Detailed Comments on the Carbon Capture and Sequestration Protocol Under the Low Carbon Fuel Standard

Protocol section	Current text	Proposed revision	Comment
3(27)	"CO2 stream" means CO2 that has been captured from an emission source (e.g., a power plant), plus incidental associated substances derived from the source materials and the capture process, and any substances added to the stream to enable or improve the injection process.	"CO2 stream" means CO2 that has been captured from an emission source (e.g., a power plant), plus incidental associated substances derived from the source materials and the capture process, and any substances added to the stream to enable or improve the injection process or EOR production.	The definition should recognize that there may be substances added to a CO_2 stream in the context of CO_2-EOR that are added to the stream to enable or improve the production of oil.
3(99)	"Site closure" means the point or date, after at least 100 years and as determined by the Executive Officer following the requirements under subsection C.5.2, at which point the CCS Project Operator is released from post-injection site care responsibilities.	"Site closure" means the point or date, ~~after at least 100 years and as~~ determined by the Executive Officer following the requirements under subsection C.5.2, at which point the CCS Project Operator is released from post-injection site care responsibilities.	As explained further in the cover letter to these comments, the requirement for a minimum of 100 years from the cessation of CO_2 injection to the achievement of site closure does not make sense and is at odds with every other existing and recommended regulatory framework for CCS.
C.2.2(d)	Risk scenarios identified as part of this assessment must be classified according to probability of occurrence during a 100-year period (see Table 1, below).	Risk scenarios identified as part of this assessment must be classified according to probability of occurrence during a 100-year period (see Table 2~~1~~, below).	Make correction to change the Table reference from Table 1 to Table 2.
C.2.4.2(d)(5)	Model results must be presented in contour maps, cross sections, and/or graphs showing plume and pressure front migration as a function of time, and that the application for Sequestration Site Certification submittal must include the outcome	Model results must be presented in contour maps, cross sections, and/or graphs showing plume and pressure front migration as a function of time, and ~~that~~ the application for Sequestration Site Certification submittal must include the outcome	Delete "that" as shown to correct a typo. As currently written, the sentence is ungrammatical and does not make sense.

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	of parameter sensitivity analysis and model calibration.	of parameter sensitivity analysis and model calibration.	
C.2.4.3(d)	Prior to CCS Project Certification, CCS Project Operators must perform corrective action on all wells within the delineated AOR that require corrective action.	Prior to CCS Project Certification, CCS Project Operators must implement the corrective action plan and perform corrective action on all wells within the delineated AOR that require corrective action prior to CO_2 plume and pressure front movement into the area where the wells are located.	The final protocol should allow a phased approach to corrective action as USEPA has done in its Class VI rule (40 CFR 146.84(b)(2)(iv)). As USEPA noted in the preamble to the final rule: "Due to the anticipated large size of the AoR for Class VI wells, EPA proposed allowing owners or operators to conduct corrective action on a phased basis during the lifetime of the project, at the discretion of the Director. In these cases, corrective action would not need to be conducted throughout the entire AoR prior to injection. Corrective action would only be necessary in areas near the injection well with a high certainty of CO_2 exposure during the first years of injection as informed by site-characterization data and model predictions. Artificial penetrations in areas farther from the injection well would be addressed after injection has commenced, but prior to CO_2 plume and pressure front movement into that area." USEPA retained the option of phased corrective action in the final rule, and that approach should be used in the final protocol as well for the

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			same reasons.
C.2.5(a)	The CCS Project Operator must submit a Baseline Testing Plan with the application for Sequestration Site Certification.	The CCS Project Operator must submit ~~a Baseline Testing Plan~~ with the application for Sequestration Site Certification a monitoring strategy and plan to address surface, near-surface, and deep subsurface for CO2 leakage that may endanger public health or the environment.	The final protocol should not dictate the specific monitoring approach and methods used to address surface, near-surface, and deep subsurface for CO2 leakage that may endanger public health or the environment. Research has shown that collecting baseline and background data for comparison with future collected data may not be the most effective approach. What is most important is to have an effective strategy and approach for determining whether observed CO_2 is attributable to the CO_2 sequestration operation. There are a number of ways this can be done effectively, and some of those would avoid the expense and intrusiveness of elaborate monitoring arrays such as those that have failed to collect meaningful data from numerous pilot and demonstration projects to date.
C.2.5(d)	Baseline data on CO2 concentrations and fluxes collected prior to operation must be used for history matching and comparison to levels during and after the operational phase of the CCS project to detect any CO2 leakage to the deep subsurface, shallow	Baseline data on CO2 concentrations and fluxes collected prior to operation ~~must~~ may be used for history matching and comparison to levels during and after the operational phase of the CCS project to detect any CO2 leakage to the deep subsurface, shallow subsurface, and surface or	This should not be the only acceptable approach, as noted in the comment immediately above.

