Enhanced rock weathering in agriculture: Round 2 (final)

Expert elicitation: Round 2. This is the copy that will used for the final data analysis.

1. Email *

_____

2. What is your area of expertise?

Check all that apply.

- [ ] Agronomy
- [ ] Terrestrial biogeochemistry/geochemistry (incl. soil science)
- [ ] Freshwater biogeochemistry/geochemistry
- [ ] Marine biogeochemistry/geochemistry
- [ ] Hydrology
- [ ] Other

3. What is your industry? Dropdown

Mark only one oval.

- ◯ Academic
- ◯ NGO, non-CDR focused
- ◯ NGO, CDR focused
- ◯ For profit, non-CDR focused
- ◯ For profit, CDR focused
- ◯ Government
- ◯ Other

4. What percentage of research time is spent (by you or averaged across your research group, if you run a lab) on each feedstock?

Mark only one oval per row.

	<10%	11-50%	51-75%	75% +
Basalt	◯	◯	◯	◯
Wollastonite	◯	◯	◯	◯
Olivine-rich (>50%) rock	◯	◯	◯	◯
Steel slag	◯	◯	◯	◯
Agricultural lime	◯	◯	◯	◯
Cement waste	◯	◯	◯	◯

For each of the following feedstocks, please answer the following questions. Please leave no blanks, as we are also quantifying individual level uncertainty. If you answer a question, please answer the associated confidence questions as well (e.g., 10th, 90th, and certainty) so we can fully incorporate all data. Note that a confidence level of 50% is essentially saying you don't know if the true value is in or out of your range, so similar conceptually to leaving a number blank.

You will need to restart this survey for each feedstock - this will keep the responses aligned with the feedstock you chose.

5. Please select the feedstock for which you are answering the questions. Address the feedstocks independently - e.g., consider their global in isolation of the other potential amendments. However, do note we are concerned about **additional** CDR, so do consider present day practices.

Mark only one oval.

- Basalt
- Wollastonite
- Olivine-rich (>50%) rock
- Steel slag (do not include emissions associated with steel manufacturing)
- Agricultural Lime
- Concrete waste (do not include emissions associated with concrete manufacturing)

6. What percentage of your work focuses directly on enhanced weathering of this feedstock? Dropdown

Mark only one oval.

- 0-10%
- 11-50%
- 51-75%
- 76-100%

7. 1) How important do you think the following factors are to its potential use in CDR on a scale of 1 (major impediment) to 5 (not an impediment)

Mark only one oval per row.

	1	2	3	4	5
Its total availability relative to scale of potential use to achieve meaningful climate impacts	◯	◯	◯	◯	◯
Its potential to achieve permanent carbon dioxide removal	◯	◯	◯	◯	◯
Its susceptibility to in-situ processes that reduce the CDR potential (e.g., surface-passivation)	◯	◯	◯	◯	◯

Global scale impact

8. Realistically, what do you think is the **lowest plausible possibility** for system-wide, annual CO2e removal given widespread adoption? This includes emissions associated with processing, transport, and application, as well as any other GHG emissions/reductions that may occur throughout the entire process (e.g., N2O reductions, changes to organic carbon). Consider all agricultural lands (croplands, rangelands, silvicultural lands); note effectiveness may vary by land type.

   This should be a realistic estimate, and be estimated as the **additional** CO2e removal above current day removals from any amendments (e.g., present day liming).

   This estimate should include your estimates of constraints as well, such as available supply of the mineral, potential area of successful application, precipitation/moisture constraints across potential land area, health concerns at scale, etc. For the lowest plausible estimate, these would then be tight constraints. For the highest plausible estimate, these would be loose constraints.

   Dropdown

   Consider removal accounting 20 year after weathering has occurred and removal lasting for at least 100 years. It should be your best estimate of the lower end of the 5% confidence interval. In this case, a negative value would be net emissions into the atmosphere, positive value net removals (carbon flux out of atmosphere).

   Mark only one oval.

