CLASS VI PERMIT APPLICATION NARRATIVE
40 CFR 146.82(a)

FRONT RANGE STORAGE COMPLEX

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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	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

Carbon Storage Solutions, LLC (CSS) is the Applicant and the owner/operator of the geologic sequestration (GS) facility. CSS is a wholly owned subsidiary of Front Range Energy, LLC (FRE) – owner/operator of an existing dry-mill ethanol plant in Windsor, CO that produces fuel-grade ethanol and other products. The overall goal of the project is to implement a successful GS project for the FRE/CSS facilities by accomplishing the following objectives:

- Capture up to 127,800 metric ton per year of carbon dioxide (CO_2) from the existing fermentation off-gas system at the FRE ethanol plant
- Liquefy the captured CO_2 using surface equipment co-located at the FRE ethanol plant
- 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
- Inject the CO_2 into the storage complex for at least 12 years, followed by post-injection site care (PISC) and site closure per US EPA regulations.

Figure A.1-1 shows the GS storage complex is located beneath the FRE/CSS facility, with surface location of the injection well Front Range 1-1 (FR 1-1) located on site, and the bottom-hole location of Front Range 1-1 located approximately ½-mi southeast of the Front Range 1-1 surface location. The inner irregular circle (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. 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). The outer irregular circle (dashed pink line) represents the maximum monitoring area (MMA), defined in 40 CFR 98.448 and 449 as the areal extent of the AoR plus a ½-mi 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 FRE facility. The addition of the GS project diverts CO_2 emissions from the existing fermentation off-gas system into long-term underground storage.

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: Front Range 1-1 was drilled as a stratigraphic test well under a permit issued by the Colorado Energy and Carbon Management Commission (ECMC) and used to gather site-specific technical data for this Class VI permit. CSS intends to re-permit Front Range 1-1 as a Class VI injection well, and later re-purpose it as a monitoring well during post-injection.
- Area of Review: The inner irregular circle (solid pink line) represents the areal extent of the AoR. The outer irregular circle (dashed pink line) represents the MMA.

