydrography Dataset 2023, Buchanan et al. 2008) and found no evidence of springs within the areal extent of the AoR or MMA. Literature suggests small un-recorded springs or seeps are common in the region and may occur in low-lying areas near the tributaries to Cedar Creek.
- Mines and Quarries: No surface or subsurface mines or quarries were identified within the areal extent of the AoR or MMA.
- Water Wells: No water wells that penetrate the confining zones were identified within the areal extent of the AoR, MMA, and vicinity.
- Structures for Human Occupancy: The GS site and general vicinity are in a sparsely populated rural area. Within the areal extent of the AoR there are two residences with associated outbuildings (e.g., garage, workshop, barn) and two standalone grain storage bins. There are two residences with associated outbuildings and one standalone grain storage bin outside the areal extent of the AoR but within the MMA, and there are several additional residences with associated outbuildings in proximity to the MMA. The nearest high concentration of human occupancy is the City of Bunker Hill, KS (Population: 103, per 2020 census) located 2 ½ miles east of CSS #1.

Figure A.1-3. Detailed Map of Project Site



- Boundaries and Roads: The entire site lies within Russell County, KS; the site does not cross any state, tribal, or territorial boundaries. Several public roads provide access to the site as shown on the map.
- Faults and Fractures: PCC has found no evidence to date of any faults or fractures large enough to offset strata or located in a manner that would interfere with containment. Sources examined within the AoR include open literature sources, analysis of the baseline 3D surface seismic survey conducted for the project, and observations and analysis of data obtained during the drilling of CSS #1. Two key open literature sources used to identify faults and fractures for the project area are Barrs and Watney 1991 and Levandowski et al. 2018.

The GS project site is entirely within the State of Kansas; no tribal or territorial authorities have jurisdiction over the GS site. Contact information for several pertinent agencies within the State of Kansas is provided in Table A.1-1 per 40 CFR 146.82(a)(1).

Table A.1-1. State of Kansas Contacts

Agency	Address	Phone
Kansas Corporation Commission	Main Office: 1500 SW Arrowhead Road Topeka, KS 66604-4027	Main Office: (785) 271-3100
	Conservation Division 266 N. Main St., Ste. 220 Wichita, KS 67202-1513	Division Office: (316) 337-6200 Abandoned Well Plugging: (316) 337-6207
	District Office No. 4 2310 E. 13th Street Hays, KS 67601-2651	District Office: (785) 261-6250
Kansas Department of Health and Environment	1000 SW Jackson Topeka, KS 66612	Main Office: (785) 296-1500 Division of Environment: (785) 291-3092 Bureau of Water: (785) 296-5560 Geology & Well Technology: (785) 296-5560 Underground Injection Control: (785) 296-5554 Division of Public Health: (785) 296-1086
Kansas Water Office	900 SW Jackson, Suite 404 Topeka, KS 66612	Main Office: (785) 296-3185
Kansas Geological Survey	Main Office: 1930 Constant Ave. Lawrence, KS 66047-3724	Main Office: (785) 864-3965 Core Library: (785) 864-2098
	Sample Repository: 4150 W. Monroe Street Wichita, KS 67209-2640	Main Office: (316) 943-2343
Kansas Department of Wildlife & Parks	Office of the Secretary 1020 S. Kansas, Rm 200 Topeka, KS 66612-1327	Main Office: (785) 296-2281
	Hays Region 1 Office 1426 U.S. 183 Bypass P.O. Box 338 Hays, KS 67601-0338	Main Office: (785) 628-8614

GSDT Submission - Project Background and Contact Information
GSDT Module: Project Information Tracking ***Tab(s):*** General Information tab; Facility Information and Owner/Operator Information tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Required project and facility details ***[40 CFR 146.82(a)(1)]***

A.2. Site Characterization

PCC provides a Site Characterization attachment to the Application Narrative that meets the requirements of 40 CFR 146.82(a)(2), (3), (5), (6) and 40 CFR 146.83. The types of site characterization information provided include:

An overview of regional geology, hydrogeology, and local structural geology [40 CFR 146.82(a)(3)(vi)]

A thorough evaluation of regional geology, hydrogeology, and local geology is presented using geologic maps, topographic maps, and cross sections. The full stratigraphic sequence from ground surface to Precambrian basement is provided, along with hydrogeologic units and their associated structures. In the vicinity of the GS site, the shallow geologic units include a series of interbedded shales, limestone, and sandstone formations. The corresponding aquifer systems generally include a shallow (water-table) aquifer, and the Dakota Aquifer (aka Great Plains aquifer) that is the lowermost Underground Source of Drinking Water (USDW) in the region.

