Appendix C:
Economic Analysis

Proposed California Carbon Capture, Removal, Utilization, and Storage Program Regulations and Associated Regulatory Amendments

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I. Introduction

Chapter VIII of the Initial Statement of Reasons (ISOR) provides an overview of the costs of the Proposed California Carbon Capture, Removal, Utilization, and Storage Program Regulations and Associated Regulatory Amendments ("Proposed Regulation"). This appendix contains the detailed inputs and methods used to calculate the estimated incremental costs to regulated parties that will result from adoption of the Proposed Regulation. The analysis covers a six-year period beginning with the year that the Proposed Regulation is expected to go into effect. All costs are presented in 2025 dollars. This appendix also includes apportionment of costs between regulated carbon management entities including carbon capture projects, carbon dioxide removal (CDR) projects, and geologic carbon storage (GCS) sites, and cost estimates for alternatives to the Proposed Regulation.

II. Summary Cost Tables for the Proposed Regulation

Costs for each carbon capture/CDR project are estimated as $14,200 per year and $6,000 on an ongoing basis (see Table 1 in Chapter VIII of the ISOR). Costs for each GCS site are estimated as $1,046,900 in the first year and $702,300 on an ongoing basis. Using an analysis time horizon of six years, the total statewide cost over that period is estimated at $58.3 million.

Staff evaluated costs over a six-year period from 2028 to 2033 to capture both the expected peak implementation cost and the projected peak number of carbon management projects operating in California in 2033, the year when the 45Q federal tax credit–an important incentive for CO_2 storage–sunsets (26 U.S.C § 45Q).

The remainder of this section details assumptions, costs broken down by provision, and share of costs by industry.

Staff does not expect operators to incur costs or achieve cost savings for the following proposed amendments:

- The Proposed Regulation includes renaming of the Carbon Capture and Sequestration (CCS) Protocol to the Geologic Carbon Storage (GCS) Protocol and proposed amendments to introduce primarily technical and administrative updates to testing, monitoring, and risk management requirements. Because the GCS Protocol remains voluntary, staff did not quantify costs associated with these proposed amendments.
- The Proposed Regulation includes proposed amendments to the Cap-and-Invest Regulation which would incorporate by reference the GCS Protocol, thus enabling a covered facility to reduce its Cap-and-Invest compliance obligation by capturing CO_2 and storing it following the requirements of the GCS Protocol. Use of the proposed GCS Protocol would remain voluntary under the Proposed Regulation; therefore, no compliance responses are expected. It is unlikely that the Proposed Regulation would directly lead to new development of carbon capture projects, CDR projects, or GCS sites. Therefore, the costs of the proposed amendments are not quantified.
- The Proposed Regulation includes proposed amendments to the Low Carbon Fuel Standard (LCFS) program, including the reorganization of certain sections of the CCS

protocol into the new Low Carbon Fuel Standard Quantification Methodology (LCFS QM). Use of the LCFS QM would remain voluntary under the Proposed Regulation.. The proposed amendments would not result in any physical construction, equipment installation, or other on-site compliance actions. Therefore, the costs of the proposed amendments are not quantified.

- The Proposed Regulation includes proposed amendments to the Regulation for the Mandatory Reporting of Greenhouse Gas Emissions which would consist of minor text revisions to clarify existing requirements and support the Cap-and-Invest Program by requiring data already collected to be separately categorized and reported. Additionally, the proposed amendments would remove the verification threshold described above, instead requiring all GCS operators to complete annual verification of reported data. Staff did not identify any GCS sites expected to fall under the threshold of projects injecting less than 25,000 metric tons CO_2e annually; therefore, these costs were not included for the projected population.

III. Data, Calculations, and Assumptions used throughout the Cost Analysis

A. Businesses Impacted

Businesses that would be impacted by the Proposed Regulation include carbon capture projects, CDR projects, and GCS sites voluntarily operating within California. Data for carbon capture projects was obtained from CARB's CCUS and CDR project list that was last updated on October 13, 2025 (CARB, 2025b). Data for GCS sites were obtained from the U.S. Environmental Protection Agency (U.S. EPA) Class VI well permitting database (U.S. EPA, 2026b). For this economic analysis, each carbon capture/CDR project and GCS site is treated as an individual business.

The rate at which planned projects are able to begin construction and come online depends on several external factors, including permitting timelines. The external factors that would influence a project developer to plan and implement a new CCS project, CDR project, or GCS site are similarly highly uncertain and beyond the control or influence of the Proposed Regulation. For this reason, staff present potential development scenarios only for projects currently planned and announced in California, as documented in CARB's CCUS and CDR Project List (CARB, 2025b).

