CLEAN AIR TASK FORCE

April 23, 2018

Submitted electronically
Clerk of the Board
California Air Resources Board
1001 I Street
Sacramento, CA 95814
https://www.arb.ca.gov/lispub/comm/bclist.php

Re: Clean Air Task Force comments on Carbon Capture and Sequestration Protocol under the Low Carbon Fuel Standard

Dear Clerk of the Board,

Clean Air Task Force (CATF) appreciates the continued opportunity to provide comments to California Air Resources Board (CARB) on the proposed amendments to the Low Carbon Fuel Standard (LCFS) regulation, specifically Appendix B – Attachment 1: Carbon Capture and Sequestration Protocol (Protocol).

CATF believes that any successful solution to preventing the worst effects of climate change will invariably have to include better and cheaper low-carbon technologies that can be deployed at industrial scale, with carbon capture and storage (CCS) representing one of the key feasible strategies. For more than two decades CATF has applied its technical and policy expertise to develop solutions to the climate challenge. Most recently, CATF succeeded in a joint-effort to extend and expand federal tax incentives (45Q) encouraging carbon capture utilization and storage.

CATF appreciates the effort that the CARB has invested in developing the Protocol and strongly supports CCS as an integral part of the LCFS. CATF believes CCS can play an important role in the reduction of fossil carbon emissions in California.

This letter provides our comments on the Protocol, which we believe will serve to strengthen it. We recognize that many hours have been spent by the staff developing the draft and we appreciate the opportunities that CARB has provided for input over the past several years.[1] Please note that we

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[1] John Thompson, CATF, PowerPoint, "CCS Perspectives and Recommendations on Quantification Methodologies," (Feb. 12, 2016), *available at*: https://www.arb.ca.gov/cc/ccs/meetings/CATF_Presentation_2-12-16.pdf; Bruce Hill, CATF, PowerPoint "Considerations in Developing QM for EOR Storage," (Aug. 23, 2016), *available at:* https://www.arb.ca.gov/cc/ccs/meetings/CATF_Presentation_8-23-16.pdf; Bruce Hill, CATF, Testimony at ARB Public Workshop, (Feb. 12, 2016), *available at:* https://www.arb.ca.gov/cc/ccs/meetings/CATF_Comments_2-12-16.pdf; Bruce Hill, CATF, "Comments to ARB on Quantitative Methodology, Accounting," (Apr. 28, 2016), *available at:* https://www.arb.ca.gov/cc/ccs/meetings/Bruce_Hill_CATF_Comments_4-28-16.pdf; Letter from Jeffrey Bobeck, Global Carbon Capture and Storage Institute, *et al.*, to Alexander Mitchell, ARB, (May 30, 2017), *available at:* https://www.arb.ca.gov/cc/ccs/meetings/Various_Comments_5-30-17.pdf; Letter from Jeffrey Bobeck, Global Carbon Capture and Storage Institute, *et al.*, to Samuel Wade, ARB (Oct. 20, 2017), *available at*: https://www.arb.ca.gov/fuels/lcfs/workshops/10202017_coalition.pdf; Letter from Jeffrey Bobeck, Global Carbon

have also co-submitted, with Dr. Susan Hovorka from the University of Texas, an edited version of the Protocol. That submission, however, did not include CATF's input pertaining to sections B.3, C.1, C.5, C.7, and appendix G. Those provisions are conceptually addressed in this letter, with proposed language to implement the recommendations included in the attached redline.

I. A Performance-Based Approach Will Provide Better Long-Term Storage Security.

A performance-based approach is necessary to secure subsurface storage of carbon dioxide (CO_2) in saline projects and will provide the added benefit of better integrating the requirements in the Protocol for use in commercial enhanced oil recovery (EOR) projects. Monitoring, in general, should be designed to detect leakage in a wide range of geologic project environments, some of which could be outside of the State of California.