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	subsurface, and surface or atmosphere.	atmosphere.	
C.2.5(f)(2)	For soil and air sampling, the spatial distribution of soil CO2 fluxes and concentrations must be determined on a site-specific basis, but requires, at a minimum, repeat measurements at several fixed sites, and over a period of one year, to capture any seasonal or diurnal variations. CCS Project Operators must plan the location of soil gas and surface air sampling points based on the following considerations:	For any soil and air sampling, the ~~spatial distribution of soil CO_2 fluxes and concentrations must be determined on a site-specific basis, but requires, at a minimum, repeat measurements at several fixed sites, and over a period of one year, to capture any seasonal or diurnal variations.~~ CCS Project Operators must plan the location of soil gas and surface air sampling points based on the following considerations:	The provision in C.2.5(f)(1) is sufficient as a requirement because it dictates reliance on the site-specific risk assessment and the use of a site-specific approach. The specific approach of examining potentially irrelevant CO_2 fluxes should not be dictated. Nevertheless, directing careful location of any monitoring arrays and sampling points used is sensible.
C.2.5(g)(1)	The CCS Project Operator must submit a descriptive report of baseline monitoring data and interpretations with the application for CCS Project Certification. The report must include surface air or soil gas analyses, and CCS Project Operators must submit, at a minimum, the following: (A) Site characteristics (e.g. soil type, soil organic carbon content, vegetation type and density, topography, surface water hydrology); (B) Sampling locations (in map form) and dates sampled;	The CCS Project Operator must submit a descriptive report of ~~baseline~~ monitoring strategy, data collection, and corresponding interpretations with the application for CCS Project Certification. ~~The report must include surface air or soil gas analyses, and CCS Project Operators must submit, at a minimum, the following:~~ ~~(A) Site characteristics (e.g. soil type, soil organic carbon content, vegetation type and density, topography, surface water hydrology);~~ ~~(B) Sampling locations (in map form)~~	The final protocol should not dictate the specific monitoring approach and methods used to address surface, near-surface, and deep subsurface for CO2 leakage that may endanger public health or the environment. Research has shown that collecting baseline and background data for comparison with future collected data may not be the most effective approach. What is most important is to have an effective strategy and approach for determining whether observed CO_2 is attributable to the CO_2 sequestration operation. There are a number of ways this can be done effectively, and some of those

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	(C) Atmospheric conditions; (D) Sampling and analytical methods, including detection limits; (E) Results presented as concentrations and fluxes in tabular and graphic form, including quality assurance (QA) samples and analyses; (F) Methods and results of regression analyses; and (G) Methods and results of any ecological modeling or sensitivity analysis performed, including input data and outputs. (h) The CCS Project Operator must demonstrate that the locations sampled represent a reasonable grid size and that potential point sources are represented and will serve as a good baseline to compare to future monitoring data. The CCS Project Operator must also demonstrate that seasonal and diurnal variations in CO2 levels have been captured and describe the variability in the data for future reference. If an inadequate time series of analyses was performed or if there are concerns regarding the quality of analytical data, the CCS Project Operator may need to collect and	~~and dates sampled;~~ ~~(C) Atmospheric conditions;~~ ~~(D) Sampling and analytical methods, including detection limits;~~ ~~(E) Results presented as concentrations and fluxes in tabular and graphic form, including quality assurance (QA) samples and analyses;~~ ~~(F) Methods and results of regression analyses; and~~ ~~(G) Methods and results of any ecological modeling or sensitivity analysis performed, including input data and outputs.~~ ~~(h) The CCS Project Operator must demonstrate that the locations sampled represent a reasonable grid size and that potential point sources are represented and will serve as a good baseline to compare to future monitoring data. The CCS Project Operator must also demonstrate that seasonal and diurnal variations in CO2 levels have been captured and describe the variability in the data for future reference. If an inadequate time series of analyses was performed or if there are concerns regarding the quality of analytical data, the CCS Project Operator may need to collect~~	would avoid the expense and intrusiveness of elaborate monitoring arrays such as those that have failed to collect meaningful data from numerous pilot and demonstration projects to date.