To account for deployment uncertainty when estimating implementation costs for this Proposed Regulation, staff evaluated High and Low project-deployment scenarios to represent the range of possible carbon management development. Staff evaluated costs over a six-year period from 2028 to 2033 to capture both the expected peak implementation cost and the

projected peak number of carbon management projects operating in California in 2033, the year when the 45Q federal tax credit–an important incentive for CO_2 storage–sunsets.[1]

Additionally, for both the High and Low project-deployment, staff established a baseline growth rate for carbon management deployment–including CCUS and CDR as described in the Proposed Regulations description above–beginning in 2029, the first year of implementation. For carbon capture and CDR projects, staff assumed a 4.8% growth rate, consistent with estimates from academic literature projecting needed adoption of carbon capture in California (Neutel et al., 2025 and CARB, 2025c).[2,3] And for GCS site growth, staff assumed two projects would come online each year, reflecting historic submission rates for U.S. EPA Class VI well permit applications. Staff also assumed that carbon management deployment would continue up to the 45Q tax credit sunset in 2033.[4]

Under the High Scenario, staff assumed that 33 carbon capture and CDR projects and 13 storage projects are planned to come online by 2029. Based on this assumption and the baseline growth described above, staff projected that 41 carbon capture/CDR projects and 21 GCS sites would come online by 2033 under the High scenario.

Under the Low Scenario, staff assumed that projects would face longer development timelines (e.g., from possible labor shortages, obstacles to securing pipeline rights-of-way, supply chain issues, and broader economic uncertainty leading up to 2029). This assumption results in only one capture project and five storage projects becoming operational by 2029. After 2029, we applied the same baseline growth rates used in the High Scenario to estimate when carbon capture, CDR projects and GCS sites would become operational. Based on these assumptions, staff projected that one carbon capture/CDR project and thirteen GCS sites would become operational by 2033 under the Low Scenario.

For purposes of estimating the annual compliance costs for this Proposed Regulation, staff averaged the High and Low Scenario projections of the regulated community, carbon management projects, from 2029 through 2033. Based on this average, staff projects that approximately 26 businesses would be subject to the regulation in 2029, increasing to 38 businesses by 2033. There is no significant projected carbon management deployment between 2027 and 2028 due to project permitting and construction lead times (Peridas, 2021).[5]

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[1] 26 U.S.C. § 45Q (Credit for carbon oxide sequestration, 2022).

[2] Derived from the DEcarbonization CALifornia (DECAL) model prescribed carbon capture growth rate across industry within the State (Neutel et al., 2025).

[3] The number of MRR compliant industrial facilities is used to calculate the weighted average growth rate derived from the DECAL model (CARB, 2025c).

[4] See supra note 1.

[5] Calculated as the difference between the estimated CCS project development time of 5.5 years based on the LLNL report and U.S. EPA Class VI permit new project permitting time (i.e., final permit decision date - application received data) of 3.5 years (Peridas, 2021).

B. Inflation adjustments

The costs in this analysis are presented in 2023 dollars. Cost data from prior to 2023 was adjusted based on the change in the California Consumer Price Index (CPI) for "All Urban Consumers" from the California Department of Industrial Relations (DIR, 2026). To make these inflation adjustments, the original cost was multiplied by the appropriate adjustment factor from Table C-1.

Table C-1. California Consumer Price Index and Inflation Adjustment Factors

Year	California Consumer Price Index, All Urban Consumers	Adjustment Factor (to adjust to 2025$)*
2025	352.508	1.000
2024	341.951	1.031
2008	224.807	1.568

*Adjustment factor is the ratio of the California Consumer Price Index (CPI) in 2025 to the California CPI in the year identified in the row. Note: Only includes the years for which adjustment factors were used in the cost analysis.

C. Labor cost rates

Labor cost rates for new tasks required by the Proposed Regulation were estimated based on the type of personnel who would perform the task. In this analysis, nine types of labor tasks were considered, each with a different cost. In each case, staff used the California average (mean) labor rate of a representative job category from the U.S. Bureau of Labor Statistics (U.S. BLS) for 2023 (U.S. BLS, 2025). These labor rates were increased to account for wages and benefits by dividing the wage-only rate reported by U.S. BLS by 0.701.[6] The resulting labor rates that were used throughout this analysis are as follows:

- Administrative:[7] $43.39/hr
- Technician (civil engineering technician):[8] $64.36/hr
- Engineering (civil engineer):[9] $93.65/hr

[6] 0.701 is the private sector share of employer costs attributable to wages and salaries (U.S. BLS, 2026).

[7] California average (mean) labor rate for the job title "Secretaries and Administrative Assistants, Except Legal, Medical, and Executive" including benefits.

[8] California average (mean) labor rate for the job title "Civil Engineering Technologists and Technicians" including benefits.

[9] California average (mean) labor rate for the job title "Civil Engineers" including benefits.

