U.S. and Canada Biochar

Protocol | Version 1.0 | March 19, 2024

CLIMATE ACTION RESERVE

Climate Action Reserve
www.climateactionreserve.org

Released March 19, 2024

Acknowledgements

Reserve staff (alphabetical)

Version 1.0

Holly Davison
Jon Remucal
Marissa Spence

Technical Support

John Nickerson	Dogwood Springs Forestry

Workgroup

The list of workgroup members below comprises all individuals and organizations that have advised the Reserve in development of this protocol and have provided independent expert review. Their participation in the Reserve process is based on their technical expertise and does not constitute endorsement of the final protocol. The Reserve makes all final technical decisions and approves final protocol content. For more information about the protocol development process, refer to the Reserve Offset Program Manual.

Akio Enders	Cornell University; International Biochar Initiative
Allison Flynn	Global Green Energy Solutions Corporation
Bruce Springsteen	Placer County Air Pollution Control District
Daniel Sanchez	University of California, Berkeley / Carbon Direct
David Morell	Sonoma Ecology Center
Hannes Etter	South Pole
Jeff Cole / JP Bayangos	Shell
Johannes Lehmann	Cornell University
Jonah Levine	Biochar Solutions
Josiah Hunt	Pacific Biochar
Kevin Fingerman	Cal Poly Humboldt / Schatz Energy Research Center
Matt Ramlow	World Resources Institute
Melissa Leung	GECA Environment
Micah Elias	University of California, Berkeley / Blue Forest
Nathaniel Anderson	U.S. Forest Service
Patricio Ortiz	ACT Commodities
Phil Saksa	Blue Forest
Rachel Rubin	Woodwell Climate Research Center
Shawn McMahon	Aster Global
Tristan R. Brown	SUNY College of Environmental Science & Forestry
Xiaomei Li	Viresco Solutions Inc.

Financial Support

The process to develop this protocol was supported in part by grant funding from:

- USDA Forest Service through the Wood Innovations Program
- California Department of Forestry and Fire Protection through the Forest Health Program

Table of Contents

List of Tables

List of Figures

List of Equations

Abbreviations and Acronyms

Btu	British thermal unit
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CH_4	Methane
CRT	Climate Reserve Tonne
GHG	Greenhouse gas
IBI	International Biochar Initiative
kWh	Killowatt-hour
MWh	Megawatt-hour
N_2O	Nitrous oxide
Reserve	Climate Action Reserve
SSR	Source, sink, and/or reservoir
t	Metric ton (or tonne)
WBC	World Biochar Certificate

1 Introduction

The Climate Action Reserve (Reserve) U.S. and Canada Biochar Protocol provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions and carbon removals associated with the production and application of biochar.

The **Climate Action Reserve** is the most trusted, efficient, and experienced offset registry for global carbon markets. A pioneer in carbon accounting, the Reserve promotes and fosters the reduction of greenhouse gas (GHG) emissions through credible market-based policies and solutions. As a high-quality offset registry for voluntary carbon markets, it establishes rigorous standards involving multi-sector stakeholder workgroup development and local engagement and issues carbon credits in a transparent and publicly available system. The organization also supports compliance carbon markets in California, Washington, and internationally. The Reserve is an environmental nonprofit organization headquartered in Los Angeles, California, with staff members located around the world. For more information, please visit www.climateactionreserve.org.

Project developers that initiate biochar projects use this document to quantify and register GHG reductions and carbon removals with the Reserve. The protocol provides eligibility rules, methods to calculate reductions and removals, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions and removals is provided in the Reserve Verification Program Manual[1] and Section 8 of this protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions and carbon removals associated with a biochar project.[2]

[1] Available at http://www.climateactionreserve.org/how/program-resources/program-manual/.
[2] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Background

Biochar, the product of the heating of biomass at high temperatures in an oxygen-limited setting, is a carbon-densified material that has a growing list of beneficial uses, including as a soil amendment or as an additive for other agricultural, industrial, and commercial purposes. The soils of *Terra Preta de Indio* in the Amazon are often recognized as the most prominent evidence of the historical application of biochar to soils resulting in improved productivity. Furthermore, they are a testament to the long-term persistence of the organic carbon in biochar. Indeed, evidence from around the globe points to the use and persistence of biochar and biochar-like materials at agricultural sites for thousands of years (Wiedner et al., 2015). This protocol addresses the sequestration benefits related to the carbon contained in biochar, identifying the conditions that must be met for the potential net climate benefits from biochar to be realized.

Biochar can provide not only highly persistent carbon that remains out of the atmosphere for centuries, if not millennia, but also a variety of potential ancillary greenhouse gas benefits, depending on how it is applied, such as reduced methane emissions from enteric fermentation when biochar is used as a livestock feed additive (Man *et al.*, 2021) or reduced nitrous oxide emissions when applied to soils (Woolf *et al.,* 2021). Although the Reserve recognizes such ancillary GHG outcomes are possible and often quite likely, the accounting of such benefits is currently not included in this protocol owing to the inability of the current certainty in the scale and scope of such benefits to allow them to be incorporated into a standardized quantification approach, especially in ways that lends itself to practical monitoring and verification. Thus, the ancillary GHG benefits from biochar will be considered for future updates to the protocol and/or may be accounted for by other offset protocols that may be able to address such benefits more effectively, such as the Reserve's Soil Enrichment Protocol.

2.2 Project Definition

For the purpose of this protocol, a biochar project is defined as the set of activities related to the diversion of biomass from "business as usual" (baseline) uses, its conversion into biochar, and its application to a durable use that results in the long-term storage of carbon. Biochar is defined here as the carbonaceous solid material resulting from the thermochemical conversion of biomass in an oxygen-limited environment.

Project activities are those activities that are necessary for the production and application of biochar in a way that produces net climate benefits relative to the baseline scenario. Three distinct phases comprise the scope of a biochar project under this protocol: 1) biomass acquisition, 2) biochar production, and 3) biochar application. No specific configuration is required with respect to the activities from each phase comprising a project. Rather, the combination of such activities must, as a whole, produce quantifiable climate benefits. Nevertheless, activities that are eligible for inclusion within a given project are limited as follows for each phase.

2.2.1 Biomass Acquisition

Eligible biochar feedstocks must fall into one of two categories:

- Biomass that is a waste stream, by-product or residue from forest, agricultural, and other resource management industries (hereafter, waste and by-product biomass).
- Biomass grown under certain limited conditions for the purpose of producing biochar (hereafter, purpose-grown biomass).

A positive list of eligible feedstocks is contained in a separate document called the Eligible Biochar Feedstocks List on the Reserve's Biochar Protocol webpage. The list indicates the assumed baseline fate of each feedstock and any additional environmental safeguards or other limits to the use of a given feedstock. Feedstocks must also satisfy requirements specified under this protocol pertaining to additionality (Section 3.4.1.1), regulatory compliance (Section 3.6), and environmental safeguards (Section 3.7).

The Reserve may periodically review and update the Eligible Biochar Feedstocks List to incorporate additional feedstock types[3] and to ensure the list continues to effectively screen projects and associated feedstocks for the requirements outlined in this protocol. Project developers have 90 days from the date on which an updated list is released to submit a project that includes a removed feedstock. The project must still complete verification within its initial verification deadline, otherwise the feedstock will be deemed ineligible for the project.

Registered projects may continue to use feedstocks that are removed from the Eligible Biochar Feedstocks List for the duration of their current crediting period if they have previously verified and been issued credits for that feedstock or if they submit the verification that includes the removed feedstock to the Reserve within 12 months of the release of the updated list.

All feedstock sources must be clearly identified by the project developer as part of chain of custody tracking, including the physical location (parcel, facility, etc.) of each source and the date the biomass was obtained by the biochar producer. For additional details regarding chain of custody information provided for each feedstock source, see Section 6.2.

2.2.2 Biochar Production

Biochar produced via pyrolysis, gasification, and other thermochemical conversion processes are eligible to the extent that the resulting biochar meets all eligibility requirements under this protocol, including containing persistent organic carbon that can be reasonably expected to remain sequestered, as further described in Section 3.5. The intent is not to limit production process eligibility other than to those that are capable of meeting the requirements of this protocol, including demonstrating the long-term durability of the carbon in the biochar produced. This includes biochar generated during bioenergy production that is typically re-injected into the boiler furnace to be combusted but, under a project under this protocol, could be diverted so the biochar carbon remains sequestered and is put to another use.

Production processes must also adhere to all relevant environmental, health, and safety laws and regulations, as further described in Section 3.6.

[3] Feedstocks may be proposed to the Reserve for inclusion in the Eligible Biochar Feedstocks List.

2.2.3 Biochar Application

To be eligible under this protocol, the biochar produced as part of a project must be applied to an end use that ensures the long-term persistence of the sequestered carbon. Biochar may be used in soil applications or in non-soil applications, including in construction materials or other uses that result in the long-term storage of carbon, as discussed further in Section 3.5, so long as such applications comply with all pertinent additionality requirements, relevant legal obligations, environmental safeguards, and materials standards requirements under this protocol. Energy production is not an eligible application of biochar, nor are applications for which storage is highly variable, uncertain, or is expected to be short-term.

A positive list of eligible applications for biochar is provided as a separate document called the Eligible Biochar End Uses List on the Reserve's Biochar Protocol webpage and indicates any limits to their eligibility. The application of biochar under a project must also satisfy all requirements specified in relation to additionality (Section 3.4.1.3), regulatory compliance (Section 3.6), and environmental safeguards (Section 3.7).

The Reserve may periodically review and update the Eligible Biochar End Uses List, at its sole discretion, to incorporate additional end uses and to ensure the list continues to effectively screen projects and associated end uses for the requirements outlined in this protocol. In instances when an end use is removed from the Eligible Biochar End Uses List, the removed end use will remain eligible for the duration of the project crediting period, subject to the requirements of Sections 3.4.2 (Legal Additionality Test) and 3.6 (Regulatory Compliance), as long as:

- The project is a new project that is submitted[4] within 90 days of the release date of the updated list and the initial verification deadline is met; or
- The project has already been listed or registered prior to the release date of the updated list and:
    - The project has already been verified for the removed end use; or
    - The first verification of the removed end use is submitted to the Reserve within 12 months of the release date of the updated list.

Demonstration of end-use application is performed via chain of custody tracking, as further described in Section 6.2. Only those amounts of biochar for which chain of custody tracking is performed may be included for credit quantification purposes in Section 5. In instances where biochar is transferred to an intermediary that will subsequently transfer the biochar to an ultimate end user,[5] the end use may be reported based on the ultimate end use that may be reasonably assumed based on supporting evidence, such as marketing materials from the intermediary end user. In such cases, chain of custody tracking will only be required to such intermediary end users.

2.3 The Project Developer

The "project developer" is an entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Under this protocol, the project developer is assumed to be the biochar producer since their actions transform the carbon in biomass to a more persistent state.

[4] The project must still complete verification within its initial verification deadline, otherwise the end use will be deemed ineligible for the project.

[5] E.g., a retail store selling bags of biochar for application to home gardens or a "mixer" adding biochar to other materials, such as compost or concrete, with a known ultimate end use.

Furthermore, biochar producers have direct influence, via control of distribution, over the end use of the biochar—and hence its permanence—whether it is applied to an end use by the producer directly or is applied by an entity to whom the producer has chosen to distribute the biochar.

However, a project developer may be another entity involved with the project, such as the end user of the biochar or an entity coordinating the reporting and registration of a project,[6] as long as that entity has a documented agreement that conveys to them the ownership of the carbon credits. Such agreements must include an acknowledgement by the biochar producer of the existence of the carbon project and the transfer of credit ownership to the project developer. For example, a farmer applying biochar to their soil may be the project developer if they provide a documented agreement through which they obtain from the biochar producer the ownership of the carbon credits.

In any event, the project developer, whether the biochar producer or designee through agreement, must have clear ownership of the project's carbon credits. The project developer must also attest to such ownership by signing the Reserve's Attestation of Title form.[7] Furthermore, the project developer must notify end users of the carbon credits associated with the biochar and must provide evidence of such notification with specific language within purchase orders, sales receipts, or other verifiable documentation.

[6] Which may include the aggregation of several smaller producers.
[7] Attestation of Title form available at http://www.climateactionreserve.org/how/program-resources/forms/.

3 Eligibility Rules

Projects that meet the definition of a GHG removal project in Section 2.2 must fully satisfy the eligibility rules summarized here in order to register with the Reserve. The remainder of this section provides complete details of all eligibility requirements.

Section 3.1	Location	→	*U.S. and Canada and their tribal lands and territories*
Section 3.2	Project Start Date	→	*Date of project submission or date biochar production is initiated**
Section 3.3	Project Crediting Period	→	*Carbon removals may only be reported during the crediting period; the crediting period may be renewed twice*
Section 3.4	Additionality	→	*Meet performance standard test(s)*
		→	*Exceed regulatory requirements*
Section 3.5	Permanence	→	*Biochar is applied to eligible end use that provides long-term storage of carbon*
Section 3.6	Regulatory Compliance	→	*Compliance with all applicable laws*
Section 3.7	Environmental and Social Safeguards	→	*Comply with specified safeguards*

**See Section 3.2 for exception for projects with start dates prior to the adoption of this protocol.*

3.1 Location

Only projects located in the United States and Canada, their territories, and on tribal/First Nation lands within each country are eligible to register with the Reserve. Under this protocol, all phases of sourcing, production, and end use of the biochar must occur in eligible jurisdictions. Project activities may occur on locations where activities from other carbon project types are occurring, as long as such projects are in good standing with the program in which they were or are enrolled. However, such project stacking is subject to prior approval from the Reserve and guidance for any adjustments that may be required of the biochar project to ensure additionality and overall eligibility, as well as to prevent double-counting of credits, as described in Section 3.4.3.1.

3.2 Project Start Date

The project start date may be identified by the project developer based on one of the following:

- The date the project is submitted to the Reserve,[8] subject to considerations of historical biochar production levels, as described in Section 3.4.1.2.
- The date that biochar production commences using the production technology employed under the project. For projects employing mobile production equipment, including equipment that can be loaded onto a truck or other vehicle and transported to a new location, the date that biochar production commences using the production technology

[8] Projects are considered submitted when the project developer has fully completed and filed the Biochar Project Submittal Form, available at https://www.climateactionreserve.org/how/protocols/ncs/biochar/.

employed under the project is based on discrete undertakings that may be defined by relevant factors, such as contractual agreements (e.g., written agreement to produce biochar onsite from biomass removed during forest fuel thinnings on a given forest owner's tract of land) or production locations that have no direct or clear relationship with a prior production location (e.g., onsite production from biomass harvested from Farmer Chan's land in Minnesota using the same equipment that had previously been used to produce biochar on Farmer Olson's land in Ontario).

- Under certain circumstances, the start date may be defined as a date up to 12 months after biochar production first commences (as described above). The Reserve allows project developers to undergo a start-up testing period for a maximum of 12 months to complete project initiation activities prior to the project start date. The project developer must provide verifiable evidence to support that, during this period of time prior to the start date, the biochar production operation was not in business or functioning at scale (as reduced production rates relative to production after the start date). Documentation may include but is not limited to performance standard checks to confirm operability, internal communication, and/or project monitoring data.

Projects with start dates based on the date biochar production commences using the production technology employed under the project must be submitted to the Reserve no more than 12 months after the project start date, unless the project is submitted during the first 12 months following the date of adoption of this protocol (Version 1.0) by the Reserve board (the Effective Date). For a period of 12 months following the Effective Date, projects may be submitted with start dates up to 24 months prior to the Effective Date, subject to the Performance Standard Test identified for biochar production in Section 3.4.1.2. Specifically, projects may identify start dates on or after March 19, 2022, to register with the Reserve if submitted by March 18, 2025. Projects may not have start dates prior to March 19, 2022, under this protocol. For projects that are transferring to the Reserve from other offset registries, start date guidance can be found in the Reserve Offset Program Manual.

3.3 Project Crediting Period

The project "crediting period" defines the period of time over which a project's net carbon removals are eligible to be verified as CRTs. The crediting period for projects under this protocol is ten years, renewable up to two times for a potential total of thirty years of crediting. Each crediting period is composed of multiple reporting periods that meet the requirements in Section 7.4. The initial project crediting period begins at the project start date regardless of whether sufficient monitoring data are available to verify carbon removals from the project. At the end of each crediting period for a project, the project developer may apply for eligibility under another crediting period. However, the project must meet all eligibility requirements of the most current version of the protocol at the time of such application. If a project developer wishes to apply for eligibility under an additional ten-year crediting period, they must re-submit a project submittal form within six months of the end date of the current crediting period.

A project may be eligible for additional crediting periods even if the project has failed to maintain continuous reporting up to the time of applying for a second crediting period, provided the project developer elects to take a zero-credit reporting period for any period for which continuous reporting was not maintained.[9] Any additional crediting period shall begin on the day

[9] See zero-credit reporting period guidance and requirements in the Reserve Offset Program Manual, http://www.climateactionreserve.org/how/program/program-manual/.

following the end date of the initial crediting period. For example, if the first crediting period ends on June 30, 2034, the second crediting period start date would be July 1, 2034.

The Reserve will cease to issue CRTs for carbon removals if at any point in the future, the production and/or use of biochar becomes legally required, as defined by the terms of the legal requirement test (see Section 3.4.2). Thus, the Reserve will issue CRTs for carbon removals quantified and verified according to this protocol for ten-year crediting periods after the project start date, or until the project activity is enforced by law.

3.4 Additionality

The Reserve registers only projects that yield surplus GHG removals that are additional to what would have occurred in the absence of a carbon offset market.

Projects must satisfy the following tests to be considered additional:

1. The performance standard test
2. The legal requirement test

3.4.1 The Performance Standard Test

Projects must meet relevant performance thresholds for each phase to pass the overall performance standard test.

