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Chief, Transportation Fuels Branch  
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California Air Resources Board  
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July 5th, 2018

Dear Mr. Wade,

California Air Resources Board has asserted that 100 years of monitoring is required to insure secure geologic storage of CO<sub>2</sub> in the Carbon Capture and Sequestration Protocol and defined Geologic Carbon Sequestration (GCS) as "the permanent ( $\geq 100$  years) containment of CO<sub>2</sub> within deep subsurface rock formations..."

#### **Discussion**

We do not oppose the concept of 100 years as the benchmark for which CO<sub>2</sub> must be kept from the atmosphere to insure reductions in global climate change potential, however the language of the protocol is too literal in the interpretation of 100 years. An example of which is §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 a minimum of 100 years." The following citations will illustrate that 100 years of monitoring is not required if a level of functional equivalence can be reached. The core argument that staff has had to 100 years of monitoring is that assurance must be reached in the protocol that the CO<sub>2</sub> is entrained and separated from the atmosphere, this argument is not in question; but the assertion that a literal 100 years must pass in order to prove that the CO<sub>2</sub> does not make it back into atmosphere is overly conservative. Overly extensive monitoring requirements and timeframes could hamper participation in the CCS protocols as project developers could have few options for development of the surface once injection has ceased but still have to maintain access and equipment for monitoring as required for a lengthy period of time as the protocol suggests.

Additionally, we applaud the efforts that CARB has made to address stakeholder concerns in regards to the financial liability related to the 100 year requirement with the introduction of the 50 yr/5% mandate. This is an innovative approach to insure that the buffer insurance pool can sustain any reversals that could need remediation; however, flexibility in this concept is key. The citations below will tie into a concept of performance based approach to this as well.

#### **CarbFix**

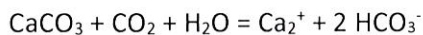
The CarbFix project located outside Reykjavik, the Iceland capital has shown that rapid carbon mineralization is possible through CO<sub>2</sub> injection into basalt formations. This CCS project take CO<sub>2</sub> from

a power plant and injects it into a basalt formation with resulting mineralization of 95% of the injectant in 2 years.<sup>1</sup> The project essentially has turned CO<sub>2</sub> into Calcium Carbonate (CaCO<sub>3</sub>) or limestone a stable rock. This stable rock essentially has entrained what would have been free flowing CO<sub>2</sub> in the subsurface.

Basaltic rocks are highly reactive containing up to 25% by weight of calcium, magnesium and iron and among the most common rock types on Earth. Comprising 10% of the continental surface area and most of the ocean floor.

### The Science

CarbFix utilizes the known chemical reaction between Calcium and CO<sub>2</sub> with water to facilitate the reaction.



Injecting CO<sub>2</sub> into the calcium rich rock results in the formation of calcite in a short period of time. Within 56 days of injection the project showed a decrease of pH levels illustrating the relatively quick reaction time with the basaltic rock in which the CO<sub>2</sub> was injected into.<sup>2</sup>

### Proposal

Modify

§5.2(b)(2) from: *“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 minimum of 100 years.”*

To:

*“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 the minimum time specified in the approved post injection site care plan.”*

Modify

Definition (99) from: *“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.’*

To:

*“Site closure” means the point or date, equal to the lessor of 100 years after and as determined by the Executive Officer following the requirements under subsection C.5.2, at which point the*

<sup>1</sup> <http://sciencenordic.com/pumping-co2-volcanic-rock-transforms-it-limestone-record-time> , Henrik Bendix, June 15, 2016

<sup>2</sup> Rapid carbon mineralization for permanent disposal of anthropogenic carbon dioxide emission, Juerg M. Matter, Martin Stute, Sandra Ó. Snæbjörnsdóttir, Eric H. Oelkers, Sigurdur R. Gislason, Edda S. Aradóttir, Bergur Sigfusson, Ingvi Gunnarsson, Holmfrídur Sigurdardóttir, Einar Gunnlaugsson, Gudni Axelsson, Helgi A. Alfredsson, Domenik Wolff-Boenisch, Kiflom Mesfin, Diana Fernandez de la Reguera Taya, Jennifer Hall, Knud Dideriksen, Wallace S. Broecker; Science 352 (6291), 1312-1314

CCS Project Operator is released from post-injection site care responsibilities or functional equivalence of 100 years of permanence has been met as determined by the Executive Officer.'

Modify

§5.3(F) from *"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. Monitoring must include:"*

To:

*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 post injection for the lessor of 100 years after injection is complete or the time frame in which functional equivalence of 100 years is met as stated in the post injection site care plan, minus the time it takes for the CO2 plume to reach stability. Monitoring must include:*

**With regard to the 5% buffer contribution:**

Processes such as those shown with rapid mineralization at the CarbFix site not only show that a project can have high performance in meeting the 100 year mandate but also demonstrate that near zero risk of reversal is also possible. High performance projects should not be penalized for investments in lower performing technologies. Therefore staff should make the contributions to the buffer pool for reduced financial liability as part of the application process in which the applicants may choose the level of financial liability they wish to take. The 15 day package eludes to performance basis with regard to the buffer account when describing verification activities.

*"...staff proposes that the verification team review the operator's CCS project's risk rating for determining its contribution to the LCFS Buffer Account, as calculated under Appendix G. The changes are needed to ensure that the determination made by the operator is reasonable and meets the regulatory requirements."*

USEPA regulation on carbon sequestration already allow for a performance based reduction to its 50 year mandate. The ADM Illinois Basin – Decatur Project has been granted a 40 year reduction to its post injection monitoring requirement making it just 10 years of monitoring.

Extrapolating from staffs reasoning of 1% for every 10 years of liability from the overall 100 years and extending that formulaically CARB could allow for a reduction of the financial liability down to a minimum of the EPA requirement. This would help synergize the two regulatory mandates and reduce the overall project burden on CARB staff. Additionally, as this is a performance based approach and as mentioned in the 15-day package that staff will use annual verification processes to insure that buffer contributions are adequate based on the performance of the site and its operators it should be noted that not only should buffer contributions be able to be increased if risk is evaluated higher but also decreased as well.

It should be noted that we believe that the 1% premium for 10 years is a conservative estimate and recognized that CARB required a starting point in designing this buffer pool layer. Therefore we strongly recommend that additional language be added to the protocol to allow for modifications to the

percentage based on reassessed risk matrixes utilizing data submitted; this type of procedure would mirror that of insurance actuarial processes as they examine risk and insurance premiums. We believe a change such as this would promote techniques and procedures that would have the highest standards so that project operators would have the lowest "premiums".

### Conclusion

The modifications to the proposed protocol language will allow for projects with secure sequestration techniques that currently exist and that will be invented and deployed in the future to take advantage of the shorter timeframes in which secure CO2 permanence can be met. This pathway to relatively short timeframes to insure 100 years of storage such as the techniques currently being deployed in the CarbFix project will incentivize more innovative technologies to be developed that can show equivalent or better performance than what currently exists today. CARB should strongly consider these modifications to the protocol language to increase the viability of the protocol and the deployment of CCS/CCUS throughout the world.

Regards,



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