- Geological Technician:[10] $62.46/hr
- Geologist (mining and geological engineer):[11] $107.61/hr
- Lawyer:[12] $173.00/hr
- Web Developer:[13] $92.43/hr
- Annual Reports to regulators and recordkeeping for all data gathering activities labor rate:[14] $173.47/hr
- Interpreter:[15] $59.26/hr

D. Capital Recovery Factor

One-time capital costs in this provision and others under Alternative 2 are amortized into annual costs to reflect that businesses generally do not pay the total cost up front and to allow annual cost to be compared to annual emission reductions. One-time costs are amortized using the Capital Recovery Factor (CRF), as defined in the following equation:

Equation 1 :

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

where,
CRF is the Capital Recovery Factor
i is the discount rate; 0.05 (assumed to be 5%)
n is the five-year time horizon

The 5% discount rate was chosen because it is the average of what the United States Office of Management and Budget (OMB) recommends (OMB 2003; three and seven percent) and what U.S. EPA has used historically for regulatory analyses. Evaluating Equation 1 results in a CRF of 0.231 which is used in this analysis to amortize the costs of capital equipment.

E. Geologic Carbon Storage Cost Assumptions

Staff developed parameters for an average GCS site from which to base capital and operating costs to operators/owners. The average GCS site is assumed to include four injection well

[10] California average (mean) labor rate for the job title “Geological Technicians, Except Hydrologic Technicians” including benefits.
[11] California average (mean) labor rate for the job title “Mining and Geological Engineers, Including Mining Safety Engineers” including benefits.
[12] California average (mean) labor rate for the job title “Lawyers” including benefits.
[13] California average (mean) labor rate for the job title “Web Developers” including benefits.
[14] Based on EPA Underground Injection Control (UIC) Cost Analysis labor cost for recordkeeping adjusted to 2025$ (U.S. EPA–OWP, 2010).
[15] California average (mean) labor rate for the job title “Interpreters” including benefits.

heads[16] and injection is assumed to occur for a duration of 33 years, based on the data for GCS sites in the U.S. EPA Class VI permitting queue as of July 2026 (U.S. EPA, 2026).[17]

F. Rounding

Throughout this analysis, the values shown in this appendix are rounded; however, the underlying calculations were generally performed without rounding. Therefore, if a reader attempts to reproduce the calculations of this analysis using rounded intermediate values shown in this appendix, it may produce slightly different results.

IV. Cost Data and Calculations by Provision for the Proposed Regulation

A. General Project Disclosure for Carbon Capture, CDR, and GCS Project Operators

The Proposed Regulation requires carbon capture, CDR projects, and GCS site operators to create a data information listing on a public-facing webpage that hosts project monitoring plans and up-to-date compliance status information. Reported information would include permitting activities and obligations and general project information. For GCS sites, operators must also post an air pollutant, air mitigation, and surface CO_2 monitoring plan; annual summaries for air monitoring activities; subsurface CO_2 plume and pressure monitoring plan; baseline, operational, and post-injection seismic monitoring plans; and the Emergency Remedial Response Plan (ERRP).

Staff estimated that operators will need a total of 88 labor hours to complete the initial posting of all required information. This estimate assumes an equal split between a web developer, who builds the webpage, and a civil engineer, who provides and reviews the technical content. Staff also assume an administrative worker provides support for required disclosures. The 44-hour labor burden per role is based on the U.S. EPA Cost Analysis for the Final GCS Rule, which evaluated annual reporting and recordkeeping needs for GCS sites (U.S. EPA, 2010).

For subsequent years, staff conservatively estimated 44 hours of civil engineer and 44 hours of administrative worker labor time for annual updates. This results in a first-year estimated disclosure cost of $14,200 ($93.65/hr x 44 hours + $92.43/hr x 44 hours + $43.39/hr x 44 hours) and an ongoing annual estimated cost of $6,000 ($93.65/hr x 44 hours + $43.39/hr x 44 hours) for each carbon capture, CDR project, and CDR site operator subject to these requirements.

[16] Average number of U.S. EPA Class VI wells within GCS sites located in California (U.S. EPA, 2026).

[17] Staff assumption based on average U.S. EPA Class VI permit reported sequestration potential of GCS facilities of 38.9 $MMTCO_2$ divided by an annual injection rate of 1.2 $MMTCO_2$ per year (U.S. EPA, 2026).

B. Subsurface Plume and Pressure Monitoring

Under this Proposed Regulation GCS operators would need to meet the requirements for plume and pressure tracking under U.S. EPA's Class VI well regulations. Because GCS operators will already be operating under the U.S. EPA Class VI permit, they would not need to drill additional monitoring wells to comply with the plume tracking requirements under the Proposed Regulation. The only additional compliance responses under the Proposed Regulation involve planning, publishing the monitoring plan, and ensuring no leakage out of the storage complex during the post-injection.[18] The proposed requirements would not result in any physical construction, equipment installation, or other on-site compliance actions. As a result, the only compliance responses associated with this provision relate to the preparing and updating plans.