3.4.1.1 Biomass Acquisition

For the biomass acquisition phase, separate performance thresholds are identified for waste and by-product biomass and for purpose-grown biomass.

Waste and By-Product Biomass

The performance threshold for waste and by-product biomass is based on the common fate of such biomass. Waste and by-product biomass is, by definition, not put to productive uses and is eligible under this protocol if it typically has short lifespans before the carbon it contains is released into the atmosphere, either via combustion (e.g., logging slash piled and burned) or decomposition (e.g., manure spread on fields). As such, the production and use of biochar derived from such feedstocks can produce net carbon removals relative to the baseline, as determined in Section 5, provided the project meets all other eligibility requirements under this protocol. This includes biochar produced as a by-product during bioenergy generation process in which such biochar is prevented from being reinjected into the boiler furnace and combusted. Projects using waste and by-product feedstocks pass the performance standard test for the biomass acquisition phase if the following conditions are met:

1. The feedstocks being diverted under the project must be on the Eligible Biochar Feedstocks List, as described in Section 2.2.1.

2. The project developer must be able to characterize the typical fate of the project feedstocks, considering the local conditions and context of the project, to demonstrate that the source biomass was diverted from uses consistent with the assumed business as usual fate of the feedstock, as indicated in the Biochar Feedstocks Eligibility List, including in relation to supply conditions of biomass otherwise used for bioenergy production. Supporting evidence/documentation may be necessary to support the characterization for verification and may include (though is not limited to) governmental

resource reports, peer-reviewed studies, referred consultations with local resource agencies/experts, or direct records of prior disposition of a feedstock stream (e.g., if waste biomass produced on an ongoing basis from a facility is being redirected for biochar production).

The performance standard test for waste and by-product biomass is applied each reporting period. The basis for the performance standard test will be re-evaluated periodically by the Reserve to assess its ongoing validity, with modifications made as necessary to ensure the additionality of all projects in relation to the acquisition of waste and by-product feedstocks.

Purpose-Grown Biomass

Purpose-grown biomass is assumed to generate net carbon removals under this protocol to the extent quantified under Section 5 when two conditions are met in relation to the context in which they are cultivated:

1. They must be acquired from either marginal lands or from reclaimed mining sites. For the purposes of this protocol, marginal lands are those identified as being in Land Capability Class 5 or 6, based on standardized definitions recognized and spatial delineations established by the U.S. Department of Agriculture – Natural Resources Conservation Service[10] and Agriculture and Agri-Food Canada.[11] Although current economic conditions for the biochar industry likely minimize the risk of purpose-grown biomass replacing a commodity crop on a given area of land, the use of an area for the cultivation of biomass used in biochar production may lead to increased GHG emissions beyond the project boundaries if land use changes occur elsewhere as a result of the project activity (i.e., activity-shifting leakage). For example, the cultivation of biomass for biochar production on lands where commodity crops were cultivated may result in increases in commodity crop production elsewhere, including potentially via conversion of previously non-cultivated lands.

   In addition to being produced on marginal croplands or reclaimed mining sites, purpose-grown biomass must not be acquired from sites that, within the three years prior to its use for supplying biomass for biochar production under the project, were used for the production of commodity crops, underwent a land use change from a natural or native vegetation type, or were converted from a vegetation type with a higher carbon-density. Furthermore, the project developer must demonstrate that a waste management plan is in place that will limit emissions associated with anaerobic decomposition that may occur while the purpose-grown biomass is being stored prior to being transferred for conversion to biochar.

2. They must be grown under conditions whereby there is little to no ecosystem carbon loss associated with the biomass when it is harvested to produce biochar, excluding feedstock production-related emissions and activity-shifting leakage, which are otherwise addressed in Section 5.2.1.1 and Section 5.3, respectively. In other words, the harvesting of the biomass must not result in either the loss of carbon in the cultivated crop that is not typically recovered by regrowth within a year or the depletion of soil organic carbon in the near-term. For example, biomass from perennial grass species that are grown and harvested with minimal soil disturbance, thus preventing the

[10] SSURGO soil survey data, available at https://websoilsurvey.nrcs.usda.gov/app/
[11] National Soil Database, available at https://sis.agr.gc.ca/cansis/nsdb/index.html

depletion of soil organic carbon stocks, have no carbon debt in this regard when used as a feedstock for biochar production. Project developers using purpose-grown biomass must use a type included on the Eligible Biochar Feedstocks List. They must also identify the harvest conditions associated with the project feedstocks and be able to attest that no tillage occurred as a part of the cultivation cycle for the biomass harvested for use under the project.

The performance standard test for purpose-grown biomass is applied each reporting period. The basis for this performance standard test will be re-evaluated periodically by the Reserve to assess its ongoing validity, with modifications made as necessary to ensure the additionality of all projects in relation to the acquisition of purpose-grown biomass.

3.4.1.2 Biochar Production

The performance standard for biochar production is based on the effect of the incentive of the issuance of carbon credits to foster the production and use of biochar in ways that are eligible under this protocol and provide net climate benefits.

The production of biochar in the US and Canada faces numerous impediments. Despite the known benefits already demonstrated for biochar, including in relation to agricultural soils and productivity, the biochar market has experienced highly constrained growth to date, with companies often struggling to maintain production over time. This is due in part to uncertain demand for biochar, feedstock supply chain inconsistency, and high sales prices typically required to cover production costs (Elias et al., 2023; Thengane et al., 2021). Although there is growing interest in the production and use of biochar, it remains an uncommon use for biomass supplies, resulting in approximately 200,000 tons of biochar produced annually in the US and Canada (IBI and US Biochar Initiative, 2024) despite well over 1 billion tons of waste or residual biomass being potentially available each year (Lefebvre et al., 2023; Karan et al., 2023). Emphasizing the industry's nascent status is the lack of a commodity market for biochar. In the absence of the incentive provided by carbon markets, muted biochar production levels would likely remain over the near term. However, revenue from carbon credit sales has been anticipated by biochar producers to improve the viability of their operations (Thengane et al., 2021). Credit sales have also been shown through economic analysis to provide improved and often positive rates of return to biochar production operations (Elias et al., 2023). Carbon crediting opportunities that have emerged in recent years have already spurred growth in the market[12] as carbon revenues provide more favorable cost-revenue profiles to participating producers.

Despite challenging conditions faced by the industry, there may be pre-existing operations that have been producing biochar prior to the project's start date (i.e., when the start date is based on submitting a project to the Reserve). In such cases, production levels prior to the project start date are not eligible for crediting as such activities are viewed as "business as usual." Therefore, the project developer must determine the maximum annual output of the operations during the three years immediately prior to the project start date as the benchmark for any business-as-usual activities. That maximum annual output will be entered into the credit quantification for the project as a deduction to the amount of biochar produced by the operations after the project start date, as outlined in Section 5.2.2. Thus, a project meets the performance standard test for biochar production to the extent such production and its associated end use(s) meet all other eligibility requirements and produce net carbon removals, including relative to the

[12] See https://www.cdr.fyi/

production of biochar by the project operations prior to the project start date, as quantified according to Section 5.

Production of biochar using mobile equipment (i.e., can be moved from one location and not fixed to a single location on a permanent basis) is considered pre-existing when such production is associated with a coordinated production effort underway prior to the submission of the project under this protocol, whereby biochar was already being produced and would continue to be produced regardless whether a carbon project were to be registered. (See the related discussion under Section 3.2 with respect to start dates.) For example, if a landowner contracted with a mobile biochar producer to generate biochar from biomass removed during forest fuel treatments and biochar had already been produced under that contract prior to the submission of the project to the Reserve, such production would be considered pre-existing. However, if that same biochar producer were to contract with another landowner, use the same mobile equipment, and submit the carbon project when production first begins, that project would be considered to have no pre-existing production.

If a project developer believes they have a case for additionality despite historical production during the three years prior to the project start date (e.g., subsidies making production possible being extinguished, highly specific end use/client that is no longer an option), they may contact Reserve staff prior to submission for listing to have a determination made on the potential additionality of the project with respect to prior biochar production.

The performance standard test for biochar production is applied at the time a project applies for initial registration with the Reserve, as well as at the start of any additional crediting periods. The basis for the performance standard test will be re-evaluated periodically by the Reserve to assess its ongoing validity, with modifications made as necessary to ensure the additionality of new projects and projects seeking to renew their crediting period. Nevertheless, projects that pass the performance standard test, whether at the time of initial registration or when renewing their crediting period, remain eligible in this regard throughout their crediting period.

3.4.1.3 Biochar Application

The performance threshold for the biochar application phase is based on the durability of biochar produced under a project in the context of the end use to which it is applied. Biochar produced under this protocol must not only be of sufficient quality to provide for the potential long-term sequestration of the carbon it contains, as described in relation to permanence in Section 3.5. It must also be applied in an end use that provides for the realization of that potential for long-term sequestration. As such, projects meet the performance standard for biochar application by employing end uses identified on the Biochar End Uses Eligibility List, as previously described in Section 2.2.3.

3.4.2 The Legal Requirement Test

All projects are subject to a legal requirement test to ensure that the GHG reductions and removals achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or other legally binding mandates.

To satisfy the legal requirement test, the production of biochar and its application in an eligible end use must not be legally mandated. Project developers must submit a signed Attestation of Voluntary Implementation form[13] prior to the commencement of verification activities each

[13] Attestation forms are available at http://www.climateactionreserve.org/how/program/documents/.

reporting period that is verified (see Section 8). In addition, the project's Monitoring Plan (Section 6) must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the legal requirement test. If the production and use of biochar becomes legally required after a project has initiated, carbon removals may be reported to the Reserve up until the date that the requirement for such production and use comes into effect and is enforced.

3.4.3 Ecosystem Services Payment Stacking

When multiple ecosystem services credits or payments are sought for a single activity on a single piece of land or facility, with some temporal overlap between the different credits or payments, it is referred to as "credit stacking" or "payment stacking," respectively (Cooley & Olander, 2011). Under this protocol, credit stacking is defined as receiving both carbon offset credits and other mitigation credits for the same activity on spatially overlapping areas (i.e., in the same acre or the same facility or operations) associated with any phase of a biochar project. Mitigation credits are any instruments issued for the purpose of offsetting the environmental impacts of another entity, such as emissions of GHGs, removal of wetlands or discharge of pollutants into waterways, to name a few. Payment stacking is defined as receiving payments for a best management or conservation practice that is also funded by the government or other parties via grants, subsidies, payment, etc., on the same land or in the same facility or set of operations.

Any type of conservation or ecosystem service payment received for activities on the project area must be disclosed by the project developer to the verification body and the Reserve on an ongoing basis. Failure to disclose such payments may result in project ineligibility.

3.4.3.1 Credit Stacking

The Reserve has identified only one type of mitigation credit market opportunity that needs to be assessed as part of the eligibility of a biochar project. Activities attributable to a given biochar project may spatially and temporally overlap with the activities attributable to other carbon or GHG mitigation project types, such as improved forest management projects or projects registering under the Reduced Emissions from Megafires (REM) Forecast Methodology with the Reserve's Climate Forward Program. Project stacking (where project activities are reported under multiple protocols as separate projects with distinct climate benefits) may impact project eligibility if the additionality of any individual project being stacked is affected, or if it results in conflicting claims of credit ownership or double-counting of credits. For example, biochar for which credits are sought under this protocol likely would not be allowed to be applied to soils on fields enrolled in a carbon project under a protocol focused on GHG benefits from agricultural practices unless the increases in soil organic carbon directly attributable to biochar amendments are not accounted for under the agricultural project, though other benefits from the application of biochar to soils, such as reduced nitrous oxide emissions, may be accounted for. On the other hand, credit stacking between a biochar project and a project registered under the REM Forecast Methodology may be allowed as long as additionality is not impacted for either project as a result of such stacking and the carbon sequestered in the biomass removed from the forest during fuel treatments and stored in harvested wood products is not accounted for under the REM project, thereby avoiding potential double-counting.

Any intended project stacking must be disclosed to the Reserve when the project is submitted for listing and prior to any time such stacking occurs during a project's crediting period. Reserve staff will determine if stacking is approved and will provide guidance on any further adjustments

that may be required of the project to ensure additionality and all other eligibility requirements can be met, and to avoid double-counting of credits.

3.4.3.2 Payment Stacking

The Reserve has identified one general type of payment that supports the activities being credited under this protocol. These types of payments are known as "enhancement" payments.

Enhancement payments provide financial assistance to landowners to implement discrete conservation practices that address natural resource concerns and deliver environmental benefits. An example of relevant enhancement payments are cost-share payments administered by the NRCS Environmental Quality Incentives Program (2014 Farm Bill). However, since multiple phases are required to undertake a biochar project and enhancement payments tend to only address a single project phase, such payments are not likely to impact project additionality and are generally allowed to be pursued by project developers.

Nevertheless, project developers should inquire of entities associated with any project phase whether they are receiving enhancement payments in relation to the project activities. Because every available enhancement payment is not comprehensively addressed by the protocol at this time, the project developer must still disclose any such payments to the verifier and the Reserve on an ongoing basis.

3.5 Permanence

The Reserve requires that credited reversible GHG reductions and removals be effectively "permanent" in order to serve as valid offset credits. For purposes of this protocol, permanence relates to the persistence of the organic carbon in biochar on a 100-year basis. A tonne of biochar produced and utilized is considered permanent, and credited as such, based on the relative amount of the tonne that remains sequestered over the 100-year period. For biochar applications that are not anticipated to maintain sequestered carbon for the full 100-year term, the average amount of each tonne anticipated to be sequestered throughout the 100-year period will be credited. For each project, the permanence of the biochar produced is based on the end use(s) of the biochar. The quantification approach outlined in Section 5 relies on the application of default permanence factors to estimate the proportion of carbon remaining sequestered based on the end use(s) of the project biochar. Only those end uses for which there are reasonable levels of certainty about the long-term fate of the applied biochar and the carbon it contains are eligible for crediting under this protocol and included in the Eligible Biochar End Uses List.

Regardless of the end use, the biochar produced under a project must have a demonstrated level of potential for long-term stability commonly associated with biochar, resulting from the highly persistent molecular structure of biochar established during the thermochemical conversion process. Under this protocol, this persistence is evidenced indirectly by biochar having a molar ratio of hydrogen to organic carbon ($H:C_{org}$) less than 0.7 (Budai et al., 2013), in line with the International Biochar Initiative's *Standardized Product Definition and Product Testing Guidelines for Biochar that Is Used in Soil* (IBI, 2015) and based on the sampling and laboratory analysis results for $H:C_{org}$, as further described in Section 6.3. If ongoing sampling and laboratory analyses results in an updated $H:C_{org}$ value equal to or above 0.7, biochar produced under the project will be ineligible (i.e., no CRTs issued) for that period of time until additional sampling and analysis results lower the value below 0.7.

Beyond long-term degradation of biochar, the primary risk of carbon in biochar being reversed and released into the atmosphere is from combustion. As described in Section 2.2, combustion for energy production purposes is not an eligible end use for biochar under this protocol. Additionally, since only biochar that is verified to have been applied to eligible reported end uses by the project developer may be credited, any loss of carbon associated with combustion after biochar is produced but prior to end use application is already accounted for via project reporting and quantification requirements. Thus, the remaining combustion risk is post-application, when the risk is negligible.

3.6 Regulatory Compliance

Project developers must attest that project activities do not cause material violations of applicable laws (e.g., air, water quality, safety, etc.). The determination of regulatory compliance must take into consideration processes and outcomes related to all activities accounted for under the chain of custody tracking requirements (Section 6.2), i.e., from the time feedstocks are diverted (waste/by-product biomass) or harvested (purpose-grown feedstocks), through when biochar is delivered to the end user. This includes entities temporarily taking custody of feedstocks or biochar between project phases, such as transporters or storage facilities. To satisfy this requirement, project developers must submit a signed Attestation of Regulatory Compliance form[14] prior to the commencement of verification activities each time the project is verified.

Project developers are also required to disclose in writing to the verifier any and all instances of legal violations – material or otherwise – caused by the project activities. A violation would be considered to be "caused" by project activities if it can be reasonably argued that the violation would not have occurred in the absence of the project activities. If there is any question of causality, the project developer shall disclose the violation to the verifier.

If a verifier finds that project activities have caused a material violation, then CRTs will not be issued for GHG reductions that occurred during the period(s) when the violation occurred. Individual violations due to administrative or reporting issues, or due to "acts of nature," are not considered material and will not affect CRT crediting. However, recurrent administrative violations directly related to project activities may affect crediting. Verifiers must determine if recurrent violations rise to the level of materiality. If the verifier is unable to assess the materiality of the violation, then the verifier shall consult with the Reserve.

3.7 Environmental and Social Safeguards

This protocol is intended to credit for the carbon removals associated with the production of biochar and long-term maintenance of the carbon it contains out of the atmosphere. All three phases of a biochar project have the potential to occur within or interact with natural and working lands and thus have the potential to degrade ecosystem services such as water quality, biodiversity, and air quality. This protocol relies primarily on the feedstock and end use eligibility positive lists (described in Section 2.2) and existing laws and regulatory programs (described in Section 3.6) to ensure community standards for such issues are met. While the positive eligibility lists provide specific limits with respect to allowable conditions for biomass sourcing and eventual biochar application, the regulatory compliance requirements in the preceding section set out guidance for ensuring no legal standards or obligations are violated, including laws relating to broader non-GHG impacts of projects. The obligation to comply with relevant legal requirements includes those laws and regulations pertaining to worker health and safety.

[14] Attestation forms are available at http://www.climateactionreserve.org/how/program/documents/.

Additionally, projects involving field-based biochar production must provide a safety plan outlining procedures and precautions meant to ensure worker safety during operations if such procedures are not already required by law.