   - ◯ < -2 Gt CO2e (net emission)
   - ◯ -1.5 Gt CO2e
   - ◯ -1 Gt CO2e (net emission)
   - ◯ -0.75 Gt CO2e (removal)
   - ◯ -0.5 Gt CO2e (net emission)
   - ◯ -0.25 Gt CO2e (net emission)
   - ◯ -0.1 Gt CO2e (net emission)
   - ◯ -0.01 Gt CO2e (net emission)
   - ◯ 0 Gt CO2e (no impact)
   - ◯ 0.01 Gt CO2e (net removal)
   - ◯ 0.1 Gt CO2e (removal)

- [ ] 0.25 Gt CO2e (net removal)
- [ ] 0.5 Gt CO2e (removal)
- [ ] 0.75 Gt CO2e (removal)
- [ ] 1 Gt CO2e (removal)
- [ ] 1.5 Gt CO2e (removal)
- [ ] 2.0 Gt CO2e (removal)
- [ ] 2.5 Gt CO2e (removal)
- [ ] 3 Gt CO2e (removal)
- [ ] 4 Gt CO2e (removal)
- [ ] > 5 Gt CO2e (removal)

9. Realistically, what do you think is the **highest plausible possibility** for system-wide, annual CO2e removal given widespread adoption? It should be your best estimate of the higher end of the 95% confidence interval.

   This includes emissions associated with processing, transport, and application, as well as any other GHG emissions/reductions that may occur throughout the entire process (e.g., N2O reductions, changes to organic carbon). Consider all agricultural lands (croplands, rangelands, silvicultural lands); note effectiveness may vary by land type.

   This should be a realistic estimate, and be estimated as the **additional** CO2e removal above current day removals from any amendments (e.g., present day liming). Dropdown

   This estimate should include your estimates of constraints as well, such as available supply of the mineral, potential area of successful application, precipitation/moisture constraints across potential land area, health concerns at scale, etc. For the lowest plausible estimate, these would then be tight constraints. For the highest plausible estimate, these would be loose constraints.

   In this case, a negative value would be net emissions into the atmosphere, positive value net removals (carbon flux out of atmosphere).

   Mark only one oval.

   - < -2 Gt CO2e (net emission)
   - -1.5 Gt CO2e
   - -1 Gt CO2e (net emission)
   - -0.75 Gt CO2e (net emission)
   - -0.5 Gt CO2e (net emission)
   - -0.25 Gt CO2e (removal)
   - -0.1 Gt CO2e (net emission)
   - -0.01 Gt CO2e (net emission)
   - 0 Gt CO2e (no impact)
   - 0.01 Gt CO2e (removal)
   - 0.1 Gt CO2e (removal)

- [ ] 0.25 Gt CO2e (removal)
- [ ] 0.5 Gt CO2e (removal)
- [ ] 0.75 Gt CO2e (removal)
- [ ] 1 Gt CO2e (removal)
- [ ] 1.5 Gt CO2e (removal)
- [ ] 2.0 Gt CO2e (removal)
- [ ] 2.5 Gt CO2e (removal)
- [ ] 3 Gt CO2e (removal)
- [ ] 4 Gt CO2e (removal)
- [ ] > 5 Gt CO2e (removal)

10. Realistically, what do you think is the **most likely amount** of system-wide, annual CO2 removal given widespread adoption? It should be your best estimate of the 50th percentile.

This includes emissions associated with processing, transport, and application, as well as any other GHG emissions/reductions that may occur throughout the entire process (e.g., N2O reductions, changes to organic carbon). Consider all agricultural lands (croplands, rangelands, silvicultural lands); note effectiveness may vary by land type.

This should be a realistic estimate, and be estimated as the **additional** CO2e removal above current day removals from any amendments (e.g., present day liming).

Dropdown

This estimate should include your estimates of constraints as well, such as available supply of the mineral, potential area of successful application, precipitation/moisture constraints across potential land area, health concerns at scale, etc. For the lowest plausible estimate, these would then be tight constraints. For the highest plausible estimate, these would be loose constraints.

In this case, a negative value would be net emissions into the atmosphere, positive value net removals (carbon flux out of atmosphere).

Mark only one oval.