Particular attention is given to the Arbuckle Group (gross injection interval within Arbuckle of 3,448 to 3,606 feet below ground surface [ft bgs]) since it contains the target injection zone, and also provides the primary upper confining layer and a lower confining unit. The majority of the Arbuckle Group is composed of porous carbonates. Additionally, the Arbuckle injection zone is vertically separated from the lowermost USDW by a thickness of approximately 2,900 feet (ft) that includes multiple confining units comprised of multiple shale sequences plus thick anhydrite and salt zones. Detailed information is provided on the Arbuckle Group depositional setting, geologic structure, and the regional aquifer system associated the group (extent, salinity, hydraulic head, groundwater velocity, and groundwater temperatures). The Lansing (2,993 to 3053 ft bgs) and Kansas City Groups (3,053 to 3,133 ft bgs) provide a potential second injection zone for permitting at a later date.

Maps and cross sections of the AoR [40 CFR 146.82(a)(3)(i) and 146.82(a)(2)]

Data from a combination of CSS #1 well logs, adjacent well logs, and information from the baseline 3D seismic survey were used to create structural cross sections, seismic cross lines, and isopach maps to aid in the evaluation of the AoR and its vicinity. The assessment indicates that both the sequestration interval and the confining units are present and continuous across the AoR, and the site and its vicinity are characterized by uninterrupted flat-lying stratigraphy.

The location, orientation, and properties of known or suspected faults and fractures that may transect the confining zone(s) in the AoR, along with a determination that they will not interfere with containment [40 CFR 146.82(a)(3)(ii)]

PCC has found no evidence to date of any faults or fractures large enough to offset strata or located in a manner that would interfere with containment. Sources examined within the AoR include: open literature sources, analysis of the baseline three-dimensional (3D) surface seismic survey conducted for the project, and observations and analysis of data obtained during the drilling of CSS #1.

Injection and confining zone details [40 CFR 146.82(a)(3)(iii)]

Data on the depth, areal extent, thickness, mineralogy, porosity, permeability, and capillary pressure of the injection and confining zone and on lithology and facies changes are provided. This information was assembled and evaluated by PCC as part of site characterization from literature and the site-specific pre-operational testing program. There are numerous confining layers separating the Arbuckle Group from the lowermost USDW: over 20 shale layers, the Stone Corral Anhydrite, and the Hutchinson Salt.

Geomechanical information within the confining zone(s) [40 CFR 146.82(a)(3)(iv)]

Geomechanical information on fractures, stress, ductility, rock strength, and in situ fluid pressures was assembled from literature and site-specific data obtained from pre-operational testing of CSS #1. A fracture gradient of 0.78 psi/ft for the top of the Arbuckle Group injection zone is utilized, consistent with the results from the geomechanics model based on dynamic elastic properties (Young's modulus, Poisson's ratio) estimated from the density log and compressional and shear interval transit time logs from CSS #1 with confirmation of elastic properties from triaxial compressive strength testing of CSS #1 core samples.

Information on the seismic history of the area, including the presence and depths of seismic sources, and a determination that the seismicity will not interfere with containment [40 CFR 146.82(a)(3)(v)]

PCC searched two seismic event databases and found three recorded events with a local magnitude (M_L) of 2.7 M_L or greater in Russell County. These occurred between 2018 and 2022 – two 2.8 M_L events located more than 16 miles from CSS #1, and one 2.7 M_L event located approximately 11.4 miles away from CSS #1. PCC found over forty additional records for seismic events less than 2.7 M_L in Russell County.

PCC believes the risk of a seismic event occurring with sufficient intensity to interfere with containment for the GS project is low, mitigated by the following factors:

- Favorable Seismic History – Records show little evidence of past events in the area with sufficient intensity to damage infrastructure.
- Favorable Site Stratigraphy – The stratigraphic column at CSS #1 provides confining layers both above and below the injection zone, plus the Reagan Sandstone layer beneath the lower

confining layer serves as a dissipation interval to further mitigate the impact of seismic events on containment. The Arbuckle Group has been the focus of multiple regional studies since it has been identified as a primary target for carbon sequestration.