Biochar feedstocks under a project may contain mineral additives, such as ash, lime or rock minerals. Feedstocks may similarly contain contaminants. However, projects must remain in material compliance with all applicable laws and regulations, including those related to contaminants contained in biochar and the end(s) uses to which biochar is applied. Project developers must test for contaminants in biochar produced under the project, as further outlined in Section 6.3.1.2, to show the standards and limits relevant to the end use to which the biochar is applied have been met. For those jurisdictions for which limits on contaminants are not specified, biochar produced under a project must comply with the basis for limits referenced for each end use in the Eligible Biochar End Uses List.

Given a current lack of environmental standards for organic contaminants in end use products, this protocol specifies limits for their presence in project biochar, as indicated in Table 3.1. However, production conditions may minimize the risk of resulting biochar containing certain contaminants. The following conditions, when present, indicate an increased risk for the presence of organic contaminants in project biochar and for which testing for a specific set of contaminants is required when the end use for the biochar results in environmental exposure.

Table 3.1. Organic contaminant concentration limits and conditions for testing

Contaminant	Maximum concentration*	Conditions Under Which Testing Is Required
Polychlorinated Biphenyls (PCBs)	0.2 mg/kg (DM)	Feedstocks contain significant levels of chlorine and biochar production temperatures <500° C Feedstocks with high chlorine content risk are identified in the Biochar Feedstocks Eligibility List
Dioxins/Furans (PCDD/Fs)	20 ng/kg (I-TEQ OMS)	Biochar production temperatures <500° C
Polycyclic Aromatic Hydrocarbons (PAHs)	8 EFSA PAH: Agricultural/urban applications = 1.0 g/t DM; 4.0 g/t DM for all other end uses	Biochar production temperatures >500° C When one of the following conditions (based on Buss et al., 2022) is not met: • Pyrolysis gases and solids are separated within the pyrolysis unit, such as occurs when pyrolysis gases are extracted close to the feedstock entry point. • If pyrolytic gases and solids are not separated within the pyrolysis unit, the discharge chamber is heated (either actively using external input or passively via residual heat from the pyrolysis unit) to maintain a temperature similar to that within the pyrolysis unit.

*Based on limits identified by the *World Biochar Certificate – Guidelines for a Sustainable Production of Biochar* (2023)

Contaminant testing is not required for end uses that prevent environmental exposure of contaminants, so long as the project developer can demonstrate that no relevant laws or regulations otherwise limit contaminants in that end use.

Although biochar projects are expected to be developed in ways that provide a variety of environmental benefits, the project developer should nonetheless take all reasonable precautions to ensure no broader harms are caused by the project. Furthermore, the Reserve urges project developers to describe any significant impacts (positive or negative) that their GHG projects will have on other environmental issues such as air and water quality, endangered species and natural resource protection, and environmental justice. Although such reporting is optional, the intent with this guidance is to encourage project developers to better highlight the ways in which their projects positively or negatively affect such goals and, where potential negative environmental and socio-economic impacts are identified, describe the steps that have been, or will be, taken to mitigate and/or monitor them. The Reserve provides an SDG Reporting Tool on its website[15] to facilitate the reporting of co-benefits in relation to the United Nation's Sustainable Development Goals.

[15] http://www.climateactionreserve.org/how/program-resources/forms/

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that must be assessed by project developers in order to determine the net change in emissions caused by a biochar project.

Figure 4.1 illustrates all relevant GHG SSRs associated with biochar project activities and delineates the GHG Assessment Boundary. GHG SSRs are included for assessment where the differences between project and baseline quantification are likely to be significant.

Table 4.1 provides greater detail on each SSR and justification for the inclusion or exclusion of certain SSRs and gases from the GHG Assessment Boundary.

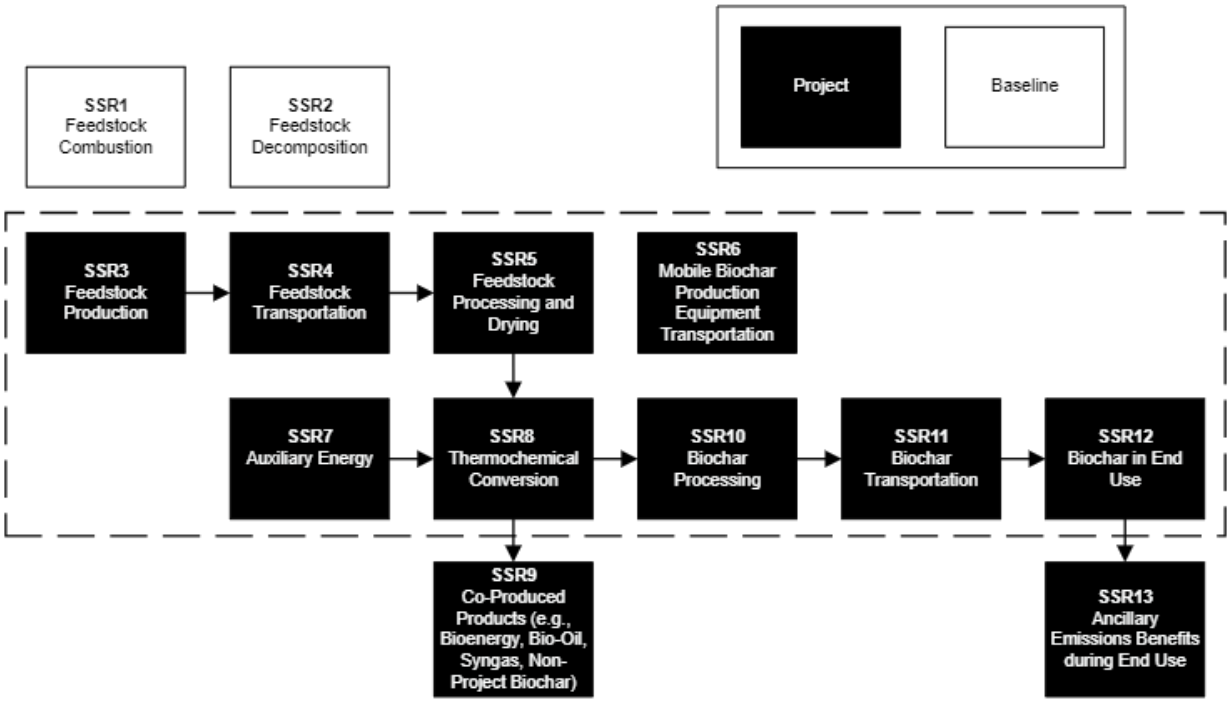

Figure 4.1. General illustration of the GHG Assessment Boundary. SSRs within the dashed lines are included in project accounting.

Table 4.1. Description of all Sources, Sinks, and Reservoirs

SSR	Source Description	Gas	Included (I) or Excluded (E)	Baseline (B) or Project (P)	Justification/Explanation
1	Feedstock Combustion	CO_2 CH_4	E	**Baseline:** Assumed to be zero for eligible feedstocks, thus effectively excluded **Project:** N/A	Although the combustion of biomass under the baseline scenario would result in GHG emissions, those emissions are not quantified under this protocol on a conservative basis, as described in Section 5.1.
2	Feedstock Decomposition	CO_2 CH_4	E	**Baseline:** Assumed to be zero for eligible feedstocks, thus effectively excluded **Project:** N/A	Although the decomposition of biomass under the baseline scenario would result in GHG emissions, those emissions are not quantified under this protocol on a conservative basis, as described in Section 5.1.
3	Feedstock Production (Fossil Fuels, Fertilizer)	CO_2	I (conditionally included when purpose-grown biomass is used)	**Baseline:** N/A **Project:** Calculated from chain of custody or other documentation and standardized emissions factors	Emissions associated with the production of waste and by-product feedstocks is not required to be accounted for under this protocol since such emissions would have occurred even in the absence of the project. However, the cultivation of purpose-grown biomass to provide a feedstock supply for biochar production can result in significant emissions that would not have occurred if not for the project. Such emissions are associated with fossil fuel consumption from equipment and fertilizer use during cultivation and harvest.
4	Feedstock Transportation	CO_2	I	**Baseline:** N/A **Project:** Calculated from chain of custody or other documentation and standardized emissions factors	Emissions from the transportation of feedstocks have the potential to be significant, in particular when biochar is produced at a location not in close proximity to the biomass source.

SSR	Source Description	Gas	Included (I) or Excluded (E)	Baseline (B) or Project (P)	Justification/Explanation
5	Feedstock Processing and Drying (Electricity, Fossil Fuels)	CO_2	I (conditionally included when feedstocks are actively processed and/or dried)	**Baseline:** N/A **Project:** Calculated from electricity and fossil fuel consumption records and standardized emissions factors	When fossil fuels are combusted or electricity is consumed to process biomass prior to conversion to biochar, significant emissions can be generated.
6	Mobile Biochar Production Equipment Transportation	CO_2	I (conditionally included when mobile biochar production equipment is used and transported under the project)	**Baseline:** N/A **Project:** Calculated from chain of custody or other documentation and standardized emissions factors	Emissions from the transportation of mobile biochar equipment have the potential to be significant, in particular when such equipment is moved long distances to be located near a particular feedstock source.
7	Auxiliary Energy (Electricity, Fossil Fuels)	CO_2	I	**Baseline:** N/A **Project:** Calculated from electricity and fossil fuel consumption records and standardized emissions factors	Electricity use and fossil fuel combustion to support the thermochemical conversion process can lead to significant emissions.
8	Thermochemical Conversion	CH_4	I (conditionally included for certain thermochemical conversion processes)	**Baseline:** N/A **Project:** Calculated from reported biochar output and standardized emissions factors by biochar production process	For thermochemical conversion processes that do not recover or combust methane, such emissions may be significant and must be accounted for.

SSR	Source Description	Gas	Included (I) or Excluded (E)	Baseline (B) or Project (P)	Justification/Explanation
9	Co-Produced Products (e.g., Bioenergy, Bio-Oil, Syngas, Non-project Biochar)	CO_2 CH_4 N_2O	E	**Baseline:** N/A **Project:** N/A	Although materials co-produced at the same facility as project biochar may have emissions or sequestered carbon associated with their use, such emissions and carbon are excluded from the scope of project accounting since baseline emissions affiliated with such products are also not accounted for under this protocol.
10	Biochar Processing (Electricity, Fossil Fuels)	CO_2	I (conditionally included when biochar is actively processed prior to application)	**Baseline:** N/A **Project:** Calculated from electricity and fossil fuel consumption records and standardized emissions factors	Electricity use and fossil fuels combustion to process biochar can produce significant emissions and must be accounted for, whether such processing is performed by the biochar producer, an end user, or an entity acting as an intermediary between the biochar producer and the ultimate end user(s).
11	Biochar Transportation	CO_2	I	**Baseline:** N/A **Project**: Calculated from chain of custody or other documentation and standardized emissions factors	Emissions from the transportation of biochar has the potential to be significant, in particular when biochar is produced at a location not in close proximity to the biochar end use. For certain end uses for which biochar serves as a substitute for another material, such transportation emissions are excluded from project accounting. Such applications are identified in the Eligible Biochar End Uses List.
12	Biochar in End Use	CO_2	I	**Baseline:** N/A **Project:** Calculated from chain of custody documentation, laboratory analyses results, and standardized factors	Carbon sequestered in a highly persistent molecular structures within biochar is the primary climate benefit accounted for under this protocol.
13	Ancillary Emissions Benefits during End Use	CO_2 CH_4 N_2O	E	**Baseline:** N/A **Project**: N/A	Although ancillary GHG benefits may be produced when biochar is applied to certain end uses under appropriate circumstances, such benefits are not accounted for under this protocol at this time.

5 Quantifying Carbon Removals

Carbon removals from a biochar project are quantified by comparing actual project emissions and sequestered carbon to the calculated baseline emissions and sequestered carbon. Baseline emissions and carbon stocks are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred, as well as the carbon that would remain sequestered, in the absence of the project. Project emissions and carbon stocks are actual GHG emissions and sequestered carbon from sources, sinks, and reservoirs within the GHG Assessment Boundary. The difference between baseline and project emissions and baseline and project carbon stocks serves as the basis for the project's total net carbon removals (Equation 5.1).

Equation 5.1. Calculating net carbon removals

$$\boldsymbol{QR = (BE - PE) - (BC - PC) - SE}$$

Where,

			Units
QR	=	Total quantified removals for the reporting period	tCO_2e
BE	=	Total baseline emissions for the reporting period, from all emission-based SSRs in the GHG Assessment Boundary Baseline emissions are assumed to be zero for all projects (refer to Section 5.1).	tCO_2e
PE	=	Total project emissions for the reporting period, from all SSRs in the GHG Assessment Boundary (as calculated in Section 5.2)	tCO_2e
BC	=	Total carbon sequestered in the baseline scenario for the reporting period. Carbon stocks are assumed to be zero for all projects (refer to Section 5.1).	tCO_2e
PC	=	Total carbon sequestered by the project for the reporting period	tCO_2e
SE	=	Emissions associated with secondary effects from projects required to report such emissions (see Section 5.3)	tCO_2e

The Reserve provides a Biochar CRT Calculation Tool, a spreadsheet-based quantification tool, for use with all projects to facilitate the calculations required under this protocol. Carbon removals must be quantified and verified on at least an annual basis. Project developers may choose to quantify and verify carbon removals on a more frequent basis if they desire. The length of time over which carbon removals are periodically quantified and verified is called the "reporting period," as further described in Section 7.4.

Note that global warming potential (GWP) values in the equations in this section are specified as variables. The GWP values used are based on those currently required programmatically by the Reserve. At the time of initial adoption, the 100-year GWP values specified for use under the Reserve's protocols are from the Fifth Assessment Report (AR5) from the Intergovernmental Panel on Climate Change (Myhre et al., 2013). GWPs applicable at any given time are incorporated into the Biochar CRT Calculation Tool, which will be updated any time the Reserve updates its programmatic GWP values.

5.1 Quantifying the Baseline

The baseline approach employed under this protocol assumes no emissions occur under the baseline. Although there would be emissions expected to be associated with the fate of the

feedstock biomass in the absence of the project, it is conservative to assume a value of zero for the variable *BE* in Equation 5.1.

Although some carbon in eligible waste and by-product feedstock types may be sequestered under the baseline scenario, the vast majority of such carbon combusts or decomposes over relatively short time scales. Any remaining carbon would be insignificant relative to those emissions from combustion or decomposition. Since such emissions are assumed to be zero under this protocol, baseline carbon stocks (variable *BC* in Equation 5.1) may also be assumed to have a value of zero while maintaining a conservative baseline overall. As such, there is no requirement to account for baseline carbon stocks.

5.2 Quantifying Project Emissions and Carbon Removals

Project emissions and carbon removals are actual GHG emissions and removals that occur within the GHG Assessment Boundary as a result of the project activity. Project emissions and removals must be quantified every reporting period on an *ex post* basis.

5.2.1 Calculating Project Emissions

Estimates of GHG emissions associated with the project are based on the sources included in the GHG assessment boundary for the project, as identified in Table 4.1. Depending on the configuration of project phases, these may include emissions from the transportation of feedstocks, drying and processing of feedstocks, use of auxiliary fuels and/or electricity during biochar production, and processing of the outputs from thermochemical conversion. The total project emissions for a reporting period are based on the calculation described in Equation 5.2 and are entered into Equation 5.1 as *PE*.

Equation 5.2. Project emissions

$$PE = PE_{FProd} + PE_{FT} + PE_{FProc} + PE_{MT} + PE_{AE} + PE_{TC} + PE_{BP} + PE_{BT}$$

Where,			Units
PE	=	Total emissions from the project for the reporting period	tCO_2e
pE_{FProd}	=	Emissions from production of feedstocks for the reporting period (see Equation 5.4)	tCO_2e
PE_{FT}	=	Emissions from transportation of feedstocks for the reporting period (see Equation 5.5)	tCO_2e
pE_{FProc}	=	Emissions from processing and drying of feedstocks at biochar production facility for the reporting period (see Equation 5.6)	tCO_2e
PE_{MT}	=	Emissions from transportation of mobile biochar production equipment for the reporting period (see Equation 5.7)	tCO_2e
PE_{AE}	=	Emissions from auxiliary energy use during biochar production for the reporting period (see Equation 5.8)	tCO_2e
PE_{TC}	=	Emissions from thermochemical conversion under biochar production conditions that do not recover or combust non-CO_2 GHGs for the reporting period (see Equation 5.9)	tCO_2e
PE_{BP}	=	Emissions from processing of biochar for the reporting period (see Equation 5.10)	tCO_2e
PE_{BT}	=	Emissions from transportation of biochar to end use location for the reporting period, when applicable (see Equation 5.11)	tCO_2e

If emissions from fossil fuel combustion or electricity from any of the emissions sources described below are attributable to a facility rather than an individual source (e.g., feedstock processing, auxiliary emissions), the emissions for the facility may be calculated and reported under one of the sources. For example, if a biochar production facility has fossil fuel combustion and electricity consumption data for the facility as a whole rather than separately for the feedstock processing, auxiliary energy, and biochar processing processes, the project developer may enter the facility-level data in the feedstock processing emissions section of the Biochar CRT Calculation Tool and provide a corresponding description of the facility-wide nature of the data in the Project Data Report.

