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Chapter 1. Purpose and Definitions

1.1. Purpose

- (a) The purpose of the Compliance Offset Protocol Rice Cultivation Projects (protocol) is to quantify and report greenhouse gas (GHG) emission reductions associated with changes in rice cultivation practices that would otherwise be released to the atmosphere as a result of conventional rice cultivation practices.
- (b) AB 32 exempts quantification methodologies from the Administrative Procedure Act (APA);¹ however, those elements of the protocol are still regulatory. The exemption allows future updates to the quantification methodologies to be made through a public review and Board adoption process but without the need for rulemaking documents. Each protocol identifies sections that are considered quantification methodologies and exempt from APA requirements. Any changes to the non-quantification elements of the offset protocols would be considered a regulatory update subject to the full regulatory development process. Those sections that are considered to be a quantification methodology are clearly indicated in the title of the chapter or subchapter if only a portion of that chapter is considered part of the quantification methodology of the protocol.

1.2. Definitions

- (a) Definitions. For the purpose of this protocol, the following definitions shall apply:
 - (1) “Accuracy” is as defined in section 95102 of the Mandatory Reporting Regulation.
 - (2) “Baseline Period,” in the context of this protocol, means a period of at least five years immediately prior to the commencement of a project that comprises at least two cropping cycles. Each cropping cycle must include at least one rice cultivation year.
 - (3) “Baseline Scenario” means a counterfactual scenario that forecasts the likely stream of emissions or removals to occur if the Offset Project Operator does not implement the project.

¹ Health and Safety Code section 38571

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- (4) “Butte Sink Wildlife management Area” means the area as defined by U.S. Fish and Wildlife Service at http://fws.gov/refuge/butte_sink/. (Last accessed 02/10/2014.)
- (5) “Calibration” or “Model Calibration” means the process of tuning the coefficients of model parameters of a process-based model such as DNDC to observations.
- (6) “Cap-and-Trade Regulation” or “Regulation” means ARB’s regulation establishing the California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms set forth in title 17, California Code of Regulations Chapter 1, Subchapter 10, article 5 (commencing with section 95800).
- (7) “Checks” or “Field Checks” mean low dikes that are employed to control water distribution to fields.
- (8) “Cropping Cycle” means the sequence of a cropping system. For example, if a cropping system is wheat-wheat-rice, then a complete cropping cycle is three cultivation years.
- (9) “Cultivation Year” or “Year” means the period between the first day after harvest of the last crop in the field and the last day of harvest of the current crop in area field. A cultivation year may be longer or short than 12 months. Each cultivation year is a reporting period.
- (10) “DD50” means a computerized rice management program that assist with management decisions based on rice growth stages.
- (11) “Drained field” means a field with exposed soil and no standing water.
- (12) “Draining” means stopping water applications to a flooded or non-flooded field and/or removing water out of the field to expose soil.
- (13) “Dry Seeding” means sowing of dry seeds into dry or moist, non-puddled or non-flooded soil.
- (14) “Fallow Year” means a field is left unseeded during a growing season.
- (15) “Field” or “Rice Field” means a contiguous parcel of land with homogeneous management on which rice is grown semi-continuously (i.e., at least three out of the last six cultivation years). A Rice Field has

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one water inlet and one outlet and is usually separated by checks inside of perimeter levees that delineate the field's boundaries.

- (16) "Flooded Field" means a rice field that is completely inundated by water, with no visible soil or mud.
- (17) "Heading" means the time when the panicle begins to exert from the boot. It may take over 10 to 14 days for heading to take place due to variations within tillers on the same plant and between plants in the field.
- (18) "Heading date" is the time when 50 percent of the panicles have at least partially exerted from the boot.
- (19) "Historical Period" means the 20-year period used for model simulation to allow the DNDC model to attain equilibrium in certain critical variables for which empirical data is lacking.
- (20) "Mandatory Reporting Regulation" or "MRR" means ARB's regulation establishing the Mandatory Reporting of Greenhouse Gas Emissions set forth in title 17, California Code of Regulations Chapter 1, Subchapter 10, article 2 (commencing with section 95100).
- (21) "Model Parameter" means a data item that is supplied as input to a process-based model.
- (22) "Model Validation" means the process of evaluating calibrated model results using field-measured data and quantifying the residual (structural) uncertainty.
- (23) "Monte Carlo Simulation" means a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results; typically one runs simulations many times over in order to obtain the distribution of an unknown probabilistic entity.
- (24) "Parameterization" means the selection of Model Parameters that a process-based model such as DNDC will use for simulation.
- (25) "Precision" means the degree to which repeated measurements under unchanged conditions show the same results.

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- (26) “Primary Effect” means the direct or intentional effect as a result of a project. Primary effect emissions mainly come from sources within the biogeochemical process that the DNDC model simulates.
- (27) “Project Activity,” for purposes of this protocol, means change in agronomic management that leads to a reduction in GHG emissions in comparison to the baseline management and GHG emissions.
- (28) “Project Area,” for purposes of this protocol, means a rice field or a group of rice fields on which project activities take place.
- (29) “Project Commencement Date” means, for the purposes of this protocol, the earliest first day of the first rice cultivation year of a project.
- (30) “Regional Calibration” means the specific steps required to Calibrate and Validate the DNDC model for a Rice Growing Region and specific Project Activities.
- (31) “Reporting Period” means, for the purposes of this protocol, a rice cultivation year. When a project comprises multiple rice fields, the reporting period starts on the earliest first day of a cultivation year of a field in the project and ends on the latest last day of a cultivation year of a field in the project.
- (32) “Rice Growing Region” means a geographic region in which the climate and rice management practices are relatively homogeneous. There are two major Rice Growing Regions in the United States: California Rice Growing Region and Mid-South Region. California Rice Growing Region includes Sacramento Valley only. Mid-south Rice Growing Region includes (1) Mississippi River Delta mainly in Arkansas, extending into Mississippi and Missouri and (2) Gulf Coast area in Louisiana. A Rice Growing Region represents the geographical region that reflects the area over which one Calibration of the DNDC model remains valid.
- (33) “Rotation Crop” means the crop planted as part of the practice of growing a series of dissimilar types of crops in the same area in sequential seasons.

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- (34) “Secondary Effect” means indirect or unintentional changes as a result of a project. Secondary effect emissions mainly come from sources such as farming equipment that is used for land preparation, irrigation, sowing, harvesting, transporting, etc.
- (35) “Start Date” means the start of the vintage year for the first rice field in the Project, as determined per section 4.6.
- (36) “Structural Uncertainty” means the inherent uncertainty of process-based models that remains even if all input data were error-free.
- (37) “Uncertainty Deduction” means deduction, accounting for both uncertainty in input parameters and model Structural Uncertainty, applied to the emission reductions calculated by DNDC to ensure that credited emission reductions remain conservative.
- (38) “Wet Seeding” means sowing pre-germinated seed or sprouted seeds into puddled soil.
- (b) For terms not defined in section 2.2(a), the definitions in the Regulation apply.
- (c) Acronyms. For purposes of this protocol, the following acronyms shall apply:
 - (1) “ARB” means the California Air Resources Board.
 - (2) “AWD” means alternate wet and dry.
 - (3) “DNDC” means DeNitrification and DeComposition model.
 - (4) “ha” means hectare.
 - (5) “HP” means horsepower.
 - (6) “Kg” means kilogram.
 - (7) “MT” means metric ton.
 - (8) “SSR” means greenhouse gas sources, sinks, and reservoirs.
 - (9) “SSURGO Database” means Soil Survey Geographic (SSURGO) Database.
 - (10) “STATSGO Database” means State Soil Geographic Database.

Chapter 2. Eligible Project Activities – Quantification Methodology

This protocol includes three rice cultivation project activities designed to reduce GHG emissions that result from the rice cultivation process at rice fields in the California Rice

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Growing Region and the Mid-South Rice Growing Region. The following types of rice cultivation activities are eligible:

2.1. Dry Seeding Activities

This protocol applies to rice cultivation projects that sow seed into a dry or moist seedbed by drilling or broadcasting seed onto rice fields, resulting in the reduction of methane that would otherwise be released into the atmosphere if the seeds were wet-seeded.

- (a) For dry seeding activities, permanent flooding must be delayed until the rice stand is established to a four to six leaf stage.
- (b) The management records specified in appendix A for the baseline period for rice fields implementing dry seeding activities must be available.
- (c) Only fields that were wet seeded during each rice cultivation year of the baseline period are eligible for crediting.
- (d) Only dry-seeding projects located in the California Rice Growing Region are eligible for crediting.

2.2. Early Drainage Activities

This protocol applies to rice cultivation projects that drain or dry standing water from rice fields earlier during the rice growing season in preparation for harvest, resulting in the reduction of methane that would otherwise be released into the atmosphere if the rice fields were drained or dried on the customary date.

- (a) The management records specified in appendix A for the baseline period for rice fields implementing early drainage activities must be available.
- (b) For early drainage activities, standing water cannot be drained within 25 days after seventy-five percent heading. Each field must be sampled to determine seventy-five percent heading using the following criteria:
 - (1) At least three samples must be taken;
 - (2) At least one sample must be taken within 50 feet of the water inlet; and
 - (3) At least two thirds of the samples must meet seventy-five percent heading.

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**Stakeholder Input Requested: Determination of Seventy-Five Percent
Heading**

Does the seventy-five percent criterion make sense and can it be applied consistently across projects? Should other criteria be used?