- Modest Injection Rate – The GS project injection rate is up to 150,000 metric ton per year = 3,200 barrels per day (bpd), which is modest when compared to total injection rates for existing Class II wells within Russell County.
- Integrated Testing and Monitoring Plan – The plan contains integrated mechanical integrity testing and monitoring elements to assure the GS project wells are in suitable mechanical condition to withstand expected seismic intensities over their service life. The plan also integrates elements for continuous monitoring of two regional earthquake monitoring networks and a dedicated passive seismic system to track micro-seismic events across the GS site, which together provide timely information to properly manage GS project operations.
- Aligned Emergency and Remedial Response Plan – The Emergency and Remedial Response Plan defines suitable actions to be followed in case of a seismic event and is aligned with the response plan delineated in the Kansas Seismic Action Plan that state-level agencies follow for regulation of Class I through V wells in Kansas.

Maps and stratigraphic cross sections indicating the general vertical and lateral limits of all USDWs, water wells, and springs within the AoR, their positions relative to the injection zone(s), and the direction of water movement (where known) [40 CFR 146.82(a)(5)]

The Dakota Formation outcrops in eastern Russell County in the low-lying valleys associated with the Smoky Hill River, Saline River, and Cedar Creek systems. Springs and seepages are known to occur where these valley systems erode into the top of the Dakota. The general horizontal groundwater flow direction is toward the east to northeast on a regional and local basis. The vertical groundwater flow direction is typical downward from the shallow aquifers into the underlying Dakota formation, except where these overlying units are absent, and the Dakota formation outcrops. Due to the high total dissolved solids (TDS) content in the Dakota, this formation is used mainly for agricultural purposes and limited potable consumption. Few water wells occur within the areal extent of the AoR, and fewer still penetrate the Dakota - the bottom of the deepest water well within the areal extent of the AoR is over 3,000 ft above the Arbuckle.

Baseline geochemical data on subsurface formations, including all USDWs in the AoR [40 CFR 146.82(a)(6)]

Site-specific baseline geochemistry data have been collected for the Dakota Formation groundwater (lowermost USDW), the Water Table aquifer groundwater, the vadose zone, and at ground surface since the Fall of 2022. Collectively, these are referred to as the "Shallow Zones". Groundwater in the Dakota is relatively hard, has a high TDS, and exhibits variable salinity content. "Deep Zones" are those below the Dakota Formation (lowermost USDW), for which data collection started with pre-operational testing of CSS #1. These data will be used as a baseline for comparison of groundwater samples taken during the Injection and PISC periods to

monitor for changes in groundwater quality that could warn of unanticipated movement of formation fluids or non-containment of CO_2.

Data to support a demonstration to the Project Director of site suitability for the GS project with respect to injection zone and confining zone(s) properties [40 CFR 146.83]

PCC believes the site is suitable for the GS project. The injection zone is of sufficient areal extent, thickness, porosity, and permeability to receive the total anticipated volume of the carbon dioxide stream. The computational model, which is based upon site-specific reservoir properties, predicts the AoR is an inverted irregular circular cone with an areal extent of 3.1 mi^2 for a total injection of 1.8 million metric ton CO_2, resulting in a storage capacity of 580,000 metric ton CO_2/mi^2. There is confinement with sufficient areal extent and integrity to contain the injected carbon dioxide stream and displaced formation fluids and allow injection at proposed maximum pressures and volumes without initiating or propagating fractures in the confining zones.

See the Site Characterization document for additional information.

A.3. AoR and Corrective Action

PCC provides an AoR and Corrective Action Plan that meets the requirements of 40 CFR 146.82(a)(13) and 146.84(b). The plan details the method used for delineating the AoR, and provides descriptions for: (i) the 5-year minimum fixed frequency for re-evaluation of the AoR, (ii) monitoring and operational conditions that warrant re-evaluation of the AoR prior to the next scheduled re-evaluation, (iii) how monitoring and operational data will be used to inform an AoR re-evaluation, and (iv) how corrective action will be conducted on all wells in the AoR that are determined to need corrective action.

The AoR is delineated from the computational model as the three-dimensional union of the maximum extent of the pressure front (Year 12 pressure front) and the maximum extent of the plume (Year 62 plume). The resulting AoR has the shape of an inverted irregular circular cone with an areal extent of 3.1 mi^2. Other findings predicted by the computational model include:

- The pressure-front retreats quickly after cessation of injection. The minimum threshold pressure is reached across the entire reservoir within 1 month after cessation of injection, resulting in minimal risk of forcing formation fluids into the lowermost Underground Source of Drinking Water (USDW) after this point in time.
- Buoyancy forces create additional plume migration after cessation of injection, expanding the areal extent of the plume from 0.85 mi^2 at Year 12 to 3.1 mi^2 at Year 62.