Staff also estimated costs for evaluation and documentation requirements. Staff assumed that 110 labor hours in the first year and 20 labor hours annually thereafter for evaluation and documentation, split evenly between an administrative worker and a geological engineer. These labor needs result in first-year estimated costs of $8,300 ($43.39/hr x 55 hours + $107.61 x 55 hours) and annual recurring costs of $1,500 ($43.39/hr x 10 hours + $107.61 x 10 hours). Staff also included annual recordkeeping estimated costs of $7,600 ($173.37 x 44 hours) for subsurface plume and pressure monitoring, based on the 44-hour labor estimate and cost assumptions from the U.S. EPA Cost Analysis for the Final GCS Rule (U.S. EPA, 2010).

The Proposed Regulation extends the subsurface and plume tracking requirements for an additional 50 years after the U.S. EPA Class VI requirements end. Therefore, associated equipment costs are not included in the total cost estimates for the Proposed Regulation because they occur outside the six-year economic analysis period.

C. Surface and Near Surface CO_2 Monitoring

Air Pollutant Monitoring

To meet the air pollutant monitoring requirements of the Proposed Project, GCS operators may need to install at least one air pollutant monitoring station at the GCS site. More than one monitoring station could be required if sensitive receptors are identified downwind of the project that could be impacted by project activities. A typical air pollutant monitoring station would include a carbon monoxide (CO) analyzer, a nitrogen dioxide (NO_x) analyzer, a sulfur dioxide (SO_2) analyzer, an ozone (O_3) analyzer, a particulate matter ($PM_{2.5}$) analyzer, a hydrogen sulfide (H_2S) analyzer, a power source (e.g., solar panels), a data logger, and a system capable of transmitting data to a centralized repository. The exact equipment configuration would depend on the pollutants being measured and the instrumentation

[18] GCS operators that receive U.S. EPA Regional Director approval for an alternative post-injection site care timeframe may still be required to reinstate or continue CO_2 plume monitoring and pressure tracking if there is evidence of leakage occurring during the 100 years post-injection.

selected by the operator. Generally, an air pollutant monitoring station can be housed in a temperature-controlled enclosure or installed on a standalone pole or bracket. Additionally, GCS operators would be required to develop an air mitigation plan and implement minimization strategies on air quality impacts identified.

Based on the rulemaking performance parameters, as shown in Table C-2, staff assumed a standard air monitoring station would include a CO analyzer, NO_x analyzer, SO_2 analyzer, O_3 analyzer, $PM_{2.5}$ analyzer, H_2S analyzer, a power source (e.g., solar panels), a data logger, and equipment to transmit data to a central repository (CARB, 2025f; Kern County CTV1 EIR, 2024).

Stations may be mounted on existing infrastructure or installed on a standalone pole or bracket. GCS operators would also need to install meteorological monitoring equipment since meteorological data are essential for supporting air pollution quality assurance and interpreting local dispersion patterns.

Staff assumed that each GCS site will have one air pollutant monitoring station located at the GCS site. The upfront (non-amortized) equipment cost was estimated to be $130,200 (Table C-2). When annualized over five years using the Capital Recovery Factor (Equation 1), this results in a total amortized estimated cost of $147,400 or $29,500 annually. Annual calibration and maintenance costs were estimated to be $42,300 and $300 respectively.

Staff estimated 110 labor hours in the first year and 20 labor hours annually thereafter for evaluation and documentation, split evenly between an administrative worker and a geological engineer. These labor needs result in first-year estimated costs of $8,300 and recurring estimated annual costs of $1,500. Staff also estimated annual recordkeeping costs of $7,600 for air pollutant monitoring, based on the 44-hour labor estimate and cost assumptions from the U.S. EPA Cost Analysis for the Final GCS Rule.

Table C-2. Estimated Equipment Costs for a Single Air Pollutant Monitoring Station

Air Pollutant Monitoring Equipment	**First Year Cost**
CO analyzer - equipment	$20,090.00
CO analyzer - calibration	$5,459.24
NO_x analyzer - equipment	$28,754.00
NO_x analyzer - calibration	$7,047.55
SO_2 analyzer - equipment	$20,311.00
SO_2 analyzer - calibration	$7,467.28
O_3 analyzer - equipment	$17,051.00
O_3 analyzer - calibration	$4,077.41
$PM_{2.5}$ - equipment	$34,520.00
$PM_{2.5}$ - calibration	$15,690.91
H_2S analyzer - equipment	$8,195.82
H_2S analyzer - calibration	$2,586.86
Data transmitter	$318.24
Data receiver	$364.74
Weather Station	$2,041.00
Solar Panel	$570.00
Total	***$130,174.80***

Surface CO_2 Monitoring

To meet the surface and near surface CO_2 monitoring requirements of the Proposed Regulation, GCS operators would need to install monitoring stations at certain legacy wells,

fault zones, and injection well pads throughout the GCS site. Based on the rulemaking performance parameters, staff assumed a standard CO_2 monitoring station would include a CO_2 analyzer, a power source (e.g., solar panels), a data logger, and equipment to transmit data to a central repository (CARB, 2025f). Stations may be mounted on existing infrastructure or installed on a standalone pole or bracket.