In a performance-based approach, project operators build a model of the storage complex, identify areas of potential leakage risk, and tailor the monitoring plan to the risk model and local geology. A performance-based approach will enable operators and CARB to effectively determine, for each different project, what combination of performance criteria and monitoring will provide a sufficient level of certainty that CO_2 will be securely stored over the 100-year permanence period and well beyond. In the case of EOR, monitoring data may include CO_2 conformance metrics already in use by the project. The plan should describe the detection process, and the effective threshold at which leakage from any possible pathway from reservoir to surface will be detected. This would include a detailed explanation (using maps and modeling) of what measurement and modeling steps will be used to trigger a finding of leakage detection. The plan should explain in detail the process by which leakage will be verified, quantified, and mitigated, and if mitigated how the mitigation will be validated, including the accuracy and precision of the methods utilized. Dr. Hovorka has submitted some suggested changes to the Protocol, accompanied by our letter of support, which we believe will help make it more performance based.

II. "Storage Complex" and "Elevated Pressure" Should Define Investigation and Monitoring.

The "area of review" (AOR) and plume and pressure front concepts are adopted from the Federal Underground Injection Control Rule Class VI requirements, which are integral to the Safe Drinking Water Act and protection of groundwater from brine intrusion. Much has been learned since the promulgation of that rule.

First, the risk of elevated pressure that is referred to in the Protocol as a pressure front pertains to protection of groundwater supplies. The underlying concern pertains to the risk of driving saline brine into freshwater aquifers rather than CO_2 leakage to the atmosphere. Imposing this requirement across all project types could unwittingly result in an unreasonably large review volume, in some cases, infinite, such as where there is natural hydrostatic pressure emanating updip from the formation - as possibly present California's mountainous regions.

Capture and Storage Institute, *et al.*, to Samuel Wade, ARB (Dec. 4, 2017), *available at*: https://www.arb.ca.gov/fuels/lcfs/workshops/12042017_coalition.pdf.

Second, the pressure front itself can be a misleading conceptual model for describing how injected CO_2 interacts with reservoir formations, given the subsurface heterogeneity in mineralogy, grain size, cements, composition, and structures. Pressure may extend outward from an injection well, but it is incorrect to think of it as a circumference of pressure extending radially from the injected CO_2 location, but better instead to conceptualize response as "areas of elevated pressure." Furthermore, in EOR projects, injection wells are surrounded by production wells which generate low pressure around them, and therefore a pressure front approach cannot effectively be applied to EOR projects. To easily remedy this, Dr. Hovorka's edited Protocol submission further recommends elimination of the word "front" to be replaced globally in the document with "elevated", thus, "elevated pressure."[2] In concert with this change, we recommend replacement of the "area of review" (AOR) and instead recommend defining the review volume using the term already defined in the Protocol, "storage complex," meaning the volume of rock that is predicted to contain the CO_2 plume permanently.[3] Under this recommended approach, the terms "elevated pressure" and "storage complex" will apply to both saline brine and EOR projects. For example, within the storage complex, all subsurface permeability zones, fracture zones, faults, and legacy wells that are transmissive with potential for induced seismicity will be risks that are identified and corrective action will be taken to avoid leakage. These conditions will then be monitored to determine if the corrective action was successful, and to determine whether these features pose risks to permanence. The term "area of review" (the surface overlying the storage complex) should then be only used to define important *surface* resources.

In summary, the maximum acceptable space for the CO_2 plume to migrate should be a volume rather than an area. As an example, a horizontal well drilled outside an AOR might be deviated into the storage complex volume at depth. A three-dimensional review will assess risk from all sources. Therefore, for all projects, we recommend that CARB require a three-dimensional model of the "storage complex" with all of the risk zones highlighted, and the approach to monitoring the risk zones included.

III. Improving Storage Security of Enhanced Oil Recovery Projects.

While the Protocol states that it anticipates EOR, the Protocol as drafted takes an approach that is largely focused on saline storage, similar to the Environmental Protection Agency's Underground Injection Control Rule, Class VI. In order to better improve the security of CO_2 stored in oilfields, and, at the same time, encourage those projects, the design of the Protocol must take into account the inherent differences in pressure management during CO_2 injection for EOR projects that plan to store CO_2 rather than taking a saline project centric approach.