- (c) For wildlife conservation purposes in the California Rice Growing Region, at least fifteen percent of a participating field's perimeter must not be shared with a public road, a field that is also employing early drainage activates or land zoned for commercial, industrial, residential, planning, special, or mixed use to be eligible for crediting.
- (d) Fields whose tail water flows directly into a natural wetland, which has no standing water at the beginning of the drainage, without going through another rice field, drain canal, or irrigation canal first, are not eligible for crediting.
- (e) Early drainage projects located in both the California and Mid-South Rice Growing Regions are eligible for crediting.

2.3. Alternate Wet and Dry Activities

- (a) This protocol applies to rice cultivation projects that cyclically wet and dry the rice fields during the growing season to reduce methane emissions that would otherwise be released into the atmosphere if the project employed continuous flooding.
- (b) The management records specified in appendix A for the baseline period for rice fields implementing AWD activities must be available.
- (c) For AWD activities, the following requirements apply and soil moisture samples must be taken as specified below:
 - (1) At the end of each "drying," the top 10 centimeter soil must reach a non-saturated point, but maintain a moisture level above thirty-five percent;
 - (2) Areas of the rice field that are still saturated with water are ineligible for crediting;

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- (3) For fields that are not zero-percent graded but sloped towards the outlet at least one soil moisture sample point must be taken within 50 feet of the water outlet; and
- (4) For fields that are zero-percent graded, the following requirements apply.
 - (A) A field that is less than or equal to 50 acres must have at least three equally spaced soil moisture samples taken, including one within 50 feet of the water inlet and one within 50 feet of the water outlet.
 - (B) A field that is greater than 50 acres must have at least five equally spaced soil moisture samples taken, including one within 50 feet of the water inlet and one within 50 feet of the water outlet.
- (d) Only AWD projects located in the Mid-South Rice Growing Region are eligible for crediting.

Stakeholder Input Requested: Soil Moisture Sampling Requirements

What are the types of soil moisture sampling procedures, equipment, calibration schedule and maintenance requirements necessary to ensure accurate data?

Chapter 3. Eligibility

In addition to the offset project eligibility criteria and regulatory program requirements set forth in the Regulation, rice cultivation offset projects must adhere to the eligibility requirements below.

3.1. General Eligibility Requirements

- (a) Offset projects developed using this protocol must:
 - (1) Only include rice fields in the project area that have planted rice for at least two rice cultivation years in the baseline period before the project commencement;
 - (2) Grow rice of the same maturity characteristics during the crediting period as the baseline period;

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- (3) Employ homogeneous water, fertilizer, and crop residue management across each participating rice field area within each reporting period;
- (4) Have at least two years of rice yield and management data specified in Management records for baseline period for each field within the baseline period;
- (5) Employ one or multiple eligible activities as specified in Chapter 2;
- (6) Have soil with organic carbon content less than or equal to three percent in the top ten centimeters of soil in each eligible field;
 - (A) The organic content of a field must be determined using SSURGO data posted on ARB's website at <http://www.arb.ca.gov>.
 - (B) If SSURGO data is not available, STASGO data posted on ARB's website at <http://www.arb.ca.gov> must be used.
 - (C) If neither SSURGO or STASGO data is available, one of the following methods may be chosen to determine soil characteristics:
 - 1. A government soil database;
 - 2. A state university published soil database; or
 - 3. Soils samples may be taken to determine the soil parameters, for a participating field. Soil samples must be taken per USDA's Soil Quality Test Kit Guide (July 2001), available at http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051290.pdf² and tested by a USDA APHIS inspected facility authorized to receive soil (http://www.aphis.usda.gov/wps/portal/aphis/ourfocus/planthealth?1dmy&urile=wcm%3apath%3a%2Faphis_content_library%2Fsa_our_focus%2Fsa_plant_health%2Fsa_import%2Fsa_permit%2Fsa_plant_pests%2Fsa_soil%2Fct_soil_labs³).
- (7) Have not generated ARB or voluntary registry offset credits for fallow or rotation crop years; and

² Last accessed 03/12/2014.

³ Last accessed 03/12/2014.

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- (8) Have not grown wild rice cultivars since the first year of the baseline period.
- (b) Offset Project Operators or Authorized Project Designees that use this protocol must:
 - (1) Provide the listing information required by section 95975 of the Regulation and section 7.1 of this protocol;
 - (2) Monitor GHG emission sources and sinks within the GHG Assessment Boundary as delineated in Chapter 4 per the requirements of Chapter 6;
 - (3) Quantify GHG emission reductions per Chapter 5;
 - (4) Prepare and submit annual Offset Project Data Reports (OPDRs) that includes the information requirements in section 7.2; and
 - (5) Undergo annual, independent verification by an ARB-accredited verification body in accordance with section 95977 of the Regulation and Chapter 8.

3.2. Location

- (a) Only projects located in an approved Rice Growing Region for which the DNDC model has been calibrated and validated against field measured methane emission, and a regional performance standard has been evaluated, are eligible for crediting.
- (b) Only projects located in the following Rice Growing Regions are eligible:
 - (1) California Rice Growing Region defined as Sacramento Valley, but outside of the Butte Sink Wildlife Management Area.
 - (2) Mid-South Rice Growing Region defined as:
 - (A) Mississippi River Delta in Arkansas, Mississippi and Missouri; and
 - (B) Gulf Coast area in Louisiana.
- (c) An offset project situated on the following categories of land is only eligible under this protocol if it meets the requirements of this protocol and the Regulation, including the waiver of sovereign immunity requirements of section 95975(l) of the Regulation:

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- (1) Land that is owned by, or subject to an ownership or possessory interest of a Tribe;
- (2) Land that is “Indian lands” of a Tribe, as defined by 25 U.S.C. 81(a)(1); or
- (3) Land that is owned by any person, entity, or Tribe, within the external borders of such Indian lands.

3.3. Offset Project Operator or Authorized Project Designee

- (a) The Offset Project Operator or Authorized Project Designee is responsible for project listing, monitoring, reporting, and verification.
- (b) The Offset Project Operator or Authorized Project Designee must submit the information required by Subarticle 13 of the Regulation and in Chapter 7 of this protocol.
- (c) The Offset Project Operator must have legal authority to implement the offset project.
- (d) For purposes of this protocol, the Offset Project operator must be either the land owner or leasee.
- (e) Within 30 calendar days of a change of Offset Project Operator due to a change of land ownership, management or tenant occupancy, the new Offset Project Operator must submit to both ARB and the offset project registry (OPR) the following information which will be made public:
 - (1) The name, address, phone number, and email address of the new Offset Project Operator;
 - (2) The name address, phone number and email address of the original Offset Project Operator and Authorized Project Designee, if applicable;
 - (3) The date of change of land ownership, management or tenant occupancy; and
 - (4) The signed attestations found in section 95975(c) of the Regulation.
- (f) If the new Offset Project Operator elects to continue the project they must continue the existing project and crediting period. Upon the end of the current crediting period, the new Offset Project Operator may opt to renew the project pursuant to section 95957 of the Regulation using the existing project’s baseline.

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3.4. Additionality

Offset projects must meet the additionality requirements set out in section 95973(a)(2) the Regulation, in addition to the requirements in this protocol. Eligible offsets must be generated by projects that yield surplus GHG reductions that exceed any GHG reductions otherwise required by law or regulation or any GHG reduction that would otherwise occur in a conservative business-as-usual scenario. These requirements are assessed through the Legal Requirement Test in section 3.3.1 and the Performance Standard Evaluation in section 3.3.2.

3.4.1. Legal Requirement Test

- (a) Emission reductions achieved by a Rice Cultivation project must exceed those required by any law, regulation, or legally binding mandate as required in 95973(a)(2)(A) and 95975(n) of the Regulation.
- (b) The following legal requirement test applies to all Rice Cultivation projects:
 - (1) If no law, regulation, or legally binding mandate requiring the implementation of project activities at the field(s) in which the project is located exists, all emission reductions resulting from the project activities are considered to not be legally required, and therefore eligible for crediting under this protocol.
 - (2) If any law, regulation, or legally binding mandate requiring the implementation of project activities at the field(s) in which the project is located exists, only emission reductions resulting from the project activities that are in excess of what is required to comply with those laws, regulations, and/or legally binding mandates are eligible for crediting under this protocol.

3.4.2. Performance Standard Evaluation

- (a) Emission reductions achieved by a Rice Cultivation project must exceed those likely to occur in a conservative business-as-usual scenario.
- (b) The performance standard evaluation is satisfied by the following activities depending on project location:
 - (1) Dry Seeding Activities in the California Rice Growing Region.

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- (2) Early Drainage Activities in both Rice Growing Regions.
- (3) Alternate Wet and Dry Activities in the Mid-South Rice Growing Region.

3.5. Methane Source Boundaries

- (a) The methane emission reductions from the rice cultivation protocol must be from project activities that reduce methane emissions that would otherwise be emitted into the atmosphere during the course of normal rice cultivation activities.
- (b) The physical boundaries for an offset project, including for all project activities, are one or more rice fields.
- (c) Only reductions in methane emissions are eligible for ARB offset credits. GHG emission reductions or removal enhancements due to changes in N₂O or soil organic carbon are not eligible for crediting.

3.6. Offset Project Commencement

- (a) The offset project commencement date is the first day of the cultivation cycle during which a project activity is first implemented.
- (b) The offset project commencement date must be after December 31, 2006.

3.7. Reporting Period

- (a) For the purposes of this protocol, the reporting period is defined as the period between the first day after harvest of the last crop in the project area and the last day of harvest of the current crop in the project area.
- (b) A reporting period could be either longer or shorter than a twelve-month period.
- (c) A rotation crop year or fallow year is considered a reporting period. The Offset Project Operator and/or Authorized Project Designee must indicate this situation in the Offset Project Data Report immediately following the rotation or fallow year and should report zero GHG emission reductions.