- < -2 Gt CO2e (net emission)
- -1.5 Gt CO2e
- -1 Gt CO2e (net emission)
- -0.75 Gt CO2e (net emission)
- -0.5 Gt CO2e (net emission)
- -0.25 Gt CO2e (net emission)
- -0.1 Gt CO2e (net emission)
- -0.01 Gt CO2e (net emission)
- 0 Gt CO2e (no impact)
- 0.01 Gt CO2e (removal)
- 0.1 Gt CO2e (removal)

- [ ] 0.25 Gt CO2e (removal)
- [ ] 0.5 Gt CO2e (removal)
- [ ] 0.75 Gt CO2e (removal)
- [ ] 1 Gt CO2e (removal)
- [ ] 1.5 Gt CO2e (removal)
- [ ] 2.0 Gt CO2e (removal)
- [ ] 2.5 Gt CO2e (removal)
- [ ] 3 Gt CO2e (removal)
- [ ] 4 Gt CO2e (removal)
- [ ] > 5 Gt CO2e (removal)

11. How **confident** are you that your defined range contains the true probability? In other words, a score of 50% means there are even odds your value contains the true probability, a score of 90 or 100% means you are extremely confident your range includes the true probability. (The purpose of this question is scaling responses between observers.)

Dropdown

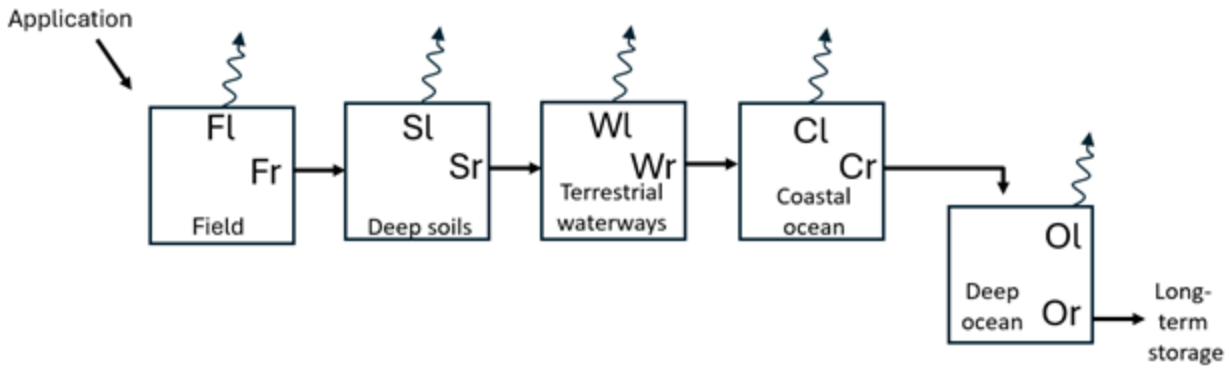
Mark only one oval.

- [ ] 50%
- [ ] 55%
- [ ] 60%
- [ ] 65%
- [ ] 70%
- [ ] 75%
- [ ] 80%
- [ ] 85%
- [ ] 90%
- [ ] 95%
- [ ] 100%

12. What are 1-3 top variables that informed your estimate?

13. What are 1-3 factors that, if given better data, would best reduce our uncertainty in the overall potential? (text response)

Stages



In this study, for each of the types of materials that might be applied to the soil, we are interested in understanding how captured carbon will move through the system towards eventual long-term storage. That is, we are interested in estimating how much carbon is lost or retained as it moves through the ecosystem, and identifying areas of greater or lesser uncertainty.

The questions in the elicitation are framed around inefficiencies in carbon removal— relative to the stoichiometric ideal of an alkaline feedstock or of a specified flux of weathering products from one environment to another (e.g., from the lower soil column to rivers). With this framing, downstream processes that increase the efficiency of the CDR process should be factored into estimates of the efficiency *within* the environmental zone being considered. For instance, denitrification is a common process in soils and surface waters. The product of this microbial process is bicarbonate. We encourage a holistic look at the process—where one would not only consider bicarbonate exported from soils, but the cations and anions being exported and their fate downstream as they influence carbon movement.

Rather than ask you to keep track across the full chain we are going to ask you to assume that the input to each stage (except the first) is 10 tons of fixed inorganic carbon and ask you to assess the fraction of that 10 tons that that moves on without achieving any capture. Note that other material may come along with that, depending on the feedstock.