PCC searched multiple public databases and analyzed site-specific data including well logs and the baseline seismic survey to identify potential natural and artificial penetrations of the confining zone within: the AoR, the maximum monitoring area (MMA) defined in this instance by the areal extent of the AoR plus a ½-mile buffer zone, and the vicinity of the MMA. No confining zone penetrations of the AoR or MMA were found for the following: State- or United States Environmental Protection Agency (US EPA)-approved subsurface clean-up sites, mines or

quarries, faults or fractures that would likely affect confinement, active or planned oil and gas wells, Underground Injection Control (UIC) Class I through VI wells, deep stratigraphic test wells (other than CSS #1 and MW #1), and water wells. The nearest active or planned oil and gas well that penetrates the confining layers lies outside the MMA at a distance of ~2 miles from CSS #1. Four legacy oil and gas wells were identified as penetrating the upper confining zone within the AoR; further evaluation indicates corrective actions are needed for all four wellbores, which will be completed as part of a phased corrective action plan. The search also found several legacy oil and gas wells that penetrate the upper confining zone within the MMA but outside the areal extent of the AoR. None of these wells require corrective action under 40 CFR 146.84 since they are outside the AoR. The search also found one active UIC Class II injection well (Thacker #2, API: 15-167-22858-0002) located outside the MMA but ~2.1 miles away from CSS #1. This Class II well is unlikely to cause interference given that it injects into a different zone than the GS project, and no overlap of the surface projections of the plumes is anticipated. Figure B.1-1 contains a map of the areal extent of the AoR, the MMA, locations for GS project assets, water wells, legacy oil and gas wells, and the nearby UIC Class II.

See the Area of Review and Corrective Action Plan for more information, including tabulation of all wells within the AoR that penetrate the confining zone per 40 CFR 146.82(a)(4), and computational modeling details per 40 CFR 146.84(c).

AoR and Corrective Action GSDT Submissions
GSDT Module: AoR and Corrective Action ***Tab(s):*** All applicable tabs Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Tabulation of all wells within AoR that penetrate confining zone ***[40 CFR 146.82(a)(4)]*** ☒ AoR and Corrective Action Plan ***[40 CFR 146.82(a)(13) and 146.84(b)]*** ☒ Computational modeling details ***[40 CFR 146.84(c)]***

A.4. Financial Responsibility

PCC provides a demonstration of financial responsibility pursuant to 40 CFR 146.82(a)(14) and 146.85. A combination of instruments (i.e., surety bonds and insurance) from qualified institutions are utilized to demonstrate financial responsibilities for corrective action, well plugging and abandonment, post-injection site care (PISC) and site closure, and emergency and remedial response, which when considered as a whole sufficiently addresses the potential endangerment of underground sources of drinking water (USDW) per 40 CFR 146.85(a)(3). The coverage of each instrument meets/exceeds the estimated cost for performing the work by a qualified independent third-party, where per 40 CFR 146.85(c)(1) the independent third party is neither a parent nor a subsidiary of the owner or operator.

See the Financial Responsibility Demonstration attachment for additional information.

Financial Responsibility GSDT Submissions
GSDT Module: Financial Responsibility Demonstration ***Tab(s):*** Cost Estimate tab and all applicable financial instrument tabs Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Demonstration of financial responsibility ***[40 CFR 146.82(a)(14) and 146.85]***

A.5. Well Construction

A.5.1 Proposed Stimulation Program

No stimulation program for CSS #1 is proposed at this time. If PCC later determines that stimulation techniques are needed, a stimulation plan will be developed and submitted for review and approval by the Program Director. Such plan will conform to the requirements of 40 CFR 146.82(a)(9) and include a description of stimulation fluids to be used and a determination that stimulation will not interfere with containment. Once the plan is approved, PCC will notify the US EPA Program Director in writing 30 days in advance of any planned stimulation activities per 40 CFR 146.91(d)(2).