3.8. Project Crediting Period

The crediting period for this protocol is ten reporting periods.

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3.9. Regulatory Compliance

- (a) An Offset Project Operator or Authorized Project Designee must fulfill all applicable local, regional, and national requirements on environmental impact assessments that directly apply to the offset project.
- (b) Offset projects must fulfill all local, regional, and national environmental and health and safety laws and regulations that directly apply to the offset project.
- (c) The project is out of regulatory compliance if the project activities were subject to enforcement actions by a regulatory oversight body during the Reporting Period.
- (d) Offset projects are not eligible to receive ARB or registry offset credits for GHG emission reductions or GHG removal enhancement for the entire Reporting Period if the offset project is not in compliance with regulatory requirements directly applicable to the offset project during the Reporting Period.

Chapter 4. GHG Assessment Boundary - Quantification Methodology

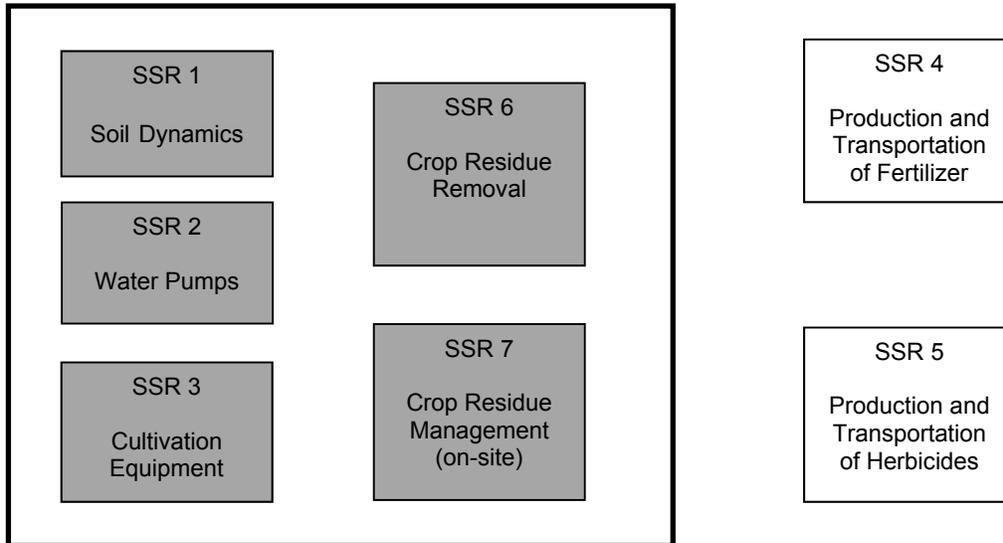
The greenhouse gas assessment boundary, or offset project boundary, delineates the SSRs that shall be included or excluded when quantifying the net change in GHG emissions associated with the adoption of eligible rice cultivation activities. The following GHG assessment boundaries apply to all rice cultivation projects.

4.1. Greenhouse Gas Assessment Boundary

- (a) Figure 4.1 illustrates the GHG assessment boundary of rice cultivation projects, indicating which SSRs are included or excluded from the offset project boundary.
- (b) All SSRs within the bold line are included and must be accounted for under this protocol.

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Figure 4.1. Illustration Of The Greenhouse Gas Assessment Boundary For Rice Cultivation Projects.



Stakeholder Input Requested: Accounting for Project GHG Emission Boundary

- 1. For crop residue removal, how should we account for any off-site emissions? The off-site emissions may include rice straw end-use emissions.*
- 2. Is it likely that there will be little increase in GHG emissions from SSR 4 and SSR 5 as a result of project activities? What are the technical challenges to include these emissions sources?*

- (c) Table 4.1. List of the Greenhouse Gas Sinks, Sources and Reservoirs for Rice Cultivation Projects indicates which gases are included or excluded from the offset project boundary.

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Table 4.1. List of the Greenhouse Gas Sinks, Sources and Reservoirs for Rice Cultivation Projects

SSR	Description	GHG	Baseline Scenarios (B) or Project (P)	Included/ Excluded	Quantification Method	Explanation
Primary Effect Sources, Sinks, and Reservoirs						
1	The biogeochemical interaction between soil, plants, and nutrients that produce greenhouse gases including CO ₂ , CH ₄ , N ₂ O, and changes in soil carbon stocks.	CO ₂	B,P	Included	DNDC	May be significant changes in CO ₂ emissions due to changes in soil carbon stocks as a result of project activities.
		CH ₄	B,P	Included	DNDC	Primary effect of the protocol is reduction in CH ₄ emissions due to reduced organic decomposition as a result of reduced flooding or reduced organic residues.
		N ₂ O	B,P	Included	DNDC	May be a significant source of emissions if project activities affect fertilizer application or practices.
Secondary Effect Sources, Sinks, and Reservoirs						
2	Indirect fuels or electricity used to operate water pumps to transport water onto fields.	CO ₂	B,P	Excluded	N/A	Project activities are likely to only result in decreased fossil fuel use which is not credited.
		CH ₄	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
		N ₂ O	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
3	Greenhouse gas emissions increase as a result of equipment use for rice cultivation activities.	CO ₂	B,P	Included	Emission Factors	Emissions may be significant if project activities alter management practices.
		CH ₄	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
		N ₂ O	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.

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SSR	Description	GHG	Baseline Scenarios (B) or Project (P)	Included/ Excluded	Quantification Method	Explanation
4	Greenhouse gas emissions from manufacturing and transporting fertilizer to rice fields	CO ₂	N/A	Excluded	N/A	Incremental increase assumed to be small, excluded to simplify accounting.
		CH ₄	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
		N ₂ O	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
5	Greenhouse gas emissions from manufacturing and transporting herbicide to rice fields	CO ₂	N/A	Excluded	N/A	Incremental increase assumed to be small, excluded to simplify accounting.
		CH ₄	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
		N ₂ O	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
6	Greenhouse gas emission from baling and transporting rice straw for offsite use/management	CO ₂	P, B	Included	N/A	Emissions may be significant if project activities alter residue management.
		CH ₄	P,B	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
		N ₂ O	P, B	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
7	Greenhouse gas emission from rice straw use/management (onsite or offsite)	CO ₂	P, B	Included	Emission Factors	May be a significant source of emissions for rice straw burning
		CH ₄	P, B	Included	Emission Factors i	May be a significant source of emissions from anaerobic decomposition of rice straw base on end use
		N ₂ O	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.

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Chapter 5. Quantifying GHG Emission Reductions - Quantification Methodology

- (a) GHG emission reductions from a rice cultivation project are quantified by comparing actual project emissions to project baseline emissions that would have occurred in the absence of the rice cultivation project.
- (b) Offset Project Operators and Authorized Project Designees must use the calculation methods provided in this protocol to determine baseline and project GHG emissions.
- (c) GHG emission reductions must be quantified on a reporting year basis.
- (d) Global warming potential values must be determined consistent with the definition of Carbon Dioxide Equivalent in MRR section 95102(a).

5.1. Calculating GHG Emission Reductions

- (a) Total GHG emission reductions (ER) for each rice field for a reporting period must be quantified by subtracting secondary emission increases (SE) from modeled primary emission reductions (PER) using equation 5.1.

Equation 5.1 Calculating GHG Emission Reductions

$ER = PER - SE$		
Where,		Units
ER	= Total emission reductions from the project area for the reporting period	MTCO ₂ e
PER	= Total modeled primary source GHG emission reductions from soil dynamics (SSR 1) during the reporting period	MTCO ₂ e
SE	= Total secondary source GHG emission increases caused by project activity during the reporting period	MTCO ₂ e

- (b) Total modeled primary source GHG emission reductions (PER) must be calculated using the DNDC model as specified in section 5.2.
- (c) Total secondary source GHG emission increases (SE) must be calculated as specified in section 5.3.

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5.2. Modeled Primary Emission Reductions

- (a) Quantifications performed in this section must use the DNDC model Version X.X (2014), posted at ARB's website at <http://arb.ca.gov>.
- (b) Modeled primary emission reductions for each rice field must be calculated following these procedures:
 - (1) Perform a field-specific calibration on the DNDC model, as specified in section 5.2.1.
 - (2) Quantify unadjusted baseline GHG emissions, as specified in section 5.2.2.
 - (3) Quantify unadjusted project GHG emissions, as specified in section 5.2.3.
 - (4) Quantify primary emission reductions, as specified in section 5.2.4.
- (c) For steps identified in section 5.2(b)(1) through (3), The DNDC model must be populated with climate, soil, and cropping data for the applicable rice field(s) within the project.
 - (1) Soil data must be obtained per section 3.1(a)(6)(A) through (C).
 - (2) Daily climate data must include daily data on precipitation, wind speed, maximum temperature, minimum temperature, and solar radiation (MJ/m²day) and must be obtained from the closest weather station located within an elevation difference of no more than 300 feet from the project location. If the project is located in an air basin, the weather station must be located within the same air basin.
 - (3) Farming management practices must include total simulation years, number of cropping systems sequentially applied during the total years, related cropping system and cycle information, and management practices that include crop, tillage, fertilization, manure management, irrigation, flooding, plastic, and grazing or cutting information.
 - (4) Cropping data for baseline scenarios must be determined per section 5.2.2.1.
 - (5) Farming management practices for projects must be determined based on actual data.
 - (6) Detailed model parameters are listed in Table 6.1.

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- (d) All DNDC variable data format must be consistent with what is specified in the DNDC User Guide Version XXX posted on ARB’s website at <http://arb.ca.gov>.