We recommend the following changes to improve the applicability of the rule to EOR:

- Critical consideration must be given to the fact that CO_2 injection and resultant changes in formation pressure are managed through production in EOR. In EOR fields, injector wells are at the center of a pattern of production wells which produce effective low-pressure zones, and therefore the concept of a pressure front is not relevant. One simple modification in the Protocol, as described above, would significantly improve the efficacy of the overall approach by changing the term "pressure front" to areas of "elevated pressure" globally, throughout the Protocol.

- The Protocol should require measuring fluid flow at the correct points to obtain high quality accounting. Currently the Protocol specifies measuring injection mass just before the injection well. In EOR this measuring point will include recycled CO_2 (CO_2 produced, separated, and reinjected) along with newly supplied CO_2. This should be avoided because it results in "double counting." Because of the possible complexity and unique surface processing during EOR, the Protocol should require the operator to identify and justify the locations and processes by which the best quality measurements can be obtained. At minimum this includes: 1) the new CO_2 supplied to the project attributed to source, 2) its allocation to injection wells, and 3) an explanation of recycled fluid accounting, including any losses or releases.
- Because seal quality of a hydrocarbon reservoir is relatively well known compared to a saline formation, a best practice for EOR is to focus on history matching and analyzing past production and to expend less effort in collecting data about the seal properties. This will require, instead, that data be collected to produce a model that can be used to define the storage complex that will accept and retain CO_2.
- A principal risk in oilfields is legacy well integrity. The Protocol currently requires substantial due diligence to identify oil wells in the project area, however, it could be strengthened by requiring a description of the completeness of well database, as completeness may vary from state to state.
- Accounting is needed for off-lease migration. Not new to the industry, off-lease migration can be a significant problem for operators, as they may lose out-of-pattern oil or CO_2. Operators encountering this problem are routinely using conformance metrics (a form of monitoring) to track CO_2. Where CO_2 loss is a risk, water curtains can be set up (injected water blocking CO_2) and production at the boundary of a pattern or lease may, and discussions initiated with adjacent operators. Although the CO_2 may migrate outside the project boundary, it still may be largely stored if the adjacent operator is also recycling CO_2. Operators should report off-lease migration, and describe the estimated volumes, and methods to account for the CO_2, as well as steps taken to secure the migrated CO_2. Off-lease migration will typically terminate when injection ceases; therefore, the use of a water curtain may be an effective mitigation strategy during injection. The use of CO_2 conformance metrics be included in the tools recommended for monitoring CO_2 in EOR fields as they will help identify off-lease migration.

IV. **Baseline Monitoring Approach**.

Baseline soil flux monitoring is a cornerstone strategy of the Protocol, which could result in false positives or miss leakage altogether because of a proven lack of broad reliability, with results confounded by natural processes. Using a baseline strategy, a monitoring technology provides a "snapshot" of the current condition and can be compared to a similar snapshot at a future date. Using a baseline strategy, a false indicator of leakage will trigger further investigation which may require substantial investment. Moreover, methodologies and technologies will evolve and therefore monitoring strategies should take into account that it may be a challenge to compare the results of newer technologies with older technologies in the future.

In contrast, soil baselines have been demonstrated to be unreliable and may lead to greater uncertainty and wasted monitoring resources such as in the Kerr Farm incident (*see, e.g.*, Romanak et al. (2013) https://www.sciencedirect.com/science/article/pii/S1876610213005699). Soil fluxes may vary with season, from year to year, and will undoubtedly change as climate change affects soils and natural gaseous components such as methane and CO_2. Instead, a more effective approach is to require that operators propose and demonstrate the effectiveness of monitoring tools appropriate for the geologic and ecological environments within which the operate. Our recommendation relative to soil flux monitoring is to eliminate the word "baseline," and instead establish soil concentrations to be utilized in a *process-based* approach rather than establishing these measurements as a snapshot at a certain period of time.[4] Tasks to facilitate process-based monitoring may include: 1) base characterization: measure ratios of gases (N, CO_2, O_2, CH_4) in ambient atmosphere, soils, AZMI; 2) develop workplan and timeframe for collecting samples; 3) attribution strategy (*see* ARB presentation by K. Romanak). Strategies should also take into account soil gas trends related to climate change over the requisite monitoring period.