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	submit additional data.	~~and submit additional data.~~	
C.3.1(c)(4)	The integrity and location of the cement must be verified using technology capable of (1) evaluating cement quality radially and (2) identifying the location of channels to ensure the likelihood of an unintended release of CO2 from the sequestration zone above the storage complex is not likely.	The integrity and location of the cement must be verified using technology capable of (1) evaluating cement quality radially and (2) identifying the location of channels to ensure ~~the likelihood of~~ that an unintended release of CO2 from the sequestration zone above the storage complex is not likely.	There is an error in the current language. The suggested revision would cure the error, as would a change to say "ensure **against** the likelihood" while deleting "is not likely" at the end of the sentence.
C.3.3.(b)	The CCS Project Operator must ensure that injection pressure does not exceed 80 percent of the fracture/parting pressure of the sequestration zone so as to ensure that injection does not initiate or propagate existing fractures in the sequestration zone. In no case may injection pressure initiate fractures in the confining layer, or cause movement of the injection or formation fluids out of authorized zones.	The CCS Project Operator must ensure that injection pressure does not exceed 80 percent of the fracture/parting pressure of the sequestration zone so as to ensure that injection does not initiate or propagate existing fractures in the sequestration zone. In no case may injection pressure initiate fractures in the confining layer, or cause movement of the injection or formation fluids out of authorized zones.	The use of an 80 percent limit is arbitrary and will serve to unnecessarily limit projects that could be extremely effective in mitigating GHG emissions. All that is necessary is a limit that precludes injection pressures that could create fracture pathways through the confining layers. USEPA uses 90 percent, but even that is arbitrary. If a limit is imposed, there should also be an alternative for demonstrating that a project can rely on alternative means for ensuring that injection does not initiate or propagate existing fractures that would create pathways out of the sequestration zone.
	The CCS Project Operator must perform continuous and intermittent geochemical monitoring of the soil and vadose zone, including	The CCS Project Operator must ~~perform continuous and intermittent geochemical monitoring of the soil and vadose zone, including sampling~~	The final protocol should not dictate the specific monitoring approach and methods used to address surface, near-surface, and deep subsurface for CO2

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	sampling of CO2, natural chemical tracers, and introduced tracers, in order to detect potential releases from wellbores, faults, and other migration pathways, and must consider the following methods:	~~of CO2, natural chemical tracers, and introduced tracers, in order to~~ implement a strategy to detect potential releases from wellbores, faults, and other migration pathways, and ~~must~~ should consider the following methods:	leakage that may endanger public health or the environment. Research has shown that collecting baseline and background data for comparison with future collected data may not be the most effective approach. What is most important is to have an effective strategy and approach for determining whether observed CO_2 is attributable to the CO_2 sequestration operation. There are a number of ways this can be done effectively, and some of those would avoid the expense and intrusiveness of elaborate monitoring arrays such as those that have failed to collect meaningful data from numerous pilot and demonstration projects to date.
C.4.3.2.2(f)	Monitoring should include soil gas and surface air monitoring around the wellbore, and should focus on identifying CO2 flux around the wellbore that may indicate a catastrophic leak.	A monitoring strategy must be specified and should ~~include soil gas and surface air monitoring around the wellbore, and should~~ focus on identifying CO2 flux around the wellbore that may indicate a catastrophic leak.	See comment above; the strategy adopted may take alternative forms that would prove more effective, less costly and less environmentally intrusive.
C.5.2(b)(2)	After injection is complete, the CCS Project Operator must continue to conduct monitoring as specified in this section and the Executive Officer-approved Post-Injection Site Care and Site Closure Plan for	After injection is complete, the CCS Project Operator must continue to conduct monitoring as specified in this section and the Executive Officer-approved Post-Injection Site Care and Site Closure Plan ~~for a~~	As noted by Dr. Sue Hovorka, "The 100 year duration of storage is assured by a robust calibrated model, based on long time scales typical of geologic processes. It is not conjectural.

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	a minimum of 100 years.	~~minimum of 100 years~~ based on a demonstration that the injected CO2 stream is not expected to migrate in the future in a manner likely to result in surface leakage.	"The CCS technical community has not considered tools that could be used over 100 years post closure. It is not clear how 100 years of monitoring data can be used to further improve a robust model, or be effective in detecting previously unimagined failure."[1/] See also the comments of Dr. Jens Birkholzer, Director Energy Geosciences Division, Berkeley Lab: "My experience is that a 100-year time period for monitoring well leakage is overly conservative and not supported by the current scientific knowledge of GCS and its potential risks."
C.5.2(b)(3)(F)	The CCS Project Operator must conduct leak detection checks at each well that is part of the CCS project, and in the near surface close to each plugged and abandoned well, every five years for 100 years after injection is complete, minus the time it takes for the CO2 plume to reach stability.	The CCS Project Operator must conduct leak detection checks at each well that is part of the CCS project, and in the near surface close to each plugged and abandoned well, every five years until the Executive Officer has authorized site closure ~~for 100 years after injection is complete, minus the time it takes for the CO2 plume to reach stability~~.	As noted by Dr. Sue Hovorka, "The 100 year duration of storage is assured by a robust calibrated model, based on long time scales typical of geologic processes. It is not conjectural. "The CCS technical community has not considered tools that could be used over 100 years post closure. It is not clear how 100 years of monitoring data can be used to further improve a robust

1/ Comments [rv. 1] from S. D Hovorka, University of Texas at Austin, On Draft Accounting and Permanence Protocol for Carbon Capture and Geologic Sequestration under Low Carbon Full Standard.