5.2.1. Field-Specific Crop Calibration

- (a) A field specific crop yield calibration for the DNDC model must be performed once for every project before all other quantification starts. The field specific crop yield calibration for the DNDC model must be performed in accordance with the requirements set forth in appendix B.
- (b) The “Max. biomass production” and “Thermal degree days for maturity” values determined during the field-specific DNDC crop calibration must be used for all subsequent runs of the DNDC model for calculating unadjusted baseline and project emissions.
- (c) Prior to modeling the unadjusted baseline and unadjusted project emissions for the first reporting period of each field, the DNDC crop parameters must be calibrated with baseline input data from the baseline period, that comprises at least two cropping cycles when rotation crop or fallow year exists, prior to offset project commencement.
- (d) Crop parameters must be taken from table B.1.

5.2.2. Unadjusted Baseline Emissions

- (a) Unadjusted baseline emissions must be quantified for each field for each reporting period.
- (b) The baseline scenario for each reporting period must be established per section 5.2.2.1.
- (c) For the initial reporting year, the unadjusted baseline modeling must be equilibrated with at least 20 years of historical data covering complete cropping cycles, including rotation crop(s) and fallow year, by repeating all parameters from the baseline period before the start of the crediting period four times. The 20-year spin up must include data for all crop and fallow years, not just rice crop years. The following data must be used:
 - (1) Current soil data;
 - (2) Current year climate data; and

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- (3) Baseline period historical farming management practices.
- (d) For each subsequent year of the crediting period, the unadjusted modeling must be equilibrated with at least 20 years of data from the baseline period as described in section 5.2.2(c) and data from all preceding years in the crediting period.
- (e) Unadjusted baseline GHG emissions for each rice field must be determined with the DNDC model based on the farming management information parameters determined for the baseline scenario in section 5.2.2.1 below and the soil and climate profile parameters for the current rice cultivation cycle. The following DNDC parameters must be varied according to appendix E:
- (1) Soil clay;
 - (2) Bulk density;
 - (3) SOC content; and
 - (4) pH value.
- (f) The direct GHG emission parameters identified in Box 5.1 are retrieved from the DNDC runs.

Box 5.1. Recovered Baseline Parameter

<u>Recovered Baseline Parameters</u>			
$N_2O_{Dir,B,i,j}$	=	Baseline N_2O emissions from rice field i from Monte Carlo run j	kg N_2O -N/ha
$N_{Leach,B,i,j}$	=	Baseline nitrate leaching loss from rice field i from Monte Carlo run j	kg NO_3 -N/ha
$N_{Vol,B,i,j}$	=	Baseline ammonia volatilization from rice field i from Monte Carlo run j	kg NH_3 -N + kg NO_x -N-N/ha
$CH_4_{B,i,j}$	=	Baseline CH_4 emissions from rice field i from Monte Carlo run j	kg CH_4 -C/ha
$SOC_{B,i,j}$	=	Baseline soil organic carbon content from rice field i from Monte Carlo run j	Kg SOC-C/ha

- (g) Total average unadjusted baseline GHG emissions from two thousand runs of Monte Carlo simulations for field i must be calculated using equation 5.2 below.

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Equation 5.2. Calculating GHG Emissions from Monte Carlo Runs for Field i

$N_2O_{B,i} = \frac{\sum_{j=1}^{2000} \{(N_2O_{Dir,B,i,j} + (N_{Leach,B,i,j} \times EF_{Leach}) + (N_{Vol,B,i,j} \times EF_{Vol})\}}{2000} \times 1.571 \times GWP_{N_2O}$		
$CH_{4B,i} = \frac{\sum_{j=1}^{2000} (CH_{4B,i,j})}{2000} \times 1.333 \times GWP_{CH_4}$		
$SOC_{B,i} = \frac{\sum_{j=1}^{2000} (SOC_{B,i,j})}{2000} \times 3.667$		
Where,	Units	
i	= Fields	
j	= Monte Carlo runs	
$N_2O_{B,i}$	= Average reporting period direct and indirect N_2O emissions for the baseline scenario from rice field i, equal to the average value of all Monte Carlo runs j	kg CO_2e/ha
$N_{Leach,B,i,j}$	= Reporting period nitrate leaching loss from rice field i for the baseline scenario from Monte Carlo run j	kg NO_3-N/ha
EF_{Leach}	= Emission factor for N_2O emissions from N leaching and runoff, equal to 0.0075	kg $N_2O-N/kg NO_3-N$
$N_{Vol,B,i,j}$	= Reporting period ammonia volatilization and nitric oxide emissions from rice field i (for either the baseline or project scenario) from Monte Carlo run j	kg $NH_3-N + kg NO_x-N /ha$ volatilized
EF_{Vol}	= Emissions factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces and subsequent volatilization, equal to 0.01	kg $N_2O-N/(kg NH_3-N + kg NO_x-N)$
1.571	= Unit conversion from kg N_2O-N to kg N_2O	
$CH_{4B,i}$	= Average reporting period CH_4 emissions (for either the baseline or project scenario) from rice field i, equal to the average value of all Monte Carlo runs j	kg CO_2e/ha
$CH_{4B,i,j}$	= Reporting period CH_4 emissions from rice field i (for either the baseline or project scenario) from Monte Carlo run j	kg CH_4-C/ha
1.333	= Unit conversion of C to CH_4	
$SOC_{B,i}$	= Average reporting period final SOC, equal to the average value of all Monte Carlo runs j, of the soil organic carbon content of rice field i on the last day of the reporting period (for either the baseline	kg CO_2e/ha

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		or project scenario)	
$SOC_{B,i,j}$	=	SOC content of rice field i on the last day of the reporting period (for either the baseline or project scenario) from Monte Carlo run j	kg SOC-C/ha
3.667	=	Unit conversion of C to CO ₂	
0.0075	=	Emission factor for N ₂ O emissions from N leaching and runoff	kg N ₂ O-N / kg NO ₃ -N
0.01	=	Emission factor for N ₂ O emissions from atmospheric deposition of N on soils and water surfaces and subsequent volatilization	kg N ₂ O-N / (kg NH ₃ -N + kg NO _x -N)
GWP_{N_2O}	=	The GWP value for N ₂ O	
GWP_{CH_4}	=	The GWP value for CH ₄	

5.2.2.1. Baseline Scenarios Establishment

The Offset Project Operator or Authorized Project Designee must determine the baseline scenarios for each cropping parameter for each reporting period. The baseline scenarios must be established according to the following requirements:

- (a) Soil data must be determined per section 3.1(a)(6)(A) through (C).
- (b) Climate data must use respective reporting year’s climate data as specified in section 5.2(c)(2).
- (c) Cropping data must be determined as specified in section 5.2.2.1(d) through (I).
- (d) Plant Date is the actual planting date for the current rice cultivation cycle.
- (e) Tillage Events: the actual tillage events for the current rice cultivation cycle will be used to determine the baseline scenario tillage events.
- (f) Fertilization Events
 - (1) For California, the baseline scenario fertilization events will be grouped by type of fertilizer for each application and multiple applications of the same type of fertilizer will be distinct fertilization events under the baseline scenario.
 - (A) The baseline scenario fertilization event dates are determined by adding the average number of days from planting to the fertilization

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- event for all the rice cultivation years in the baseline period to the planting date of the current rice cultivation cycle;
- (B) The baseline scenario fertilization rates are the average rate for each event during baseline period prior to offset project commencement; and
 - (C) The baseline scenario fertilizer application technique is the most common technique for each application used during the baseline period.
- (2) For the Mid-South, the DD50 model will be used to determine the baseline scenario fertilization events by using the current rice cultivation cycle emergence date.
- (g) Flooding Date
- (1) For California, the flooding date is determined by subtracting the average number of days from flooding to planting during the baseline period from the current rice cultivation cycle planting date.
 - (2) For the Mid-South, the DD50 model will be used to determine the baseline scenario flood date by using the current rice cultivation cycle emergence date.
- (h) Drain Date
- (1) For California, the baseline scenario drain date is determined by adding the average number of days from planting to drain date during the baseline period to the planting date of the current rice cultivation cycle.
 - (2) For the Mid-South, the DD50 model will be used to determine the baseline scenario drain date by using the current rice cultivation cycle emergence date.
- (i) Harvest Date
- (1) For California, the baseline scenario harvest date is determined by adding the average number of days from planting to harvest during the baseline period to the planting date of the current rice cultivation cycle.

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- (2) For the Mid-South, the DD50 model will be used to determine the baseline scenario harvest date by using the current rice cultivation cycle emergence date.
- (j) Winter Flooding Date: the actual winter flood date for the current rice cultivation cycle will be used to determine the baseline scenario winter flood date.
- (k) Winter Drain Date: the actual winter drain date for the current rice cultivation cycle will be used to determine the baseline scenario winter drain date.
- (l) Yield: the baseline scenario yield is determined by the actual rice yields during all rice growing years in the baseline period.
- (m) If any field is ineligible for a protocol practice, the relevant cropping parameters from the current rice cultivation cycle will be used in place of the methods above.

5.2.3. Unadjusted Modeled Project Emissions

- (a) For each project year, the unadjusted project modeling must be equilibrated with at least 20 years, covering complete cropping cycles, including rotation crop(s) and fallow year, of historical data by repeating all parameters from the baseline period before the start of the crediting period four times. The 20-year spin up must include data for all crop and fallow years, not just rice crop years. The following data must be used.
 - (1) Current soil data;
 - (2) Current year climate data; and
 - (3) Current year farming management practices.
- (b) Unadjusted project GHG emissions for each field must be determined by performing two thousand runs of Monte Carlo simulations with the DNDC model based on soil, climate, and cropping parameters information for the current rice cultivation cycle. The following parameters will be selected for variation using the DNDC default range for each value:
 - (1) Soil clay;
 - (2) Bulk density;
 - (3) SOC content; and
 - (4) pH value.