In the box diagram above, for example, Sr is the amount of fixed inorganic carbon that is retained as it moves through the deep soil zone from the field into terrestrial waterways, and Sl is the amount material is lost (in any form no longer compatible with long-term CDR) while in the soil stage.

Please consider only inorganic carbon, not changes in organic carbon, for these stage estimates.

Conditions

The products of enhanced weathering will move from the field through the soil column into surface waters, the nearshore (coastal), and eventually the deep ocean. Although enhanced weathering can be deployed in a wide range of agroecosystems, for the purposes of these questions please consider deployment in loamy soils in American Midwest that have an average pH value of 5.5-6, a base saturation of 65%, and a cation exchange capacity of 10 meq. Assume a grind size <100 um. Assume that the field is not tile drained and not irrigated.

We are considering the American Midwest given the presence of extensive agricultural infrastructure could allow for a rapid upscaling of enhanced weathering deployments. Answers to these questions should be based on your mechanistic understanding of key processes as they apply in this location.

Some of the questions in the elicitation consider two timeframes—twenty years after rock

addition to soils (or rock weathering) and 100 years after rock addition. The point of these questions is to compare near-term and long-term impacts. The inclusion of two timeframes is an acknowledgement that some processes occur on decadal time scales (e.g., weathering and cation sorption in soils) and that 100 years is a commonly considered threshold for durability in CDR frameworks.

Note the questions reference the carbon that makes it through each stage, not overall – consider each stage independently, not cumulatively.

Application Stage (shallow soils on a field)

Surface to bottom of rooting zone

14. Consider the case where enough material (note that the total amount would vary depending on the feedstock you are answering) is applied to *potentially* fix 10 tons of CO2/ha. Realistically, what do you think is the **lowest plausible amount** of that fixed CO2 which moves out of the surficial soils and into the vadose zone and groundwater within 20 years? In the figure, this is Fr. This is your best estimate of the lower end of the 5% confidence interval. Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

15. Consider the case where enough material (note that the total amount would vary depending on the feedstock you are answering) is applied to *potentially* fix 10 tons of CO2/ha. Realistically, what do you think is the **highest plausible amount** of that fixed CO2 which moves out of the surficial soils and into the vadose zone and groundwater within 20 years? In the figure, this is Fr. This is your best estimate of the upper end of the 95% confidence interval.

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

16. Consider the case where enough material (note that the total amount would vary depending on the feedstock you are answering) is applied to *potentially* fix 10 tons of CO2/ha. Realistically, what do you think is the **most plausible amount** (50th percentile) of that fixed CO2 which moves out of the surficial soils and into the vadose zone and groundwater within 20 years? In the figure, this is Fr.

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

17. How **confident** are you that your defined range contains the true probability? In other words, a score of 50% means there are even odds your value contains the true probability, a score of 90 or 100% means you are extremely confident your range includes the true probability.

Dropdown

Mark only one oval.

- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

18. Given current methodologies for measuring loss (empirical or modeled), what do you think the likely relative error of the estimate would be relative to the true value, given a reasonable level of effort to quantify the error? Low values mean relatively little error, high values mean more error. 100% is meant to be interpreted as the error is equal to the estimate, >100% means the error is larger than the estimated value. Dropdown

Mark only one oval.

- Approximately 10%
- Approximately 30%
- Approximately 50%
- Approximately 70%
- Approximately 90%
- Approximately 100%
- Approximately 200%
- Approximately 500%
- Approximately 1000%
- > 1000%

19. What 1-3 factors that informed your estimate?

_____

20. What are 1-3 factors that, if given better data, would best reduce your uncertainty in the overall potential? This could be improved measurement techniques, maps, or anything else you think would help better resolve these percentages.

_____

21. What is your assessment of the probability that this feedstock will cause significant ecosystem or human health damage at this stage when applied at commercially/climatically relevant amounts and scales? For this question, consider if this process was scaled up, not just the 10 tons of C in the example.

Dropdown

Mark only one oval.