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			model, or be effective in detecting previously unimagined failure.”[2/] See also the comments of Dr. Jens Birkholzer, Director Energy Geosciences Division, Berkeley Lab: “My experience is that a 100-year time period for monitoring well leakage is overly conservative and not supported by the current scientific knowledge of GCS and its potential risks.”
C.6.1(c)(8)	The timeline for review of the Emergency and Remedial Response Plan, no less than once every five years following its approval by the permitting agency, within one year following and AOR reevaluation, and within a prescribed period to be determined by CARB following any significant changes to the injection process or CCS project.	The timeline for review of the Emergency and Remedial Response Plan, no less than once every five years following its approval by the permitting agency, within one year following an~~d~~ AOR reevaluation, and within a prescribed period to be determined by CARB following any significant changes to the injection process or CCS project.	Typo needs to be corrected to change “and” to “an”.
C.9(c)	The CCS Project Operator must show proof that there is binding agreement among relevant parties that drilling or extraction that penetrate the confining layer above the sequestration zone are prohibited within the AOR to ensure public safety and the	The CCS Project Operator must show proof that there is binding agreement among relevant parties that drilling injection or extraction wells that are not part of the CCS project and that penetrate the confining layer above the sequestration zone are prohibited within the AOR to ensure public	The current language is overly broad because it appears to prohibit the drilling of wells that are part of the CCS project and any associated EOR operation. Even this language seems overly restrictive because it would preclude future CCS projects in deeper formations even though techniques are

2/ Comments [rv. 1] from S. D Hovorka, University of Texas at Austin, On Draft Accounting and Permanence Protocol for Carbon Capture and Geologic Sequestration under Low Carbon Full Standard.

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	permanence of stored CO_2.	safety and the permanence of stored CO_2.	readily available to ensure that any wells drilled through an existing CCS project would include application of controls to prevent any release of sequestered CO_2.

Detailed Comments on the Low Carbon Fuel Standard Proposed Order

Proposed Order section	Current text	Proposed revision	Comment
95490(a)(1)	Alternative fuel producers, refineries, and oil and gas producers that capture CO_2 on-site and geologically sequester CO_2 either on-site or off-site.	Alternative fuel producers, refineries, and oil and gas producers that capture CO_2 on-site and geologically sequester CO_2 either on-site or off-site or that produce fuels using oil or gas for CO_2-EOR operations that use captured CO_2.	The rule is too restrictive because it appears to preclude credit for CCS conducted in compliance with the CCS protocol at an EOR operation that uses CO_2 captured by a power plant or industrial facility that is not located at the CO_2-EOR project. The Order should allow credit for CCS projects where the CO_2 is captured at any power plant or industrial facility, transported to an EOR project and injected in accordance with the CCS protocol.
95490(c)(1)	An application must be filed jointly by an entity that captures CO_2 and an entity that sequesters the resultant CO_2, unless the same entity is responsible for CO_2 capture and sequestration.		This provision confirms the clear intent to allow credit where CO_2 is captured at one site and then transported to another site for injection as part of either a geological sequestration project or as part of a CO_2-EOR project.

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95490(c)(2)(B)	An engineering drawing(s) or process flow diagram(s) that illustrates the project and clearly identifies the system boundaries, relevant process equipment, mass flows, including the quantity of CO_2 injected into pipeline or delivered by other modes of transport for CO_2 injection, and energy flows necessary to calculate the CCS credit;		This provision likewise confirms the clear intent to allow credit where CO_2 is captured at one site and then transported to another site for injection as part of either a geological sequestration project or as part of a CO_2-EOR project.
95490(g)	*Recordkeeping*. Pursuant to section 95491.1 and the CCS Protocol, each applicant that receives approval as a CCS credit generator must maintain records for the CCS project, including records necessary to verify permanent sequestration. At a minimum, the following records must be kept: (1) The quarterly volume of alternative fuel, petroleum fuel, crude oil/natural gas produced and delivered to California; (2) Energy use and chemical use data for the carbon capture facility and CO_2 injection facility;	*Recordkeeping*. Pursuant to section 95491.1 and the CCS Protocol, each applicant that receives approval as a CCS credit generator must maintain records for the CCS project, including records necessary to verify permanent sequestration. At a minimum, the following records must be kept: (1) The quarterly volume of alternative fuel, petroleum fuel, crude oil/natural gas produced and delivered to California; (2) Energy use and chemical use data for the carbon capture facility and CO_2 injection facility;	This provision likewise confirms the clear intent to allow credit where CO_2 is captured at one site and then transported to another site for injection as part of either a geological sequestration project or as part of a CO_2-EOR project.