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- (c) The direct GHG emission parameters identified in Box 5.2 are recovered from the DNDC runs

Box 5.2. Recovered Baseline Parameter

<u>Recovered Project Parameters</u>			
$N_2O_{Dir,P,i,j}$	=	Project N_2O emissions from rice field i from Monte Carlo run j	kg N_2O -N/ha
$N_{Leach,P,i,j}$	=	Project nitrate leaching loss from rice field i from Monte Carlo run j	kg NO_3 -N/ha
$N_{Vol,P,i,j}$	=	Project ammonia volatilization from rice field i from Monte Carlo run j	kg NH_3 -N + kg NO_x -N-N/ha
$CH_4_{P,i,j}$	=	Project CH_4 emissions from rice field i from Monte Carlo run j	kg CH_4 -C/ha
$SOC_{P,i,j}$	=	Project soil organic carbon content from rice field i from Monte Carlo run j	Kg SOC -C/ha

- (d) Total average unadjusted project GHG emissions from two thousand runs of Monte Carlo simulations must be calculated using equation 5.3 below.

Equation 5.3. Calculating GHG Emissions from Monte Carlo Runs for Field i

$N_2O_{P,i} = \frac{\sum_{j=1}^{2000} \{ (N_2O_{Dir,P,i,j} + (N_{Leach,P,i,j} \times EF_{Leach}) + (N_{Vol,P,i,j} \times EF_{Vol}) \}}{2000} \times 1.571 \times GWP_{N_2O}$		
$CH_4_{P,i} = \frac{\sum_{j=1}^{2000} (CH_4_{P,i,j})}{2000} \times 1.333 \times GWP_{CH_4}$		
$SOC_{P,i} = \frac{\sum_{j=1}^{2000} (SOC_{P,i,j})}{2000} \times 3.667$		
Where,		Units
i	= Fields	
j	= Monte Carlo runs	
$N_2O_{P,i}$	= Average reporting period direct and indirect N_2O emissions (for either the baseline or project scenario) from rice field i, equal to the average value of all Monte Carlo runs j	kg CO_2e /ha
$N_{Leach,P,i,j}$	= Reporting period nitrate leaching loss from rice field i (for either the baseline or project scenario) from Monte Carlo run j	kg NO_3 -N/ha

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EF_{Leach}	=	Emission factor for N_2O emissions from N leaching and runoff, equal to 0.0075	kg N_2O -N/kg NO_3 -N
$N_{Vol,P,i,j}$	=	Reporting period ammonia volatilization and nitric oxide emissions from rice field i (for either the baseline or project scenario) from Monte Carlo run j	kg NH_3 -N + kg NO_x -N /ha volatilized
EF_{Vol}	=	Emissions factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces and subsequent volatilization, equal to 0.01	kg N_2O -N/(kg NH_3 -N + kg NO_x -N
1.571	=	Unit conversion from kg N_2O -N to kg N_2O	
$CH_4_{P,i}$	=	Average reporting period CH_4 emissions (for either the baseline or project scenario) from rice field i, equal to the average value of all Monte Carlo runs j	kg CO_2 e/ha
$CH_4_{P,i,j}$	=	Reporting period CH_4 emissions from rice field i (for either the baseline or project scenario) from Monte Carlo run j	kg CH_4 -C/ha
1.333	=	Unit conversion of C to CH_4	
$SOC_{P,i}$	=	Average reporting period final SOC, equal to the average value of all Monte Carlo runs j, of the soil organic carbon content of rice field i on the last day of the reporting period (for either the baseline or project scenario)	kg CO_2 e/ha
$SOC_{P,i,j}$	=	SOC content of rice field i on the last day of the reporting period (for either the baseline or project scenario) from Monte Carlo run j	kg SOC-C/ha
3.667	=	Unit conversion of C to CO_2	
0.0075	=	Emission factor for N_2O emissions from N leaching and runoff	kg N_2O -N / kg NO_3 -N
0.01	=	Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces and subsequent volatilization	kg N_2O -N / (kg NH_3 -N + kg NO_x -N)
GWP_{N_2O}	=	The GWP value for N_2O	
GWP_{CH_4}	=	The GWP value for CH_4	

5.2.4. Calculating Modeled Primary Emission Reductions

- (a) Total modeled primary source GHG emission reductions from soil dynamics (SSR 1) during the reporting period must be calculated using Equation 5.4.
- (b) The model structural uncertainty will be calculated according to appendix C and published on the ARB's website (arb.ca.gov) by December 31, of each year.

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- (c) The input structural uncertainty for each field will be calculated as the half-width of the 90% confidence interval of the modeled primary emission reduction from each Monte Carlo simulation expressed as a fraction of the mean GHG emission from each field, as specified in appendix C.

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Equation 5.4. Calculating Primary Source GHG Emissions Reductions

$PER = \mu_{struct} \times \sum_i (\mu_{inputs_i} \times PER_i \times A_i)$		
<i>Where,</i>		<u>Units</u>
PER	= Primary source GHG emission reductions over the entire project area, accounting for uncertainty deductions	MTCO ₂ e
$\mu_{inputs,i}$	= Accuracy deduction factor for the reporting period for individual rice field <i>i</i> due to soil input uncertainties	fraction
PER _{<i>i</i>}	= Primary source GHG emission reductions for field <i>i</i>	MTCO ₂ e
μ_{struct}	= Accuracy deduction from model structural uncertainty for the reporting period, values available on ARB's website	
A _{<i>i</i>}	= Area of field <i>i</i> in hectares	ha
With:		
$PER_i = \frac{MIN[(N_2O_{B,i} - N_2O_{P,i}), 0] + (CH_{4B,i} - CH_{4P,i}) - MAX[(SOC_{B,i} - SOC_{P,i}), 0]}{1000}$		
<i>Where,</i>		<u>Units</u>
PER _{<i>i</i>}	= Primary effect GHG emission reductions for field <i>i</i> * (unadjusted for uncertainty)	MTCO ₂ e
N ₂ O _{B,<i>i</i>}	= Average baseline reporting period N ₂ O emissions for field <i>i</i>	kg CO ₂ e/ha
N ₂ O _{P,<i>i</i>}	= Average project reporting period N ₂ O emissions for field <i>i</i>	kg CO ₂ e/ha
CH _{4B,<i>i</i>}	= Average baseline reporting period CH ₄ emissions for field <i>i</i>	kg CO ₂ e/ha
CH _{4P,<i>i</i>}	= Average project reporting period CH ₄ emissions for field <i>i</i>	kg CO ₂ e/ha
SOC _{B,<i>i</i>}	= Average SOC value on the last day of the baseline reporting period for field <i>i</i>	kg CO ₂ e/ha
SOC _{P,<i>i</i>}	= Average SOC value on the last day of the project reporting period for field <i>i</i>	kg CO ₂ e/ha
1000	= Unit conversion kg to metric tonne	kg/MT

5.3. Calculating Secondary Emissions

- (a) If project activities result in the increase of secondary source GHG emissions, the increased emissions must be quantified using equation 5.6.

Equation 5.6. Total Secondary Source GHG Emissions Increases

$SE = MAX \left[\sum_i (SE_{FF,i} + SE_{BR,i}), 0 \right]$		
Where,		<u>Units</u>
SE	= Total secondary source emission increase	MTCO ₂ e
SE _{FF,i}	= Total secondary source GHG emissions from increased fossil fuel combustion for field i, as calculated in Equations 5.7 through 5.9.	MTCO ₂ e
SE _{BR,i}	= Total secondary source GHG emissions from on-site rice straw open burning for field i, as calculated in equation 5.10	MTCO ₂ e

5.3.1. Calculating Secondary Source Emissions From Fossil Fuel Combustion

- (a) Secondary source GHG emissions increases from fossil fuel combustion (SE_{FF,i}) must be calculated using equation 5.7 if baseline scenario and project fuel consumption is available.
- (1) If rice cultivation occurred during at least three of the last five cultivation cycles prior to offset project commencement, then the average baseline scenario fuel consumption (FF_{B,k,i}) is determined by averaging fuel consumption from all the rice cultivation years in the last five cultivation cycles prior to offset project commencement.
 - (2) If rice cultivation did not occur at least three times during the five years prior to project commencement, then the average baseline scenario fuel consumption (FF_{B,k,i}) is determined by averaging fuel consumption from the three most recent rice cultivation cycles prior to offset project commencement.
- (b) If fuel consumption data is unavailable, secondary source GHG emissions increases from fossil fuel combustion (SE_{FF,i}) must be calculated using equation 5.8.
- (1) If rice cultivation occurred during at least three of the last five cultivation cycles prior to offset project commencement, then the average baseline scenario time required (t_{B,i,i}) and equipment horsepower (HP_{B,i,i}) are determined by averaging the time required and equipment horsepower

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from all the rice cultivation years in the last five cultivation cycles prior to offset project commencement.

- (2) If baseline scenario equipment horsepower ($HP_{B,i}$) is not available, then the highest equipment horsepower from the current reporting period must be used.
- (3) If baseline scenario time required ($t_{B,l,i}$) or project time required ($t_{P,l,i}$) are not available, then they both must be estimated using equation 5.9.