Where biochar is not the sole product of the facility where it is produced for the project, auxiliary emissions attributable to the biochar project are determined on a proportional basis relative to the total product output generated by the project facility, resulting in the adjustment factor (*AF*) applied in Equation 5.4, Equation 5.5, Equation 5.6, Equation 5.8, and Equation 5.9. A common metric based on the energy content of all relevant facility outputs is employed to determine the combined output of the facility and to determine the proportion emissions attributable to the biochar project. Conversion factors for energy content are provided in the Biochar CRT Calculation Tool, to which facility output amounts are to be applied to determine the values for the variables in Equation 5.3. Project-specific energy content for co-products such as bio-oil and syngas may be substituted for default factors provided in the tool when the project developer is able to provide verifiable laboratory testing results. When a co-produced output is used onsite and is not directly measured (e.g., electricity used at the facility rather than being sent to the grid), the project developer must provide a reasonable estimation of the amount produced and describe the basis for their estimation. If a project developer is unable or unwilling to determine appropriate data for the calculation of the adjustment factor, they may opt to apply a value of 100% for *AF*, which would provide a conservative estimate of the emissions associated with the project.

Equation 5.3. Adjustment factor for proportional allocation of emissions in co-production settings

$$AF = {(M_B \times EE_B)}/{E_{ProdTot}}$$

Where,

			Units
AF	=	Proportional adjustment to emissions to account for only project-related emissions	%
M_B	=	Total mass of biochar produced under the project in a co-production setting for the reporting period	tonnes
EE_B	=	Energetic equivalent average, per unit of mass, of all biochar generated under the project for CRT quantification purposes for the reporting period	Btu/tonne
$E_{ProdTot}$	=	Total energetic equivalent output of all co-products generated by the facility producing biochar for the project during the reporting period	Btu

And

$$E_{ProdTot} = (M_B \times EE_B) + (EP_{Tot} \times EE_{EP}) + (TE_{Th}) + (M_O \times EE_O)$$

Where,

EP_{Tot}	=	Total amount of electricity generated by the facility producing biochar for the project during the reporting period, excluding parasitic load.	MWh
EE_{EP}	=	Energetic equivalent, per unit, of electricity generated by the biochar production facility for the reporting period	Btu/MWh
TE_{Th}	=	Total units of usable thermal energy generated by the biochar production facility for the reporting period and not used in thermal or electrical energy generation (e.g., steam for heating, food, and/or fiber processing)	Btu
M_O	=	Total units of all other products other than heat or electricity produced by the biochar production facility for the reporting period, including but not limited to non-project biochar, hydrogen, gas, and bio-oil.	Variable units
EE_O	=	Energetic equivalent, per unit, of all other products other than heat or electricity generated by the biochar production facility for the reporting period, including but not limited to non-project biochar, hydrogen, gas, and bio-oil.	Btu/unit

5.2.1.1 Feedstock Production Emissions

When biomass grown for the purpose of providing a feedstock source for biochar production is used by a project, the emissions associated with the production of that crop are required to be accounted for, as described in Equation 5.4, since such emissions would not have occurred if not for the project taking place. For the purposes of this protocol, default emissions factors are provided for the quantification of feedstock production emissions, with emissions based on the total mass of the biomass delivered for biochar production. The intent is to account for emissions associated with the operation of fossil fuel-powered equipment used for the cultivation and harvesting of such biomass, as well as emissions associated with fertilizer applications. Standardized emissions factors, based on crop type, are provided in the Biochar CRT Calculation Tool. Production emissions are not quantified for feedstocks that are waste or by-product materials.

Equation 5.4. Feedstock production emissions

$$PE_{FProd} = \sum_{F} M_F \times EF_F \times AF$$

Where,			Units
PE_{FProd}	=	Total emissions from production of purpose-grown biomass feedstocks for the reporting period	tCO_2e
M_F	=	Mass of purpose-grown biomass feedstock *F*	tonnes (dry)
EF_F	=	Emissions factor for production of purpose-grown biomass feedstock type *F*	tCO_2e/tonne
AF	=	Proportional adjustment to emissions to account for only project-related emissions (see Equation 5.3)	%

5.2.1.2 Feedstock Transportation Emissions

Emissions from the transport of feedstock materials to production are determined using Equation 5.5 and are entered as PE_{FT} in Equation 5.1. Transportation emissions may be calculated based on fuel records, if available, or on the transportation mode, mass of feedstock transported, and distance traveled. Default emissions factors for either approach are provided in the Biochar CRT Calculation Tool. Projects producing biochar at the site of the feedstock source are not required to calculate feedstock transportation emissions.

Equation 5.5. Feedstock transportation emissions

Equation 5.5a: Calculation of feedstock transportation emissions based on fuel records

$$PE_{FT} = \sum_{ff} V_{ff} \times EF_{ff} \times AF$$

Where,			Units
PE_{FT}	=	Total emissions from transportation of feedstocks for the reporting period	tCO_2e
V_{ff}	=	Volume of fuel type *ff* consumed	unit of volume
EF_{ff}	=	Emissions factor for fuel type *ff*	tCO_2e/unit of volume
AF	=	Proportional adjustment to emissions to account for only project-related emissions (see Equation 5.3)	%

Equation 5.5b: Calculation of feedstock transportation emissions based on transportation type, mass of feedstock transported, and distance traveled

$$PE_{FT} = \sum_{tr} M_{tr} \times D_{tr} \times EF_{tr} \times AF$$

Where,			Units
M_{tr}	=	Mass of feedstock transported by transportation type *tr*	tonnes
D_{tr}	=	Total distance feedstocks were transported using transportation type *tr* for the reporting period	km
EF_{tr}	=	Emissions factor for transportation type *tr*	tCO_2e/tonne-km
AF	=	Proportional adjustment to emissions to account for only project-related emissions (see Equation 5.3)	%

5.2.1.3 Feedstock Processing Emissions

Processes used to prepare feedstocks for thermochemical conversion may require the use of energy. The emissions associated with such energy use must be accounted for, whether occurring in the field or at a production facility. The preparation of feedstocks for biochar production may involve fossil fuel combustion or the use of electricity. Emissions from feedstock processing are determined using Equation 5.6.

Equation 5.6. Feedstock processing emissions

Equation 5.6a: Calculation of feedstock processing emissions based on fuel and/or electricity consumption records

$$\boldsymbol{PE_{FProc} = \left(PE_{FProc,FC} + PE_{FProc,EC}\right) \times AF}$$

Where,

			Units
PE_{FProc}	=	Total emissions from processing of feedstocks for the reporting period	tCO_2e
AF	=	Proportional adjustment to emissions to account for only project-related emissions (see Equation 5.3)	%

And

$$\boldsymbol{PE_{FProc,FC} = \sum_{ff} FC_{FProc,ff} \times EF_{ff}}$$

Where,

$PE_{FProc,FC}$	=	Emissions associated with the combustion of fuels for the processing of feedstocks in preparation for biochar production	tCO_2e
$FC_{FProc,ff}$	=	Total mass or volume of fuel type *ff* consumed for feedstock processing purposes for the reporting period	mass or volume unit
EF_{ff}	=	Emissions factor for the fuel type *ff*	tCO_2e/(mass or volume unit)

And

$$\boldsymbol{PE_{FProc,EC} = \sum_{EC} EC_{FProc,EC} \times EF_{EC}}$$

Where,

$PE_{FProc,EC}$	=	Emissions associated with the use of electricity for the processing of feedstocks in preparation for biochar production	tCO_2e
$EC_{FProc,EC}$	=	Total amount of electricity consumed for feedstock processing purposes for the reporting period	kWh
EF_{EC}	=	Emissions factor for electricity at the feedstock processing location *EC*[16]	tCO_2e/kWh

[16] Based on factors from the Emissions & Generation Resource Integrated Database (eGRID) (US) or *Canada's National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada* for grid-connected electricity and from the US EPA GHG Emissions Hub for non-grid-connected electricity

Equation 5.6b: Calculation of feedstock processing emissions based on processing type and mass of feedstocks processed,

$$PE_{FProc,EC} = \sum_{fp} M_{fp} \times EF_{fp} \times AF$$

Where,

			Units
M_{fp}	=	Total mass of feedstocks processed using feedstock processing type *fp*	tonnes
EF_{fp}	=	Emissions factor for electricity consumption using feedstock processing type *fp*	tCO_2e/tonne
AF	=	Proportional adjustment to emissions to account for only project-related emissions (see Equation 5.3)	%

5.2.1.4 Mobile Biochar Production Equipment Transportation Emissions

When mobile biochar production equipment is used under a project, the emissions from the transport of such equipment must be determined using Equation 5.7 and are entered as PE_{MT} in Equation 5.1. Transportation emissions may be calculated based on fuel records, if available, or on the transportation mode, mass of mobile production equipment transported, and distance traveled. Default emissions factors for either approach are provided in the Biochar CRT Calculation Tool. Projects producing biochar at a stationary facility are not required to calculate feedstock transportation emissions.

Equation 5.7. Mobile biochar production equipment transportation emissions

Equation 5.7a: Calculation of mobile equipment transportation emissions based on fuel records

$$PE_{MT} = \sum_{ff} V_{ff} \times EF_{ff}$$

Where,

			Units
PE_{MT}	=	Total emissions from transportation of mobile biochar production equipment for the reporting period	tCO_2e
V_{ff}	=	Volume of fuel type *ff* consumed	unit of volume
EF_{ff}	=	Emissions factor for fuel type *ff*	tCO_2e/unit of volume

Equation 5.7*b: Calculation of mobile equipment transportation emissions based on transportation type, mass of equipment transported, and distance traveled*

$$PE_{FT} = \sum_{tr} M_{tr} \times D_{tr} \times EF_{tr}$$

Where,

			Units
M_{tr}	=	Mass of equipment transported by transportation type *tr*	tonnes
D_{tr}	=	Total distance equipment was transported using transportation type *tr* for the reporting period	km
EF_{tr}	=	Emissions factor for transportation type *tr*	tCO_2e/tonne-km

5.2.1.5 Auxiliary Energy Emissions

For some projects, the combustion of fossil fuels or the use of electricity is required during the process of thermochemically converting feedstocks into biochar. When such energy is used, the associated emissions must be accounted for under this protocol based on Equation 5.8. However, when electricity is generated as a co-product of the biochar production process, the associated emissions do not need to be calculated.

Equation 5.8. Auxiliary energy emissions

$$\boldsymbol{PE_{AE} = \left(PE_{AE,FC} + PE_{AE,EC}\right) \times AF}$$

Where,

			Units
PE_{AE}	=	Total emissions from auxiliary energy used to produce biochar for the reporting period	tCO_2e
AF	=	Proportional adjustment to emissions to account for only project-related emissions (see Equation 5.3)	%

And

$$\boldsymbol{PE_{AE,FC} = \sum_{ff} FC_{AE,ff} \times EF_{ff}}$$

Where,

$PE_{AE,FC}$	=	Emissions associated with the combustion of fuels to facilitate the production of biochar	tCO_2e
$FC_{AE,ff}$	=	Total mass or volume of fuel type *ff* consumed for biochar production purposes for the reporting period	mass or volume unit
EF_{ff}	=	Emissions factor for the fuel type *ff*	tCO_2e/(mass or volume unit)

And

$$\boldsymbol{PE_{AE,EC} = \sum_{EC} EC_{AE,EC} \times EF_{EC}}$$

Where,

$PE_{AE,EC}$	=	Emissions associated with the use of electricity to facilitate the production of biochar	tCO_2e
EC_{AE}	=	Total amount of electricity consumed for biochar production purposes for the reporting period	kwh
EF_{EC}	=	Emissions factor for electricity at the feedstock processing location[17]	tCO_2e/kwh

5.2.1.6 Thermochemical Conversion Emissions

Emissions of CO_2 during the thermochemical conversion process are excluded from project accounting since such emissions are biogenic and considered carbon neutral relative to baseline emissions, as long as projects satisfy all relevant eligibility standards under this protocol, including feedstock eligibility requirements. Each project must account for methane emissions produced during thermochemical conversion using Equation 5.9 unless the project developer is able to demonstrate that emissions controls are in place so that emitted methane is combusted or recovered. Evidence supporting the claim of methane combustion or recovery

[17] Based on factors from the Emissions & Generation Resource Integrated Database (eGRID) (US) or *Canada's National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada* for grid-connected electricity and from the US EPA GHG Emissions Hub for non-grid-connected electricity

may include a combination of production technology characterization, manufacturer documentation of testing results, and/or peer reviewed studies. The production technology employed by the project must match the conditions described by the manufacturer/study.

For those projects required to quantify methane emissions from thermochemical conversion, standardized emissions factors are provided in the Biochar CRT Calculation Tool based on the production process or technology used by the project. Production processes or technologies that are recognized for combusting or capturing methane emissions are included in the tool with an emissions factor of zero. For biochar production processes or emissions control technologies for which an emissions factor is not provided in the tool, a default emissions factor based on a conservative methane emissions rate must be used. Project developers may propose the addition of new emissions factors for production processes and emissions control technologies not covered by the tool based on supporting evidence such as peer-reviewed studies or publications from governmental agencies. The Reserve will update emissions factors provided in the Biochar CRT Calculation Tool at its sole discretion.

Equation 5.9. Thermochemical conversion methane emissions

$$\boldsymbol{PE_{TC} = \sum_{b,TC} EF_{TC} \times M_{b,TC} \times GWP_{CH4} \times AF}$$

Where,			Units
PE_{TC}	=	Total methane emissions from thermochemical conversion of feedstocks for the reporting period	tCO_2e
EF_{TC}	=	Emissions factor for thermochemical conversion process *TC* used to produce biochar	tCH_4/t biochar
$M_{b,TC}$	=	Mass (dry basis) of biochar type *b* produced during the reporting period using thermochemical conversion process *TC*	t biochar
GWP_{CH4}	=	Global warming potential (100-year basis) of CH_4	tCO_2e/tCH_4
AF	=	Proportional adjustment to emissions to account for only project-related emissions (see Equation 5.3)	%

5.2.1.7 Biochar Processing Emissions

For projects involving the processing of biochar in preparation for its end use, project developers must account for the emissions associated with such activities using Equation 5.10. Biochar processing may involve grinding, sifting, blending, and other similar actions. For projects under which biochar processing takes place after delivery to an end user, emissions are determined using default emissions factors applicable on a per tonne of delivered biochar basis, assuming certain processing practices to prepare biochar for the anticipated end use. The Eligible Biochar End Uses List provides assumed conditions for biochar at the time of end use application, against which project developers must compare the condition of delivered biochar to determine an appropriate type of processing practice to use for estimating emissions.

Equation 5.10. Biochar processing emissions

Equation 5.10a: Calculation of feedstock processing emissions based on fuel and/or electricity consumption records

$$\boldsymbol{PE_{BP} = \left(PE_{BP,FC} + PE_{BP,EC}\right)}$$

Where,

			Units
PE_{BP}	=	Total emissions from energy used to process biochar prior to end use application for the reporting period	tCO_2e

And

$$\boldsymbol{PE_{BP,FC} = \sum_{ff} FC_{BP,ff} \times EF_{ff}}$$

Where,

$PE_{BP,FC}$	=	Emissions associated with the combustion of fuels to process biochar	tCO_2e
$FC_{BP,ff}$	=	Total mass or volume of fuel type *ff* consumed for biochar processing purposes for the reporting period	mass or volume unit
EF_{ff}	=	Emissions factor for the fuel type *ff*	tCO_2e/(mass or volume unit)

And

$$\boldsymbol{PE_{BP,EC} = \sum_{EC} EC_{BP,EC} \times EF_{EC}}$$

Where,

PE_{BP}	=	Emissions associated with the use of electricity to process biochar	tCO_2e
$EC_{BP,EC}$	=	Total amount of electricity consumed for biochar processing purposes for the reporting period	kwh
EF_{EC}	=	Emissions factor for electricity at the feedstock processing location[18]	tCO_2e/kwh

Equation 5.10b: Calculation of biochar processing emissions based on processing type and mass of feedstocks processed,

$$\boldsymbol{PE_{BP,FC} = \sum_{bp} M_{bp} \times EF_{bp}}$$

Where,

			Units
M_{bp}	=	Total mass (dry basis) of biochar processed using processing type *bp*	tonnes
$EF_{EC,bp}$	=	Emissions factor for processing type *bp*	tCO_2e/tonne

5.2.1.8 Biochar Transportation Emissions

Emissions from biochar transportation are required to be accounted for when biochar is being applied for certain end uses that are not a replacement or alternative to other materials. The

[18] Based on factors from the Emissions & Generation Resource Integrated Database (eGRID) (US) or *Canada's National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada* for grid-connected electricity and from the US EPA GHG Emissions Hub for non-grid-connected electricity

Eligible Biochar End Uses list indicates whether transportation emissions must be determined for each end use listed. The results from Equation 5.11 are entered into Equation 5.1 as PE_{BT}.

Equation 5.11. Biochar transportation emissions

Equation 5.11a: Calculation of feedstock transportation emissions based on fuel records

$$\boldsymbol{PE_{BT} = \sum_{ff} V_{ff} \times EF_{ff}}$$

Where,

			Units
PE_{BT}	=	Total emissions from transportation of biochar for the reporting period	tCO_2e
V_{ff}	=	Volume of fuel type *ff* consumed	unit of volume
EF_{ff}	=	Emissions factor for fuel type *ff*	tCO_2e/unit of volume

Equation 5.11b: Calculation of feedstock transportation emissions based on transportation type, mass of feedstock transported, and distance traveled

$$\boldsymbol{PE_{BT} = \sum_{tr} M_{tr} \times D_{tr} \times EF_{tr}}$$

Where,

			Units
M_{tr}	=	Mass of biochar transported by transportation type *tr*	tonnes
D_{tr}	=	Total distance biochar was transported using transportation type *tr* for the reporting period	km
EF_{tr}	=	Emissions factor for transportation type *tr*	tCO_2e/tonne-km

5.2.2 Calculating Project Removals

The long-term storage of carbon in biochar is the primary GHG benefit expected to be generated by projects under this protocol. Calculations of total project removals (Equation 5.12) rely on metrics derived from the type of biochar (*b*) and end use (*EU*). If applicable, they must also consider historical production rates, as described in Section 3.4.1.2. The type of biochar (*b*) is based on biochar represented by the results from a given set of Initial Parameter Sampling and ongoing Retention Sampling and associated laboratory testing, as described in Section 6.3. The final end use(s) of biochar produced by the project determines the expected longevity of the sequestered carbon. For each end use, the applicable permanence factor (P_{EU}) is indicated in the Eligible Biochar End Uses List and incorporated in the Biochar CRT Calculation Tool.