- 0%
- 5%
- 10%
- 15%
- 20%
- 25%
- 30%
- 35%
- 40%
- 45%
- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

22. At this level of probability, is there likely to be public concerns and/or pushback?

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Don't know

23. If ERW were to become a fully-fledged CDR strategy and commercialized to make compensatory claims what do you think are necessary steps for quantification at this stage?

Mark only one oval.

- ◯ Fully empirical measurements
- ◯ Tightly data constrained model
- ◯ Model-based estimates with empirical checks
- ◯ Fully model-based

Note that the following questions use a slightly different baseline – starting with a fixed amount of carbon already in the process, not based on applied material.

Deep Soils: Lower vadose zone and groundwater flow paths

This stage starts at the bottom of the rooting zone

24. Consider the case where 10 tons of fixed CO2/ha enters the lower vadose zone and groundwater flow paths as bicarbonate. Realistically, what do you think is the **lowest plausible amount** of that fixed CO2 which moves through and out into the freshwater system? This is your best estimate of the lower end of the 5% confidence interval.

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

25. Realistically, what do you think is the **highest plausible amount** of that fixed carbon that moves through and out into the freshwater system? This is your best estimate of the upper end of the 95% confidence interval.

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

26. Realistically, what do you believe **most accurately** represents the most likely percentage (50th percentile)?

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

27. How **confident** are you that your defined range contains the true probability? In other words, a score of 50% means there are even odds your value contains the true probability, a score of 90 or 100% means you are extremely confident your range includes the true probability.

Dropdown

Mark only one oval.

- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

28. Given current methodologies for measuring loss (empirical or modeled), what do you think the likely relative error of the estimate would be relative to the true value, given a reasonable level of effort to quantify the error? Low values mean relatively little error, high values mean more error. 100% is meant to be interpreted as the error is equal to the estimate, >100% means the error is larger than the estimated value. Dropdown

Mark only one oval.

- Approximately 10%
- Approximately 30%
- Approximately 50%
- Approximately 70%
- Approximately 90%
- Approximately 100%
- Approximately 200%
- Approximately 500%
- Approximately 1000%
- > 1000%

29. What 1-3 factors that informed your estimate?

_____

30. What are 1-3 factors that, if given better data, would best reduce your uncertainty in the overall potential? This could be improved measurement techniques, maps, or anything else you think would help better resolve these percentages.

_____

31. What is your assessment of the probability that this feedstock will cause significant ecosystem or human health damage at this stage when applied at commercially/climatically relevant amounts and scales? For this question, consider if this process was scaled up, not just the 10 tons of C in the example.

Dropdown

Mark only one oval.

- 0%
- 5%
- 10%
- 15%
- 20%
- 25%
- 30%
- 35%
- 40%
- 45%
- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

32. At this level of probability, is there likely to be public concerns and/or pushback?

Mark only one oval.

- Yes
- No
- Don't know

33. If ERW were to become a fully-fledged CDR strategy and commercialized to make compensatory claims what do you think are necessary steps for quantification at this stage?

Mark only one oval.

- Fully empirical measurements
- Tightly data constrained model
- Model-based estimates with empirical checks
- Fully model-based

Freshwater system

34. Consider the case where 10 tons of fixed CO2/ha as bicarbonate enters the freshwater stream system from the lower vadose zone/groundwater system above. Realistically, what do you think is the **lowest plausible amount** of that fixed carbon that moves through and out into the nearshore marine system? This is your best estimate of the lower end of the 5% confidence interval.

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

35. Realistically, what do you think is the **highest plausible amount** of that fixed CO2 which moves through and out into the nearshore marine system? This is your best estimate of the upper end of the 95% confidence interval.

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

36. Realistically, what do you believe **most accurately** represents the most likely percentage (50th percentile)?

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

37. How **confident** are you that your defined range contains the true probability? In other words, a score of 50% means there are even odds your value contains the true probability, a score of 90 or 100% means you are extremely confident your range includes the true probability.

Dropdown

Mark only one oval.

- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

38. Given current methodologies for measuring loss (empirical or modeled), what do you think the likely relative error of the estimate would be relative to the true value, given a reasonable level of effort to quantify the error? Low values mean relatively little error, high values mean more error. 100% is meant to be interpreted as the error is equal to the estimate, >100% means the error is larger than the estimated value. Dropdown

Mark only one oval.