A.5.2 Construction Procedures

PCC will utilize the following wells to meet the requirements of the US EPA UIC Class VI rule:

CSS #1: This well was designed, drilled, and cased in 2022 as a stratigraphic test well under a permit issued to PCC by the State of Kansas - Kansas Corporation Commission (American Petroleum Institute [API] number 15-167-24129) for the purpose of providing necessary field data to support a US EPA UIC Class VI permit application. The stratigraphic test well was designed and built to the injection well requirements of 40 CFR 146.86. The plan is for CSS #1 to be re-permitted and completed as a Class VI injection well for the Injection period, and later re-purposed as a monitoring well during the PISC period.

MW #1: This well is designed as a dual zone monitoring well that penetrates the upper confining zones and injection zone. The upper zone of MW #1 allows for formation fluid sampling and pressure/temperature measurements in the first aquifer above the primary upper confining zone (i.e., the Iola Limestone member in the Kansas City Group). The lower zone of MW #1 allows for direct monitoring of the CO_2 plume and pressure front by formation fluid sampling and pressure/temperature measurements in the injection zone (i.e., the Arbuckle Group). MW #1 is designed to the standards of 40 CFR 146.86 since it penetrates the upper confining zones within the Area of Review (AoR). The design of MW #1 also provides long-term flexibility in project configuration should PCC decide to re-permit for injection into the secondary injection zone target (i.e., Lansing-Kansas City Groups) at a future date.

Groundwater Monitoring Wells: A series of above confining zone monitoring wells are used to provide information on groundwater conditions in the water table and lowermost USDW across the MMA.

Soil Gas Monitoring Wells: A series of above confining zone monitoring wells are used to provide information on soil gas conditions in the upper and lower vadose zone across the MMA.

Passive Seismic Sensor Wells: A series of monitoring wells house seismometers that provide information on micro-seismic activity across the extent of the GS project.

See Attachment A.II Well Construction Details to the Application Narrative for additional information.

A.6. Pre-Operational Testing Program

PCC has and will carry out a Pre-Operational Testing Program in conformance to 40 CFR 146.82(a)(8) and 146.87. The plan includes: (a) Comprehensive logging and testing to ensure CSS #1 (and MW #1) conforms to Class VI well construction standards, and establish a baseline of formation properties (depth, thickness, porosity, permeability, lithology, salinity) from field data collected during drilling of CSS #1 and MW #1, (b) Coring and formation fluid sampling in all relevant geologic formations from the upper secondary confining zones down through the lower pressure dissipation zone, (c) Measurement of injection zone fluid temperature, pH, conductivity, reservoir pressure, and static fluid level, (d) Method for determining fracture pressure and other physical and chemical characteristics of the injection and confining zones, and (e) Pressure fall-off test and a pump/injectivity test of CSS #1 to determine near-wellbore formation properties.

See the Pre-Operational Testing Program for additional information.

Pre-Operational Logging and Testing GSDT Submissions
GSDT Module: Pre-Operational Testing ***Tab(s):*** Welcome tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Proposed pre-operational testing program ***[40 CFR 146.82(a)(8) and 146.87]***

A.7. Well Operation

Table A.7-1. Proposed Operational Parameters

Parameter	Measurement Location	Limitation or Permitted Values		
Daily Injection Rate	FE-0501 Injection Flow Meter	Average	433	metric tons/day
		Maximum	563	metric tons/day
Total Injection	FE-0501 Injection Flow Meter	Maximum	1,800,000	metric tons
Injection Pressure	PT-0505 Downhole - Proximate to packer	Maximum	2,133 2,147	psig psia
Annulus Pressure	PT-0504 Surface - Wellhead Annulus	Minimum	100 114	psig psia
Annulus Pressure - Tubing Differential	PT-0504 - PT-0503 Surface	Minimum	100	psi

psi = pound-force per square inch

psia = pound-force per square inch, absolute

psig = pound-force per square inch, gauge

A.7.1. Operational Procedures [40 CFR 146.82(a)(10)]

Table A.7-1 provides the proposed operational parameters. The design basis for the permit is a CO_2 injection rate of 150,000 metric ton per year over a 12-year Injection period, resulting in a total injection of 150,000*12 = 1,800,000 metric ton for the project. The average daily injection is calculated using an assumption of 8,316 operating hours per year (accounts for outages of CO_2 supply and downtime for project equipment), resulting in 150,000/8,316*24 = 433 metric ton per day. The batch fermentation system that produces the CO_2 stream creates sinusoidal flow variations with an amplitude of 15-20% of the average value and a period of approximately 12 hours. The maximum daily injection rate is set at 30% above the average daily injection rate to provide an adequate margin to handle peak flow rates.