Equation 5.7. Project Emissions from Cultivation Equipment (fuel based)

$SE_{FF,i} = \frac{\sum_i \sum_k ((FF_{P,k,i} - FF_{B,k,i}) \times EF_{FF,k})}{1000}$		
<i>Where,</i>		<u>Units</u>
$SE_{FF,i}$	= Increase in secondary emissions from a change in cultivation equipment on field <i>i</i>	Mg CO ₂ e/ha
$FF_{P,k,i}$	= Fossil fuel consumption for field <i>i</i> during the reporting period, by fuel type <i>k</i>	gallons
$FF_{B,k,i}$	= Average baseline scenario fossil fuel consumption for field <i>i</i> , by fuel type <i>k</i>	gallons
$EF_{FF,k}$	= Fuel-specific emission factor from Appendix F	kg CO ₂ /gallon fossil fuel
<i>k</i>	= Fuel type	
1000	= Kilograms per metric tonne	kg CO ₂ /Mg CO ₂

Equation 5.8. Project Emissions from Cultivation Equipment (time based)

$SE_{FF,i} = \left(\sum_l (EF_{HP-hr,P,l,i} \times HP_{P,l,i} \times t_{P,l,i}) - \sum_l (EF_{HP-hr,B,l,i} \times HP_{B,l,i} \times t_{B,l,i}) \right) \times 10^{-6}$		
<i>Where,</i>		<u>Units</u>
$SE_{FF,i}$	= Increase in secondary emissions from a change in cultivation equipment on field <i>i</i>	Mg CO ₂ e/ha
EF_{HP}	= Emission factor for project operation <i>l</i> on field <i>i</i> . Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled	g CO ₂ e/HP-hr

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hr _{P,l,i}	operations	
HP _{P,l,i}	= Equipment horsepower for project operation <i>l</i> on field <i>i</i>	HP
t _{P,l,i}	= Time required to perform project operation <i>l</i> on field <i>i</i>	hr/field
EF _{HP-hr,B,l,i}	= Default emission factor for baseline operation <i>k</i> on field <i>f</i> Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations	g CO ₂ e/HP-hr
HP _{B,l,i}	= Equipment horsepower for baseline operation <i>l</i> on field <i>i</i>	HP
t _{B,l,i}	= Time required to perform baseline operation <i>l</i> on field <i>i</i>	hr/field
<i>l</i>	= Project operation	
10 ⁻⁶	= G per metric ton	

Equation 5.9. Project Emissions from Cultivation Equipment: Option 3 (field dimension based)

$t_{(B \text{ or } P),l,i} = \frac{A_i}{(\text{width} \times \text{speed} \times 1000)} \times 10,000$		
<i>Where,</i>		<u>Units</u>
T _{(B or P),l,i}	= Time requirement for field operation <i>l</i> on field <i>i</i>	hr
10,000	= Area unit conversion	m ² /ha
width	= Application width covered by equipment	m
speed	= Average ground speed of the operation equipment	km/hr
1000	= Length unit conversion	m/km
A _{<i>i</i>}	= Size of field <i>i</i>	ha

Stakeholder Input Requested: Accuracy and Stringency of Project Emissions from Cultivation Equipment

To ensure the maximum accuracy for reported project emissions from cultivation equipment, equation 5.9 must be more conservative than equation 5.8 which should be more conservative than equation 5.7. Are the numbers presented in these three equations reflecting this logic?

5.3.2. Calculating Secondary Source Emissions from On-Site Rice Straw Management

- (a) Secondary source GHG emission increases from rice straw management practices must be calculated using equation 5.10.

Equation 5.10. Project Emission from Rice Straw Open Burning for Field i

$$SE_{BR,i} = \sum_i (Area_{BR,P,i} \times (EF_{BR,CH4} + EF_{BR,CO2})) - \sum_U (Area_{BR,P,i} \times (EF_{BR,CH4} + EF_{BR,CO2}))$$

Where,			<u>Units</u>
$SE_{BR,i}$	=	Project emission from rice straw open burning	Kg
$Area_{BR,i}$	=	Area of rice straw burned on field i	ha
$EF_{BR, CH4}$	=	8.04 Methane emission factor for rice straw open burning	Kg/ha
$EF_{BR, CO2}$	=	26.8 Carbon dioxide emission factor for straw open burning	Kg/ha

5.4. Conversion Factors

For the purposes of this protocol, the following conversion factors apply.

- (a) 1 hectare (ha) equals 2.4711 acres.
- (b) 1 pound (lb) equals 0.4536 kilogram (Kg).
- (c) 1 foot (ft) equals 0.3048 meter.

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Chapter 6. Monitoring – Quantification Methodology

6.1. General Project Monitoring Requirements

The Offset Project Operator or Authorized Project Designee is responsible for monitoring all parameters prescribed in Table 6.1.

Table 6.1. Monitoring Parameters Quantification Methodology

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Climate	GPS location of field	° decimal to four places	m	Once per project	User defined
	Atmospheric background NH ₃ concentration	µg N/m ³	r	Once per crediting period	DNDC default
	Atmospheric background CO ₂ concentration	ppm	r	Once per crediting period	DNDC default
	Daily precipitation	cm	m	Daily	See section 5.2(c)(2)
	Daily maximum temperature	°C	m	Daily	See section 5.2(c)(2)
	Daily minimum temperature	°C	m	Daily	See section 5.2(c)(2)
	N concentration in rainfall	mg N/l or ppm	r	Once per crediting period	DNDC default
Soils**	Land-use type	type	m	Once per project	User defined
	Clay content	0-1	m/r	Annual	See section 5.2(c)(1)
	Bulk density	g/cm ³	m/r	Annual	See section

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Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
					5.2(c)(1)
	Soil pH	value	m/r	Annual	See section 5.2(c)(1)
	SOC at surface soil	kg C/kg	m/r	Annual	See section 5.2(c)(1)
	Soil texture	type	m/r	Annual	See section 5.2(c)(1)
Crop	Planting date	date	m	Annual	OPO records
	Harvest date	date	m	Annual	OPO records
	C/N ratio of the grain	ratio	m/r	Once per variety	DNDC default
	C/N ratio of the leaf + stem tissue	ratio	m/r	Once per variety	DNDC default
	C/N ratio of the root tissue	ratio	m/r	Once per variety	DNDC default
	Fraction of leaves + stem left in field after harvest	0-1	m	Annual	OPO records
	Maximum yield	kg dry matter/ha	m	Annual	OPO records
	Number of tillage events	number	O	Annual	OPO records
	Date of tillage events	date	O	Annual	OPO records
	Depth of tillage events	cm (select from 7 default depths) †	O	Annual	OPO records

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Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Tillage	Number of fertilizer applications	number	O	Annual	OPO records
	Date of each fertilizer application	date	O	Annual	OPO records
	Application method	surface / injection	O	Annual	OPO records
Fertilization	Type of fertilizer	type*	O	Annual	OPO records
	Fertilizer application rate	kg N/ha	O, C	Annual	OPO records (field average if using variable rate applications)
	Number of organic applications per year	number	O	Annual	OPO records
	Date of application	date	O	Annual	OPO records
	Type of organic amendment	type	O	Annual	OPO records
Manure amendment ⁴ (if used)	Application rate	kg C/ha	O	Annual	OPO records
	Amendment C/N ratio	ratio	O	Annual	DNDC defaults
	Number of irrigation events	number	O	Annual	OPO records
	Date of irrigation events		O	Annual	OPO records

⁴ DNDC allows for data on any soil amendment to be input into the model, and provides default parameters (i.e. C/N ratio) for several types of soil amendments. See Appendix B Step 1.4 for further guidance.

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Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
	Irrigation type	Must use the 'flood' default type	O	Annual	OPO records
Irrigation	Irrigation application rate	mm	O	Annual	OPO records
	Date of flood-up for growing season	date	O	Annual	OPO records
	Date of drain for crop harvest	date	O	Annual	OPO records
	Date of flood-up for winter flooding (if applicable)	date	O	Annual	OPO records
Flooding	Date of drain for winter flooding (if applicable)	date	O	Annual	OPO records
Fuel usage	For Equation 5.7: fossil fuel consumption	Quantity of fossil fuel Fuel type Equipment horsepower	O	Annual (aggregated by event consumption)	OPO records
	For Equation 5.8	Fuel type Equipment horsepower	O	Annual (aggregated by event consumption)	

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Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
		Equipment operation time			
	For Equation 5.9	Time requirement Field dimension	O	Annual (aggregated by event consumption)	
Straw management parameters	Fraction of rice straw burned in either the fall burn or spring burn event.	date	O	Annual, event based	OPO records

6.2. General Document Retention

- (a) The Offset Project Operator or Authorized Project Designee is required to keep all documentation and information outlined in the Regulation and this protocol. Record retention requirements are set forth in section 95976 of the Regulation.
- (b) Information that must be retained by the Offset Project Operator or Authorized Project Designee includes:
 - (1) All data inputs for the calculation of the project baseline scenario emissions and project emission reductions including:
 - (A) DNDC inputs for farming management information and soil and climate profile parameters;
 - (B) Recovered parameters from DNDC runs;
 - (C) Historical data used to determine baseline scenarios;
 - (D) Fuel purchase records;
 - (E) Documentation of farm equipment purchased or leased;

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- (F) Straw management records;
 - (G) Documentation of water usage including deliveries, drainage, and pumping; and
 - (H) Documentation of fertilizer, herbicide, and pesticide acquisition and application;
- (2) Emission reduction calculations;
 - (3) Land ownership and lease documents, if applicable, and air, water, and land use permits;
 - (4) Notices of Violation (NOVs), and any administrative or legal consent orders related to project activities dating back at least three years prior to offset project commencement date and for each year within the project's crediting period; and
 - (5) Documentation of field boundaries throughout the project life.