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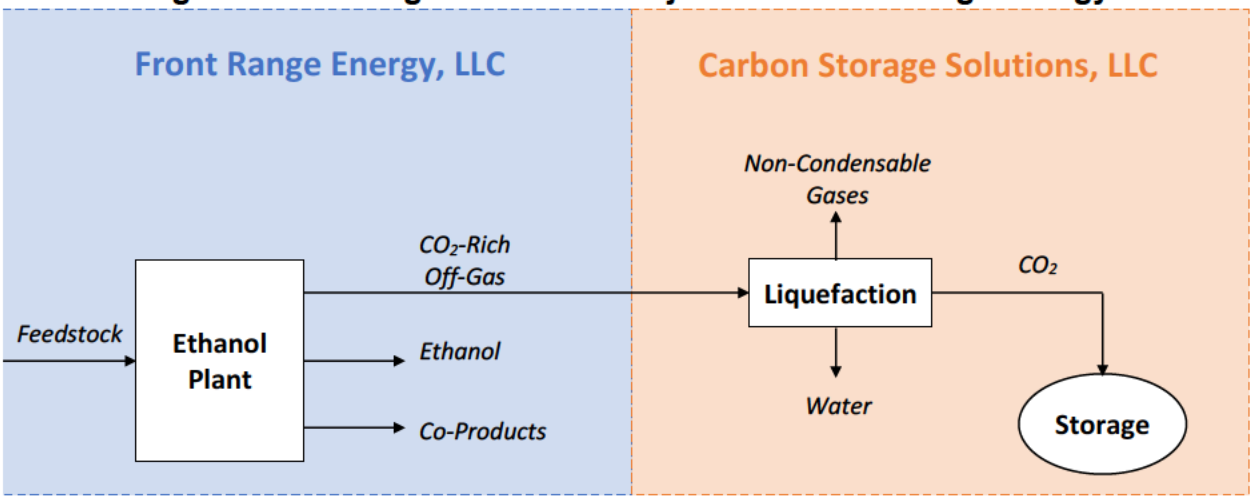
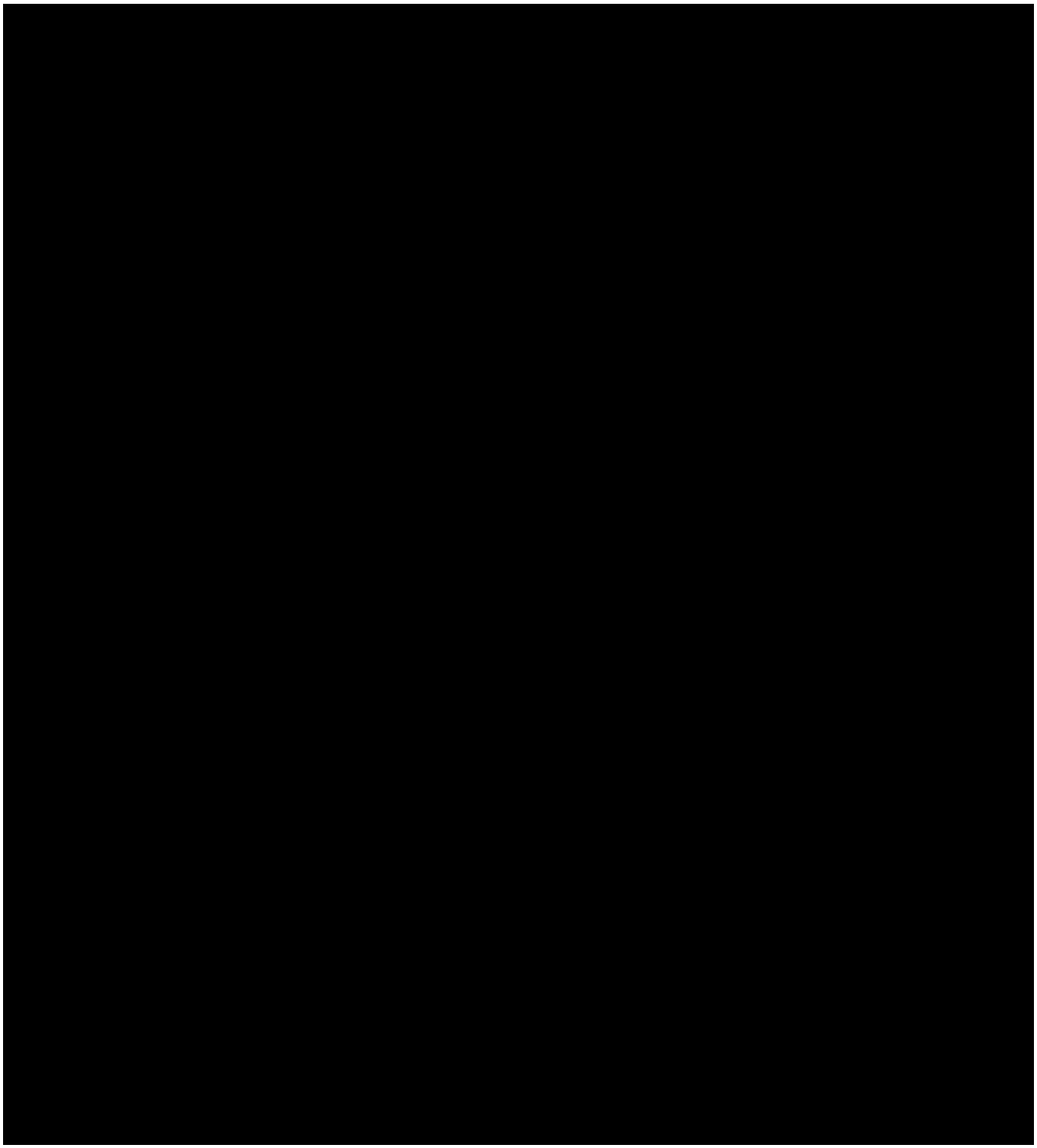
Figure A.1-2. Integration of GS Project with Front Range Energy