The maximum injection pressure, which serves to prevent confining-formation fracturing, was calculated from hydrostatic head calculations to account for the difference in depth between the CSS #1 downhole pressure gauge (PT-0505) and the top of the injection zone, with the pressure at the top of the injection zone set using a fracture gradient of 0.78 psi/ft multiplied by a safety factor of 80% (0.8). The 80% (0.8) safety factor is used for consistency with CARB Permanence Certification requirements, even though 40 CFR 146.88(a) allows up to a 90% (0.9) safety factor for US EPA UIC Class VI permits.

The annulus pressure and annulus press/tubing differential values are set from system hydraulic calculations during injection operations that assure the annular fluid is always at a higher pressure than the injection fluid along the entire run of the injection tubing.

The design basis flow rate may change over time as the ethanol plant providing the CO_2 stream continually de-bottlenecks operations, implements capacity expansion projects, etc. The design basis duration for the injection period may also change depending upon future policy on regulatory credits and other issues. Material changes to either the design basis flow rate or duration of the injection period will warrant formal updates, reviews, and approvals by the Program Director.

A.7.2. Proposed Carbon Dioxide Stream [40 CFR 146.82(a)(7)(iii) and (iv)]

Table A.7-2 shows the injectate stream is expected to be nearly pure CO_2. The source is CO_2-rich fermentation off-gas that has been water washed to reduce traces of ethanol and other volatile organic compounds, with additional water removal occurring during the compression and dehydration steps used to prepare the stream for pipeline transport.

Table A.7-2. Expected Chemical Composition of Injectate

Constituent	Concentration
Carbon Dioxide	> 99% volume (dry)
Nitrogen	< 0.5% volume (dry)
Oxygen	< 0.5% volume (dry)
Water	< 400 ppmv
Ethanol	< 100 ppmv
Other VOCs	< 50 ppmv total

ppmv = parts per million by volume

PFI has regularly measured the chemical composition of the CO_2 source (prior to compression and dehydration) as part of its air emissions testing and reporting program. Table A-7.3 shows the source composition has been relatively consistent over time, especially after adjusting the as-reported results for the potential of slight air contamination introduced during sampling and/or analysis activities. The main impact of compression, dehydration, and pipeline transport on stream composition is expected to be the selective removal of water; CO_2, inert gases, ethanol, and other volatile organic compounds (VOCs) are expected to remain in the stream as it is compressed, dehydrated, and transported by pipeline to the injection site.

Table A.7-3. Historical Data on Chemical Composition of CO_2 Source

Measurements Taken Prior to Compression and Dehydration

Date	Bulk Constituents, Mole Fraction - Dry Basis						Water Vapor, Mole Fraction	Trace Constituents, ppmv	
	As Reported			Air-Free*					
	CO_2	N_2	O_2 + Ar	CO_2	N_2	O_2 + Ar		Ethanol	Other VOCs
10/12/2022	0.990	0.005	0.005	0.996	0.000	0.004	2.62	45.9	9.6
11/13/2019	0.970	0.020	0.010	0.996	0.000	0.004	5.00	56.2	24.2
12/2/2016	0.990	0.005	0.005	0.996	0.000	0.004	2.84	14.3	21.8
			Average	0.996	0.000	0.004	3.49	38.8	18.5

* Assumes the composition of air is y_{N2} = 0.781 and y_{O2+Ar} = 0.219 per ASTM D1945

Additional testing conducted by PFI of the CO_2 source for other species of potential interest found an absence of hydrogen, carbon monoxide, methane and other higher hydrocarbons, hydrogen sulfide, and sulfur dioxide; if present, the concentrations of these species were below the detection limits of the test methods utilized (ASTM International [ASTM] D1945, ASTM D6228). See Section E.5 of the Testing and Monitoring Plan for additional information.

A.8. Testing and Monitoring

The Testing and Monitoring Plan describes how PCC will monitor the Russell CO_2 Storage Complex site pursuant to 40 CFR 146.90. In addition to demonstrating 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 also be used to validate and adjust the geological models used to predict the distribution of the CO_2 within the storage zone to support AoR re-evaluations and a non-endangerment demonstration.