GCS operators would also need to install meteorological monitoring equipment since meteorological data are essential for supporting CO_2 measurement quality assurance and interpreting local dispersion patterns.

Staff assumed that surface and near surface CO_2 monitoring would occur at each of the four injection wellheads at the GCS site (U.S. EPA 2026). The upfront (non-amortized) equipment cost was estimated to be $41,900 (Table C-3). When annualized over five years using the Capital Recovery Factor (Equation 1), this results in a total amortized cost of $47,400, or $9,500 annually. Annual calibration and maintenance costs were estimated to be $2,900 and $1,000, respectively.

Table C-3. Estimated Equipment Costs for a Single Surface Monitoring Station

Surface Monitoring Equipment	**First Year Cost**
CO_2 analyzer - equipment	$7,180.00
CO_2 analyzer - calibration	$354.00
CO_2 analyzer - Data transmitter	$318.24
CO_2 analyzer - Data receiver	$364.74
Weather Station	$2,041.00
Solar Panel	$570.00
Total	***$10,473.98***

Staff also estimated costs for evaluation and documentation requirements. Staff assumed that 110 labor hours in the first year and 20 labor hours annually thereafter for evaluation and documentation, split evenly between an administrative worker and a geological engineer. These labor needs result in first-year estimated costs of $8,300 ($43.39/hr x 55 hours + $107.61 x 55 hours) and annual recurring costs of $1,500 ($43.39/hr x 10 hours + $107.61 x 10 hours). Additionally, staff included annual recordkeeping estimated costs of $7,600 ($173.37 x 44 hours) for surface and near surface CO_2 monitoring, based on the 44-hour labor estimate and cost assumptions from the U.S. EPA Cost Analysis for the Final GCS Rule (U.S. EPA, 2010).

D. Baseline Seismic Monitoring

The Proposed Regulation requires GCS operators to establish a seismic monitoring array capable of monitoring within and around the surface projection of the storage complex. Using that seismic array, GCS operators are required to develop and publicly disclose a baseline monitoring plan, perform a site-based seismic risk assessment to inform the thresholds of a Traffic Light System, and characterize the resulting background seismic data.

To comply with the Proposed Regulation, GCS operators may need to install new seismic monitoring wells and associated supporting infrastructure. A typical seismic monitoring network includes solar and battery powered seismic sensors (e.g., seismometers or accelerometers) installed in deep boreholes and near-surface post-holes. Deep borehole monitoring involves installing a down-borehole sensor, which may involve drilling a new borehole several hundred feet. Near-surface monitoring involves excavating a post-hole between 1.5 and 60 feet deep and installing a concrete instrument enclosure to house the monitoring equipment.

Staff assume that a representative GCS site would require an average of six newly drilled seismic stations installed at various depths to comply with the Proposed Regulation (CGS, 2026).[19] To account for differences in geology and site conditions, staff developed high- and low-depth scenarios for borehole drilling as displayed in Table C-4. The high-depth scenario includes one near-surface seismic sensor and the remaining five installed at 1,000 feet, while the low-depth scenario also includes one near-surface sensor but places the remaining five at 300 feet.

Table C-4. Borehole Depth Scenario for Seismic Sensor Placement

Scenario	**Number of 50ft boreholes**	**Number of 300ft boreholes**	**Number of 1,000ft boreholes**
High Scenario – deep borehole placement	1	0	5
Low Scenario – shallow borehole placement	1	5	0

The cost of near-surface post-hole drilling includes hollow stem auger drilling—typically used for shallow, unconsolidated sediments—which generally requires a two-person crew. The cost of deep borehole drilling includes mud rotary drilling—preferred for deeper wells—typically requires an operator and two support staff and provides effective fluid management through groundwater zones (CGS, 2026). Table C-5 includes representative equipment, maintenance,

[19] California Geological Survey (CGS) provided this assumption to CARB staff (CGS, 2026). The assumption is supported by existing GCS sites (U.S. EPA, 2026).

and labor costs from a California contractor. Labor costs include labor per diem and travel costs to the drilling site. These estimates vary significantly depending on project conditions, materials, unexpected operational issues, and contractor rates.