For soil applications and other similar end uses, the permanence factor applicable to a given amount of biochar is based on the equation described by Woolf et al. (2021). See the Eligible Biochar End Uses List for further details. The equation is dependent on both the molar ratio of hydrogen to organic carbon ($H:C_{org}$), as indicated by laboratory analysis of biochar samples from the project, and the average soil temperature of the location(s) where biochar is applied, as reported via chain of custody tracking. As described under Section 3.5, the long-term durability of biochar is derived from the highly persistent molecular structure resulting from the thermochemical conversion process that results in a lowered $H:C_{org}$ ratio relative to the biomass source.

Degradation of a portion of biochar does occur over time in soils (and similar settings), with the rate of degradation increasing with soil temperature and decreasing over time. Thus, for projects involving soil or similar applications, the end uses *EU* must also be differentiated by soil temperature groups as well. The Reserve provides a standardized spatial layer of mean annual soil temperature[19] to be used by project developers to determine the soil temperature of end use locations associated with the biochar from the project. For situations where biochar is provided to an intermediary end user, as discussed in Section 2.2.3, where the final location of soil application is unclear, the range of potential locations where the biochar may be applied must be identified and the most conservative soil temperature applied for CRT quantification.

If biochar produced under a project is stored for more than a year prior to application to an end use for which no ongoing degradation is assumed (e.g., P_{EU} is not determined from the equation from Woolf et al. (2021)), the project must account for the loss of carbon resulting from degradation that may have occurred since the biochar was produced (and quantitative metrics based on laboratory testing of sampled biochar were established). In such instances, the annualized degradation rate based on the application of the equation from Woolf et al. (2021) for the location where the biochar was stored must be used to adjust the carbon removal estimate. For soil applications and other end uses for which P_{EU} is determined from the equation from Woolf et al. (2021), the degradation occurring prior to end use application is already accounted for when calculating the value for P_{EU}.

For those permanence factors based in part on the $H:C_{org}$ ratio of project biochar, the upper bound of the 95% confidence interval of the mean value of the $H:C_{org}$ ratio determined from sampling and laboratory analyses must be used. Values for $H:C_{org}$, DM_b and OC_b are updated over time based on ongoing sampling performed throughout the course of the project. See Section 6.3 for detailed guidance on sampling and laboratory analyses.

[19] Available at https://www.climateactionreserve.org/how/protocols/ncs/biochar/

Equation 5.12. Carbon removals

$$\boldsymbol{PC = \sum_{b} PC_b}$$

Where,

			Units
PC	=	Total C removals for the reporting period	tCO_2e
PC_b	=	C removals for biochar type *b*	tCO_2e

And

$$\boldsymbol{PC_b = \sum_{b,EU} \left(M_{b,EU} \times DM_{b,EU} \times OC_b \times P_{EU} \times 3.67 \times PA \right)}$$

Where,

$M_{b,EU}$	=	Mass (wet) of biochar type *b* for end use type *EU* for the reporting period, net of historical production rate, as applicable. Historical production rate is based on the maximum annual rate of production of biochar (mass, wet) produced during the 3-year period prior to the project start date (see Section 3.4.1.2).	tonnes
OC_b	=	Organic carbon content of biochar type *b* for the reporting period, based on the lower bound of the 95% confidence interval of the mean value determined from sampling and laboratory analysis (see Section 6.3.1)	%
P_{EU}	=	Permanence factor for end use *EU*	%
3.67	=	Factor to convert from tC to tCO_2e	

And

$$\boldsymbol{DM_{b,EU} = \sum_{b,u,EU} \left(DM_{b,u,EU} \times M_{b,u,EU} \right) \Big/ \sum_{b,EU} M_{b,u,EU}}$$

Where,

$DM_{b,EU}$	=	Weighted average dry matter content of biochar type *b* for end use type *EU*	%
$DM_{b,u,EU}$	=	Dry matter content of weighed unit *u* of biochar type *b* for end use type *EU*, based on the sampling and analysis (see Section 6.3.2)	%
$M_{b,u,EU}$	=	Mass (wet) of unit *u* biochar type *b* for end use type *EU**	tonnes

And

If P_{EU} is based on Woolf et al. (2021), then: $\boldsymbol{PA = 100\%}$

If P_{EU} is not based on Woolf et al. (2021), then: $\boldsymbol{PA = 100\% - \left(\frac{100\% - P_{soil}}{100} \times t_{yrs,stor} \right)}$

Where,

PA	=	Permanence adjustment for non-soil end uses (or similar) to account for degradation during storage of biochar for longer than one year	%
P_{soil}	=	Permanence factor (100-year basis) for soil applications, based on Woolf et al. (2021) (see Eligible Biochar Feedstocks List)	%
$t_{yrs,stor}$	=	Number of years (to nearest month) biochar was stored prior to end use application (only if stored for longer than one year)	years

*Mass of biochar reported must not include non-biochar materials weighed alongside biochar, such as pallets, shipping bags, etc.

5.3 Secondary Effects

The risk of secondary effects—often referred to as leakage and including a shifting of GHG emissions outside of the project boundaries as an indirect effect of the project—is generally limited or non-existent in most scenarios under which biochar projects will be developed for climate benefits, in particular when eligible waste or by-product biomass is used as a feedstock since such biomass is typically not being diverted from an alternative productive use. Nevertheless, two situations have been identified that present a risk of leakage: 1) the use of purpose-grown feedstocks and 2) the diversion of biomass from bioenergy production, including within-facility diversions.

The eligibility requirements of Section 2.2, Eligible Biochar Feedstocks List, and Section 3.4.1 limit purpose-grown feedstocks to those for which a leakage risk is insignificant. In particular, since production of purpose-grown feedstocks is limited to marginal lands or reclaimed mining sites, as previously described in Section 3.4.1.1, there is minimal risk that additional land would be converted—with associated GHG emissions and releases of sequestered carbon—to make up for any production from the land being used for biochar feedstock production. As such, no leakage calculation is required for projects using eligible purpose-grown feedstocks.

If biomass is diverted from bioenergy production, any resulting decrease in bioenergy output may be compensated for with fossil fuel-based energy. Such leakage would lower the climate benefits of a biochar project using the diverted biomass. If a project developer is acquiring feedstocks from a landscape where that biomass source is typically used for bioenergy and the project developer is unable to confirm that bioenergy production is not supply-limited, the project would not be eligible, per the Performance Standard Test outlined in Section 3.4.1.1. If bioenergy production is not supply-limited, however, no leakage would occur as a result of the diversion of feedstock since the bioenergy output would not be impacted by an eligible biochar project.

For projects involving the diversion of biochar from within a bioenergy production process (e.g., diversion of portions of fly ash containing high organic carbon content from reinjection into a bioenergy furnace), the project developer must demonstrate that bioenergy production levels are being maintained such that the energy output of the facility does not decrease by more than 5 percent annually based on average daily output. If energy production decreases by more than 5 percent when compared to the average daily output from the facility for three years immediately preceding the start date (or for as long as the facility has been in operation if less than three years), the project must calculate the emissions associated with leakage from the project based on replacement of the energy output decreases in excess of 5 percent based on electrical grid emissions rates from the location of the biochar facility. This calculation is performed using Equation 5.13, with the resulting value for *SE* inserted into Equation 5.1. However, if the project developer is able to demonstrate that a decrease in energy production of more than 5 percent did not occur as a result of biochar production but rather was caused by an unrelated factor, such as prolonged extreme weather conditions (e.g., drought) or energy market participatory conditions (e.g., being obligated to lower energy production as a result grid requirements and/or per power purchase agreements), calculating leakage would not be required.

Equation 5.13. Secondary effects emissions

$$If\ \boldsymbol{EP_{Post}} \geq \boldsymbol{EP_{Pre}} \times \mathbf{95\%}$$

$$then\ \boldsymbol{SE} = \mathbf{0}$$

$$If\ \boldsymbol{EP_{Post}} < \boldsymbol{EP_{Pre}} \times \mathbf{95\%}$$

$$then\ \boldsymbol{SE} = \left(\left|\frac{\boldsymbol{EP_{Post}} - \boldsymbol{EP_{Pre}}}{\boldsymbol{EP_{Pre}}}\right| - \mathbf{0.05}\right) \times \boldsymbol{EP_{Pre}} \times \boldsymbol{t_{days,RP}} \times \boldsymbol{EF_{EC}}$$

Where,			Units
SE	=	Secondary effects emissions associated with the replacement of energy output resulting from decreases from bioenergy facilities from which biomass feedstocks were diverted for biochar production	tCO_2e
EP_{Post}	=	Average daily amount of grid-connected electricity produced during the reporting period	kwh/day
EP_{Pre}	=	Average daily amount of grid-connected electricity produced during the three years immediately preceding the project start date	kwh/day
$t_{days,RP}$	=	Total number of days comprising the current reporting period	days
EF_{EC}	=	Emissions factor for grid-connected electricity at the bioenergy facility location[20]	tCO_2e/kwh

In addition to co-production of electricity, for which potential leakage impacts are addressed as described above, bio-oil and syngas are also recognized as potential co-products alongside biochar. Projects producing bio-oil and/or syngas in addition to biochar are not required to calculate leakage in relation to co-production under this protocol. However, given the ongoing innovation around biochar production, project developers intending to incorporate processes resulting in other co-products must contact the Reserve for approval for the use of such processes under this protocol and potential guidance to address possible leakage impacts.

5.4 Reconciliation with Stacked Projects

As previously described, biochar projects have the opportunity to be implemented in such a way that project activities overlap with the project activities attributable to another project type. If such project stacking is approved by the Reserve, guidance may be required to be provided by Reserve staff to reconcile the quantification of the biochar with the quantification of the stacked project(s) to ensure no double-counting/crediting of GHG impacts occurs. The Reserve maintains the right to determine if any reconciliation between a biochar project and another project with which it is stacked is necessary and what the requirements for such reconciliation may be.

[20] Based on factors from the Emissions & Generation Resource Integrated Database (eGRID) (US) or *Canada's National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada*

6 Project Monitoring

Monitoring is the process of regularly collecting data related to a project's performance for reporting purposes. Project developers are required to gather data pertaining to a biochar project on a regular basis and report such data for each reporting period, as further described in Section 7.4. Thus, project developers are responsible for monitoring the performance of the project and ensuring that the operation of all project-related equipment is consistent with the manufacturer's recommendations (as applicable) and that all project-related processes are compliant with all relevant legal and regulatory requirements. Monitoring is required for the duration of the crediting period.

6.1 Monitoring Plan

The Reserve requires a monitoring plan to be established for all monitoring and reporting activities associated with the project. The monitoring plan is to be included in the Project Data Report (see Section 7.2) and will serve as the basis for verifiers to confirm that the monitoring and reporting requirements in this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record keeping is ongoing at the project site. The monitoring plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.7 will be collected and recorded.

At a minimum, the monitoring plan shall include the following details:

1. General description of the project, including:
    a. Feedstock characterization
    b. Biochar production process(es) employed, including configurations of production parameters, as defined by unique combinations of feedstock compositions and biochar production temperature and residence time (Section 6.3)
    c. End uses of biochar
2. A description of how the eligibility requirements are met
    a. The monitoring plan must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the legal requirement test (Section 3.4.2) and maintains regulatory compliance (Section 3.6).
    b. A description of any ecosystem services payments stacking and/or project stacking occurring or expected to occur.
3. The frequency of instrument cleaning, inspection, field check, and calibration activities (if relevant), including for scales used to determine the mass of biochar produced and transferred to eligible end uses and instrumentation used to measure the dry matter content of (or water inputs to) biochar.
4. A description of each monitoring task to be undertaken, and the technical requirements therein.
5. Roles, responsibilities, and capacity of monitoring team and management.
6. Data to be collected per chain of custody tracking requirements (Section 6.2), including location data, and process for collecting and compiling such data.
7. Parameters to be measured, including any parameters additional to those specified in Table 6.7.

8. Data to be collected and data collection techniques and sample designs for directly sampled parameters, per requirements outlined in Section 6.3.
9. For projects metering water inputs to determine the dry matter content of biochar, a description of mitigation measures to be taken to prevent the addition of unmetered water to project biochar prior to mass measurements of the biochar are taken.
10. Operational data to be documented, including production parameters.
11. Frequency of data acquisition. At a minimum, the data required for quantification of biochar projects shall be monitored and recorded (or documented, as appropriate) for each reporting period.
12. Data archiving procedures (see Section 7.3 for minimum record keeping requirements)
13. QA/QC provisions to ensure that data acquisition, compilation, and reporting are carried out consistently and with precision (where relevant).

The Reserve will make available a template for the Project Data Report (see Section 7.2) that includes sections for all required Monitoring Plan information. Use of the template is not required but is strongly recommended.

6.2 Chain of Custody Tracking

The project developer must collect and maintain documentation on the chain of custody of the biochar, from the biomass acquisition, through biochar production, and biochar application. At all stages, this should include the names, addresses, and contact information of the parties in the chain of custody at a minimum. Chain of custody requirements for each phase are identified in Table 6.1 below. Chain of custody should be tracked by bills of lading, invoices, and/or receipts, which may be electronic or physical documentation. Only the amounts of biochar that are properly documented in the chain of custody may be included for credit quantification.

Table 6.1. Chain of Custody Requirements

Phase	Chain of Custody Requirements
Biomass Acquisition	▪ Name of each party ▪ Address of each party ▪ Contact information of each party, including phone number and email address ▪ Identification of feedstock, which must be on the Eligible Biochar Feedstocks List ▪ Physical location (parcel, facility, etc.) of the feedstock source, including KML file and/or shapefile (if available) ▪ Date the feedstock was obtained/harvested ▪ Mass of feedstock obtained/harvested
Biochar Production	▪ Name of each party ▪ Address of each party ▪ Contact information of each party, including phone number and email address ▪ Physical location ▪ Date the biomass was acquired ▪ Mass of biomass acquired ▪ Date the biochar was produced ▪ Mass of biochar produced ▪ Date it was transported from the production facility

Phase	Chain of Custody Requirements
Biochar Application	▪ Name of each party ▪ Address of each party ▪ Contact information of each party, including phone number and email address ▪ Mass of biochar received by each party ▪ End-use application, which must be included on the Eligible Biochar End Uses List* ▪ Location of end-use application,**
Temporary custody between other phases (e.g., transporters, storage facilities)	▪ Name of each party ▪ Address of each party ▪ Contact information of each party, including phone number and email address ▪ Date the biomass or biochar was acquired ▪ Location of storage, if biomass or biochar was stored enroute to destination ▪ Date the biomass or biochar was sent, if applicable

*For projects distributing biochar to an intermediary entity that will subsequently distribute the biochar (as described in Section 2.2.3), chain of custody tracking is only required to the transfer of the intermediary entity, with the assumed end-use application similarly documented.
**If end-use application is an intermediary entity as described above and the applicable permanence factor depends on a determination of soil temperature, the range of locations for ultimate end use (based on either the known or potential distribution of biochar from the intermediary entity) must be identified. If the range of potential ultimate end use locations is unable to be identified and substantiated, the most conservative values for the relevant permanence factor must be used.

6.3 Biochar Sampling and Testing Guidance

Ongoing sampling and testing of biochar quality is critical to properly assessing the eligibility of a project and quantifying the climate benefits it provides. Project developers must provide documentation describing the biochar sampling and laboratory analysis methods employed. While this protocol does not require specific sampling and laboratory analysis methods to be used by all projects, it does require that a set of minimum standards be met, as outlined in this section.

Direct measurement of various characteristics of biochar must be performed via sampling to establish eligibility and certain credit quantification parameters (Table 6.2). Measurements related to eligibility include the $H:C_{org}$ ratio and levels of constituent chemicals in relation to environmental safeguards, as described in Sections 3.5 and 3.7. Quantification parameters derived from biochar sampling include percent dry matter ($DM_{b,s}$) and percent organic carbon (OC_b) and may also include the $H:C_{org}$ ratio for certain end uses.

Estimates derived from sampling are subject to statistical uncertainty. Where statistical confidence is low, there is an increased risk of overestimating the amount of persistent organic carbon contained in the biochar produced and therefore a higher risk of over-crediting carbon removals. To ensure that estimates of removals are conservative, projects must determine the statistical accuracy of sampling outcomes and apply parameter estimates as described in Table 6.2.

Table 6.2. Required Outcomes Reported from Sampling and Laboratory Analysis

Analytical Target	Metric to be Applied	Protocol Application
$H:C_{org}$	Upper bound of 95% confidence interval of the sample mean	<0.7 for eligibility of biochar Calculation of permanence factor (P_{EU}) for certain end uses (equation provided in Eligible Biochar End Uses List)
OC_b	Lower bound of 95% confidence interval of the sample mean	Calculation of total carbon removals from the project (*PC*) in Equation 5.12
Contaminants (e.g., heavy metals, PAHs, PCBs)	Declared value based on laboratory analysis of all composite samples taken during initial parameter sampling combined into a single sample	Must be below maximum allowance threshold, per contaminant, based on legal requirements or environmental safeguards specified in Section 3.7 and in the Eligible Biochar End Uses List
$DM_{b,u}$	Dry matter content value determined for each unit of biochar weighed.	Calculation of total carbon removals from the project (*PC*) in Equation 5.12

6.3.1 Biochar Quality Sampling and Testing

Qualities of biochar can vary depending on the combination of feedstocks used and the thermochemical conversion process employed. Important quality parameters—$H:C_{org}$ ratio, organic carbon content, and contaminant levels—must be measured to ensure alignment with eligibility criteria and facilitate quantification of carbon removals.