- Oil & Gas Wells: The project site is located within an active oil & gas basin. There are planned, active, and legacy oil & gas wells within the areal extent of the AoR but none were identified that penetrate the confining zones. Two legacy wellbores were identified that penetrate the confining zones within the MMA, but they both lie outside of the AoR.
- UIC Class I through Class VI Wells: No planned, active, 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 Front Range 1-1 – the stratigraphic test well drilled by CSS under a Colorado Energy and Carbon Management Commission (ECMC) permit and used to obtain site-specific technical information for this permit. In addition, CSS has applied to ECMC for a second stratigraphic well Front Range 2-1 to collect additional subsurface information to support this Class VI application. CSS intends to re-purpose Front Range 2-1 as a deep zone monitoring well for the GS project.
- State- or US EPA-approved subsurface Clean-up Sites: No State- or US EPA-approved subsurface clean-up sites that penetrate the confining zones were identified within the areal extent of the AoR or MMA.
- Surface Bodies of Water: The Cache de la Poudre River and un-named tributaries of the Cache de la Poudre River 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: No springs were identified within the areal extent of the AoR or MMA. The nearest identified spring is 3.5 mile east of the Front Range 1-1 bottomhole location.
- Mines and Quarries: No surface or subsurface mines or quarries that penetrate the confining zones were identified within the areal extent of the AoR, MMA, and vicinity.
- 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 lies underneath an industrial park containing multiple workplaces including the FRE ethanol plant and CSS liquefaction facility. In addition, there are multiple residences within the areal extent of the AoR, MMA, and vicinity as indicated in Figure A.1-3.
- Boundaries and Roads: The GS project site is entirely within Weld County, with portions of the site lying within the Town of Windsor. The site does not cross any state, tribal, or territorial boundaries. There are multiple roads across the areal extent of the AoR, MMA, and vicinity as indicated in Figure A.1-3.
- Faults: CSS has found no evidence to date to suggest that any faults, fractures, or other natural penetrations within the AoR or MMA are large enough to offset strata or located in a manner that would interfere with containment.

See Section B.5 of the Area of Review and Corrective Action Plan and Sections A.I.2.5, A.I.4, and A.I.4.3.2 of Site Characterization for additional supporting information.