- Approximately 10%
- Approximately 30%
- Approximately 50%
- Approximately 70%
- Approximately 90%
- Approximately 100%
- Approximately 200%
- Approximately 500%
- Approximately 1000%
- > 1000%

39. What 1-3 factors that informed your estimate?

_____

40. What are 1-3 factors that, if given better data, would best reduce your uncertainty in the overall potential? This could be improved measurement techniques, maps, or anything else you think would help better resolve these percentages.

_____

41. What is your assessment of the probability that this feedstock will cause significant ecosystem or human health damage at this stage when applied at commercially/climatically relevant amounts and scales? For this question, consider if this process was scaled up, not just the 10 tons of C in the example.

Dropdown

Mark only one oval.

- 0%
- 5%
- 10%
- 15%
- 20%
- 25%
- 30%
- 35%
- 40%
- 45%
- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

42. At this level of probability, is there likely to be public concerns and/or pushback?

Mark only one oval.

- Yes
- No
- Don't know

43. If ERW were to become a fully-fledged CDR strategy and commercialized to make compensatory claims what do you think are necessary steps for quantification at this stage?

Mark only one oval.

- Fully empirical measurements
- Tightly data constrained model
- Model-based estimates with empirical checks
- Fully model-based

Nearshore marine system

44. Consider the case where 10 tons of fixed CO2/ha as bicarbonate enters the nearshore marine system from the freshwater system above. Realistically, what do you think is the **lowest plausible amount** of that fixed CO2 as bicarbonate that moves through and out into the deepwater marine system? This is your best estimate of the lower end of the 5% confidence interval.

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

45. Realistically, what do you think is the **highest plausible amount** of that fixed CO2 which moves through and out into the deepwater marine system? This is your best estimate of the upper end of the 95% confidence interval.

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

46. Realistically, what do you believe **most accurately** represents the most likely percentage (50th percentile)?

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

47. How **confident** are you that your defined range contains the true probability? In other words, a score of 50% means there are even odds your value contains the true probability, a score of 90 or 100% means you are extremely confident your range includes the true probability.

Dropdown

Mark only one oval.

- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

48. Given current methodologies for measuring loss (empirical or modeled), what do you think the likely relative error of the estimate would be relative to the true value, given a reasonable level of effort to quantify the error? Low values mean relatively little error, high values mean more error. 100% is meant to be interpreted as the error is equal to the estimate, >100% means the error is larger than the estimated value. Dropdown

Mark only one oval.

- Approximately 10%
- Approximately 30%
- Approximately 50%
- Approximately 70%
- Approximately 90%
- Approximately 100%
- Approximately 200%
- Approximately 500%
- Approximately 1000%
- > 1000%

49. What 1-3 factors that informed your estimate?

_____

50. What are 1-3 factors that, if given better data, would best reduce your uncertainty in the overall potential? This could be improved measurement techniques, maps, or anything else you think would help better resolve these percentages.

_____

51. What is your assessment of the probability that this feedstock will cause significant ecosystem or human health damage at this stage when applied at commercially/climatically relevant amounts and scales? For this question, consider if this process was scaled up, not just the 10 tons of C in the example.

Dropdown

Mark only one oval.

- 0%
- 5%
- 10%
- 15%
- 20%
- 25%
- 30%
- 35%
- 40%
- 45%
- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

52. At this level of probability, is there likely to be public concerns and/or pushback?

Mark only one oval.

- Yes
- No
- Don't know

53. If ERW were to become a fully-fledged CDR strategy and commercialized to make compensatory claims what do you think are necessary steps for quantification at this stage?

Mark only one oval.

- Fully empirical measurements
- Tightly data constrained model
- Model-based estimates with empirical checks
- Fully model-based

Deepwater marine system

54. Consider the case where 10 tons of fixed CO2/ha as equilibrated dissolved inorganic carbon enters the deepwater marine system from the nearshore marine system above. Realistically, what do you think is the **lowest plausible amount** of that fixed carbon that will be retained for at least 100 years? This is your best estimate of the lower end of the 5% confidence interval.