Project biochar is tested for quality parameters based on Initial Parameter Sampling and ongoing Retention Sampling, as described in Table 6.3. The overall approach to sampling and testing is intended to ensure that the quantification parameters used at any given point in time during the crediting period reflect any changes to the quality of biochar over time. Sampling process standards are described below for both Initial Parameter Testing (Table 6.4) and Retention Testing (Table 6.5).

Table 6.3. Overview of biochar quality sampling and testing structure

Initial Parameter Sampling and Testing
▪ Establishes a pool of sample results that serve as the basis for credit quantification parameters $H:C_{org}$ and OC_b and project eligibility ($H:C_{org}$ and contaminant levels), as described in ▪ Table 6.2. ▪ Performed at the start of crediting period and as needed during crediting period (see Figure 6.1).
Retention Sampling and Testing
▪ Performed after completion of Initial Parameter Sampling to update quantification parameters $H:C_{org}$ and OC_b. ▪ Required each day biochar is produced, though only a selection of samples are tested (see Table 6.5). ▪ Used to supplement the sample pool or replace any previous sample(s) removed from the sample pool as a result of time restrictions outlined below. ▪ Continued until/unless new Initial Parameter Sampling and associated testing is evoked.

Limitations on Sampling
▪ Sample pool used to determine credit quantification parameters (and project eligibility under Initial Parameter Sampling) must comprise at least 10 samples at all times. ▪ Samples may be included in the sample pool for up to 12 months, after which time they must be removed and potentially replaced. ▪ At least one retention sample must be tested every two months (see Table 6.5 for further description).

The major factors affecting the parameters used to determine biochar quality and credit quantification are the types of feedstocks used, the temperature of the thermochemical conversion process, and the length of time biomass is subject to the thermochemical conversion process (residence time). When substantial changes in the feedstocks used or the thermochemical conversion process employed occur, changes to biochar quality may also occur. As a result, the samples taken previously—and associated testing results—may not accurately represent the biochar produced after those changes take place.

The flowchart in Figure 6.1 outlines the relationship between Initial Parameter Sampling and Retention Sampling and how project developers are to determine when each is to be performed.

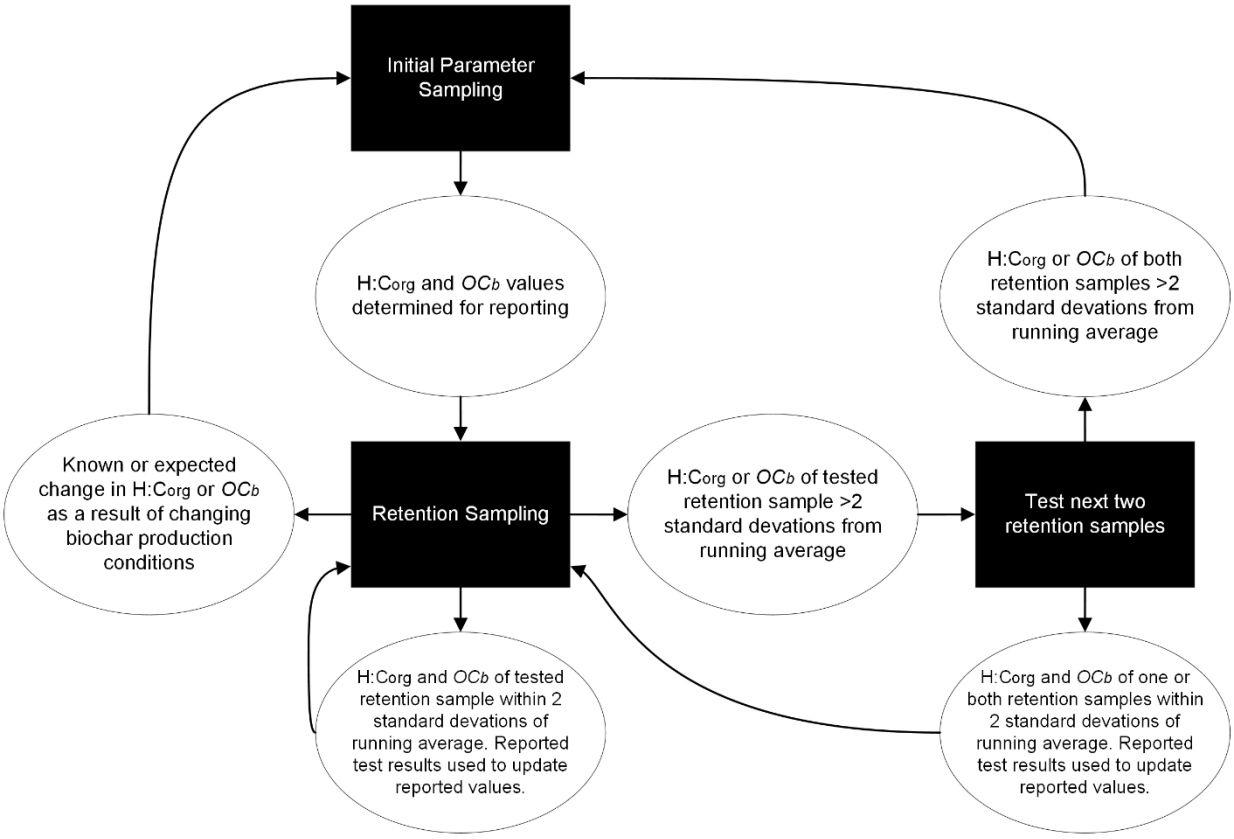

Figure 6.1. Flowchart guide to relationship between Initial Parameter Sampling, Retention Sampling, and testing results

The Reserve provides a Biochar Sample Reporting Tool[21] that helps project developers document how ongoing laboratory results compare to the running averages from prior results and determine if new Initial Parameter Sampling must be performed.

Project developers may exclude biochar produced on a given day from project reporting, including if they believe the quality of biochar on that day is abnormal relative to the biochar otherwise being produced, which may lead to retention sampling and testing indicating the need for new Initial Parameter Sampling to be undertaken. This option may only be used if the amounts of biochar being removed from reporting can be clearly excluded from the total amount of biochar from the project and such biochar is not otherwise mixed with biochar that is included in project reporting.

6.3.1.1 Biochar Quality Sample Design and Collection

Project developers must describe their sampling approach in the Monitoring Plan and adhere to the minimum standards identified below for Initial Parameter Sampling (Table 6.4) and Retention Sampling (Table 6.5).

Table 6.4. Initial Parameter Sampling Requirements

Category	Guidance
Purpose	To establish the values for the H:C_{org} ratio and for the variable OC_b in Equation 5.12 at the start of biochar production under a given set of production parameters and to test for other biochar properties related to eligibility, initial parameter sampling must be performed based on the following guidance.
Key Concepts	▪ Initial Parameter Sampling is to be performed each day biochar is produced under the project: o From the first day of biochar production under the project and during the reporting period for which the associated laboratory analysis results are first applicable; o From the first day when biochar quality is expected to be changed significantly as a result of changes to biochar production parameters and the project developer opts to begin new Initial Parameter Sampling; o From the time testing from Retention Sampling indicates a significant change in biochar quality, as previously described. ▪ Samples from a given biochar production process are submitted for laboratory analysis (see Section 6.4.2). ▪ A minimum of 10 daily samples are the basis for assessing the values to be applied for the parameters H:C_{org} and OC_b, though project developers are otherwise allowed to determine the number of daily samples that will comprise the Initial Parameter Sampling effort.
Sample Collection Process	▪ A 1-liter composite sample composed of a minimum of 6 subsamples that are representative of the biochar produced on a given day are to be drawn and placed in a container for storage and shipping to a laboratory for analysis. ▪ Project developers may determine how best to obtain daily samples within the project's biochar production cycle. The sample collection process used must be described in the Monitoring Plan, indicating (at a minimum):

[21] Available at https://www.climateactionreserve.org/how/protocols/ncs/biochar/

Category	Guidance
	○ When subsamples are to be collected. ○ How subsamples are to be collected. At a minimum, subsamples must be drawn from random locations from the biochar being sampled, including surface and subsurface draws or as grab samples (for continuous production systems only). ○ How the sampling process employed ensures each daily composite sample will be representative of the biochar produced throughout the course of the day and in the context of the production cycle being used, especially if sampling does not occur throughout the course of the day. ▪ Sampling must be performed before post-processing when biochar is processed in the following ways: ○ Biological activation ○ Mixing/blending/adding non-biochar material ▪ Sampling may be performed after post-processing when biochar is processed in all other ways. ▪ Samples must be: ○ Placed in containers made of material appropriate for the type of laboratory analyses being performed, as described in the *IBI Standardized Product Definition and Product Testing Guidelines for Biochar that Is Used in Soil* (IBI, 2015); ○ Securely packaged and clearly labeled. ▪ Projects employing multiple production units may sample from a single unit as long as the production parameters are sufficiently similar, as previously described in Section 6.3, so as not to require a separate sampling effort. ▪ Sampling details (dates, times, personnel involved, biochar production configuration) must be documented for all sampling performed for the project.

The focus of Retention Sampling is similar to Initial Parameter Sampling and, as such, is based on a similar overall approach (Table 6.5). The primary difference is that a relatively small proportion of retention samples are sent for laboratory analysis, while the rest are retained for archival purposes, to be analyzed only as needed.

Table 6.5. Retention Sampling Requirements

Category	Guidance
Purpose	To ensure ongoing alignment with quantification parameter values for OC_b and, as needed, $H:C_{org}$ previously reported (Figure 6.1), to update the values for OC_b and, as needed, $H:C_{org}$ used for quantification, and to collect daily samples for archival purposes.
Key Concepts	▪ Retention Sampling is initiated immediately after Initial Parameter Sampling is completed and continues unless/until new Initial Parameter Sampling occurs. ▪ Retention samples are to be drawn each day biochar continues to be produced under the project. ▪ A small portion of retention samples are sent for laboratory analysis to determine OC_b and, as needed, $H:C_{org}$ to ensure alignment with previously reported results and to update values used for credit quantification.

Category	Guidance
	▪ Retention samples not sent for laboratory testing o Are to be retained for archival purposes, to be analyzed only as needed. o Must be retained until the verification is complete and credits are issued for the reporting period during which the samples were drawn.
Sample Collection Process	▪ Same as indicated for Initial Parameter Sampling in Table 6.4
Sampling approach	▪ At a minimum, one retention sample must be submitted for laboratory analysis from any two-month period during which biochar is produced under the project. However, additional retention samples may be submitted for laboratory analysis to improve the ongoing statistical outcomes of the parameters used for credit quantification and to ensure at least 10 samples drawn within the past year will continue to comprise the pool of samples used to calculate statistical outcomes. ▪ At the end of each month, the Reserve will post to the protocol webpage a list of randomized dates for the previous two-month period. The Project Developer must retrieve the list for any two-month period during which biochar was produced under the project. For example, if biochar was first produced by the project on March 7, the project developer would retrieve the list for March/April. If they continue to produce biochar each month thereafter, they would next retrieve the list for May/June. The retention sample from the first date on the list during which biochar was produced for that period must be submitted for laboratory analysis. If multiple samples are being submitted to improve statistical outcomes, those additional samples to be submitted must be based on the subsequent randomized order of dates. o For example, if the randomized list for March/April of a given year indicates April 9th, March 24th, April 29th, April 17th, and March 3rd as the first five dates and biochar was produced under the project on March 3rd, March 24th, and April 29th but not on April 9th or April 17th, the project developer would be required to submit the sample from March 24th for analysis since it is the first date on the list on which biochar was produced under the project. o If the project developer was submitting two additional samples for the month, they would then submit samples from April 29th and March 3rd. ▪ Laboratory results for $H:C_{org}$ and organic carbon content from testing of a new retention sample will be added to the results from the current sample pool being used to determine quantification parameter values.

When a higher frequency of contaminant testing is required for certain combinations of feedstocks and end uses (e.g., use of treated lumber waste to produce biochar to be used as a soil amendment), retention samples retained over the course of a given month are to be used to produce a single composite sample of approximately 1 liter in volume to be sent for laboratory analysis, using the sampling collection process for contaminant testing and sample handling requirements specified for Initial Parameter Sampling in Table 6.4.

The Reserve may, at the time of its own choosing, coordinate with the project developer to conduct its own sampling of biochar being produced under the project as a check on the sampling and laboratory analyses being reported for the project.

6.3.1.2 Biochar Quality Laboratory Analysis

Project developers must describe in the Monitoring Plan the types of laboratory analyses to be performed on the biochar samples from the project and the methods used for each. All projects must have biochar samples analyzed to determine the organic carbon content (OC_b) and the $H:C_{org}$ ratio. Additional laboratory analyses to be performed are based on the regulatory requirements associated with the end use for the biochar, as described in Section 3.6 and any additional environmental safeguards described Section 3.7 in the Eligible Biochar Feedstocks List or the Eligible Biochar End Uses List. Specific analytical methods employed must be in line with the methods specified by either the *IBI Standardized Product Definition and Product Testing Guidelines for Biochar that Is Used in Soil* or the *World Biochar Certificate – Guidelines for a Sustainable Production of Biochar*. Additional analytical standards may be approved by the Reserve. A complete list of approved analytical standards will be maintained on the Biochar Protocol webpage.[22]

Sample homogenization and testing must be performed by a laboratory that is accredited under a relevant national governing body or international standard-setting body, such as the National Environmental Laboratory Accreditation Program (NELAP), American Association for Laboratory Accreditation (A2LA), or International Standards Organization (ISO). The laboratory must be specifically accredited under ISO/IEC 17025 "General Requirements for the Competence of Testing and Calibration Laboratories." Alternatively, testing may be performed by a laboratory accredited under a state- or province-approved certification program based on laboratory performance and proficiency. Additionally, project developers must obtain quality assurance/quality control information from the laboratory analyzing the project samples, which shall be reviewed during verification for reasonableness.

6.3.2 Dry Matter Sampling and Analysis

Sampling and analysis to determine dry matter content (Table 6.7) is performed in a separate process from the sampling and testing required for biochar quality. The intent of the approach to dry matter sampling is to ensure samples drawn to determine dry matter content are representative of the biochar being reported under the project, specifically at the time the mass of biochar is measured. Results from dry matter sampling are used to determine the percent dry matter associated with each unit of biochar weighed.

Table 6.6. Dry matter sampling requirements

Category	Guidance
Purpose	To collect composite samples of biochar to determine dry matter values to be applied in Equation 5.12.
Key Concepts	▪ Sampling for dry matter is intended to quantify the biochar net of moisture at the time its mass is measured for project quantification and reporting purposes. ▪ Because it is not directly related to the quality of biochar resulting from the production process employed by the project, sampling for dry matter occurs as a separate effort from Initial Parameter Sampling and Retention Sampling for organic carbon content and $H:C_{org}$.

[22] https://www.climateactionreserve.org/how/protocols/ncs/biochar/

Category	Guidance
Sample collection process	▪ A minimum of 10 subsamples for every unit of biochar being sampled must be taken and combined into a composite sample, with a minimum combined sample volume of approximately 2 liters. ▪ Samples must be drawn at approximately the same time each unit of biochar is weighed for mass reporting purposes. ▪ Project developers may determine how best to obtain samples within the biochar production and distribution cycle employed under the project. The sample collection process to be used must be described in the Monitoring Plan, indicating (at a minimum): o When subsamples are to be collected. o How subsamples are to be collected. At a minimum, subsamples must be drawn from random locations from at least 10 cm below the surface of the biochar being sampled. o How the sampling process to be employed ensures the sample will be representative of the project biochar in the context of the production and distribution cycle being used and, more specifically, that moisture content samples are drawn from the same units that serve as the basis for mass measurements for biochar. For example, if biochar is weighed by truckload, samples should be drawn from each truckload being weighed; if biochar is weighed by shipping bag, samples should be drawn from each shipping bag. ▪ One of the following procedures is to be used to determine moisture content: o ISO 589 method for determining moisture content o DIN 51718 method for determining moisture content o The following method: ▪ Mass of the composite sample is measured prior to drying, with mass value reported to the nearest gram ▪ Sample is dried at 110 degrees C for 16 hours or more ▪ Mass of sample must be taken immediately after being removed from the drying oven for appropriate results

Dry matter content is then calculated by dividing the mass of the biochar sample after drying by the mass of the sample before drying. The percent dry matter content determined for each portion of biochar sampled is applied as the value for $DM_{b,u}$ in Equation 5.12.

Alternatively, dry matter sampling may be foregone if the project uses a water meter that accurately measures the amount of water added to biochar, which can then be used to deduce the percent dry matter from the mass of the biochar. Project developers would subtract the total amount of water added to biochar to determine the dry mass of the biochar. When water meters are being used to determine dry matter content, additional water may not be added to biochar prior to weighing it to measure the total mass of the biochar unless the additional water is also metered and correctly factored into the dry matter content calculation. Project developers must ensure no unmetered water (e.g., from precipitation) is added to biochar for which dry matter content is determined in this manner and must outline in the Monitoring Plan how they are mitigating against the risk of such water from being added.