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

Table A.1-1. State of Colorado Contacts

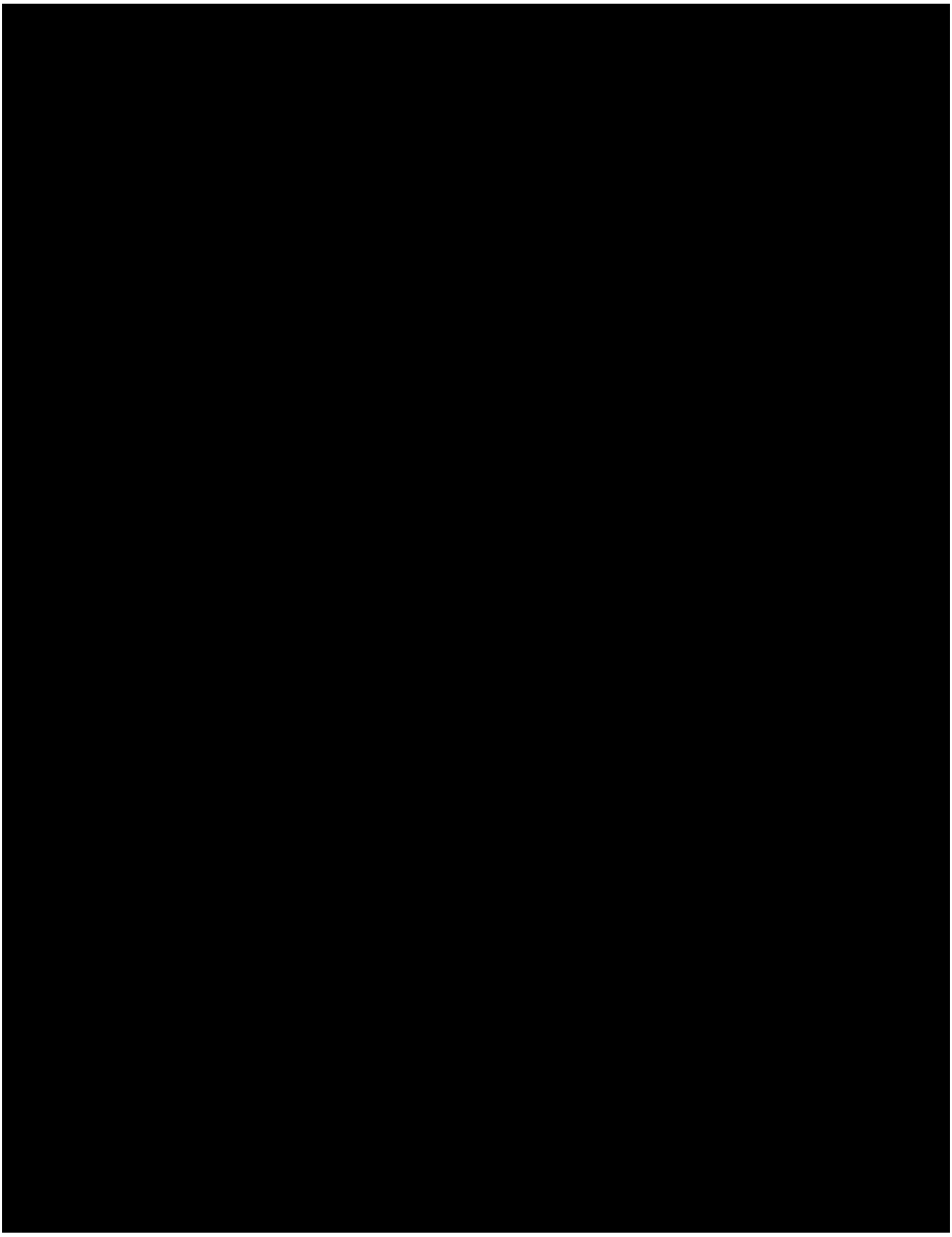
Agency	Address	Phone
Colorado Energy and Carbon Management Commission	1120 Lincoln Street, Suite 801 Denver, CO 80203	(303) 894-2100
Colorado Department of Public Health & Environment	4300 Cherry Creek Drive South Denver, CO 80246	(303) 692-2000
Colorado Division of Water Resources – Division 1 Main Office	1809 56th Avenue Greely, CO 80634	(970) 352-8712
Colorado Geological Survey	1801 Moly Road Golden, CO 80401	(303) 384-2655
Colorado Parks & Wildlife – Denver Office	6060 Broadway Denver, CO 80216	(303) 291-7227