Table C-5. Borehole Depth Drilling Labor and Equipment Costs

Category	**Cost of 50ft boreholes (2025$)**	**Cost of 300ft boreholes (2025$)**	**Cost of 1,000ft boreholes (2025$)**
Equipment and materials	$4,300	$16,500	$76,200
Labor	$2,500	$6,400	$6,900
Total	***$6,800***	***$22,900***	***$83,100***

Based on these inputs, staff estimated average costs for borehole drilling across the high- and low-depth scenarios to be $236,200 and average materials and labor costs to be $34,500 per GCS site. These costs were amortized and included in the seismic monitoring equipment costs.

The upfront (non-amortized) drilling labor and equipment and seismic equipment and installation cost was estimated to be $417,600 (Table C-5 and Table C-6). When annualized over five years using the Capital Recovery Factor (Equation 1), this results in a total amortized cost of $472,900, or $94,600 annually. Annual calibration and maintenance are estimated at $19,800, with an additional $12,000 per year for software and server maintenance for the seismic network, and $3,600 per year for communications needed to transmit real-time seismic data.

Table C-6. Estimated Equipment and Installation Costs for a Single Seismic Monitor (totals are rounded)

Seismic Monitoring Equipment	**First Year Cost** [20]
Seismic Sensor + Data Logger	$11,000.00
Sensor Cable	$10,080.00
Modem	$619.00
Charge Controller	$298.00
Battery	$360.00
Solar Panel	$95.00
Labor	$2,040.00
Total	***$24,500.00***

Staff also estimated costs for evaluation and documentation requirements. Staff assumed that 110 labor hours in the first year and 20 labor hours annually thereafter for evaluation and documentation, split evenly between an administrative worker and a geological engineer. These labor needs result in first-year estimated costs of $8,300 ($43.39/hr x 55 hours + $107.61 x 55 hours) and annual recurring estimated costs of $1,500 ($43.39/hr x 10 hours + $107.61 x 10 hours) for the baseline monitoring phase. Staff also assumed that additional analyses such as the site characterization, seismic risk assessment (including identification of plausible risks and development of the Traffic Light System), and summary data evaluation would each require an additional $8,300 ($43.39/hr x 55 hours + $107.61 x 55 hours) in evaluation and documentation labor costs.

Finally, staff also included annual estimated recordkeeping costs of $7,600 ($173.37 x 44 hours) for seismic monitoring, based on a 44-hour labor estimate and cost assumptions from the U.S. EPA Cost Analysis for the Final GCS Rule (U.S. EPA, 2010).

E. Operational Seismic Monitoring

The operational phase covers the period during which CO_2 injection is actively occurring at the GCS site. During injection, GCS operators would need to analyze seismic monitoring and operational data (e.g., injection rate, down-hole pressure) to determine if injection activities are

[20] Seismic equipment costs provided to CARB staff by CGS (CGS, 2026).

causing induced seismicity. GCS operators would also be required to analyze monitoring data and prepare annual summaries that will be disclosed biennially and retained for at least 10 years.

Seismic monitoring equipment costs are assumed to be incurred during the initial operating years (i.e., four years following the baseline monitoring year) and again at 15-year replacement intervals, consistent with amortized costs included in the baseline monitoring phase. Annual replacement battery costs are estimated at $300 (CGS, 2026). Annual equipment calibration and maintenance are estimated at $19,800, with an additional $12,000 per year for software and server maintenance and $3,600 per year for real-time seismic data communications (CGS, 2026).

Staff also estimated costs for evaluation and documentation requirements. Staff assumed that 110 labor hours in the first year and 20 labor hours annually thereafter for evaluation and documentation, split evenly between an administrative worker and a geological engineer. This results in first-year estimated operational costs of $8,300 ($43.39/hr x 55 hours + $107.61 x 55 hours) and annual recurring costs of $1,500 ($43.39/hr x 10 hours + $107.61 x 10 hours). Additional analyses required during the operational phase, such as evaluating monitoring and operational data, and summarizing those results, each adds an additional $8,300 in first-year estimated operational phase labor and $1,500 annually thereafter.

F. Post-Injection Seismic Monitoring

Once CO_2 injection ceases, the post-injection phase begins. During this phase, GCS operators would be required to conduct continuous seismic monitoring until they receive approval for an alternative post-injection timeframe by the U.S. EPA Director. Once proof of U.S. EPA-approval for site closure is provided to CARB, GCS operators would be able to apply for a full or partial retirement of their seismic array. If CARB approves a full or partial retirement of the seismic array, the GCS operator would maintain their connection to the California Integrated Seismic Network (CISN) and continue preparing seismic monitoring summaries every five years and incidental reports until site closure.[21,22]

Staff also estimated costs for evaluation and documentation requirements. Staff assumed that 110 labor hours in the first year and 20 labor hours annually thereafter for evaluation and documentation, split evenly between an administrative worker and a geological engineer. This results in first-year estimated post-injection phase costs of $8,300 and recurring costs of $1,500. Staff assumed additional analyses will further increase labor cost, and therefore include an additional $8,300 in evaluation and documentation costs for each of the following: updates to seismic monitoring design and implementation to meet monitoring duration requirements, continuous collection and evaluation of seismic data, annual summaries of

[21] Site closure may be declared 100 years after the final day of injection, provided there is evidence that the stored CO_2 no longer poses a threat to public health or the environment.