6.4 Monitoring Permanence

As described in Section 3.5, the long-term stability of the carbon contained in biochar is indicated by an $H:C_{org}$ ratio of <0.7, which is demonstrated through biochar quality sampling and

testing described in Section 6.3.1. The primary risk of biochar carbon being released to the atmosphere in amounts otherwise not accounted for under this protocol stems from the risk of combustion. In most cases, the initial application of biochar signifies the end use considered for permanence purposes, for which there are reasonably high assurances that the biochar will not be altered or impacted in a way that releases the carbon it contains prior to the end of the time it is assumed to remain sequestered. However, there may be initial applications of biochar for which permanence is not ensured until the biochar is applied to an ultimate end use. For example, biochar initially used for agricultural filtration purposes may end up being combusted or it may be applied to soils as an amendment. To be eligible for crediting purposes under this protocol, biochar must be applied to an end use for which the permanence of the carbon sequestered in project biochar is reasonably assured, as described in Section 3.5, including those situations where the length of time the carbon can reasonably be expected to remain sequestered is less than 100 years. As such, only biochar used in those applications listed in the Eligible Biochar End Uses List may be included for project reporting and credit quantification purposes. In some cases, eligible end uses may be limited to situations where the ultimate end use for project biochar can also be demonstrated by the project developer.

6.5 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.7.

Table 6.7. Biochar Project Monitoring Parameters

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Baseline Calculation Parameters						
Eq. 5.1	*BE*	Total baseline emissions for the reporting period, from all emission-based SSRs in the GHG Assessment Boundary.	tCO_2e	r	n/a	Assumed to be zero
Eq. 5.1	*BC*	Total carbon sequestered in the baseline scenario for the reporting period	tCO_2e	r	n/a	Assumed to be zero
Project Calculation Parameters						
Eq. 5.3	M_B	Total mass of biochar produced under the project in a co-production setting for the reporting period	tonnes	m	Each reporting period	
Eq. 5.3	EE_B	Energetic equivalent of all biochar generated under the project for CRT quantification purposes for the reporting period	Btu/tonne	r	Each reporting period, if applicable	
Eq. 5.3	EP_{Tot}	Total amount of electricity generated by the facility producing biochar for the project during the reporting period	MWh	o	Each reporting period, if applicable	
Eq. 5.3	EE_{EP}	Energetic equivalent, per unit, of electricity generated by the biochar production facility for the reporting period	Btu/MWh	r	Each reporting period, if applicable	
Eq. 5.3	TE_{Th}	Total usable thermal energy generated by the biochar production facility for the reporting period and not used in electricity generation (e.g., steam for heating, food, and/or fiber processing)	Btu	o	Each reporting period, if applicable	
Eq. 5.3	M_O	Total amount of all other products other than heat or electricity produced by the biochar production facility for the reporting period, including but not limited to non-project biochar, hydrogen, gas, and bio-oil.	variable units	o	Each reporting period, if applicable	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Eq. 5.3	EE_O	Energetic equivalent of all other products other than heat or electricity generated by the biochar production facility for the reporting period, including but not limited to non-project biochar, hydrogen, gas, and bio-oil.	Btu/unit	r	Each reporting period, if applicable	
Eq. 5.4	M_F	Mass of purpose-grown biomass feedstock *F*	tonnes	m	Each reporting period, if applicable	
Eq. 5.4	EF_F	Emissions factor for production of purpose-grown biomass feedstock type *F*	tCO_2e/tonne	r	Each reporting period, if applicable	
Eq. 5.5a, Eq. 5.7a, Eq. 5.11a	V_{ff}	Volume of fuel type *ff* consumed	CO_2e	o	Each reporting period, if applicable	
Eq. 5.5a, Eq. 5.6a, Eq. 5.7a, Eq. 5.8, Eq. 5.10a, Eq. 5.11a	EF_{ff}	Emissions factor for fuel type *ff*	tCO_2e/unit of volume	r	Each reporting period, if applicable	
Eq. 5.5b, Eq. 5.7b, Eq. 5.11b	M_{tr}	Mass of biomass or biochar transported by transportation type *tr*	tonnes	m	Each reporting period, if applicable	
Eq. 5.5b, Eq. 5.7b, Eq. 5.11b	D_{tr}	Distance biomass or biochar transported by transportation type *tr*	km	o	Each reporting period, if applicable	
Eq. 5.5b, Eq. 5.7b, Eq. 5.11b	EF_{tr}	Emissions factor for transport by transportation type *tr*	tCO2e/tonne-km	r	Each reporting period, if applicable	
Eq. 5.6a	$FC_{Fproc,ff}$	Total mass or volume of fuel type *ff* consumed for feedstock processing purposes for the reporting period	mass or volume unit	o	Each reporting period, if applicable	
Eq. 5.6b	M_{fp}	Total mass of feedstocks processed using feedstock processing type *fp*	tonnes	m	Each reporting period, if applicable	
Eq. 5.6b	EF_{fp}	Emissions factor for feedstock processing type *fp*	tCO_2e/tonne	r	Each reporting period, if applicable	
Eq. 5.6a	EC_{FProc}	Total amount of electricity consumed for feedstock processing purposes for the reporting period	kWh	o	Each reporting period, if applicable	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Eq. 5.6a, Eq. 5.8, Eq. 5.10a, Eq. 5.13	EF_{EC}	Emissions factor for electricity at the relevant location	tCO_2e/kWh	r	Each reporting period, if applicable	
Eq. 5.8	$FC_{AE,ff}$	Total mass or volume of fuel type *ff* consumed for biochar production purposes for the reporting period	mass or volume unit	o	Each reporting period, if applicable	
Eq. 5.8	EC_{AE}	Total amount of electricity consumed for biochar production purposes for the reporting period	kWh	o	Each reporting period, if applicable	
Eq. 5.9	EF_{TC}	Emissions factor for thermochemical conversion process *TC* used to produce biochar	tCH_4/t biochar	r	Each reporting period	
Eq. 5.9	$M_{b,TC}$	Mass of biochar type *b* produced during the reporting period using thermochemical conversion process *TC*	t biochar	m	Each reporting period	
Eq. 5.9	GWP_{CH4}	Global warming potential of CH_4	tCO_2e/tCH_4	r	Each reporting period	
Eq. 5.10a	$FC_{BP,ff}$	Total mass or volume of fuel type *ff* consumed for the processing of biochar for the reporting period	mass or volume unit	o	Each reporting period, if applicable	
Eq. 5.10b	M_{bp}	Total mass of biochar processed using biochar processing type *bp*	tonnes	m	Each reporting period, if applicable	
Eq. 5.10b	EF_{bp}	Emissions factor for biochar processing type *bp*	tCO_2e/tonne	r	Each reporting period, if applicable	
Eq. 5.10a	EC_{BP}	Total amount of electricity consumed for biochar processing purposes for the reporting period	kWh	o	Each reporting period, if applicable	
Eq. 5.12	$M_{b,EU}$	Mass (wet) of biochar type *b* for end use type *EU* for the reporting period	tonnes	m	Each reporting period	Must be net of non-biochar materials weighed alongside biochar, such as pallets, shipping bags, etc.
Eq. 5.12	$M_{hist,EU}$	Maximum annual rate of production of biochar (wet mass) of biochar historically produced for end use type EU for the reporting period; for projects not required to account for historical biochar production, the value would be zero.	tonnes/yr	m	Each reporting period	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Eq. 5.12	$M_{b,u,EU}$	Mass (wet) of unit *u* of biochar type *b* for end use type *EU*	tonnes	m	Each reporting period	Must be net of non-biochar materials weighed alongside biochar, such as pallets, shipping bags, etc.
Eq. 5.12	$DM_{b,u,EU}$	Dry matter content of weighed unit *u* of biochar type *b* for end use type *EU*, based on the sampling and analysis (see Section 6.3.2)	%	m	Each reporting period	
Eq. 5.12	OC_b	Organic carbon content of biochar type *b* for the reporting period, based on the lower bound of the 95% confidence interval of the mean value determined from sampling and laboratory analysis (see Section 6.3)	%C	m	Each reporting period	
Eq. 5.12	P_{EU}	Permanence factor for end use *EU*	%	c, r	Each reporting period	
Eq. 5.12	P_{soil}	Permanence factor for soil applications, based on Woolf et al. (2021)	%	c, r	Each reporting period	Equation provided in Biochar Eligible End Uses List
Eq. 5.12	$t_{yrs,stor}$	Number of years (to nearest month) biochar was stored prior to end use application	years	o	Each reporting period, if applicable	
Eq. for P_{EU} for soil applications	c_{hc}	Co-efficient for calculation of soil application-related permanence factor, dependent on soil temperature	n/a	r	Each reporting period, if applicable	Equation provided in Biochar Eligible End Uses List
Eq. for P_{EU} for soil applications	m_{hc}	Co-efficient for calculation of soil application-related permanence factor, dependent on soil temperature	n/a	r	Each reporting period, if applicable	Equation provided in Biochar Eligible End Uses List
Eq. for P_{EU} for soil applications	$H:C_{org}$	H:C_{org} ratio based on the upper bound of the 95% confidence interval of the mean value determined from sampling and laboratory analysis (see Section 6.3)	molar ratio	m	Each reporting period, if applicable	Equation provided in Biochar Eligible End Uses List.
Eq. 5.13	EP_{Post}	Average daily amount of grid-connected electricity produced during the reporting period	kWh/day	o	Each reporting period, if applicable	
Eq. 5.13	EP_{Pre}	Average daily amount of grid-connected electricity produced during the three years immediately preceding the project start date	kWh/day	o	Each reporting period, if applicable	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Eq. 5.12, Eq. 5.13	$t_{days,RP}$	Total number of days comprising the current reporting period	days	o	Each reporting period, if applicable	

7 Reporting Parameters

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers. Project developers must submit verified emission reduction reports to the Reserve for every reporting period.

7.1 Project Submittal Documentation

Project developers must provide the following documentation to the Reserve to submit a biochar project for listing:

- Project Submittal form
- KML and shapefile of biochar production location

Project developers must provide the following documentation to the Reserve each time a biochar project is verified to have CRTs issued:

- Project Data Report
- Monitoring Plan
- Chain of custody documentation
- Biochar CRT Calculation Tool
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Verification Report
- Verification Statement

At a minimum, the above project documentation will be available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available on a voluntary basis through the Reserve. Project submittal forms can be found at http://www.climateactionreserve.org/how/protocols/ncs/biochar/.

7.2 Project Data Report

A Project Data Report (PDR) is a required document for reporting information about a project. The document must be submitted for every reporting period. An updated PDR must be provided to verification bodies whenever a biochar project undergoes verification. All PDRs are due within 12 months of the end of the Reporting Period, including for any reporting period for which verification is being deferred (see Section 7.4 for further information about deferred verifications). PDRs must include the following:

1. Monitoring Plan, as outlined in Section 6.1
2. Records and results from data collection and monitoring indicated in the monitoring plan for the project, including but not limited to:
    a. Description of the project configuration (feedstocks, production parameters, end uses) for the reporting period, including any production-related problems or stoppages that may have an impact on credit quantification and materials standards requirements under this protocol

   b. Indication of how Performance Standard Test and Legal Requirements Test were met
   c. Description of compliance with relevant laws and regulations, as well as environmental and social safeguards
   d. Information pertaining to sampling of biochar performed during the reporting period
   e. Description of and results from laboratory analyses performed for the reporting period
   f. Data and supporting documentation for monitoring parameters identified in Table 6.7.
3. Chain of custody documentation to corroborate reported data, including location data as KML files and shapefiles for production locations, at a minimum, and for feedstock source and biochar end use locations as available.
4. Description of any ecosystem services payments and/or project stacking, if occurring, with prior approval and guidance from the Reserve.
5. A copy of Biochar CRT Calculation Tool with credit quantification results.

A PDR template has been prepared by the Reserve and is available on the Reserve's website.[23] The template is arranged to assist in ensuring that all requirements of the protocol are addressed. PDRs are intended to serve as the main project document that thoroughly describes how the project meets eligibility requirements, discusses the quantification methodologies utilized to generate project estimates, outlines how the project complies with terms for additionality, and indicates CRT quantification results for the reporting period. For biochar projects, the PDR must also contain the monitoring plan for the project, as described in Section 6.1. PDRs must be of professional quality and free of incorrect citations, missing pages, incorrect project references, etc.

7.3 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. This information will not be publicly available, except as indicated in Section 7.1, but may be requested by the verifier or the Reserve.

System information the project developer should retain includes:

1. All data inputs for the calculation of the project emission reductions, including all required sampled data (data only; biochar samples only need to be retained through credit issuance)
2. Chain of custody documentation, including distances traveled
3. System characterization, including feedstocks composition, production parameters (e.g., production temperature and residence time), and operational records such as problems and production stoppages relevant to project reporting
4. Copies of all permits, Notices of Violations (NOVs), and any relevant administrative or legal consent orders dating back at least 3 years prior to the project start date

[23] Available at https://www.climateactionreserve.org/how/protocols/ncs/biochar/

5. Executed Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Voluntary Implementation forms
6. Fossil fuel use records
7. Grid electricity use records
8. Results of CO_2e carbon removal calculations for each reporting period
9. Initial and annual verification records and results
10. All maintenance records relevant to the monitoring equipment.

7.4 Reporting Period

A reporting period is a discrete period of time for which a project developer quantifies and reports GHG reductions and removals, as well as required project data to the Reserve. The maximum length of a reporting period (including the initial reporting period) is 12 months. An exception is made for the initial reporting period for pre-existing projects (i.e., projects with start dates preceding the Effective Date of this protocol), which may extend from the project start date to 12 months after the Effective Date (i.e., maximum initial reporting period of 36 months). Project developers may choose to have a sub-annual reporting period and verification schedule (e.g., monthly, quarterly, or semi-annually). In all instances, reporting periods must be contiguous, i.e., there must be no gaps in reporting during the crediting period of a biochar project once the initial reporting period has commenced. Even if there are gaps in project activities being reported (i.e., periods during which no biochar production occurs), such gaps must be included in reporting periods and verified accordingly.

7.5 Verification Period and Cycle

The verification period is the period of time for which GHG emissions reductions and/or removals from project activities are verified and credits are issued. A verification period may include multiple reporting periods. The end date of any verification period must correspond to the end date of a reporting period. A full verification[24] involving a site visit is required for a project's initial reporting period and at a minimum every two years thereafter or as may be required as described in Table 7.1. Optional verifications, known as desktop verifications, may be conducted at the project developer's discretion for crediting between required verifications. Project developers must provide an updated PDR, covering a maximum reporting period length of 12 months, to the Reserve no later than 12 months following the end of each reporting period, including for reporting periods for which verification is deferred.

Required verification documentation (see Section 7.1) must be submitted within 12 months of the end of the reporting period(s) being verified, regardless of the length of the reporting period(s).

[24] General descriptions of verification types are provided in the Verification Program Manual, available on the Reserve website at https://www.climateactionreserve.org/how/program-resources/program-manual/.

Table 7.1. Reporting and Verification Frequency Requirements

Type	Required Frequency
Reporting	
Project Data Report	Submitted for every reporting period, within 12 months of the end of the reporting period and covering a maximum reporting period length of 12 months
Verification	
Full verification with site visit	▪ Initial reporting period ▪ Every two years from the ending date of the last reporting period for which a site visit was conducted ▪ When there are significant changes in the technology used to produce biochar or the processes used to process feedstocks or biochar ▪ Any time the verification is being conducted by a different verification body than conducted the previous site visit
Desktop verification	▪ Any frequency, subject to maximum reporting period length and site visit frequency obligations

The Reserve may allow for a virtual site visit in place of an in-person site visit. At a minimum, the Reserve requires an in-person site visit at least once every four years. Use of a virtual site visit requires prior approval from the Reserve. Furthermore, the Reserve maintains discretion to require a site visit for a reporting period when other circumstances arise that may warrant a site visit verification, such as approval of a significant variance during the reporting period.

Credits will only be issued after verification is successfully completed and the Reserve completes its review of the verification documentation. For example, a project developer opting to defer the verification of its second reporting period until after the completion of the third reporting period would not have any CRTs issued in recognition of the carbon removals achieved in the second reporting period until the verification of the second and third reporting periods is complete. However, to provide additional flexibility, project developers may also opt to delay verification for other reasons (e.g., for periods of inactivity during which no biochar is being produced) on the condition that they acknowledge no CRTs will be issued for any period of time that falls outside the standard window for completing verification of project data and documentation. Such zero-credit reporting periods are further described in the Reserve Offset Program Manual.[25]

[25] Found on the Reserve website at https://www.climateactionreserve.org/how/program-resources/program-manual/.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions associated with the project activity. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities specifically related to biochar projects.

Verification bodies trained to verify biochar projects must be familiar with the following documents:

- Reserve Offset Program Manual
- Verification Program Manual
- Biochar Protocol
- Eligible Biochar Feedstocks List
- Eligible Biochar End Uses List
- Any applicable policy memos and errata and clarifications

The Reserve Offset Program Manual, Verification Program Manual, and protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

Only ISO-accredited verification bodies trained by the Reserve are eligible to verify biochar project reports. Information about verification body accreditation and Reserve project verification training can be found on the Reserve website at http://www.climateactionreserve.org/how/verification/.

8.1 Standard of Verification

The Reserve's standard of verification for biochar projects is the Biochar Protocol (this document), the Reserve Offset Program Manual, and the Verification Program Manual. To verify a biochar project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.2 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record keeping is ongoing at the project site. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.7 are collected and recorded.

8.3 Verifying Project Eligibility

Verification bodies must affirm a biochar project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for biochar projects. This table does not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria for a Biochar Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	For 12 months following the Effective Date of this protocol, a pre-existing project may be submitted based on a start date on or after January 24, 2022; after this 12-month period, project start dates must be based on the date the project is submitted for listing, when production of biochar commences using the production technology employed under the project, or a date determined by the project developer within 12 months of when production of biochar commences	Once during first verification
Location	All project phases taking place in the United States, Canada, their territories, and/or tribal/First Nation areas	Every verification
Performance Standard Test	Performance Standard Test has been met based on guidance provided in Section 3.4.1	Every verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures for ascertaining and demonstrating that the project passes the legal requirement test	Every verification
Regulatory Compliance	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verifier; project must be in material compliance with all applicable laws	Every verification
Environmental and Social Safeguards	All environmental and social safeguards have been met, including in relation to acceptable material properties of biochar based on the reported end use of project biochar.	Every verification

8.4 Core Verification Activities

The Biochar Protocol provides explicit requirements and guidance for quantifying the carbon removals associated with the biochar project. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a biochar project, but verification bodies must also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment that includes a data sampling and testing effort designed to ensure that the risk of reporting error is assessed and qualified. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs (SSRs)
2. Reviewing monitoring and measurement methodologies
3. Verifying GHG emissions and carbon removal estimates

Identifying emission sources, sinks, and reservoirs
The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, based on the guidance in Section 4.