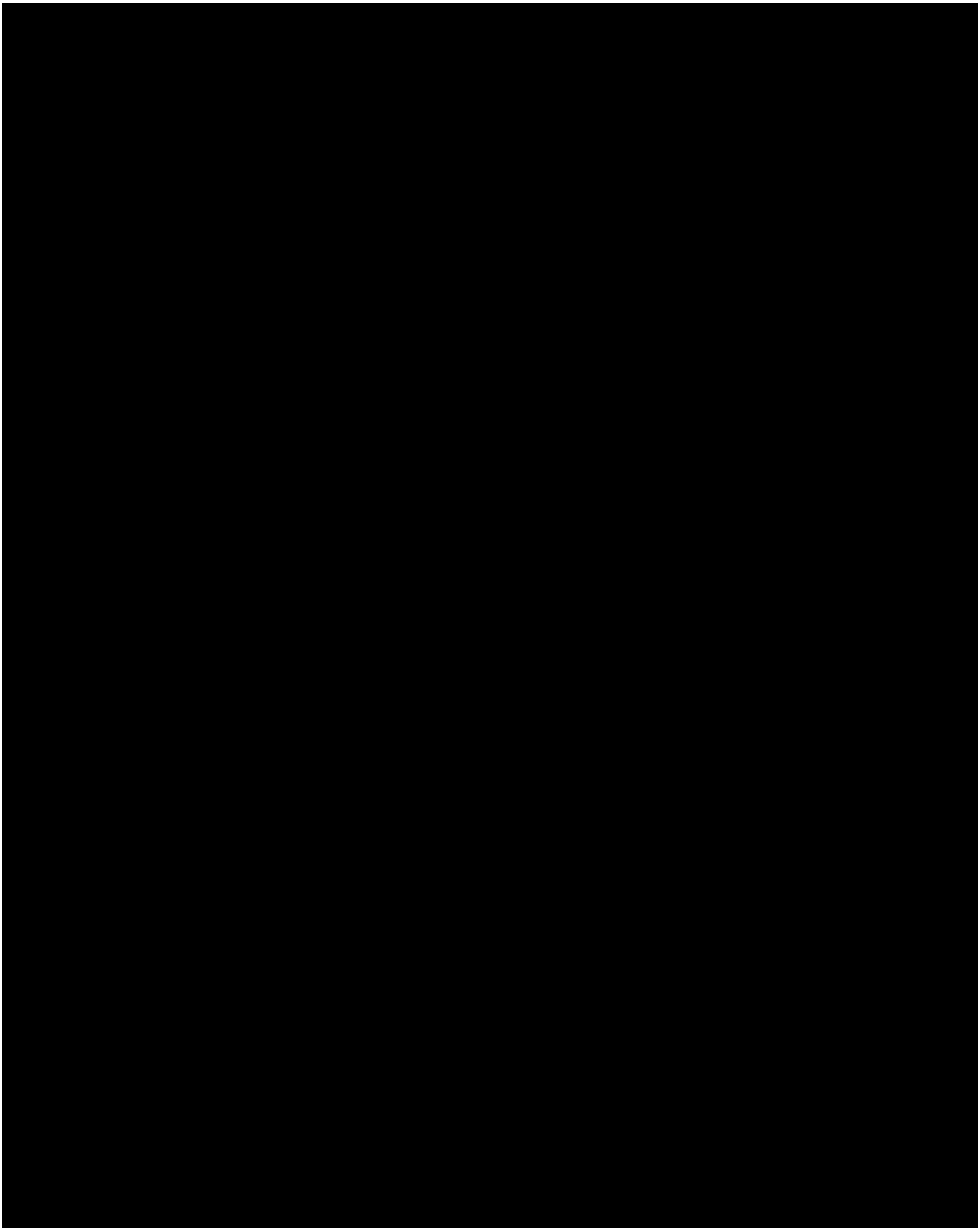
GSDT Submission - Project Background and Contact Information

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





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A.3. AoR and Corrective Action

CSS provides an Area of Review (AoR) and Corrective Action Plan that meets the requirements of 40 CFR 146.84. 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 an irregular cylinder with areal extent of 6.4 mi^2, as delineated from the computational model as the union of the maximum extent of the pressure front (Year 12) and the maximum extent of the plume (Year 32). Other findings from the computational model results include:

- The pressure field has the shape of an irregular cylinder at the cessation of injection
  - The injection zone is under-pressured relative to a normal hydrostatic gradient, which lessons the extent of the pressure front
  - Pressure at any point in the reservoir falls rapidly after cessation of injection
  - The maximum pressure at any point in time and space occurs at Front Range 1-1, thus Front Range 1-1 pressure and Front Range 1-1 pressure differential can be used as limiting case proxies for the entire pressure field

- The plume is an irregular inverted circular diamond at any point in time
  - The areal extent of the plume is defined by the widest point of the plume, which occurs roughly in the lower quarter of the inverted diamond within the zone of highest flow
  - The areal extent of the plume expands slightly after cessation of injection
  - Dissolution of free-phase CO_2 into the formation fluid is readily apparent during post-injection, with only minor plume spreading from buoyancy

No corrective action plan is needed since there are no known penetrations of the confining zones within the AoR, with the exception of Front Range 1-1 and Front Range 2-1 that are to be constructed, operated, and plugged and abandoned to Class VI standards thus needing no further evaluation of corrective action at this time. CSS searched multiple databases to identify potential natural and artificial penetrations of the confining zone within the AoR, within the maximum monitoring area (MMA) defined as the areal extent of the AoR plus a ½-mile buffer zone, and within the vicinity of the MMA. Section A.I.4.1 of Site Characterization shows no evidence has been found to date to suggest that any faults, fractures, or other natural penetrations within the

AoR are large enough to offset strata or located in a manner that would interfere with containment. Several artificial penetrations of the confining zone have been identified within the outer reaches of the MMA and vicinity, but none are located within the AoR, thus eliminating the need for corrective action evaluation.