6.2.1. Documentation for Dry Seeding Activities

- (a) Seeding equipment purchase or rental records, and/or seeding service contracts/agreements/receipts.
- (b) At least four time-stamped digital photographs per field 'check' taken from various vantage points no more than 15 days after seeding. The pictures must clearly show an establishing stand with no standing water present. Each photograph must also include a field check's coordinates and local newspaper with a date on it.
- (c) At least four time-stamped digital photographs per field 'check' taken from various vantage points during flood-up. The pictures must clearly show the established stand.
- (d) Satellite pictures, with a date clearly marked on the picture, may be used to meet the requirements set forth in section 6.2.1(b) & (c).

6.2.2. Documentation for Early Drainage Activities

- (a) At least four time-stamped digital photographs per field 'check' taken from various vantage points to clearly show the established stand with no standing

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water present. Each photograph must also include a field check's coordinates and local newspaper with a date on it.

- (b) Remote sensing data, with a date clearly marked on the picture or file, may be used to meet the requirements set forth in section 6.2.2(a).

6.2.3. Documentation for Alternate Wet and Dry Activities

- (a) For each round of wet and dry, at least four time-stamped digital photographs per field 'check' taken from various vantage points during flood-up and draining, respectively. The pictures must clearly show the established stand. Draining pictures need to clearly show no standing water present. Each photograph must also include a field check's coordinates and local newspaper with a date on it.
- (b) For each round of wet and dry, soil moisture samples must be taken following the requirements specified in section 2.3(c). The following parameters must be monitored and documented for each participating field:
 - (1) A diagram that includes dimensions and shows where samples are taken in a field;
 - (2) The date when the field was flooded or received water;
 - (3) The date when the soil moisture samples were taken; and
 - (4) The field grading status.

Stakeholder Input Requested: Project Documentation and Verification

Do verifiers have any recommendations on additional documentation to support project verification? Example: For early drainage, how can the verifiers ensure that the time-stamped photos were taken exactly on the day shown on the photos but not a few days later? Can cloud-based or escrow data uploading potentially assist in this?

Chapter 7. Reporting

7.1. General Project Listing Requirements

- (a) Listing information must be submitted by the Offset Project Operator or Authorized Project Designee no later than the date on which the Offset Project

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Operator or Authorized Project Designee submits the first Offset Project Data Report.

- (b) In order for a Rice Cultivation Compliance Offset Project to be listed, the Offset Project Operator or Authorized Project Designee must submit the information required by section 95975 of the Regulation, in addition to the following information:
- (1) Offset project name;
 - (2) Rice cultivation activity types (i.e., dry seeding activity, early drainage activity, and/or alternate wet and dry activity);
 - (3) Contact information, including name, phone number, mailing address, physical address (if different from mailing address), and e-mail address for the:
 - (A) Offset Project Operator; and
 - (B) Authorized Project Designee (if applicable);
 - (4) CITSS ID number for the:
 - (A) Offset Project Operator; and
 - (B) Authorized Project Designee (if applicable);
 - (5) Contact information, including name, phone number, mailing address, physical address (if different from mailing address), and e mail address for:
 - (A) Person submitting the listing information; and
 - (B) Technical consultants;
 - (6) Date of listing information submission;
 - (7) A description of the field ownership and operational structures;
 - (8) Documentation (e.g., title report, lease, etc.) showing the Offset Project Operator's legal authority to implement the offset project;
 - (9) Physical address, latitude and longitude coordinate and parcel number recorded in the County Assessor's Office for each field;
 - (10) The Rice Growing Region(s) where the project is located;
 - (11) Number of fields and size (acres or hectares) of each field;

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- (12) Indicate if the project occurs on private or public lands and further specify if the project occurs on any of the following categories of land:
- (A) Land that is owned by, or subject to an ownership or possessory interest of a Tribe;
 - (B) Land that is “Indian lands” of a Tribe, as defined by 25 U.S.C. §81(a)(1); or
 - (C) Land that is owned by any person, entity, or Tribe, within the external borders of such Indian lands; and
- (13) If the project is located on one of the above categories of land, a description and copies of documentation demonstrating that the land is owned by (or subject to an ownership or possessory interest of) a tribe or private entities.

7.2. Offset Project Data Report

- (a) Offset Project Operators or Authorized Project Designees must submit an Offset Project Data Report (OPDR) at the conclusion of each Reporting Period within four months after ARB’s publication of the DNDC structural uncertainty as specified in section 5.2.4(b).
- (b) In addition to information submitted as specified in section 7.2.(c), the Offset Project Operators or Authorized Project Designees must report to ARB their project acreage in each Rice Growing Region for each reporting period no later than November 30 of that year.
- (c) Offset Project Operators or Authorized Project Designees must submit the information required by section 95976 of the Regulation, in addition to the following information:
 - (1) Offset project name and identification numbers;
 - (2) Rice cultivation activity types employed (i.e., dry seeding activity, early drainage activity, and/or alternate wet and dry activity) for each rice field;
 - (3) Contact information, including name, phone number, mailing address, physical address (if different from mailing address), and e-mail address for the:

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- (A) Offset Project Operator; and
- (B) Authorized Project Designee (if applicable);
- (4) CITSS ID number for the:
 - (A) Offset Project Operator; and
 - (B) Authorized Project Designee (if applicable);
- (5) Contact information, including name, phone number, mailing address, physical address (if different from mailing address), and e-mail address for:
 - (A) Person submitting the listing information; and
 - (B) Technical consultants;
- (6) Date of Offset Project Data Report submission;
- (7) Reporting period;
- (8) Offset project commencement date;
- (9) Statement as to whether all the information submitted for project listing is still accurate. If not, provide updates to the relevant listing information;
- (10) Statement as to whether the project has met all local, state, and federal regulatory requirements during the reporting period. If not, an explanation of the non-compliance must be provided;
- (11) Unadjusted baseline scenario primary source GHG emissions during the reporting period ($N_2O_{B,i}$, $CH_4_{B,i}$, $SOC_{B,i}$) for each field following the requirements of Chapter 5;
- (12) Unadjusted project primary source GHG emissions during the reporting period ($N_2O_{P,i}$, $CH_4_{P,i}$, $SOC_{P,i}$) for each field following the requirements of Chapter 5;
- (13) Primary source project emissions reductions (PER) for each field during the reporting period;
- (14) Total secondary source GHG emissions from increased fossil fuel combustion ($SE_{FF,i}$) for each field during the reporting period following the requirements of Chapter 5;

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- (15) Total secondary source GHG emissions increase (SE_{RM}) from rice straw burning for each field during the reporting period following the requirements of Chapter 5;
- (16) Total emission reductions (ER) from each field and the entire project area, respectively, during the reporting period following the requirements of Chapter 5;
- (17) Project baseline scenario parameters for each field;
- (18) Whether there was a rotation crop or fallow year in between this reporting period and the previous reporting period. If yes, identify the year and practice for each field; and
- (19) If there is an event of an anthropogenic or natural soil alternation or movement, the event date and new soil characteristics have to be documented.

Chapter 8. Verification Requirements

- (a) All Offset Project Data Reports are subject to regulatory verification as set forth in section 95977 of the Regulation by an ARB-accredited offset verification body.
- (b) The Offset Project Data report must receive a positive or qualified positive offset verification statement to be issued ARB or registry offset credits.
- (c) The Offset Verification Report must be received by ARB or the Offset Project Registry within eleven months after ARB's publication of the DNDC's structural uncertainty as specified in section 5.2.4(b).
- (d) Each verification team must include an expert with one of the following qualifications:
 - (1) An agronomist with at least five years of direct professional experience in rice cultivation; or
 - (2) A local or state agricultural cooperative rice farming advisor.

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Appendix A. Management records for baseline period

For a project to be eligible, the following information from the baseline period must be available upon project listing and retained for 15 years from the project commencement date:

- (a) General information for each field:
 - (1) Field geographic coordinates, county, and state for each field, and parcel number;
 - (2) Flooding⁵ and drainage⁶ dates (during the growing season and during post-harvest period);
 - (3) Begin and end date of harvesting on the field;
 - (4) Post-harvesting residue management (e.g. burning, incorporation or baling) description and dates;
 - (5) Amount of herbicides applied for the baseline period cultivation cycle and the project scenario cultivation cycle;⁷
 - (6) Fertilization types, amounts, and application dates;⁸
 - (7) Harvest date; and
 - (8) Mass of rice straw removed after harvest, the fraction of removed rice straw and end use of rice straw removed.
- (b) Information for drying seeding:
 - (1) Planting preparation description and date;
 - (2) Planting date and method; and
 - (3) The date a field is fully flooded in preparation for seeding.
- (c) Information for early drainage in preparation for harvest:
 - (1) The date that the water board was pulled or the flooding of the field was stopped; and
 - (2) Harvest date.

⁵ For each field, the flood date shall be equal to the date that the flooding starts.

⁶ For each field, the drainage date shall be equal to the date that the water board is pulled or soil is exposed without standing water.

⁷ Amounts of herbicide used in the baseline scenario cultivation cycle do not need to be verified.

⁸ The fertilizer type must correctly reflect its ammonium-nitrate composition. .

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- (d) Information for alternate wet and dry:
 - (1) The dates that the water board was pulled or the flooding of the field was stopped; and
 - (2) Soil moisture sampling date, number of samples, and the results of sampling.

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Appendix B. Crop Calibration Methodology - Quantification Methodology

The field-specific crop calibration must always use historically observed rice yield data and employ the following steps:

Step 1 – selecting the right parameter set for the variety used.