Reviewing GHG management systems and estimation methodologies
The verification body reviews and assesses the appropriateness of the methodologies and management systems that the biochar project developer uses to gather data and calculate baseline and project emissions.

Verifying emission reduction estimates
The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project facility (or facilities if the project includes multiple facilities) to ensure the systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the project developer in order to double-check the calculations of carbon removals.

8.4.1 Desktop Verifications

When the verification cycle allows, as described in Section 7.4, project developers may opt to undertake a desktop verification to have credits issued between required full verifications. Desktop verifications involve the same level of scrutiny as a full verification, with the exception that direct observations of project conditions and procedures are not made by the verification body. As such, the verification items described in the following section are applicable for every verification except components that involve direct observations at the project location(s).

8.5 Biochar Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a biochar project. The tables include references to the section in the protocol where requirements are further specified. The tables also identify items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide sufficiently prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to biochar projects that must be addressed during verification.

8.5.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for biochar projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or subset of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that the project meets the definition of a biochar project.	No
2.3	Verify ownership of the reductions by reviewing the Attestation of Title. Also confirm that a properly completed Attestation of Biochar Use has been provided, along with documentation related to the notification to end users of the carbon credits associated with the project biochar.	No

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
	If the project developer is not the biochar producer, confirm the ownership of credits through review of signed contracts or other relevant documents.	
3.2	Verify project start date as either: ▪ The date the project was submitted to the Reserve, especially for projects with historical biochar production. ▪ The date that production of biochar using the production technology employed under the project is initiated, confirming any start-up testing period identified is not more than 12 months prior to the project start date and is supported by documentation provided by the project developer.	Yes, for evaluation of start-up testing period, if employed by project
3.3	Verify that project is within its ten-year crediting period.	No
3.4.1.1	Verify that the project meets the performance standard test for biomass acquisition, as described in Section 3.4.1.1: a) For waste and by-product feedstocks, confirm that: a. Feedstocks reported for the project are on the Eligible Biochar Feedstocks List. b. Project developer has demonstrated the typical fate of the feedstocks used by the project are consistent with the business as usual fate identified for the feedstock type in the Eligible Biochar Feedstocks List. If the project is drawing feedstocks from a location where such feedstocks are typically used for bioenergy production, the project developer has provided reasonable evidence that the use of such feedstocks is not limiting the feedstock supply for bioenergy production. b) For purpose-grown biomass, confirm: a. Feedstock type is on the Eligible Biochar Feedstocks List. b. The locations of feedstock production is correctly identified as being on marginal land (Land Capability Class 5 or 6 per spatial data from US Department of Agriculture-Natural Resources Conservation Service and/or Agri-Food Canada) or a reclaimed mining site. c. In the three years prior to its use for supplying biomass for the project, the source location was not: i. Used for the production of commodity crops ii. Converted from a natural or native vegetation type, or iii. Converted from a vegetation type with a higher carbon density. d. A waste management plan is in place that will limit emissions from anaerobic decomposition between the time purpose-grown biomass is harvested and when it is transferred for conversion to biochar. e. Project developer has identified the harvest conditions and attested that no tillage occurred as part of the cultivation cycle for the biomass harvested.	Yes, with respect to typical fate of project feedstocks being consistent with business as usual fate identified in the Eligible Biochar Feedstocks List
3.4.1.2	Verify that the project meets the performance standard test biochar production: a) If biochar production was occurring using the same facilities or equipment prior to the project start date, the maximum annual	No

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
	output from the three years prior to the start of the project has been determined and incorporated into b) Equation 5.12. c) For projects employing mobile equipment, the project developer is able to affirm that the use of such equipment is not part of a pre-existing effort, as described in Section 3.4.1.2. If the project does not meet a) or b) above, confirm the project has received approval from the Reserve for additionality with respect to pre-existing biochar production.	
3.4.1.3	Verify that project biochar is applied to an end use listed in the Eligible Biochar End Uses List.	No
3.4.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the legal requirement test.	No
3.4.2	Verify that the project Monitoring Plan contains a mechanism for ascertaining and demonstrating that the project passes the legal requirement test at all times and that the project passes the test each reporting period.	No
3.4.3	Confirm that the project developer has reported any ecosystem services payments received for project activities. If the project is being stacked with another project type, verify that the project developer has obtained approval and guidance from the Reserve with respect to such credit stacking and that the project developer has correctly applied the guidance correctly.	No
3.5	Verify the $H:C_{org}$ reported from laboratory testing of biochar (as performed according to the requirements of Section 6.3.1) is less than 0.7.	No
3.6	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form.	Yes
3.6	Verify that all parties in the chain of custody (from biomass acquisition to end use application, including transporters or storage facilities) are in regulatory compliance. In cases where violations have occurred, confirm they are considered neither material nor caused by project activities.	Yes
3.7	Verify the project complies with any applicable environmental safeguards specified in the Eligible Biochar Feedstocks List and Eligible Biochar End Uses List, including any end use-related contaminant limits.	Yes
3.7	Confirm organic contaminant testing has been performed, if applicable, and test results are within specified limits.	No
6.1	Verify that the project has documented and implemented a Monitoring Plan meeting the minimum requirements in Section 6.1.	No
6.2	Verify that the project meets chain of custody requirements, and that only biochar that meets the requirements is included in credit quantification.	No
6.3.1	Verify that the project meets biochar quality sampling and testing guidance: ▪ Confirm sampling design is consistent with the standards outlined in Table 6.4 and Table 6.5. ▪ Ensure the process for sample collection provides a representative sample from biochar produced each day.	Yes, for representa-tiveness of samples and for review of laboratory

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
	▪ During site visit, review sampling procedures employed to collect composite samples and prepare them for shipment for laboratory analyses and/or storage for retention purposes. ▪ Confirm laboratory that performed analyses of project samples is accredited to either of the following: o ISO/IEC 17025 standard under an appropriate national or international accreditation body, such as NELAP, A2LA, or ISO. o State- or province-approved certification program based on performance and proficiency. ▪ Review QA/QC documentation from laboratory performing analyses for reasonableness. ▪ Confirm analyses performed by laboratory used approved methods, as outlined in the *IBI Standardized Product Definition and Product Testing Guidelines for Biochar that Is Used in Soil* or the *World Biochar Certificate – Guidelines for a Sustainable Production of Biochar* or other approved standard.	QA/QC documents
6.3.2	Verify that the project meets the dry matter content sampling and analysis guidance: ▪ Confirm sampling design is consistent with the standards outlined in Table 6.6. ▪ Ensure the process for sample collection provides a representative sample from sampled biochar. ▪ During site visit, review sampling procedures employed to collect and analyze composite samples to ensure consistency with allowed methods. For projects using water meters: ▪ Review the water meter(s) during site visit. ▪ Confirm mitigation measures have been specified and followed to avoid the addition of unmetered water to biochar between metered applications of water and weighing of biochar for total mass.	Yes, for representa-tiveness of samples
	If any variances were granted, verify that variance requirements were met and properly applied.	No

8.5.2 Quantification

Table 8.3 lists the items that verification bodies shall include in their risk assessment and recalculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that all SSRs in the GHG Assessment Boundary are accounted for, including for conditional SSRs such as feedstock production emissions,	No

Protocol Section	Quantification Item	Apply Professional Judgment?
5.1	Verify that the baseline emissions are assumed to be zero	No
5.2.1	Verify the inputs for the calculation of the adjustment factor are determined correctly. If the project developer is providing project-specific energy content factors for co-products such as bio-oil or syngas, documentation of laboratory testing results supporting the factors used has been provided. For any co-product used onsite and for which direct measurements are not taken, the project developer has provided an estimate of the amount produced and the method for estimation is reasonable.	Yes, for estimates of non-measured co-products
5.2.1.1	Verify that the feedstock production emissions were correctly calculated, if applicable, and are consistent with reported source data	No
5.2.1.2	Verify that the feedstock transportation emissions were correctly calculated, if applicable, and are consistent with chain of custody reporting for each feedstock source	No
5.2.1.3	Verify that the feedstock processing emissions were correctly calculated, if applicable, and are consistent with reported source data	No
5.2.1.4	Verify that the mobile biochar production equipment transportation emissions were correctly calculated, if applicable, and are consistent with reported source data	No
5.2.1.5	Verify that the auxiliary energy emissions were correctly calculated, if applicable, and are consistent with reported source data	No
5.2.1.6	Verify that the thermochemical conversion emissions were correctly calculated, if applicable, and are consistent with reported source data, including the selection of the appropriate thermochemical conversion emissions technology (and associated emissions factor) in the Biochar CRT Calculation Tool. Projects claiming no emissions from the thermochemical conversion process have provided supporting evidence in the form of manufacturer documentation, peer reviewed studies, and/or other appropriate documentation.	Yes, for projects claiming no emissions as a result of emissions controls
5.2.1.7	Verify that the biochar processing emissions were correctly calculated, if applicable, and are consistent with reported source data. If the biochar provided by the biochar producer is not consistent with the assumed biochar condition for the specified end use(s), an appropriate process has been assumed to be applied by the end user and has been selected in the Biochar CRT Calculation Tool.	No
5.2.1.8	Verify that the biochar transportation emissions were correctly calculated, if applicable, and are consistent with chain of custody reporting for reported biochar end use(s)	No
5.2.2, 6.3	Verify that the project removals were correctly calculated, including: ▪ Reported biochar amounts are consistent with chain of custody reporting for reported biochar end use(s) ▪ Correct permanence factor(s) (P_{EU}) have been applied based on reported end use(s) that are corroborated by chain of custody tracking. For soil-based applications or similar, this includes the correct application of the equation from Woolf et al. (2021), as specified in the Eligible Biochar End Uses List, and consistency of soil temperature(s) applied to calculate P_{EU} with reported end use location(s).	No

Protocol Section	Quantification Item	Apply Professional Judgment?
	▪ Sampling and laboratory analyses results have been applied correctly, including with any ongoing updates to parameters resulting from Retention Sampling. ○ 95 percent confidence intervals have been constructed correctly for $H:C_{org}$ and organic carbon content (OC_b). ○ Upper bound of the confidence interval for $H:C_{org}$ has been applied. ○ Lower bound of the confidence interval for OC_b has been applied. ▪ New Initial Parameter Sampling has been initiated as a result of outlier biochar quality sampling and testing results, as indicated in Figure 6.1. ▪ Dry matter sampling and testing results have been incorporated correctly. ▪ Historical production amounts were determined appropriately, as described in Section 3.4.1.2, and correctly incorporated into the removals calculation. ▪ The amount of carbon in biochar stored for more than a year prior to end use application and for which a non-soil-based permanence factor is applicable has been adjusted to reflect potential degradation that occurred during storage.	
5.3	Verify that leakage is appropriately accounted for, if applicable. If the project involves the diversion of biochar from reinjection into a bioenergy furnace, changes in bioenergy facility production rates have been documented and leakage has been calculated for instances where the average daily bioenergy production rate has decreased more than 5 percent relative to the average daily production rate during the three years preceding the project start date.	No
6.5	Verify that the baseline and project calculation parameters meet the requirements outlined in Table 6.5.	

8.5.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6.1	Verify that the project Monitoring Plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6.1	Verify that an appropriate Monitoring Plan is used to meet the sampling and laboratory analysis requirements of Section 6.3	No
6.1	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6.1	Verify that appropriate training was provided to personnel assigned to GHG reporting duties	Yes

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6.1	Verify that all contractors are qualified for managing and reporting GHG emissions if relied upon by the project developer. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
6.2	Verify that chain of custody documentation comprehensively tracks feedstocks and biochar reported for quantification purposes under the project.	No
6.3	Verify that the sampling design for biochar quality and for dry matter content analysis each provide reasonable assurances that samples drawn and tested are representative of the biochar being produced by the project.	Yes
7.2	Verify that the Project Data Report is submitted for each reporting period and meets the requirements in Section 7.2	No
7.3	Verify that all required records have been retained by the project developer.	No

8.5.4 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verifier	A verification firm approved by the Climate Action Reserve to provide verification services for project developers.
Additionality	Project activities that are above and beyond "business as usual" operation, exceed the baseline characterization, and are not mandated by regulation.
Additive	Mineral-based inorganic material deliberately added to or inadvertently intermixed with feedstocks prior to biochar production.
Btu	British thermal unit.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Contaminant	Based on the International Biochar Initiative definition (IBI, 2012): An undesirable material in a biochar material or biochar feedstock that compromises the quality or usefulness of the biochar or through its presence or concentration causes an adverse effect on the natural environment or impairs human use of the environment (adapted from Canadian Council of Ministers of the Environment, 2005). Contaminants include fossil fuels and fossil fuel-derived chemical compounds, glass, and metal objects.
Direct emissions	GHG emissions from sources that are owned or controlled by the reporting entity.
Effective Date	The date of adoption of this protocol by the Reserve board: March 19, 2024.
Emission factor (EF)	A unique value for determining an amount of a GHG emitted for a given quantity of activity data (e.g., metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.

GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.
kWh	Kilowatt-hour.
Metric ton (t, tonne)	A common international measurement for the quantity of GHG emissions, equivalent to about 2,204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG consisting of a single carbon atom and four hydrogen atoms.
Mobile combustion	Emissions from the transportation of employees, materials, products, and waste resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g., cars, trucks, tractors, dozers, etc.).
MWh	Megawatt-hour.
Project baseline	A “business as usual” GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project developer	An entity that undertakes a GHG project, as identified in Section 2.2 of this protocol.
Verification	The process used to ensure that a given participant’s GHG emissions or emission reductions have met the minimum quality standard and complied with the Reserve’s procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	A Reserve-approved firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.

10 References

Budai, A., Zimmerman, A. R., Cowie, A. L., Webber, J. B. W., Singh, B. P., Glaser, B., Masiello, C. A., Andersson, D., Shields, F., Lehmann, J., Camps Arbestain, M., Williams, M., Sohi, S., & Joseph, S. (2013). *Biochar Carbon Stability Test Method: An assessment of methods to determine biochar carbon stability.* International Biochar Initiative.

Buss, W., Hilber, I., Graham, M. C., & Mašek, O. (2022). Composition of PAHs in biochar and implications for biochar production. *ACS Sustainable Chemistry & Engineering*, *10*(20), 6755-6765.

Cooley, D., & Olander, L. (2011). *Stacking Ecosystem Services Payments: Risks and Solutions.* Nicholas Institute for Environmental Policy Solutions.

Elias, M., Dees, J., Cabiyo, B., Saksa, P., & Sanchez, D. L. (2023). Financial Analysis of Innovative Wood Products and Carbon Finance to Support Forest Restoration in California. *Forest Products Journal*, *73*(1), 31-42.

International Biochar Initiative. (2015). *Standardized Product Definition and Product Testing Guidelines for Biochar That Is Used in Soil, Version 2.1.* International Biochar Initiative. Retrieved from https://www.biochar-international.org. Version 2.1 from 23 November 2015.

International Biochar Initiative and US Biochar Initiative (2024). 2023 Global Biochar Market Report. International Biochar Initiative.

ISO/IEC 17025:2017 General Requirements for The Competence of Testing dan Calibration Laboratories. International Organization for Standardization.

Karan, S. K., Woolf, D., Azzi, E. S., Sundberg, C., & Wood, S. A. (2023). Potential for biochar carbon sequestration from crop residues: A global spatially explicit assessment. *GCB Bioenergy*, *15*(12), 1424-1436.

Lefebvre, D., Fawzy, S., Aquije, C. A., Osman, A. I., Draper, K. T., & Trabold, T. A. (2023). Biomass residue to carbon dioxide removal: quantifying the global impact of biochar. *Biochar*, *5*(1), 65.

Man, K. Y., Chow, K. L., Man, Y. B., Mo, W. Y., & Wong, M. H. (2021). Use of biochar as feed supplements for animal farming. *Critical Reviews in Environmental Science and Technology*, *51*(2), 187-217.

Myhre, G., Shindell, D., Bréon, F. M., Collins, W., Fuglestvedt, J., Huang, J., ... & Midgley, P. M. (2013). Climate Change 2013: The Physical Science Basis: Contribution of Working Group I to the Fifth Assessment Report of the IPCC.

Thengane, S. K., Kung, K., Hunt, J., Gilani, H. R., Lim, C. J., Sokhansanj, S., & Sanchez, D. L. (2021). Market prospects for biochar production and application in California. *Biofuels, Bioproducts and Biorefining*, *15*(6), 1802-1819.

Wiedner, K., & Glaser, B. (2015). Traditional use of biochar. In J. Lehmann, & S. Joseph (Eds.), *Biochar for environmental management – science, technology and implementation,* 2nd ed (pp. 15– 38) Routledge.

Woolf, D., Lehmann, J., Ogle, S., Kishimoto-Mo, A. W., McConkey, B., & Baldock, J. (2021). Greenhouse gas inventory model for biochar additions to soil. *Environmental science & technology*, *55*(21), 14795-14805.

World Biochar Certificate. (2023). *World Biochar Certificate – Guidelines for a Sustainable Production of Biochar and its Certification.* Carbon Standards International, Frick, Switzerland. Retrieved from https://www.european-biochar.org. Version 1.0 from 15 September 2023.