The plan is designed with a suite of methods covering:

- Well Integrity – An integrated set of testing and monitoring elements are utilized to assure mechanical integrity for the GS project wells.
- Operational Testing and Monitoring During Injection – A comprehensive program consisting of: Analysis of CO_2 Stream, Monitoring of Operational Parameters, Corrosion Monitoring, and Pressure Fall-Off Testing.
- Groundwater Quality and Geochemical Monitoring – A series of monitoring stations have been established across the project site to support testing of groundwater quality and geochemical monitoring of groundwater at key locations above the primary upper confining zone.
- Plume and Pressure Front Tracking – Plume tracking is performed by direct measurements on injection zone fluid samples from MW #1, plus indirect geophysical measurements using time-lapse surface seismic surveys across the GS project site. Pressure front tracking is performed by direct measurement of downhole pressures at CSS #1 and MW #1, plus indirect geophysical measurements using micro-seismic event tracking across the GS project site.

- Additional Testing and Monitoring – Implementation of Soil Gas Monitoring, Ecosystem Stress Monitoring, and Surface CO_2 Monitoring programs to improve the ability to detect potential leaks of CO_2 to surface, plus implementation of a Seismic Monitoring program for timely detection of induced and/or natural seismic activity.

See the Testing and Monitoring Plan for additional information.

Testing and Monitoring GSDT Submissions
GSDT Module: Project Plan Submissions ***Tab(s):*** Testing and Monitoring tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Testing and Monitoring Plan ***[40 CFR 146.82(a)(15) and 146.90]***

A.9. Injection Well Plugging

PCC will plug and abandon CSS #1 in accordance with 40 CFR 146.92. After serving as an injection well, CSS #1 will be re-purposed as a monitoring well for the PISC period. Well plugging and abandonment of CSS #1 will occur after completion of its duty as a monitoring well during PISC.

See the Injection Well Plugging Plan for additional information.

Injection Well Plugging GSDT Submissions
GSDT Module: Project Plan Submissions ***Tab(s):*** Injection Well Plugging tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Injection Well Plugging Plan ***[40 CFR 146.82(a)(16) and 146.92(b)]***

A.10. Post-Injection Site Care and Site Closure

The PISC and Site Closure plan describes the activities that PCC will perform to meet the requirements of 40 CFR 146.93. PCC is not requesting an alternative PISC timeframe at this time, thus the default 50-yr PISC timeframe applies to this GS project. PCC may propose an alternate PISC timeframe at a later date when additional field data have been collected and integrated into the computational model. Any change to the PISC timeframe will necessitate amending the permit for compliance with 40 CFR 146.93(c) and approval of the US EPA UIC Program Director.

PCC may not cease post-injection monitoring until a demonstration of non-endangerment of USDWs has been approved by the US EPA UIC Program Director pursuant to 40 CFR 146.93(b)(3). Following approval for site closure, PCC will plug all monitoring wells, restore the site, and submit a site closure report and associated documentation.

See the Post-Injection Site Care and Site Closure Plan for more information.

PISC and Site Closure GSDT Submissions
GSDT Module: Project Plan Submissions ***Tab(s):*** PISC and Site Closure tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ PISC and Site Closure Plan ***[40 CFR 146.82(a)(17) and 146.93(a)]***
GSDT Module: Alternative PISC Timeframe Demonstration ***Tab(s):*** All tabs (only if an alternative PISC timeframe is requested) Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Alternative PISC timeframe demonstration ***[40 CFR 146.82(a)(18) and 146.93(c)]***

A.11. Emergency and Remedial Response

PCC provides a single Emergency and Remedial Response Plan that meets the requirements of both the US EPA UIC Program (i.e., 40 CFR 146.94(a)) and the California Air Resources Board (CARB) Carbon Capture and Sequestration (CCS) Protocol under the Low Carbon Fuel Standard (i.e., CARB CCS Protocol C.6). PCC shall: a) take actions to address movement of the injection fluid or formation fluid in a manner that may endanger a USDW during the Construction, Injection, or Post-Injection Site Care (PISC) periods per 40 CFR 146.94(a), and b) take actions in the event of an emergency at the site that has the potential to endanger public health or the environment during construction, operation, and PISC periods per CARB CCS Protocol C.6. If PCC obtains evidence for either a) or b) then PCC must perform the following actions:

1. Initiate shutdown plan for the injection well.
2. Take all steps reasonably necessary to identify and characterize any release.
3. Notify the following of the event within 24 hours:
    a. US EPA UIC Program Director
    b. CARB Executive Officer
4. Implement applicable portions of the approved Emergency and Remedial Response Plan.