V. Dissipation interval.

Dissipation interval, defined at (44), is an approach recommended in the 2017 white paper prepared at the request of the CARB by Lawrence Berkeley National Laboratory (LBNL). While the LBNL provides potentially useful criteria for application in certain parts of California, the approach has the following fundamental flaws when utilized as a general global approach:

1. Rock sequences are by their very nature heterogeneous. For example, in the San Joaquin Valley, the sands are fluvial in origin which means they may be laterally discontinuous (imagine an ancient meandering river) however robust they may look in a wellbore or core sample. The requirement to present three clear zones may lead to inaccurate geologic section descriptions.
2. Out-of-state projects qualifying under the LCFS will likely have very different geological settings, such as carbonate sequences where a pressure dissipation interval does not exist, yet the storage complex is demonstrably secure for permanent storage (e.g., reservoirs of the Permian Basin capped with salts).
3. A storage complex should be defined as a sequence of rocks that will contain CO_2 permanently, and the pressure dissipation interval, if present, is an asset.
4. A pressure dissipation interval could be used as a primary storage reservoir given that, by definition, that interval must be overlain by a robust seal.
5. The LBNL approach ignores that projects that qualify for the LCFS may be in other states. Dissipation interval (also AZMI) may be a positive qualifying attribute for monitoring and as a secondary storage compartment above the primary seal, but this attribute should *not* be required. Applying the LBNL approach globally could eliminate many secure sites.

Our recommendation is that ARB eliminate "dissipation interval" at definition (106) (a) as integral to storage complex and as a requirement at 2.1 (a)(4) and (5). Instead we suggest it can remain in the Protocol as an optional feature (e.g. as required in the storage complex geologic description in 2.3 (C)(3)(c)(5)) that could provide lower risk in some projects. Moreover, the interval, if present, may be useful for above – zone monitoring or mitigation – if it is not being considered as a primary storage zone.

VI. Seal Concept and Testing Requirement.

It is incorrect to define a seal strictly in the context of San Joaquin Valley geology that is characterized by a thick sequence of shale overlying the potential saline reservoir sequence (that furthermore must be tested for its capillary entry pressure and ductility). We recommend that CARB broaden its concept of a seal to include a sequence of rocks (confining system) with the demonstrated ability to secure CO_2 permanently (meaning on a geologic time scale). A sealing/trapping sequence need not be narrowly defined as a shale as a result of the testing requirement, (e.g evaporites, carbonates, etc). It is acceptable to keep such types of tests as an option in the Protocol, but we recommend that CARB eliminate these tests as fundamental *requirements* in the it.

VII. Developing a Performance-Based Post-Injection Monitoring Plan.

CATF strongly supports the inclusion of CCS within the LCFS regulation. The proposed Protocol requires all projects, irrespective of storage site characteristics or risk profile, to perform post-injection field monitoring for a minimum of 100 years to demonstrate permanent sequestration of CO_2. The Protocol defines "Permanent sequestration" or "permanence," to mean that "sequestered CO_2 will remain within the storage complex for at least 100 years"[5] Regarding the issue of permanence, CATF would emphasize that in order to reverse climate change, CO_2 that is captured and stored must remain sequestered permanently for much longer timeframes than 100 years. On post-injection monitoring requirements, CATF proposes that CARB develop a performance-based approach that will support the development and operation of CCS projects that will ensure secure sequestration of CO_2 on a geological time scale.