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

55. Realistically, what do you think is the **highest plausible amount** of that fixed CO2 which will be deposited and retained for at least 100 years? This is your best estimate of the upper end of the 95% confidence interval.

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

56. Realistically, what do you believe **most accurately** represents the most likely percentage (50th percentile)?

Dropdown

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

57. How **confident** are you that your defined range contains the true probability? In other words, a score of 50% means there are even odds your value contains the true probability, a score of 90 or 100% means you are extremely confident your range includes the true probability. Dropdown

Mark only one oval.

- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

58. Given current methodologies for measuring loss (empirical or modeled), what do you think the likely relative error of the estimate would be relative to the true value, given a reasonable level of effort to quantify the error? Low values mean relatively little error, high values mean more error. 100% is meant to be interpreted as the error is equal to the estimate, >100% means the error is larger than the estimated value. Dropdown

Mark only one oval.

- Approximately 10%
- Approximately 30%
- Approximately 50%
- Approximately 70%
- Approximately 90%
- Approximately 100%
- Approximately 200%
- Approximately 500%
- Approximately 1000%
- > 1000%

59. What 1-3 factors that informed your estimate?

_____

60. What are 1-3 factors that, if given better data, would best reduce your uncertainty in the overall potential? This could be improved measurement techniques, maps, or anything else you think would help better resolve these percentages.

_____

61. What is your assessment of the probability that this feedstock will cause significant ecosystem or human health damage at this stage when applied at commercially/climatically relevant amounts and scales? For this question, consider if this process was scaled up, not just the 10 tons of C in the example.

Dropdown

Mark only one oval.

- 0%
- 5%
- 10%
- 15%
- 20%
- 25%
- 30%
- 35%
- 40%
- 45%
- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

62. At this level of probability, is there likely to be public concerns and/or pushback?

Mark only one oval.

- Yes
- No
- Don't know

63. If ERW were to become a fully-fledged CDR strategy and commercialized to make compensatory claims what do you think are necessary steps for quantification at this stage?

Mark only one oval.

- Fully empirical measurements
- Tightly data constrained model
- Model-based estimates with empirical checks
- Fully model-based

This last question is about the overall integrated efficiency of atmospheric CO2 removal via inorganic carbon facilitated by ERW. Use the same scenario as above.

64. Consider the case where enough material (note that the total amount would vary depending on the feedstock you are answering) is applied to potentially fix 10 tons of CO2/ha. Realistically, what do you think is the **lowest plausible amount** of that fixed inorganic CO2 which is stored for at least 100 years.

Dropdown

This is your best estimate of the lower end of the 5% confidence interval.

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

65. Consider the case where enough material (note that the total amount would vary depending on the feedstock you are answering) is applied to potentially fix 10 tons of CO2/ha. Realistically, what do you think is the **highest plausible amount** of that fixed inorganic CO2 which is stored for at least 100 years.

Dropdown

This is your best estimate of the upper end of the 95% confidence interval.

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

66. Consider the case where enough material (note that the total amount would vary depending on the feedstock you are answering) is applied to potentially fix 10 tons of CO2/ha. Realistically, what do you think is the **most plausible amount** of that fixed inorganic CO2 which is stored for at least 100 years. Dropdown

This is your best estimate (50th percentile).

Mark only one oval.

- 0.0 tons (none)
- 0.5 tons
- 1.0 tons
- 1.5 tons
- 2.0 tons
- 2.5 tons
- 3.0 tons
- 3.5 tons
- 4.0 tons
- 4.5 tons
- 5.0 tons
- 5.5 tons
- 6.0 tons
- 6.5 tons
- 7.0 tons
- 7.5 tons
- 8.0 tons
- 8.5 tons
- 9.0 tons
- 9.5 tons
- 10.0 tons (all)

67. How **confident** are you that your defined range contains the true probability? In other words, a score of 50% means there are even odds your value contains the true probability, a score of 90 or 100% means you are extremely confident your range includes the true probability.

Dropdown

Mark only one oval.

- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

68. What 1-3 factors that informed your estimate?

_____