See the Emergency and Remedial Response Plan for more information.

Emergency and Remedial Response GSDT Submissions
GSDT Module: Project Plan Submissions ***Tab(s):*** Emergency and Remedial Response tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Emergency and Remedial Response Plan ***[40 CFR 146.82(a)(19) and 146.94(a)]***

A.12. Injection Depth Waiver and Aquifer Exemption Expansion

No Injection Depth Waiver or Aquifer Exemption Expansion is required.

Injection Depth Waiver and Aquifer Exemption Expansion GSDT Submissions
GSDT Module: Injection Depth Waivers and Aquifer Exemption Expansions ***Tab(s):*** All applicable tabs Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☐ Injection Depth Waiver supplemental report ***[40 CFR 146.82(d) and 146.95(a)]*** ☐ Aquifer exemption expansion request and data ***[40 CFR 146.4(d) and 144.7(d)]***

A.13. Optional Additional Project Information [40 CFR 144.4]

The US EPA UIC Program must ensure Federal laws listed in 40 CFR 144.4 are followed prior to the issuance of UIC permits. PCC has reviewed 40 CFR 144.4 and provides the following representations to assist US EPA in its compliance efforts:

§ 144.4(a) The Wild and Scenic Rivers Act (16 U.S.C. 1273 *et seq.*) Not applicable. The project will not impact any rivers that are: (i) authorized for inclusion in the Act, or (ii) designated as wild, scenic, or recreational rivers per the terms in the Act.

§ 144.4(b) The National Historic Preservation Act of 1966 (16 U.S.C. 470 *et seq.*) Applicable. PCC is conducting a historic and cultural resource survey that identifies properties listed or eligible for listing in the National Register of Historic Places that may be affected by the activities associated with the proposed project. PCC will provide US EPA with an electronic copy of the written survey report, upon final completion of the survey.

§ 144.4(c) The Endangered Species Act (16 U.S.C. 1531 *et seq.*) Applicable. PCC is conducting an endangered or threatened species survey that identifies any endangered or threatened species that may be affected by the activities associated with the proposed project. PCC will provide US EPA with an electronic copy of the written survey report, upon final completion of the survey.

§ 144.4(d) The Coastal Zone Management Act (16 U.S.C. 1451 *et seq.*) Not applicable. The project will not impact any coastal zones, where coastal zones are defined in 16 U.S.C. 1453.

§ 144.4(e) The Fish and Wildlife Coordination Act (16 U.S.C. 661 *et seq.*) Applicable. PCC has designed the project, including implementation of construction techniques, to avoid adverse impacts to fisheries and wildlife. As part of the Endangered Species Act review mentioned above, PCC will be consulting with the US Fish and Wildlife Service to address any concerns and will provide US EPA with an electronic copy of their findings.

§ 144.4(f) Executive Orders Not applicable. The published online text in the National Archives does not identify any applicable executive orders as of August 2023[1]. PCC intends to assist US EPA with its compliance efforts should an executive order be deemed applicable in the future.

A.14. Other Information

No other information has been requested by the US EPA UIC Program Director.

A.15. References

Baars, D. L. and Watney, W. L., 1991. Paleotectonic control of reservoir facies. Kansas Geological Survey Bulletin, 233, 253–262. https://www.kgs.ku.edu/Publications/Bulletins/233/Baars/baars.pdf

Buchanan, R., Swain, R., Lebsack, W., 2008. Kansas Springs, Kansas Geological Survey, Public Information Circular II, Oct. 1998, Revised May 2008. Available at: https://kgs.ku.edu/sites/kgs/files/files/PICpdfs/PIC11KansasSprings.pdf

Levandowski, W., Herrmann, R. B., Briggs, R., Boyd, O., and Gold, R., 2018. An updated stress map of the continental United States reveals heterogeneous intraplate stress. Nature Geoscience, 11(6), 433-437. https://doi.org/10.1038/s41561-018-0120-x

USGS National Hydrography Dataset 2023, https://www.usgs.gov/national-hydrography/national-hydrography-dataset . The dataset is transitioning to become part of the USGS 3D Hydrography Program: https://www.usgs.gov/3dhp .

[1] See: https://www.ecfr.gov/current/title-40/chapter-I/subchapter-D/part-144/subpart-A/section-144.4