In a performance-based approach, storage security is a function of the quality of the geologic storage site, which is a product of the site selection process, the design of the injection, and the tailoring the monitoring and verification methods to the leakage vulnerabilities, using tools that can detect CO_2 in the project environment over the desired timeframe. For the practical purposes of accounting, demonstrating that stored CO_2 has achieved an equilibrium state with the host rock, such that it will not migrate out of the prequalified volume defined as the storage complex, is the goal of the Protocol. For storage in the deep subsurface, monitoring at the surface for 100 years has minimal value. Demonstration of permanence can be accomplished with highest certainty by combining analyzed plume monitoring data collected in the subsurface, and using matched models to demonstrate a robust trend in CO_2 stability.

The proposed method of post injection monitoring using CO_2 concentration in the soil gas is not reliable. Robust scientific research on the ability of baseline soil gas methods to detect leakage, suggests that the use of soil gas monitoring is fraught with uncertainty. In some cases of known leakage, nothing is detected in the soil; in other cases an observed change in CO_2 concentration is

[5] California Air Resources Board, Appendix B – Attachment 1: Carbon Capture And Sequestration Protocol Under The Low Carbon Fuel Standard, at page 17, *available at:* https://www.arb.ca.gov/regact/2018/lcfs18/appb.pdf

related to the ecosystem and unrelated to the injected CO_2. Furthermore, location and placement of instrumentation is tricky and must be designed to monitor areas with best chance of detection. As an example, at Aliso Canyon, leakage from the subsurface blowout manifested itself at the surface at a distance from the wellhead, at the bottom of the hillside, such that a monitor near the wellhead may have not detected the blow-out early. Critically, if leakage is detected in soils it is too late to mitigate; whereas subsurface detection methods would in many cases allow prevention of significant leakage.

In CATF's comments,[6] submitted on February 1, 2018, we provide legal reasons for why 100 years of monitoring required in the forest offset protocol *does not* necessitate requiring comparable monitoring techniques and methods under the CCS protocol. Permanence in geologic settings is fundamentally different than the timber harvesting risk in forestry. CO_2 stored in mile-deep reservoirs is covered by a thick overburden of rock, typically very impermeable. Vertical migration, if pathways are present, other than through well penetrations, will take much longer timeframes. Failing to recognize these differences and failing to tailor the Protocol to the factors relevant to geologic sequestration would be unreasonable and does not fulfill CARB's fundamental objective of sequestration permanence.[7]

This being said, and despite our objection to what we view as some overly rigid 100 year monitoring requirements, we have endeavored in our comments and proposed language to make judicious recommendations to make the rule more performance-based, within the confines of the 100 year requirement. If CARB wishes to retain the 100-year post injection monitoring requirement in the Protocol then CATF would urge CARB to make changes to the regulatory language as described below that preserve CARB's authority to impose various conditions but lessen the list of mandatory monitoring provisions applicable to all projects. The specific changes have been added as redline comments in Appendix A.

Our recommendations introduce several additional rule components that will facilitate the development of the most technically sound CCS projects and reduce obligatory monitoring not tailored to the risk profile of a particular project. We are confident that these approaches will enable performance-based monitoring and financial responsibilities throughout the life of CCS projects and the permanence period.

1. We recommend authorizing the complete transfer of project responsibilities including the Permanence Certification from a project operator to a third-party subject to Executive Officer approval. *See* redline recommendation in section C.1.2 in Appendix A. Long term, public entities will likely be established to manage carbon sequestration sites in the most secure and efficient manner given the strategies and technologies available in the future.