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

CSS provides a demonstration of financial responsibility pursuant to 40 CFR 146.82(a)(14) and 146.85. No financial instrument for corrective action is needed to satisfy the requirement of 40 CFR 146.85(a)(2)(i) since no corrective actions have been identified - see Section B.5 of the Area of Review and Corrective Action Plan for additional discussion. A combination of instruments (i.e., surety bonds and insurance) from qualified institutions are utilized to demonstrate financial responsibilities for well plugging and abandonment, PISC and site closure, and emergency and remedial response, which when considered as a whole sufficiently addresses the potential endangerment of USDWs 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

CSS does not currently anticipate the need for stimulation to enhance injectivity for Front Range 1-1. If CSS determines in the future that stimulation techniques are needed, CSS will notify the Program Director in writing 30 days in advance of any planned stimulation activities per 40 CFR 146.91(d)(2). The notice will conform to the requirements of 40 CFR 146.82(a)(9) by providing a description of stimulation fluids to be used and a determination that stimulation will not interfere with containment. No stimulation activities will be conducted without prior approval of the Program Director.

A.5.2 Construction Procedures

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

Front Range 1-1: This well was designed, drilled, and cased as a deviated stratigraphic test well under a permit issued to CSS by the State of Colorado - Energy and Carbon Management Commission (ECMC) under American Petroleum Institute (API) Number 05-123-51898-0000. The purpose of the well was to provide 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 Front Range 1-1 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.

Front Range 2-1: This well is designed as a three-zone monitoring well that penetrates the upper confining zones, the injection zone, the lower confining zones, and into the Ingleside aquifer below the injection zone. The upper zone of Front Range 2-1 allows for formation fluid sampling and pressure/temperature measurements in the first aquifer above the primary upper confining zone (Entrada). The middle zone of Front Range 2-1 allows for direct monitoring of the plume and pressure front by formation fluid sampling and pressure/temperature measurements in the injection zone (Lyons). The lower zone of Front Range 2-1 allows for formation fluid sampling and pressure/temperature measurements in the Ingleside.

Groundwater Monitoring Wells: A series of above confining zone monitoring wells are used to provide information on groundwater conditions in the water table and Upper Pierre aquifer (commonly used USDW) across the GS project site.

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 GS project site.

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

A.6. Pre-Operational Testing Program

CSS 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 Front Range 1-1 (and Front Range 2-1) 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, (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 Front Range 1-1 to determine near-wellbore formation properties.