1. Input the default crop parameters using the appropriate rice variety values from the table B-1.

Table B.1 DNDC input parameters default values for crop calibration

DNDC Input Parameters	California	Mid-south	
	All non-wild rice	MRD ⁹	LGC ¹⁰
Initial_biomass	12.5	0	0
Cover_Crop	0	0	0
Perennial_Crop	0	0	0
Grain_fraction	0.6	0.5	00.41
Shoot_fraction	0.3	0.23	0.25
Root_fraction	0.1	0.05	0.1
Grain_CN	30	45	4
Shoot_CN	65	85	85
Root_CN	65	85	85
TDD	3000	3200	3800
Water_requirement	508	508	508
Optimum_temp	25	20	25
Max_LAI	6		
N_fixation	1.05	1.05	1.05
Vascularity	1	1	1

⁹ Mississippi River Delta Rice Growing Region

¹⁰ Louisiana Gulf Coast Rice Growing Region.

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Step 2 – tuning the “maximum biomass” parameter of the DNDC model.

1. The “maximum biomass” parameter of the DNDC model must be manually tuned using yield data so that DNDC predicts the recorded yields during at least three out of five years before the start of the Project with a maximal relative Root Mean Squared Error (RMSE) of 10% of the observed means.
2. If rice is grown only two out of the five years preceding the Project Start Date, applying this test with two years of data suffices.
3. If this is not possible by adjusting the “maximum biomass” parameter, the “thermal degree days for maturity” must be adjusted until modeled yields are within a maximal relative RMSE of 10% of observed means.
 - a) If the "Crop" pane indicates that the “Temperature demand” value is greater than the value for “Thermal degree days for maturity,” the “Thermal degree days for maturity” (equal to the “TDD” parameter in the .dnd file) must be reduced until the “Temperature demand” is smaller than or equal to the value of “Thermal degree days for maturity.”

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Appendix C. Structural Uncertainty Deduction Factor – Quantification

Methodology

The structural uncertainty deduction factor will be determined by ARB using the following formulas. ARB will publish participating project acreage annually on its website at <http://www.arb.ca.gov> to determine which structural uncertainty deduction factor should be used for a specific Rice Growing Region. In general, structural uncertainty deduction factor, are determined by the following equations.

		$\mu_{struct} = \frac{s\sqrt{2(1-\rho)}}{\sqrt{n}} \times t_{inv}(0.95, k)$ $\mu_{struct} = e^{-\frac{s\sqrt{2(1-\rho)}}{\sqrt{n}} \times t_{inv}(0.95, k)}$				
<i>Where:</i>	Values	California	Mississippi	Missouri	Louisiana	Arkansas
μ_{struct}	= Structural uncertainty factor					
s	= Standard deviation	X	X	X	X	X
ρ	= Correlation between project residuals and baseline residuals	X	X	X	X	X
t_{inv}	= Inverse of the cumulative t-distribution with a specific confidence and degrees of freedom	X	X	X	X	X

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k	=	Number of pairs of modeled and measured values used for model verification	X	X	X	X	X
n	=	Number of fields reporting	ARB	ARB	ARB	ARB	ARB

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Appendix D. Emission Factors – Quantification Methodology

An Offset Project Operator or Authorized Project Designee must use the emission factors in Table D-1 for fuel combustion activities, except that for projects located in the California Rice Growing Region, the emission factors for fossil fuel combustion are zero.

Table D.1. Emission Factors for Fuel Use

Fuel Type	Default High Heat Value	Default CO₂ Emission Factor	Default CO₂ Emission Factor
Coal and Coke	MMBtu / short ton	kg CO₂ / MMBtu	kg CO₂ / short ton
Anthracite	25.09	103.54	2597.819
Bituminous	24.93	93.40	2328.462
Subbituminous	17.25	97.02	1673.595
Lignite	14.21	96.36	1369.276
Coke	24.80	102.04	2530.592
Mixed (Commercial sector)	21.39	95.26	2037.611
Mixed (Industrial coking)	26.28	93.65	2461.122
Mixed (Electric Power sector)	19.73	94.38	1862.117
Natural Gas	MMBtu / scf	kg CO₂ / MMBtu	kg CO₂ / scf
(Weighted U.S. Average)	1.028 x 10 ⁻³	53.02	0.055
Petroleum Products	MMBtu / gallon	kg CO₂ / MMBtu	kg CO₂ / gallon
Distillate Fuel Oil No. 1	0.139	73.25	10.182
Distillate Fuel Oil No. 2	0.138	73.96	10.206
Distillate Fuel Oil No. 4	0.146	75.04	10.956
Distillate Fuel Oil No. 5	0.140	72.93	10.210
Residual Fuel Oil No. 6	0.150	75.10	11.265
Used Oil	0.135	74.00	9.990
Kerosene	0.135	75.20	10.152
Liquefied petroleum gases (LPG)	0.092	62.98	5.794
Propane	0.091	61.46	5.593
Propylene	0.091	65.95	6.001
Ethane	0.069	62.64	4.322
Ethanol	0.084	68.44	5.749
Ethylene	0.100	67.43	6.743
Isobutane	0.097	64.91	6.296
Isobutylene	0.103	67.74	6.977
Butane	0.101	65.15	6.580
Butylene	0.103	67.73	6.976
Naphtha (<401 deg F)	0.125	68.02	8.503
Natural Gasoline	0.110	66.83	7.351
Other Oil (>401 deg F)	0.139	76.22	10.595
Pentanes Plus	0.110	70.02	7.702

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Fuel Type	Default High Heat Value	Default CO₂ Emission Factor	Default CO₂ Emission Factor
Coal and Coke	MMBtu / short ton	kg CO₂ / MMBtu	kg CO₂ / short ton
Petrochemical Feedstocks	0.129	70.97	9.155
Petroleum Coke	0.143	102.41	14.645
Special Naphtha	0.125	72.34	9.043
Unfinished Oils	0.139	74.49	10.354
Heavy Gas Oils	0.148	74.92	11.088
Lubricants	0.144	74.27	10.695
Motor Gasoline	0.125	70.22	8.778
Aviation Gasoline	0.120	69.25	8.310
Kerosene-Type Jet Fuel	0.135	72.22	9.750
Asphalt and Road Oil	0.158	75.36	11.907
Crude Oil	0.138	74.49	10.280
Other fuels (solid)	MMBtu / short ton	kg CO₂ / MMBtu	kg CO₂ / short ton
Municipal Solid Waste	9.95 ¹	90.7	902.465
Tires	26.87	85.97	2310.014
Plastics	38.00	75.00	2850.000
Petroleum Coke	30.00	102.41	3072.300
Other fuels (gaseous)	MMBtu / scf	kg CO₂ / MMBtu	kg CO₂ / scf
Blast Furnace Gas	0.092 x 10 ⁻³	274.32	0.025
Coke Oven Gas	0.599 x 10 ⁻³	46.85	0.028
Propane Gas	2.516 x 10 ⁻³	61.46	0.155
Fuel Gas ²	1.388 x 10 ⁻³	59.00	0.082
Biomass Fuels (solid)	MMBtu / short ton	kg CO₂ / MMBtu	kg CO₂ / short ton
Wood and Wood Residuals	15.38	93.80	1442.644
Agricultural Byproducts	8.25	118.17	974.903
Peat	8.00	111.84	894.720
Solid Byproducts	25.83	105.51	2725.323
Biomass Fuels (gaseous)	MMBtu / scf	kg CO₂ / MMBtu	kg CO₂ / scf
Biogas (Captured methane)	0.841 x 10 ⁻³	52.07	0.044
Biomass Fuels (liquid)	MMBtu / gallon	kg CO₂ / MMBtu	kg CO₂ / gallon
Ethanol	0.084	68.44	5.749
Biodiesel	0.128	73.84	9.452
Rendered Animal Fat	0.125	71.06	8.883
Vegetable Oil	0.120	81.55	9.786

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Appendix E. Soil Uncertainty Analysis - Quantification Methodology

- (a) There are two allowable methods for modeling the unadjusted baseline and project emissions.
- (b) Method 1: Monte Carlo simulation of soil input uncertainty
 - (1) 2000 runs of Monte Carlo simulation varying the identified parameters must be run independently for the baseline and the project scenario.
 - (1) If NRCS SSURGO soil survey data are used for setting soil parameter values, then default uncertainty estimates must be set based on the uncertainty estimates and probability distribution functions (PDF) listed in Table E.1.
 - (2) For each soil stratum, the mean value shall be calculated as the area-weighted sum of the representative values for all of the relevant SSURGO data.

Table E.1. Uncertainty Estimates and Probability Distribution Functions for Soil Parameters

Parameter	PDF	Uncertainty
Bulk density	Log-normal	+/- 0.1 g/cm ³
Clay content	Log-normal	+/- 10%
SOC	Log-normal	+/- 20%
pH	Normal	+/- 1 pH unit

(Source: Selected from <http://www.abdn.ac.uk/modelling/cost627/Questionnaire.htm>.)

- (3) If field measurements are used, then the uncertainty level for each soil parameter shall be +/-10 percent of the mean at a 90 percent confidence level.
- (c) Method 2: Min/Max analysis of soil input uncertainty
 - (1) 16 runs of the DNDC model comprised of every possible combination of the minimum and maximum uncertainty values for each soil parameter will be run.

**Stakeholder Input Requested: Sufficiency of Runs of Monte Carlo
Simulation**

The rice field soil parameters can greatly affect DNDC emission reduction calculations necessitating evaluation of soil uncertainty when determining creditable emission reductions. Traditionally this has been done through Monte Carlo simulation to estimate and evaluate the uncertainty. This is a relatively time consuming process. Are there alternatives to the methods provided in this protocol that would produce similar results with significantly less computational time? For example, would 16 runs of DNDC with every possible combination of the minimum and maximum uncertainty values for each of the four identified soil parameters provide the certainty required for offset crediting.