[22] During the post-injection phase, GCS operators may need to reinstate their seismic monitoring system if a Traffic Light System threshold yellow-light is triggered.

post-injection monitoring results, and reevaluation of the post-injection seismic monitoring plan when key elements change.

Additionally, staff included annual recordkeeping estimated costs of $7,600 for post-injection seismic monitoring, based on the 44-hour estimate and cost assumptions from the U.S. EPA Cost Analysis for the Final GCS Rule (U.S. EPA, 2010).

However, these post-injection costs are not included in the total cost estimates for the Proposed Regulation because they are not expected to occur within the six-year economic analysis period.

G. GCS Emergency Remedial Response Plan

Under U.S. EPA's Class VI regulations, permitted storage projects must already develop Emergency Remedial Response Plans (ERRP) that include notification procedures and remedial actions that address any movement of the injection or formation fluids that could endanger an Underground Source of Drinking Water (USDW) during construction, operation, and post-injection site care.[23] These ERRP requirements apply from construction phase of a geologic project through up to 50 years after injection has ceased (i.e., post-injection phase). Under the Proposed Regulation, GCS operators would need to include in those ERRP seismicity-related risks and extend responsibilities to cover the full 100-year post-injection phase. GCS operators would also need to provide additional notification and reporting anytime the ERRP is triggered.

Staff also estimated costs for evaluation and documentation requirements. Staff assumed that 110 labor hours in the first year and 20 labor hours annually thereafter for evaluation and documentation, split evenly between an administrative worker and a geological engineer. This results in first-year estimated costs of $8,300 and recurring annual costs of $1,500. Staff also expect additional required analyses to increase labor needs. Accordingly, staff included an additional $8,300 in evaluation and documentation costs for each of the following: developing a Traffic Light System (TLS) to manage seismicity and related risks through the end of the post-injection monitoring phase; establishing detailed procedures and remedial actions for confirmed or suspected CO_2 releases; and providing notification and reporting details in the event the ERRP is triggered.

H. Financial Responsibility for GCS sites

Under U.S. EPA's Class VI regulations, permitted storage projects must meet financial responsibility provisions that include covering cost for corrective action, well plugging and abandonment, post-injection site care (PISC), and emergency remedial response plans.[24] These financial responsibility provisions apply from the start of permit issuance up to 50 years

[23] 40 C.F.R. § 146.94 (UIC-ERR, 2010).
[24] 40 C.F.R. § 146 (UIC-CS, 2010).

during the post-injection phase. Under the Proposed Regulation, GCS operators would need to expand coverage to incorporate additional air pollution and surface CO_2 monitoring for a minimum of 50 years, as well as additional seismic monitoring and extended ERRP coverage for 100 years post-injection.

Compliance activities under this section would require GCS operators to submit a financial plan attesting that they have expanded coverage sufficiently to ensure completion of additional monitoring and emergency preparedness. For at least 100 years after injection ends, operators would be required to continue performing annual cost adjustment estimates as required by U.S. EPA Class VI, report changes in financial coverage to CARB and notify CARB if adverse financial conditions occur, such as bankruptcy, or a change in ownership.

Staff estimated annual financial responsibility costs by extrapolating reported PISC cost estimates from GCS sites currently in the U.S. EPA Class VI permitting queue (CTV1, 2023; CTV IV, 2023; Montezuma Carbon LLC, 2023; Pelican Renewables LLCS, 2023). Using data from 12 projects under review and one approved project, staff calculated annualized PISC costs by dividing each project's reported PISC cost by its PISC duration. Staff then averaged these annualized values and applied the 50-year compliance period to estimate costs for GCS operators in California (i.e., average annual PISC cost x 50-year compliance period). Based on this method, staff estimated total average PISC costs at $10.1 million per project.

Financial responsibility costs associated with air pollutant and surface CO_2 and seismic monitoring were based on the recurring annual equipment, operations, and maintenance costs described in those sections. The costs for air pollution and surface CO_2 monitoring were annualized over the required 50-year post-injection monitoring period yielding total average estimated costs of $4.3 million per GCS site. The costs for seismic monitoring were annualized over the 100-year period post-injection monitoring period, yielding total average estimated costs of $5.8 million for seismic monitoring per GCS site.

Emergency and Remedial Response (ERR) coverage costs for seismic events were assumed to match existing ERR financial responsibility requirements under U.S. EPA Class VI, including activities such as well plugging in the event of CO_2 leakage The total average ERR cost over the 50-year period was estimated at $10.1 million per project.