2. The Protocol should more clearly delineate the responsibilities for the different phases of the project. The current protocol contains a section on Injection Monitoring Requirements at C.4 but the Testing and Monitoring provision expands the scope of testing and monitoring requirements under this section to the "post-injection site care period" at C.4.1(a). We recommend removing this ambiguity by more clearly limiting this Testing and Monitoring

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[6] Clean Air Task Force (CATF), Stakeholder letter in response to LCFS workshop Nov. 6, 2018 (Feb. 1, 2018), *available at:* https://www.arb.ca.gov/fuels/lcfs/workshops/02012018_catf.pdf.
[7] *Comms. for a Better Env't v. Cal. Resources Agency*, 103 Cal. App. 4^{th} 98, 109 (2002)

provision at C.4.1(a) to the "active life of the CCS project" which is the injection period. *See* redline in Appendix A.

3. Post-injection monitoring obligations are best addressed in the section entitled Post-Injection Site Care and Site Closure at C.5.2. The Protocol already requires and enables a thorough review of the Post-Injection Site Care and Site Closure Plan under C.5.3. This comprehensive review should be based on the best available science at the time of the review, and would reference the project's historical performance including regulatory compliance, technical performance, and all other project components. At the conclusion of the review, the Post-Injection Site Care and Site Closure Plan will establish the monitoring obligations and financial responsibilities of the project for the remainder of the 100- year period. Our recommended changes to C.5.2(b) (Post-injection site care and monitoring) have been crafted to empower the Executive Officer with full authority to impose all necessary obligations to ensure permanence but also to enable the Executive Officer to not be required to impose standardized monitoring on all projects. *See* redline in Appendix A.

4. On issues of Financial Responsibility found in C.7, we find the Protocol to be unduly rigid in some respects. Overall, the commencement of the project is the vantage point utilized for assessing the necessary resources. We understand that the need for this approach during the period of initial review and approval of the Permanence Certification. However, after the CCS project has an established operational history and compliance record, we think that the risk assessment should be revisited. We have several specific recommendations in this regard.

    a. Regarding the risk of CO_2 leakage, the current language is insufficiently precise regarding the nature of the risk that must be covered by the financial responsibility instruments. We have suggested specific language to define this more clearly in the first sentence of C.7(a)(3).
    b. Regarding the risk of atmospheric CO_2 leakage, we recommend that the credits that a project has deposited into the buffer pool of LCFS credits during the course of the injection period be taken into account. Using this approach, the account balance for a project would be calculated after the injection period using a new section B.3(e). The proposed approach would recognize all credits contributed and adjust the balance by any leakage that has occurred during the CCS project's active life.
    c. Regarding financial responsibility in the post injection period, we are recommending that CARB recognize the buffer pool contributions that a specific project has made during its active life as a qualifying financial responsibility instrument under C.7(a)3. This financial responsibility instrument could only be used to address the financial risk of atmospheric CO_2 leakage post injection.
    d. We think that the Protocol would benefit from the establishment of a methodology to calculate the risk of atmospheric leakage of CO_2 for Financial Responsibility purposes. We are recommending that CARB utilize the same risk matrix approach that already exists in Table G.1 of Appendix G but apply it to the Financial responsibility section via C.7(a)(3). Post-injection, we recommend that this risk be recalculated based on project performance and compliance history. We recommend a new risk matrix approach as proposed in a new Table G.3.

VIII. Conclusion

In conclusion, CATF urges CARB to more broadly implement a performance-based monitoring approach and to integrate the other specific recommendations we have submitted to the record. Our recommendation aligns with the California Legislature's direction to "substitute[e] performance standards for prescriptive standards wherever performance standards can be reasonably expected to be as effective and less burdensome."[8]

We look forward to continuing our work with CARB on the Protocol and appreciate the ongoing opportunity to provide feedback and recommendations. We also look forward to the development of CCS projects that meet the final Protocol's requirements, and to the continued refinement of the regulatory structure based on real world experience, science and technology.

Respectfully,

Deepika Nagabhushan
Energy Policy Associate
(847) 505-4149
dnagabhushan@catf.us

James P. Duffy, Associate Attorney
Bruce Hill, Ph.D., Chief Geoscientist
John Thompson, Director, Fossil Transition Project
Kurt Waltzer, Managing Director

[8] CA Govt. Code § 11340.1(a).