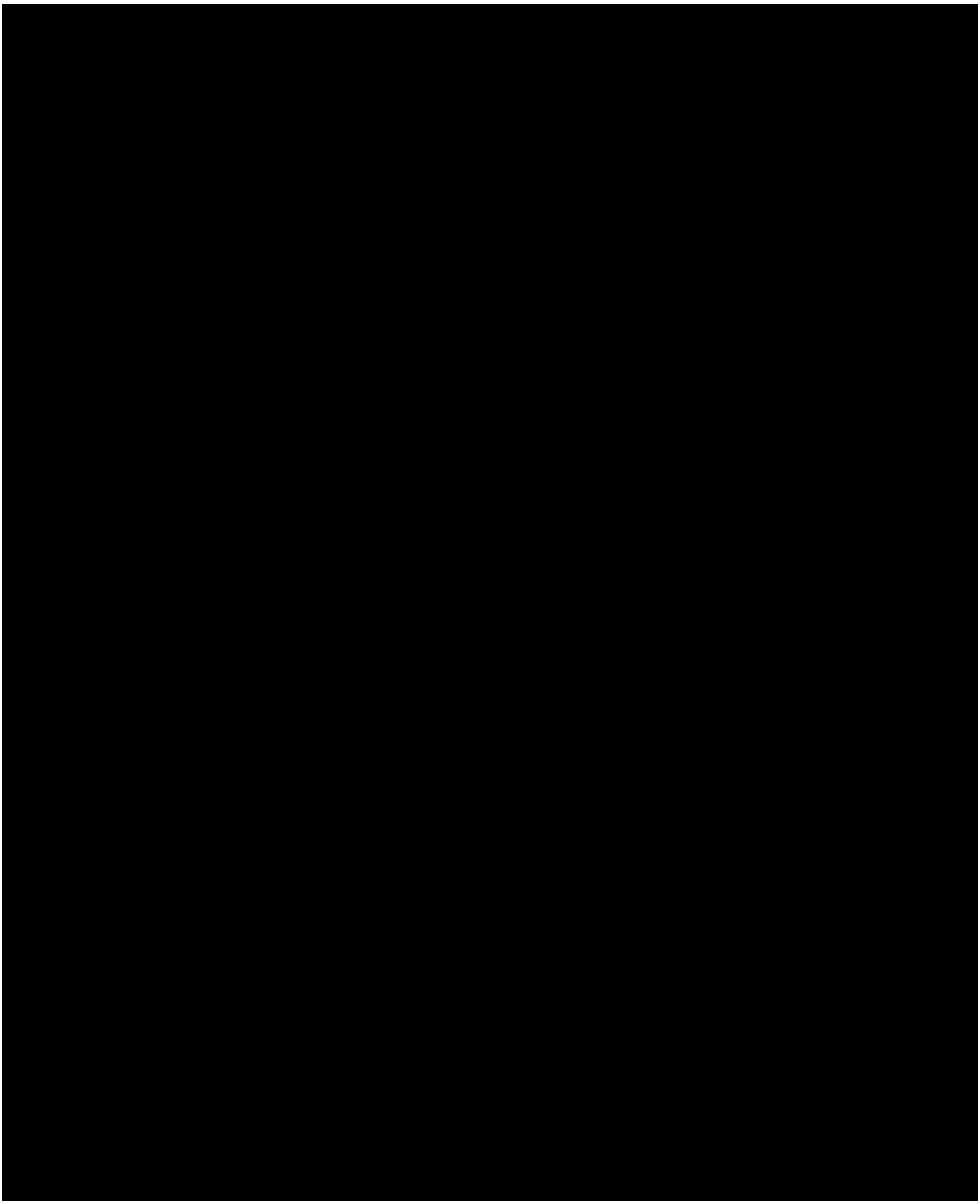
See the Pre-Operational Testing Program for additional information.

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



A.8. Testing and Monitoring

The Testing and Monitoring Plan describes how CSS will monitor the project 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 Underground Source of Drinking Water (USDW), the monitoring data will be used to validate and adjust the geological models used to predict the distribution of the CO_2 within the storage zone to support area of review (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 geologic sequestration (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 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 Front Range 2-1, plus indirect geophysical measurements using time-lapse vertical seismic profiles. Pressure front tracking is performed by direct measurement of downhole pressures at Front Range 1-1 and Front Range 2-1.
- Additional Testing and Monitoring – Implementation of Soil Gas 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 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

CSS will plug and abandon Front Range 1-1 in accordance with 40 CFR 146.92. After serving as an injection well, Front Range 1-1 will be re-permitted as a monitoring well for the PISC period. Well plugging and abandonment of Front Range 1-1 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 CSS will perform to meet the requirements of 40 CFR 146.93. CSS will monitor groundwater quality and track the position of the plume and pressure front for an alternative PISC timeframe of 20 years. Changing the PISC timeframe from the 50-year default to the proposed 20-year alternative timeframe will be accomplished in accordance with 40 CFR 146.93(c).

CSS may not cease post-injection monitoring until a demonstration of non-endangerment of Underground Sources of Drinking Water (USDWs) has been approved by the United States Environmental Protection Agency (US EPA) Underground Injection Control (UIC) Program Director pursuant to 40 CFR 146.93(b)(3). Following approval for site closure, CSS 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, including supporting information for the alternative PISC timeframe demonstration.

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

The Emergency and Remedial Response Plan describes actions that CSS shall take to address movement of the injection fluid or formation fluid in a manner that may endanger a USDW during the construction, operation, or Post-Injection Site Care periods.

If CSS obtains evidence that the injected carbon dioxide stream and/or associated pressure front may cause an endangerment to a USDW, CSS 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 permitting agency (UIC Program Director) of the emergency event within 24 hours
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

[redacted]