U.S. EPA's UIC Program estimates that securing or maintaining financial instruments typically costs between 0.5 and 2 percent of the total instrument amount, excluding collateral or deposits (U.S. EPA, 2010). Staff applied a rate of 1.5 percent to the compliance cost totals (PISC, seismic monitoring, air pollution and surface CO_2 monitoring, and ERR coverage) to estimate annual financial responsibility costs, assuming payments begin at the start of injection and that operators have sufficient financial strength to avoid significant collateral requirements.

Based on these assumptions, annual financial responsibility costs for GCS operators is $454,300 consisting of the following:

- $152,100 per year for the PISC period
- $63,800 per year for surface and near surface CO_2 monitoring coverage
- $87,500 per year for seismic monitoring coverage
  $150,900 per year for seismic coverage under the ERRP

Project management costs were estimated to require 24 hours of legal attorney work resulting in costs of $16,600 per year per GCS site. These costs were based on the 12-hour estimate and cost assumptions from the U.S. EPA Cost Analysis for the Final GCS Rule which Staff doubled to account for increased financial responsibility requirements in the Proposed Rulemaking (U.S. EPA, 2010).

I. Legal Instruments for Proof of Agreement

To meet the requirements of the Proposed Regulation, GCS operators would need to obtain a legal agreement prohibiting drilling or extraction which could penetrate the storage complex of the GCS site with all relevant parties and submit the agreement to CARB. Subsequently, operators would need to comply with the agreement's prohibition for at least 100 years after the last date of injection, and until it has been determined there is no threat to public health or the environment through risk of CO_2 leakage to the atmosphere. Activities under this provision involve preparing and submitting legal agreements to CARB and maintaining the long-term prohibition on drilling or extraction activities.

Staff estimated that preparing and submitting the required legal agreements will require 100 hours of legal support, resulting in costs of $17,300 per GCS site.

J. Community Communication

The Proposed Regulation would require GCS operators to inform communities through direct communications of project development milestones and project operations.

Reasonably foreseeable activities include planning, outreach, and community engagement. Most activities are administrative; however, community engagement could result in additional mitigation measures at project sites. Because the scope and nature of any potential mitigation are unknown, their economic impacts cannot be evaluated at this time.

Staff assumed 12 hours of labor time (including travel) for an administrative staff member and an engineer to attend the meeting, along with costs of the venue and equipment at $400 per hour. The estimated cost for one eight-hour workshops is $7,200 (i.e., [$400/hour x 8 hour x 1 event per site] + (12 x labor wages)]. Recordkeeping and reporting are assumed to be included in staff labor time for Carbon Capture, CDR Projects, and GCS sites. Staff anticipate community engagement costs to be fulfilled after 2033 when the impacted community has peaked (i.e., no new projects).

V. Cost Data and Calculations for Alternatives to the Proposed Regulation

A. Alternative 1

Alternative 1 is a less stringent version of Section 95704.2 of the Proposed Regulation, which establishes surface and near surface CO_2 monitoring requirements for GCS sites. Specifically, under this scenario, GCS operators would be required to install stationary CO_2 monitoring

stations at one location upwind and one location downwind of the surface projection of the storage complex. That is, only two monitoring stations are required under Alternative 1. The costs of Alternative 1 are the costs of the Proposed Regulation less the cost of the two additional surface CO_2 monitoring stations, resulting in annual cost reductions compared to the Proposed Regulation of $14,700 per GCS site.

This results in six-year cost reductions compared to the Proposed Regulation of $969,400. Thus, the total estimated six-year cost of Alternative 1 is $57.3 million.

B. Alternative 2

Alternative 2 is a more stringent version of Section 95704.2. In addition to meeting the stationary monitoring requirements outlined in Section 95704.2(a), operators would conduct quarterly surface emissions monitoring (SEM). The costs of Alternative 2 are the costs of the Proposed Regulation plus additional costs for SEM at the surface projection of the GCS storage complex. The costs of the additional SEM procedures are estimated as $35,284 per GCS site per year (i.e., 8,772 acres x $16.09/acre x 4 quarterly events per year x 6.25% of the surface projection of the storage complex). The average total surface projection of the storage complex with quarterly SEM is estimated to be 8,772 acres based on active and planned GCS site disclosed information (U.S. EPA, 2017). Staff assume annual coverage of 25% of the surface projection via SEM per year such that 100% of the surface projection is monitored every four years. SEM monitoring time per acre per event at 25 ft spacing for an engineering technician is estimated to cost $16.09 per acre derived from the CARB Landfill Methane Regulation cost analysis (CARB, 2025d).

This results in additional six-year costs of $2.3 million. The total estimated six-year cost of Alternative 2 (including the costs of the Proposed Regulation) is therefore $60.6 million.

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